SUMMIT LAKE WATER QUALITY IMPROVEMENT ANNALYSIS
For
THE VILLAGE OF PHILMONT
BROWNFIELD OPPORTUNITY GRANT
PHASE 1

RENEWAGE LLC

renewage

March 2016

SUMMIT LAKE WATER QUALITY IMPROVEMENT ANNALYSIS
THE VILLAGE OF PHILMONT

Introduction and Problem Statement

The Village of Philmont is concerned with water quality improvement in the 21.3 acre Summit Reservoir, a vital economic and recreational resource. The Village seeks innovative green engineering solutions utilizing an economical and ecological BMP solution to halt further deterioration and begin the process of revitalizing the reservoir. Sediment entering the reservoir from the Agawamuck Creek has created a large delta at the stream inlet and has partially filled the bottom of the reservoir to an average depth of 2 to 5 feet (WCSWCD, 2014). Based on multiple vintages of aerial imagery, delta formation appears to be accelerating following Tropical Storm Irene in 2011.

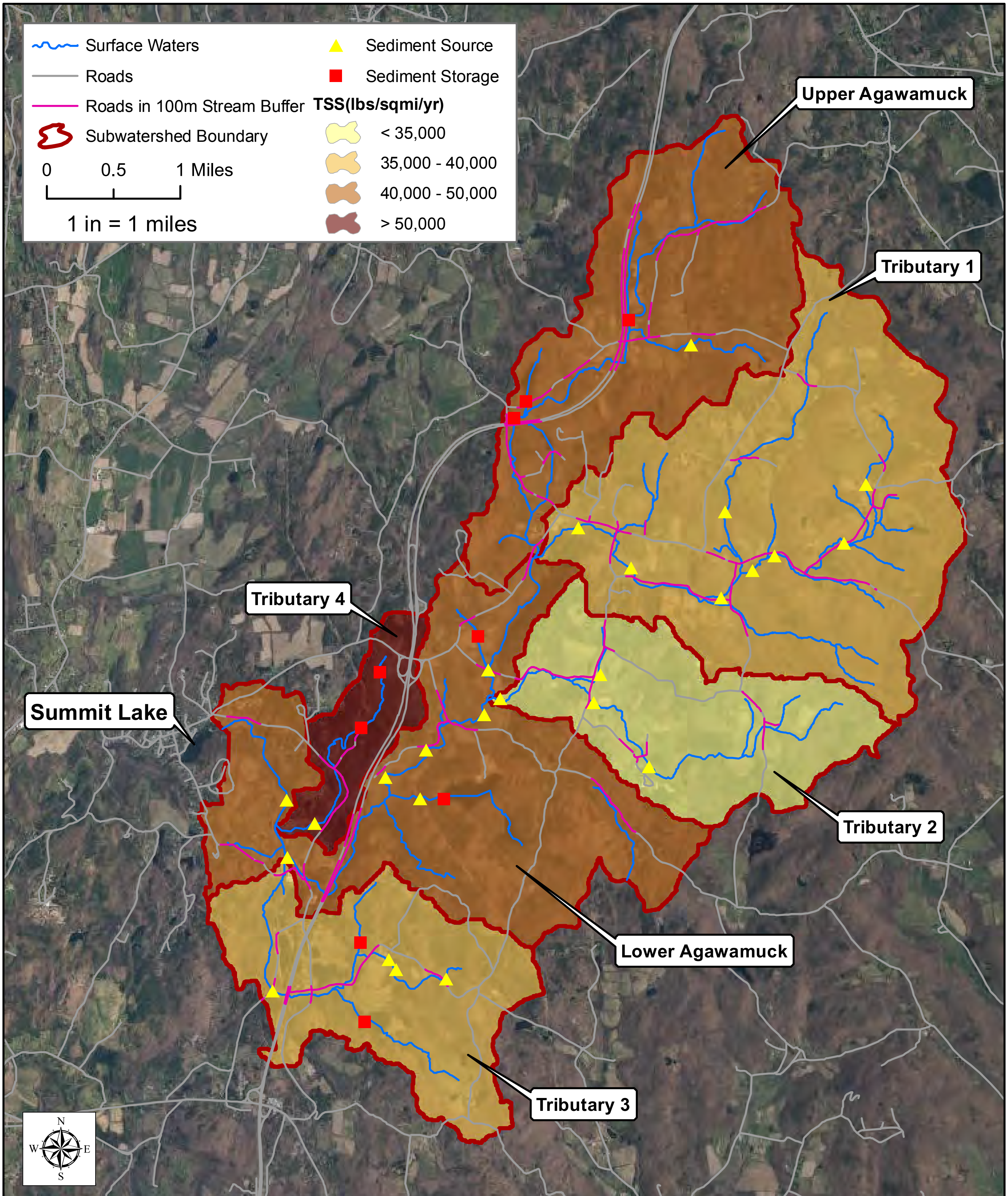
The Agawamuck Creek watershed draining to the reservoir is approximately 21.4 square miles (13,700 acres) with a combination of forest, agricultural fields, and low to moderate density residential areas. An additional 0.17 square miles (103 acres) drain directly to the Reservoir and include southern portions of the Village situated along the lakeshore (i.e., Lake View Drive). Approximately 6.5 miles of the Taconic Parkway run through the western portion of the watershed. The reservoir and watershed assessment conducted by Warren County Soil & Water Conservation District identified urban stormwater runoff, agricultural areas, and streambank/in-stream erosion as primary mechanisms for sediment and nutrient delivery to the reservoir (WCSWCD, 2014).

Stormwater Runoff and Pollutant Loading Analysis

1. *Watershed Delineation and Flow Estimates*
   We began our runoff and pollutant loading analysis with the delineation of the Summit Reservoir watershed and major subwatersheds using the USGS Streamstats application. We divided the watershed into the upper Agawamuck and four (4) major tributaries, and included direct drainage to the Reservoir and the entire Reservoir drainage area in all analyses. Streamstats calculates the return interval flow rates for each watershed based on drainage area, lag factor, storage (wetlands and ponds), and mean annual runoff. Estimated flows for the 2-year, 10-year, and 100-year storms are shown in **Table 1**. Runoff rates were highest in Tributaries 1, 2, and 4 where the watersheds are steeper and have less storage area.

Table 1: Estimated flows for selected return interval storms. Flows shown in cubic feet per second (cfs) and area normalized flow cfs/square mile (csm)

Watershed	Watershed Drainage Area (Mi^2)	Flow Return Interval: Q 2		Q 10		Q 100	
		cfs	csm	cfs	csm	cfs	csm
Summit Reservoir	21.40	760	36	1,610	75	3,210	150
Upper Agawamuck	3.98	164	41	357	90	724	182
Tributary 1	6.12	324	53	712	116	1,430	234
Tributary 2	2.67	131	49	293	110	603	226
Tributary 3	2.81	98	35	219	78	456	162
Tributary 4	0.86	52	60	116	135	236	274



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Philmont, NY

Notes:
- Sediment sources and storages were identified remotely using several imagery sources and vintages
- SIMPLE method used to estimate watershed scale sediment loading

Map 1

2. *Land Cover Classification*

Land cover mapping was created in a GIS for the Summit Reservoir watershed from the 2011 National Land Cover Dataset (Homer *et al.*, 2015).

The watershed is comprised of mainly forested, agriculture, and residential lands. The NLCD classifications contained 16 different land cover types within the watershed. We combined these into four categories (**Table 2**) to facilitate pollutant loading calculations. Impervious cover was estimated based on land cover type. Agricultural land cover is relatively consistent across the watershed, with slightly higher coverage in the tributary 1 subwatershed, and the lowest coverage in the subwatersheds for tributaries 3 and 4 and the direct drainage to the Reservoir. Residential development was also similar except for low coverage in the Lower Agawamuck subwatershed and a high percentage of residential development in the tributary 4 subwatershed and in the direct drainage to the reservoir.

Table 2: Land cover results for the Summit Reservoir watershed and major subwatersheds.

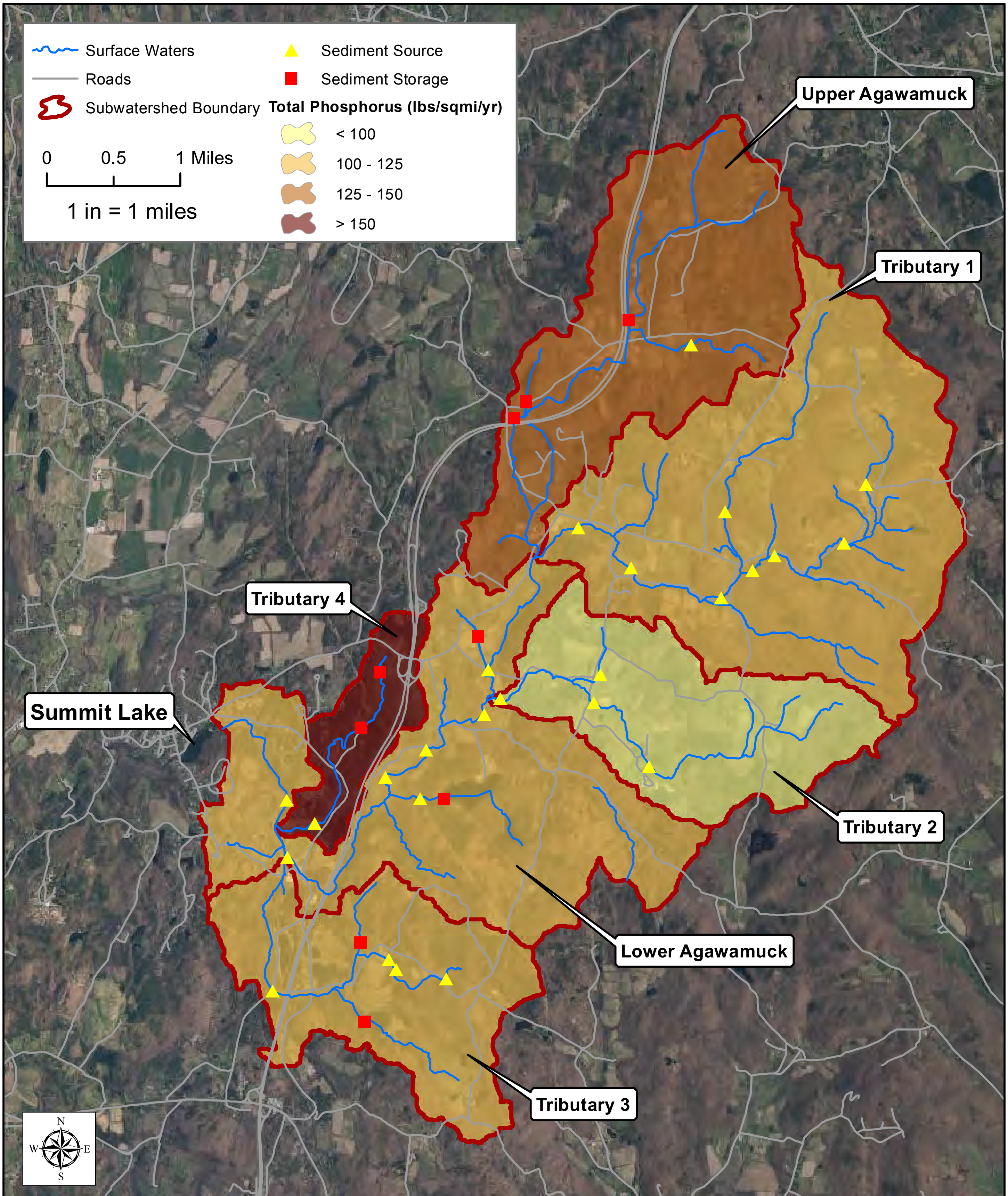
Watershed	Drainage Area (sqmi)	% Impervious	% Agriculture	% Forest/ Rural	% Residential	% Water/ Wetland
Agawamuck Creek (at inlet)	21.40	3.88	21%	66%	7%	5%
Lower Agawamuck**	4.97	4.67	17%	74%	1%	8%
Upper Agawamuck	3.98	3.06	24%	62%	8%	5%
Agawamuck Tributary 1	6.12	2.03	26%	66%	5%	2%
Agawamuck Tributary 2	2.67	4.31	24%	67%	3%	4%
Agawamuck Tributary 3	2.81	9.35	13%	69%	8%	7%
Agawamuck Tributary 4	0.86	0.53	13%	59%	18%	8%
Direct Runoff to Reservoir	0.17	7.89	5%	60%	16%	19%

*Source: 2011 National Land Cover Dataset

**Portion of Agawamuck Watershed between Summit Reservoir and Tributary 4 confluence

3. *Road Density Analysis*

The road network within each watershed was described in total length, road density, and the length of road within a 100m buffer of the stream centerlines. Roads located close to streams are of particular concern for stormwater impacts, due to an increased likelihood that those impervious surfaces are directly connected to the surface waters (i.e., ditches or culverts) and may convey sediment and non-point source pollutants to the stream. Tributary 4 had the highest road density, however it also had the lowest density of roads near a stream (**Table 3**).



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Map 2

Table 3: Road density analysis results for the Summit Reservoir watershed and major subwatersheds.				
Watershed	**Watershed Drainage Area (mi^2)**	**Road Length (mi)**	**Road Density (mi/mi^2)**	**Road Length Within 100m Stream Buffer (mi)**
Agawamuck Creek (at inlet)	21.40	60.9	2.85	21.1
Lower Agawamuck	4.97	14.6	2.94	4.3
Upper Agawamuck	3.98	13.4	3.37	6.3
Agawamuck Tributary 1	6.12	13.3	2.17	5.2
Agawamuck Tributary 2	2.67	5.0	1.87	2.3
Agawamuck Tributary 3	2.81	9.3	3.31	1.9
Agawamuck Tributary 4	0.86	5.3	6.16	1.0
Direct Runoff to Reservoir	0.17	1.4	8.29	0.6

4. *Pollutant Loading Analysis*

The "Simple Pollutant Loading Method", like the name suggests, is a fast and effective planning tool which uses several land use inputs and precipitation data to make estimates of annual pollutant and solute loads in urban watersheds (NYDEC, 2001). Using the subwatershed boundaries and characteristics, the Simple Method was utilized to estimate annual pollutant loads in each subwatershed draining to the reservoir. Percent impervious cover in each subwatershed was used with Equation 1.0 (see below) to determine the runoff coefficient (Rv). The calculated runoff coefficient was then used in Equation 2.0 to determine the annual runoff volumes and loads from each subwatershed. Annual precipitation data was derived from historic rainfall records from the National Weather Service stations in Albany and Poughkeepsie. Once annual runoff was calculated for each subwatershed, the Simple Method calculation was performed using Equation 3.0.

Equation 1.0 $Rv = 0.05 + 0.9\, I_a$

Where:
I_a = Impervious fraction
R_v = Runoff coefficient

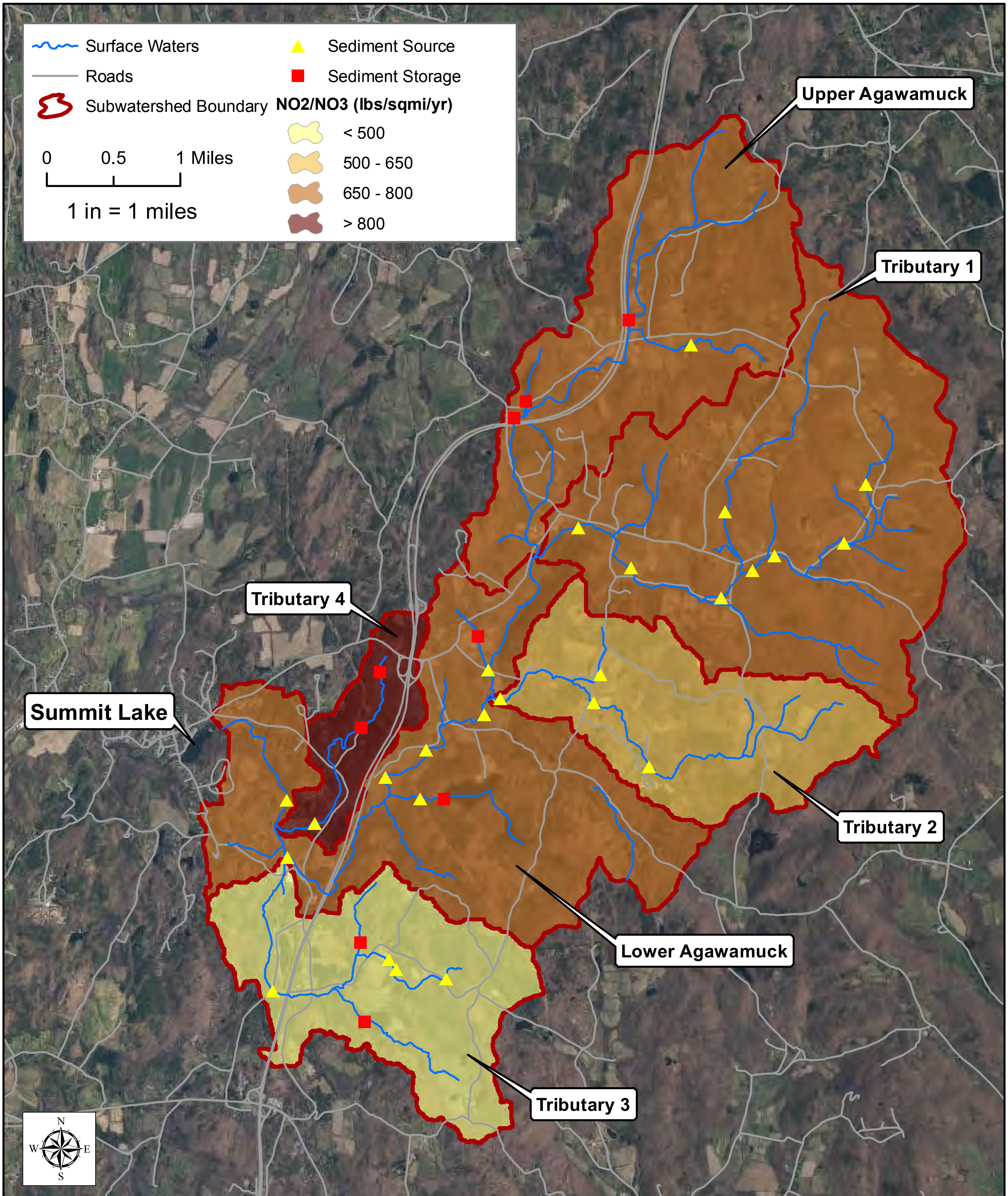
Equation 2.0 $R = P * P_j * R_v$

Where: R = Annual runoff (inches)
P = Annual rainfall (inches)
P_j = Fraction of annual rainfall events that produce runoff

Equation 3.0 $L = 0.226 * R * C * A$

Where:
L = Annual load (lbs)
C = Pollutant/Solute concentration (mg/L)
A = Area (acres)
0.226 = Unit conversion factor

Pollutant loading estimates are summarized in **Table 4**, including gross and relative loading rates. Maps 1 through 3, attached to this summary, depict the relative (per mi^2) annual sediment and pollutant load to Summit Reservoir by subwatershed. The area normalized loads for each subwatershed are shown in **Table 5**. These results suggest that the land cover in the Upper Agaqamuck and the Tributary 4 subwatersheds are contributing disproportionately higher loads of sediment and nutrients to Summit Reservoir.



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Philmont, NY

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-SIMPLE method used to estimate sediment loading

Map 3

Table 4: Estimated annual load of sediment and nutrients based on subwatershed land cover.

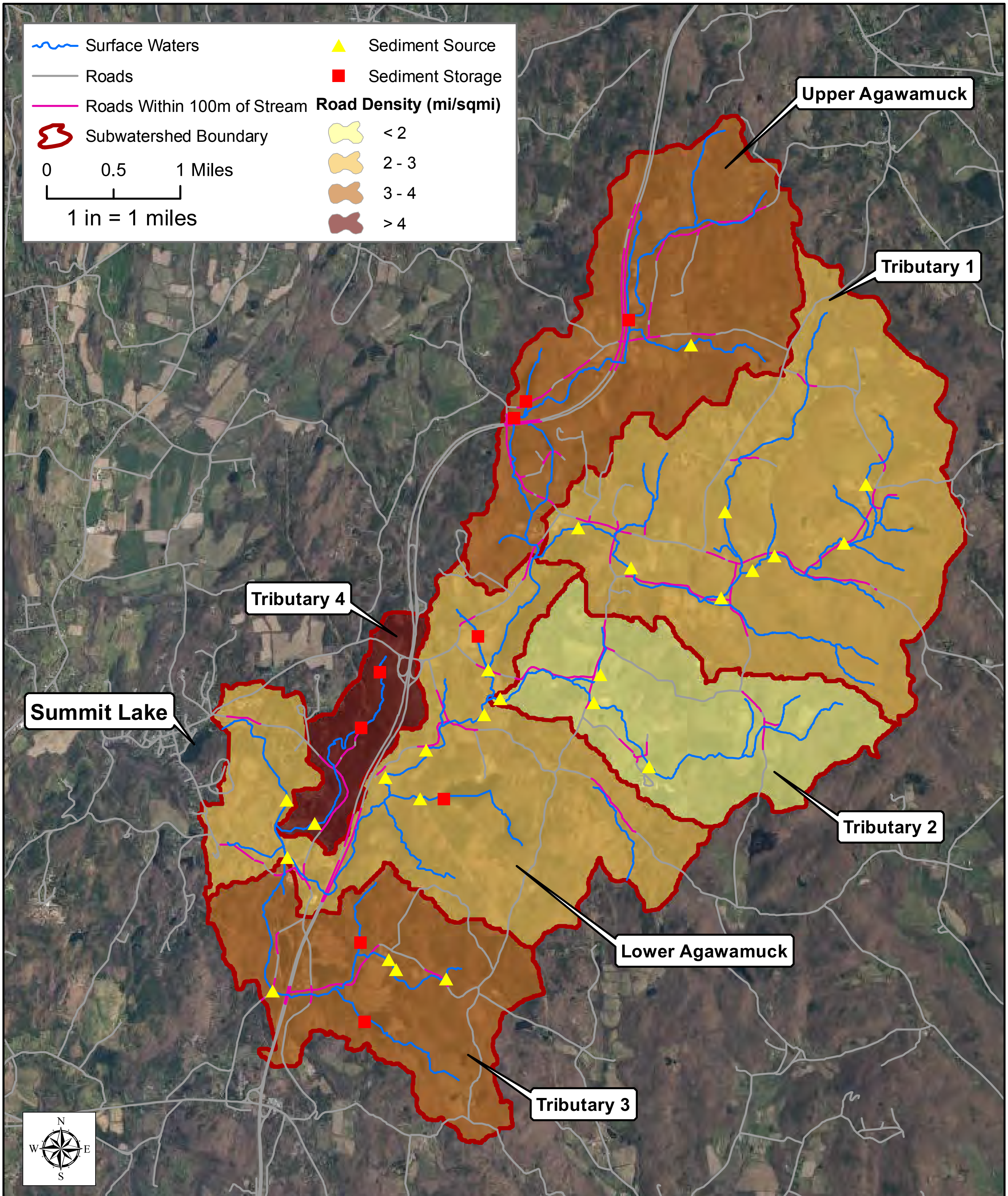
Watershed	Annual Load Parameters (lbs)			% of Watershed Load			% of Drainage Area
	TSS	TP	NO_2/NO_3	TSS	TP	NO_2/NO_3	
Agawamuck Creek (at inlet)	874,489	2,593	14,101	--	--	--	--
Lower Agawamuck	200,996	561	3,074	23%	21%	22%	23.0%
Upper Agawamuck	181,460	572	3,093	21%	22%	22%	18.5%
Agawamuck Tributary 1	242,058	743	4,099	27%	28%	29%	28.4%
Agawamuck Tributary 2	89,817	268	1,506	10%	10%	11%	12.4%
Agawamuck Tributary 3	109,140	293	1,564	12%	11%	11%	13.0%
Agawamuck Tributary 4	51,018	155	765	6%	6%	5%	4.0%
Direct Runoff to Reservoir	7,357	20	97	1%	1%	1%	0.8%

Table 5: Area normalized sediment and nutrient loads.

Watershed	Annual Load Parameters (lbs/mi^2)		
	TSS	TP	NO_2/NO_3
Agawamuck Creek (at inlet)	40,864	121	659
Lower Agawamuck	40,442	113	618
Upper Agawamuck	45,593	144	777
Agawamuck Tributary 1	39,552	121	670
Agawamuck Tributary 2	33,639	100	564
Agawamuck Tributary 3	38,840	104	557
Agawamuck Tributary 4	59,323	181	890
Direct Runoff to Reservoir	43,275	116	573

4. *Other Sediment and Nutrient Sources*

It is challenging to remotely identify in-stream sediment and nutrient sources; however the availability of several sources and vintages of high resolution aerial imagery for the watershed allowed for preliminary identification of many potential sediment source and storage areas. The imagery clearly indicated several streams and small tributaries that are carrying high sediment loads. Following these upstream we identified mass failures (i.e., valley erosion), channel avulsions, bank erosion, degraded buffers, and steep dirt road crossings as potential sediment sources. We also identified several important sediment storage areas which included floodplains, beaver ponds, and small natural or man-made impoundments. These source and storage locations are included on Maps 1 through 4 (attached) and may be very important for prioritizing BMP implementation. The large complex of beaver ponds and wetlands in the lower portion of the Upper Agawamuck subwatershed likely attenuate some of the increased sediment and nutrient loading predicted from land cover and road density. Conversely, the Tributary 1 subwatershed is predicted to have lower land cover and road based sediment and nutrient loading, but we identified several large eroding banks, mass failures, and steep dirt road crossings.



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Philmont, NY

Notes:
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-SIMPLE method used to estimate sediment loading

Map 4

Conclusions

- Summit Lake is a man-made reservoir fed by Agawamuck Creek, a large stream which carries a significant sediment and nutrient load.
- The river network maps show erosion areas – (yellow triangles) and sediment storage areas (red squares). These indicate areas of increased sediment and nutrient loading from in-stream sources (i.e., unstable banks) and storage. These sources and sinks appear to be more important in certain subwatersheds.
- Given the lake's size (both area and volume) relative to the upslope drainage area (21 square miles), the lake will continue to capture and store sediment and nutrients carried by Agawamuck Creek.
- The direct drainage portion of the Summit Lake watershed in the Philmont Village does not include significant amounts of impervious surfaces, and has very small sediment and nutrient loads relative to the upslope Agawamuck Creek watershed. However, there are likely opportunities to address direct stormwater inputs near the shoreline.
- Improve aquatic eco system and diversity by reducing and controlling nutrients loading into lake

Recommendations

- A watershed-scale approach to mitigating both in-stream and upland sources of sediment and nutrient loads is needed to manage water quality in the long term. As long as these sources are not addressed, in-lake treatment will not be cost-effective, i.e., ssediment needs to be controlled upstream of lake.
- Once sedimentation is controlled, water recirculation, aeration and other BMP practices can be introduced for water quality improvements in the lake, to remove existing lake pollution, clear aquatic vegetation and target other nutrients from within the lake.
- Study and identify opportunities to remediate stormwater runoff from the Village and at new proposed development on lake.

Next Steps

- A Comprehensive upslope analysis with greater detail on sedimentation sources
- More detailed study of sedimentation sources from Village (urban runoff)
- Conduct field reconnaissance to validate and prioritize upstream problem areas
- Develop plans to stabilize banks using various practices including bio-engineering methods, stone to stabilization, riparian plantings, and nearby floodplain reconnections.
- Develop an education program for residents in the area (farmers)
- Plans for riparian corridors – easements, conservation, multiple pronged approaches to attenuate sediment and nutrients upstream of the lake.
- Work with County soil and water district – (who have on the ground knowledge of problem areas and landowners but may lack the technical expertise)
- Identification of locations for aforementioned practices
- Preliminary design adequate to obtain permitting approvals and funding

Estimated Cost – Phase 2
$25,000 - $30,000

References

Warren County Soil & Water Conservation District (WCSWCD), 2014, Summit Lake Reservoir Watershed Assessment. Prepared for the Columbia County Soil & Water Conservation District, March 2014.

Homer, C.G., Dewitz, J.A., Yang, L., Jin, S., Danielson, P., Xian, G., Coulston, J., Herold, N.D., Wickham, J.D., and Megown, K., 2015, Completion of the 2011 National Land Cover Database for the conterminous United States-Representing a decade of land cover change information. *Photogrammetric Engineering and Remote Sensing*, v. 81, no. 5, p. 345-354

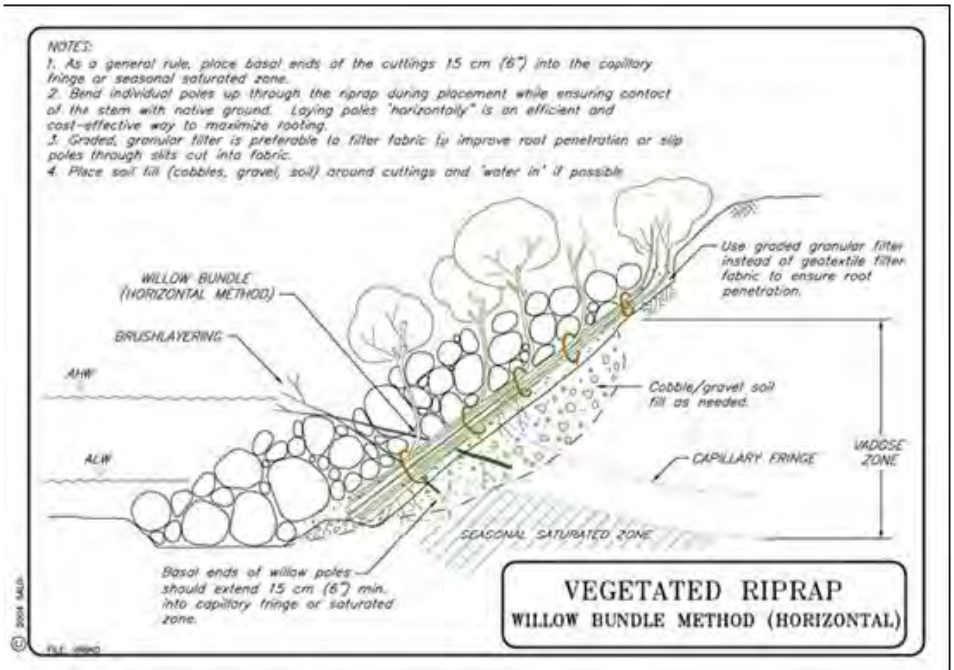
NYDEC (New York Department of Environmental Conservation), 2001, New York State Stormwater Management Design Manual, Appendix A: The Simple Method to Calculate Urban Stormwater Loads. http://www.cdrpc.org/NET/WQ/StmWDMan.html

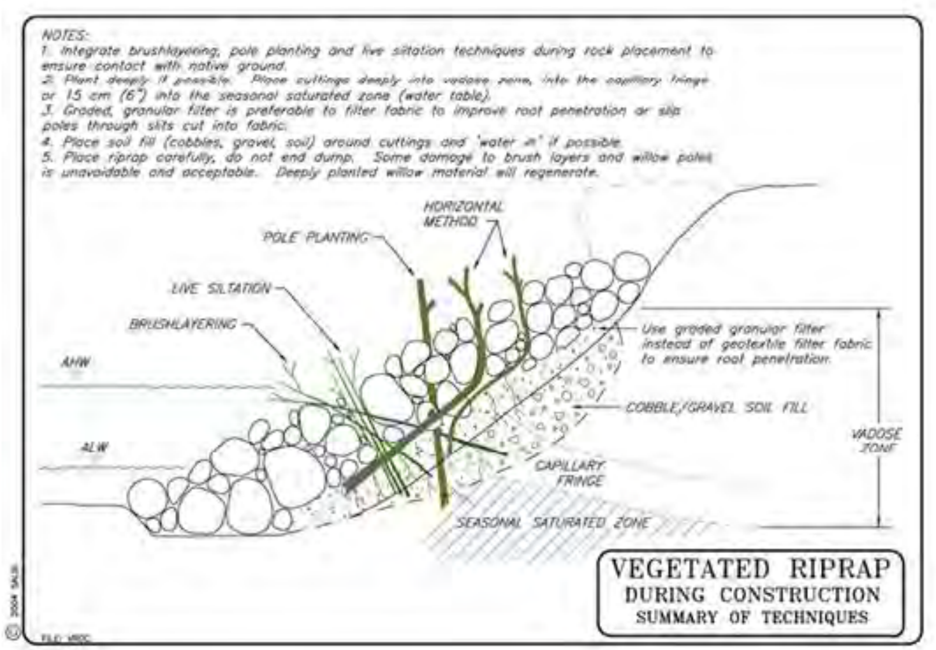
APPENDICIES
EXAMPLES OF WATERSHED RESTORATION PRACTICES

Summit Lake Restoration Project
Philmont, NY

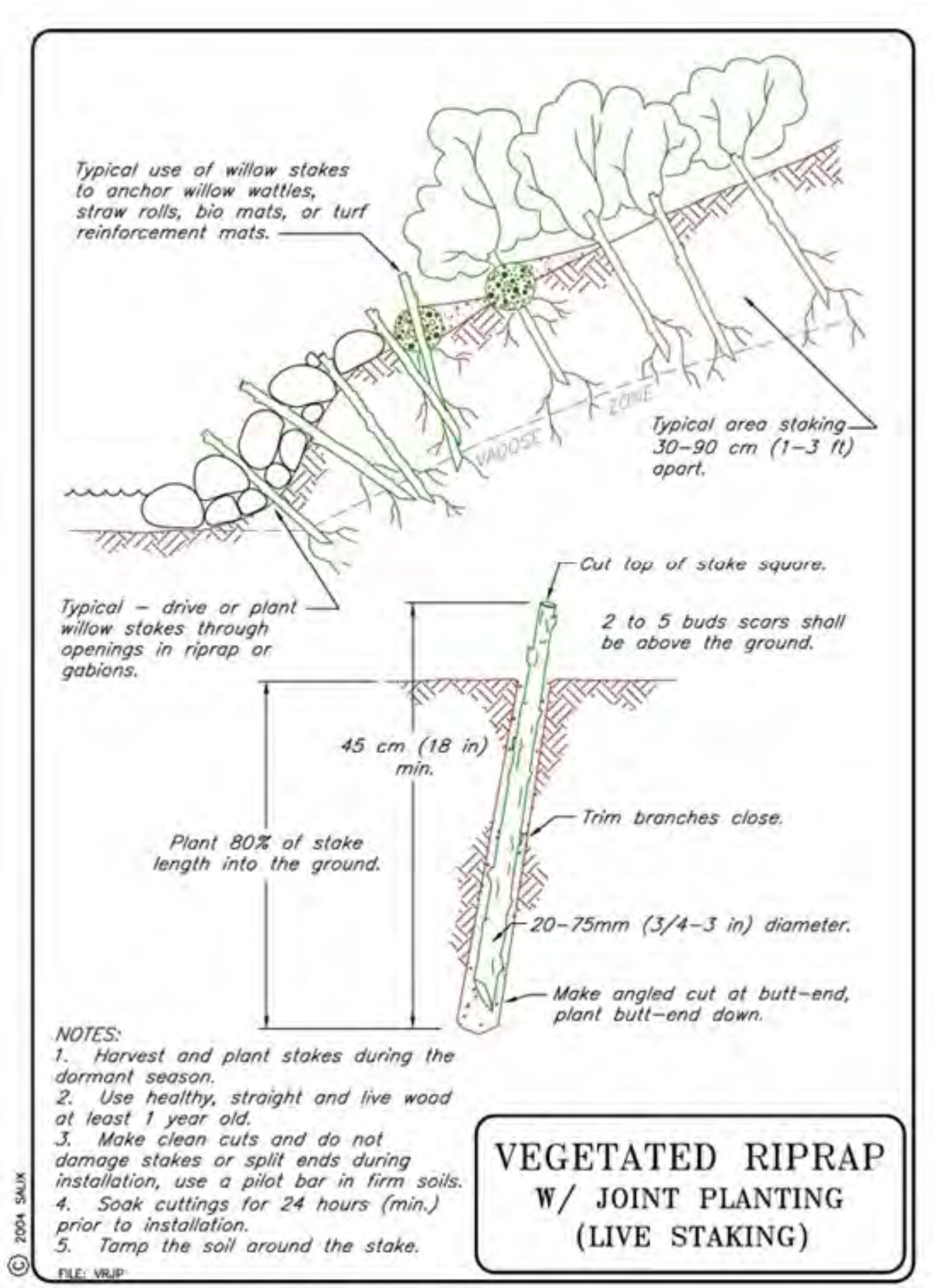
The following images and details illustrate potential best management practices and restoration approaches for addressing sediment sources upstream of Summit Lake along Agawamuck Creek.

Bioengineering – Slope Stabilization





Environmentally Sensitive Channel- and Bank-Protection Measures (McCullah and Gray, 2005)



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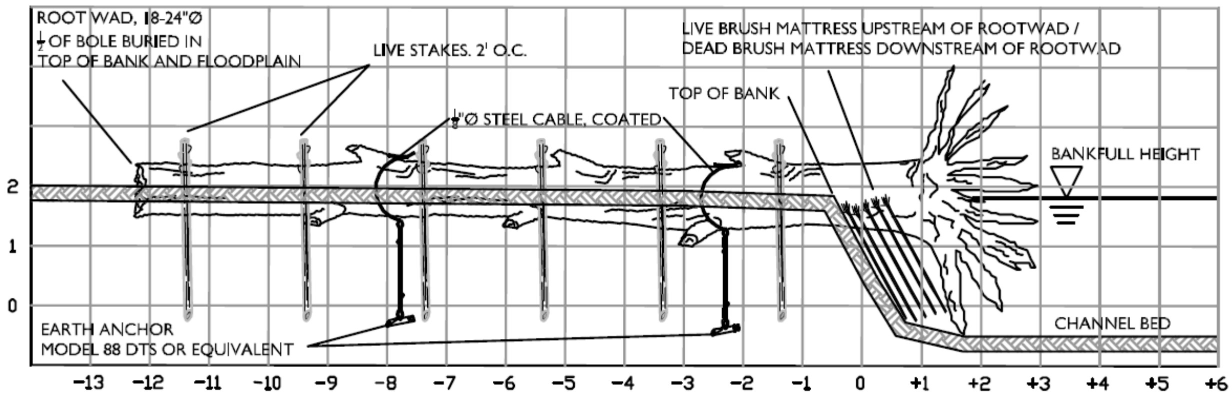
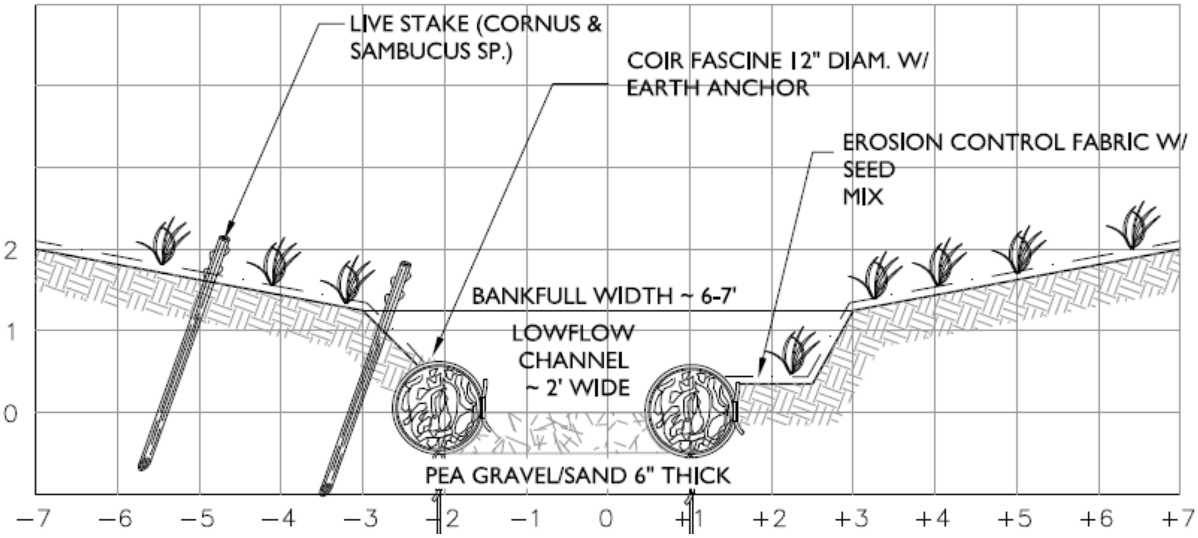


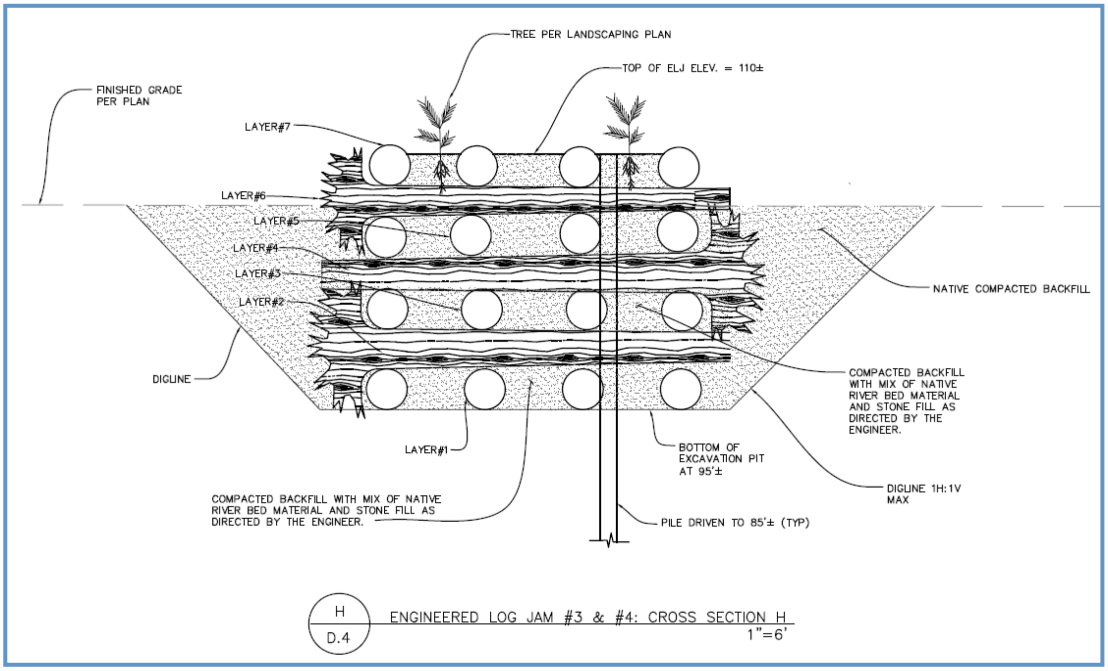
ROOT WAD & WOODY DEBRIS TREATMENT
CROSS SECTION



Bioengineering – Channel Restoration

Highgate and St. Albans, VT

(Fitzgerald, Whitney, and Redondo, 2010-2012)



Engineered Log Jams, Stone Toe Stabilization, and Bioengineering Slope Stabilization.

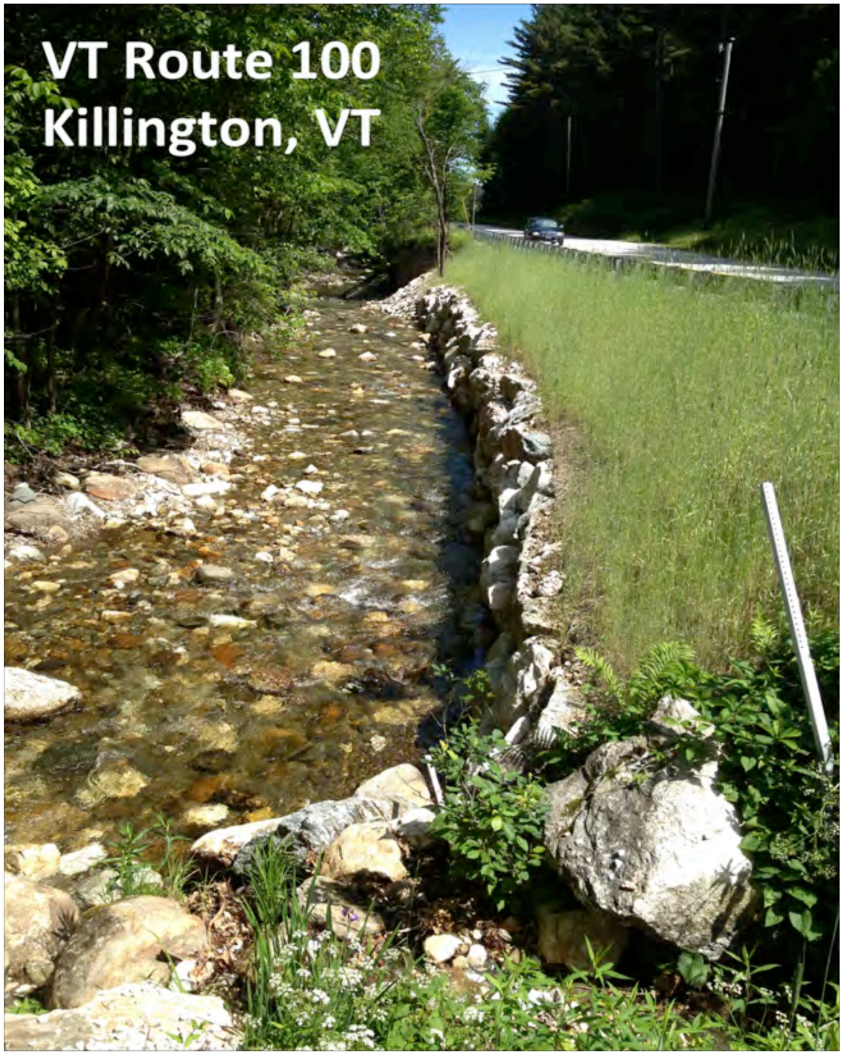
Boquet River Bank Stabilization Project, Willsboro, NY

(Fitzgerald Environmental & KAS, Inc., 2013-2015)

Terracing and Branch Layering

Boquet River , Willsboro, NY (E. Fitzgerald, 2015)

Lake Champlain, Alburgh, VT (EcoSolutions & Fitzgerald Environmental, 2014)



VT Route 155, Mt. Holly, VT

E. Fitzgerald, 2013

Placed Riprap Wall

Vermont State Highways, Tropical Storm Irene Recovery (Fitzgerald Environmental & VTrans, 2012-2013) renewage Sustainable Water Treatment Solutions

Ecological Storm-water Management

Water Quality Improvement and Hazard Mitigation
Gravel Filter Wetland Treatment System

Village of Wappingers Falls NY

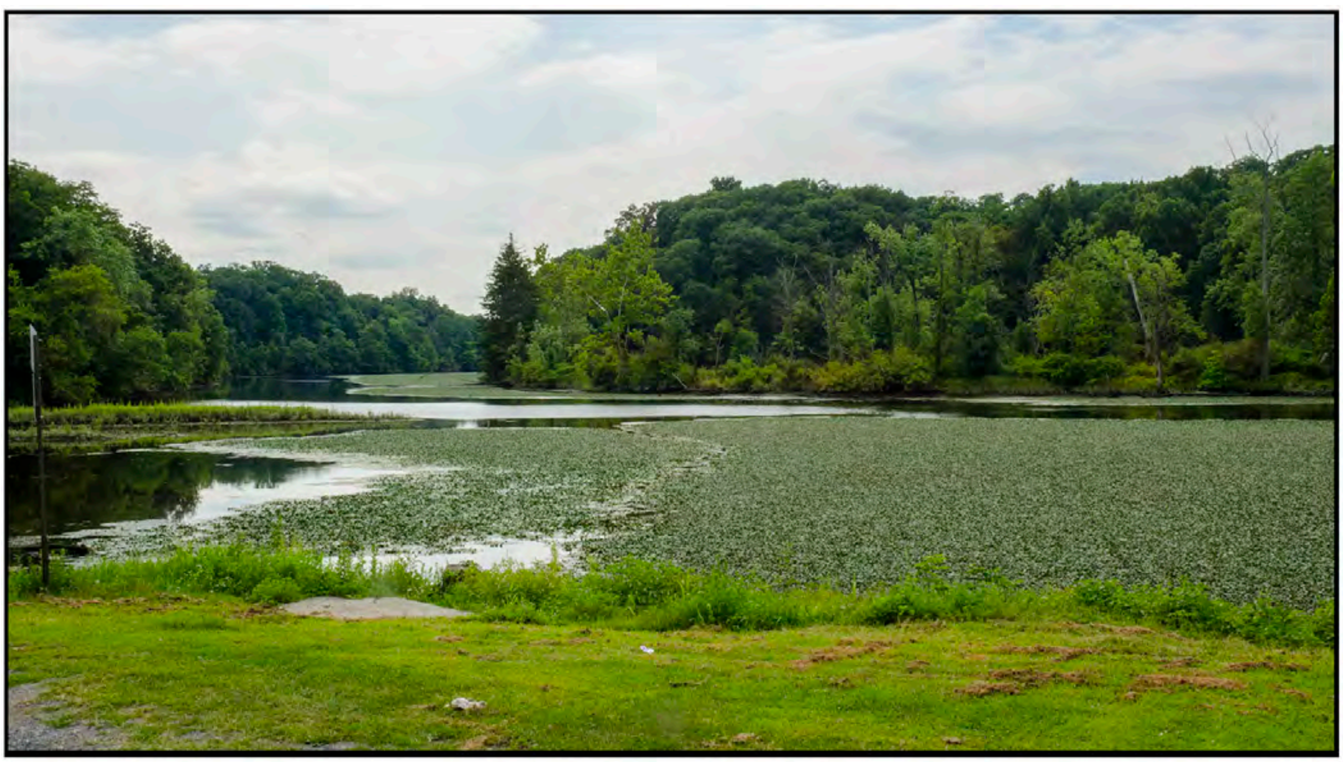
October 2014

ECOLOGICAL STORMWATER WETLAND TREATMENT AND MANAGEMENT
CASE STUDY: A NEW APPROACH IN WAPPINGERS FALLS NY

The Village of Wappingers Falls and other communities in the Wappinger Creek Watershed, (the largest in Dutchess County NY), have been concerned for many years with the deterioration of water quality throughout the watershed. Wappinger Lake is a man-made reservoir formed on Wappinger Creek. It is a community landmark that serves as a significant source of groundwater recharge for the Village's drinking water wells, recreation and wildlife habitat. The water depth and quality have been decreasing steadily in recent years, primarily due to sediment deposition and associated nutrient loading.

Some of the key problems include:

- **Flooding** – minimal flood mitigation resilience practices
- **Rising Cost of Disaster Prevention and Clean Up –** ineffective solutions, old-practices and short-term fixes
- **Declining Groundwater Quality** - Reduced quality and increased contamination of hazardous substances
- **Deterioration of Drinking Water** – Increased remediation costs, raised risk of poor health and well-being of residents
- **Destruction of the Eco-system** - Lost recreational assets and damaged aquatic community
- **Stagnant Economic Growth** - declining property values, reduced municipal tax base



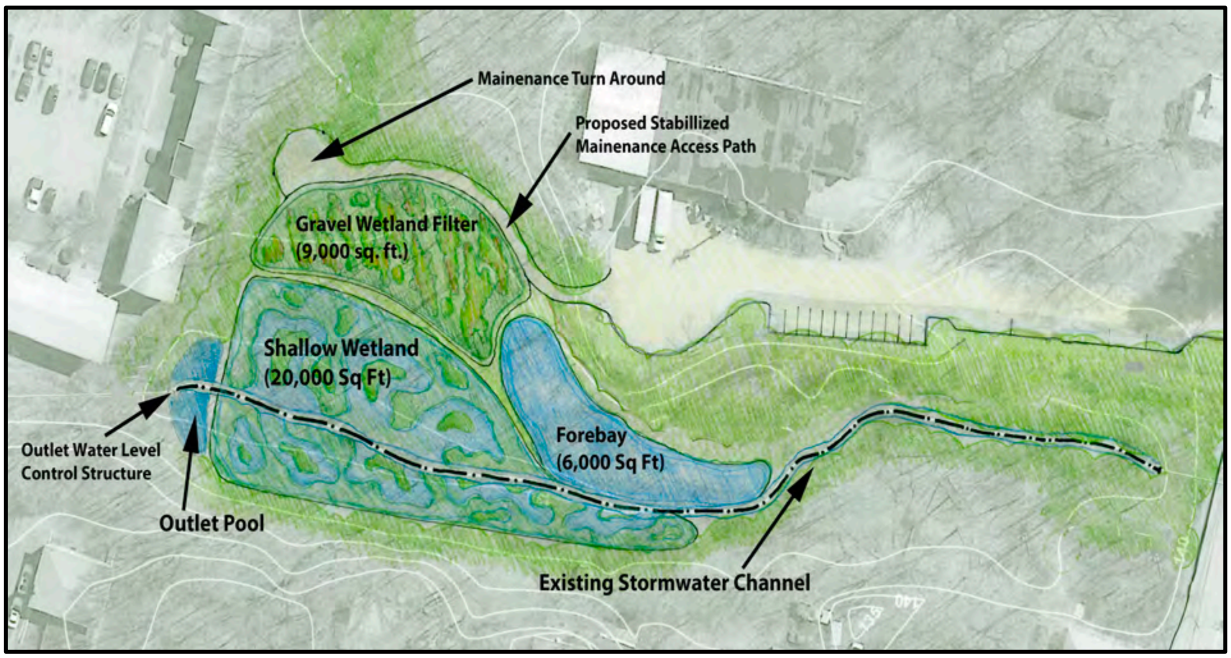
Wappinger Lake

The Village of Wappingers Falls contributes only a small percentage of sediment into the watershed, however proportionally it contributes a significantly higher concentration of sediment per square mile.

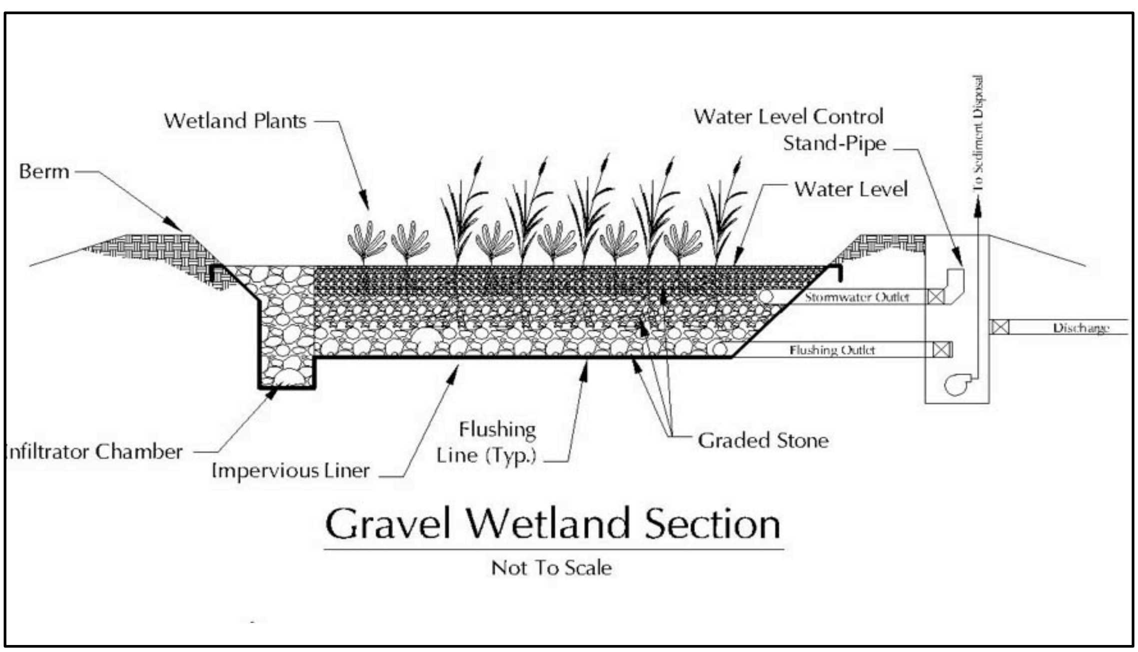
BEST MANAGEMENT PRACTICE PLAN

Building on two prior studies, a preliminary plan for the entire 220 square mile watershed was developed by Renewage LLC* in 2010, that proposed utilizing gravel filter wetland treatment systems at critical outfall points, to both manage and treat stormwater run-off before it reached critical loading points in the watershed. The proposed network of integrated Green Infrastructure (GI) practices would provide flood resiliency using retention ponds, but would also provide significant water quality improvement using gravel filter wetlands to trap sediment (and attached phosphorus, nitrogen and other unwanted nutrients) before it could re-enter the creek and adversely impact the aquifers, drinking water resources and surrounding eco-system.

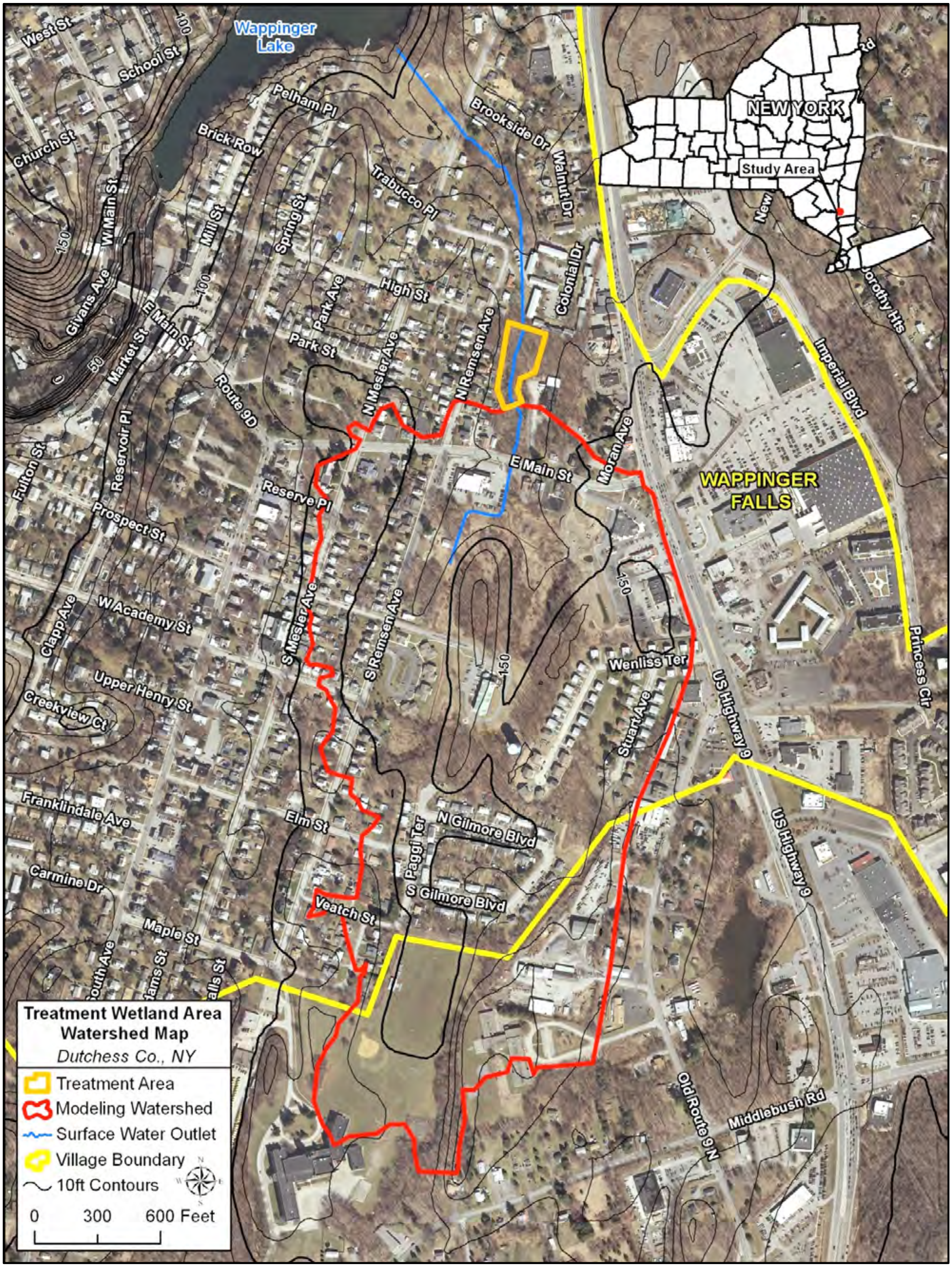
In 2011 The Village was awarded a Green Innovation Grant from NYS Environment Facilities Corp, to design and build a gravel-filter wetland storm water treatment at an infill site in the Village to be a demonstration of this approach, and as a first phase in the remediation of the lake and it's watershed.



Planning rendering of Treatment system showing retention forebay, wetland treatment area and outlet



An infill site on a drainage swail taking storm-water run-off into the lake taking was located, and the Village was able to arrange a permanent easement for construction of the treatment system.



Drainage area to treatment system at an infill site in The Village of Wappingers Falls NY

VILLAGE OF WAPPINGERS FALLS STROMWATER TREATMENT SYSTEM

The Wappingers Falls Storm-water Wetland Treatment system is designed to manage and capture 85-95% of the sediment from run-off from the drainage area into the lake. The system was approved by all regulatory agencies and constructed in 2013. It exceeds the goals and guidelines of current NY storm-water regulations and is the first of its type and scale built in NY State. It will serve as an example of how this low impact design technique is an effective urban retrofit strategy, supports “smart growth” principals and can be replicated throughout The Wappinger Creek watershed and elsewhere in other challenged watersheds and communities experiencing similar issues.

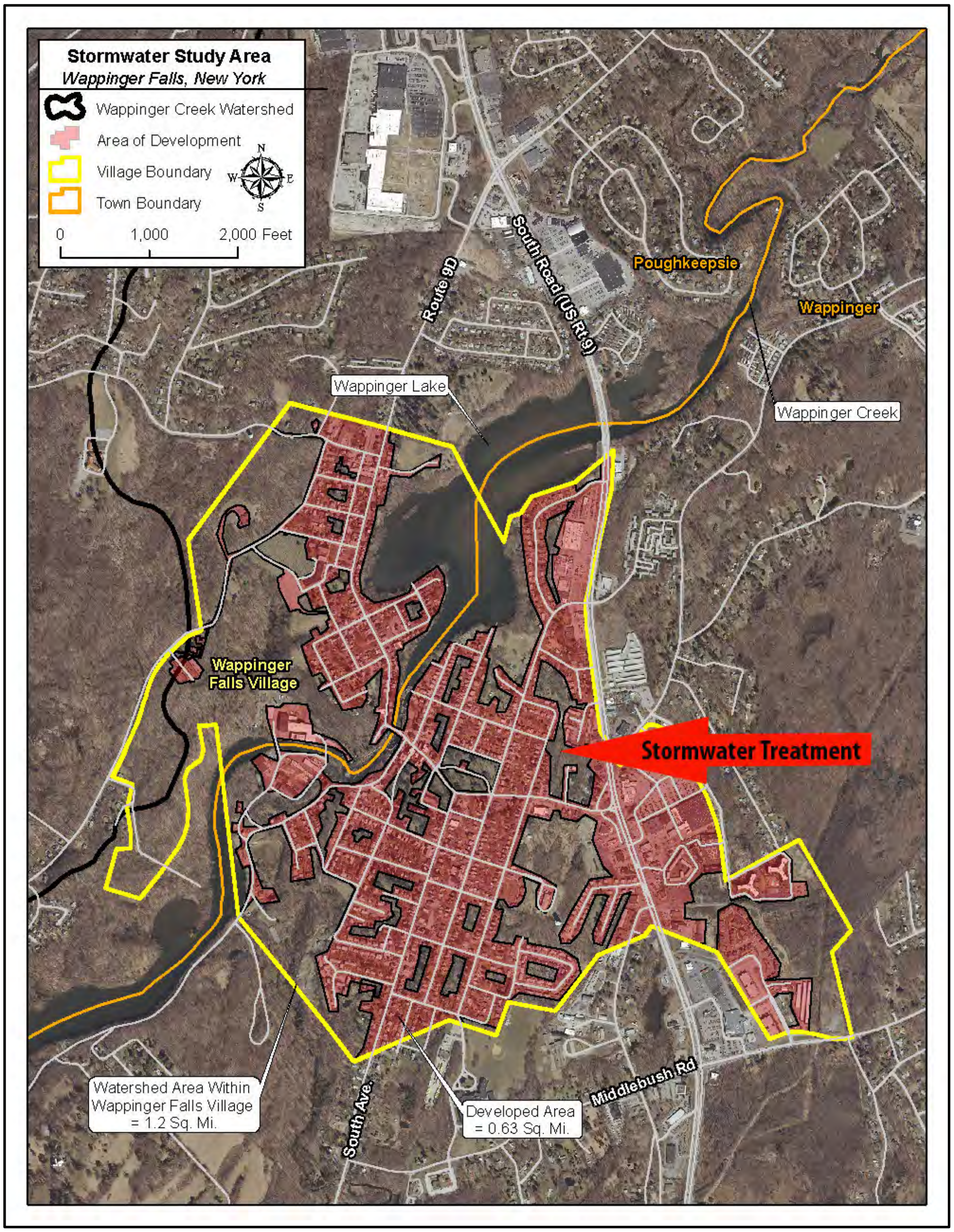
The storm-water system is located on 2 acre undeveloped, and privately owned site in The Village. The site was selected because it is able to capture the greatest outfall into the lake at a major culvert where frequent stormwater flooding has damaged neighboring residences. The system will addresses water quality in Wappinger Lake, as well as stormwater storage capacity associated with storm events to prevent flooding.

The system is comprised of four treatment stages that include a sediment forebay, gravel wetland filter, shallow wetland system and an outlet pool. Sub-surface flow gravel wetlands trap and treat 85-95% of sediment and suspended solids. Accumulated sediment is safely flushed, enhancing treatment and extending the life of the system indefinitely.

Sediment within the gravel wetland is removed using a unique flushing system. The flushing system pumps air into the base of the wetland, using a small compressor. While the sediment is agitated within the wetland, it is pumped out, into a silt bag. The silt bag captures the suspended sediment, and the filtered water drains back into the storm-water treatment system, replacing what had been previously pumped out. This process is conducted twice annually.

Operation and Maintenance costs are minimal and the system can be managed locally and will become an integral, aesthetic and educational part of the community. The system should be routinely inspected for invasive species, signs of erosion, or washout.

Storm water run-off can be treated to a higher level than alternative approaches and exceed MS4 standards.



WAPPINGERS FALLS TREATMENT SYSTEM DATA

Overall Wappingers Creek Watershed: 220 Sq Miles
Sub Watershed Area being treated – 1.2 Square miles (Area within Village of WF)
Drainage Area= 240 acres (overall drainage area into treatment facility)
Wetland Treatment Area= 9,000 sq-ft,
Total storm-water treatment system is 35,000 sq-ft (0.8 acres), including the wetland
Infill site encompassing treatment system = 2 acres
Water Quality Volume Treated (draining to location) = 182,000 cu-ft
Storm Attenuation Treatment: up to a 25-YR/24-HR (existing discharge culverts)
Note: (A planned next phase 60 inch diameter ADS N-12 HDPE outlet culvert will handle peak discharge from a 100 year storm event)
Cost of Project: $ 750,000 (aprox.)
Funding: NYS EFC Green Innovation Grant $635,000
(NYS EFC GIGP 362 CWSRF# 5325-02-00)
Village Match: 10%
Estimated Annual Operating Cost: $6-8,000
Estimated Return on Investment 6-8 years

3 different size layers of gravel backfilled onto wetland
August 2013

Sedimentary forebay (retention pond) in foreground, with gravel wetland filter above and outlet pool on right

F

Forebay filled with stormwater

Construction Complete, site planted and landscaped – Oct. 2013

After heavy spring rains, retention pond full, outlet overflow pond full, April 2014

Wide view of forebay and inlet channel, Vegetation filling in June 2014

Southern Dutchess News
Vol. 62, # 38 75 cents | Fishkill, East Fishkill, Wappingers Falls & Poughkeepsie | September 18-24, 2013

'Community' shines in Wappinger, E. Fishkill

Village shows off its new weapon in drainage war

By Ray Fashona

WAPPINGERS FALLS – We at the Southern Dutchess News are often asked: What's all that construction going on in back of your building?

Our answer until now was: We're not really sure, but it has something to do with drainage.

A presentation last week to communities in the Wappinger Creek watershed made the picture much clearer. Organized by Mayor Matthew Alexander and Village Clerk John Karge, who heads the village's storm drainage efforts, the talk and field trip demonstrated how the construction project is one step in trying to clean up Wappinger Lake.

After the talk at village hall, participants traveled to the excavation site to see the work in progress.

Funded by a $638,000 Green Innovation Grant from the state Environmental Facilities Corp., the huge pit being dug behind the Southern Dutchess News building is actually the first wetland storm water treatment facility of its kind in the state. The object is to keep storm drainage – and the harmful sediment, phosphorus and nitrogen it brings with it – from flowing into the lake.

Steve Gruber of Renewage, an environmental company involved with sustainable water treatment solutions, explained that the object of the facility is to manage storm water before it hits sensitive bodies of water, such as Wappinger Lake, and to prevent flooding by storm water runoff.

"The idea is to capture and manage storm water," he said.

A previous study had pinpointed the area now being excavated as a key pathway for storm runoff. What the storm water wetland treatment system does is allow for large volumes of water to be channeled into what amounts to a huge holding area, which is coated with an impervious liner and then covered with gravel. The gravel acts like a filter, taking out pollutants and sediment. On top of the gravel are plants intended to absorb even more water.

The filtered water is then allowed to drain slowly into the lake, minus the unwanted chemicals and sediment.

Gruber said the system should be cleaned out twice a year to remove the sediment that has been collected.

He added that the state Department of Environmental Conservation supports the approach taken by Renewage and the village.

Alexander said it was not after he took office in 2006 that he and other village officials made cleaning up Wappinger Lake one of their top priorities. Between the sediment buildup and the chemicals in the water, he said, people in the village were "losing a recreational asset, a source of clean water and a cultural asset."

Although encouraged by the innovative approach to storm water control, the mayor is realistic about the amount of work ahead to really clean up Wappinger Lake.

A broad assessment must done of the entire Wappinger Creek watershed, including how communities upstream from the lake are dealing with their storm water runoff. The majority of the sediment and pollution in the lake, he said, comes from the creek itself, not from runoff produced in the village.

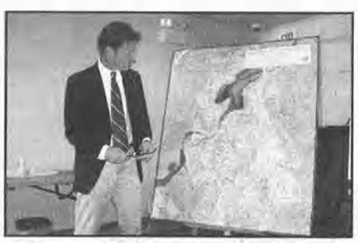
At some point, he added, once the runoff problem is addressed throughout the watershed, the lake will have to be dredged to remove the excess sediment and pollution. That will be an expensive proposition, he added.

Gruber noted that with the recent spate of heavy rainstorms in the Northeast, and the consequent flooding, it would behoove all communities to begin looking at solutions to drainage and runoff.

"The Hudson Valley is growing at a rapid rate," Gruber said, "and as it grows, more and more open land is paved over. It gets to the point where there is nowhere for the rainwater to be absorbed."

Workers put the finishing touches on the drainage project in Wappingers Falls.

-Photos by Ray Fashona



Mayor Matt Alexander explains aspects of the drainage project before a trip to the site.

SUMMARY

The communities: The Village of Wappingers Falls, The Town of Wappinger and the Town of Poughkeepsie seek funding to conduct a study that will deliver an actionable plan for water quality improvement and hazard mitigation projects that are Low Impact Design and utilize Best Management Practices to:

- Identify significant point and non-point stormwater runoff at critical locations throughout the targeted area of the watershed and sub-watershed that contribute to the deterioration of water quality in the lake and the lower part of the creek through sedimentation
- Identify key locations that adversely impact communities and vital (developed and natural) resources, where a stormwater management / treatment practice could provide or enhance hazard mitigation protection and provide significant water quality improvement.
- Propose specific stormwater projects that provide cost effective benefit to the affected communities, including: Opportunity for new “smart growth” development
- Increase revenues
- Sustainable and easily operated hazard mitigation and water quality infrastructure

RENEWAGE
STATEMENT OF QUALIFICATIONS

Renewage is an ecological water treatment consultant, offering a wide variety of innovative "bio-mimicry" wastewater treatment solutions and stormwater practices that provide water quality improvement and hazard mitigation.

Renewage services de-centralized residential, commercial, industrial and agricultural businesses and communities. Renewage LLC was founded in 2009 and has offices in Bridgehampton New York, Hoboken New Jersey and Renewage Canada Ltd in Toronto.

Renewage and it's team partners have designed, built, installed and manage numerous projects in many areas of the United States, Canada and around the world.

Renewage is a network of innovative, leading engineers, environmental scientists, planners, academics, architects, and builders whose objective is to provide low impact designed sustainable, economical and ecological storemwater and wastewater treatments solutions.

Renewage uses Best Management Practices that have low operational costs and unlimited life cycles. These technologies support new "smart growth" development, and "green" remediation of older wastewater treatment infrastructure.

Renewage technologies provide a positive cost / benefit and return to end users.

Renewage provides unique bio-regenerative wetland mimicry technologies treat large and small flow domestic and industrial waste-waters.

Renewage is the exclusive distributor of Busse Green Technology in New York and elsewhere

Renewage uses Best Management Practices that have low operational costs and unlimited life cycles.

Steven Gruber (Project Team Leader)

Mr. Gruber is a leading ecological wastewater and stormwater treatment consultant in Canada and The US. Mr Gruber has over 25 years background in green building and land development, with a unique expertise in large-scale projects planning and management that utilize sustainable design and bio-mimicry technologies. His projects are residential industrial and commercial. Recognizing the importance and value of "green infrastructure" water and wastewater treatment in de-centralized communities, he has built a team of experts in the field , including leading engineers to architects, environmental scientists, . Mr. Gruber has developed practical and innovative ways of bringing sustainable technology and ethical enterprise together. Today Mr Gruber is one of the foremost authorities on its application for both residential and commercial uses.

David H. Whitney – Civil and Environmental Engineer

EDUCATION & REGISTRATION

2010 ***Professional Engineer (PE)***, District of Columbia, Certification No. 906088.
2008 ***Professional Engineer (PE)***, State of Hawaii, Certification No. 12843-C.
2007 ***Professional Engineer (PE)***, State of Missouri, Certification No. 30834.
2006 ***Professional Engineer (PE)***, State of Vermont, Certification No. 8255.
2003 ***Master of Science***, Department of Civil & Environmental Engineering, University of Vermont. Focus on sustainable wastewater design, natural treatment systems, and phytoremediation.
1998 ***Bachelor of Science***, Civil Engineering, with an emphasis on Environmental Engineering, University of Vermont, Burlington, VT.
1998 ***Engineer-In-Training (EIT)***, Certification No. 2729.

WORK EXPERIENCE

May 2005 to Present – ***President and Principal Engineer***, of EcoSolutions, LLC which is a design/build company that specializes in the integration of function and aesthetics through the installation of innovative wastewater treatment system technologies such as the Advanced Wetland Treatment System, and other low-impact development strategies.

January 2009 to Present – ***Academic Mentor and Guest Lecturer***, in the Graduate School of Design, at Harvard University. Responsibilities include technical review of project designs for a landscape architecture studio design course concerned with 'Sustainable Design'.

January 2008 to Present – ***Adjunct Professor***, in the Department of Civil & Environmental Engineering, at the University of Vermont. Teaching responsibilities included 'Analytical Methods' (CE 154), and Senior Design Seminar (CE176), 'Engineered Wetlands' (CE295), all of which are senior level class for civil and environmental engineers.

June 2003 to December 2006 – ***Civil and Environmental Engineer***, at Engineered Solutions, Inc. whose responsibilities include the project management, design and permitting of innovative wastewater treatment systems, environmentally sensitive land development, and low-impact stormwater treatment systems.

June 2002 to December 2002 – ***Project Engineer and Construction Manager***, for the Wetland Research Center (WRC) at the University of Vermont. Responsibilities included project design, coordination, construction management, and facility operation.

March 2002 – Design of a greywater treatment wetland for La Ecocina Restaurant in Akumal, Mexico.

July 2001 to September 2001 – ***Civil and Environmental Engineer***, Design and installation of a greywater recycling system, Il Castello Di Spannocchia, Siena, Italy.

March 2000 to September 2001 – ***Civil and Environmental Engineer***, Feasibility Study and preliminary design of the Wetland Research Center (WRC) at the University of Vermont.

November 1998 to December 1999 – ***Civil and Environmental Engineer***, Delon Hampton and Associates, Chartered, Rockville, Maryland. Focus on water main rehabilitation for the District of Columbia's Water and Sewer Authority. Performed engineering tasks such as, but not limited to, research, cost estimating, and drafting.

RESEARCH EXPERIENCE

June 2003 to August 2003 – ***Research Assistant***, for the Gund Institute for Ecological Economics (GIEE) at the University of Vermont. Development of an onsite sewage disposal system implementation strategy for non-sewered communities to reduce nitrogen discharge from non-point sources into the Chesapeake Bay.

January 2000 to December 2002 – ***Graduate Teaching and Research Assistant***, Department of Civil & Environmental Engineering, University of Vermont. Developed the Wetland Research Center (WRC) with a team of research professors from the Department of Civil and Environmental Engineering and the Department of Plant and Soils Science at the University of Vermont. The WRC is an interdisciplinary research cooperative that focused on the treatment of stormwater runoff from dairy farm barnyards, and as well as other high organic and nutrient strength wastewaters. The WRC is located at the University's dairy farm located South Burlington. Additional responsibilities included grant writing to secure more than $650,000 of funding for the development, design, installation and continued research at the WRC. Concurrently, I developed and conducted laboratory experiments on constructed wetlands for wastewater treatment. Performed water quality analysis, data interpretation, and published results.

December 2001 – ***Principal Researcher,*** Assessed the performance of several constructed wetlands designed to treat domestic wastewater in the Playa del Akumal, Quintana Roo, Mexico. Work was done in collaboration with the Centro Ecologico Akumal and the University of Vermont.

AWARDS & SCHOLARSHIPS

May, 2006 – ***Vice President***, of the Vermont Professional Chapter of Engineers Without Borders (EWB).

May, 2002 – ***Graduate Student of the Year***, Department of Civil and Environmental Engineering, University of Vermont.

April, 2001 – ***Research Grant***, Lake Champlain Research Consortium, Middlebury, Vermont.

February, 2001 – ***SUGR & FAME Scholarship***, University of Vermont.

PUBLICATIONS

Taylor, S.L., Whitney, D.H., McIntosh, A., Fitzgerald, E.P., and Kominami, H. 2009. Balancing Ecosystem Services on a Grass-Based Dairy at Shelburne Farms, Vermont, In Proceedings of American Ecological Engineering Society Annual Meeting, Corvallis, OR

Whitney, D.H. and Fitzgerald, E.P. 2008. An Advanced Application of a Gravel Wetland for Stormwater Treatment in South Burlington, Vermont, In Proceedings of American Ecological Engineering Society Annual Meeting, Blacksburg, VA

Whitney, D.H., Liner, M.O., Fitzgerald, E.P. 2007. Application of Engineered Wetlands in Stormwater Management. Stormwater, January/February, 2008.

Whitney, D., Hayden, N., Hession, W., and Tignor, M. 2001. Developing a constructed wetland center at the University of Vermont. In: Wetland Systems for Water Pollution Control. International Water Association. Buena Vista, FL.

Whitney, D., Hayden, N., and Rossman, J. 2003. Evaluating an existing subsurface flow constructed wetland in Akumal, Mexico. J. Eco. Eng. 20(1): 105-111.

Whitney, D., Hayden, J., Hession, W., and Tignor, M. In review. Effects of supplemental aeration on dairy wastewater treatment efficiency in laboratory-scale subsurface flow constructed wetlands. J. Eco. Eng.

Fitzgerald Environmental Associates, LLC.

Applied Watershed Science & Ecology

Renewage Teaming Partner

Fitzgerald Environmental Qualifications:

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Company Summary

Fitzgerald Environmental Associates, LLC (FEA) is water resources consulting firm located in Colchester, Vermont. It was established in 2006 by Evan Fitzgerald, a Vermont native with extensive experience in the fields of watershed hydrology and river geomorphology. FEA offers professional technical services in the applied watershed and ecological sciences, specializing in fluvial geomorphology, watershed hydrologic modeling, river and floodplain hydraulic modeling, river corridor restoration planning and design, and watershed master planning. FEA is currently engaged in watershed planning work throughout the states of Vermont, New Hampshire, and New York.

FEA's core focus is river hydrology and geomorphology work in support of:

1) Transportation planning to improve compatibility between road and river networks;
2) River and floodplain restoration designs that result in the least erosive river conditions to mitigate flood and erosion risks for infrastructure in towns and villages; and
3) Watershed restoration through the identification, design, and implementation of stormwater mitigation projects.

FEA has conducted field-based river and floodplain geomorphology studies on over 350 river miles and more than 50 hydrologic and hydraulic analysis (including over 30 river hydraulic models) throughout the Northeastern U.S. (see maps on pages 10 and 11). FEA has completed over a dozen river corridor plans throughout the New England; most of these planning projects involved extensive landowner outreach and public presentations as part of the project development and implementation process.

Selected Staff Biographies

Below are brief professional biographies of key FEA personnel.

Evan P. Fitzgerald, CPESC, Principal Hydrologist/Geomorphologist
Evan Fitzgerald founded Fitzgerald Environmental Associates, LLC in 2006. He is a Certified Professional in Erosion and Sediment Control (CPESC) with fifteen years experience in applied hydrology, fluvial geomorphology, watershed science, and geospatial science. Evan holds a Bachelor of Science Degree in Environmental Sciences from the University of New Hampshire, and a Master of Science degree in Aquatic Ecology and Watershed Science from the University of Vermont. As Principal of FEA, Evan has managed numerous large-scale river assessment, modeling, and restoration design projects. Evan is experienced with watershed hydrologic analyses and river and floodplain modeling using one-dimensional and two-dimensional hydraulic models throughout Vermont and New York. Through his research affiliated with the University of Vermont and the Vermont Department of Environmental Conservation (VTDEC), and subsequent consulting work and collaboration with VTDEC, Evan helped test and improve Vermont's geomorphic assessment protocols and associated river corridor planning methods. Evan has worked extensively with the Vermont Agency of Transportation since the Tropical Storm Irene flood in 2011 to incorporate fluvial geomorphic science into permanent roadway repairs and future designs.

Joseph H. Bartlett, Watershed Scientist

Joe Bartlett holds a Bachelor of Science Degree in Water Resources from the University of Vermont (UVM). Joe has been with Fitzgerald Environmental since 2011, and is currently completing his Masters degree at UVM's Rubenstein School of Natural Resources. Joe's familiarity with river hydrology and geomorphology studies dates back to 2004, when he assessed numerous river reaches in northwestern Vermont as part of a larger research study conducted by the University of Vermont. At Fitzgerald Environmental, Joe is responsible for field surveys involving high-resolution GPS data collection, and detailed river surveys in support of river restoration projects such as floodplain restoration and improvements to aquatic organism passage at stream crossings. Joe has extensive experience developing river and floodplain hydraulic models (i.e., HEC-RAS, Flo-2D) in support of flood mitigation projects. He is currently involved with several river assessment and restoration projects in the wake of Tropical Storms Irene and Lee throughout Vermont and New York.

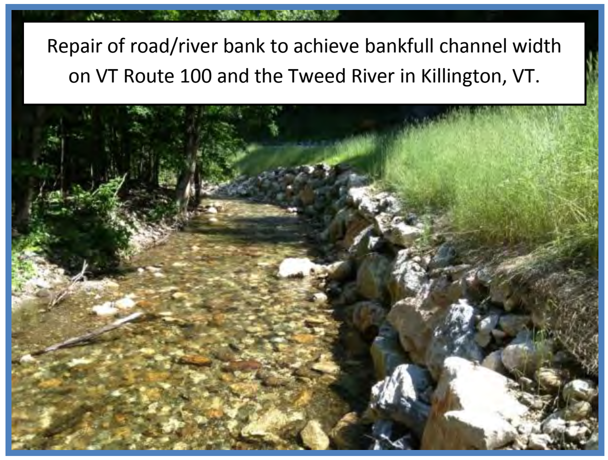
Qualifications: Selected Project Summaries

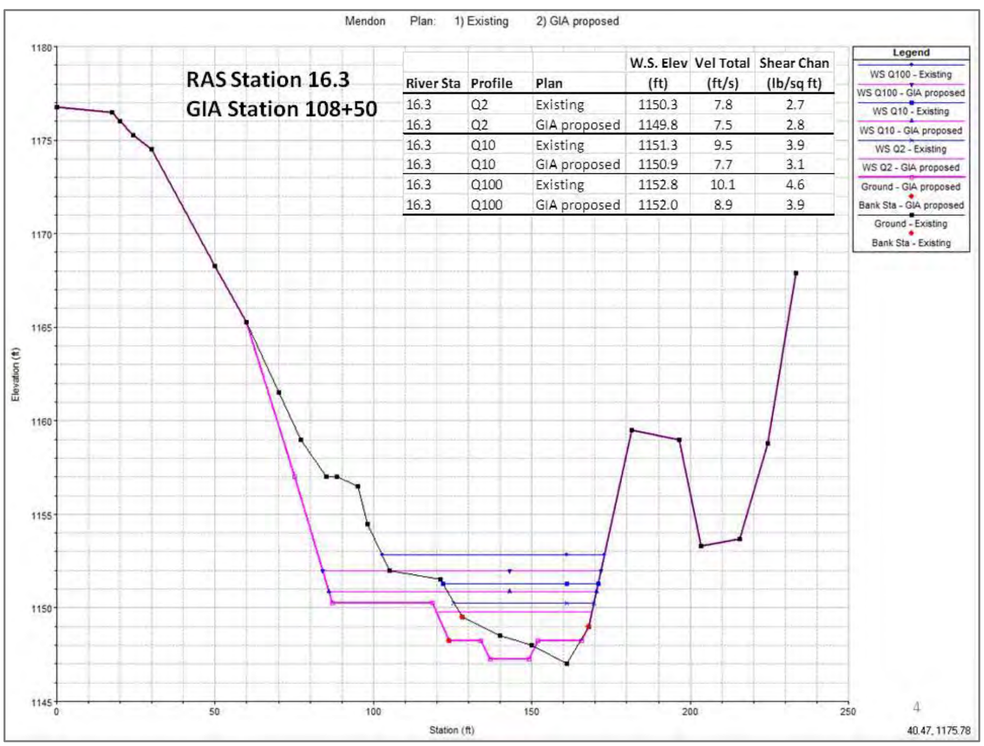
Project Title: Road Embankment & River Restoration Design, Permitting, and Construction Oversight Statewide, Vermont

Client: VTrans

Project Dates: 2012 - 2015

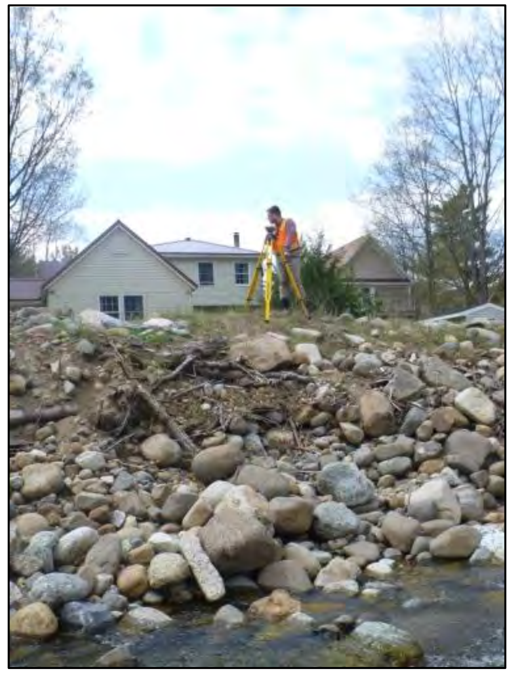
Fitzgerald Environmental Associates (FEA) is working with VTrans, VTDEC, and USACE to incorporate geomorphology guidance into permanent structural repairs along road and river corridors throughout Vermont following severe flood damage incurred during Tropical Storm Irene in 2011. Evan Fitzgerald was selected by VTrans to be the lead coordinator of a team of five consulting river scientists and engineers from various firms to address over 150 unstable roadway areas throughout Vermont. Evan Fitzgerald and Joe Bartlett have provided technical design guidance including hydrologic-hydraulic modeling and mapping of erosion hazards. Evan has been responsible for coordinating statewide permitting efforts, and overseeing construction on over 40 sites in Vermont since 2012. FEA is also carrying out river-road corridor vulnerability assessments in various hard hit areas using LiDAR data to develop hydraulic models and slope instability predictions.


Repair of road/river bank to achieve bankfull channel width on VT Route 100 and the Tweed River in Killington, VT.



River Sta	Profile	Plan	W.S. Elev (ft)	Vel Total (ft/s)	Shear Chan (lb/sq ft)
16.3	Q2	Existing	1150.3	7.8	2.7
16.3	Q2	GIA proposed	1149.8	7.5	2.8
16.3	Q10	Existing	1151.3	9.5	3.9
16.3	Q10	GIA proposed	1150.9	7.7	3.1
16.3	Q100	Existing	1152.8	10.1	4.6
16.3	Q100	GIA proposed	1152.0	8.9	3.9

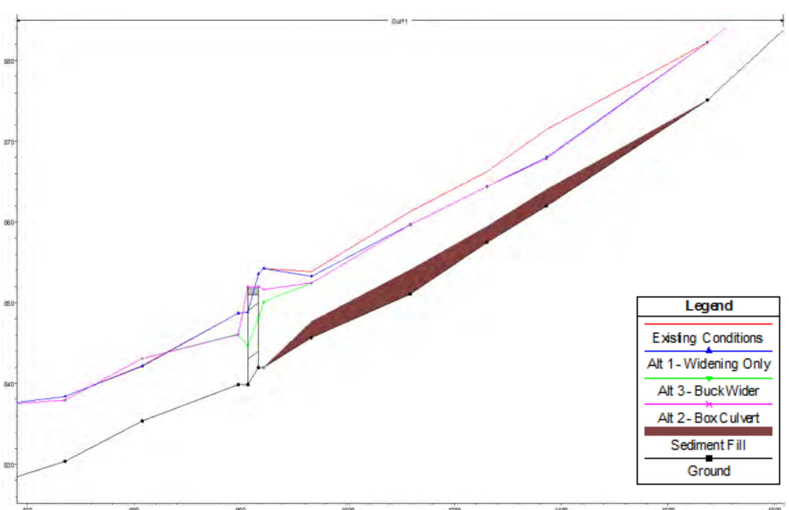
Project Title: Gulf Brook Channel Restoration and Flood Mitigation, Keene, NY
Client: Town of Keene, NY
Project Dates: 2014 - 2015



Fitzgerald Environmental Associates (FEA) was a principal team member with engineering firm ESPC working under contract to the Town of Keene to develop a stream channel restoration design for a segment of Gulf Brook that flows through the Village of Keene. The Gulf Brook overflowed its banks during Tropical Storm Irene causing extensive damage in the Village. During flood recover the channel was dredged and hard armored on one bank; the habitat was severely degraded by the effects of the flood and the recovery work. Our Project Team was tasked with developing a solution to improve the channel to increase flood resiliency, control sediment transport, and provide aquatic and riparian habitat within the project area.

FEA provided a comprehensive assessment of existing river conditions and design support, including:

- fluvial geomorphic assessments
- aquatic habitat assessments
- hydrologic and hydraulic modeling
- river structure designs



Through simulations of flow and sediment deposition in the channel, FEA determined that the discharge during Irene was likely double the previously-estimated 100-year flood. FEA and ESPC designed five (5) boulder cross vanes, flood benches, and vegetated armor slopes to increase flood resiliency and improve aquatic habitat. The project was constructed in November, 2014. FEA and ESPC provided full-time construction oversight services.

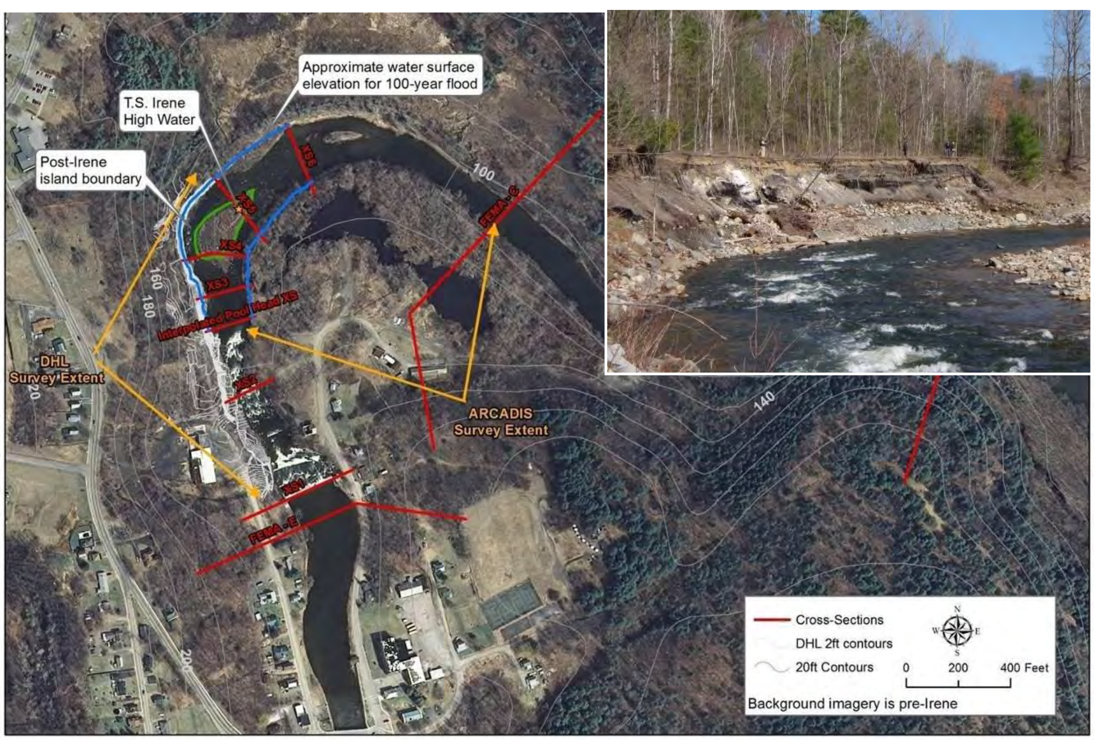
Project Title: Boquet River Bank Stabilization Project, Willsboro, NY

Client: Town of Willsboro, NY

Project Dates: 2013 - 2015

Fitzgerald Environmental Associates (FEA) is a principal team member with ESPC, Inc. working under contract to the Town of Willsboro to evaluate existing conditions, develop alternative solutions, prepare detailed design plans, and manage construction for a large bank stabilization project on the Boquet River. The project is located just downstream of the existing crib dam in the Boquet River. Severe erosion occurred in this area in 2011 during Topical Storms Irene and Lee releasing tons of sediment into the lower reach of the Boquet River and Lake Champlain. The project location is also the site of a former paper mill with many structural remains present right on the banks of the river, and it is a very popular site for anglers.

FEA completed a comprehensive assessment of existing river conditions including fluvial geomorphic assessments, aquatic habitat assessments, hydrologic and hydraulic modeling (HEC-RAS), and an assessment of environmental resources. FEA assisted with an analysis of several alternatives that would stabilize the bank, preventing further erosion, while also improving the aquatic and riparian habitat within the project area. A preferred alternative has been selected consisting of a series of engineered log jams, with a stacked stone bench between them and a stabilized upper bank using bioengineered stabilization techniques. The project required permits from the NYSDEC (delegated to Essex County SWCS), ACOE, and variance from the APA. Construction is expected the summer of 2015.



Project Title: Rock River Channel Restoration: Alternatives Analysis, Design, and Permitting Highgate, Vermont

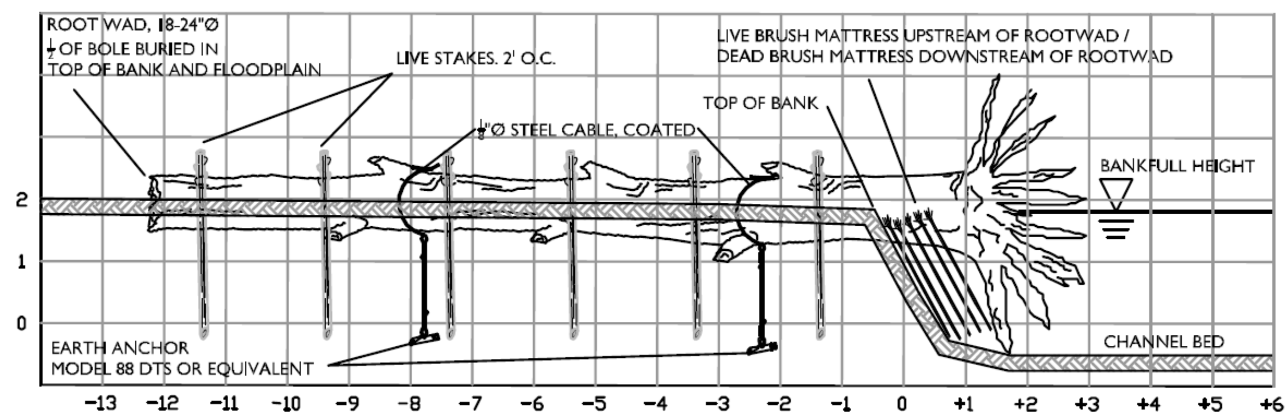
Client: Northwest Regional Planning Commission

Project Dates: 2008 - 2009


Degraded channel in the Rock River Watershed
Highgate, VT

Fitzgerald Environmental Associates, LLC., with the support of additional subconsultant engineers and scientists, carried out an alternatives analysis to evaluate stream restoration approaches for a small stream impacted by agricultural land use in the Rock River watershed. The design process included detailed site surveys (Phase 3 geomorphic assessment, GPS), hydrologic (TR-20) and hydraulic (HEC-RAS) modeling to determine the frequency of channel flooding, ecological benefit-cost analysis, wetland delineation, environmental permitting, and a water quality analysis to predict downstream pollutant loading.

The overall objective of the project was to develop restoration recommendations and a final design and contract documents for the site to: (1) improve floodplain access and thus on-site retention of sediment and phosphorus, and (2) improve habitat in the riparian corridor. The project was implemented in the fall of 2009.



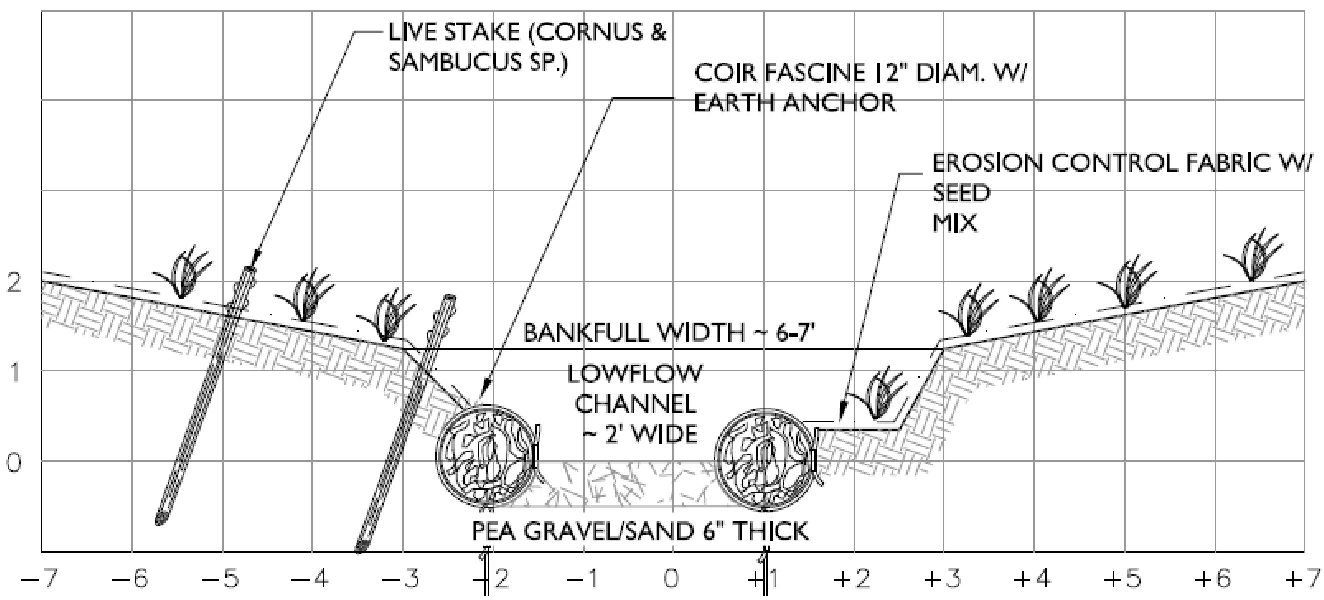
ROOT WAD & WOODY DEBRIS TREATMENT
CROSS SECTION

Project Title: Collins Perley Sports Facility Water Quality Restoration Planning & Design St, Albans, Vermont

Client: Northwest Regional Planning Commission; VTANR

Project Dates: 2009 - 2011

The Collins Perley Sports Complex is located within the Rugg Brook watershed in St. Albans, Vermont. Under contracts to the Northwest Regional Planning Commission and VTANR Center for Clean and Clear, Fitzgerald Environmental (in coordination with other firms) provided ecosystem protection and restoration services for various sites throughout the complex to address flooding and water quality issues. The project involved stormwater runoff modeling, hydraulic modeling of closed and open channel systems, design of LID stormwater treatment systems, and design and permitting services for the daylighting of a stream previously buried in a culvert. The stream daylighting project was carried out in 2012 (see photo to right) and is functioning well as a restored natural channel following several large runoff events.

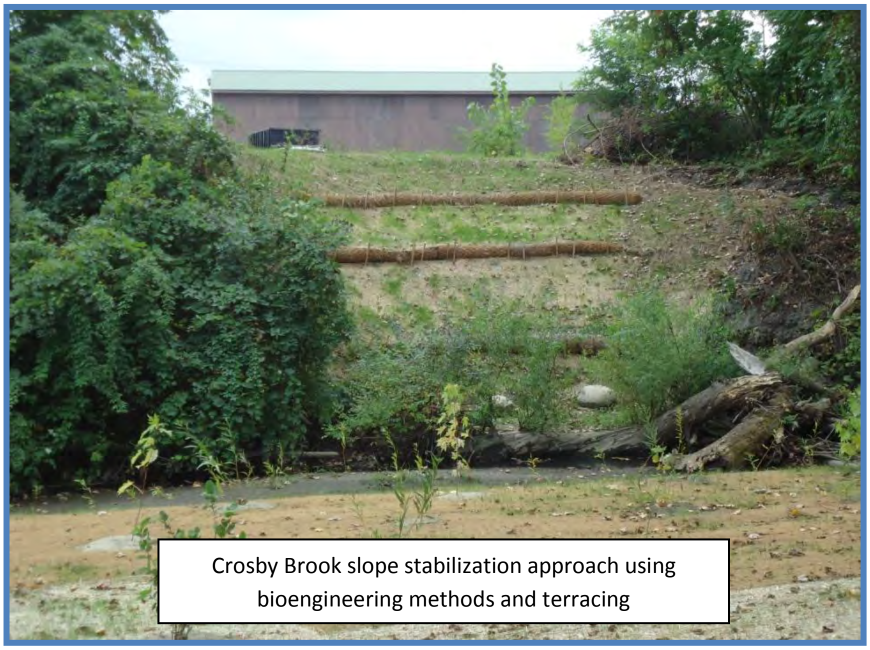


Project Title: Crosby Brook Geomorphic Assessments, Corridor Plan, and Restoration Designs Brattleboro, Vermont

Client: Windham County Natural Resources Conservation District (WCNRCD)

Project Dates: 2008 - 2012

Fitzgerald Environmental Associates, LLC (FEA) carried out Phases 1 and 2 Stream Geomorphic Assessments (VTANR, 2009a) for an urbanizing watershed in Brattleboro, Vermont that drains to the Connecticut River. Historically, Crosby Brook sustained a native brook trout fishery and provided a cold-water refuge from the Connecticut River; however the fishery is currently degraded by increased sediment loading due to changes in watershed hydrology (i.e., stormwater runoff) and bank instability. In an effort to improve the biotic conditions and reduce fluvial erosion hazards, SGA data was collected to better understand the physical stability and biotic habitat within the watershed at the reach scale. Stream crossings were evaluated along the entire channel network for geomorphic compatibility and aquatic organism passage. The SGA data was used to identify specific project areas where active (e.g., culvert replacements) or passive (e.g., buffer plantings) restoration approaches will enhance the biotic habitat.



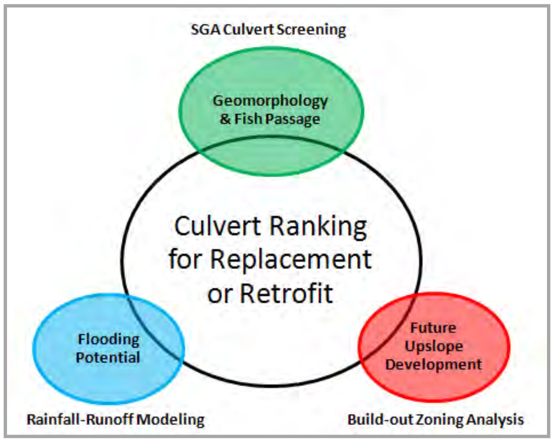
Crosby Brook slope stabilization approach using bioengineering methods and terracing

Following SGA Phases 1 and 2, FEA was contracted again by WCNRCD to further develop a Stream Corridor Plan, generate Fluvial Erosion Hazard Zones, develop detailed planting plans for three sites in the Crosby Brook corridor, and carry out a slope stabilization approach using natural materials and terracing (see image above). An additonal floodplain restoration plan in the lower watershed, funded by Section 319 funds, was carried out in 2011-12. FEA conducted Phase 3 SGA surveys (VTANR, 2009b) and modeling of watershed hydrology and reach-scale hydraulics in support of a natural restoration design to restore equilibrium conditions and improve biotic habitat.

Project Title: Bartlett & Potash Brook Culvert Assessment, Prioritization, and AOP Restoration Designs South Burlington, Vermont

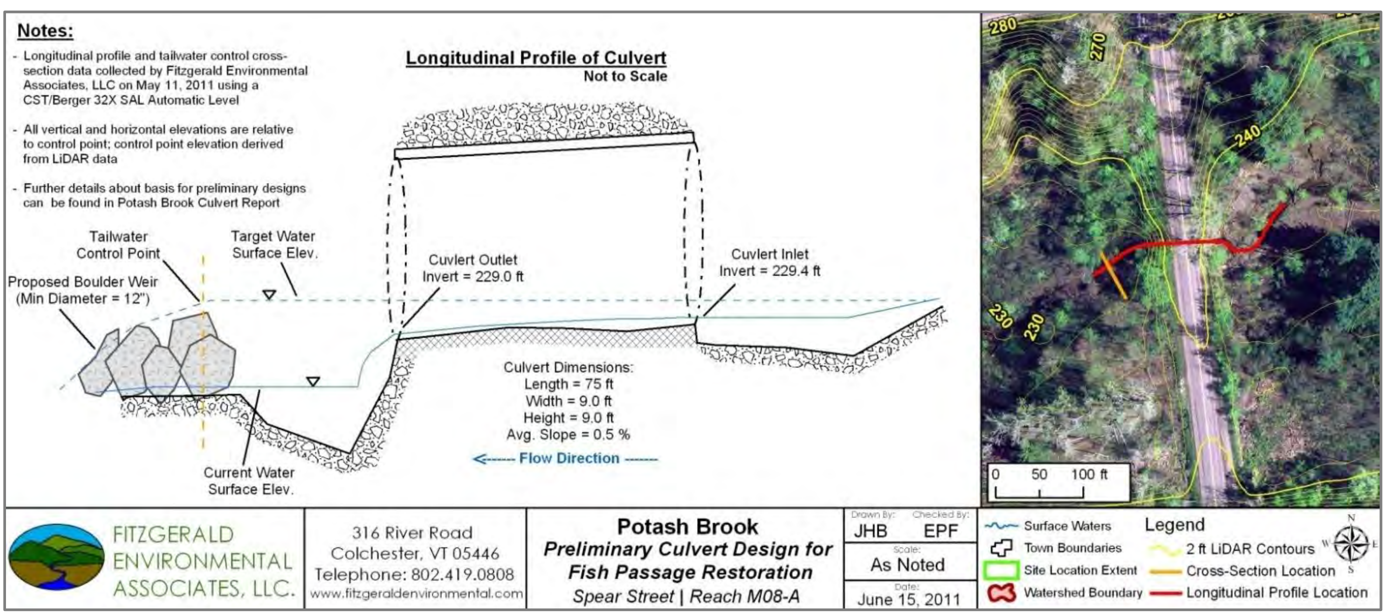
Client: City of South Burlington

Project Dates: 2009 - 2011

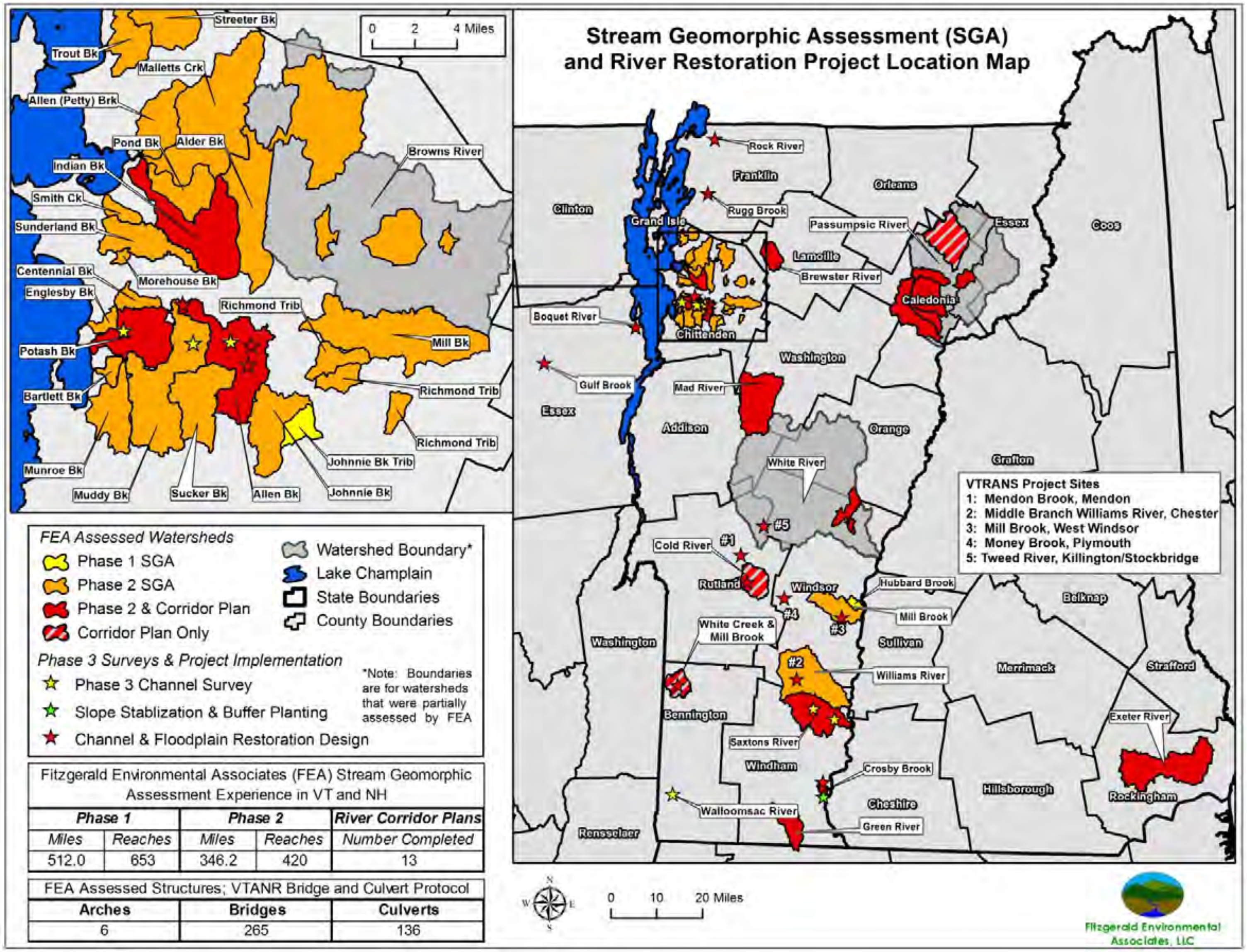


In 2009, Fitzgerald Environmental Associates, LLC. (FEA) helped the City of South Burlington develop and carry out a pilot approach for identifying and prioritizing culverts in need of replacement or retrofit in the Bartlett Brook watershed. The study utilized a multi-faceted approach based on the VTANR-based culvert data, hydrologic and hydraulic modeling data, and town zoning data to evaluate the effect of increased stormwater runoff from new development. Both Aquatic Organism Passage (AOP) and geomorphic compatibility screening tools were utilized. Hydrologic and hydraulic modeling was conducted to estimate the peak discharge of design storms and structure capacity under existing and full build-out conditions in the City.

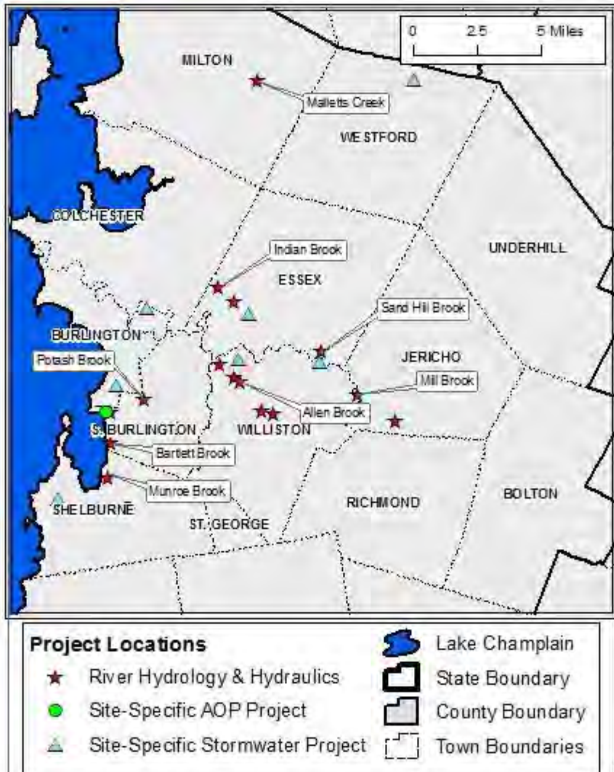
FEA completed a similar study for Potash Brook in 2011, including the prioritization of 36 culverts along the mainstem and tributary reaches. Three (3) high-priority structures were selected for further analysis to improve AOP and geomorphic compatibility. Detailed channel surveys were completed in the vicinity of the selected culverts following Chapter 3 (pre-design) of the Vermont Fish and Wildlife Department's *Guidelines for the Design of Stream/Road Crossings for Passage of Aquatic Organisms in Vermont.* FEA used *FishXing* modeling software to develop preliminary restoration designs to improve AOP for target fish species. The Spear Street AOP restoration project was completed by the City in spring of 2013.

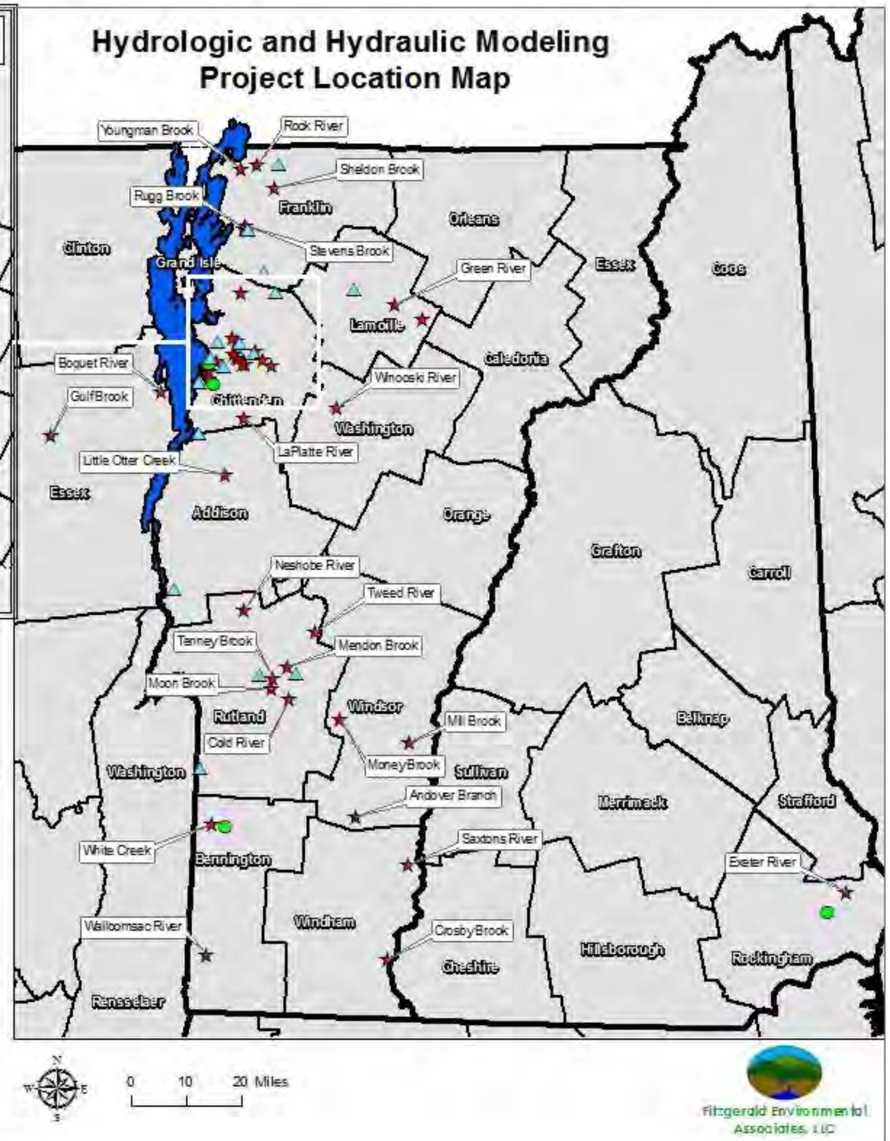


Qualifications: Map of Completed Geomorphic Assessments & River Restoration Projects in VT, NY, and NH



Qualifications: Map of Completed Hydrologic & Hydraulic Modeling Projects in VT, NY, and NH





River Hydrology & Hydraulics projects typically involve field survey of channel cross-sections, estimation of watershed hydrology using hydrologic models (i.e., TR-20) or available USGS gaging data and/or regressions, and development of one-dimensional (i.e., HEC-RAS) or two-dimensional (i.e., Flo-2D) models to evaluate proposed restoration or mitigation projects.

Site-Specific Aquatic Organism Passage (AOP) projects typically involve field survey of channel cross-sections and longitudinal profiles, estimation of watershed hydrology using available USGS gaging data and/or regressions, and use of USFS FishXing software to evaluate proposed mitigation measures.

Site-Specific Stormwater projects involve development of rainfall-runoff models (i.e., TR-20, Rational Method) to evaluate the sizing and treatment efficiency of stormwater best management practices.