Onondaga Creek Restoration Project Report

Trolley Lot Restoration Conceptual Design

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10 December 2009

ERE 596/496 Ecosystem Restoration Design

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Proposed Project Site Information

Project Name ....Trolley Lot Restoration Conceptual Design

Street Address .... Dickerson Street north to West Jefferson

Town...Syracuse

County .... Onondaga

State .... New York

Latitude/Longitude..43.046^{o}N, -76.156^{o}W

Hydrologic Unit Code (HUC) 04140201

Property Owner ....Onondaga County / City of Syracuse

Waterway.. Onondaga Creek

Authority ....Army Corps of Engineers, EPA, DEC, City of Syracuse, Onondaga Co.

Consultant...SUNY ESF Ecosystem Restoration Design

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I. Project Description

Problem Overview

Onondaga Lake, an approximately five-mile long by 1-mile wide body of water that is considered one of the most polluted lakes in the United States. Most of the pollution in this 4.6 square mile lake, north of the City of Syracuse, has been the result of combined sewer overflows (CSOs) and a history of hazardous waste dumping by local industry in Solvay, New York. The history of Syracuse as the "Salt City" began in the 1600's with the discovery of salt springs along the lakeshore. Chemical production of soda ash by the Solvay Process Company (later purchased by Allied Chemical) increased during the 1800's and early 1900's to levels that resulted in mining of millions of tons of halite and an enormous waste stream. Every pound of soda ash produced resulted in 1.5 pounds of waste, containing calcium carbonate (limestone), sodium chloride, and calcium chloride. By the middle of the 20th century the waters of Onondaga Lake had become hypersaline (Kappel et al., 2008).

Onondaga Creek, one of the major tributaries to Onondaga Lake, has also directly contributed to the degradation by delivering high nutrient and sediment loads to the lake. The headwaters of Onondaga Creek originate 27 miles south of the city of Syracuse, NY near Vesper, NY. The creek flows through Tully Valley and through the city of Syracuse where it empties into Onondaga Lake. The watershed is comprised of mixed land use of about 80% forest, rural, and agriculture, and 20% urban. The major tributaries of Onondaga Creek are the West Branch of Onondaga Creek, Hemlock Creek, and Rattlesnake Gulf.

Polluted rural and urban non-point source runoff and urbanization of Onondaga Creek are the primary sources of the problem. The high nutrient load is mainly caused by CSOs and nitrogen and phosphorous inputs from surrounding agriculture, although urban contributions via lawn waste and fertilizer are also an issue. Most of the sediment load delivered by these events is from re-suspended stream sediment and eroded bank material located along the main channel of Onondaga Creek. The Tully mudboils have historically increased sediment loading to levels of 15 tons per day. After creation of an impoundment dam and installation of depressurizing wells the sediment load was reduced to 1.5 tons per day. As proposed by the Onondaga Lake Partnership (OLP) the mudboils require a long-term management plan. If nothing is done in 2012 the mudboils will return to their pre-control status and contribute high sediment loads to Onondaga Creek (Snead, 2009). Severe deterioration of water quality has been documented downstream of the mudboils following runoff events, including less diversity and density of aquatic habitat. Table 1 illustrates the major contributing factors to the problem; channelization, reduced and straightened banks, and urbanization. This is especially problematic during storms and other high flow runoff events.

Method of Urbanization	**Ecological Consequence**	
	Increase	*Decrease*
Channelization	• Stream flow velocity and flashiness	• Macroinvertebrate diversity • Fish diversity and biomass • Habitat diversity • Connectivity with riparian zone
Elimination of pools, riffles, and point bars	• Stream flow velocity and flashiness	• Macroinvertebrate diversity • Fish diversity and biomass • Habitat diversity
Settlement along bank		• Riparian zone (replaced by urban infrastructure) • Floodplain
Increased impervious surfaces	• Runoff volume and velocity • Stream flow velocity and flashiness	• Lower water table • Infiltration • Annual fluxuation within water table
Combined sewer overflows	• Nutrient load • Algal blooms • Eutrophic potential • Stream flow velocity and flashiness	

Table 1: Effects of Stream Urbanization

For successful creek restoration, a comprehensive watershed management plan to improve the water quality of the entire Onondaga Creek watershed must be designed and implemented. The restoration should focus on decreasing erosion, sedimentation, channelization, and nutrient loads, while effectively restoring floodplains and native habitat. The purpose of this project is to investigate a local site in dire need of revitalization and develop a restoration design plan with recommendations that meet a series of social, ecological, and biophysical goals. The goals and recommendations of the Onondaga Creek Conceptual Revitalization Plan (OCRP) have been reviewed and implemented wherever possible. Revitalization of Onondaga Creek in its entirety is a huge restoration effort that will take time and require substantial funding, but will result in a waterway with improved water quality, enhanced ecological benefits, and societal improvements that will benefit local residents.

Combined Sewer Overflow Abatement Project

Onondaga County is under a federal court order to improve the water quality, such that it is safe for swimming and fishing, while also complying with the federal Clean Water Act (CWA) administered by the United States Environmental Protection Agency (EPA). Onondaga County has been in and out of court since 1998 for the cleanup of Onondaga Lake. They have worked out a new plan with support from the state Department of Environmental Conservation and Atlantic States Legal Foundation, which are the other two parties in the federal lawsuit regarding lake pollution. The county's plan is to get rid of the gray infrastructure and implement natural systems, such as green infrastructure to control stormwater. This stormwater can fill the sewers and sending about 600 million gallons a year of untreated sewage and pollutants into Onondaga Creek and Harbor Brook, which are tributaries to Onondaga Lake.

To prevent the stormwater from entering the storm drains; trees, rain gardens, trenches, and rain barrels would be built. The plan anticipates that approximately 250 million gallons of stormwater would be diverted by the use of these structures and 150 million gallons would be held in two new storage tanks.

As stipulated by a 1998 Amended Consent Judgment between Onondaga County, New York State, and Atlantic States Legal Foundation, Onondaga County is required to put into action a comprehensive program that focuses on improving the water quality of Onondaga Lake. The Onondaga County Combined Sewer Overflow (CSO) Lake Improvement Program is a collection of projects that focuses on meeting the requirements of the ACJ to improve Onondaga Lake water quality. One element of the comprehensive Lake Improvement Program is the Clinton Street CSO Abatement Project (Miller, 2005). The elimination of these CSO's along with the cities plan to implement green infrastructure are among the small steps taken to help restore Onondaga Creek.

Onondaga County's CSO control and upgrade program is expected to achieve the elimination or the capture for treatment of no less than 85% by volume of the combined sewage collected in the combined sewer system during precipitation events, the elimination or minimization of floating substances in Onondaga Lake attributed to the County's CSO's; and achieve all water quality standards for bacteria for all portions of the lake under New York's rules and regulations. All elements of the CSO control and Upgrade schedule must be fulfilled and in full operation on or before January 1, 2012 (Miller, 2005).

Clinton Station, also known as the Trolley Lot, is just one of seven potential sites for the CSO abatement facilities. The Clinton Street CSO service area encompasses approximately 970 acres of urban residential, commercial and industrial areas. Other possible locations for the facility included Tully Street, West Onondaga Street, West Washington Street, Wyoming Street, Gifford Street and Dickerson Street all located around Onondaga Creek. The Trolley Lot CSO facility will be an underground structure to maximize the use of the land. Once facility structures are in place, sand and grass can be placed over top. Non-permanent structures above the CSO facility provide the most access to the tanks in case of a structural/internal problem.

The Onondaga Creekwalk Project

The plan for the Onondaga Creekwalk was initially proposed in 1979 to extend a continuous biking and pedestrian path from the southeast shore of Onondaga Lake to the

Onondaga Nation located just south of Syracuse. The plan consists of three phases to reach this goal, Phase I of the Creekwalk will link two existing trails located in Franklin Square and at the Inner Harbor will also add northern and southern extensions. Phase II will extend the trail south from Amory Square to Kirk Park, and Phase III will continue south to the city's southern border located at Dorwin Avenue.

The Linking Section of Phase I will connect two existing trail segments and will run 0.1 mile beginning at Spencer St. and running to Kirkpatrick St. For the Phase I Northern Extension the Creekwalk will extend approximately 0.5 mile starting at the ending point of the current trail located just north of Bear Street. The trail will run on the west bank of the Barge Canal traveling north to Hiawatha Blvd at which point it will cross the Barge Canal to the east bank and extend north to Onondaga Lake where it will eventually connect to the Carousel Center and a planned 12-mile "Loop the Lake" trail. The 0.6 mile Southern Extension will begin at Franklin Square at the ending point of the current trail and will extend south alongside Onondaga Creek down to Amory Square (Figure 1).

Figure 1: Visualization of Creekwalk Design currently being implemented just to the west of Armory Square. This improvement is designed to visually improve the site and facilitate connection between Armory and Phase I of the Creekwalk. C&S is currently leading the restoration on this site.

The ground breaking for Phase I took place on November 6, 2009. The project is budgeted at $6.7 million and is set to be completed by the end of 2011. Once finished, Phase I will span 2.2 miles with an average width of 13 feet reaching from the Southern shore of Onondaga Lake to West Jefferson St. located near Armory Square. Feasibility studies for Phase II were completed in February 2008. However, this phase of the project still lacks funding and Phase III of the plan is still in a conceptual state.

Constraints

There are multiple challenges to ecosystem restoration in urban areas. Zoning, obtaining appropriate permits, local, state and federal regulations, and multiple levels of jurisdiction all are issues to be dealt and complied with. Altering the geomorphology of the creek is constrained by smaller, highly developed parcels within the city. Funding is another major obstacle. Without the funding to complete the restoration, nothing will happen. The proposed design is for just one area of this watershed. In order for the restoration efforts to be effective, changes must be made throughout the entire watershed.

Urbanization of catchments leads to changes of streams along three axes: 1) geomorphic simplification in that habitat heterogeneity and floodplain connectivity are reduced; 2) diminished societal value in that stream channels become increasingly unattractive and are avoided for recreational purposes; and 3) ecological simplification in that stream biodiversity declines and stream ecosystem functioning is impaired (Bernhardt and Palmer 2007). The goal of restoration should be to move the stream as far back along the three axes as is possible given existing constraints, which in urbanized areas like Syracuse, can be quite extensive. Property boundaries, underground utilities, existing buildings, available space, economics, and social concerns are all factors influencing, and potentially limiting, restoration of urban waterways. Restoration to some historic or other reference condition is not a realistic option. Thus, managers must make compromises between the ideal restoration design for achieving management goals and the restoration design that will fit within the available space (Bernhardt and Palmer 2007).

Site Description – The Trolley Lot

The site chosen for restoration is called the Trolley Lot. It is located between Dickerson St. and West Jefferson St., including Onondaga Creek and is depicted on the United Stated Geologic Survey (USGS) Quadrangle: Syracuse West found as an attachment in this document. Properties involved along the east side of Onondaga Creek include two asphalt paved parking lots. A 2.79± acre Onondaga County lot and a 3.42± acre City of Syracuse lot, both of which are bounded on the northeast by a railroad track overpass. A lot on the west side of the Creek owned by the City of Syracuse is also included in the project.

The project site is located within the Onondaga Trough, a broad, deep soil-filled bedrock trough extending from Homer, NY, through the Tully Valley to Onondaga Lake. The glacially carved valley was filled with a variety of sediments deposited at the end of the most recent glacial period, approximately 12,000 to 14,000 years ago, by slow to rapid flowing streams or lakes formed against the retreating glaciers. Based on profiles prepared by the USGS (Kappel and Miller, 2005), the natural soils filling the valley include the following units from the ground surface downward:

- Alluvial Deposits: silt, sand, gravel, and organic soils, with occasional wood and marl
- Glaciofluvial Deposits: silt, sand, and gravel
- Glaciolacustrine Deposits: fine sand, silt, and clay
- Glacial Till Deposits: silty sand with gravel, cobbles, and boulders

Haley and Aldrich performed an extensive geotechnical evaluation of the project site in 2005 for the Onondaga County Clinton St. CSO abatement project. The local stratigraphy was found to consist of Soil Fill, Alluvial Deposits, Glaciolacustrine Deposits, and Glaciofluvial Deposits from the ground surface down, respectively (Haley & Aldrich, 2006). A soil boring location map as well as a cross section of the project site showing the local stratigraphy can be found in the attachments section of this document.

Onondaga Creek has a mean annual flow of approximately 176 cfs or 79,000 gpm. At the Trolley Lot site, the normal creek level is approximately El. 378' above mean sea level (amsl) (Haley & Aldrich, 2006). However, due to the flashiness of the creek, there is potential for the water level to rise significantly during storm events. Based on observation well data, groundwater flows toward the creek during normal conditions and the water table ranges from El. 373.7 to El. 383.1 across the site (Haley & Aldrich, 2006).

II. Project Objectives

Based on the OCRP, the plan is for Onondaga Creek to be a place where the community can see the natural beauty of the creek and enjoy the wonders that come with it. Major areas of concern to address along the creek are (OCRP Executive Summary, 2009):

- Water quality
- Human health and safety
- Ecological health and habitat
- Access, recreation, and use
- Education

Additional, site-specific concerns include access to the underground storage tanks, potential loss of parking space, and the expense of restoration implementation and upkeep. The Trolley Lot project strives to address these concerns by aiming to enhance the connection between the local community and Onondaga Creek while restoring necessary habitat and ecological function to the area. This is to be accomplished through social aspects such as recreation, integrating art, community involvement, site and aesthetic improvement, education, and ecologically by enhancements along the creek to improve function and to return to more natural conditions.

III. Proposed Restoration

The site was split into five zones (Figure 2.) based on the current plan for installing subterranean CSO storage tanks, information from the OCRP, and a general idea about how current residents would like to utilize the area. Table 2 outlines the proposed site modifications by zone.

Figure 2: Trolley Lot Site Zones

Zone	Proposed Modifications
1	• Install baseball diamond, volleyball courts, and concession stand
2	• Connect to Creekwalk • Install art mural, educational signage, additional lighting, and photovoltaic strip • Replace asphalt with porous pavement • Retain parking space
3	• Remove fence • Regrade banks • Replant with riparian vegetation
4	• Remove fence • Regrade banks • Replant with riparian vegetation
5	• Remove concrete channel • Install cross- and j-hook-vanes • Create riffle-pools

Table 2: Proposed Site Modifications by Zone

Zones 1 & 2: Stormwater Reduction & Community Enhancement

Urbanization simultaneously increases the loading of water and nutrients while simplifying the receiving channels, turning the urban river from a functioning ecosystem to an efficient gutter (Bernhardt and Palmer, 2007). Historically, there was a necessity to remove water, and in turn, wastes from populated areas as quickly as possible to combat potential disease. In most cityscapes, stormwater systems have been designed to either drain directly into local waterways or are combined with sewer systems which overflow into streams through CSOs during storm events. The impervious nature of urban environments negatively impacts these systems by increasing runoff. An altered hydrograph with high peak flows and reduced baseflows is the most obvious and consistent effect of catchment urbanization on stream hydrology. As a result of increasing impervious cover in developing catchments, evapotranspiration and soil infiltration are reduced. The result is higher peak discharges, flashier stream flows, and reduced groundwater-surface water exchange with potential for an overall reduction in groundwater recharge and hyporheic zone size (Bernhardt and Palmer, 2007). This is certainly the situation with Onondaga Creek.

The Trolley Lot section alone has a number of CSO discharge locations. Identified by the City of Syracuse as the Clinton St. CSO service area, the contributory watershed encompasses approximately 970 ± acres of urban residential, commercial and industrial areas (Figure 3) (http://ongov.net/lake/ol30641.htm).

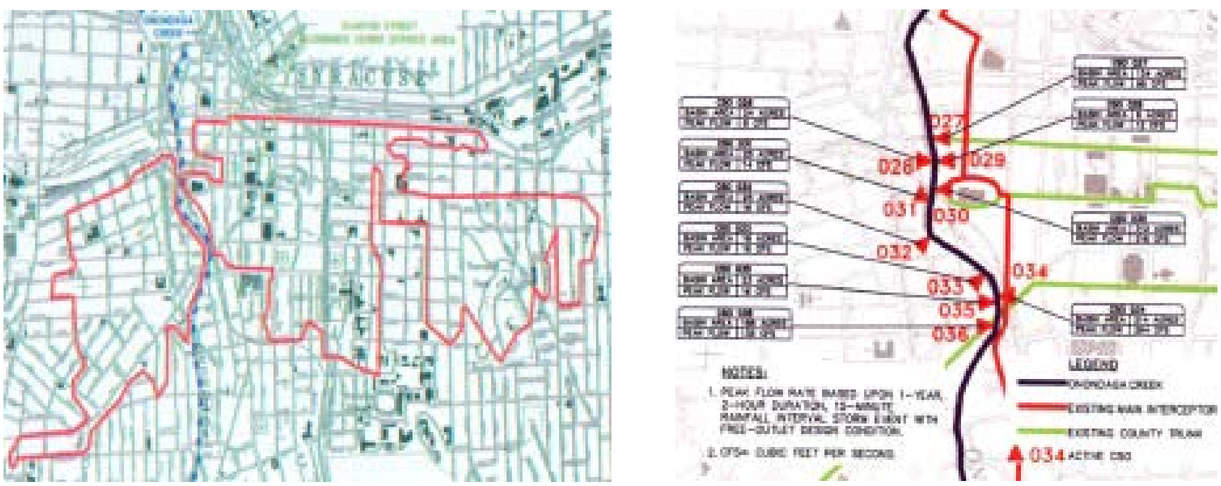

Figure 3: Clinton Street CSO Service Area and Location Map. The image on the left outlines the drainage area. The right image shows the location of the CSO outlets on or near the project site. (Image Source: http://ongov.net/lake/ol30641.htm)

Onondaga County is currently planning to eliminate the 10 CSO discharge locations on or near the project site, shown in the above right image. In Zone 1, plans include the construction of two underground tanks (Susan Miller, personal communication) for temporary storage of these CSO discharges during storm events. The above ground infrastructure will be minimal, allowing for use of this space for recreational activities. It is proposed that construction of a baseball diamond (Figure 4), up to 3 volleyball courts, and a concession stand be placed in this location. Considering the proximity to Armory Square, there is great potential for use by after-work sports leagues and by little league teams on weekends. Furthermore, the pervious nature of these propositions will allow for significant stormwater infiltration, reducing the flashiness of Onondaga Creek. This would also allow for relatively inexpensive, easy access to the storage tanks through excavation if necessary.

Figure 4: Proposed Recreation Areas Located in Zone 1.

Zone 2 currently serves as overflow parking space for Armory Square. Since parking in the area is limited, parking should remain this zone's primary use (Figure 5). However, the current pavement should be replaced with pervious and porous materials such as "flexipave" to decrease the amount of stormwater runoff to the creek.

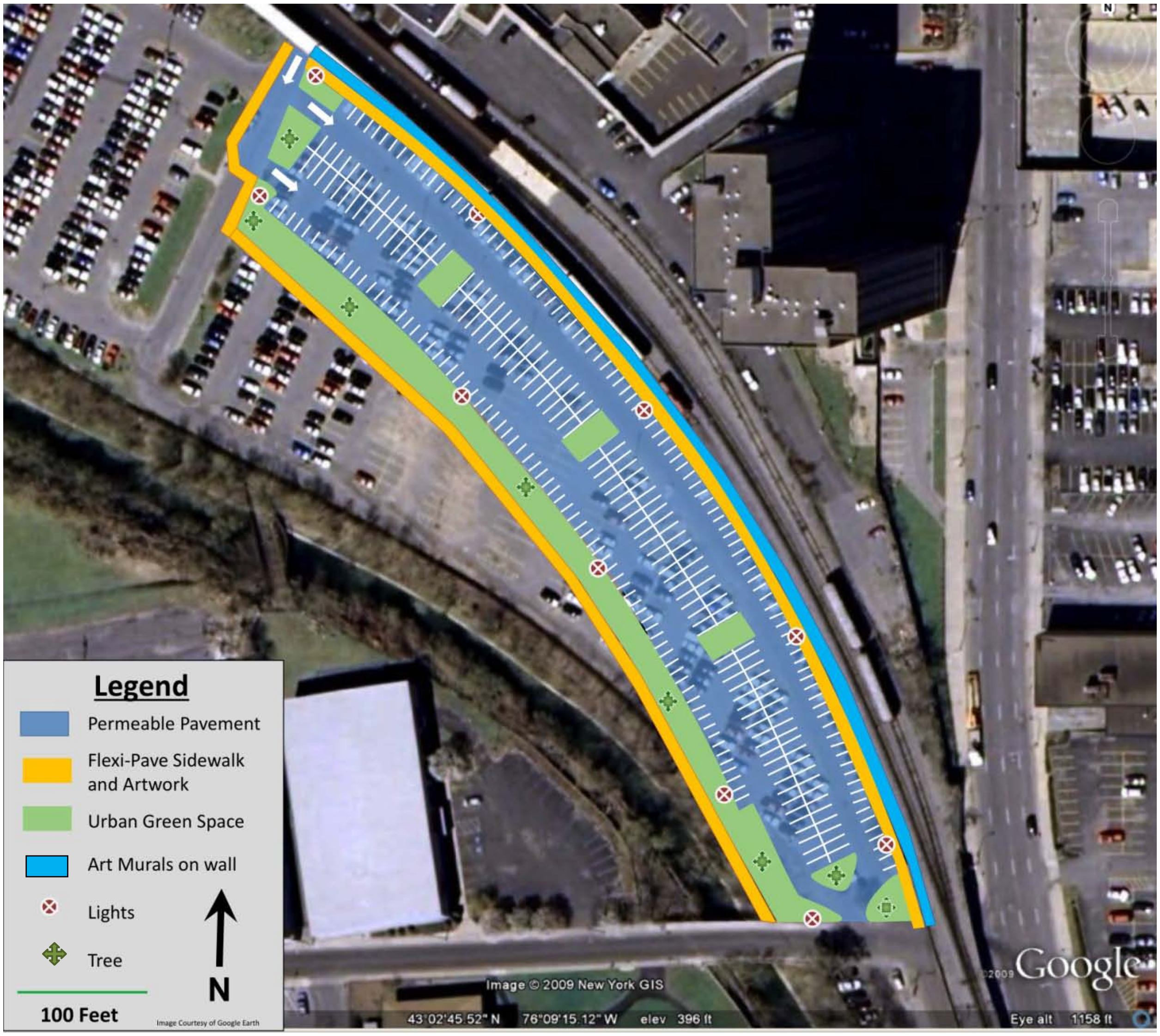

Figure 5: Zone 2 Parking Area, Creekwalk, and Art Mural Proposed for this area

In both zones 1 and 2, the proposed design extends the Creekwalk along the railroad wall with the perimeter of the parking area. This has the benefit of connecting this site with others along the creek as well as creating access to the railroad wall. The wall and tunnel between the site and Armory Square provide opportunities for beautification, to create community interactions, and to show off local talent by making it a place for local artists to display their work. Specifically, local artists could be asked to do a mural on the walls that are currently bare concrete. As an annual community event, the wall can be whitewashed and repainted with a new mural. This event could take place every spring to bring all ages to the downtown area to display their artwork and could possibly coincide with an annual opening of the Creekwalk. To make the area safer, more lighting will be installed in both of these sections. It may be possible to also install a photovoltaic strip on the railroad track to help power the additional lights and keep the space green.

Green Roof Application Opportunity in Surrounding Area

New "green technologies" have emerged that may influence urbanized contributions to stormwater runoff. Vegetated, or green, roofs use engineered growing media, drought-tolerant plants, and specialized roofing materials that can be installed on existing structures. This creates a rooftop which can absorb and utilize precipitation rather than shedding it into the stormwater system (Carter and Rasmussen, 2005). There is the potential to greatly reduce the urban effect of storm events on Onondaga Creek through this method. Carter and Rasmussen (2005) showed a constructed green roof in Georgia to retain on average just under 78% of runoff for 32 storm events recorded over a one year period. These results support that retrofitting existing buildings with a green roof can significantly reduce and in some cases eliminate the stormwater contribution from the existing structure. There are many buildings within downtown Syracuse in the vicinity of our project location which have the potential for green roof technologies to be applied (Figure 6). Perhaps further work with local governments could provide an incentive for such reductions in stormwater.

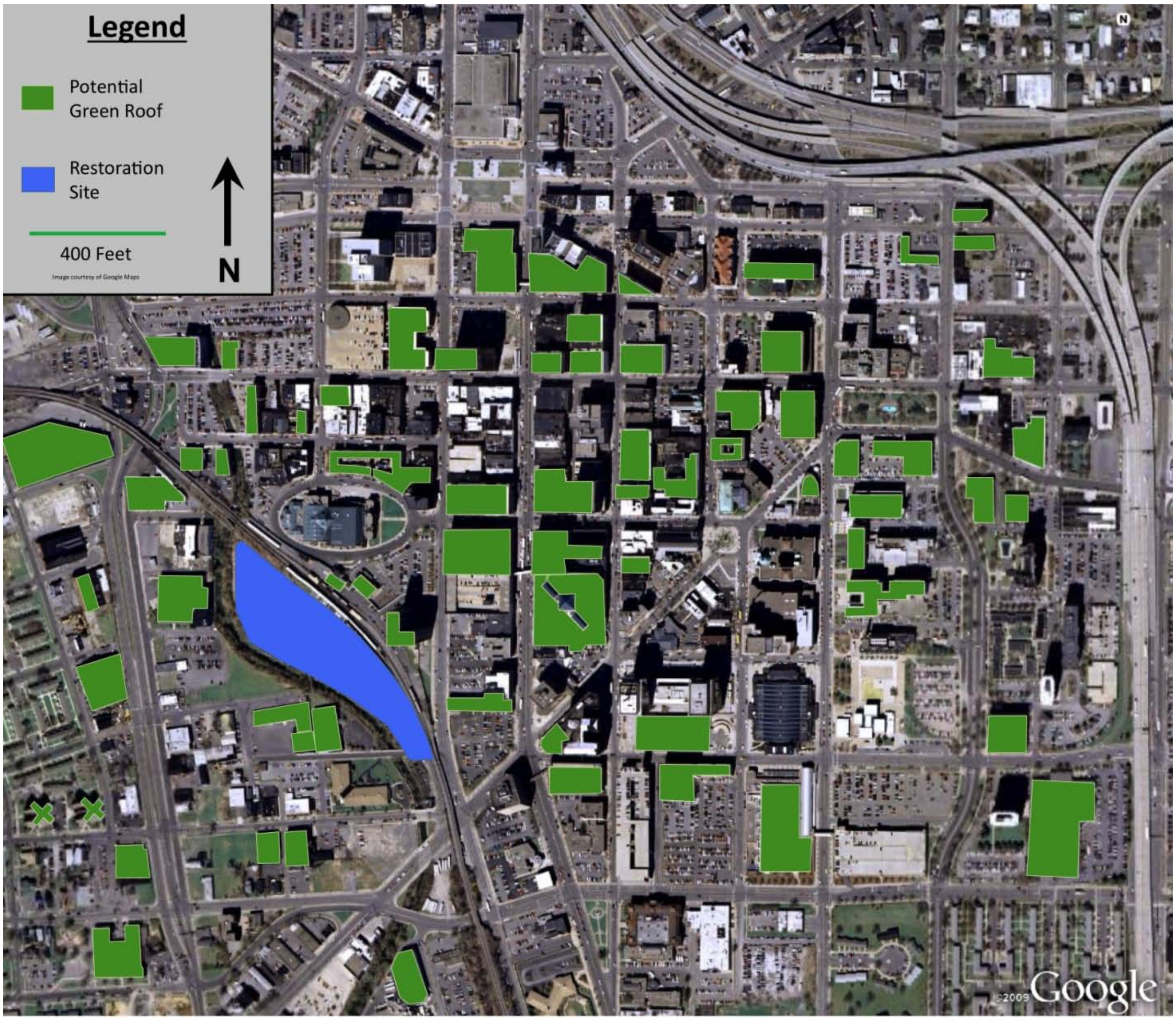

Figure 6: Potential Flat Roofs for Green Technology Near the Project Site.

Zones 3 & 4: Riparian Zone Creation

Most urban stream banks have been hardened using over-sized boulders or rip-rap to prevent lateral channel migration and bank erosion (Bernhardt and Palmer, 2007). This is evident throughout the urbanized portion of Onondaga Creek (Figure 8). Impaired ecosystem functioning can extend out of the channel into the riparian zone if the water table drops below the rooting zone of riparian plants because of channel incision (Groffman et al., 2003). The disconnection or loss of riparian zone has a multitude of implications.

These functionally disconnected riparian zones in urban catchments may have reduced efficiencies of nutrient removal (Groffman et al., 2002, 2003). The lack of water interaction with the adjacent vegetated banks removes a natural filtering system. It has been shown that riparian zones influence nutrient cycling from runoff and within stream. Bernhardt and Palmer (2007) found that re-grading stream banks to reduce incision and allow more stream water to move through the upper layers of the riparian soil resulted in significant increases in denitrification relative to unrestored reaches.

Zone 3 is the buffer zone between the creek and zone 2 (Figure 7). In order to maximize parking space in zone 2, the major proposals for zone 3 are to remove the current fence and vegetation along the top of the bank, in order to regrade the slope and replant with riparian species. This will help increase bank stabilization and create a larger flood-plain area for the creek at this location.

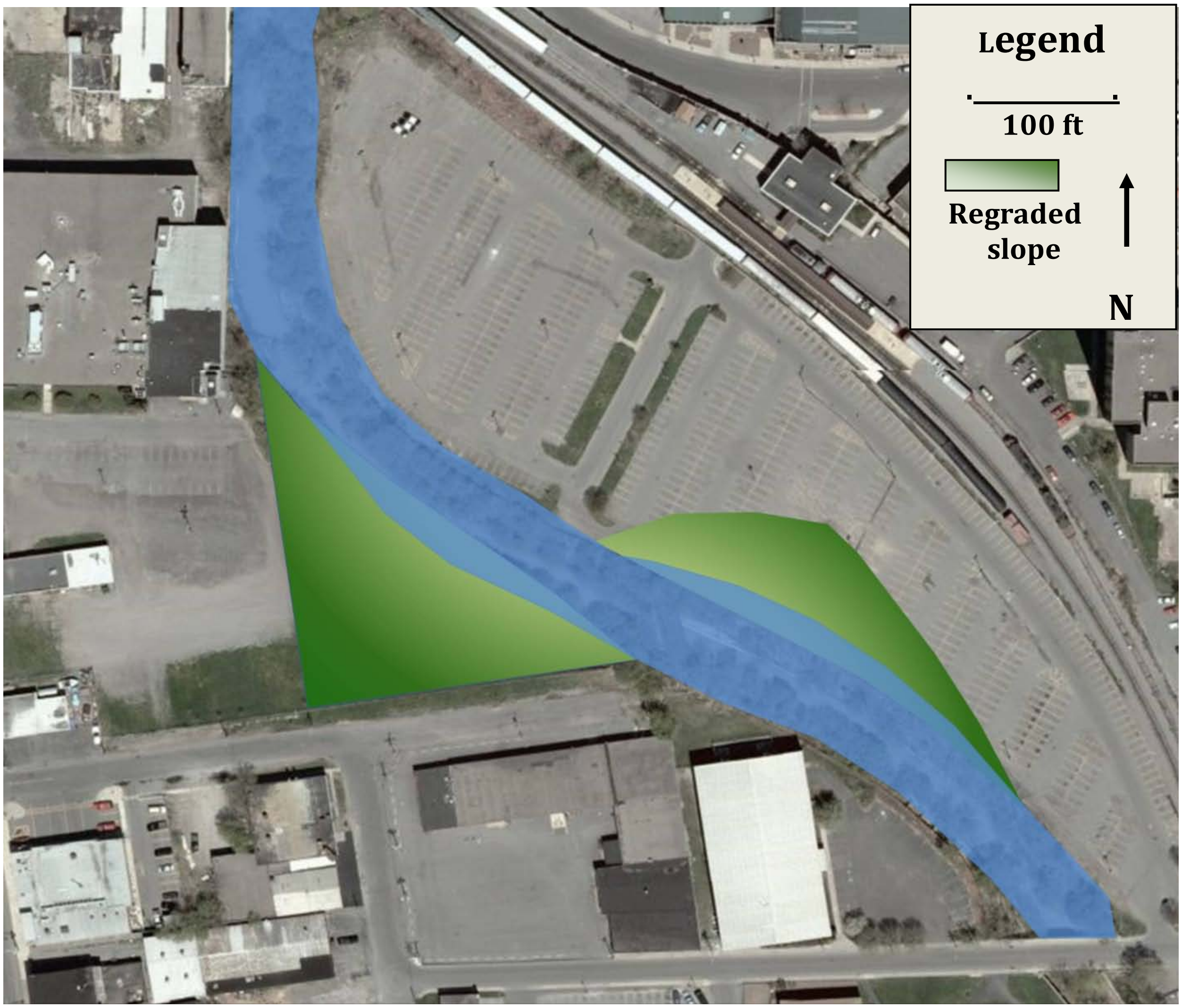

Figure 7: Zones 3 and 4

Zone 4 is across the creek from the other sections (Figure 7). Similar to zone 3, this area will have the fencing removed and be regraded and replanted. Since there is no parking to preserve, the grade for this slope can be more gradual and a transition from riparian plantings in the lower area to trees at the top can be implemented. The vegetation at the top can act as natural fencing. This will increase floodplain area which will help decrease the amount of flash flooding that this stretch of the creek currently experiences.

Zone 5: Creating Channel & Habitat Heterogeneity

Zone 5 is the creek channel running along the Trolley Lot site (Figure 2). The primary objective for this zone is to increase habitat availability.

Channelization

There is a tendency for urban waters to become channelized from confinement in concrete channels and incisement of stream banks with rip-rap to prevent bank erosion and channel migration. The section of Onondaga Creek that flows along the Trolley Lot has undergone this type of degradation (Figure 8). Channelization results in loss of structural complexity, simplified flow patterns, and decreased availability of microhabitats for a wide array of lotic organisms (Petersen et al., 1987). The reduction of habitat availability and altered hydrology results in lower amounts of aquatic biomass as compared to natural stream and river ecosystems. Given their flashy hydrographs, low habitat heterogeneity and high contaminant loads, recent research has documented that urban fish and invertebrate assemblages are typically species poor in urban streams(Bernhardt and Palmer, 2007).

Figure 8: Onondaga Creek Channelization in Concrete. Left image: looking upstream of the project site. Right image: at the south end our our site, looking downstream (north).

The loss of topographic heterogeneity through channelization reduces in-stream habitat availability and species diversity. Reduced spatial heterogeneity due to river straightening resulted in decreasing species number, diversity, stock density and biomass in the River Melk in lower Austria (Jungwirth et al., 1995). Urbanized streams end up losing important components with the reach such as riffle-pool sequences. Riffles are the principle spawning beds for trout and the primary habitat for aquatic insects (Petersen et al., 1987). One of the primary components of in-stream restoration within urban catchments is restoring topographic heterogeneity to the channel. The goal is to make the streambed more heterogeneous by adding various restoration structures such as: boulder dams and flow deflectors, or gravel beds to improve trout spawning habitat (Muotka et al., 2002).

The effect of topographic heterogeneity is a complex three-dimensional landscape that exerts tremendous influence on the composition and function of ecological systems. Topographic heterogeneity is know to affect several classes of response variables, including 1) abiotic factors and ecosystem processes; 2) distribution of organisms; 3) genetic, reproductive, and developmental attributes; and 4) animal habitat use, behavior, and trophic interactions (Falk et al., 2006). This is evident in river restoration projects conducted in lower Austria. The Melk River project showed that regained spatial heterogeneity of the riverbed led rapidly to a significant recovery of the fish stock. Due to the improvement of the aquatic environment with respect to variable depths, flow velocities, and substrate types, both the density and biomass of the total fish stock tripled (Jungwirth et al., 1995). In addition, Oscoz et al. (2005) found in Northern Spain that the inclusion in the channelized section of structures to improve the aquatic habitat heterogeneity, rehabilitation of riffle-pool sequence and riparian vegetation, helped to make the fish community composition and structure similar to that found in unaltered points in the Larraun River. The effect of heterogeneity restoration can extend to multiple trophic levels. Muotka et al., (2002) found a remarkable long-term recovery potential for benthic assemblages following restoration-related changes in habitat structure and resource availability in Finland. This suggests that if the presence of suitable habitat is a prerequisite for the establishment of a more natural-like invertebrate assemblage, then the fact that the stream habitat had recovered almost fully within less than 10 years shows great promise for the conservation of benthic diversity through river restoration.

Cross-Vane Insertion

The cross-vane (Figure 9) is a grade control structure that decreases near-bank shear stress, velocity and stream power, but increases the energy in the center of the channel. Cross-vanes will create grade control, reduce bank erosion, establish a stable width/depth ratio, preserve channel capacity, while maintaining sediment transport capacity, and sediment competence. The cross-vane is also a stream habitat improvement structure due to: 1) an increase in bank cover due to an difference in water level at the surface in the bank region; 2) the formation of holding and refuge cover during both high and low flow periods in the deep pool; 3) the development of feeding lanes in the flow separation zones (the interface between fast and slow water) due to the strong downwelling and upwelling forces in the center of the channel; and 4) the creation of spawning habitat in the tail-out or glide portion of the pool.

Figure 9: Cross-vanes in Nine Mile Creek at Marcellus Park.
(Diagram Source: http://www.wildlandhydrology.com/assets/The_Cross_Vane_W-Weir_and_J-Hook_Structures_ Paper_ Updated_ 2006%20.pdf)

J-Hook-Vane Insertion

J-Hook rock vanes (Figure 10) are grade control devices designed to reduce the harmful energy a stream can create, essentially protecting the stream banks. These vanes are made up of natural materials such as boulders, logs or root wads, depending on the purpose and local availability. The basic function of the device utilizes the principle that water will flow over immovable objects at right angles. The device is constructed of large stones that are trenched into the stream bank and bed. The stone is trenched in two rows at an upstream angle and then formed into a hook shape as the device moves further out into the stream, with the tip of the hook pointing downstream. The downstream row of rock is trenched into the stream bottom so that the top of the rock is approximately level with the stream bottom. The second row of rock is then placed just upstream of that row of rock slightly overlapping it so that as the water flows over the top of the upstream line of rock it will flow onto the downstream line of rock. This creates a stable surface on which the energy of the stream can be dissipated without completely scouring (eroding) the stream bottom. As the stream dissipates its energy, it will scour the stream bottom slightly, creating a small scour pool immediately downstream of the device that cans serve as a source of habitat for fish.

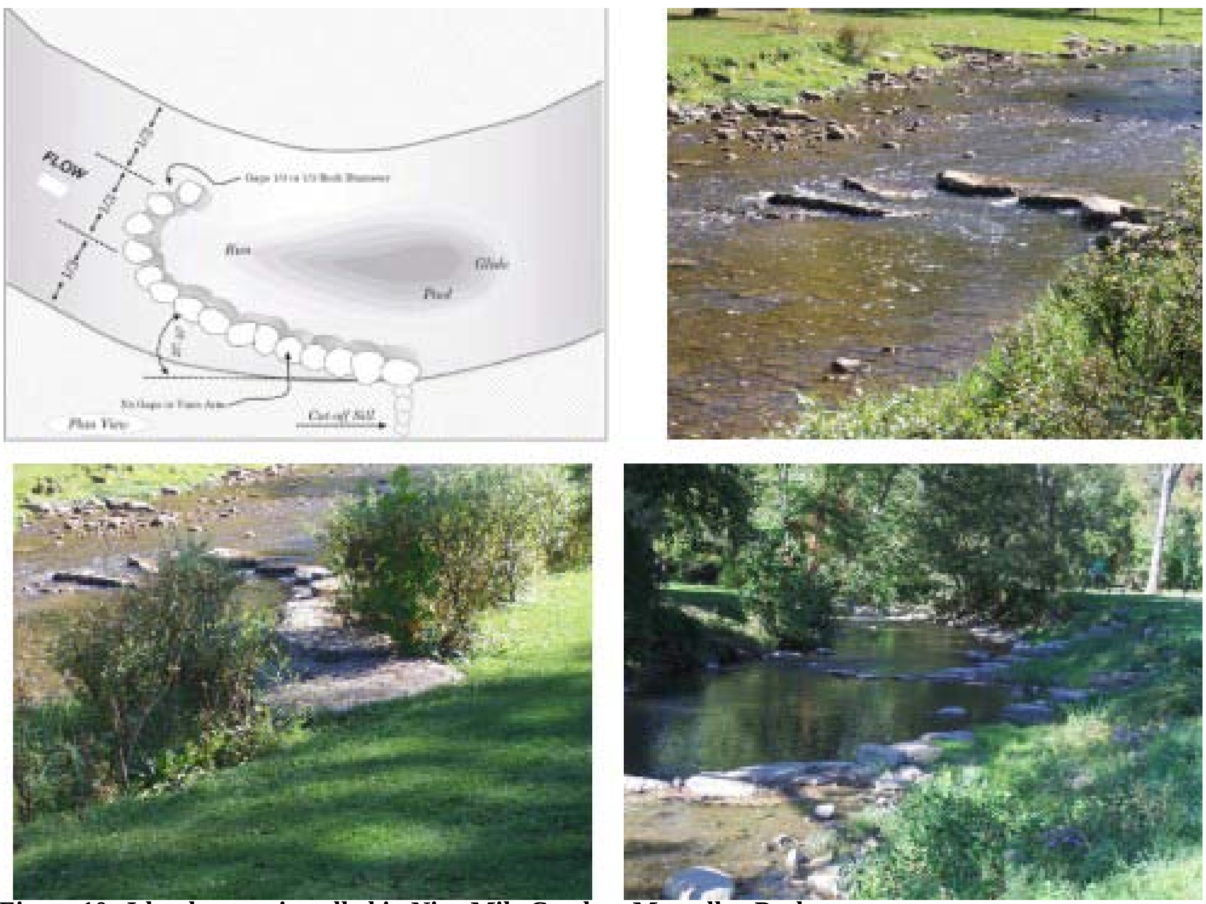

Figure 10: J-hook vanes installed in Nine Mile Creek at Marcellus Park.
(Diagram Source: http://www.wildlandhydrology.com/assets/The_Cross_Vane_W-Weir_and_J-Hook_Structures_Paper_Updated_2006%20.pdf)

Riffle-Pool Creation

The riffle-pool sequence (Figure 11) is usually found in a straight or non-meandering channel and alternates between shallow and deep sections. The riffle section is the shallower section made up of larger rocks while the pool section is the deeper part. Riffle-pools reduce bank erosion, control grade, have increased substrate capacity, short-term sediment/bedload capture and storage, and provide habitat heterogeneity within the stream reach.

Figure 11: Riffle-pool Sequence in Nine Mile Creek at Marcellus Park (Image Source: http://www.lakecountyil.gov/Stormwater/LakeCountyWatersheds/BMPs/StrmRestoration.htm)

In order to regain topographic and habitat heterogeneity, as well as assist with bank stabilization and flow control, the channel morphology needs to be altered (Figure 12). Removing the concrete in the channel is the first step. This will allow connection with riparian zones and increased groundwater interaction at the streambed. Installing a J-hook just north of Dickerson St. will protect the southwest bank of the creek and direct flow towards the newly graded riparian area in Zone 3. This should be followed by a riffle sequence created by installing various sizes of boulders and cobble within the streambed. Just before the end of Zone 3, another J-hook should be installed to stabilize the banks at the boundary between Zones 1 and 2 and direct flow towards the regraded riparian area at

Zone 4. A cross-vane could then be used near the location of the first building on the west side of the creek, creating a pool habitat between Zones 4 and 1. The remainder of the reach would be focused on streambed heterogeneity with riffle-pool sequences.

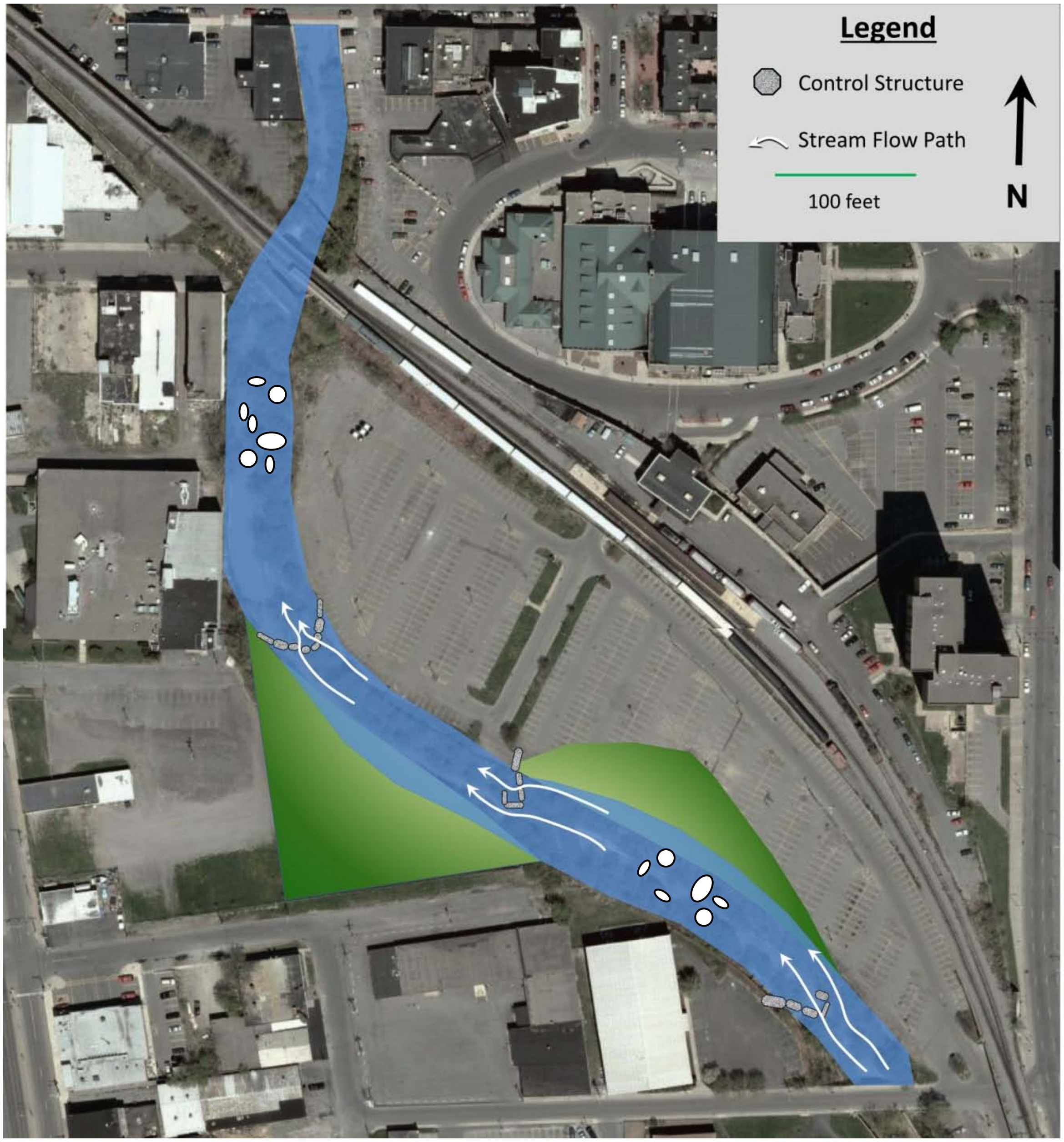

Figure 12: Channel Heterogeneity Modifications

Potential Negative Repercussions

The proposed restoration plan strives to address concerns brought up in the Onondaga Creek Revitalization Plan and the current state of ecological disconnect at the Trolley Lot. However, some of the proposed actions may have outcomes which are undesirable or less successful than predicted.

Trolley Lot serves as overflow parking for Armory Square. The restoration plan attempts to preserve some of this functionality. However, between the CSO abatement project and the riparian zone creation in zone 3, up to 75% of the current parking capacity may be lost. Due to the dearth of parking in the square, this is possibly too much parking space to lose during peak times.

If not properly constructed, the cross-vane and j-hook-vane insertions may erode. This could lead to general erosion of the bank and the loss of newly created habitat. Loss of habitat will result in loss of aquatic organism diversity. These eroded structures would also be costly to reinstall.

The restoration plan does not include any means of increasing access to Trolley Lot from the west side of the creek. This will result in a continued community disconnect between the two sides of the site. Moreover, the proposed recreational opportunities and community activities, specifically using the railroad wall as a public art space, may not garner as much interest as anticipated or be sanctioned by the City of Syracuse or owners of the railroad.

IV. Conclusions

Project Outcomes

The proposed site modifications address all of the areas of concern outlined in the project objectives: water quality; human health and safety; ecological health and habitat; access, recreation, and use; education; access to the underground storage tanks; potential loss of parking space; and the expense of restoration implementation and upkeep. Water quality will be improved by both the attention to creating more pervious surfaces in the recreational and parking areas to reduce runoff and the creation of riparian zones on either side of the creek to increase natural filtration. Human safety will be improved inherently through the improved water quality, by the addition of further lighting around Trolley Lot, and by the creation of riparian zones to act as floodplain and reduce the flashy nature of the creek and, thus, make proximity to the water less hazardous.

The ecological health and habitat will be enhanced by the removal of the concrete channel liner to reconnect the creek with the riparian zone and by the installation of structures to create channel and habitat heterogeneity which will encourage aquatic species to return to the site and boost the species count. Connecting it to the Creekwalk, installing recreational opportunities, and using the railroad wall to display local art will increase the access to and use of the site. Strategically placed signage about the site restoration and new technology will provide educational opportunities for visitors of all ages. While the underground storage tanks have not been made more accessible, the choice of a baseball field over other possible recreation structures maintains a similar level of accessibility as not using the space. Approximately 25% of the original parking space has been retained. With regard to cost, connecting the site to the Creekwalk may help provide project funding, installing easily and inexpensively maintained recreational areas and the potential installation of photovoltaic cells to power the lights will reduce future costs and may generate power to offset some of the initial spending. Overall, this conceptual plan provides a multiple phased approach to restoration that will reconnect the downtown Syracuse community with Onondaga Creek on several levels while also reverting this section of the creek to a more natural appearance and functional state. Moreover, aspects of this plan can be applied to many other locations along Onondaga Creek.

Future Considerations

Monitoring and consideration of ecological restoration success needs funding and organization beyond the initial channel modifications, regrading, and revegetation of the site. This is an essential part of the restoration process, so funding requests must include this in their proposed budgets. Additionally, a responsible party should be charged with overseeing the collection and maintenance of data assessing the ecosystem health and carrying out required actions associated with the continued success of the restoration.

There are annual costs associated with maintenance of the parking lot, sidewalks, recreation fields, landscaping, and lighting system. The city of Syracuse must include these expenses in future city planning and associated budgets.

Future Direction of Study/Effort

Feasibility studies for the proposed modifications must be conducted to determine the finer details of the plan from a reference ecosystem for the ecological propositions to the cost of each phase for budgeting purposes.

Branching into the surrounding area, the green roof potential should be investigated for qualified flat roof residential and commercial structures.

This plan should be adapted to use at similar sections of Onondaga Creek. Such sections should be identified and the proposal process begun.

Finally, this project can be used as a living laboratory for elementary, middle, and high schools, as well as local colleges. By implementing new green technologies, the community can take pride in this area, as well as use it to teach future generations.

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VI. Attachments

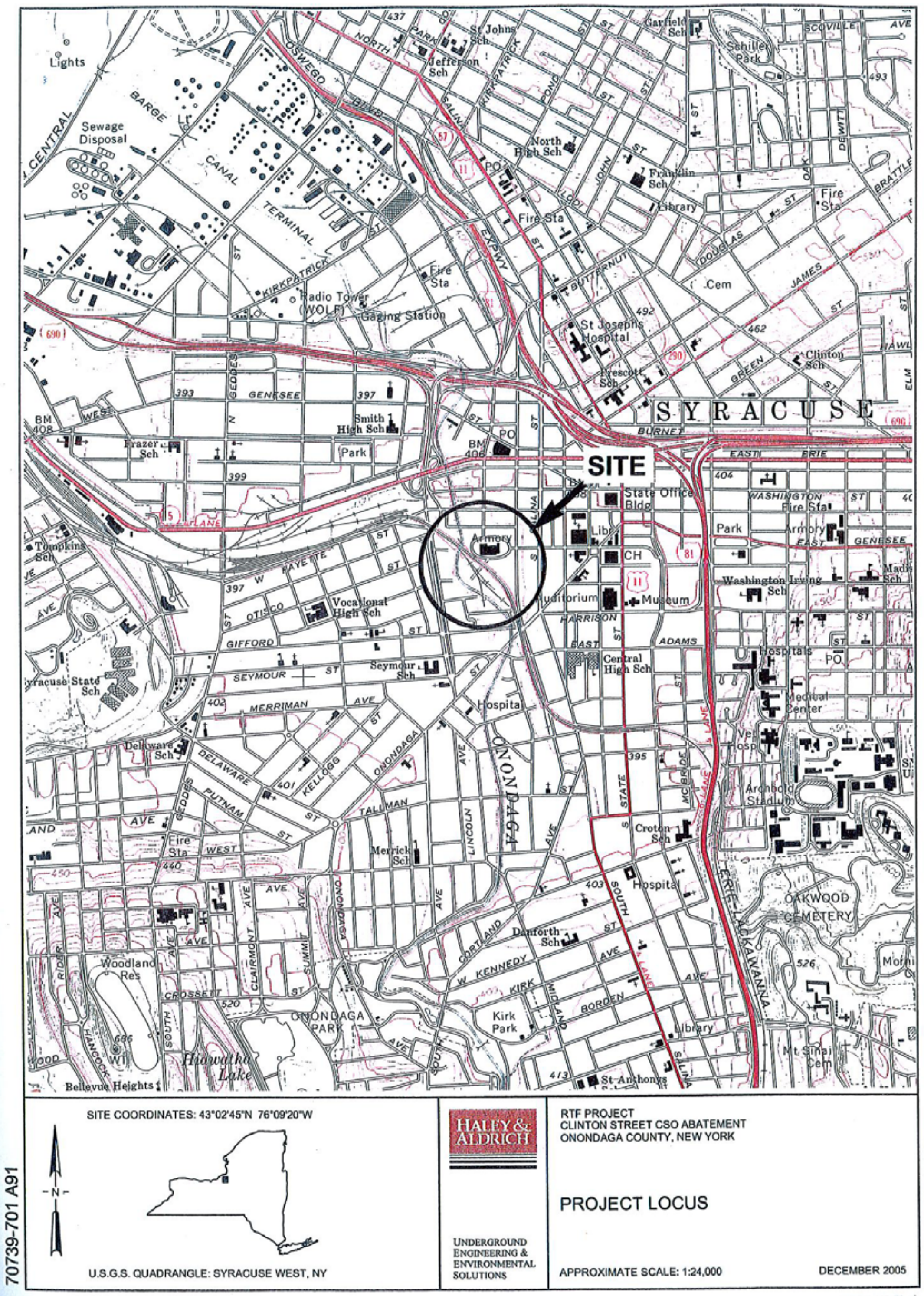
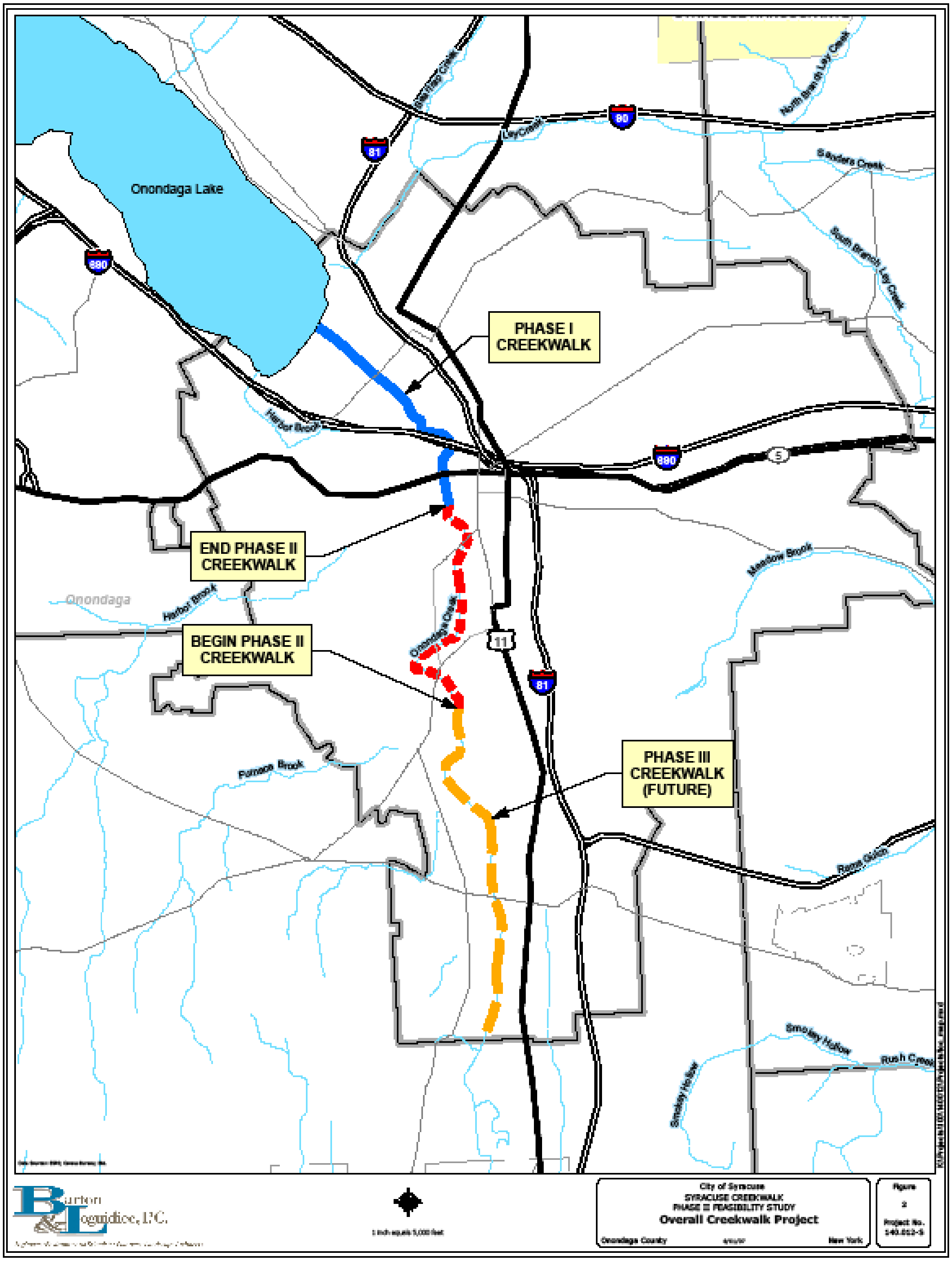


FIGURE 1



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