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Solving a Crisis:
Water Quality & Storm Water Infrastructure in
New York City

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Professor Van Buren

Environmental Studies Internship

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This past semester I have been given the privilege of working with an organization that is at the forefront of environmental protection and combating environmental injustices. This organization, the Bronx River Alliance, is fighting a battle against those that believe minorities and low-income groups have less of a right to live in a safe and healthy environment. The Bronx River Alliance created a set of guidelines and principles to operate under and then proceeded to support and develop projects as concrete solutions to environmental degradation in the Bronx. One of these projects, which is growing substantially, is the SWIM coalition. The coalition is currently comprised of 47 different sponsor organizations.¹ These organizations consist of all types of activist groups in the tri-state area, including those which claim the environment as their central issue and others fighting for broader social justice concerns. The name SWIM is an acronym for Storm Water Infrastructure Matters, and represents the coalition's goal of making much of the water in New York City safe enough for swimming. One of the major sources of pollution in city waterways is the result of poorly planned and inadequate sewer and stormwater systems. The coalition is working to rectify these problems by raising awareness of the issue, pressuring politicians for better legislation, and aiding in the restoration of highly-polluted waterways.

This paper will first examine the problems within the storm water infrastructure and the current state of the water in New York City. Secondly, this study will look at the many possible solutions for properly managing stormwater. These include practices already in place in the city and strategies used in other cities which have potential for application in New York City. Additionally, these plans will be critiqued for their practicality and validity in solving the problem of New York's polluted water systems.

¹ S.W.I.M. Partner List. <http://swimablenyc.info/?page_id=5> 21 April 2008.

Stormwater solutions lie at every level, from the individual to business and government. No one solution may be viable alone, but together these strategies have a real chance of succeeding at solving New York City's stormwater and water pollution crisis.

State of the Water

It can be assumed that most people know that water is absolutely essential to sustaining life. Why then do so many people treat water as though it is an infinite resource that cannot be damaged or depleted? New York City is lucky in that it has one of the best water resources just north of the city. While we may not be running out of water yet, we are dangerously close to damaging our water to a point of disrepair. Currently, the drinking water in New York City is unfiltered water that flows out of the mountains of upstate New York's Catskills. Through a series of aqueducts and reservoirs, the city is able to meet its water demand and provide clean water to city residents. This privilege, however, is getting close to being taken away. As development around the water system increases, mounting signs of strain on the water supply system are appearing. Stormwater run-off which captures toxins and debris on its way to rivers and streams is a major part of the problem. As the water quality diminishes the need for costly filtration of the cities water may quickly become a reality. The Croton Aqueduct system, the smaller of the two water systems, has already been forced to begin filtering its water.² A new filtration system estimated at \$4.57 billion to as high as \$8 billion³ has been considered for New York City's Catskill Delaware Water District. If filtration is

² Lenzer, Anna and Jarrett Murphy. "Water Pressure: Facing the Challenge of New York's Endless Sewage Spill." City Limits Investigates Summer 2007: p. 19.

³ Murphy, Jarrett. "A Passing Fad: The Watershed Wishlist." City Limits Investigates Summer 2007: p. 12.

mandated and new filtration plants built, it could subsequently raise water prices by 45 percent.⁴ It is easy to see where this story is heading if New York does not get its water situation under control. The city is growing and with growth comes added strain on aging infrastructure and an outdated water system. Unfortunately for many of New York's waterways, the damage already done has been extensive. What once were healthy ecosystems and valuable natural resources are now too dangerous for even human contact. One of the prominent icons of this tragedy is the Bronx River. The river was once an ecological oasis, but due to irresponsible use and mismanagement the river has become severely damaged. Fortunately, an increasing number of organizations are working to reverse this trend and restore the river to its former state. With a few committed organizations on its side, the Bronx River is slowly recovering. One of the main problems holding the river back from a full recovery is inadequate stormwater infrastructure. If this problem is addressed and rectified the Bronx River may finally get its chance to be a safe and valuable resource for the Bronx.

Like many older cities, New York has a combined sewer system. This means that storm water and other runoff enters into a system along with the raw sewage generated by human and industrial waste. As the city has grown, the sewage system has not. The biggest problems arise during rains when the sewer system and sewage plants are unable to handle the high volume of wastewater. When the system reaches its capacity, the excess storm water and raw sewage are dumped into waterways throughout the city. These acute points of dispersal are known as Combined Sewer Overflow (CSO) outflows and 494 in the city exist in the city. CSO's in New York dump 25 billion gallons of

⁴ Hutch, Daniel J. "Smart Growth Tools for Revitalizing Environmentally Challenged Urban Communities." *As it appears in Growing Smarter: Achieving Livable Communities, Environmental Justice, and Regional Equity*. MIT Press: Cambridge, MA, 2007. p. 350.

stormwater and 2 billion gallons of untreated sewage in the average year.⁵ These outflows are not only threatening to the ecosystems that they intrude upon, but endanger the water that New Yorkers use to boat, fish, and even swim in. The SWIM coalition has made it their mission to fix the problems of the combined sewer overflow system by focusing on education, legislation, and restoration.

The SWIM coalition has spearheaded their efforts by seeking out support from influential groups in the New York City area. This includes publicized letters to Mayor Bloomberg, the New York Times, and the New York State Department of Environmental Conservation.⁶ The coalition recently endorsed a bill for the city council which calls for sustainable design, minimizing storm water runoff on city-funded capital projects, and planting trees and vegetation on streets in a way that maximizes stormwater capture.⁷

While the SWIM coalition has publicly supported Mayor Bloomberg's PlaNYC initiative, they have also called for further action.⁸ Many critics claim that the Mayor's plan for water quality is not nearly as progressive as other parts of the plan. PlaNYC calls for few changes in stormwater infrastructure and are in some ways less progressive than the 1977 Clean Water Act. In fact, New York City has doled out millions of dollars in fines for violating the Clean Water Act and other federal and state laws.⁹ Additionally, some waterways appear to be entirely ignored by PlaNYC. In a specific proposal regarding opening up tributaries for primary or secondary contact, the entire Bronx River remains unchanged. According to the plan, even by 2030 the Bronx River will not be

⁵ Lenzer, Anna and Jarrett Murphy. "Water Pressure: Facing the Challenge of New York's Endless Sewage Spill." City Limits Investigates Summer 2007: p. 4.

⁶ SwimmableNYC. <http://swimmablenyc.info/?page_id=8> 21 April 2008.

⁷ SWIM Coalition. "Fact Sheet: Cleaner Waters Through Better Stormwater Management." 29 Oct. 2007.

⁸ SWIM Coalition "Open Letter to Mayor Michael R. Bloomberg" 7 March 2007

⁹ Lenzer, Anna and Jarrett Murphy. "Water Pressure: Facing the Challenge of New York's Endless Sewage Spill." City Limits Investigates Summer 2007: p. 19.

safe for any form of contact.¹⁰ Another of the major criticisms is that the Mayor's plan focuses too heavily on end-of-pipe regulations, rather than focusing on green infrastructure which reduces wastewater.¹¹ After the release of PlaNYC, water advocates began pushing for a more substantial management plan. Among it many accomplishments the SWIM coalition along with other groups, was able to successfully lobby the city to create a comprehensive plan that addresses the stormwater infrastructure.¹² The city is currently taking bids on this plan and local law No. 630 requires that a sustainable storm water management plan be submitted to the mayor, city council, and public by October 1, 2008.¹³

Steps to Success: Possible Solutions to Stormwater Infrastructure

The SWIM coalition and their respective members participate in rigorous educational campaigns which aim to raise awareness of the issue of storm water infrastructure. Many people may be unaware of this type of problem since they are not constantly in connection with the rivers. Another barrier to raising awareness of water pollution is that is not always obviously visible. From a distance a person may not be able to tell that a river has become severely degraded and is actually unsafe for human contact. But the pollution does exist and some New Yorker realize this every year when city wide warnings go out about the danger of swimming and fishing in some areas on

¹⁰ Mayor's Office of New York City. "PlaNYC: A Greener, Greater New York" 22 April 2007.

¹¹ SWIM Coalition "Open Letter to Mayor Michael R. Bloomberg" 7 March 2007

¹² Gaia Institute. "Councilman Gennaro and Environmental Advocates Hail Passage of Comprehensive Stormwater Management Plan" 7 February 2008.

¹³ Law: No. 630. New York City Council. Signed: 1 February 2008.

certain days. In 2006, 256 “Wet Weather Advisories” were issued at the city’s beaches.¹⁴ These advisories are meant to warn people that the water may have unsafe levels of bacteria or toxins. These advisories are the result of even small amounts of rain which is capable of overflowing the sewers and dumping hazardous water into swimming areas. Many people, though, are unaware of how storm water infrastructure works. That is why any solution must include extensive public education. Creating well-informed citizens is the first step in solving the water crisis. In their goals and strategies environmental organizations and water advocates always include educational efforts. It is important for them to make people aware that their water is not safe and that it is possible to change this fact with enough support from local communities.

The organizations working to rectify the problem of storm water infrastructure are attacking the problem from a number of angles. First there is the attempt to fix the problems with the actual sewage system, which can mean increasing the capacity and efficiency of sewage treatment plants as well as working to separate stormwater from sewage. One strategy for dealing with increased waste is building additional retention tanks for wet-weather water. The retention tanks could hold water or rather sewage until a time when sewage treatment centers could handle the water. Some cities have widely embraced this idea, including Chicago, which is currently building an underground pipeline and reservoir which will eventually be able to hold 18 billion gallons of wastewater. Critics of this solution point out, though, that retention tanks are not only costly, but they are often unwelcome additions to a neighborhood. Undoubtedly most people would not be completely comfortable having millions of gallons of untreated

¹⁴ Lenzer, Anna and Jarrett Murphy. “Water Pressure: Facing the Challenge of New York’s Endless Sewage Spill.” City Limits Investigates Summer 2007: p. 11.

sewage sitting around in their neighborhood either right below the surface or above.¹⁵

Another of the proposed plans is to separate storm drains from the sewer system. Partial separation means that stormwater would go down separate drains that would lead directly to ambient water and not flow through the sewage pipes, thus decreasing the likelihood of an overflow. These solutions, however, require massive infrastructure overhauls, which can be timely and costly. Moreover, increasing the capacity of sewage treatment plants is only putting a “band-aid” on a larger problem. SWIM and its members have instead chosen to focus more heavily on increasing green infrastructure. Green infrastructure refers to different types of ways in which stormwater can be retained, thus decreasing its flow into sewage pipes. Additionally, many advocates of water issues have criticized others’ focus on point-sources as the best place to address the problems associated with CSOs. In James Nickum’s article “After the Dam Age is Done: Social Capital Eco-partnerships in Urban Watersheds,” he is critical of clean-up efforts which as he says, “have been directed at partial, localized, point sources in a static framework rather than at watershed dynamics, the hydrological cycle, and non-point sources.”¹⁶ Nickum is suggesting that the real solution to rainwater management lies in the reduction of wastewater entering the system, rather than only improving the actual system. This strategy then requires extensive community and business efforts to try and reduce the amount of water flowing into sewage pipes.

In order to solve this water management crisis people’s perception of rain water must change. Instead of viewing rainwater as harmful and something that should be

¹⁵ Lenzer, Anna and Jarrett Murphy. “Water Pressure: Facing the Challenge of New York’s Endless Sewage Spill.” *City Limits Investigates* Summer 2007: p. 15.

¹⁶ Nickum, James E. “After the Dam Age is Done: Social Capital Eco-partnerships in Urban Watersheds” *As it appears in Cities and the Environment: New Approaches for Eco-Societies*. United Nations University Press: Tokyo, 1999. p. 142.

disposed of quickly and away from their communities, people should embrace rainwater as a valuable natural resource. If people are convinced that rainwater is beneficial to their community they may be less inclined to dispose of it so quickly or participate in activities which directly contaminate the water. On an individualist level, the SWIM coalition is educating people about the water system and showing them that what they put down their drains may end up in directly in the river. Improper disposal of garbage either within or outside of the home often makes its way to the cities open waterways.

On a community level there are numerous ways to decrease stormwater runoff. Some of these green infrastructure solutions include greenroofs, greenstreets, community gardens, and greenways, among other things. These additions all allow for increased permeable surfaces which trap water in the soil. Increased absorption of water means water does not cross over impermeable surfaces, pick up toxins, and transport those toxins to waterways. Increasing vegetation also aids in treating poor air quality by processing carbon dioxide and removing particulate matter from the air. Greenroofs have many benefits and are increasingly feasible when it comes to financing them. In urban areas, especially New York City, there tends to be large numbers of flat roofs, often on apartment buildings and schools. These types of roofs can easily be converted to greenroofs. Most standard roofs are capable of supporting an extensive greenroof which is not meant for human traffic and makes use of low-growing plants which can thrive in shallow soil. In newly developed properties and some existing buildings it is possible to install an intensive greenroof. These roofs are capable of supporting people traffic and larger plants, including trees. These types not only provide environmental benefits, but are aesthetically pleasing and provide additional open space.

Recently, greenwalls have also been embraced as another aspect of greenbuilding. They provide many of the same benefits as greenroofs and can add appeal to building designs. In order to fully develop this potential resource, however, a substantial greenroof industry must exist. Some organizations or groups are calling for a massive campaign to place greenroofs on almost every rooftop in New York City. In order for this to happen an industry must exist in order to supply the necessary components. As demand for greenroofs has increased recently there have been promising signs that this industry is expanding. More and more companies are emerging to offer greenroof services and products. Greenroofs do require a level of care that will need to be met by individual homeowners since they are not entirely self-sustaining systems. The maintenance of greenroofs and greenwalls can be justified not only by way of the environmental benefits, but also the financial benefits of greenroofs. These systems are natural insulators for the building and further protect the outer-shell from harsh weather or climate conditions. Additionally, vegetation keeps the roof at a more constant temperature, meaning there is much less expansion and contraction which can damage the roof. The virtues of greenroofs and greenwalls make them appealing solutions to the stormwater problems in many major cities.

Community gardens also provide many environmental benefits and additionally promote a sense of community among those involved in such projects. Gardens increase the amount of permeable surface area and contain vegetation which helps reduce air and water pollution. Additionally, many gardens use rain barrels which not only keep water from entering sewers, but also provide water during dry days, eliminating the need for watering hoses. Gardens can also be a valuable food source for families and a tool for

food education. School's rooftops provide a prime location for gardens and can easily be integrated into the curriculum. Just recently the Gaia Institute, also one of SWIM's sponsors, installed a greenroof garden at St. Simon Stock Elementary School in the Bronx.¹⁷ The roof makes use of the Gaia Institute's patented GaiaSoil, which is ultra-lightweight soil designed for greenroofs. Students at the school are using the roof garden to grow fruits and vegetables as part of their classwork. The garden at St. Simon Stock is a prime example of turning unused space into a valuable resource. In urban areas including the Bronx, there are many vacant lots which may be hazardous or unsightly and can be converted to community gardens. Urban gardens can also create greater awareness for environmental issues by providing a visible symbol to the community. A garden is a constant reminder of the beauty of nature and its valued place in society. Community gardens provide community members with a sense of connection to the Earth and thus a responsibility to maintain its health.

Community gardens can also be integrated into another popular form of green infrastructure, greenways. Greenways can be implemented anywhere including streets and often alongside waterways. Not only do they provide park space, but they act as natural buffers between developed properties and the water. Vegetation in these greenways can act as natural filters, removing toxins and debris that eventually end up in the water. Greenways are also an important tool for connecting greenspaces in cities. They provide recreational space, transportation alternatives, and a better ecological framework for wildlife.¹⁸ Greenways, however, require an immense amount of cooperation between communities, businesses, and government. They usually entail land

¹⁷ The Gaia Institute. "Greenroofs at St. Simon Stock" <<http://www.gaiainstituteny.org/>> 22 April 2008.

¹⁸ Erickson, Donna. MetroGreen: Connecting Open Space in North American Cities. Island Press: Washington DC, 2006.

acquisition and sometimes the relocation of businesses or buildings to successfully connect a network of parks and pathways. Greenway developers can also find themselves in competition with real-estate developers because greenways are often located on lucrative waterfront properties. Greenways in communities, however, often mean increased land value. The creation of a greenway is no easy task, and they often require a substantial amount of money at the startup and then a constant source of money for maintenance. Greenways require a coalition of supporters with considerable amount of credibility, support, and finances.

In addition to greenways a similar system of bluebelts can be used as a way to mitigate stormwater. Bluebelts are a series of conjoined wetlands which are extremely efficient at trapping rainwater during rainstorms and minimizing the impact of flooding. Additionally, wetlands are natural filters that are proficient in cleaning water. Bluebelts also provide the necessary habitat for a diverse range of species. Bluebelt systems are a very cost-efficient solution for capturing stormwater; however, not many places are appropriate for this type of system. In New York City an extensive Bluebelt system already exists in southern Staten Island. Plans have already been made to expand the Bluebelt system and increase the stormwater capacity.¹⁹

Another feasible solution to storm water management is Greenstreets. These specially designed streets replicate natural ecosystems and significantly decrease the amount of non-permeable surfaces. Trees and other vegetation can be integrated into large sidewalks and unused roadway which maximizes water absorption. While street trees have existed for quite some time, they are often planted haphazardly or in ways that

¹⁹ Department of Environmental Protection. "The Staten Island Bluebelt: A Natural Solution to Stormwater Management" <http://www.nyc.gov/html/dep/html/dep_projects/bluebelt.shtml>. 21 April 2008.

do not maximize water absorption and constrict the growth of the tree. Additionally, there are technologies currently being development that may eliminate the need for traditional asphalt or concrete. What is being called pervious concrete is a possible solution for stormwater because it allows water to drain through the concrete while providing the support needed for roadways, parking lots, and sidewalks.²⁰ Greenstreets act in a way similar to natural ecosystems. The aim of greenstreets is to return areas back to their natural state. This provides sufficient water management through the use of swales which replace traditional curbs and supply a permeable surface for water absorption.

Another potential infrastructure solution may be the use of cisterns or holding tanks for rainwater. These systems could be added on to commercial or private properties in a range of sizes. Existing downspouts can most often be easily diverted from the sewage system and into a cisterns or water-retention tanks. The cisterns could serve two purposes. Firstly, one the cistern could merely be a holding basin for stormwater which could be released after a storm had subsided and the sewage capacity returned to normal. More than this, cisterns could be used in greywater systems which reuse rainwater and lightly used water for certain functions in the home, such as toilets. Instead of using the same water that comes out of the faucets to flush the toilet, greywater makes use of a resource which is normally discarded after its first use. Systems such as these, however, do require individual homeowners take an active role in managing the system. Inspections of the systems would also need to be required to ensure proper function and maintenance. The government of New York City has also recognized the potential in developing more greywater systems and included greywater systems among

²⁰ PerviousConcrete.com <www.perviousconcrete.com> 21 April 2008.

potential solutions in PlaNYC.²¹ Greywater systems reduce storm water run-off and reduce water use which further diminishes the amount of water going through the sewer systems.

These green infrastructure implementations are extremely important in addressing sewage concerns in the long-term. Instead of expanding sewer systems which eventually become out-dated and insufficient, we must focus on ways to reduce the need for sewer systems by capturing water and waste before they enter the system. While the SWIM coalition has already achieved accomplishments worth noting, much more must be done in order to solve this water crisis.

Learning from Others: Looking to Other Nations for Solutions

The United States, unfortunately, has not been at the forefront of the green movement and green innovation. The country has been slow to mobilize and lags significantly behind other countries in its investment in alternative energy, green infrastructure, and recycling among others things. Stormwater infrastructure is no exception. But while the country may be progressing at a slower pace, it does not mean that we cannot and should not look to more progressive nations for solutions to our problems. New York City is now in a phase of pilot programs which are aimed at determining which solutions to environmental problems are the most feasible. Some of the best pilot programs to which we should be looking, however, are actually not in this country at all. Other countries, mostly in Europe have been embracing higher environmental standards for years. By examining the successes and failures of other

²¹ Mayor's Office of New York City. "PlaNYC: A Greener, Greater New York" 22 April 2007.

nations, primarily European nations, it is possible to determine which practices are applicable to US cities.

Already in some countries, governments have been addressing the issue of storm water management with success. In the German city of Saarbrücken, the government is providing grants to citizens who propose a project to conserve water and reduce storm water runoff.²² Grants can amount to up to \$5,400 US dollars and can be applied to implementing rainwater capture systems, de-sealing pavement, or installing greenroofs. Currently in New York City a similar program exists, although it only covers the cost of installing a green roof.²³

Another much more controversial program in the European countries is the use of green taxes. Green taxes entail placing penalties on toxic waste, water pollution, and emissions in hopes to encourage greater conservation by imposing the real cost of pollution on polluters.²⁴ In 1996 a study by the European Environmental Agency found that these taxes were generally well received and considered a success.²⁵ Implementing environmental taxes in America is sure to be a very contentious issue, especially since green taxes would likely place a higher burden on businesses rather than the individual. A drastic change such as that would be extremely difficult in a system which is beholden to business interests.

If a situation becomes drastic enough and public interest becomes stagnant, mandating strict water-use rules may need to be implemented as a strategy. This may

²² Beatley, Timothy. Green Urbanism: Learning from European Countries. Washington D.C.: Island Press, 2000. p. 216.

²³ Bill Summary - A10234 New York State Assembly. <<http://assembly.state.ny.us/leg/?bn=A10234>>.

²⁴ Beatley. p. 252

²⁵ European Environment Agency. "Environmental Taxes: Implementation and Environmental Effectiveness. Copenhagen: 1996. *As it appeared in* Beatley. p. 252.

need to be the case in New York City. In an article by Klaus W. König, “Rainwater in Cities: A Note on Ecology and Practice,” he writes that it may be necessary to impose regulations on developments to install rainwater capture systems.²⁶ If incentives are not successful, at times strict policies are needed. König suggestion was aimed at large developments, but it would be possible to apply this strategy to smaller projects. One problem that might arise if this plan were implemented in New York City, is that in areas like Bronx, there is not as many new buildings being built. In the case of the Bronx it would be more necessary to integrate stormwater systems into existing buildings. König also refers to Germany’s practice of a charging two separate water fees. One bill would be for soiled wastewater and the other for rainwater.²⁷ This approach would require a system which could measure rainwater coming off buildings and impermeable surfaces which would eventually enter into the sewer system. By charging a fee on rainwater the hope is that it will encourage people to be more responsible when managing their stormwater.

A few different options are also being explored on ‘the other end of the pipe.’ If overflows continue to occur, there needs to be systems in place to treat water once it has reached the larger body of water. One of the more popular suggestions recently is the use of mussel beds near CSOs. Mussels naturally filter water and are a native species to New York City waterways. Included in PlaNYC is a proposal for a pilot program in Jamaica Bay which calls for the use of ribbed mussel beds in areas of high pollution, particularly near CSO outflows.

²⁶ König, Klaus W. “Rainwater in Cities: A Note on Ecology and Practice.” P. 208. *As is appears in – Cities and the Environment: New Approached for Eco-Societies*. United Nations University Press: Tokyo, 1999.

²⁷ König. p.208.

Addressing storm water management is something that needs to be done on many levels. Even though water management might not be as recognized as it should be, it has a major impact on communities and human health. In order to bring more attention to this issue we must give water management a greater presence in communities. Instead of hiding water, it must be showcased and thus understood. An interesting project that has just been completed is a nature walk in the Newtown Creek Wastewater Treatment Plant. The treatment plant is the largest in the city and has a capacity of 310 million gallons per day.²⁸ In 2007 the DEP, with help from a local grassroots organization, the Newtown Creek Monitoring Committee, unveiled a nature walk at the wastewater treatment plant in Greenpoint, Brooklyn.²⁹ The Nature Walk is open to the public and showcases the Treatment plant through a series of walkways and art works. The art included at the site pays tribute to the Creek's past and water-history in New York. The nature walk is a remarkable integration of industry and public space. The project breaks down the stereotype that wastewater should be separate from the public sphere because it is somehow unsightly or 'dirty'. Plans exist for further development of the walkway which will include a bridge over the creek and another entry point to the park.³⁰ Public art acts as a symbol which reminds people that their water systems are important, complex, and worth caring about. In other words, public art can work with public education to inform citizens about the dangers of poor water management.

When approaching the issue of storm water management, it is important to involve all aspects of society. The individual must do their part, the government, and

²⁸ Department of Environmental Protection. "New York City's Wastewater Treatment System." 2008.

²⁹ Department of Environmental Protection. "DEP Opens Waterfront Nature Walk at Newtown Creek Wastewater Treatment Plant." 29 September 2007.

³⁰ Department of Environmental Protection. "The Newtown Creek Nature Walk."
<http://www.nyc.gov/html/dep/pdf/newtown_creek_nature_walk_flyer.pdf>. 23 April 2008.

certainly the business. Not only should each sector be involved in the process of managing stormwater, but there needs to be a medium in place that brings all three together for a public discourse. An example of a successful coalition such as this is the Kwinana Communities-Industries Forum in Western Australia. The partnership was formed as a way for business, communities and government to work together to achieve a common goal, and the forum has been responsible for many positive outcomes.³¹ Using the forum as a platform for collaboration, hundreds of businesses developed linkages between companies for shared waste. In other words, the waste from one industry could be transferred for use in another industry, thus decreasing overall waste. The forum also developed an air quality monitoring system, a training program for local youths, and reductions in wastewater entering marine ecosystems.³² In New York some steps have been made in order to create a similar coalition, however, they have not yet reached the breadth of the Kwinana Communities-Industries Forum. PlaNYC does call for a special inter-agency task force.³³ The task force would monitor pilot programs and make suggestions about the best possible solutions for stormwater infrastructure. While this inter-agency task force is a good start it is no where near as encompassing as is required. In addition to agency involvement there needs to be community groups, non-profits, and importantly businesses, involved in planning. These coalitions are about getting everyone on the same page as to what is going on and then combining resources to come up with the best possible solutions.

³¹ Newman, Peter and Isabella Jennings. Cities as Sustainable Ecosystems: Principles and Practices. Island Press: Washington DC, 2008. p. 175

³² Newman. p.175.

³³ Mayor's Office of New York City. "PlaNYC: A Greener, Greater New York" 22 April 2007.

In any stormwater management plan, it is important to continue to research and better understand the problem and possible solutions. Solving environmental problems is a tricky issue. Technological solutions that appear to be panaceas may in the end turn out to be equally detrimental to another part of the ecological system. For this reason it is important that any plan not rely solely on one solution. Rather the strategy for solving stormwater infrastructure problems must remain diverse to ensure continued sustainability.

Conclusions

The intent of this essay is not to choose which solution is best, but rather that each solution has valid points and make the most appropriate form of action in some communities while not in others. Not only is New York City diverse in its population, but it is diverse in its geography and infrastructure. Mussel beds might work in Jamaica Bay, but they may not work in the Bronx River. Greenroofs might be appropriate in neighborhoods where flat-roofs prevail, but in some residential neighborhoods where the majority of homes have sloped roofs, greenroofs might not be the best option. For reasons such as these it is important to get as many people involved from as many neighborhoods as possible. The solution to stormwater management is going to have to come from many places. These problems require imagination, ingenuity, and a real understanding of specific neighborhoods. Grassroots organizations neighborhood groups play a pivotal role in the supply of information and support to causes such as this one. Each sector of this city; the businesses, the communities, and the government need to work from their end in order to successfully save the city's waterways. As with most

problems, the first step is education and changing attitudes toward water. Water needs to be viewed as a sacred resource that must be protected as well as enjoyed. Stormwater is not a nuisance to be disposed of, but rather a resource to be valued. Once everyone realizes this fact a real solution to this crisis will prevail.

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