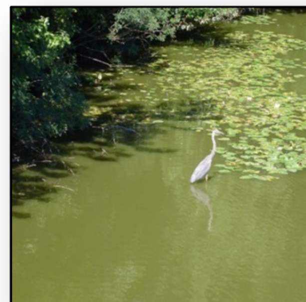
The Deal Lake
2010 319(h) Implementation Project
Final Report
Grant # RP10-088

Grantee and Lead Planning Agency:



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Executive Summary

Deal Lake is the largest of the State's Coastal Lakes. With a history extending back into the 1800s, Deal Lake has provided a variety of recreational opportunities to the surrounding community. Although the lake continues to be a community focal point, its water quality and ecology have been severely degraded over time as extensively documented in numerous reports prepared over the years by the Deal Lake Commission (DLC). The most extensive and recent assessment of the lake and its watershed is provided in the 2011 Deal Lake Watershed Protection Plan (DLC 2011). The Characterization and Assessment section of the Watershed Protection Plan (WPP) clearly documented that the majority of the lake's past and continuing problems are directly linked to the inadequate management of the stormwater discharged from the surrounding watershed into the lake and its tributaries. This is a common theme for all of New Jersey's coastal lakes. Historically, little effort has been taken to manage the volume, rate and especially the quality of stormwater runoff prior to its release into the lake or its tributaries. The DLC has repeatedly documented that the existing stormwater infrastructure system uses the lake as a regional stormwater management "basin" for the surrounding communities. The data and information compiled in the Characterization and Assessment section of the WPP clearly showed that any meaningful improvement in the water quality of Deal Lake and its tributaries will not be possible unless a series of measures are put in place to address the lack of proper stormwater management. As such, the WPP laid out a plan to address the lake's various water quality and environmental problems, as summarized below:

1. Implement local and regional stormwater management solutions that correct, upgrade, replace and/or retrofit the existing stormwater management infrastructure;
2. Stabilize the lake's eroding stream channels and where possible reconnect the streams to their floodplains;
3. Control of the influx of floatables;
4. For all new development as well as redevelopment projects proposed throughout the watershed, require municipalities to implement better stormwater management planning and design, emphasizing stormwater recharge to help moderate base flows, decrease storm surges and flooding, and lessen the opportunity for streambed and bank scouring;
5. Implement much needed dredging projects to reclaim the sediment-infilled areas of the lake and develop a long-term management plan to ensure that the factors responsible for sediment-infilling are corrected and that the reclaimed areas can be easily and effectively maintained over time;
6. Decrease the occurrence of invasive plant species within the lake and within the riparian areas of the lake and its tributaries;
7. Decrease the frequency and magnitude of algae blooms;
8. Improve the lake's fishery and use this as a major means of improving the lake's overall use; and
9. Decrease fecal coliform loading through better stormwater management and the correction of any remaining sanitary cross-connections and combined sewer overflows.

Shortly following the finalization of the WPP, the DLC applied for funding through the New Jersey Department of Environmental Protection (NJDEP) for a 319(h) Implementation Grant. The direct purpose of the grant was to conduct specific stormwater projects identified in the WPP with the goal of better managing stormwater inputs to the lake. The DLC sought to implement measures that reduced the rate, volume and pollutant load conveyed by runoff entering the lake and its tributaries. This report details the design, construction, and effectiveness of the three (3) projects conducted by the DLC using the funds provided by the NJDEP through Grant # RP10-088.

The first of the three projects involved the installation of a manufactured treatment device (MTD) to treat runoff generated from a highly urbanized subwatershed located on the southern shoreline of the lake, in the City of Asbury Park. The MTD was installed at the base of Comstock Avenue adjacent to the Asbury Park High School. The MTD was designed and its installation supervised by L.S. Avakian, Inc., the consulting engineer of the DLC. The overall objective of this project was to reduce sediment, particulate pollutant, *E. coli* and floatable loading to the lake. The selected Comstock Avenue outfall had been documented in past by the DLC as a major source of floatable loading to the lake.

The second project involved the restoration of riparian buffers and the creation of three bio-infiltration stormwater management basins at the Colonial Terrace Golf Course, a municipally owned and operated facility located on the north shore of the lake in Ocean Township. The golf course has had a long history of Canada goose related problems that has contributed to the measurement of elevated nutrient and *E. coli* loading to the lake. This was confirmed through the sampling of runoff emanating from this site which was conducted during the preparation of the WPP and as part of work conducted as part of this project.

The third project arose as a result of the Comstock Avenue and Colonial Terrace projects being completed ahead of schedule and under-budget. With the remaining funding, the DLC was able to repair and replant approximately 400' linear feet of eroded and sloughing shoreline located immediately adjacent to the lake's primary boat launch in Asbury Park.

The report that follows provides details of each of the three projects. This includes the presentation and discussion of data documenting the water quality benefits of the Comstock Avenue MTD and the Colonial Terrace bio-infiltration basins. Although each of the three projects implemented as part of Grant # RP10-088 is relatively small in scope, each is consistent with the types of restoration activities emphasized in the WPP. Additionally, each can be easily replicated elsewhere in the watershed thus providing the DLC with definitive proof that meaningful stormwater management and pollutant loading can be accomplished in a highly urbanized watershed without the use of large, conventional stormwater management basins.

1.0 Introduction

1.1 Overview of Deal Lake and the Deal Lake Watershed

With a total surface area of approximately 155 acres and a watershed encompassing 4,400 acres, Deal Lake is New Jersey's largest coastal lake. The lake is located within NJDEP's Watershed Management Area (WMA) 12. Once an estuary with free flow to the Atlantic Ocean, the lake was created in the 1800s when an earthen embankment and integral flume structure were constructed at the confluence of the estuary and the Atlantic Ocean (Robinson, 1997). Deal Lake has had various names each reflective of its history; Lake Uliquecks, Whites Pond, Drummonds Pond, Corlies Pond, Great Pond and Boyleston Great Pond (Robinson, 1997).

A unique attribute of Deal Lake is its sprawling, dendritic form. There are five primary arms of the lake that extend westward from the main lake basin (Map A, Appendix A). Seven municipalities border the lake: the City of Asbury Park, the Village of Loch Arbour, the Boroughs of Allenhurst, Deal and Interlaken and the Townships of Neptune and Ocean. Over the years road crossings created distinct sub-impounded sections of the lake that although connected to the lake are separated from the main body by weirs and low head dams. The most notable of these are the Hollow Brook and Colonial Terrace Arms, Lollipop Pond (also referred to the Ditmar Arm) and Fireman's Pond.

Seven major tributaries feed into Deal Lake from the western reaches of the lake's 4,400 acre watershed. From south to north, these are Hollow Brook, Seaview Brook, four unnamed streams and Harvey Brook (once known as Hog Swamp Brook). The two largest tributaries are Hollow Brook and Harvey Brook, both of which extend from the lake farther west than any of the other tributaries (Map A, Appendix A). As part of a 314 Clean Lakes Diagnostic Feasibility Study conducted in 1984, details were prepared of the lake's hydrology (Princeton Aqua Science, 1984). As per the results of that study, total inflow to the lake from these streams was calculated to be 8,080,000 cubic meters (2.14 billion gallons) annually, with an additional 1,920,000 cubic meters (507,210,338 gallons) entering the lake from stormwater runoff (via both overland flow and the local storm sewer system) for a total annual inflow of 10 million cubic meters or 2.64 billion gallons. The total volume of the lake's main basin was calculated at 928,000 cubic meters (245,151,664 gallons) (Princeton Aqua Science, 1984). As based on these data the lake's annualized flushing rate is approximately 33 days. This means that on average if the lake was completely emptied it would take only 33 days to refill. This is a very short flushing rate. It should be noted that the lake's flushing is complicated by ocean tidal cycles. During high tides ocean water enters the lake via the flume that regulates the lake's outflow. Additional details of the flume are provided below.

As previously noted the lake was created by erecting an embankment and installing a flume structure at the eastern end. The flume permits outflow from the lake through a sluice gate while, for the most part, limiting inflow from the Atlantic Ocean into the lake. The sluice gate can be opened and closed manually to allow for the lake's drawdown, for example, to facilitate dredging or cleanup activities and to release water during storm events. However, the flume is not a flood control device. Owing to the relative topographic elevation of the lake and the ocean, during periods of high-tides the flume cannot prevent ocean water from entering the lake. Such tidal surges limit the rate at which water can be discharged from the lake. As a result, this negates the ability of the flume to function as a flood control structure. In addition, the flume also provides a conduit for migrating blueback herring (a food source for bass), which return to the lake from the ocean to spawn each year (Jaroszewski, n.d.).

Throughout its history, Deal Lake has been heavily utilized for recreational activities, especially boating and fishing. Rowers continue to make extensive use of the southern portions of the lake throughout the Sunset Landing reach and from the mouth of Harvey Brook to the main body. Power boats, jet skis and an occasional water skier use the easternmost main body of the lake. Fishing is popular throughout the lake, both from the shore and from boats. The lake is the site of bass fishing tournaments and is routinely stocked by the NJDEP. The most recent stocking of game fish and forage fish was conducted by NJDEP Fish and Wildlife during the summer of 2013.

Deal Lake's watershed is highly urbanized. The majority of the developed lands can be best characterized as high- and medium-density residential development, mixed business and commercial land uses, and light industrial use. Development of the lake's immediate watershed can be traced back to the late 1800s. Over the years, increasing development was accompanied by an increase in the amount of pollutants entering the lake. Early on, these included wastewater and sewage discharged to the lake via combined sewer overflows (CSOs). With improvements and modernization of the watershed's sewage system and the elimination of CSOs, the primary source of non-point source (NPS) pollutant loading became stormwater runoff (Map B, Appendix A).

Studies conducted under the direction of the DLC over the past 30 years clearly document that Deal Lake's water quality is impacted by a variety of NPS pollutants. The majority of these pollutants now enter the lake as a result of inadequately managed stormwater runoff. NPS pollutant loading has taken a toll on the water quality and ecology of the lake. As early as the 1950s reports document the common symptoms of accelerated eutrophication; algal blooms, dense aquatic weed growth, high bacterial concentrations and fish kills (Princeton Aqua Science, 1984). These conditions persist to the current day even despite the implementation of a variety of restoration strategies by the DLC and member municipalities. The reoccurring conclusion of past lake studies is the need for a concerted reduction in NPS loading achieved through better stormwater management.

1.2 Deal Lake Commission and Its Project History

The Deal Lake Commission (DLC) was chartered in 1974 by the seven municipalities that abut Deal Lake. The DLC's mission is to provide leadership, guidance and resources to preserve and restore Deal Lake and its tributaries as a healthy and stable ecosystem. As per the DLC's Mission Statement, the DLC's goals include:

- Educating the community, including our school children, to increase awareness and appreciation for the natural environment of the lake
- Providing leadership concerning issues related to Deal Lake within and outside our community
- Helping homeowners and public groups recognize and mindfully solve problems related to water quality, siltation, and lake restoration
- Serving as the liaison between lakeside communities, County agencies, and the NJDEP to implement a Regional Storm Water Management Plan
- Proactively suggesting practical ideas to improve overall the environmental quality of properties throughout the Deal Lake watershed

The DLC has long-recognized that the implementation of watershed-based stormwater management is central to the improvement of the lake's water quality. In 2004, the DLC was awarded a grant through the New Jersey Department of Environmental Protection's (NJDEP's) 319(h) Nonpoint Source (NPS) Pollution Control and Management program. The purpose of the grant was to develop a Regional Stormwater Management Plan (RSWMP) for the Deal Lake watershed, the objective of which was to:

- Effectively reduce the influx of stormwater-based nutrient and other pollutant loading to Deal Lake,
- Control the erosion of the lake's tributary streams,
- Reduce the sedimentation and infilling of the lake and its tributaries, and
- Control the influx of floatables and urban debris entering the lake with stormwater.

As a result of recent changes pertaining to the State's position on RSWMPs, the DLC was directed by the NJDEP in October 2010 to convert the RSWMP into a WPP. The resulting conversion of the RSWMP into a WPP did not alter the technical approach to the restoration and management of the lake nor the focus placed on watershed-based stormwater management. The intent of the WPP remained the same as that of the RSWMP: protect the lake from future watershed based water quality impairments and to correct the lake's existing problems through the implementation of measures aimed at decreasing pollutant and pathogen loading and slowing down the lake's eutrophication. However, converting the RSWMP into a WPP made the implementation of the recommended measures and specified projects voluntary efforts. As a result, all watershed initiatives, changes in regulations and ordinances and stormwater management projects would be conducted by the DLC and the municipalities as funding became available. The three projects that are the subject of this report were conducted as part of a NJDEP 319(h) grant (#RP10-088) and represent the first three projects implemented in accordance with the WPP guidance.

1.3 Regulatory Programs Supporting the #RP10-088 Implementation Projects

There are a number of relevant regulations in place today that support the projects implemented as part of this grant and future projects conducted in accordance with the NJDEP approved WPP. The most significant of those are the State's stormwater management regulations (N.J.A.C. 7:8 and N.J.A.C. 7:15). Each municipality within the Deal Lake watershed complies with the NJDEP stormwater regulations for new development (N.J.A.C. 7:8) and has prepared individual Municipal Stormwater Management Plans and Ordinances as per N.J.A.C. 7:15. Other supporting regulatory programs that protect and enhance the water quality, wetland resources and riparian buffers of Deal Lake and its tributaries are the Freshwater Wetland rules (N.J.A.C. 7:7A), the State's Surface Water Quality Standards (N.J.A.C. 7:9B), and the Flood Hazard Area regulations (N.J.A.C. 7:13). These regulations were incorporated as appropriate within the Deal Lake WPP as a means of providing the legal authorization and framework within which water resources projects are conducted on a uniform basis from town to town. For example, the Flood Hazard Area Rules establish a minimum 50 foot riparian zone for all freshwater streams. However, the width of the riparian zone is increased to 150 feet for streams with underlying acid producing soils. Such soils are common throughout Monmouth County and within the Deal Lake watershed. These regulations, which largely govern NJDEP protected lands, serve as a backbone for the WPP's stormwater projects and related land use measures conducted in wetlands, floodplains and riparian areas. Compliance however with the water quality standards, stormwater rules and municipal water quality management plans also provide a framework for stormwater projects and related land use measures conducted in upland areas.

Each municipality within the WPP study area has been actively involved in updating their Master Plans, ordinances and zoning amendments. Additionally some have pursued opportunities to preserve open space. Each has also been has engaged in the State-wide planning efforts of the NJ Department of Community Affairs (DCA). These actions are reflected in the WPP recommendations and represent a mechanism by which to prevent the further degradation of Deal Lake and its tributaries.

As such, in accordance with the WPP's comprehensive blueprint for the restoration of Deal Lake and its tributaries, and the WPP's emphasis on stormwater management, the projects conducted as part of Grant #RP10-088 represent the first step of many needed to properly restore, protect and enhance the water, wetland and riparian resources of Deal Lake and its watershed. The DLC recognizes that the three projects that are the subject of this report are a small sub-set of the work needed to restore Deal Lake. Nonetheless, these projects are the starting point for a series of projects that should be funded going forward by the NJDEP through such programs as 319(h).

2.0 NJDEP Water Resource Designations For Deal Lake and the Deal Lake Tributaries

Deal Lake is located in WMA 12, (HUC 02030104090030). The water quality of Deal Lake has been monitored since the early 1980s and has been the focus of a number of water quality monitoring programs conducted under the guidance of the DLC with assistance from both the NJDEP and Monmouth County Health Department. The data from the original Deal Lake 314 Study (Princeton Aqua Science, 1984) were utilized by the State as the basis for the preparation of the phosphorus and pathogen Total Maximum Daily Load (TMDL) developed for lake and Hollow Brook. The more recent monitoring of the lake and its tributaries conducted as part of the WPP's Characterization and Assessment study revealed, as did the earlier studies, elevated levels of several NPS pollutants, including: phosphorus, nitrogen, sediment, fecal coliform bacteria and floatables. These pollutants originate from many diverse sources and are transported into the lake and its streams largely as the result of stormwater runoff. There are more than 135 storm sewer outfalls that discharge directly to the lake (Monmouth County Board of Health, 1989). Many of these outfalls were re-inspected and mapped as part of a more recent project conducted by Monmouth University (Monmouth University, 2007).

As per Appendix A of the 2008 *New Jersey Integrated Water Quality Monitoring and Assessment Report*, Deal Lake (WMA-12, HUC 02030104090030-01) appears on Sublist 5 for Aquatic Life-General, Sublist 4A for Recreation, Sublist 2 for Drinking Water Supply, and Agricultural Water Supply, Sublist 5 for Industrial Water Supply, and Sublist 3 for Fish Consumption. As per Appendix B of the same document, NJDEP also gives the lake a rank of L for pH. Also as per Appendix C of the 2008 *New Jersey Integrated Water Quality Monitoring and Assessment Report,* the lake has been delisted from Sublist 5 for pathogens. As noted above it is now on Sublist 4A. This is summarized in Table 1. It should also be noted that although Hollow Brook was listed in the *Integrated Water Quality Monitoring and Assessment Report* published in 2004 and 2006*,* it is not included in the 2008 report.

The NJDEP approved a TMDL for the reduction of total phosphorus in Deal Lake (NJDEP, 2003a, 2004). The phosphorus impairment of Deal Lake is almost exclusively attributed to nonpoint stormwater sources and the TMDL identifies a need for a 79% reduction. The lake is considered highly eutrophic, and is impacted quite frequently by intense blue-green algae blooms and excessive densities of invasive aquatic macrophytes. It is often very turbid, as a result of the influx of large amounts of sediments. These sediments not only originate as particulate material transported into the lake via runoff, but as the result of the scour and erosion of the beds and banks of the lake's feeder streams. Contact recreational use of the lake is impeded by fecal coliform (*E. coli*) levels that frequently exceeded the State's water quality standard. Further impacting the lake are large volumes of floatables, most of which again enter the lake via runoff. These floatables are transported from the roads and urban landscape immediately adjacent to the lake. The data developed through the Characterization and Assessment element of the WPP further quantified and confirmed that NPS pollutant loads are the primary cause of the lake's documented impairments.

With respect to the lake's tributaries, the NJDEP approved a TMDL to address the reduction of pathogens in Hollow Brook (NJDEP, 2003b). The reduction of total phosphorus loading was another recommendation contained in the Hollow Brook TMDL. With regard to pathogen loading (fecal coliform), the data used to develop the Hollow Brook TMDL confirmed the State's water quality standard for contact recreation was frequently contravened. More recent Microbial Source Tracking data (MST) developed by Monmouth University (2007) showed pathogen sources to be variable and linked to goose, pet, and even human sources. Further sampling of the tributary streams conducted as part of the WPP and detailed in the WPP Characterization and Assessment Report, further documented especially high pathogen concentrations in Hollow Brook.

Table 1 - Existing Stream Impairments in the Deal Lake Watershed, as per the 2008 *New Jersey Integrated Water Quality Monitoring and Assessment Report*.

Waterbody	Sublist 5 (impaired)	Sublist 2	Sublist 4A	Sublist 4 (TMDL)	Sublist 3 (insufficient data)
Deal Lake	Industrial Water Supply	Drinking, Agricultural Water Supply	Recreation	Phosphorus	Fish Consumption
Hollow Brook	no listing/assessment				
Harvey Brook					
Unnamed tributary streams	no listing/assessment				

The purpose of the Deal Lake WPP was to develop a "blue-print" of how to effectively reduce the influx of NPS pollutants to Deal Lake. The WPP integrates various watershed management practices. These include both regulatory related measures (ordinances, more effective and consistent application of existing rules) and restoration/mitigation projects (efforts aimed at controlling and reducing documented NPS inputs and stormwater related problems). Emphasis was placed in the WPP on the reduction of pathogen loading, the control of sedimentation and erosion in the lake's tributary streams, the reduction of floatable and other particulate stormwater-related pollutant loading, and the reduction of phosphorus loading. While the WPP stressed the need for regional stormwater management, through Grant #RP10-088 the DLC had the opportunity to demonstrate that stormwater management can also be accomplished on a more localized level and need not rely only on regional solutions. The Comstock Avenue MTD installation can be replicated anywhere in the watershed. The MTD is installed below ground and without any significant modification of the existing stormwater collection or discharge infrastructure. As such it represents one of many retrofit projects that could be implemented anywhere throughout the watershed.

The Colonial Terrace Golf Course basins and swale conversely required the construction of a surface feature to collect, infiltrate and treat runoff. While the construction of such basins or swales may not be practical in the more ultra-urbanized areas of the watershed, there are new developments being planned where such BMPs could realistically be implemented. Furthermore, there are a number of under-performing detention basins located throughout the watershed that could be retrofitted or modified to function similar to the Colonial Terrace Golf Course basins and swale. If modified, these existing basins would provide a higher degree of pollutant removal and, if re-designed to promote recharge, actually decrease the volume of runoff discharged to the lake or its tributaries during every storm event.

Finally, although the bank restoration work conducted at both the Colonial Terrace Golf Course and at the Asbury Park boat launch benefitted only a small amount of the lake's shoreline, these projects represent the types of bioengineered solutions that could be implemented in many other areas of the lake or along the eroded stream channels of the lake's tributaries.

Again, as noted at the close of Section 1, the three projects completed through Grant #RP10-088 represent the beginning of a series of projects that should be funded going forward by the NJDEP.

3.0 Description of The Deal Lake Watershed

3.1 Introduction

The Deal Lake watershed encompasses all or part of seven municipalities: Ocean Township, Neptune Township, Asbury Park City, Interlaken Borough, Deal Borough, Allenhurst Borough and Loch Arbour Village. Table 2 provides the breakdown of the Deal Lake Watershed area by municipality. Approximately 55% of the watershed (2,419 acres) lies within Ocean Township. Smaller but significant portions of the watershed are associated with Neptune Township (755) and Asbury Park (580 acres).

Table 2 - Municipal Areas within the Deal Lake Watershed.

Municipality	Acres within the Deal Lake Watershed	Square miles within the Deal Lake Watershed	Percentage of total watershed area
Ocean Township	2,419.44	3.78	54.91
Neptune Township	754.87	1.18	17.13
Asbury Park City	579.74	0.91	13.16
Interlaken Borough	247.27	0.39	5.61
Deal Borough	193.94	0.30	4.40
Allenhurst Borough	138.14	0.22	3.14
Loch Arbour Village	72.76	0.11	1.65
TOTAL WATERSHED	**4,406.16**	**6.88**	**100%**

The densely populated, urbanized nature of the watershed and proximity of large-scale development to the lake and its tributaries are directly responsible for a number of impacts. These include elevated bacteria and nutrient levels, eroded stream channels, flooding, and large quantities of floatable inputs to the lake and its streams. Simply put, with more development has come more stormwater runoff. The improper or insufficient management of this runoff has led to a host of environmental impacts and has accelerated the eutrophication of the lake.

3.2 Land Use Attributes of the Deal Lake Watershed

As part of the WPP an update of the land use and land cover (LU/LC) attributes was conducted for the entire Deal Lake watershed using GIS based mapping technology. The watershed breakdown of land use is provided in Table 3.

Table 3 - General Land Use/Land Cover Categories in the Deal Lake Watershed.[1]		
LU/LC Category	**Acres**	**Percentage of Total Watershed Area**
High/Medium Density Residential	1,843.78	41.85%
Commercial	493.96	11.21%
Forest	483.65	10.98%
Wetlands	374.15	8.49%
Low Density/ Rural Residential	355.01	8.06%
Recreational Land	286.77	6.51%
Water/Lakes	175.98	3.99%
Other Urban/Built-up Area	153.33	3.48%
Industrial	105.75	2.40%
Transportation	84.69	1.92%
Barren/Transitional	32.09	0.73%
Agricultural	14.30	0.32%
Beaches	2.70	0.06%
TOTAL WATERSHED AREA	**4,406.16**	**100%**

As per the data contained in Table 3 high- and medium-density residential development are the dominant land uses in the Deal Lake watershed, covering approximately 1,844 acres or 42% of the total watershed area. The majority of this residential development (948 acres) lies within Ocean Township. Both commercial development and forested lands also comprise significant portions of the Deal Lake watershed, at 494 acres (11.21%) and 484 acres (11%), respectively. Most of the forested lands are concentrated in the western portion of the watershed, particularly the southwest

[1] General LU/LC categories are based on Anderson et al. 1976. Discrepancies in totals are due to rounding.

area in Neptune Township around State Route 18. Commercial development is found throughout the watershed, with the highest intensities concentrated along State Routes 35 and 66.

Approximately 374 acres of wetlands (8.5%) exist within the Deal Lake watershed. These wetlands are largely clustered around the lake's tributary streams, with the largest areas found in close proximity to the remaining forested lands located in the western portion of the watershed. Two other land use types each make up more than 5% of the total watershed area. These are low density/rural residential development (355 acres) and recreational land (287 acres). In addition to parks, recreational lands include golf courses, which are an important land use and recreational amenity in the watershed, particularly in Ocean Township and Deal Borough.

3.3 Pollutant Loading Attributable to Stormwater Runoff

Overall, stormwater management throughout the watershed can be characterized as largely inadequate. The more recently developed (post-2004) portions of the watershed have benefited from improved stormwater management infrastructure, including stormwater management basins and related BMPs. In addition, the member municipalities through their stormwater management plans and related ordinances have been reducing NPS loading from existing sources. This is being accomplished via street sweeping, the installation of eco-grates, the passage and enforcement of pet waste and yard waste ordinances, and for new developed sites mandated stormwater management techniques that promote stormwater recharge and better total suspended solids and nutrient removal. However, due to the age and history of most of the development within the Deal Lake watershed, especially the development immediately adjacent to the lake and east of Route 18, stormwater management and NPS control BMPs tend to be lacking or severely under designed. Specifically, there is an overall lack of BMPs that facilitate:

1. The mitigation of storm surges and the control of peak flows (contributing to flooding and stream erosion problems),
2. The compensatory recharge or infiltration of precipitation and runoff (contributing to the increased volume of runoff, the magnitude of peak flows and alterations in baseflow conditions), and
3. The proper management and reduction of pollutant loading (contributing to problems with the accumulation of floatables in the lake, the deposition of sediments and the influx of nutrient-laden runoff responsible for the lake's eutrophication.

There has also been a non-reversible loss of riparian areas, encroachment into floodplains, and historic filling, draining or piping of wetlands and open waters. Some of this riparian loss is attributable to the construction of lengthy bulkheads and filling of the lake's shoreline, but some of this extends up into the tributaries. The loss of these natural areas and their stormwater mitigation properties again exacerbates the lake's stormwater-related impacts. Impaired riparian areas also detract from the ecological characteristics of the lake and its tributaries, and have resulted in a loss of the ecological services and of essential habitat for aquatic and semi-aquatic birds and other species, and the spread of non-native, invasive emergent vegetation.

The lake itself has also been subject to the establishment of invasive aquatic macrophytes (aquatic weeds). Plants such as Eurasian watermilfoil (*Myriophyllum spicatum*) and coontail (*Ceratophyllum demersum*) compromise habitat needed for the maintenance of a healthy, ecologically balanced fishery. The composition and density of these weeds has negatively altered the quality of refuge and spawning areas for game fish and anadromous fish. The "weed" growth often reaches proportions that inhibit flow and circulation and exacerbates DO depression, especially in the upper reaches and arms of the lake. These invasive plants also reduce the recreational use of the lake, specifically with respect to boating, which tends to be a very popular use.

The volume and frequency of floatable loadings creates a significant problem for Deal Lake. The future control of floatables must be considered a priority management issue, equally important as the control and reduction of nutrient, sediment and fecal coliform loading. The influx of large amounts of floatables and other urban litter and debris creates a number of serious problems with water quality, flooding and ecological ramifications, including:

1. These floatables impact the lake's aesthetic properties by resulting in the accumulation of large amounts of trash in windward areas of the lakes and small coves.
2. The accumulated trash also impedes flow and at times blocks the outlet flume, thus adding to flooding problems throughout the lake.
3. The floatables become so concentrated at times so as to impact riparian habitat in certain areas.
4. The floatables add to the lake's inorganic pollutant loading.
5. The removal of the floatables is difficult and costly.

Details of the pollutant loading analysis and the subsequent interpretation of that data were presented in the WPP. The pollutant load modeling results are presented in Tables 4, 5 and 6 for the three pollutants of concern: Total Phosphorus (TP), Total Nitrogen (TN) and Total Suspended Solids (TSS). Table 7 presents the TP pollutant loading information (the NPS pollutant of greatest importance with respect to the lake's eutrophication), but with the results broken down for each municipality.

Table 4 - TP Loading by Subwatershed				
Subwatershed	**Total Acreage**	**% of total watershed area**	**TP Load (lbs /year)**	**% TP load**
1-Main Lake Basin	2,224.13	**50.47%**	472.36	**47.28%**
2-Harvey Brook	971.53	**22.05%**	203.78	**20.40%**
3-Lollypop Pond	204.14	**4.63%**	58.34	**5.84%**
4-Colonial Terrace	149.82	**3.41%**	53.01	**5.31%**
5-Tributary	464.88	**10.55%**	139.46	**13.96%**
6-Hollow Brook	391.66	**8.89%**	72.03	**7.21%**
TOTAL WATERSHED	**4,406.16**	**100.00%**	**998.98**	**100.00%**

Table 5 - TN Loading by Subwatershed				
Subwatershed	**Total Acreage**	**% of watershed**	**Load (lbs /year)**	**% TN load**
1-Main Lake Basin	2,224.13	**50.47%**	4,572.78	**49.29%**
2-Harvey Brook	971.53	**22.05%**	2,033.55	**21.92%**
3-Lollypop Pond	204.14	**4.63%**	479.76	**5.17%**
4-Colonial Terrace	149.82	**3.41%**	398.54	**4.29%**
5-Tributary	464.88	**10.55%**	1,080.12	**11.64%**
6-Hollow Brook	391.66	**8.89%**	713.37	**7.69%**
TOTAL WATERSHED	**4,406.16**	**100.00%**	**9,278.12**	**100.00%**

Table 6 - TSS Loading by Subwatershed				
Subwatershed	**Total Acreage**	**% of total watershed area**	**TSS Load (lbs /year)**	**% TSS load**
1-Main Lake Basin	2,224.13	**50.47%**	642,547.92	**47.04%**
2-Harvey Brook	971.53	**22.05%**	343,361.98	**25.14%**
3-Lollypop Pond	204.14	**4.63%**	62,183.55	**4.55%**
4-Colonial Terrace	149.82	**3.41%**	65,269.47	**4.78%**
5-Tributary	464.88	**10.55%**	147,498.00	**10.80%**
6-Hollow Brook	391.66	**8.89%**	105,133.84	**7.69%**
TOTAL WATERSHED	**4,406.16**	**100.00%**	**1,365,994.76**	**100.00%**

Table 7 - Annual TP Loads - Deal Lake Watershed, by Municipality				
Municipality	**Total Acreage**	**% watershed area**	**Lbs/year**	**% TP load**
Ocean Township	2,419.44	**54.91%**	556.12	**55.82%**
Neptune Township	754.87	**17.13%**	159.17	**15.98%**
Asbury Park	579.74	**13.16%**	156.51	**15.71%**
Interlaken	247.27	**5.61%**	38.27	**3.84%**
Deal Borough	193.94	**4.40%**	38.90	**3.90%**
Allenhurst Borough	138.14	**3.14%**	35.04	**3.52%**
Loch Arbour Village	72.76	**1.65%**	12.27	**1.23%**
TOTAL WATERSHED	**4,406.16**	**100%**	**996.28**	**100%**

Summarizing the data presented in the above four tables, the watershed-wide total estimated loads of each, respectively, are: 9,278 (TP), 999 (TN) and 1,365,995 (TSS) lbs/year. Predictably, Subwatershed 1, the main lake basin, has the highest computed pollutant load for TN, TP, and TSS.

Subwatershed 1 is the largest delineated subwatershed, comprising approximately 50% of the total watershed area. Largely as a result of its relative size as compared to the total watershed area, and the extent to which it has been developed, this subwatershed is responsible for approximately 48% of the lake's total annual pollutant load. This is significant as it further confirms that direct runoff of NPS pollutants to the lake is the major source of contaminants, nutrients, and sediments. This emphasizes the need for retrofit stormwater management and the correction of existing stormwater management deficiencies.

Subwatershed 2 (Harvey Brook), the second-largest drainage area within the study area at approximately 972 acres, comprises 22% of the total watershed area and contributes nearly 22% (2,034 lbs/year) of the total estimated TN load, 20% (204 lbs/year) of the estimated TP load and just over 25% (343,362 lbs/year) of the estimated TSS load for the watershed area. Again, these results are expected based on the size of this subwatershed relative to the total study area; however, the slightly higher TSS contribution relative to the subwatershed acreage is a reflection of the agricultural land uses unique to this subwatershed. The role of road runoff and stream scour will also be examined with respect to determining specific pollutant sources and developing management recommendations for this subwatershed.

In terms of the annual TP load generated by each municipality, as would be expected those municipalities encompassing larger amounts of the Deal Lake watershed contribute more of the annual TP load.

4.0 Projects Conducted Through Grant #RP10-088

The NJDEP 319(h) funding secured by the DLC was used to conduct four specific projects:

1. The installation of a manufactured treatment device at the Comstock Avenue (Asbury Park) outfall
2. The restoration and replanting of a portion of the lake's riparian/littoral zone along the shoreline of the Colonial Terrace Golf Course (Ocean Township)
3. The construction of bio-infiltration type stormwater management "basins" at the Colonial Terrace Golf Course (Ocean Township), and
4. Restoration and replanting of an eroded section of shoreline located adjacent to the City of Asbury Park boat launch, the primary public access point to the lake.

The following sections of this report review each of the above projects. Details of each are provided in the accompanying appendices that are referenced within each sub-section of the report.

4.1 Comstock Avenue Manufactured Treatment Device (MTD)

This was the first project implemented with the grant funding obtained through Grant #RP10-088. This outfall, which is located immediately west of the Asbury Park High School athletic fields was identified in the WPP as a primary implementation project for the DLC. This project was specifically identified as part of Objectives 3 and 4 in the 319(h) grant proposal submitted to the NJDEP by the DLC. As per Chapter 7.2 of the WPP, the upgrade of the Comstock Avenue outfall was needed due to the lack of any stormwater management measures in this portion of the Deal Lake watershed. Runoff is routed from this highly developed sub-section of the watershed by a curb and gutter system that directs the runoff into standard catch basins located along the roadway. Standard catch basins are intended to simply collect, concentrate, and transport storm water to a receiving waterbody as quickly as possible to avoid localized flooding. As a result, they offer little positive benefit in terms of the management of storm water from either a quantity or quality perspective. In contrast, certain manufactured treatment devices (MTDs) can convey stormwater in a manner similar to a standard catch basin, yet provide some degree of pollutant reduction. MTDs and water quality inlets should be considered for the Deal Lake watershed as a means of decreasing pollutant loading to Deal Lake and its tributaries.

MTDS are specially designed structures used to retrofit existing stormwater collection systems. Some rely on filters while others utilize enhanced settling or sediment segregation techniques to improve water quality. The pollutant removal capabilities of MTDs are limited largely to the removal of total suspended solids and floatables, and to some extent, particulate pollutants, including particulate phosphorus, and the heavy metals and petroleum hydrocarbons that adhere to sediments. There are a variety of manufactured stormwater treatment devices recognized and approved by the NJDEP. As per NJDEP, the typical TSS removal efficiency achieved with a properly sized MTD is 50%.

In Section 7.2 of the WPP the Comstock Avenue outfall was specifically identified as a significant documented source of sediment, particulate phosphorus and floatable loading to the lake. The replacement of this basin was determined to be a "viable project" as it could be conducted completely within the roadway right of way administered by the City of Asbury Park and would not involve any modification of the existing outfall and only minor changes to the stormwater collection pipe network leading to the basin.

Work on the sizing and selection of an appropriate MTD was initiated in the fall of 2010 by Leon. S. Avakian, Inc. (LSA), the consulting engineer for the DLC. The MTD sizing analysis was completed in early 2011. It was determined that a ConTech Vortechs helical separator type MTD was the best suited MTD for this application. This is a multi-chambered, shallow profile MTD. As per the manufacturer's literature the Vortechs hydrodynamic separator "can effectively remove finer sediment (e.g. 50-microns (μm), oil, and floating and sinking debris. The swirl concentration operation and flow controls work together to minimize turbulence and provide stable storage of captured pollutants".

With the Vortechs fully sized, LSA then worked closely with the City of Asbury Park to obtain all the required site survey, right-of-way, and parcel data needed for the final design of the MTD and its installation. An announcement for bidders was advertised by the DLC in early spring 2011, bids were obtained and a contract was awarded by the DLC to Precise Construction, Inc. of Freehold, NJ for the amount of $124,750.00 in June 2011. The fee covered the purchase and installation of the Vortechs unit, two (2) stormwater manhole structures and approximately twenty-five (25) linear feet of 15" reinforced concrete pipe used to connect the MTD to the existing Comstock Avenue inflow pipe network and the existing outfall and headwall structure in the lake. To avoid any traffic related issues or related matters associated with operations and activities of the Asbury Park High School, the actual installation of the MTD was delayed until the summer of 2011 when school was out of session. LSA oversaw the actual installation of the MTD and the unit was fully operational by September 2011.

4.2 Colonial Terrace Golf Course Lake Shoreline-Riparian Buffer Restoration

The Colonial Terrace Golf Course (CTGC) abuts the northern shoreline of the western portion of the Colonial Terrace arm of the lake. The CTGC is a public course owned and operated by Ocean Township. While the majority of the golf course is separated from the lake or the two tributary streams feeding the lake by a wooded riparian buffer, a section of the course adjacent to Holes 3 and 4 had mowed fairways extending directly to the edge of the lake. These edges had, over time, become eroded and unstable. Additionally, these areas provided direct access for Canada geese to the golf course. The geese create a significant amount of damage to the fairway as a result of feeding, roosting, and traversing the golf course. Their feces also impacted the quality of the turf and created a major aesthetic issue for golfers. Concerns were also raised about any health implications owing to the concentration of feces in this portion of the course. The accumulation of feces also created a water quality problem, which was documented during past studies conducted by the DLC. Water quality storm-event based sampling conducted by the DLC as part of this grant further documented the bacterial and nutrient related impacts attributable to the geese (Section 5).

The WPP established that throughout the Deal Lake watershed there was the need to repair and restore damaged or lacking riparian buffers. This applied to not only the actual shorelines of the lake but the stream banks of the lake's tributaries. As such, the restoration of the CTGC shoreline and associated riparian buffers was consistent with the recommendations contained in the WPP.

The DLC, through their environmental consultant Princeton Hydro began developing designs for the restoration of the lake-side riparian buffer and repair of the eroded lake shoreline in the spring of 2011. This work progressed in close association with the Ocean Township Department of Recreation & Human Services and the Township's Department of Public Works (DPW). While Recreation & Human Services oversees the operations of the course, the DPW is charged with its maintenance.

Because the shoreline's restoration did not involve any regrading or other physical changes to the shore, it was decided that the replanting would be conducted through the DLC as a community outreach effort using various volunteer groups.

The DLC and the project partners established four goals for the project:

- Correct existing erosion and sloughing problems and control/manage future potential erosion problems
- Create a dense enough buffer to discourage the easy passage of Canada geese from the lake onto the golf course,
- Provide a vegetated area that would passively treatment runoff from the golf course thereby decreasing local nutrient, sediment and pathogen loading to the lake, and
- Create an attractive no-mow backdrop that would complement the golf course and serve as a transition area between the lake and the actively maintained areas of the course.

Princeton Hydro developed a planting plan intended to meet all four of the above project goals. The work area encompassed approximately 300 linear feet of impacted shoreline. The width of the restored buffer area varied from a minimum of approximately 10 feet to a maximum of approximately 25 feet. Native shoreline vegetation consisting of following was used to restore the riparian buffer:

- Plug-sized aquatic and terrestrial species -

    - *Hibiscus moscheutos* (swamp rosemallow),
    - *Pontedaria cordata* (pickerelweed),
    - *Juncus effuses* (soft rush),
    - *Carex lurida* (shallow sedge),
    - *Elymus riparius* (riverbank wild rye), and

    - *Mimulus ringens* (money flower).

- Seed and three shrub species –

    - *Cephalanthus occidentalis* (buttonbush),
    - *Cornus sericea* (redosier dogwood), and
    - *Viburnum dentatum* (arrowwood viburnum).

Where turf grass existed, the native species were incorporated into the existing turf mat. Additionally, the plan called for transplanting some existing white water lily (*Nymphaea oderata*) and spadderdock (*Nuphar luteum*) adjacent to the restored buffers to complement the installed pickerel weed.

Plugs were installed in an approximately six-foot wide band along the northern shore and in a slightly wider area along the eastern shore. The shrubs were installed randomly. Wet-tolerant plants were concentrated in an area located around an eight-inch diameter pipe that conveys drainage from fairways into the lake. In addition to the planted buffer, a four-foot wide "no mow" zone was created, to further widen the buffer. Exclusion fence was installed around the entire perimeter of the planting areas to protect new plants from herbivory, discourage the use of the area by geese, and keep mowers and golfers out of the area.

All of the planting was completed in a single day by a group of volunteers organized by the DLC and coordinated by staff of Princeton Hydro. This included local Girl Scout and Boy Scout troops, the Friends of Deal Lake and others.

Two informative signs were installed on site that provided information about the importance of the vegetated buffer along the lake (refer to Appendix C). After the buffer matured, the exclusion fence was removed and "no entry" signs (Appendix C) were installed to ensure that the areas were not mowed and that golfers did not enter the buffer in search of errant balls. Education was provided to the golf course staff on the long-term maintenance of the buffer.

4.3 Colonial Terrace Bio-infiltration Basins

As noted in Section 4.2 above, storm event sampling of runoff generated from the golf course was conducted by the DLC both as part of the WPP project and as part of this project. Those data repeatedly documented elevated concentrations of pathogens and nutrients in the site's runoff. The golf course has had a long-standing problem with Canada geese. Goose dropping can be prolific in the area immediately adjacent to the lake. While restoration of the riparian buffer alongside Holes 3 and 4 will help reduce the ease of passage of geese from the lake to the course, it will not eliminate the problem.

Analysis of the site's drainage patterns showed that it was possible to position three relatively small-footprint basins to collect and treat a major amount of the runoff generated from the course. It was also possible to locate these basins in areas that would not interfere with golf play. Based on testing of the site's soils it was determined that it would be possible to design these basins to function as bio-infiltration BMPs. The basins were thus sized to intercept and treat in full the runoff generated by storms up to and including the 1-year event (approximately 2.8" of rainfall over a 24 hour period. This represents approximately 92% of all rainfall events that occur annually. For the larger less frequent storms, the basins would still be able to manage and treat the first-flush of runoff and discharge whatever runoff that was not infiltrated to lake by means of either an existing pipe-network or surface swale system.

While the CTGC project was designed to address the specific stormwater problems of the golf course, it was also envisioned by the DLC as an excellent opportunity to demonstrate the benefits of "small foot-print", low-maintenance, passive treatment bio-retention or bio-infiltration BMPs. The bio-infiltration basins constructed at the TGC site could be easily duplicated elsewhere throughout the Deal Lake watershed.

As per the grant proposal for 319(h) funding submitted by the DLC to the NJDEP, for the CTGC site, Princeton Hydro and LSA first developed the necessary hydrologic, hydraulic, and pollutant loading data needed to size and design stormwater management basins for the golf course. Due to past work conducted on the site by LSA site-survey ad topographic data were readily available as well as data concerning the site's existing stormwater pipe and swale network. Some supplemental survey data were obtained in the specific areas where the basins were proposed along with basic hand-auger obtained soil data. The design team worked in concert with Ocean Township personnel to also identify and mark out all subsurface irrigation related infrastructure (heads, lines, electrical connections, and relays). The basins' planting specifications were reviewed with the Ocean Township DPW to ensure their proper short-term and long-term maintenance requirements.

Again as previously noted, the three stormwater management basins were designed to treat the water quality design storm (1.25" of rainfall over 2 hours, which is equivalent to the 1-year event) and the first flush of larger events. The stormwater management basins were also designed to correctly pass larger storms and not create upstream or downstream flooding impacts. Some minor regrading of the site was required to facilitate the proper interception of runoff. A soil mix consisting of a sandy-loam with 5-7% organic content was used to replace the excavated native soils. Each basin was equipped with a short stand pipe, within which a baffle plate was installed. The plate promotes the extended detention of runoff in the basin thereby maximizing the opportunity for the infiltration of the captured runoff, while still allowing large storm events to pass safely. The engineering details along with photos of each basin are provided in Appendix C.

Basin 1 is actually a long, shallow swale that runs along the Hole 7 fairway, parallel to the cart path. The construction of the basin in this location required only some minor regrading of the rough adjacent to the fairway, but did necessitate the relocation of two trees. Runoff that enters the golf course from the north (including some off-tract developed area) was directed to the basin by slightly reshaping an existing shallow swale that bisects the Hole 7 fairway. The soil excavated to create the bio-infiltration swale BMP was used to create a landscaped berm. The berm helps direct runoff from the western portion of the Hole 7 fairway to the bio-infiltration swale BMP. The relocated trees were planted on the berm. Any runoff that is not infiltrated by the bio-infiltration swale BMP is directed into an existing pipe network that runs north to south near the Hole 2 green and eventually discharges into the restored riparian buffer detailed above in section 4.2.

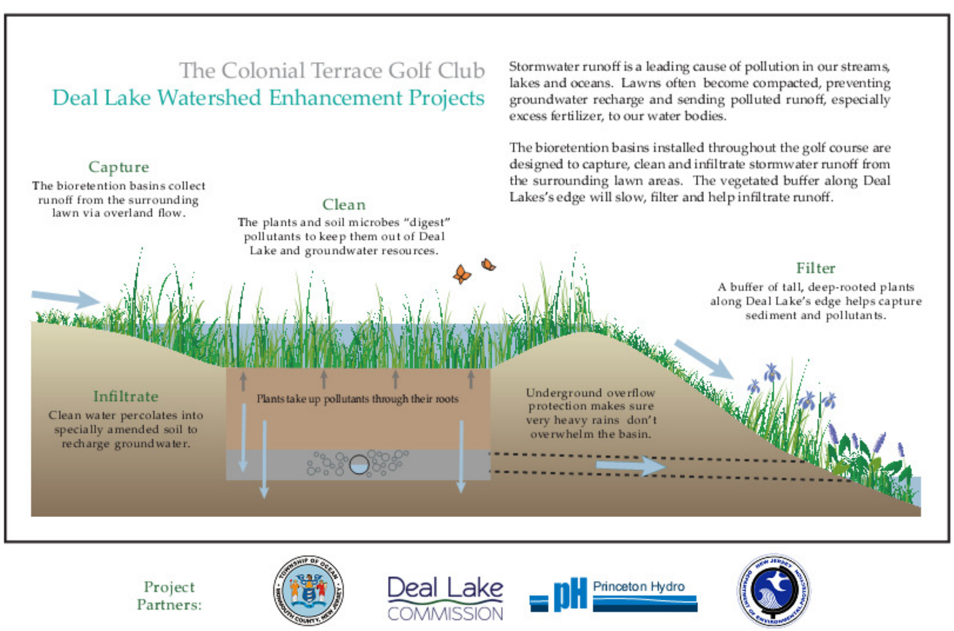
Basin 2 is located between the Hole 3 green and the Hole 4 tee-box. This basin is designed to treat runoff from a relatively large area that originates near the Hole 6 green and includes runoff from a CTGC maintenance road and a portion of the golfer's cart path. To properly direct runoff to Basin 2 from the upgradient areas it was necessary to slightly re-contour the cart path and install three small diameter, low-profile pipes. These pipes channel the collected runoff under the path to Basin 2 via a shallow grassed swale. To minimize golfer traffic (by foot and cart) through the swale, a paving stone walk way was created. Basin 2 is a long-rectangular structure located adjacent to the Hole 3 green. The construction of the basin involved the excavation and removal of the native soils and their replacement with a sand-loam mix containing 5-7% organic material. As is the case with the Basin 1 bio-infiltration swale, Basin 2 is also equipped with a short riser in which a baffle plate was installed. Any runoff that is not infiltrated is discharged via a distribution pipe set in a stone berm. Runoff that trickles out of the stone berm then flows via a grassed swale towards the lake, passing through the restored riparian buffer (Section 4.2) before being discharged into the lake.

Basin 3, the largest of the three CTGC basins, is located in an area between the fairways for Holes 4 and 5. It intercepts the drainage generated largely from the Hole 5 and 6 fairways, essentially the northwestern corner of the course. This area has constituted longstanding drainage problem for the CTGC. Runoff would pool in a dip in the center of the Hole 4 fairway turning into a muddy, rutted area. Additionally, because of its wide-open nature this area it has been a major congregating spot for geese. As a result the runoff generated from this area characteristically has had elevated concentrations of pathogens and nutrients. For example, *E. coli* concentrations measured in the pre-installation storm samples (April-May 2011) ranged from 4,250 to 129,000 colonies/100 ml; which is at least 20 fold greater than the NJDEP water quality standard (235 colonies/100 ml). Likewise the phosphorus concentrations measured in the runoff from this area were also very high; mean concentration of 0.223 mg/L for TP and 0.027 mg/L for SRP as based on the 2011 pre-installation storm samples).

Construction of Basin 3 followed the same basic approach taken for Basins 1 and 2; excavate a shallow basin, use the excavated soils to create berms that aid in the direction of runoff into the basin, replace the native soil with and engineered replacement soil and equip the basin with a short standpipe and baffle box to promote stormwater detention and infiltration (refer to Appendix C for details and photographs). Any runoff not infiltrated by the basin was directed into a new pipe system installed as a separate project by the CTGC and Ocean Township. This pipe, which runs under the

Hole 4 fairway, discharges to the same rip-rap apron as did the original surface swale that bisected the fairway.

Down to Earth Landscaping of Jackson, New Jersey constructed the three CTGC basins. Their bid totaled $98.657.50, which was significantly less than the $110,000 -$120,000 estimated for this project in the grant application. Down to Earth Landscaping initiated work on the project by early December 2012 and completed the work before the re-opening of the course in May 2013. Project oversight was provided by Princeton Hydro and close communication was maintained with Ocean Township DPW and the Department of Recreation & Human Services. Out-of-bounds signs were erected along the perimeter of each basin informing the golfers that the basins were environmentally sensitive areas and entry was prohibited. Two large educational signs were posted, one in the clubhouse and one alongside the Hole 7 bio-infiltration swale detailing the purpose and benefits of the basins.



4.4 Asbury Park Boat Launch

Due to the fact that the Comstock Avenue and CTGC projects both were completed under budget, there were enough funds remaining for the DLC to conduct a third Deal Lake project. Over the previous two years the City of Asbury Park had renovated the Asbury Park Boat Launch, improving parking, upgrading the boat launch and removing invasive vegetation (mostly Japanese knot weed, *Fallopia japonica*). The Asbury Park Boat Launch is the primary public access point of entry to Deal Lake. The facility is used extensively by rowers, anglers and pleasure boaters to launch boats, paddle boards and jet skis in the lake. An outstanding issue associated with the renovation of the boat launch was the final restoration of the shoreline, which was undercut and eroded. Additionally, the project created an opportunity for the construction of a small rain garden BMP that could be used to manage some of the runoff from the boat launch access road and parking area. The rain garden BMP would also serve as another example of an easily transferable project for other areas within the Deal Lake watershed.

With the approval of the NJDEP the DLC issued contracts to Princeton Hydro (design and contractor oversight) and Down to Earth Landscaping (construction) to implement the project. The total fee for the project, consisting of the restoration and replanting of the shoreline and the construction of the rain garden along with the fabrication and installation of interpretive signage was approximately $25,000. The work was initiated in April 2013 and finished by June 2013 in advance of the grant's completion date.

As noted above, while the City had some success in addressing the invasive species colonization of the shoreline, they did not have the resources to correct the shoreline's erosion problems. This erosion was categorized as moderate to severe erosion. Along the edge of the lake the shoreline was undercut and sloughing. Filter fabric that had been placed on the slope leading from the parking area and access road to the lake was unstable, exposed and needed to be removed. With the removal of the majority of the invasive vegetation, nearly-bare conditions could be observed along the face of the majority of the slope.

To correct the eroded and soughed shoreline, two-tiers of coir (coconut fiber) logs were installed was along the entire toe of slope, approximately 400 feet. The exposed and unstable filter fabric was removed and replaced by Down to Earth Landscaping with coir erosion control fabric. This essentially created a stabilized slope that extended form the parking terrace down to the lake. Along this slope and between the coir log tiers, a combination of native seed, plugs, trees and shrubs were installed as per the planting plan developed by Princeton Hydro. Plant species included *Iris versicolor* (blueflag iris), *Carex crinata* (fringed sedge), *Schoenoplectus tabernaemontani* (soft stem bulrush), *Clethra alnifolia* (summersweet), *Ilex verticillata* (winterberry holly) and *Liquidambar styraciflua* (sweetgum).

The parking lot demonstration rain garden was created in the entry circle of the boat launch area. A minimum amount of site grading and soil preparation was conducted by Down to Earth Landscaping. Once the site was prepared, six (6) popular, native landscape shrub species were planted: *Clethra* *alnifolia* (summersweet), *Morella pensylvanica* (northern bayberry), *Ilex verticillata* (winterberry holly), *Cornus sericea* (redosier dogwood), *Photinia pyrifolia* (red chokeberry) and *Viburnum dentatum* (arrowwood viburnum).

Princeton Hydro designed an informative educational sign for the project site. The sign was installed by the City of Asbury Park DPW within the rain garden demonstration basin. The sign provides information about the importance of lake-side vegetated buffers, identifies the shrubs used in the native demonstration rain garden, and lists additional resources about native landscaping available through the Barnegat Bay Partnership website.

5.0 Pre- and Post Stormwater Monitoring of MTD and CTGC BMPs

5.1 Quality Assurance Protection Plan (QAPP)

In accordance with the NJDEP work plan approved for the Deal Lake Gran #RP10-088, the DLC prepared in advance of conducting any water quality sampling, a Quality Assurance Protection Plan (QAPP). The preliminary draft of the QAPP was submitted to the NJDEP in 2009. Following several iterations of the QAPP to incorporate all of NJDEP's comments, the QAPP was approved by the NJDEP and received by the DLC in December of 2010. A full copy of the QAPP is provided in Appendix B.

As detailed in the QAPP, Dr. Stephen Souza of Princeton Hydro served as the project manager and was also involved in the analysis of the resulting data. Mr. Chris Mikolajczyk served as the QA/QC Officer, and oversaw all of the fieldwork associated with the collection and delivery of the stormwater samples, including the setup and programming of the ISCO samplers. Samples were delivered following a strict chain of custody procedure to Environmental Compliance Monitoring Inc. and New Jersey Analytical Laboratories for subsequent analysis. All sampling and decontamination procedures followed the standard practices and procedures listed in *Standard Methods for the Analysis of Water and Wastewater, 18th Edition* (American Public Health Association, 1992), State protocol (NJDEP, 2005) as well as all applicable USEPA guidance documents.

The locations of the pre-installation sampling stations were reviewed and approved by the NJDEP as part of the QAPP approval process. For the Comstock Avenue MTD project, pre-installation sampling involved the collection of water quality samples from a stormwater catch basin located upgradient of the proposed MTD installation. For the CTGC project, samples were collected at the terminus of a swale located on the golf course. The sampled swale was also the subject of sampling as part of the Characterization and Assessment element of the WPP. The collection and analysis of stormwater runoff at these two stations provided the pre-installation data that would be subsequently used in part to evaluate the post-installation/construction performance of the Comstock Avenue MTD and the CTGC bio-infiltration basins.

5.2 Sampling Methodology

As stipulated in the NJDEP approved QAPP, three (3) sampling events were conducted in advance of the construction/installation of the proposed BMPs and three (3) sampling events were conducted following their construction/installation. Only storm events generating at least 0.1" of rainfall were targeted for sampling. Additionally, for a storm to qualify for sampling, a minimum of 72 hours had to have elapsed since any prior storm event.

Storm event sampling, both prior to and following the construction and installation of the BMPs, was conducted using pre-programmed ISCO composite samplers. The samplers were positioned and secured in-place in advance of each targeted storm event. They were programmed in accordance with the QAPP's protocol to collect water samples over the entire hydrograph of each sampled storm event. Essentially, once enough runoff was generated, the flow-activated ISCO samplers were triggered. An initial sample representing the storm's first flush was collected. This sample was segregated form the remaining samples, which were collected at 15 minute-intervals over the duration of the event. These sub-samples were subsequently composited and used to represent the balance of the storm. As such, for each storm event, at each sampling station, a complete storm composite sample was analyzed. The ISCO collected composite water samples were also placed in coolers, stored at 4° C and transported to Environmental Compliance Monitoring (ECM) for the analysis of the previously noted parameters. A chain of custody manifest was maintained for all samples from the point of collection to the point of transfer to the laboratory. Subsequent laboratory analysis of the specified parameters was conducted by ECM and NJAL following both USEPA and NJDEP-approved, quantitative laboratory methods.

Along with the ISCO-collected samples, as part of the pre-installation/construction sampling effort a "first flush" grab sample was collected manually at the onset of each storm event and analyzed for *E. coli*. For the post-installation/construction sampling, a grab sample was collected both at the onset and at the conclusion of each storm event for *E. coli* analysis. The manually collected *E. coli* grab samples were directly collected from the incoming source of runoff using laboratory supplied NJDEP-recommended sampling containers. The samples were immediately placed in a cooler and stored at 4° C. The samples were delivered within the required 6-hour sample holding time to New Jersey Analytical Laboratories (NJAL).

The pre- and post-sampling efforts also included the use of a calibrated multi-probe for the *in-situ* measurement of dissolved oxygen (DO), temperature, pH and specific conductivity. The *in-situ* measurements were conducted manually at the onset of the storm under "first flush" conditions, as well as at the conclusion of the storm event. The instrumentation used in the collection of the *in-situ* dissolved oxygen, temperature, pH and conductivity data was calibrated in advance of its use, in conformance with the manufacturer's instructions and in accordance with the QAPP. Princeton Hydro is state-certified (ID # 10006) for the use of *in-situ* monitoring equipment for the measurement of dissolved oxygen, temperature, pH and conductivity.

5.3 Pre-Installation/Construction Stormwater Quality Sampling Results

Upon receipt of the QA/QC laboratory data, Princeton Hydro reviewed the results for any outliers, errors, or irregularities. For this project, there were no aberrant data points; as such there was no need to reject or revise any data. All data were compared to New Jersey Water Quality Standards and any applicable EPA Reference Criteria. As is documented in numerous stream and watershed studies, watersheds that typically drain more developed areas have statistically higher storm flow nutrient and sediment concentrations than watersheds draining less intensively developed area. It can be expected, due to the larger and more connected amount of impervious cover, that on a per unit area basis more non-point source pollutants will be conveyed with storm runoff generated from developed versus undeveloped areas. This is a function of a number of factors but largely reflects the more rapid mobilization and effective transport of particulate pollutants from impervious surfaces by even relatively small rainfall events. This, in part, can explain some of the water quality problems observed throughout Deal Lake, which can be characterized as a highly developed watershed.

5.3.1 - In-situ Data

pH – pH is a measure of the acidity or basicity of water. Based on a logarithmic scale ranging from 0 to 14, a pH reading of 0.0 is the most acidic, whereas a pH of 14.0 is the most basic. A pH of 7.0 is considered neutral. pH can have a profound effect on the chemistry and the biological components of an aquatic ecosystem, therefore, it is an extremely important ecological parameter.

As illustrated in the data (Appendix B), the pH of the storm runoff measured during the three storm events ranged from 5.00 to 7.64 (acidic to slightly basic), with most of the measurements in the 6.4 to 6.6 range. The results were generally within the surface water standards of 6.5 to 8.5 established by the NJDEP for FW2-NT waters.

Specific Conductivity- Specific conductivity reflects the ability of water to conduct an electrical current as a result of ionic activity and content. The higher the concentration of ionic (dissolved) constituents, the higher the specific conductivity measured in the water. Because of this, specific conductivity is typically used to evaluate the amount of dissolved substances (i.e. nutrients, minerals, salts) present in water. Therefore, samples having high specific conductivity are considered to have large amounts of dissolved substances present in the water.

The first flush of a storm event is expected to contain a high amount of particulate and dissolved substances. This is reflected in the specific conductivity readings recorded for each of the sampled storm events (Appendix B). The highest specific conductivity readings were recorded for the storm sampling conducted during the winter. This is to be expected as road, parking lot, and sidewalk salting operations can increase the salt content of the runoff conveyed to the lake.

Dissolved Oxygen- Dissolved oxygen (DO) is one of the best indicators of an ecosystem's "health". The DO concentration measured in a lake, pond, stream or river is largely the result of the diffusion of atmospheric oxygen, coupled with the oxygen generated as a result of the photosynthetic activity of macrophytes (aquatic plants) and algae. Respiration processes, which in lakes are attributable to fish, aquatic organisms, bacteria and microbes, consume oxygen. As such, peak DO concentrations typically occur in the summer when photosynthesis is greatest, but also the summer is when DO depletion is at its greatest due to the biological activity and respiratory demands of the biological community. DO concentrations can also vary with temperature. The correlation of DO to temperature is an inverse relationship. Thus, DO saturation is attained at lower concentrations as water becomes progressively warmer.

The DO concentration of stormwater runoff can be affected both positively and negatively by a number of factors. Lower DO concentrations in the receiving stream, lake, or pond are often a sign of high organic loading associated with the influx of stormwater. The biological demand associated with the decomposition of this organic loading decreases DO concentrations. Conversely, elevated DO concentrations may be a result of the added turbulence and mixing caused by the incoming runoff, but may also be caused over time by algae or weed growth that occurs due additional stormwater related nutrient loading.

As previously noted, Deal Lake is listed in the State's Surface Water Quality Standards (N.J.A.C 7:9B) as a Freshwater 2, non-trout waterbody (FW2-NT). The State's minimum DO concentration for FW2-NT waters is 5 mg/L. For the most part, using this standard to evaluate stormwater is largely meaningless due to the transitory nature of such flows. Nonetheless, the sampled stormwater runoff typically had DO concentrations well in excess of the 5.0 mg/L NJDEP surface water standard, and was often at 100% saturation. This is more likely a function of turbulence as opposed to photosynthesis or lack of DO demand.

Temperature - Water temperature greatly influences the rate and timing of an aquatic ecosystem's biological, chemical and physical interactions. As noted above, cooler water can "hold" more dissolved oxygen than warmer water. Chemical and biological processes slow as water temperatures decrease, but increase as water temperatures rise. Significant water temperature problems can occur during the summer as a result of stormwater runoff generated from large tracts of impervious surfaces. The runoff will become heated as it passes over large paved or impervious areas. The heated runoff can impact aquatic organisms or create stress when the runoff is quickly transported to the lake, its tributaries or even its wetland. However, even with the extent to which the Deal Lake watershed is developed, the water temperatures of the runoff measured during each of the sampled storms did not show any evidence of heating. As such, storm runoff temperature related impacts were not considered an issue even before the stormwater management improvements were put into place.

In summary, the pre-installation/construction *in-situ* water quality data collected during each of the three monitored storm events, at either the Comstock Avenue or CTGC site, were consistently within the ranges set by the State's Water Quality Standards.

5.3.2 - Laboratory Data Results

Total Phosphorus (TP) – For most freshwater ecosystems, phosphorus is the primary limiting nutrient. Basically this means that as phosphorus concentrations increase, the amount of primary production (macrophyte and algae growth) that can be supported also increases. Phosphorus is recognized to be the primary driving force of eutrophication. In other words, it takes very little phosphorus to stimulate large amounts of algal and/or aquatic plants growth; as phosphorus concentrations increase, the amount of algal and/or aquatic plant biomass will also increase. The State standard for TP for lakes is 0.05 mg/L; however, TP concentrations as low as 0.03 mg/L can stimulate high levels of algal and/or aquatic plant growth. The NJDEP surface water standard for TP in flowing water is 0.10 mg/L.

Deal Lake is recognized as being a highly eutrophic waterbody. Data collected over the past three decades by the DLC and more recently by Princeton Hydro documents that the TP concentrations of the lake and its tributaries routinely approach or exceed the respective NJDEP standards. Elevated TP concentrations are responsible for many of the lake's mid-summer algae blooms and helps support some of the excessive aquatic macrophyte densities that occur lake-wide. The lake's TMDL emphasizes the need to reduce phosphorus concentrations and overall loading. The TMDL along with the WPP and other earlier studies of the lake identify the stormwater conveyed to Deal Lake as the primary source of TP loading. Thus, improved stormwater management and NPS pollutant load reduction are inherently the cornerstones of the primary long term strategies developed for the improvement of the lake's water quality.

The pre-installation storm event TP concentrations measured by Princeton Hydro at the sampling sites consistently exceeded the State standard. The runoff from the sites sampled during each of the monitored storm events ranged from 0.16 mg/L to 0.36 mg/L.

Soluble Reactive Phosphorous (SRP) - While TP is used as the primary indicator of potential productivity, it is not always the most important form of phosphorus to measure. Soluble reactive phosphorus (SRP) is a component of the total phosphorus. This form of phosphorus is easily assimilated by both planktonic and benthic algae. As a result, when elevated amounts of SRP are measured, an algal bloom is likely to be experienced. The concentration of SRP in stormwater can be quite high. For Deal Lake, the pre-installation stormwater runoff concentrations of SRP ranged from 0.011 mg/L to 0.065 mg/L.

Total Suspended Solids- Total suspended solids (TSS) is a measurement of the amount of particulate matter in water. The State standard for TSS is 40 mg/L. Continuous TSS concentrations greater than 40 mg/L can negatively impact aquatic habitats as a result of the subsequent sediment in-filling of wetlands and waterways, the destruction of spawning habitat, and respiratory stresses caused by the fouling of gill surfaces with fine suspended sediments. TSS concentrations greater than 40 mg/L are perceived as being "dirty" or "muddy". Short term spikes in TSS can be expected during storm events. This can occur even in highly developed watersheds such as that of Deal Lake where there is very little barren land and large amounts of paved surfaces. In watersheds dominated by impervious surfaces there is no opportunity for rainfall to infiltrate into the underlying soils. As a result, even small rainfall events generate large amounts of runoff. As repeatedly documented in earlier studies of Deal Lake and its tributaries, stormwater runoff scours the bed and banks of the lake's tributaries, dislodging, resuspending, and transferring fine sediments into the lake. The predominant soils within the Deal Lake watershed contain high amounts of clay. These clays resist settling. As a result, the lake is frequently turbid. Additionally, phosphorus and various pollutants, including bacteria, adhere to these fine clay particles increasing the opportunity for the influx of nutrients and other contaminants into the lake. The lake's history of sediment loading has been the cause for a number of past dredging projects, one of the stimulants for the call for better stormwater management.

For each pre-installation monitoring event, the stormwater runoff TSS concentrations exceeded the State standard, being as high as 255 mg/L. As would be expected, storm event TSS concentrations were affected by the size and intensity of the sampled storm, the duration of the storm, and the amount of antecedent dry weather that preceded the storm, and time of year. Of the all of the pre-installation sampled storms, the highest observed TSS concentrations were measured during a large, spring rainfall event.

E. coli – In urban watersheds bacteria-driven stormwater quality impacts are often attributable to the mobilization and transport of pet waste and avian (Canada goose) waste from lawns, roadways, and impervious surfaces. In urban areas, the cross-connection of sanitary and stormwater lines and functioning combined sewer overflows (CSOs) are other sources of bacteria in stormwater. The DLC has worked extensively with the member municipalities to identify and correct sanitary cross-connections and eliminate CSOs. They have also worked with the public to educate them about properly managing pet waste, with many of the towns actually installing signs and pet waste collection stations. Canada geese remain a significant problem, even with the efforts taken by the DLC to discourage the feeding of waterfowl and efforts to restore riparian buffers along the lake and its tributaries.

E. coli is used as an indicator of pathogen related water quality problems. The surface water standard for *E. coli* bacteria for contact recreation (swimming) is a geometric mean of 126 colonies /100 mls or a single maximum sample concentration of 235 colonies/100 mls. During the pre-installation storm event sampling effort, the concentrations of *E. coli* measured in the stormwater runoff from a **low** of 790 colonies /100 mls to a high of 1.29 million colonies /100 mls.

5.3.4 - Summary of Pre-Installation/Construction Stormwater Sampling Results

The pre-installation/construction sampling data once again documented that the runoff generated from the Deal Lake watershed can be characterized as having elevated concentrations of total phosphorus, soluble reactive phosphorous, suspended solids and *E. coli*. These data confirmed that the stormwater loading to Deal Lake is problematic and will improve without better stormwater management.

5.4 Post-Installation/Construction Stormwater Quality Sampling Results

Following the installation of the Comstock Avenue MTD and the construction of the CTGC bio-infiltration basins, post-installation/construction stormwater sampling programs were initiated. As was the case for the pre-installation/construction stormwater sampling program, the post-installation/construction stormwater sampling programs were conducted in accordance with the NJDEP approved QAPP.

For the Comstock Avenue MTD the post-construction stormwater sampling occurred on 29 February 2012, 9 May 2012 and 19 October 2012. The MTD was designed to receive and treat in full the runoff generated from the one-year frequency design storm (approximately 2.8” of rainfall over 24 hours). By design, the runoff generated by storms of this magnitude or smaller will be fully treated by this structure prior to discharge. While larger events will also result in discharge, the first flush of these larger events is expected to be fully treated.

For the CTGC bio-infiltration basins, post-installation/construction stormwater sampling was initiated in May 2013. Although attempts were made to collect runoff from the basins on four different dates, the basins generated no discharged. That is, the intercepted runoff was either fully infiltrated or the runoff detained long enough in the basins or swale to be lost via evapotranspiration. This is consistent with design of the bio-infiltration basins and swales, which would be expected for the water quality storm event (1.25” of rain over 2 hours) to generate no discharge. Thus although there are no actual post-installation/construction results for the CTGC swale and basins, it can be concluded that these BMPs met the project goals and improved, by elimination, the quality of runoff entering the lake from the golf course sub-watershed area.

Therefore, the discussions of the data that follow are specific only to the Comstock Avenue MTD results.

5.4.1 - In-situ Data

pH – The pH of the storm runoff measured during the post-construction stormwater monitoring events ranged from 6.03 to 6.71 (somewhat acidic) but generally within the surface water standards established by the NJDEP for FW2-NT waters. Additionally, the data show that the MTD did not effect the pH of the treated stormwater. This would be expected as the Vortechs unit is a sediment trap and does not rely on any type of filter media to collect or contain pollutants.

Specific Conductivity- The first flush of a storm event is expected to contain a high amount of particulate and dissolved substances. This is reflected in the specific conductivity readings recorded for each of the sampled post-construction storm events. However, as shown, the specific conductivity of the sampled runoff was at its highest during the winter month of February when snow and ice were present on the streets of the watershed. This is to be expected as road, sidewalk, parking lot and impervious surface salting operations increase the dissolved solids load in winter runoff. The post-installation sampling showed a slight reduction in the specific conductivity of the runoff following its treatment by the MTD. This reduction is likely the result of particulate material retention in the MTD and with that some retention of adsorbed dissolved solids.

Dissolved Oxygen- The State’s DO standard for FW2-NT waters is 5 mg/L (minimum concentration). For the most part, using this standard to evaluate stormwater is largely meaningless due to the transitory nature of such flows. Nonetheless, the sampled stormwater runoff for the most part had DO concentrations well in excess of the 5.0 mg/L NJDEP surface water standard, and was often at 100% saturation.

Temperature - The water temperatures of the runoff measured during each storm did not show any evidence of heating. We would not expect to see any significant changes as the MTD is not designed to store or detain runoff.

5.4.2 - Laboratory Data Results

Total Phosphorus (TP) – Historically, the storm event TP concentrations measured over the years have been consistently above the State standard for both lakes (0.05 mg/L) and streams (0.10 mg/L). This trend was again observed during each of the sampled storms. TP concentrations in the runoff entering the MTD from the Comstock Avenue consistently exceed the 0.10 mg/L standard. However, once the runoff was treated by the MTD, the concentration of TP dropped markedly.

Soluble Reactive Phosphorous - As is the case with TP, historically the concentrations of SRP measured in storm flows and in the lake's tributaries are consistently elevated. For each of the storm events monitored as part of this project, the concentrations of SRP measured in the runoff sampled prior to entering the MTD were elevated. However, the MTD treatment of the captured runoff significantly reduced the concentration of SRP.

Total Suspended Solids- TSS concentrations also significantly improved following the passage of the collected runoff through the Comstock Avenue MTD. Specifically, TSS concentrations were reduced as much as 90% (for example, 618 mg/L entering the MTD as compared to 68 mg/L existing the MTD). The amount of reduction appeared related to the size and intensity of the sampled precipitation events, the duration of the sampled storm, the amount of antecedent dry weather and season.

E. coli - The concentrations of *E. coli* in the stormwater runoff sampled under post-construction conditions at the Comstock Avenue showed a measurable reduction as a result of treatment by the MTD (Table 8). The reductions are on the order of 15%-50% which are significant.

5.4.3 - Summary of Post-Construction Stormwater Sampling Results

As documented over the course of the post-construction sampling program, the runoff generated from the Deal Lake watershed tended to have elevated total phosphorus, soluble reactive phosphorous, suspended solids and *E. coli* concentrations. However, as can be seen in the data, the MTD is improving the quality of the treated runoff with respect to nutrient, suspended solids, bacteria (*E. coli*) and floatables removal. Table 8 summarizes the improvements in water quality attributable to Comstock Ave MTD installation.

Table 8 -Comstock Avenue MTD Performance Sampling – Comparison of In-Flow and Out-Flow Data					
Sampling Event - 2/29/2012					
Sample ID	E. coli (cols/100 mls)	SRP (mg/L)	TP (mg/L)	TSS (mg/L)	Rainfall (inches)
Comstock Ave MTD - IN	9600	0.012	5	618	1.0
Comstock Ave MTD - OUT	4300	0.03	0.76	68	
Sampling Event - 5/9/2012					
Sample ID	E. coli (cols/100 mls)	SRP (mg/L)	TP (mg/L)	TSS (mg/L)	Rainfall (inches)
Comstock Ave MTD - IN	10000	0.07	0.66	127	1.47
Comstock Ave MTD - OUT	8500	0.053	0.49	39	
Sampling Event - 10/19/2012					
Sample ID	E. coli (cols/100 mls)	SRP (mg/L)	TP (mg/L)	TSS (mg/L)	Rainfall (inches)
Comstock Ave MTD - IN	3400	0.499	1.1	27	0.25
Comstock Ave MTD - OUT	1400	0.11	0.59	16	

5.5 STEPL Model Results

Part of the process utilized to document the water quality benefits gained through the BMPs implemented as part of Grant #RP10-088 involved the application of the USEPA's STEPL Model. The STEPL (Spreadsheet Tool for the Estimation of Pollutant Load) is a simple to use Excel® spreadsheet format tool. It is used to calculate pre- and post BMP installation pollutant loads and demonstrate the stormwater quality improvements attained through the use of a specific BMP. Similar to the unit areal loading (UAL) technique used in the past to compute pollutant loads for each of the Deal Lake sub-watershed, the initial input parameters used in STEPL are the digital land-use and land-cover (LULC) data for the subject catchment area (the land draining to the BMP). The LULC data are used in concert with simple loading coefficients to generate pre-BMP installation loads for phosphorus, nitrogen, and 5-Day BOD. For sediment, a total suspended solids load is generated using the Universal Soil Loss Equation (USLE) and an appropriate sediment delivery ratio based again on the LULC of the catchment area. It should be noted that the TSS load DOES NOT account for any sediment loading resulting from stream bed or stream bank erosion, only the TSS entering the lake in the form of sheet runoff and rill erosion (the soil loss that occurs on bare, exposed land). The pollutant load reductions computed using STEPL are based on the application of BMP efficiency values. These values are derived from the literature and represent the standard removal rate for a specific BMP. Due to the simplicity of the model there are a number of assumptions integrated into STEPL and there is minimal flexibility associated with parameter entry. As a result although it is a good means of quantifying BMP performance, the resulting data should not be used as a definitive representation of a BMPs actual performance capability.

For the Deal Lake Implementation Project the STEPL model was used to compute the load reductions attributable to the CTGC bio-infiltration basins/swale. The actual field data discussed above in Section 5.4 was used to evaluate and document the improvements gained through the installation of the Comstock Avenue MTD. It should also once again be noted that although post-installation storm sampling was attempted following the construction of the CTGC bio-infiltration BMPs, none of the targeted rainfall events generated any measurable discharge from any of the BMPs. As such, for events generating as much as 1.47" of rainfall, the basins/swale infiltrate all of the resulting runoff.

Table 9 provides the results of the USEPA STEPL modeling of the CTGC BMPs. As shown in Table 9 the CTGC BMPs have very good performance characteristics. The percent reductions for phosphorus and total suspended solids (TSS), two of the pollutants that most greatly impact the lake, are very good; 69% for phosphorus and 89% for TSS. As based on current land use and watershed data for the contributing sub-watershed within which the CTGC BMPs were constructed, this translates to annual load reductions of 8 lbs. of phosphorus and 6 tons of sediment.

Table 9 – Results of STEPL Modeling of Performance of CTGC Basins

Percent N Reduction	**Percent P Reduction**	**Percent BOD Reduction**	**Percent TSS Reduction**
55.7%	69.1%	13.7%	89.2%
Annual Load Reduction Nitrogen	**Annual Load Reduction Phosphorus**	**Annual Load Reduction BOD**	**Annual Load Reduction TSS**
36.5 lb/year	8.1 lb/year	17.1 lb/year	6.2 tons/year

Overall the data for the Comstock MTD and Colonial Terrace Golf Course BMPs show that such pollutant management measures yield very positive results. As such, not only are these BMPs having a positive effect in their specific location of installation/construction, but the data show that the use of similar BMPs elsewhere in the Deal Lake watershed would be valuable and in keeping with the goals of the WPP and the TMDL.

6.0 Future Projects

In addition to the projects completed and discussed above under the Deal Lake 319(h) Implementation Grant (#RP10-088), the Deal Lake WPP identified a number of other "drainage area-specific water quality, groundwater recharge and water quantity objectives" and the projects needed to meet these objectives. These future projects collectively work toward "the elimination, reduction, and minimization of stormwater related impacts associated with new and existing land uses." As was the case for the projects detailed in Sections 4 and 5 above, these future Deal Lake projects are aimed at reducing existing NPS pollutant loading to the lake and its tributaries. More specifically, they control/correct the documented phosphorus, pathogen, sediment and floatable problems that continue to impair the water quality of Deal Lake.

6.1 Proposed Stormwater Water Quality and Quantity Management Projects

In keeping with the goals and objectives of the WPP (refer to Section 6 of the WPP), the DLC will seek through future projects to meet specific water quality and quantity objectives as outlined herein:

Objective: Address bacterial impairments

Goal: Meet water quality standards for bacteria (TMDL)

Approach: Rely on stormwater ordinances (pet waste management, waterfowl feeding, etc.) along with improvements in riparian buffers, retrofit of existing stormwater collection/conveyance system, and elimination of remaining sanitary cross-connections and combined sewer overflows (CSOs).

Focus: Retrofit of existing stormwater collection/conveyance system

Objective: Address nutrient impairment and pollutant loading

Goal: Reduce nutrient loading, reduce transport of floatables, litter and debris

Approach:

- Retrofit catchbasins with NJCAT-certified devices along Routes 35, 66 and 18
- Create regional stormwater basins at the Mayer Dam-Harvey Brook, Hollow Brook, Lollypop Pond and at Seaview Square Mall.
- Duplicate the Comstock Avenue project by installing MTDs at key outfall sources of sediment and floatables.

- Duplicate the CTGC project by constructing bioretention and bio-infiltration type BMPs. Target publically owned lands including municipal buildings, schools, DPW facilities, parks and other open space areas.

Focus: Identify sites for projects that replicate the Comstock Avenue and CTGC projects. Initiate dialog with NJDEP regarding permits needed to regional basins

Objective: Address sediment loading to watershed and stream bank erosion

Goal: Reduce stream bank erosion

Approach: Develop the hydrologic and hydraulic data needed to properly design and construct Rosgen type stream bank stabilization solutions. Focus on bio-engineered solutions that are sustainable and compliment or recreate existing riparian habitat.

Focus: Target the well documented, high erosion stream segment of Harvey Brook between Roseld Avenue and Monmouth Road for biorestoration.

Objective: Address flooding issues

Goal: Reduce flood levels

Approach: Obtain funds needed to redesign and electrify flume gates so as to allow for the quick manipulation of lake level. Conduct detailed hydrologic and hydraulic studies of Harvey and Hollow Brooks with emphasis placed on the backwater impacts caused by the various road crossings.

Focus:

- Electrify flume gates as noted above to allow for the quick and safe manipulation of the lake's pool level.
- Implement flow controls at Hollow Brook, Lollypop Pond and Terrace Pond, by converting these independently dammed sections of the lake into designated regional stormwater management basins. This will not only address localized and regional flooding issues but facilitate periodic maintenance dredging under a General Permit-1 as opposed to a General Permit-13.
- Create regional stormwater basins at Mayer Dam (at Harvey Brook), Hollow Brook, Lollypop Pond and Sea View Square. Make use of existing structures, via their renovation and/or redesign to better control peak flows and control overall flood volumes.

Objective: Increase/Improve stormwater infiltration and recharge

Goal: Increase infiltration and recharge, decrease the volume of runoff

Approach: Decrease the runoff impacts from older, existing development sites by encouraging the routing of runoff into the underlying soils. Target runoff from roof tops and parking lots.

Focus: DLC must continue to work with municipalities to implement as part of the local development ordinances for **both** new and redevelopment projects a 110% or recharge requirement.

6.3 Education and Outreach

The Deal Lake Commission has long recognized that the success of any of the DLC's long-range NPS control, stormwater management and lake restoration initiatives requires the support of the public as well as local and county government. The continued protection and preservation of the Deal Lake Watershed is contingent upon an educated audience of county and municipal leaders, residents, land owners, and the business community regarding various matters affecting the health of Deal Lake, its watershed and its critical habitat areas. The Deal Lake WPP identified the need for ongoing public education and outreach, and linked such efforts directly to the requirements set forth in NJAC 7:15, the Municipal Stormwater Management Rules. As such, as part of any future projects, the DLC will seek to obtain funding that will enable it to:

- Improve communication, training and coordination among local, county, state governments, local committees, and environmental organizations for watershed related activities.
- Improve public education and raise awareness to promote stewardship of watershed resources, improve water quality, and reduce non-point source pollutants.
- Improve environmental and land conservation efforts by preserving open space, sensitive environmental areas and habitats by promoting such concepts as riparian buffer stream bank preservation and restoration, reforestation, floodplain preservation,
- Enhance the existing volunteer stream monitoring and restoration programs in this watershed offered by DLC and the Friends of Deal Lake and the municipal committees.
- Celebrate successes to recognize noteworthy efforts, encourage participation, and continue the implementation of the Deal Lake WPP at the annual meetings.
- Prepare and disseminate the Deal Lake related information via:
    - Educational Displays and Brochures for community events
    - Demonstration projects
    - Watershed tours or hikes
    - Workshops and staff training seminars
    - Volunteer opportunities for cleanups, plantings, monitoring or stenciling storm drains

- Local planning or ordinances efforts

As noted above, the WPP linked the need for continued educational efforts directly to the requirements of NJAC 7:15, especially as it applies to the education of township employees regarding BMP maintenance and management, and stormwater permitting. Educational efforts will also be promoted in future DLC 319(h) funded projects at the general public level. This will include but not be limited to:

- Disseminating information to landowners, schools and residents of the watershed about ways in which they can make a difference in the water quality of Deal Lake.
- Stream and lake cleanups,
- Re-plantings and restoration of riparian buffers
- Topics pertaining to the control of Canada geese.
- Information about low phosphorus fertilizers and proper lawn care will be disseminated to the public.
- Outreach to Planning Board and Land Use Board members pertaining to the Deal Lake WPP (its goals and objectives) and the watershed and stormwater management activities of the DLC.

6.4 Implementation of Future Projects

Table 10 is a list of future Deal Lake projects. These future projects were identified in the WPP and are based on the most recent field and monitoring data as well as input from the community and the lake's various stakeholders. Overtime as new needs emerge or current needs are met, the list of future projects can be expected to change. Additionally, because the projected cost estimates provided in the WPP reflect 2010 dollars, each project's costs may need to be updated to reflect current labor and material costs. The projected costs provided in Table 10 should thus be considered preliminary and subject to further refinement. The timing of the installations/construction of the prioritized BMPs and other restoration measures will also likely be determined by the availability of funding.

Table 10 – Future Projects			
Project	**Description**	**Responsible Party**	**Projected Cost**
Lollypop Pond Created Wetland	Create a wetland bioretention system	DLC, Ocean Township	$165,000
Mayer Dam	Rehabilitate existing Mayer Dam on Harvey Brook arm of lake to recreate regional stormwater management basin	DLC and Ocean Township	$1.1 million
Route 35/66 MTD Installations	Remove existing catch basins on Route 35 and Route 66 in the vicinity of the Route 35/66 circle. Replace with MTDs.	DLC, NJDOT, Ocean Township, Neptune Township	$450,000
Hollow Brook Bioretention System	Convert this independently dammed section of the lake into a designated regional stormwater management basin. Will address localized and regional flooding issues and facilitate periodic maintenance dredging under a General Permit-1 as opposed to a General Permit-13.	DLC, Neptune Township, and local stakeholder organizations	$600,000
Sea View Square Bioretention Basin	Convert existing stormwater detention basins at Sea View Square Mall into bioretention basins.	DLC, Ocean Township, Sea View Square property owners	$250,000
Stream Bank Restorations	Identify appropriate areas in need of stabilization and restore eroded stream channels.	DLC and local stakeholder organizations	$300,000 to $1million
Electrification of the Deal Lake Flume Actuators	Electrify flume gates to allow for the quick and safe manipulation of the lake's pool level.	DLC, Asbury Park and Loch Arbor Village	$100,000
Continued education and outreach	Implement education and outreach elements of the WPP	DLC/ each municipality local stakeholder organizations	$3,000 - $5,000 annually
Monitoring (see 6.5)	Annual monitoring program to track changes in lake and tributary conditions Resulting from WPP implementation	DLC/ local stakeholder organizations	$12,000 - $15,000 annually

6.5 On-going Water Quality Monitoring of the Lake and Its Tributaries

As well as enable the DLC and the public to track the water quality status of Deal Lake, an on-going water quality monitoring program provided the technical database needed by the DLC and the NJDEP to assess and quantify the success of lake and watershed improvement efforts. These data can also be used to confirm compliance and performance with the regulatory design standards measures. The focus of the monitoring plan presented below pertains to the former; evaluating the improvement in the lake and its feeder streams resulting from the implementation of the various lake and watershed management projects and initiatives. Tracking these improvements in water quality will be an ongoing responsibility of the DLC, but will be conducted dependent on the availability of funding. As such, as has been the case in the past, such monitoring will more than likely be an extension of a specific BMP implementation/installation project. A conceptual, cost-effective monitoring program is detailed below (Table 11). This program is similar in context to the stream and lake quality data collection effort conducted as part of the WPP Characterization and Assessment Study (Milestone 3). Any future sampling will be conducted in accordance with the NJDEP-approved Quality Assurance Project Plan (QAPP) developed as part of the overall WPP study. Sampling events will be limited to the "growing season", May through September, as this is when water quality impacts and impairments peak in the lake and its tributaries. Sampling will be conducted under both baseflow conditions (defined as a condition of 72 continuous hours where less than 0.5 inches of rain has fallen) and storm event conditions as detailed below.

Baseflow Sampling

Baseflow sampling should be conducted on a monthly scale at the in-lake and stream stations (or as noted below) between May and September.

- Temperature (in situ)
- Conductivity (in situ)
- Dissolved Oxygen (DO) (in situ)
- pH (in situ)
- Flow (in situ, at stream stations only)
- Water Quality Chemistry (by lab analysis)
    - Total Phosphorus (TP)
    - Soluble Reactive Phosphorus (SRP)
    - Total Suspended Solids (TSS)
    - Nitrate-Nitrogen (NO^3-N)
- Bacteriological (at each stream stations, but mid-lake station only)
    - E coli
- Benthic macroinvertebrates (at stream stations only, only in June)

Table 11 - Deal Lake Long-Term Water Quality Sampling Program

Station #	Sampled parameters	Waterbody	Subwatershed	Municipality
ST-1	chemical, bacterial, biological	Deal Lake	1-Main Lake Basin	Asbury Park/ Loch Arbour
ST-2	chemical, biological	Deal Lake	1-Main Lake Basin	Asbury Park/ Interlaken
ST-3	chemical, bacterial, biological	Deal Lake	1-Main Lake Basin	Asbury Park/ Ocean Twp
ST-4	chemical, biological	Deal Lake	1-Main Lake Basin	Allenhurst / Ocean Twp
ST-5	chemical, bacterial, biological	Harvey Brook	2-Harvey Brook	Ocean Twp
ST-6	chemical, biological	Tributary to Lollypop Pond	3-Lollypop Pond	Ocean Twp
ST-7	chemical, biological	Tributary	4-Colonial Terrace	Ocean Twp
ST-8	chemical, biological	Tributary	5-Tributary	Ocean Twp
ST-9	chemical, bacterial, biological	Hollow Brook	6-Hollow Brook	Neptune Twp

Storm Event Sampling

Annually three (3) storm events should be sampled; one in May, one in July and one in September. Sampling will be limited to the five stream stations (ST-5, 6, 7, 8 and 9). The sampled parameters will be as follows:

- Temperature (in situ)
- Conductivity (in situ)
- Dissolved Oxygen (DO) (in situ)
- pH (in situ)
- Flow (in situ)
- Water Quality Chemistry (by lab analysis)
  - Total Phosphorus (TP)
  - Total Suspended Solids (TSS)
- Bacteriological (at each stream stations, but mid-lake station only)
  - E coli

Annually the results of the baseflow and storm event sampling efforts should be synthesized in a summary report. The DLC, as it now does, will make use of its website and monthly public meeting to periodically (at least annually) present the results and findings of any water quality monitoring effort conducted by the DLC or stakeholders. The findings will also be summarized with regard to ongoing progress towards the performance and implementation of the measures stated in the WPP, whether they be voluntary or required. In addition, local community events will be targeted to disseminate general educational information, update the community on the implementation of specific projects, and to recognize or honor volunteers or stakeholders working on completed project tasks.

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Appendix A

Maps of Deal Lake and Its Watershed

Appendix B

Pre- and Post-Installation Sampling

QAPP and Field Data Results

Appendix C

Plans and Specifications

Photographs of Projects