FINAL REPORT

Stormwater BMPs and LID measures to protect coastal waters near Eagle Point Golf Club

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New Hanover County Planning Department

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INTRODUCTION

Eagle Point Golf Club (EPGC) near Wilmington, NC has demonstrated its commitment to preserving the habitat and function of the coastal marshes that surround the site. In 2003, the Eagle Point Golf Course entered ~218 acres of the 231.5 acre site into a conservation easement agreement with the North Carolina Coastal Federation (NCCF), to ensure that the property would be retained in perpetuity in a predominantly natural, scenic and open space condition.

As in many other coastal areas in NC, the watershed in which EPGC is located is becoming increasingly developed. Many of these areas currently drain through EPGC following storm events, potentially delivering excess surface water pollutants such as nutrients, sediment, and fecal bacteria. Because of its landscape position, EPGC has become a potential "last line of defense" for the coastal marshes down gradient. It currently serves as a buffer for the adjacent Little Creek and Middle Sound estuary. In keeping with the commitment of EPGC and NCCF, the NCSU Department of Biological and Agricultural Engineering has assisted the NHC Planning Department in the development of stormwater practices that will help strengthen the ability of this area to protect the surrounding coastal marshes.

OBJECTIVES

The objectives for this project were as follows:

1. Evaluate watershed characteristics and water quality data to determine optimal BMP/LID locations at EPGC.

2. Produce 6 stormwater BMP/LID concept designs

3. Implement a minimum of 1 stormwater BMP/LID practice

4. Cooperate with project partners to educate area decision-makers, the public and the broader golf course community about the water quality benefits of stormwater BMP and LID practices.

PROJECT DELIVERABLES

Objective 1 - Watershed evaluation

Evaluation of the watershed surrounding EPGC was conducted through a variety of methods. Aerial photography available through New Hanover County GIS provided a coarse determination of the watershed extents, percent land use, percent imperviousness, and likely stormwater flow paths. These observations were ground-truthed by examining areas of flow into the course, namely from Plantation Village Retirement Community and Porters Neck Country Club, and the irrigation/water management infrastructure utilized by the course.

Figure A1 (located in Appendix A) shows the main drainage flows into and out of the EPGC. This map has been included as an individual sheet and can be printed to scale on a tabloid sized sheet of paper. Outlined areas have been delineated as subwatersheds within EPGC based on topography and surface conveyances. Small arrows illustrate general flow paths for each area and how they connect. The course has been broken up into 5 major drainage areas, which combine to flow through 3 major outlets into Little Creek. The main outlets are shown with large blue arrows, and each corresponds with a sampling location in the monitoring portion of the project. The largest combined watershed flows to the area labeled Bridge Outlet. Three drainages, making up the largest portion of the course, combine to generate the outflow in this area. This includes the Upper, Lower, and Main Bridge Watersheds. The drainage area flowing to the Gate Outlet appears to deliver the second most flow into the marsh. The primary EPGC areas flowing to the outlet include the maintenance shop and the par 3 course. The Hole 18 Outlet delivers the least amount of stormwater into Little Creek. This drainage consistes of only a few golf holes, but also includes the EPGC clubhouse area.

The course receives off-site stormwater inflow from 3 main areas. These inputs include pond outflow from the Plantation Village Retirement Community (Off-site Input #1), and pumped flow from the Porters Neck Country Club (Pumped Off-site Inputs #2 and #3. Stormwater flow from the buildings and parking lots in the retirement community collects in a centralized pond that flows under Porters Neck Road (large purple arrow). During larger rainfall events, this water overtops Porters Neck Road as it flows towards EPGC. Additional flow is pumped from the Porters Neck Country Club through subsurface pipes to two locations on EPGC; a force main that enters a stream (large green arrow) and into the large pond located on the Par 3 course (large red arrow). Porters Neck Country Club uses a blue dye in their ponds that was observed in the stream and par 3 pond at EPGC on several occasions.

In general, each of the Outlet areas receives runoff from impervious surfaces. However, the percentage of impervious surface at EPGC is very low. Most of the buildings and parking areas would be described as disconnected impervious surface, meaning the areas do not discharge directly into surface waters and receive at least some filtering of runoff flows. The majority of impervious surfaces draining to Little Creek are actually found off-site at either Plantation Village Retirement Community or Porters Neck Country Club. The rest of EPGC is superbly maintained and there are no obvious problem areas.

A large portion of the water flow on the 18-hole course is recycled through a unique system of created streams and ponds. This water is used for irrigation and as an aesthetic amenity to the course. Recycling water on-site in this method increases the retention time of the water originating within the perimeter of the course as well as from off-site inputs, which generally may improve downstream water quality through water treatment and outflow peak and total volume reduction. It should be noted that water from the 3 ‘Bridge Outlet’ watersheds may be mixed and redistributed based on the timing and duration of the pumping associated with this recirculation system.

In addition, historical aerial photos of the site and soils data were examined (Figure 1 and 2). A historical perspective can provide a reference to the types of changes that may have led to possible water quality or flow issues. The majority of the area is mapped as Kenansville fine sand. This soil type is extremely sandy with high infiltration rates. The soil description indicates that ponding is not a problem and drainage issues are rare. Due to the high infiltration capacity of the surrounding soils, many ponds in the area need a liner in order to hold water. An aerial photo from 1993 (Google Earth – Figure 2) shows a single main drainage feature through the site, with what may be high ground on each side that had been cleared or farmed in the past. The amount of open area seen is a suggestion of the sandy and limited fertility of these soils.

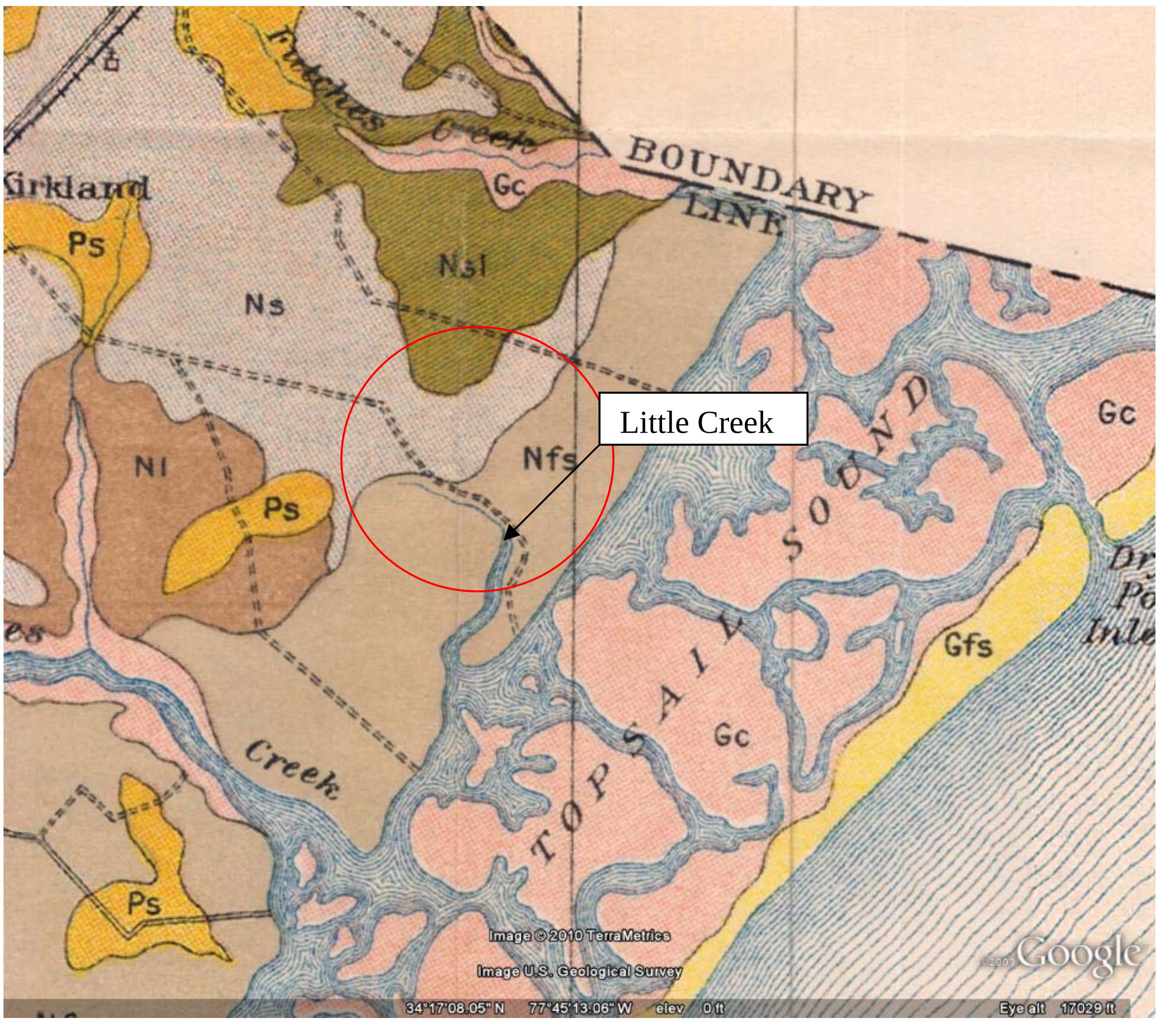

Figure 1. Historic Soil Map – 1906. Showing Little Creek and the drainage feature through the course. Source: UNC NC Maps website - http://www.lib.unc.edu/dc/ncmaps/index.html

Figure 2. 1993 satellite imagery of EPGC prior to construction (Google Earth, 2010).

It is likely that this area would naturally have very high infiltration rates, and very high evapotranspiration in a forested state. It appears that very little runoff would occur and very few water features were a part of the historical landscape. Even though the course is implementing what appears to be a very environmental water management scheme, it is a severe departure from historical natural conditions. The course development has generated a surface water based drainage system, creating a change from a watershed that would be dominated by infiltration and groundwater.

This historical perspective provides a framework for planning efforts. Any attempts to improve water quality in Little Creek should focus on returning the natural filtering and infiltration properties of the watershed. Targeting BMPs that provide runoff reduction, increased infiltration and evapotranspiration, and increased retention times where possible is the primary mechanism for accomplishing this. Based on our watershed evaluation and remaining potential given the existing site conditions, we determined strategic locations to place BMPs that would have the most impact on protection of Little Creek and the Middle Sound estuary. The focus of our BMP targeting was to reduce potential impacts of nutrients, sediment, and bacteria that may be present in stormwater outflow. The first 5 designs listed below focus around first developing BMPs that will treat stormwater as it enters the course from the retirement community and Porters Neck Country Club, and as it leaves through the headwaters of Little Creek at the Gate Outflow location. The last 5 designs include BMPs/LID measures that have the potential of enhancing and stablizing existing water management systems in areas higher in the EPGC watershed (i.e. further away from the estuary).

Objective 2 - BMP/LID designs

A limited amount of water quality data for the site existed prior to the project. Mallin et al. (2002) had found that Little Creek had generally good water quality but suspected that it would be susceptible to occasional fecal bacteria contamination. The authors recognized as the area continued to develop, other stressors such as nutrients and sediment from increased stormwater runoff could become a problem. This knowledge, coupled with the potential of nutrients and sediment loads that could be generated from within EPGC, plus our watershed assessment, drove our initial designs for BMPs at the site.

Concurrent to the development of our initial BMP designs , Dr. Mallin's team conducted a water quality assessment. In their *Eagle Point Golf Course Stormwater Assessment UNCW-CMS Report 09-05* (Mallin et al., 2009), the team verified the 2002 prediction by concluding that overall, the largest water quality issue was fecal bacteria that originated from outside EPGC and was passing through the site into Little Creek. The 200 CFU/100 mL NC standard was exceeded at least once at every sampling location. The Plantation Village Retirement Community outflow into EPGC exceeded the standard on 3 of 6 samplings (one sampling following a rainfall event was >5,000 CFU/100 mL) while outflow to Little Creek at the Gate Outflow location exceeded the standard on 4 of 4 samplings. At other sampling locations within EPGC, there appeared to be unexplained variability in fecal coliform measurements. Variable fecal bacteria concentrations measured in stormwater is not uncommon and is subject to much recent controversy on their source (from humans, animals, or disturbed sediments), persistence in the environment, and even methods in measurement (i.e. which indicator organism is the most indicative of contamination).

The report also documented that water quality related to sediment and nutrients (N and P) was high, a testament to the nutrient and water management practices employed by EPGC. However, as the watershed surrounding EPGC continued to change, inflow of these pollutants are likely to increase.

Dr. Mallin suggested that in addition to fecal bacteria, control of phosphorus should be considered since the phytoplankton in the upper portions of Little Creek appear to be phosphorus limited. Therefore, when developing BMP designs for this site, our goal was to isolate strategic locations that would maximize the potential for reducing the volume and pollutant concentrations of stormwater that could be exported from the site to Little Creek and Middle Sound estuary. We expect the levels of fecal coliform to continue to be variable. N and P should continue to be targeted because even though their levels are relatively low at this time, changes in watershed characteristics may result in increased nutrient loads in the future.

Our plan includes a total of 10 ideas for BMP implementation at EPGC. Three of these ideas were developed in detail and constructed as a part of this project. Seven additional ideas were included as preliminary concept designs for stormwater or LID measures to address critical areas. Figure A2 (Appendix A) shows the locations and sizes of the BMPs recommended. Appendix B contains photos of areas targeted with these BMPs. Below are descriptions of each and the benefits expected. Estimates for BMPs are given with the assumption that detailed design and implementation of these practices will be conducted by NCSU-BAE and EPGC maintenance personnel, with vegetation provided at current costs by local growers.

1. Stormwater wetland - Gate Area

Status: Detailed design and construction complete (June 2009). Detailed information related to design and cost is provided in the next section, while plans and photographs of the BMPs are included in Appendix C.

Rationale for recommendation:

This area originally served as a drainage outlet for surface runoff and from overflow of the main Par 3 pond. This pond receives a significant amount of pumped pond water from Porters Neck Country Club. This target area originally conveyed runoff through a swale underneath the main gate into EPGC and into Little Creek (Gate Outlet location). This area provided an ideal location to expand this drainage conveyance into a stormwater wetland. It also provided the last opportunity for water flowing from this section of EPGC to be treated before discharge into Little Creek.

Benefits expected:

Reduced peak discharge and volume of stormwater (freshwater) to marsh areas, increased stormwater retention time, high nutrient and sediment removal potential, variable to moderate fecal bacteria removal, improved aesthetic appeal of the area, high visibility for environmental awareness.

Figure 3. Completed wetland at EPGC in summer 2009.

2. Bioretention area #1
Status: Detailed design and construction complete (June 2009). Detailed information related to design and cost is provided in the next section, while plans and photographs of the BMPs are included in Appendix C.
Rationale for recommendation:
The area is located immediately adjacent to the stormwater wetland (BMP #1) and Par 3 pond, receiving surface runoff from the Par 3 course and private houses adjacent to the EPGC. This bioretention area was designed to receive surface runoff from the surrounding area via overland flow or through an 18 inch subsurface stormwater pipe that drains a linear swale on the edge of the property. It could also receive overflow from the stormwater wetland (BMP #1) during very large events. This flow otherwise would directly discharge to the marsh. Since this area would receive flow that is much more intermittent and would frequently be dry, bioretention was the better choice.
Benefits expected:
Reduced freshwater outflow to the marsh through complete infiltration of all intercepted runoff, high nutrient, sediment and fecal bacteria removal potential, improved aesthetic appeal of the area, high visibility for environmental awareness.

Figure 4. Bioretention area #1 after the initial planting.

3. Bioretention area #2
Status: Detailed design complete (June 2009) and construction initiated by EPGC as of January 2010. Detailed information related to design and cost is provided in the next section, while plans and photographs of the BMPs are included in Appendix C.
Rationale for recommendation:
A large portion of runoff from the EPGC clubhouse rooftops and parking area discharges to this flat area near the bridge across Little Creek. Concentrated stormwater flow has resulted in erosion on the bank where it has discharges into Little Creek. Site investigation and calculations indicate that bioretention is a perfect fit for this location. Bioretention will dissipate energy from stormwater and will reduce the erosion issues observed. The soil in this area is sandy which is perfect for an infiltration-type BMP. Excavation to accommodate the bioretention area will be minimal and this will be a very cost-effective BMP.
Benefits expected:
Reduced freshwater outflow to the marsh through increased infiltration, high nutrient, sediment and fecal bacteria removal potential, reduced bank erosion of the upper reach of Little Creek, improved aesthetic appeal of the area, high visibility for environmental awareness.

4. Conversion of Par 3 pond into a wet-pond with shallow littoral shelf
Status: Concept design
Rationale for recommendation:
The Par 3 Pond receives a significant portion of pumped drainage water from Porters Neck Country Club, and is situated in close proximity to the Gate Outlet to Little Creek. Increasing the storage capacity of the pond by raising the elevation of the pond outlet, while planting the inundated banks with wetland vegetation (i.e. creating a littoral shelf),

will increase the potential of this pond to function more like a combined stormwater wet pond and stormwater wetland complex. Due to its shape, this pond has a large perimeter that provides a large area for a littoral shelf.

Benefits expected:

Improved stormwater storage capacity and retention time, reduced peak flowrates, extended exposure to sunlight for improved bacterial removal, increased vegetated shallow water areas for improved bacteria and nutrient removal, increased bank stabilization for sediment control, potential increase in aesthetic appeal with additional wetland plants.

Cost Estimate:

Item	**Estimated Cost**
1 acre planting	$10,000
Outlet retrofit	$2,500
Oversight	$1,000
Total	**$13,500**

Figure 5. Example of a golf course pond with a vegetated littoral shelf.

5. Conversion hole #4 pond to include a shallow littoral shelf and stormwater wetlands complex

Status: Concept design

Rationale for recommendation:

This area receives direct flow from Plantation Village Retirement Community to the north of Porters Neck Road. This flow can exceed the capacity of the current culvert flowing underneath Porters Neck Road, resulting in flooding that overtops the road as it flows into EPGC. This stormwater has the highest mean nitrogen and bacteria concentrations entering EPGC. This pond does not appear to have the capacity to manage this runoff. Algal bloom occurrences in this pond are most likely correlated to nutrients washed into the pond during rainfall events. An addition of a small stormwater wetland and littoral shelf will increase the potential for biological treatment of these nutrients, while the additional amount of shallow water areas should improve bacteria removal.

Benefits expected:
Improved stormwater storage capacity and retention time, improved peak flow dampening, improved nutrient and bacteria removal prior to discharge into the EPGC recirculating system, potential increase in aesthetic appeal through additional vegetation planting.
Cost Estimate:

Item	Estimated Cost
Earthwork	$10,000
0.25 acre planting	$2,500
Outlet retrofit	$2,500
Oversight	$2,000
Total	**$17,000**

6. Creation of in-stream stormwater wetland by daylighting of stormwater pipe crossing #3 fairway
Status: Concept design
Rationale for recommendation:
Our recommendation to increase the assimilative capacity of the hole #4 pond is to daylight the discharge pipe flowing across #3 fairway and convert that area into a linear stormwater wetland. The removal of a stormwater pipe and installation of a stream and wetland system will dramatically improve the capacity of this area to react to peak storm flows. The expansion is targeted for an existing valley, and would require minimal earthwork and impact to the course. Other areas surrounding the pond that could be considered for this wetland are at elevations that would require extensive excavation that would otherwise make this BMP cost prohibitive for this area.
Benefits expected:
Enhance benefits of BMP#5 - Increased stormwater flow dampening, increased stormwater storage, improved hydrologic cycling, increased retention time for improved treatment of nutrients, sediment, and bacteria entering the site.
Cost Estimate:

Item	Estimated Cost
Earthwork	$20,000
1 acre planting	$7,000
Outlet retrofit	$5,000
Oversight	$5,000
Total	**$37,000**

Figure 6. Example stream and wetland complex on a golf course in eastern NC.

7. Maintenance area structural and non-structural BMPs
Status: Concept design
Rationale for recommendation:
The EPGC maintenance shop is the storage area for many vehicles, golf course equipment, and materials. The EPGC has implemented many measures to control runoff from vehicle washing and chemical storage areas, and they utilize materials recycling. Nutrient and waste (i.e. grass clippings) management by the EPGC maintenance personnel is exemplary, as evidenced by the low nutrient and sediment concentrations measured in water exported from the facility. This management could be improved by implementing some structural and non-structural BMPs around the maintenance facility. Improvements for further reducing sediment and other solids from entering the stormwater system could be realized by 1) storing sand and mulch on a covered containment pad and 2) applying mulch to landscaped bermed areas around the facility. Other recommendations to be considered include pervious parking, the regular sweeping or removal of materials and debris from impervious surfaces, and installation of cisterns or other runoff reduction strategies.
Benefits expected:
Reduced runoff volume to the stormwater system, reduced sediment and solids transported to the stormwater system, reduced loss of expensive sand and mulch, reduced visible erosion around the facility.

Cost Estimate:
It is challenging to estimate the cost of potential BMPs in this area. This would vary substantially depending on the level of implementation. Improved maintenance measures could be instituted at little cost. Small rain barrels can be outfitted for less than $100 each. Moderate sized cisterns can cost $5,000 or more to install. Storage area structures will be dependent on size and materials used.

Item	Estimated Cost
Cisterns/LID	$100-$5,000
Storage area structures	$10,000

Figure 7. A storage shed would keep materials dry, contained and accessible.

8. Recirculating stream stabilization and integration of floodplain wetlands
Status: Concept design
Rationale for recommendation:
The recirculating stream constructed on EPGC provides increased retention time of water on-site, while providing two man-made stream segments that meander through the course as a water hazard. It is also a visual amenity that adds to the course's attributes. In several locations, this stream and floodplain do not seem to be as stable as intended, particularly along hole #17 of the course. Other locations along the stream corridor also appear to be ideal locations to position small floodplain wetlands to trap runoff entering the stream from the fairways and during higher than normal flow events. The area could provide excellent treatment and would benefit from stabilization efforts and implementation of grade control structures that would improve storage and treatment.
Benefits expected:
Increased streambank stability and reduced sediment transport in the stream system, improved storage of stormwater, improved potential for nutrient reduction during baseflow, improved stream corridor aesthetics through wetland plantings.

Cost Estimate:

Item	Estimated Cost
1,500 feet stream work	$40,000
1 acre planting	$15,000
Grade structures	$12,000
Oversight	$10,000
Total	**$77,000**

Figure 8. A golf course stream with adjoining wetlands. Edenton, NC.

9. Addition of increased storage and littoral shelves to existing wet-ponds
Status: Concept design
Rationale for recommendation:
EPGC has at least 10 ponds around the golf course. All of the ponds were designed with a flow-through outlet. The latest stormwater pond designs incorporate a storage feature and a drawdown pipe which allows storm flows to be held and released over a period of several days. Many of the outlet devices on the course could be retrofitted to provide this type of storage. Plantings could be added that would improve treatment potential and biological activity in the ponds. In addition, a common course management method involves adding black colored dye to the ponds to reduce algal blooms. It is our opinion that this practice should be eliminated to enhance natural natural mechanisms for bacteria removal.
Benefits expected:
Improved bank stability, increased stormwater storage, increased potential for nutrient and bacteria treatment, improved nutrient cycling to avoid major blooms.
Per Pond Cost Estimate:

Item	Estimated Cost
Earthwork	$2,000
planting	$2,000
Outlet retrofit	$1,000
Oversight	$500
Total	**$5,500**

Figure 9. Another golf course pond with vegetated littoral shelf. Durham, NC.

10. LID measures around the EPGC clubhouse facility
Status: Concept
Rationale for recommendation:
The club and pro-shop facility comprise a significant percentage of the very small amount of impervious surface on the EPGC facility. There are several opportunities for EPGC to reduce its runoff impact around this area. Cisterns to collect runoff from roof top areas to be used in landscape irrigation, rain gardens located in low areas now receiving runoff from parking areas and concrete pads, and water collection systems to collect excess washwater generated from washing golf carts and cars that could be become reuse water.
Benefits expected: Reduced outflow of freshwater, peak runoff, bacteria, nutrients, and sediment to the 18th hole outlet to the marsh, rain gardens could serve as an aesthetic amenity.
Cost Estimate:
Cost estimates will vary depending on the number and detail of LID measures. A typical rain garden could be built here for as little as $2,000. A variety of rain gardens and other measures could be installed for $10,000-$15,000.

Item	**Estimated Cost**
Cisterns/LID	$2,000-$15,000

Figure 10. A typical bioretention area can look like a garden or be planted with grasses.

Objective 3 – Implementation

Three BMPs were constructed during this project. The construction funds were provided by the Community Conservation Assistance Program of NCDENR and EPGC. The detailed designs for the BMPs can be found in Appendix C. One stormwater wetland and two bioretention areas were installed. The wetland area covers approximately 13,500 square feet and has a total project size of 0.75 acre. The wetland captures runoff from approximately 40 acres of EPGC, and also intercepts pumped runoff from Porters Neck Golf Course. The bioretention areas capture runoff from almost 0.5 acre of impervious surfaces.

The wetland and one of the bioretention areas was constructed during a 2 week period in summer 2009. The planting of these areas was completed as an educational and volunteer effort managed by the North Carolina Coastal Federation. The event was well attended and was covered by local news sources. Over 8,000 wetland plugs and trees were planted in the BMPs. Both areas have developed well in a shortened growing season. Continued management by the golf course has allowed adjustments to be made as needed to ensure the site remains stable while vegetation develops. A controlled storage device was installed in the wetland in December 2009. The device is a series of aluminum weir plates that were attached to the existing concrete culverts. The plates allow approximately 1 foot of water to be stored in the wetland, and then is drawn down over a period of several days. The drawdown device is adjustable in order to manage water in the system more precisely. The second bioretention area was constructed in January of 2010. Planting for this area will be completed in the spring of 2010.

<u>Costs:</u>

Approximately $17,500 was spent on earthwork and plants for all of the BMPs built for this part of the project. A reasonable estimate of the breakdown would include $2,000 for each rain garden and $13,500 for the wetland. Labor for the planting of all the sites was donated by volunteers or EPGC. Construction oversight activities were provided as a part of the NCSU contract.

Objective 4 - Public outreach

NCSU-BAE assisted partners in environmental education and awareness programs. We accomplished this within 3 venues:

1. Participated in formal and informal strategic planning meetings that included EPGC, NHC, NCCF, and UNC-W staff. This forum allowed us to increase the awareness of partners on topics such as BMP strategic placement, function, and reasonable performance expectations.

2. We assisted NCCF to coordinate the planting of the stormwater wetlands and bioretention area constructed during this effort. We provided on-site guidance to volunteer planters on plant species, spacings, and locations during the planting outreach effort. An article about the volunteer planting effort was written in the Wilmington Star-News.

3. In addition, we provided editorial input for a fact-sheet developed by the NCCF on this project. Please refer to NCCF's report for more details on their impact on public outreach.

FINAL DISCUSSION AND RECOMMENDATIONS

<u>Discussion</u>

EPGC has proven to be a fantastic partner in this endeavor, and has demonstrated a genuine dedication to protecting downstream water quality. Nutrient and runoff management appears exemplary. However, it faces challenges in protecting downstream water quality brought upon by significant amounts of offsite stormwater entering EPGC, mixing with water located on-site, and discharging into Little Creek and the Middle Sound estuary. Partnerships developed during this grant between NCCF, UNC-W, NHC, NCSU-BAE and EPGC should be nurtured in the upcoming years to develop plans to implement the BMP/LID measures recommended in this report.

The UNC-W water quality report (Mallin et al., 2009) that was generated concurrently to the design and implementation portion of the project, identified fecal bacteria to be the number one target stormwater pollutant at EPGC. Levels coming into and being discharged from EPGC outlets were frequently above state levels for shellfishing and contact waters. Prior to this data, it had been our experience that target pollutants from golf course sites should be (in level of importance) nutrients, sediment, and fecal bacteria. Constructed wetlands and bioretention areas have been shown to remove all of these contaminants, and thus justified our early emphasis towards designing and implementing these BMPs at EPGC.

However, it must be noted that the performance of stormwater BMPs such as wetlands, bioretention, and wet ponds are highly variable with respect to fecal bacteria removal. It is believed that fecal bacteria can be removed in the environment and in these BMPs by the following mechanisms: solar (UV) disinfection, dessication (mainly in bioretention but possible in temporary inundation zones in stormwater wetlands), adsorption to biofilms, adsorption to soil particles during soil infiltration, sedimentation, and predation by other microbes (Kadlec and Wallace, 2009). As opposed to wastewater and water treatment plans that utilize complex, expensive, but highly successful and predictable unit processes such as intense UV irradiation and chlorination/dechlorination to aggressively remove bacteria, these stormwater BMP systems are located in an environment that is much more unpredictable at this time.

The effectiveness of bioretention is gained through infiltration of stormwater into the underlying soil. During rainfall events, these systems located in coastal regions infiltrate stormwater into the sandy underlying material and force this surface water to discharge slowly as groundwater to nearby drainage outlets. Filtration, sedimentation, predation, and dessication are the primary removal mechanisms in bioretention, making it seemingly a logical choice for fecal bacteria removal in coastal sites. Hathaway et al. (2009) documented successful reduction of fecal coliform in bioretention cells in Charlotte and Wilmington, NC. Average fecal coliform removal at the Charlotte site was from 2,420 CFU/100 mL to 258 CFU/100 mL. *E. coli* removal at the Charlotte site was around 92%, while at the Wilmington site (which had lower inlet concentrations) removal was around 60%. However, the watersheds for these bioretention areas were parking lots that had areas of 1 and 0.3 acres respectively. Therefore, despite the potential for fecal bacteria removal, utilizing this BMP for large drainage areas such as at the #4 inlet at EPGC <u>is not recommended</u> because it could not successfully infiltrate large inflows unless the bioretention area was designed to be much larger than a wetland. Therefore, bioretention should only be utilized at EPGC for smaller drainage areas with very sandy soils, but bacteria removal for these smaller areas will likely be high.

Due to the large amounts of stormwater that flow through EPGC, the existing infrastructure, and limited land area to install BMPs, wetlands and modifications of existing wet-ponds should be the primary focus moving forward to protect downstream water quality. Expectations for these systems to combat nutrient and sediment export to the downstream marsh should be high. Expectations that mean fecal bacteria concentrations exported throughout the year to be less than state limits may be unreasonable given past research on performance and the current state of the technology associated with these BMPs. Reasons for these tempered expectations are described in the next few sections.

Both wet ponds and wetlands have been shown to remove fecal bacteria. Removal mechanisms between these systems are slightly different, centering around vegetative cover and water depth. While wet-ponds have more open water area to allow for UV irradiation, deeper water limits penetration of sunlight. Vegetation in wetlands limits UV irradiation, but shallow depths and mixing (< 18 in) allow for greater penetration of the UV through the water column. Vegetation also provides biofilms to trap fecal bacteria that may make them available for predation. Since fecal bacteria adsorb to soil particles, researchers have tried to correlate removal of bacteria with the ability of wetlands and wet-ponds to remove sediment, but with mixed results. This is because the ability of wetlands and wet-ponds to remove sediment is variable and highly dependent on the design (size, depth, shape, number of pools, outlet structure, etc.) and the nature of the sediment particle size entering the systems. Based on the Mallin et al. (2009) report on the water quality at EPGC, sediment concentrations in their sampling was low, so there may not be an observable correlation to fecal bacteria concentrations at this site, so the impact of sediment on the performance of these systems should not be high.

Generally speaking, when wet-pond performance is compared to wetland performance for fecal bacteria, little difference in removal is observed (Davies and Bavor, 2000; Kadlec and Wallace, 2009). In a survey of constructed wetlands, Kadlec and Wallace (2009) found that performance of wetlands exceeded pond performance at high (10^4 – 10^6) inlet fecal bacteria concentrations, but at lower inlet concentrations the performance of wetlands diminish and approach that of pond systems. In the range of the fecal coliform concentrations observed by Mallin et al. (2009) at EPGC (about 1,000-3,000 CFUs/100 mL), wetlands can remove bacteria by about a log factor of 2 (Kadlec and Wallace, 2009), but still may export fecal coliform concentrations >200 CFUs/ 100 mL. Contributing to the performance limitations are potential inputs near the outlets by wildlife.

Recent studies by Hathaway et al. (2009) and Hathaway (unpublished data) of stormwater ponds and wetlands in the Wilmington, NC area also shows performance variability, but gives us an idea of the type of performance that will likely be observed at EPGC. A wetland of similar size to the one constructed during this project at EPGC reduced mean enterococci (another bacteria indicator with state contact limits of 104 MPN/100 mL) by 52% (1040 to 495 MPN/100 mL). A wet pond in the same study reduced enterocooci by 89% (497 to 52 MPN/100 mL).

Based on the above referenced surveys and studies, we feel that the modifications to the wet ponds and incorporation of wetlands at EPGC will reduce bacteria export to Little Creek . Addition of shallow littoral shelves to the existing ponds will enhance bacteria removal through additional storage (i.e. higher retention time), additional shallow water for UV irradiation, and additional vegetation for fecal bacteria entrapment. By adding stormwater wetlands in-line with these ponds, we hope to achieve additional removal of bacteria through the additional benefits of shallow water and vegetation. Still, consistently exporting water with what is considered low fecal bacteria <u>concentrations</u> will be difficult. Studies by Siewicki et al. (2007) in South Carolina measured fecal coliform concentrations at levels higher in a marsh than in surrounding stormwater ponds, reasoning human development pressures forced local wildlife migration to the marsh. Line et al. (2008) measured fecal coliform levels in stormwater samples (as MPN) in a mixed-use watershed in Carteret County that was similar to the range reported by Mallin et al. (2009) at EPGC. Of more interest to this discussion is Line et al. (2008) also measured reported median fecal coliform concentrations in a creek within in a nearby managed national forest of over 200 MPN/100 mL during 16 months of sampling, while there were mean values of nearly 400 MPN/100 mL during the summer months. So it should be expected that outside factors that may occur downstream and are independent of water management at EPGC may occasionally reduce the impact of the existing and proposed BMPs on fecal bacteria concentrations in Little Creek.

The fact that these wet-ponds and wetlands will be designed to increase detention time and reduce the volume of water entering Little Creek, will reduce the total bacteria loads to the marsh, a distinctly different criteria than concentration. Reduction in bacteria load, a product of bacteria concentration and volume of water exported, will likely have the largest impact in the future, because smaller delivery of fecal bacteria loads will allow Little Creek and the Middle sound estuary to more successfully assimilate them through removal mechanisms mentioned earlier plus dilution. Reduced delivery of these bacteria loads is the key in maintaining the health of the Middle Creek estuary, and our proposed BMPs will work in concert to accomplish that goal.

In summary, the implemented and proposed BMPs share a common thread in that they all work to provide natural water quality functions in an altered landscape. Each provides the benefits of reducing peak stormwater volume, increasing detention on-site, and reducing outflow volumes, which are all identified as historical features of the area. Nutrient, sediment, and fecal bacteria concentrations reductions that can be physically and biologically achieved through bioretention, stormwater wetlands, modification to the existing wet ponds, and stream restoration work, The combined effect will hopefully help restore much of the water processing capabilities of this area, and will reduce pollutant load delivery to Little Creek and the Middle Sound estuary from EPGC.

Key recommendations

1. EPGC should continue to execute its nutrient management and water management plan. In addition, EPGC should examine its use of dyes in wet-ponds that may impede UV irradiation of fecal bacteria.

2. BMPs that have been implemented at the time of this report should be maintained by EPGC with guidance from the project partners in order to achieve the full benefits of protecting Little Creek and the surrounding estuary from the effects of nutrients, sediment, bacteria, etc.

3. At the conclusion of this grant, project partners should continue to work together to find support to implement additional BMPs recommended in this report.

4. Project partners should develop a plan to identify if sources of stormwater originating from Plantation Village Retirement Community and Porters Neck Country Club can be reduced by improved stormwater management plans that may include implementation of stormwater BMPs on their property or alternative stormwater pumping schedules.

5. Conduct a detailed study of the sources of fecal bacteria entering into and existing within EPGC.

6. Develop a detailed study that assess the performance of existing and new BMPs at EPGC on the removal of nutrients, sediment, and bacteria.

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Appendix A – Watershed and BMP maps

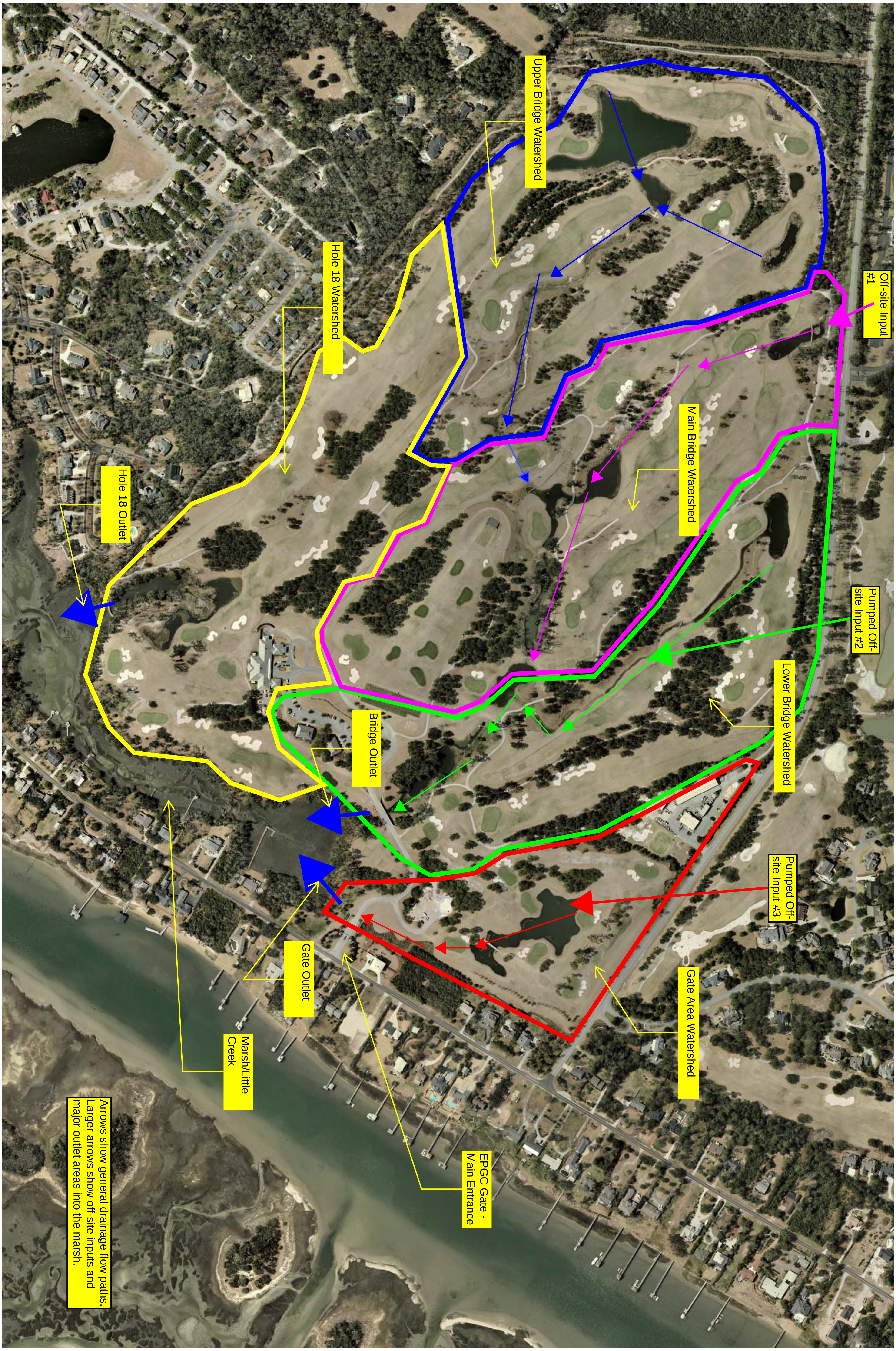

FIGURE 1

MAJOR DRAINAGES

Eagle Point Water Quality Project
Wilmington, NC

FILE:	PROJECT:	SCALE:	DATE:	CHECKED:	DESIGNED:
eagle_point0.dwg	Eagle Point	1" = 400 feet	April 2009	klb	klb, mrb

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DESIGNED:	klb, mrb
CHECKED:	klb
DATE:	Jan 2010
SCALE:	1" = 300 feet
PROJECT:	Eagle Point
FILE:	eagle_point01.dwg

POTENTIAL BMPs

Eagle Point Water Quality Project
Wilmington, NC

FIGURE

2

Appendix B – Photos of Key Locations at EPGC

Figure B1. Stormwater enters EPGC from Plantation Village Retirement Community through and 18 in pipe during normal flow or across Porters Neck Road (left) during high flow events.

Figure B2. Pond near Hole #4 tee box that receives runoff from Plantation Village Retirement Community

Figure B3. Par 3 pond that receives pumped stormwater from Porters Neck County Club

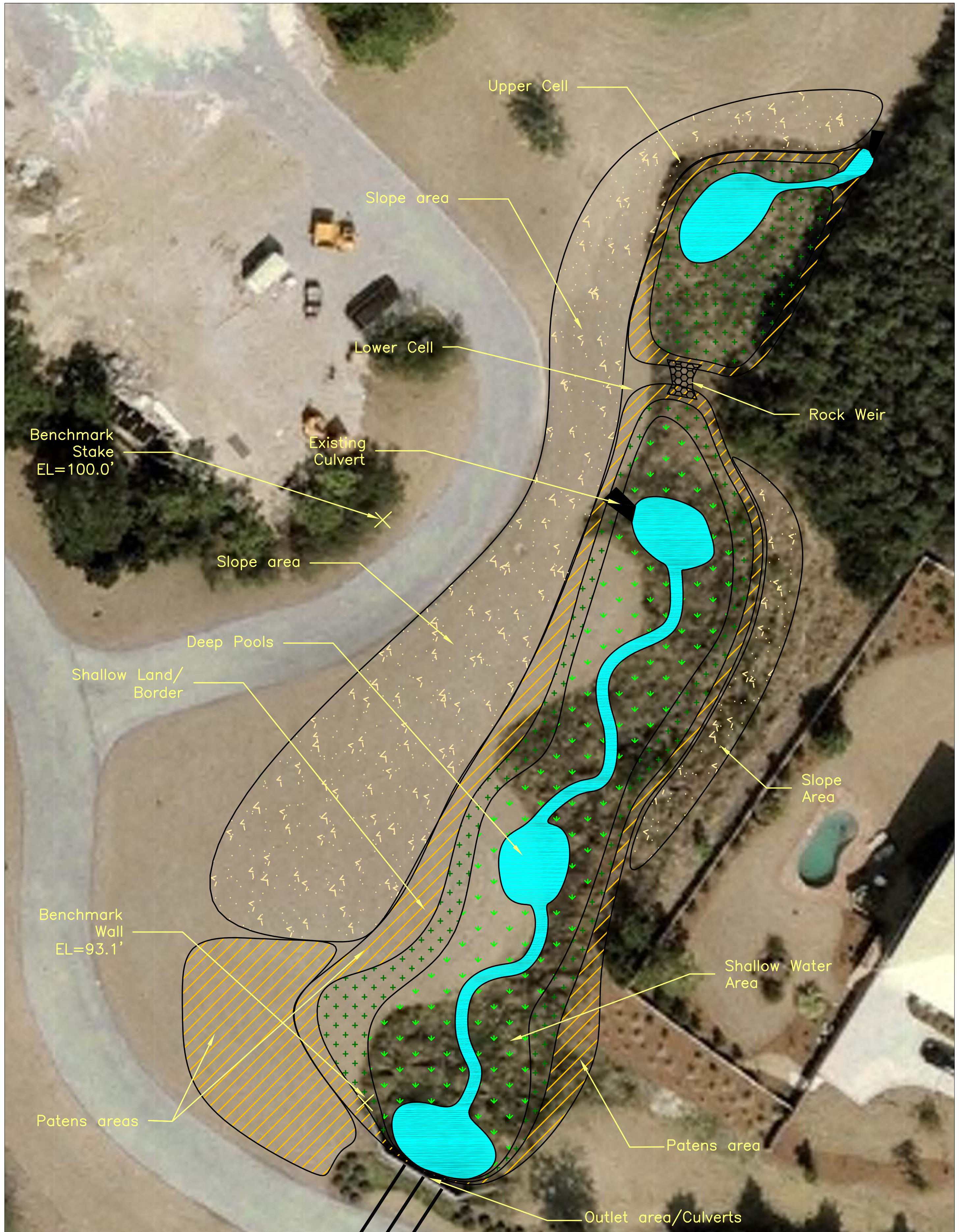
Figure B4. Gate Outlet to Little Creek and marsh area

Figure B5. Little Creek within EPGC, upstream of the Bridge Outlet

Figure B6. Area for stream stabilization and floodplain wetlands near hole #17

Figure B7. An ideal pond for adding storage and a littoral shelf

Appendix C – Detailed Plans and Construction Photos of BMPs Implemented



PROJECT NARRATIVE:
This is a joint project between Eagle Point Golf Course, New Hanover County, North Carolina Coastal Federation, the Community Conservation Assistance Program, and the NC Clean Water Management Trust Fund. The purpose of this project is to build a stormwater treatment system that will intercept golf course runoff before it outlets into the Little Creek marsh. Construction of the wetland will involve bulk grading in shallow excavations, detailed grading of wetland features and berms, with particular attention to erosion control and re-seeding/planting. The project will also involve the installation of some outlet control.

Project Managers:
Tracy Skrabal
North Carolina Coastal Federation
Shawn Ralston
New Hanover County Planning Department

Project Engineers:
Kristopher Bass PE
NCSU/BAE
919.515.8245
Mike Burchell
NCSU/BAE
919.513.7372

Project Summary:
Total Project Area: 33,500 sf
Slope Areas: 20,000 sf
Shallow Water Area: 8,000 sf
Shallow Land Areas: 3,500 sf
Open Water Areas: 2,000 sf
Total Wetland Area: 13,500 sf
Plant List

Re-seed all disturbed areas with appropriate grass mix as directed by the Project Engineer

Plant a total of 2,000 wetland plants at 2 ft center spacing. Plant in groups in Shallow Water Areas.
Pontedaria cordata
Petlandra virginica
Sparganium americanum
Saurus cernus
Sagittaria latifolia

Plant a total of 780 wetland plants at 2 ft center spacing. Plant around the wetland border in Shallow Land Areas.
Juncus Effusus
Scirpus validus
Carex Critina

Plant a total of 2,000 wetland grasses in the designated Patens areas.
Spartina patens

Shrubs
Plant a total of 100 shrubs. Plant on slopes and in upper cell as directed.
Clethra alnifolia
Ilex glabra
Hibiscus moscheutos
Rosa palustris
Cyrilla racemiflora
Lobelia cardinalis
Cephalanthus occidentalis

Trees
Plant a total of 5 trees as directed.
Taxodium distichum

80 0 20 40 80
(IN FEET)
1 inch = 40 ft.

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DESIGNED:	klb, mrb
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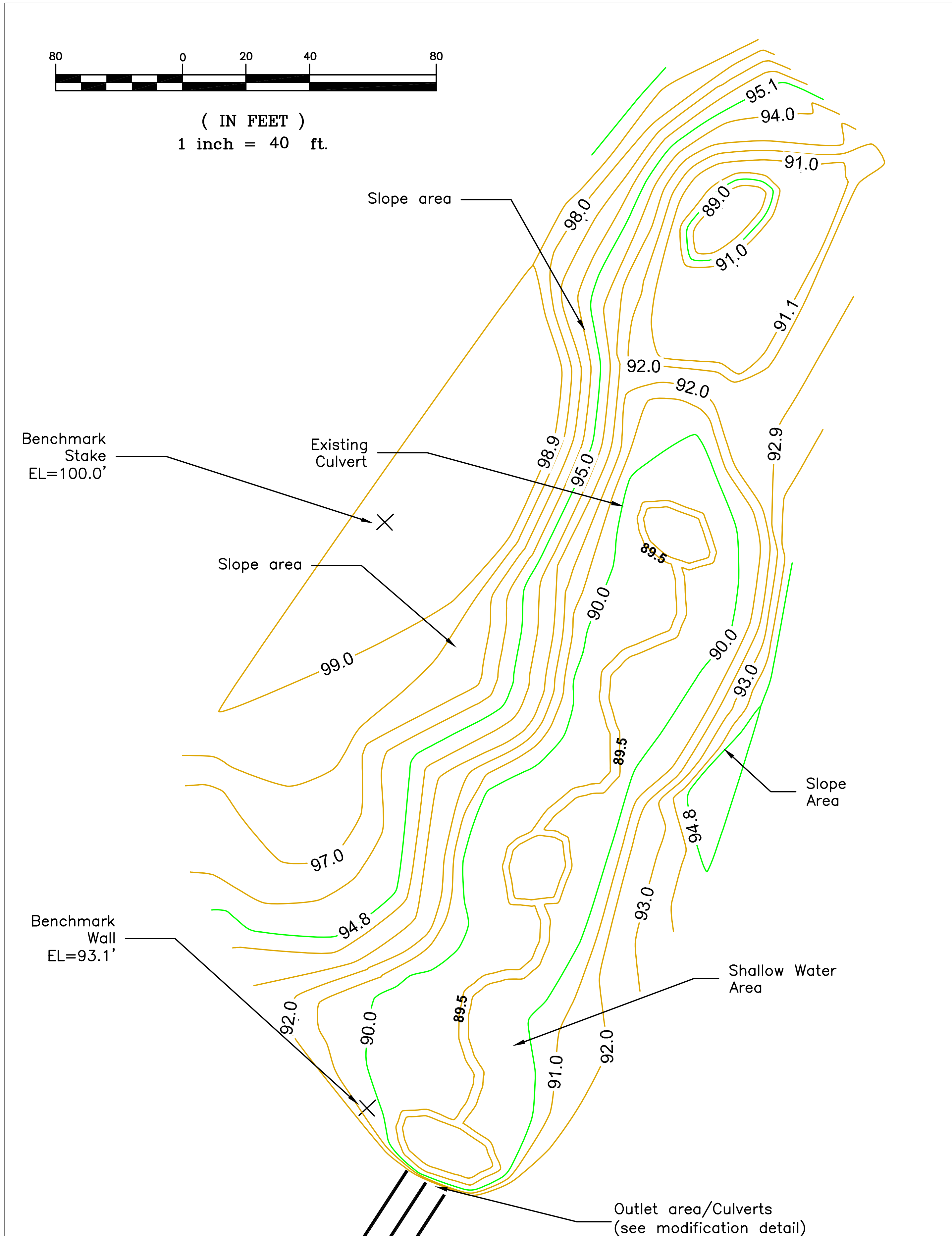
DATE:	April 2009
SCALE:	1" = 40 feet
PROJECT:	Eagle Point
FILE:	eagle_point02.dwg

PROJECT SCHEMATIC

Eagle Point Stormwater Wetland
Wilmington, NC



Instructions for Contractors

1. Protection of existing improvements and utilities is the responsibility of the contractor. Any repairs or replacement necessary will be the responsibility of the contractor.
2. Excavated material should be kept on-site for use as the Project Engineer sees fit. Extra material will be removed by the contractor upon project completion.
3. Coordination with the Golf Course for access and storage of equipment will be neccessary.
4. Repair and re-seeding of any areas outside the grading boundaries is the responsibility of the contractor.
5. All benchmarks are relative. Utilize as directed and all grading is to be completed to the extent and approval of the Project Engineer.

Materials List

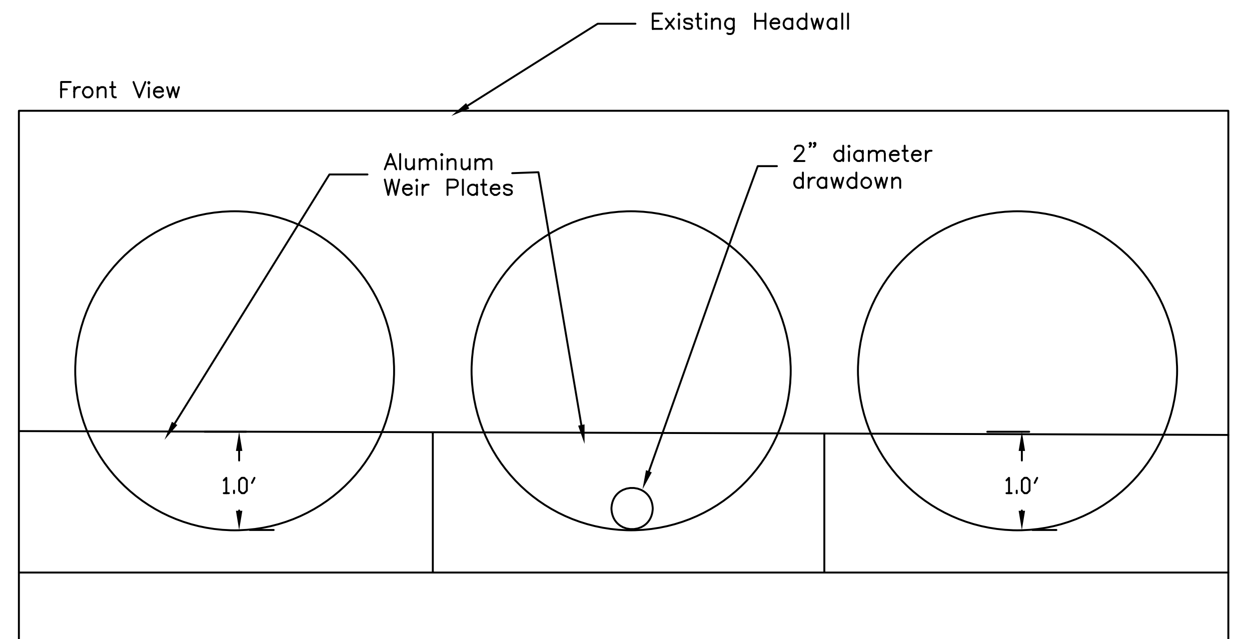
Excavation: 2,000cy
Class B Riprap: 20cy
Erosion Control Blanket: 2,000 sf (NAG SC150BN or equivalent)
Filter Fabric: 100 sf
Outlet Structure: See Details Below

Wetland Areas	Normal Depths	Ground Elevations
Deep Pools	1-2.0'	87.5'-89.5'
Low Flow Channels	1-1.5'	88.0'-89.5'
Shallow Water	0-6"	89.5'-90'
Shallow Land	0-1.0'*	90'-91'
Slopes	1.0-5'*	91'-95'

* Shallow Land and Slopes are above Normal Pool Level

Outlet Area Details
Notes:
1. Install manufactured aluminum weir plates to maintain water levels as shown.
2. Install aluminum weir plate at least 1' high or to an elevation of at least 91.0'.
3. Install concrete anchors with lag bolts to secure plates.
4. Use hydraulic cement and sealant to ensure a leakproof seal.
5. Install a 2" diameter drawdown pipe at the base of the center culvert.
6. Install drawdown elbow and extension into pool.

Front View



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DESIGNED: klb, mrb
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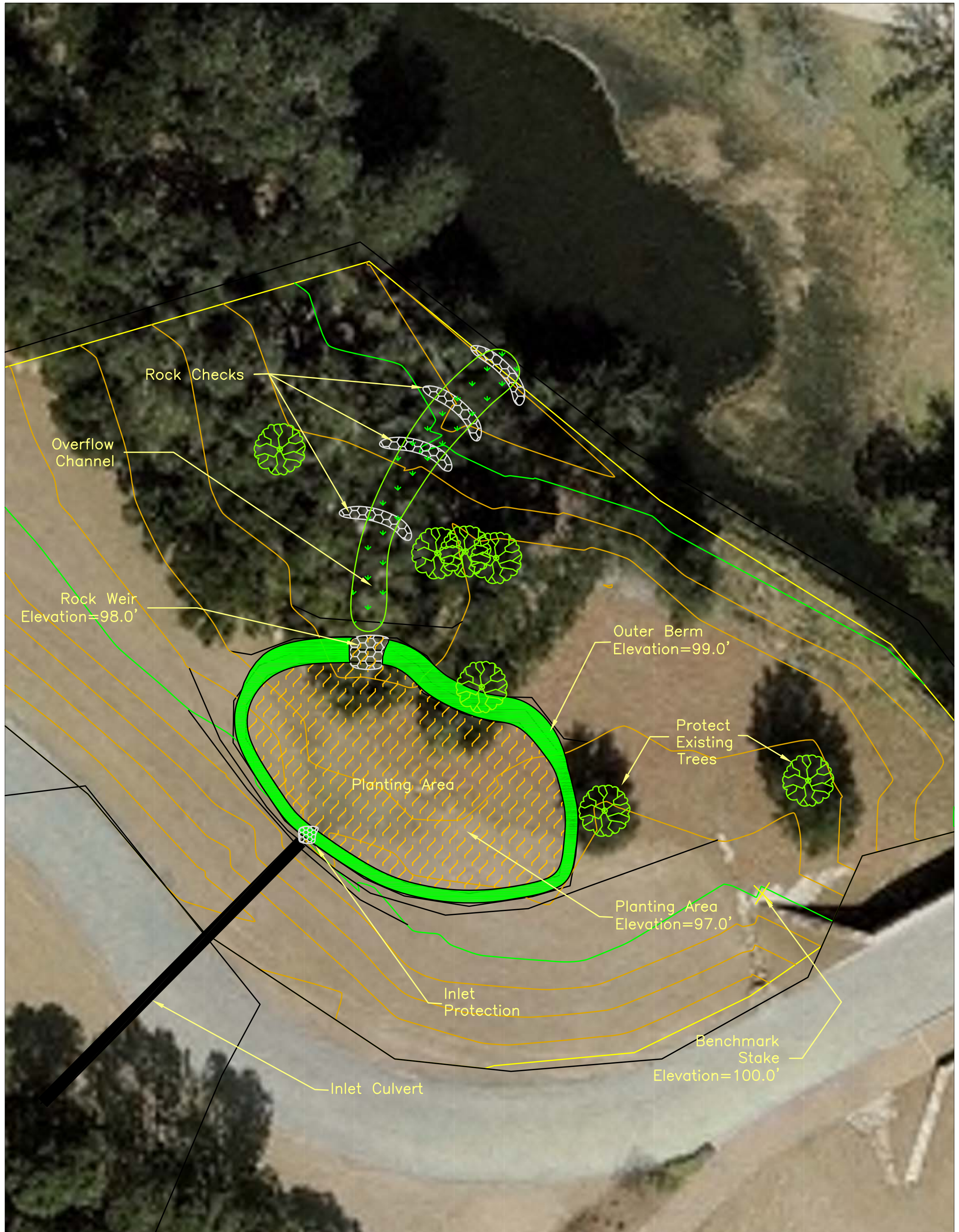
GRADING/OUTLET DETAILS

Eagle Point Stormwater Wetland
Wilmington, NC

PAGE NUMBER
2 OF 2



PROJECT NARRATIVE:
This is a joint project between Eagle Point Golf Course, New Hanover County, North Carolina Coastal Federation, the Community Conservation Assistance Program, and the NC Clean Water Management Trust Fund. The purpose of this project is to build a stormwater treatment system that will intercept golf course runoff before it outlets into the Little Creek marsh. Construction of the bioretention area will involve tilling, detailed grading of the planting area and berms, with particular attention to erosion control and re-seeding/planting. The project will also involve the installation of some outlet control and several small check dams.

Instructions for Contractors

1. Protection of existing improvements and utilities is the responsibility of the contractor. Any repairs or replacement necessary will be the responsibility of the contractor.
2. Excavated material should be kept on-site for use as the Project Engineer sees fit. Extra material will be removed by the contractor upon project completion.
3. Coordination with the Golf Course for access and storage of equipment will be neccessary.
4. Repair and re-seeding of any areas outside the grading boundaries is the responsibility of the contractor.
5. All benchmarks are relative. Utilize as directed and all grading is to be completed to the extent and approval of the Project Engineer.

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Materials List

Class B Riprap: 25cy
Erosion Control Blanket: 200sf (NAG SC150BN or equivalent)
Filter Fabric: 100 sf
Hardwood Mulch: 30cy

Project Summary:
Total Project Area: 3,700 sf
Planting Areas: 2,500 sf
Berm Area: 1,200 sf

Planting Plan

Re-seed all disturbed areas with appropriate grass mix as directed by the Project Engineer.

The Planting Area shall be levelled to the designated elevation and rip tilled to a depth of 2 feet. Additional levelling shall be completed with light or low pressure equipment.

The entirety of the planting area shall be covered with 4 inches of triple shredded hardwood mulch.

Plant a total of 275 plugs at 3 ft center spacing. Plant as directed in the Main Planting Area.
Juncus Effusus
Carex Critina
Spartina patens

Shrubs
Plant a total of 50 shrubs. Plant on slopes and in upper cell as directed.
Clethra alnifolia
Ilex glabra
Hibiscus moscheutos
Rosa palustris
Cyrilla racemiflora
Lobelia cardinalis
Cephalanthus occidentalis

Trees
Plant a total of 5 trees as directed.
Taxodium distichum
Quercus virginiana

60 0 15 30 60

(IN FEET)
1 inch = 30 ft.

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FILE:	eagle_point02.dwg

PROJECT SCHEMATIC

Eagle Point Stormwater Wetland
Wilmington, NC

Figure C1. Stormwater wetland area prior to construction

Figure C2. Stormwater wetland outlet area prior to construction (discharges to Little Creek through Gate Outlet location)

Figure C3. Bioretention area #1 prior to construction

Figure C4. Excavation of the stormwater wetland. Topsoil was stockpiled and redistributed to enhance wetland plant growth

Figure C5. Excavation of the deep pools in the stormwater wetland.

Figure C6. Construction oversight ensured designed elevations were achieved and soil was not overly compacted during excavation to enhance planting

Figure C7. Bioretention area #1 capturing runoff prior to planting

Figure C8. Stormwater wetland 2 months after planting (August 2009)

Figure C9. Bioretention area 2 months after planting (August 2009)

Figure C10. Stormwater wetland 4 months after planting (October 2009). Note the blue dye which is indicative of the impact of pumped water from Porters Neck Country Club

Figure C11. Stable banks four months after planting (October 2009). Planted with native *Spartina patens.*

Figure C12. Wetland inlet and bioretention area (October 2009).