

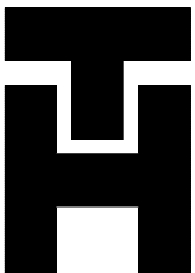
**DRAINAGE STUDY**  
**PHASE 2 – ALTERNATIVE IMPROVEMENTS**

FOR:  
**LAKWOOD – PIRATELAND SWASH**  
HORRY COUNTY, SC

PREPARED FOR:  
**HORRY COUNTY**  
**STORMWATER DEPARTMENT**

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## **BACKGROUND AND INTRODUCTION**

Horry County is experiencing rapid growth and in certain places, the pace of development continues to outgrow the capacity of the existing drainage system. Flooding concerns have been voiced by many of the businesses and residents in the Lakewood-Pirateland Swash Basin (Exhibit 1). Structural flooding of several business and/or homes has been recorded on at least two occasions in the past.

The Lakewood-Pirateland Basin drains 1,560 acres including the Lakewood and Pirateland Campgrounds, Long Bay Estates, and portions of the Myrtle Beach State Park, all east of US Highway 17 Business. West of US Highway 17 Business, the basin provides drainage for the Prestwick Subdivision and Country Club, Crystal Lakes Mobile Home Park, Seagate Village (formerly part of Myrtle Beach Air Force Base), and commercial properties along the highway. Drainage is conveyed through a swash to the Atlantic Ocean.

The Horry County Stormwater Department intends to implement a three phases approach to improving drainage in the basin – including (1) the development of a hydrology and hydraulic model, (2) alternatives analysis and recommendations, and (3) implementation of the recommended improvements if deemed financially feasible.

### Phase 1

Phase 1 of the Lakewood-Pirateland Swash Drainage Project included six tasks including:

- Task 1 – Data Collection
- Task 2 – Field Reconnaissance
- Task 3 – Surveying
- Task 4 – Existing Conditions Model Development
- Task 5 – Model Calibration
- Task 6 – Phase 1 Study Findings and Report

Phase 1 of the Lakewood-Pirateland Swash Drainage Project was documented in the report *Lakewood-Pirateland Swash Drainage Study* (Thomas & Hutton, February 29, 2012).

### Phase 1 Additional Analysis

Due to certain findings of the Phase 1 report, the Horry County Stormwater Department requested additional study of the Lakewood-Pirateland Swash Drainage Basin. In particular, the County commissioned additional survey and drainage system analysis of the minor collection system draining through Strathmill Court. The additional survey and drainage system analysis work was documented in a Technical Memorandum *Lakewood-Pirateland Swash Drainage Improvements – Strathmill Court Study Findings* (Thomas & Hutton, May 3, 2012).

### Phase 2

Phase 2 of the Lakewood-Pirateland Drainage Study included the assessment of alternatives that could be implemented within the basin that would address flood issues – particularly the structural flooding of businesses along Highway 17 Business and homes in the Prestwick subdivision. Phase 2 was conducted under the following five tasks:

- Task 1 – Alternative Projects Screening
- Task 2 – Alternative Project Evaluation
- Task 3 – Alternative Post Improvement Conditions Model Development
- Task 4 – Opinion of Probable Cost and Benefit Analysis
- Task 5 – Phase 2 Study Findings and Report

The following sections describe each task conducted as part of Phase 2 of the Lakewood-Pirateland Swash Drainage Study.

### **ALTERNATIVE PROJECTS SCREENING**

Alternative improvement projects were developed that addressed the structural flooding issues identified in Phase 1 of the project – mainly the flooding upstream of the US Hwy 17 Business at the business (Camper County) just west of the highway and the two residences in the Prestwick Sub-division (1284 and 1288 Strathmill Ct.).

Alternative improvement projects with the potential to alleviate the identified structural flooding were developed and screened for further assessment. The following projects were selected for further assessment as part of Phase 2 of the study.

- Alternative 1: Improvements to the existing culvert under US Hwy 17 Business
  - Alternative 1A: Addition of a 5'x10' CBC underneath US Hwy 17 Business and improvements to approximately 1,200 LF of Channel
  - Alternative 1B: Addition of a 7'x7' CBC underneath US Hwy 17
  - Alternative 1C: Addition of a 42" RCP underneath US Hwy 17 Business
- Alternative 2: Detention on a parcel adjacent the main channel (Graham Walden Tract)
  - Alternative 2A: Detention of flow entering the main channel from across Catherine Avenue (flow from the camper storage area along US Hwy 17 Business)
  - Alternative 2B: Diversion and detention of flows entering the pond/wetland area along Catherine Avenue (flows from the Prestwick Sub-division)
  - Alternative 2C: Off-line detention of flows in the main channel
- Alternative 3: Detention on a wooded area between Prestwick Phase IV and Sea Gate Village
- Alternative 4: Total and partial diversion of flows from the main channel (adjacent Sea Gate Village) to Crystal Lake
  - Alternative 4A: Partial diversion of high flows to Crystal Lake through a side-flow weir from the main channel
  - Alternative 4B: Total diversion of the flow from the main channel (draining the northern Sea Gate Village tributary)
  - Alternative 4C: Total diversion of the flow from the main channel (draining the northern and southern Sea Gate Village tributaries)
- Alternative 5: Detention in the common areas of Sea Gate Village
- Alternative 6: Modification of the pond control structure in Prestwick Phase 1

In addition to the alternative projects listed above that address the structural flooding (US Hwy 17 Business and Strathmill Court), local improvement alternatives that address potential flooding of the Strathmill Court residences were also selected for further assessment. These alternatives include:

- Alternative 7: Diversion of the local Strathmill Court drainage system to the main channel
- Alternative 8: Improvements to the local flood protection system along the main channel at Strathmill Court

The locations of the alternative projects are show on Exhibit 2. Detail conceptual plans for each alternative project (except Alternative 6) are illustrated in the Figures 1A, 1B, 1C, 2A, 2B, 2C, 3, 4A, 4B, 4C, 5 (2 sheets), 7 and 8.

### **ALTERNATIVE PROJECTS POST-IMPROVEMENT CONDITIONS MODEL DEVELOPMENT**

For alternative projects 1 through 6, individual post-improvement conditions ICPR stormwater models were developed to assess the effectiveness of each alternative project. The model inputs are based on the alternative project's conceptual plan depicted in the figures. The alternative projects were optimized to maximize the flood control effect of project while minimizing impact to adjacent properties or structures. The alternative projects were also refined to fit the physical parameters of the area to be improved, including elevations, storage areas, etc. The following are a brief description of each alternative as refined in the post-conditions modeling process.

#### **Alternative 1A – US Highway 17 Business Culvert Improvements and Main Channel Improvements**

This alternative consists of installing a 5'x10' CBC underneath US Highway 17 Business parallel to the existing 7'x7' CBC. The proposed alternative would include the reconstruction and expansion of the upstream and downstream headwall/wingwalls and aprons. In addition, the alternative would include improvements (widening to 20' bottom width with 2:1 side slopes) to approximately 1,200 LF of the main channel upstream of US Highway 17 Business. This alternative was optimized to prevent flood of structures (including garages) up to and including the 100-year event.

#### **Alternative 1B – US Highway 17 Business Culvert Improvements**

This alternative consists of installing a 7'x7' CBC underneath US Highway 17 Business parallel to the existing 7'x7' CBC. The proposed alternative would include the reconstruction and expansion of the upstream and downstream headwall/wingwalls and apron. The alternative produced significantly lower peak water surface elevations upstream of US Highway 17 Business and eliminated finished floor (FF) flooding (up to the 100-year event) at the two locations. However, garage flooding could continue to occur after this improvement for some larger events.

#### **Alternative 1C – US Highway 17 Business Culvert Improvements**

This alternative consists of installing a 42" RCP underneath US Highway 17 Business parallel to the existing 7'x7' CBC. The proposed alternative would include the reconstruction and expansion of the upstream and downstream headwall/wingwalls and apron. This alternative was optimized to be the minimum improvement needed to prevent FF flooding of structures (up to the 100-year event). However, similar to Alternative 1B, garage flooding could continue to occur after this improvement for some larger events.

#### Alternative 2A – Detention Pond at Catherine Drive

This alternative consists of constructing a 0.67-acre wet detention pond adjacent Catherine Drive on the Graham Walden Tract. The alternative would include diverting drainage from the exiting 30" RCP under Catherine Drive into the proposed detention pond. The ponds normal water and stormwater release would be controlled by a structure that would discharge directly to the main channel.

This alternative resulted in only minor improvements to peak water surface elevations and mainly or smaller storm events (i.e. 2-, 10- and 25-yr events), with no significant improvement for larger events.

#### Alternative 2B – Detention Pond at Catherine Drive

This alternative consists of constructing a 0.62-acre wet detention pond adjacent Catherine Drive on the Graham Walden Tract. The alternative maintains the drainage from the exiting 30" RCP under Catherine Drive in a ditch on the southeast side of the property. The alternative would divert the stormwater from the existing pond/wetland that received runoff from the Prestwick sub-division into the new pond.

The diversion would include the installation of triple 60-inch RCP pipes from the existing wetland/pond to the proposed pond. The proposed pond would outfall to the main channel through triple 60-inch RCP pipes. The alternative would also include the abandonment of the outfall of the existing pond/wetland (which is essentially a narrow ditch).

This alternative resulted in minor improvements to peak water surface elevations (mainly the area of the main channel adjacent the Strathmill Court properties), but no improvement downstream (i.e. immediately upstream of US Highway 17 Business).

#### Alternative 2C – Detention Pond at Catherine Drive

This alternative consists of constructing a 0.80-acre dry detention pond adjacent Catherine Drive on the Graham Walden Tract. The alternative maintains the drainage from the exiting 30" RCP under Catherine Drive in a ditch on the southeast side of the property. The alternative would serve as an off-line detention area for high flows from the main channel.

High flows would spill into the detention area through a rip-rap weir. The stormwater would flow back into the main channel after the storm passes, with the lowest part of the detention area being drained by a small 18-inch RCP drain pipe.

This alternative resulted in only minor improvements to peak water surface elevations and mainly for smaller storm events (i.e. 2- and 10-yr events), with no significant improvement for larger events.

#### Alternative 3 – Detention Pond at Lakeview Drive

This alternative is the construction of a 3.35-acre wet detention pond in the area between Lakeview Drive and Seagate Village (currently a wood tract of land). The detention pond would be an in-line detention pond that would receive flows from Seagate Village and Crystal Lake. The pond would outfall through a control structure immediately upstream of the bridge at Lakeview Drive.

This alternative resulted in moderate improvements to peak water surface elevations in the main channel, with improvements at the structure flooding location of nearly 0.25 feet. However, this alternative would not eliminate structural flooding for the 100-year event.

#### Alternative 4A – Crystal Lake Modifications

This alternative would be the construction of a side-discharge weir that would allow higher flows in the channel between Seagate Village and Crystal Lake to overflow into Crystal Lake during most events (including the 2-yr). The weir would be rip-rap lined at an elevation of approximately 14.5 feet, which is slightly above the NWL of the lake at the time of the survey conducted for this study (December 2011). The weir would preclude the lake from reaching water levels above 14.5 feet. A wooden raised boardwalk is proposed for the existing walking trail adjacent Seagate Village to span the proposed weir.

This alternative resulted in improvements to peak water surface elevations for the 100-year storm event by nearly 0.4 feet at the two structural flooding locations. However, this would not eliminate the potential of flooding during the 100-year rainfall event.

#### Alternative 4B – Crystal Lake Modifications

To better utilize Crystal Lake, this alternative would modify the control structure of the lake and lower the NWL to elevation of the existing outfall pipe (elevation 13.5 feet). The modification would be relatively inexpensive, but could result in areas of the lake bottom becoming partially exposed. Partial areas of the lake bottom are currently exposed (December 2011) at the current NWL of 14.39 feet.

The alternative would also include the diversion of a portion of the Seagate Village into Crystal Lake. This would include the abandonment of an existing culvert in the channel between Seagate Village and Crystal Lake that would force drainage through a proposed culvert (triple 48-inch RCP) into the lake. This alternative would convert Crystal Lake into an in-line detention pond with a portion of Seagate Village drainage passing through the lake.

This alternative is nearly successful in eliminating structural flooding at the two locations up to the 100-year rainfall event. However, it does not eliminate the potential for structural flooding through the 100-year event. This alternative would significantly impact Crystal Lake. Potentially to mitigate the effect, the lake's bottom could be lowered by dredging. However, it would be a significant project and cost to dredge out a portion of the lake.

#### Alternative 4C – Crystal Lake Modifications

To best utilize Crystal Lake would require a significant modification to the operation and appearance of the lake. This alternative would replace the lake's control structure and outfall to allow for the NWL in the lake to be elevation 10.0 feet. This would allow drainage from all of Seagate Village to be diverted to Crystal Lake and thus be detained in the large lake. The existing bottom elevation of Crystal Lake is unknown, but from visual observation, portions of the bottom are significantly higher than elevation 10.0. Thus a significant project would be required to increase the depth of the lake to accommodate this alternative.

This alternative significantly improves the peak water surface elevations downstream in the main channel (and some contributing systems). This alternative would eliminate the potential for structural flooding at the two locations up to and including the 100-year rainfall event.



### Alternative 5 – Detention Ponds at Seagate Village

The common areas of Seagate Village allow for the opportunity to construct two wet detention ponds that could provide flood protection benefits while possibly providing an amenity to the adjacent residents. The ponds would include a 6.80-acre pond in the common area between Pelican Avenue and Mockingbird Street / Hemlock Avenue. A second 2.32-acre pond would be constructed on the common area between Sycamore Avenue and Walnut Avenue. The ponds NWL would be set to the invert of the large culverts under Spruce Drive. The control structures would be constructed immediately upstream (east) of Spruce Drive and outfall through the existing culverts under Spruce Drive.

This alternative improves the downstream peak water surface elevations moderately for all storm events; however, it will not totally eliminate the potential for structural flooding from the 100-year rainfall event.

### Alternative 6 – Prestwick Pond Control Structure Modification

This alternative is the modification to the outfall control structure for the pond in Prestwick Phase 1 (located on the Prestwick Golf Course). The ponds NWL would be lowered to increase stormwater detention capacity and the outflow would be regulated to maximize detention in the pond. This alternative did not improve peak water surface elevations in the main channel and provides no flood protection benefit.

### Post-Improvement Conditions ICPR Stormwater Model Results

The post-improvement conditions ICPR stormwater model were executed for the 2-, 10-, 25-, 50- and 100-year storm events. The results (maximum simulated water surface elevations) for each alternative are compared to the existing conditions in the attached tables. Refer to Exhibit 1 for the Existing Conditions ICPR Model Link-Node Schematic for the location of the nodes included in the tables.

The tables identify the nodes associated with structural flooding - MAIN-03 (Camper Country) and MAIN-07 (1284 and 1288 Strathmill Ct.) in yellow. Structural flooding is defined as the peak water surface elevation above the finished floor elevation. Structural flooding is also highlighted in yellow at the nodes if occurring for the scenario/event. Structural flooding occurs at MAIN-03 (Camper Country) at approximately elevation 13.31 and at MAIN-07 (1284 and 1288 Strathmill Ct.) at approximately elevation 13.43. For example, MAIN-03 (Camper Country) floods under existing conditions for the 100-year storm event (elevation 13.91) and MAIN-07 (1284 and 1288 Strathmill Ct.) floods under existing conditions for the 50-year event (elevation 13.44) and 100-year event (elevation 14.13). The garages of 1284 and 1288 Strathmill Ct. are significantly lower than their finished floor elevations, and this could be subject to flooding for smaller rainfall events.

The tables also identify improvement (decrease) in predicted peak water surface elevations from existing conditions at each node as well as potential increases in predicted water surface elevations. Improvements are marked in green, while increases in water surface elevations are marked in red. Only relatively large differences in water surface elevations are noted. Minor variances (i.e. +/- 0.1 ft.) are not highlighted in the tables.

## **ALTERNATIVE PROJECTS EVALUATION**

The alternative project exhibits include information including contour elevations, existing utilities (generally buried water and sewer), edge of pavement, property lines, build footprints, and aerial photography. This information was used in refining the alternative concepts and also in developing the opinions of probable costs for the alternatives.

In addition to the ten alternatives discussed above, two additional alternatives local to the structural flooding on Strathmill Court were developed. These alternatives are discussed below.

### Alternative 7 – Strathmill Court Drainage Diversion

This alternative would divert the local Strathmill Court drainage system to the main channel. This improvement would serve to improve the capacity of the drainage system to move local drainage to the main channel and bypass the relatively flat Strathmill Court area. The improvement would include a flap gate, which with the pipe improvements would help prevent the potential backup of stormwater in the low are between the berm along the main channel and the Strathmill Court residences.

### Alternative 8 – Strathmill Court Flood Control System Improvements

The alternative would improve the existing Strathmill Court flood control system that was apparently constructed by the residents or other private entities. This alternative would include the raising (and strengthening) of the existing berm as well as the lengthening of the berm to tie to existing ground. The existing and proposed berm elevation would be 14.5 feet. This elevation is dictated by the predicted peak water surface elevation in the main channel (which is controlled by the elevation of the overtopping of US Highway 17 Business).

This alternative would also require the installation of various flap gates to control the back flow of water into the protected area. This would include various privately and publically owned drainage pipes. It should be noted that the construction methods of the existing berm and privately owned pipes is unknown and thus the structural soundness would have to be confirmed prior to being improved.

**OPINION OF PROBABLE CONSTRUCTION COST**

Individual opinions of probable construction cost were developed for each alternative. The opinions of probable construction cost are included at the end of this report and are summarized in the table below.

<b>Alternative</b>	<b>Opinion of Probable Construction Cost</b>	<b>Note</b>
Alternative: 1A - Hwy 17 Business Culvert Impr. and Channel Impr.	\$ 815,000	
Alternative: 1B - Highway 17 Business Culvert Improvements	\$ 393,000	
Alternative: 1C - Highway 17 Business Culvert Improvements	\$ 229,000	
Alternative: 2A - Detention Pond at Catherine Drive	\$ 671,000	
Alternative: 2B - Detention Pond at Catherine Drive	\$ 750,000	
Alternative: 2C - Detention Pond at Catherine Drive	\$ 541,000	
Alternative: 3 - Detention Pond at Lakeview Drive	\$ 3,317,000	
Alternative: 4A - Crystal Lake Modification	\$ 95,000	
Alternative: 4B - Crystal Lake Modification	\$ 142,000	Lake dredging not included
Alternative: 4C - Crystal Lake Modification	\$ 667,000	Lake dredging not included
Alternative: 5 - Detention Ponds at Seagate Village	\$ 4,896,000	
Alternative: 6 - Prestwick Pond Control Structure Modification	\$ 15,000	
Alternative: 7 - Strathmill Court Drainage Diversion	\$ 148,000	
Alternative: 8 - Strathmill Court Flood Protection System Imp.	\$ 110,000	

**FINDINGS AND RECOMMENDATIONS**

Based on the results of the proposed conditions ICPR modeling and the opinions of probable construction cost for Alternatives 2A, 2B, 2C, 3, 4B, 5, and 6, it appears that with the limited improvement in flooding conditions and the relatively high cost that these alternatives are not viable for implementation and thus are not considered further.

Only Alternatives 1A totally address the structural (including garage) flooding (up to the 100-yr rainfall event) reported and as identified by the existing conditions modeling. The other alternatives that had significant impact on flooding included Alternatives 1B, 1C and 4C. Alternative 4C's opinion of probable construction cost does not include a cost for the lake bottom excavation/dredging. This cost would be significant (approximately \$1M to \$3M), which

would render the alternative to be cost prohibitive. In addition, Alternative 4C would require a radical modification of the lakes operation (lower NWL by approximately 4.5 feet), which could be unacceptable to local residents.

Alternative 4A provides moderate improvement with a relatively inexpensive capital cost, but does not address structural flooding through the 100-yr rainfall event. Alternative 8 could address flooding at the Strathmill Court locations (up to the 100-year event), but would most likely need to be implemented by private entities, since most of the infrastructure is on private lands without a dedicated easement to a public entity.

It is recommended that the County pursue the implementation of Alternative 1A as a long term solution to structural flooding in the watershed and possibly implement Alternative 4A as an interim, partial solution to flooding the watershed.