Conceptual Drainage Improvement Study Alternatives

Whispering Pines Project Area

City of Wilmington

August 26, 2022

1.Introduction

The City of Wilmington (City) Stormwater Services Division (SSD) requested that HDR Engineering, Inc. of the Carolinas (HDR) perform a conceptual drainage improvement study, primarily, to identify and assess improvements to reduce areas of frequent flooding experienced by the residents in the Southeastern portion of the City between Masonboro Loop Road (MLR) Masonboro Sound Road (MSR) that discharge to the Masonboro Sound between Finian Drive and Maxwell Place. There have been multiple complaints of flooding throughout the area and the City has had to shut down portions of MSR due to roadway overtopping. In addition, the City SSD currently set up a portable pump at the intersection of Dawning Creek Way and Tree Top Way to drain the roadway during heavy rains so residents can access their homes.

HDR developed a hydrologic and hydraulic model using PCSWMM, of the existing storm drainage system to replicate and validate the current conditions and assess improvement alternatives. This report summarizes the concern areas, site survey and investigation, hydrology and hydraulic methods, and an assessment of improvement alternatives.

2.Site Description

The study area includes multiple residential neighborhoods located between MLR and MSR that drain to two outfalls that discharge directly into the Masonboro Sound between Finian Drive and Maxwell Place as shown on the vicinity map. For this study, the area was divided into three concern areas as described below and shown in Figure 1.

2.1. Whispering Pines Concern Area

The Whispering Pines concern area includes the Whispering Pines subdivision located to the west of MSR, the MSR culvert, and the downstream open channel and private driveway crossings. The Whispering Pines subdivision storm drainage system includes a series of curb inlets, drop inlets, pipes and open channels that drain to a main open channel in the middle of the subdivision. The main channel is conveyed in pipes underneath Pine Bark Court and Needle Sound Way and between some residential homes and eventually discharges to stormwater control measure (SCM) located near the intersection of MSR and Dawning Creek Way. There is another open channel that runs along the Northern property line behind the residential properties and is conveyed in pipes under Dawning Creek Way and Bohicket Way and discharges the main channel just upstream of the SCM. The SCM is located just upstream of Dawning Creek Way and has a riser structure that controls the peak discharge and a barrel that conveys the water under Dawning Creek Way to an open channel. The open channel crosses under MSR through a 30 in. Corrugated Metal Pipe (CMP). The open channel then travels in a Northeast direction crossing under three (3) private driveways through various size culverts and discharging to the Masonboro Sound.

An existing yard inlet located on 5800 Beretta Way drains to catch basins on Beretta Way that drain to an open channel that confluences with the main Whispering Pines subdivision open channel. This yard inlet also drains to an open channel to the South that eventually discharges to discharges to Whiskey Creek.

The existing storm drainage system for the Whispering Pines concern area is shown on the Whispering Pines_Exhibit 1_B.

2.2. Masonboro Sound Road at Finian Drive Concern Area

The MSR at Finian Drive concern area (MSR/Finian) includes the existing 48-inch storm drainage pipe system that drains across MSR just North of Finian Drive and discharges to an open channel that runs along the East side of the road and underneath three (3) driveways and discharges to Masonboro Sound. There is also a 30-inch pipe that drains across MSR at the existing wastewater pump station access drive located approximately 250 feet South of Finian Drive. These two (2) MSR crossings convey approximately 176 acres of stormwater between MLR, Whispering Pines subdivision and Orchard Trace.

The existing storm drainage system for the MSR/Finian concern area is shown on MSR_Finian_Exhibit_2_B.

2.3. Orchard Trace Concern Area

The existing Orchard Trace concern area includes the residential properties along Orchard Trace, the storm drainage system that drains Grainger Point Road, and the storm drainage systems along MSR. The residential properties along Orchard Trace drain to roadside ditches and that are conveyed at several locations to an open channel that runs along the Southern property line through drop inlets, pipes, and open channels. The open channel along the Southern property line has two outfalls, East and west, that drain to the South through the East & Mason development that is currently being constructed. These outfalls confluence just upstream of the Winward Oaks subdivision then runs Southeast between homes, under a driveway and private road, and to the MSR/Finian 48-inch culvert. A portion of Grainger Point Road drains to two catch basins at the roadway low point, a 24-inch pipe conveys the water to an open channel that runs along the Southern and eastern properties on Grainger Point Road. The open channel is conveyed by a 30-inch pipe between two residences on Orchard Trace and connects to storm drainage system on Orchard Trace which discharges to an open channel that runs between two (2) residences then confluences with the open channel that runs along the Southern property line to form the East outfall that runs through the East & Mason development. There is an 18-inch pipe under MSR located approximately 600 feet South of Orchard Trace that conveys the MSR roadside ditch and the area East of MSR that drains towards MSR. The 18-inch pipe discharges to a channel and runs Northwest and confluences with the East outfall. There are two additional pipe crossings on MSR. One is a 15-inch pipe just South of Orchard Trace that picks up the areas East of MSR that drains to the MSR roadside ditch and conveys the water to the MSR roadside ditch on the west side which flows North and is conveyed under Orchard Trace in a 15-inch pipe and then flows North in the MSR roadside ditch approximately 700 feet where the water is conveyed in an 18-inch RCP back across MSR to an open channel outfall that runs East to the Masonboro Sound.

The existing storm drainage system for the Orchard Trace concern area is shown on Orchard_Trace_East_Outfall_Exhibit_3_B and Orchard_Trace_Outfall_Exhibit_4_B.

3.Survey and Site Investigations

Gel Solutions, Inc. surveyed the closed storm drainage system and typical ditch sections within each of the concern areas. HDR also performed a field investigation to confirm some of the hydrologic and hydraulic assumptions. During the survey and investigations there were a few areas where features could not be identified due to either standing water, sedimentation, or blind junctions. These areas are described in more detail in the individual concern area sections.

4.Hydrology and Hydraulics

Hydrology determines how much water runs off the land during a particular rainfall event and then calculates the discharge versus time (hydrograph) at identified locations within the watershed. Hydraulics use the hydrograph along with the storm drainage system features such as ditches, pipes, and culverts to estimate the resulting water surface elevations and performance of these features. The PCSWMM version 7.5.3399 was used to perform the hydrologic and hydraulic analysis and a brief description of the hydrologic and hydraulic methods used is provided below.

4.1. Hydrology

The hydrology was created within PCSWMM using the alternative runoff method (ARM) to develop hydrographs for each subcatchment. The approx. 450-acre total drainage area was split into 111 subcatchments at key locations. Each subcatchment was assigned a runoff curve number (CN) based on the hydrologic soil group according to the USGS Web soil survey, and the land use according to the City of Wilmington Land Use data. Time of concentrations (Tc) were developed for each subcatchment using NRCS TR55 methodology. A summary of the input data is presented in Table 1 below. The subcatchments are shown on the Subcatchment Area exhibit.

Table 1 - Subcatchment Characteristics

Subcatchments	Area (ac)	CN	Tc (min)	Subcatchments	Area (ac)	CN	Tc (min)
Basin_1	4.136	69.8	23	**Basin_58**	1.037	88.4	5
Basin_2	5.201	58.7	28	**Basin_59**	1.326	89.0	6
Basin_3	0.542	80.6	5	**Basin_60**	7.604	79.7	32
Basin_4	2.072	69.5	5	**Basin_61**	0.534	87.8	5
Basin_5	1.947	88.9	5	**Basin_62**	1.347	69.3	8
Basin_6	3.395	88.6	17	**Basin_63**	0.401	75.2	5
Basin_7	1.723	88.7	5	**Basin_64**	0.188	78.3	5
Basin_8	3.617	86.0	5	**Basin_65**	5.446	68.8	15
Basin_9	1.223	88.4	5	**Basin_66**	1.437	87.6	38
Basin_10	5.819	87.0	39	**Basin_67**	0.771	87.0	5
Basin_11	2.692	50.3	29	**Basin_68**	1.966	85.9	6
Basin_12	4.526	85.7	38	**Basin_69**	3.176	86.1	29
Basin_13	8.339	85.6	40	**Basin_70**	4.292	84.4	36

Subcatchments	Area (ac)	CN	Tc (min)	Subcatchments	Area (ac)	CN	Tc (min)
Basin_14	3.679	86.0	11	**Basin_71**	0.53	88.0	5
Basin_15	6.812	87.9	15	**Basin_72**	0.799	85.9	40
Basin_16	1.47	87.7	5	**Basin_73**	2.889	83.1	16
Basin_17	0.91	74.1	5	**Basin_74**	0.953	64.2	24
Basin_18	0.787	89.6	5	**Basin_75**	1.037	62.8	5
Basin_19	0.786	84.9	45	**Basin_76**	0.782	86.5	17
Basin_20	0.649	88.1	8	**Basin_77**	0.398	88.1	5
Basin_21	11.162	84.2	37	**Basin_78**	0.333	86.8	6
Basin_22	0.319	86.9	5	**Basin_79**	0.159	86.7	5
Basin_23	4.166	83.9	19	**Basin_80**	0.586	88.5	5
Basin_24	0.675	86.8	5	**Basin_81**	0.756	84.8	18
Basin_25	1.56	86.0	18	**Basin_82**	0.237	88.7	5
Basin_26	6.141	81.3	16	**Basin_83**	0.23	88.4	5
Basin_27	5.029	81.1	36	**Basin_84**	1.16	85.8	7
Basin_28	2.839	89.1	12	**Basin_85**	0.075	91.2	5
Basin_29	2.381	82.3	16	**Basin_86**	1.404	85.5	5
Basin_30	5.556	63.6	45	**Basin_87**	0.114	86.3	5
Basin_31	5.33	87.0	44	**Basin_88**	1.435	88.5	5
Basin_32	7.115	56.7	6	**Basin_89**	0.975	86.8	5
Basin_33	1.383	85.8	21	**Basin_90**	51.073	79.7	196
Basin_35	0.67	87.3	5	**Basin_91**	46.267	85.6	29
Basin_36	1.011	86.7	6	**Basin_92**	8.984	82.1	14
Basin_37	0.479	87.0	6	**Basin_93**	4.538	83.4	25
Basin_38	1.331	86.3	9	**Basin_94**	3.137	87.8	22
Basin_39	1.426	77.1	25	**Basin_95**	116.699	83.2	176
Basin_40	1.107	86.0	23	**Basin_96**	4.899	60.3	58
Basin_41	0.818	87.1	5	**Basin_97**	6.694	74.6	40
Basin_42	2.521	88.8	5	**Basin_98**	0.196	82.7	5
Basin_43	0.377	88.4	5	**Basin_99**	1.31	86.0	5
Basin_44	0.606	88.4	8	**Basin_100**	0.941	86.8	5
Basin_45	0.472	88.8	5	**Basin_101**	0.432	92.8	5
Basin_46	1.27	87.7	5	**Basin_102**	4.416	81.6	7
Basin_47	0.866	88.1	6	**Basin_103**	0.219	89.0	5
Basin_48	0.608	89.0	5	**Basin_105**	1.678	88.7	5
Basin_49	1.067	88.9	5	**Basin_104**	1.012	86.9	5
Basin_50	0.766	89.5	5	**Basin_106**	0.135	88.1	5
Basin_51	2.426	86.0	5	**Basin_107**	1.326	88.0	10
Basin_52	1.092	86.7	5	**Basin_108**	6.812	87.8	12
Basin_53	1.532	88.6	5	**Basin_109**	5.408	80.0	24

Subcatchments	Area (ac)	CN	Tc (min)	Subcatchments	Area (ac)	CN	Tc (min)
Basin_54	1.417	88.8	5	**Basin_110**	1.041	80.0	10
Basin_55	0.529	88.4	15	**Basin_111**	2.036	80.0	24
Basin_56	2.095	87.2	5	**Basin_112**	0.867	80.0	12
Basin_57	1.741	87.7	12				

Meteorological data was added to PCSWMM model to develop the inflow hydrographs for the 2-yr, 5-yr, 10-yr, 25-yr, 50-yr, and 100-yr, and 24-hr storm events. The depth of rainfall for each event was distributed using an SCS Type III rainfall distribution. A summary of the rainfall data is presented in Table-2 below.

Table 2 - Rainfall Data

Event	Duration (hrs)	Distribution	Depth (in)
2-yr	24	Type III	4.76
5-yr	24	Type III	6.16
10-yr	24	Type III	7.39
25-yr	24	Type III	9.29
50-yr	24	Type III	11.00
100-yr	24	Type III	12.90

4.2. Hydraulics

PCSWMM was used to develop a one-dimensional (1D) hydraulic model for the identified concern areas using a combination of the field survey and existing LiDAR Digital Elevation Model (DEM) download from the North Carolina Floodplain Mapping Program (NCFMP). PCSWMM represents the pipes, open channels, and overland flow as links. The links are connected by nodes which represent the pipe inlet, catch basins, drop inlets, junction boxes, pipe outlets, and changes in the open channel cross section or slope. The model links and nodes are shown on Exhibits 1, 2, 3, and 4 in Appendix B.

To develop the representative open channel sections, the surveyed channel section was combined with a cross section generated from the LiDAR so the flow remained contained within the section. Where the existing pipes were buried due to sediment, the open channel inverts were lowered to maintain a positive slope between the nodes. It is important to note that the model assumes the closed drainage system is free of sediment and in good shape so the full section can convey the stormwater runoff.

Overland links were added to the model to represent the path water will flow if the node surcharges and water begins to pond on the ground surface and reaches an elevation where water will begin to flow to another node. In this model there were several roadway low points that will pond more than 1 foot before either flowing down the road or between residences. Weirs were

used to represent the overland flow across the roadway at culverts. For nodes that surcharged, and water could pond but did not have an overland flow link, the allow ponding option was selected to allow ponding on top of the rim elevation, within the area defined for the flooding. For nodes that surcharge but little or no ponding would occur, a surcharge depth was added.

The ARM subcatchments as described in the hydrology section were connected to the nodes at key locations within the storm drainage system. It was assumed that all the discharge can enter the link and not restricted by the inlet.

The starting downstream boundary condition was initially set as a free outfall to make sure the model was properly running and then the boundary condition was changed to the Mean Higher-High Water (MHHW) elevation. This elevation was obtained from the NOAA Tidal gage station (#8658163) at Wrightsville Beach. The vertical datum for the MHHW is NAVD88. The downstream boundary at the outlet of the closed drainage pipe on Beretta Way that discharges South of the concern area was set assuming no tailwater condition.

The dynamic wave was selected for the routing method with a simulation run-time of 24 hours. The 10-year, 24-hour, Type-III distribution storm event, which is the design event, was then run and model adjustments were made to make sure the continuity was acceptable, and the results were reasonable relative to the known flooding areas. The approximate area of flooding anticipated during the 10-year design event is shown on Exhibits 1,2,3, and 4 in Appendix B. More detailed description the model results are described in the section below.

The model results for the extent and duration of the node flooding, was confirmed by the City of Wilmington, reasonably reflected that the existing model was performing as expected to reflect the flooding that was experienced during the rainfall events and helped validate our model setup.

5. Existing Model Results and Improvement Alternatives

The existing conditions hydrologic and hydraulic model confirmed multiple areas of flooding. These areas were discussed with City and different improvement alternatives were investigated to reduce the flooding. The goal of the alternatives was to keep the roadways in the project area from flooding or keep the flooding within the easement during the 10-year design event. When this level of service could not be met because of the existing site constraints, the improvement alternative presented was considered the most reasonable improvement. This section describes the existing condition hydrologic and hydraulic model results and the different improvement alternatives investigated for each of the concern areas.

5.1. Whispering Pines Concern Area

There are several areas within the Whispering Pines concern area that the roadway floods during the 10-year design event as shown on Exhibit 1 in Appendix B. The model results show that the existing SCM located at the eastern edge of the subdivision restricts the water which increases the water surface elevation (WSE) and reduces the performance of the upstream storm drainage system causing the water to back up and flood the low points. Some of the open channels are

silted in further reducing the performance of the storm drainage system, ponding in the roads, and long draw down periods. The 30-inch CMP under MSR does not have much capacity and flood during the 10-year design event. The downstream driveways crossings vary in sizes currently overtop during the 10-year design event; however, the driveway crossings and downstream open channel do not affect the performance of the MSR culvert or Whispering Pines storm drainage system. The main areas with the Whispering Pines concern area are described in more detail below along with the potential improvement alternatives, performance, and issues associated with the improvement.

5.1.1. Tree Top/Dawning Area

The Tree Top/Dawning Area includes the intersections on Dawning Creek Way at Tree Top Way and Whispering Pines Court. These intersections are low points in Dawning Creek Way and are drained by catch basins and 18-inch storm drainage pipes that discharge to the main open channel located behind the homes on the South side of Dawning Creek Way. Currently, the open channel has been filled in with silt, vegetation, and yard debris such that the outlets to the 18-inch pipes are almost completely buried causing these intersections to frequently flood and remain flooded for long periods of time. The City SSD has set up a temporary pump station to help drain these areas. The Tree Top/Dawning area is shown if Exhibit 1 in Appendix B.

The Tree Top/Dawning Area catch basin inlets are at an elevation of 23.0 feet and the high point elevation on Tree Top Way is approximately 25.0 feet based on the LiDAR DEM. The homes in the area are generally at an elevation 26.0 feet or higher. Therefore, if the water ponds high enough, the water will flow North along Tree Top Way prior to flooding between the homes or along Pine Bark Court.

The existing conditions model which assumes the pipes and ditches are cleaned out shows that this area is still at risk of frequent flooding due to the limited storm drainage pipe system capacity and the water surface elevation at the SCM. The SCM normal pool should be at elevation 18 (currently the riser structure appears to be leaking so the normal pool is lower) and the peak water elevation during the 10-year design event is 22.3 feet. This is only 0.7 feet below the gutter line elevation at the Tree Top/Downing Area intersections. The model shows that if the existing system is cleaned out, during the 10-yr design event, the roadway will flood to a maximum depth of 25.3 feet and the area remains flooded for approximately 3.5 hours. Below are the improvements investigated to reduce this flooding.

5.1.1.1. TREE TOP/DAWNING ALTERNATIVE 1

Lower the storm drainage pipes and ditches approximately 1 foot and increase the size of the storm drainage pipes to 36-inch under Pine Bark Court and 48-inch diameters under Chukka Way and Needle Sound Way to provide a positive slope and increased conveyance. The size and depth of the storm drainage pipes are limited by the existing channel inverts and proximity of the pipes to the homes.

This improvement lowered the maximum flooding during the 10-year design event at Tree Top/Dawning to elevation 24.8 feet and the area remained flooded for approximately 1.5 hours. These improvements also reduce the flooding on Pine Bark Court, Lydford Court, and Beretta Way. These improvements increased the 10-year downstream peak discharge approximately 30

cfs over existing peak discharge. This increased the depth of flooding over the downstream private driveways between 0.2 and 0.4 feet.

A planning level cost estimate for this improvement alternative is $625,000.00

5.1.1.2. TREE TOP/DAWNING ALTERNATIVE 2

Improve the existing storm drainage system as noted above but also lower the SCM normal pool elevation and outlet structures. The pond normal pool and outlet structure could be lowered and still provide peak flow attenuation downstream. The pond existing surface area and volume can be maintained, however, these likely do not meet current NCDEQ SCM standards.

This improvement lowered the 10-year design event elevation at the SCM by 1.2 feet to elevation 21.1 and maximum flooding at Tree Top/Dawning to elevation 24.0 feet (1 foot above the gutter line) and the area remained flooded for approximately 1 hour. These improvements also reduced the flooding on Pine Bark Court, Lydford Court, and Beretta Way.

A planning level cost estimate for this improvement alternative is $825,000.00

The City SSD currently has no responsibility to maintain the SCM, therefore any improvements to this facility would require the City to accept maintenance responsibility. In addition, the SCM is a permitted facility through the North Carolina Division of Environment Quality (NCDEQ) and any revisions to this facility will also need to be approved by NCDEQ.

5.1.1.3. TREE TOP/DAWNING ALTERNATIVE 3

Add a new storm drainage pipe system from Tree Top/Dawning along Dawning Creek to the upstream side of the SCM, lower the SCM normal pool and outlet structure, and clean out the existing ditch upstream of Pine Bark Court. This diverts water from the existing storm drainage system and maintains peak flow reduction downstream.

This improvement lowered maximum flooding during the 10-year design event at Tree Top/Dawning to elevation 22.3 (below the gutter line). These improvements also reduce the flooding on Pine Bark Court, Lydford Court, and Beretta Way.

A planning level cost estimate for this improvement alternative is $ 1,680,000.000

The City SSD currently has no responsibility to maintain the SCM, therefore any improvements to this facility would require the City to accept maintenance responsibility. In addition, the SCM is a permitted facility through the North Carolina Division of Environment Quality (NCDEQ) and any revisions to this facility will also need to be approved by NCDEQ.

5.1.1.4. TREE TOP/DAWNING ALTERNATIVE 4

Add a new storm drainage pipe system along Dawning Creek Way as described in Alternative 3 but discharge downstream of the SCM. This diverts the water and does not require lowering the SCM normal pool.

This improvement lowered maximum flooding during the 10-year design event at Tree Top/Dawning to elevation 22.0 feet (1.0 foot below the gutter line) and reduces the flooding on Pine Bark Court, Lydford Court and Beretta Way, however, it increases the 10-year peak flows

downstream of the SCM from 100 cfs to 184 cfs requiring a larger culvert under Masonboro Sound Road and significantly increases the depth and frequency of flooding at the downstream private driveway crossings.

A planning level cost was not developed for this alternative.

5.1.2. MSR/Dawning Culvert

The existing culvert is a 30-inch CMP and during the existing 10-year storm there is approximately 71 cfs overtopping the roadway at a depth of approximately 0.7 feet. The crossing performance is not driven by the downstream private driveway crossings which vary in size but are generally a between a 30 and 48-inch pipe. The driveway crossings also overtop significantly during the 10-year design event. The MSR/Dawning Culvert is shown in Figure 1 in Appendix-B.

5.1.2.1. MSR/DAWNING ALTERNATIVE 1

Replace the existing 30-inch CMP with a single 48-inch RCP. Improving the MSR culvert does not increase the discharges downstream.

Planning level cost for this improvement alternative is $105,000.00.

5.1.2.2. MSR/DAWNING ALTERNATIVE 2

Replace the existing 30-inch CMP with a two 48-inch RCPs. This will increase the level of performance to greater than a 50-year event and allows for additional upstream improvements to be performed in the future without compromising the culvert performance.

Planning level cost for this improvement alternative is $135,000.00.

5.1.3. Northern Property Line

The Northern Property Line system drains portions of Tree Top Way, Whispering Pines Court, and Tall Pines Court through mainly an open channel along the Northern property line to a storm drainage pipe system that conveys the water between homes, under Dawning Creek Way and Bohicket Way, and discharges to the main open channel just upstream of the SCM. The existing open channel is in poor shape and has filled with silt, vegetation, and debris that is affecting the performance of the storm drainage system. The upper outfalls are partially buried which increases the drawdown time when the area floods. There is an access path at the Northern end of Whispering Pines Court that appears to provide vehicle access the adjacent vacant property. The open channel is conveyed under the access path through a storm drainage pipe system with drop inlets. The catch basin and 18-inch RCP at the Northern end of Tree Top Way will also convey overflow from the Tree Top/Dawning Area. The Northern Property Line System is shown in Figure

The performance of this area is affected by the SCM water surface elevation and the limited capacity storm drainage pipes. The existing conditions model which assumes the open channels and pipes are clean and have positive drainage shows that during the 10-year design event the roadway floods and water from the Tree Top/Dawning Area flows into the system. The depth of water in Tree Top Way is 2 feet deep and stays flooded for approximately 10 hours. The slow draw down is partially driven by the storm drainage pipes underneath the access path at the Northern end of Whispering Pines Court.

5.1.3.1. NORTHERN PROPERTY LINE ALTERNATIVE 1.

Remove the storm drainage system under the access path on the North end of Whispering Pines Court and replace the 24-inch RCP with a 36-inch RCP between the homes and underneath Dawning Creek Way. This improvement reduced the maximum flooding at Tree Top Way to elevation 24.5 (1.5 feet above the gutter line) and the area remained flooded for approximately 4 hours.

Planning level cost for this improvement alternative is $275,000.00

Because the flooding in this area is controlled by the water surface elevation in the SCM, similar improvements to the maximum flood depths can be expected as described in the Tree Top/Dawning Area Alternatives 2 through 4.

5.1.4. 5308 Beretta Way

The property at 5308 Beretta Way has installed a yard drop inlet with a top elevation of 23.2 feet, a 12-inch CMP that discharges to a catch basin on Beretta Way that drains to an open channel that confluences with the main subdivision open channel, and a 12-inch CMP that drains South through the yard and discharges to an open channel that ultimately discharges to Whiskey Creek. This appears to be a private system installed to drain the property. The existing condition model shows that during the 10-year design event the water from the Whispering Pines main drainage system begins to flow towards the yard drop inlet. The increased flow causes the yard inlet to flood. Removing the connection to the catch basin on Beretta Way reduces the flooding in at the yard inlet. If the yard inlet and discharge to the southern outfall is acceptable to NCDEQ, then it is recommended this yard inlet drain be disconnected from the catch basin on Beretta Way.

A planning level cost estimate for this improvement was not prepared.

5.2. Masonboro Sound Road Culvert at Finian Drive (MSR/Finian) Concern Area

The 48-inch pipe system conveys all the water from the Orchard Trace area, East & Mason development (currently under construction) and Windward Oaks development starts at a flared end section just west of a private driveway that serves 4 residences as shown on Exhibit 2 in Appendix B. The 48-inch pipe crosses under the private driveway and is assumed to connects to a sealed junction box on the East side of MSR. The pipe out of the sealed junction box is a 30-inch RCP that runs South along MSR, crosses under a private driveway and discharges to the open channel that runs South along MSR crossing under 3 driveways before discharging to the Masonboro Sound. There are two catch basins on Finian Drive near the intersection that discharge to an 18-inch RCP and a drop inlet just west of MSR that discharges to a 15-inch RCP. It is assumed these storm drainage pipes discharge to blind junction box along the 48-inch RCP just west of MSR. It is also assumed that the large open tract of land to the North and South of Maxwell Place also discharges to the sealed junction box through a 30-inch pipe that is shown on the City inventory and the inlet field verified. A local resident mentioned that this 30-inch pipe discharged to the drop inlet located near the access drive to the wastewater pump station that is approximately 250 South of Finian Drive. The resident noted that this drop inlet routinely

surcharges and floods the road. Since the 30-inch could not be seen in the drop inlet box, it was decided to assume it connected to the sealed junction box.

The existing conditions model shows that 48-inch storm drainage system is undersized and approximately 200 cfs overtops the private drive and 230 cfs overtops MSR during the 10-year design event in the vicinity of the MSR/Finian intersection. The model also shows that 80 cfs overtops MSR at the wastewater pump station access road.

The model also shows that upstream of the MSR/Finian Area through the private development, approximately 90 cfs overtops Jonquil Court but the flow stays within the open channel between the homes during the 10-year design event.

Two improvement alternatives were investigated and described below.

5.2.1. MSR/Finian Alternative 1

Install an additional 48-inch RCP underneath the Private Drive, install a new junction box on the existing 48-inch RCP just west of MSR, install two (2) new 48-inch RCPs underneath the South bound lane of MSR to just South of the wastewater pump station access drive, install a new junction box and two (2) new 48-inch RCPS under MSR that discharge just downstream of the driveway crossing. It is assumed the existing 30-inch that drains the open tract of land North and South of Maxwell place will be diverted to the new 48-inch system along with the overflow. This alternative assumes that the existing system across MSR and along the East side of MSR will remain in place to provide additional capacity and only minor improvements to the roadway shoulders will be performed. See Exhibit 2 in Appendix B.

Planning level cost estimate for this improvement alternative is $670,000.00

This improvement reduces the flow over MSR at Finian Drive to 15 cfs and reduces the flow over MSR at the wastewater pump station access drive to 32 cfs during the 10-year design event.

Improvement on the private property at the upstream end is required to capture the stormwater before flooding the private driveway, Finian and MSR. The proposed improvement at the upstream end will need to be partially constructed underneath the MSR southbound lane to remain within the MSR right of way and possibly avoid relocating the existing overhead power lines. These improvements will require the removal and replacement of the landscaping at Finian Drive intersection and installation of a temporary driveway access.

5.2.2. MSR/Finian Alternative 2

Install an additional 48-inch RCP underneath the Private Drive, install a new junction box just west of MSR, install three (3) 48-inch RCPs under Masonboro Road, replace the sealed junction box, replace the 30” RCP with three (3) 48-inch RCP under Masonboro Sound Road, increase the downstream driveway crossings to three (3) - 48-inch RCPs, widen the open channel between the driveways. Replace the 30-inch under MSR at the wastewater pump station access road with a 48-inch RCP and increase the capacity of the drop inlet to handle the overflow from the 30-inch that drains the open tract of land North and South of Maxwell place. It is assumed this 30-inch that discharges to the sealed junction box.

Planning level cost estimate for this improvement alternative is $765,000.00

This improvement reduces the flow over MSR at Finian Drive to 15 cfs which is overflow from the roadway inlets on Finian Driver and reduces the flow over MSR at the wastewater pump station access drive to 12 cfs during the 10-year design event.

Improvement on the private property at the upstream end is required to capture the stormwater before flooding the private driveway, Finian and MSR. The proposed improvements on the eastern side of MSR will require significant grading into the adjacent properties. These improvements will require the removal and replacement of the landscaping at Finian Drive intersection and installation of a temporary driveway access.

5.2.3. MSR/Finian Alternative 3

This alternative includes diverting the system that drains the open tract of land North and South of Maxwell place in a 60-inch RCP and discharge just downstream of the driveway culverts. This improvement diverts approximately 117 acres of drainage and improves the performance of Alternative 1 and if applied with Alternative 2, allows for only two (2) 48-inch RCPs to be installed instead of three (3).

Planning level cost estimates were not developed for this alternative.

5.3. Orchard Trace Concern Area

The Orchard Trace concern area is upstream of the MSR/Finian concern area and the private storm drainage system through Winward Oaks as shown on Exhibit 3 in Appendix B. The hydrologic and hydraulic model shows that the Orchard Trace concern area is hydraulically independent of the MSR/Finian concern area indicating that the flooding at the MSR/Finian does not affect the performance of the storm drainage systems in the Orchard Trace Area. Within the Orchard Trace area there are four (4) storm drainage systems that are also hydraulically independent of each other. These areas area discussed below.

5.4. Orchard Trace West Outfall

The first is the main open channel that runs behind the homes and discharges to the West Outfall through the East & Mason development. The residential properties drain to the Orchard Trace roadway and is conveyed through roadside ditches and driveway pipes to four (4) different storm drainage systems of drop inlets, pipes, and open channels to the main open channel. The main ditch also includes two roadway crossings which are currently being extended to the East & Mason development.

The existing main open channel is filled in with sediment, vegetation and debris and the pipe crossings are not large enough to convey the 10-year design event peak discharge. Three (3) of the storm drainage systems that convey water to the main ditch are undersized and the 10-year design event overtop the roadway. The most eastern system is adequately sized.

5.4.1. ORCHARD TRACE WEST OUTFALL ALTERNATIVE 1

Lower the main open channel from the headwaters to approximately the confluence of the East Outfall, increase the western roadway crossing to a 36-inch RCP, increase the storm drainage pipes on three (3) storm drainage systems that cross Orchard Trace roadway.

Planning level cost for this improvement is $425,000.00

Additional improvement alternatives were not investigated for this area.

5.5. Orchard Trace East Outfall

The hydrologic and hydraulic model showed approximately 9 cfs overtopping the Grainger Point Road at a depth of 0.3 feet during 10-year design event. The flooding is due the undersized system that drains through Orchard Trace. Based on the survey, it appears the downstream outfall pipe is higher and creating a low point in the storm drainage pipe system. The model which assumes the system is clean, does not show flooding on Orchard Trace this system is contributing to the flooding at Grainger Point Road.

5.5.1. ORCHARD TRACE EAST OUTALL ALTERNATIVE 1

Lower the main channel to the confluence with the West Outfall, increase the storm drainage pipe system under Orchard Trace Road to a 42-inch RCP, increase the storm drainage pipe upstream to Grainger Point Road to a 36-inch RCP and 30-inch RCP, and increase the storm drainage pipe under Grainger Point Road to a 24-inch RCP.

Planning level cost estimate for this improvement is $315,000.00

5.5.2. ORCHARD TRACE EAST OUTFALL ALTERNATIVE 2

Lower the main channel to the confluence with the West Outfall and increase the size of the open channel behind the properties on the South side of Grainger Point Road. This improvement did not resolve the flooding at Grainger Point Road during the 10-year design event, but it did reduce the overtopping discharge to 5.8 cfs and maximum flooding depth to 0.1 feet during the 10-year design event.

A planning level cost estimate was not developed for this alternative.

5.5.3. MSR Drainage North

The northern portion of the MSR roadway storm drainage system drains across MSR to the west and then flows north under Orchard Trace and then along MSR before crossing back under MSR to the east and discharges to an existing open channel that runs to the Masonboro Sound between two empty lots. The model, which assumes the drainage system is clean, shows the system is adequately sized and no improvements are required. The system should be cleaned, and the City should consider getting an outfall easement down the property line and grading the outfall ditch for future maintenance.

A planning level cost estimate was not developed for this recommendation.

5.4.4 MSR Drainage South

This MSR roadway storm drainage system drains west under MSR approximately 750 feet south of Orchard Trace. The outfall of the system runs through the middle of an East & Mason

development lot and discharges to the existing East outfall within the East & Mason development. The model shows this system is adequately sized and it is recommended the City consider getting an easement or realigning the outfall along the property line.

A planning level cost estimate was not developed for this recommendation.