PRIORITY HABITAT ISSUES:

ADDRESSING SANITARY SEWER OVERFLOWS ASSOCIATED WITH WASTEWATER INFRASTRUCTURE TO IMPROVE COASTAL WATER QUALITY

1.1 Issue

The water column provides essential conditions for fish survival and healthy habitats, and therefore good water quality is key to a healthy coastal ecosystem. There are many contributing sources of water quality degradation (DEQ 2016). Sanitary sewer overflows (SSOs) from wastewater collection systems are one pollutant sources that contribute to water quality degradation and impact coastal habitats. Failing and deteriorating wastewater infrastructure, often referred to as Inflow and infiltration (I & I), is often the underlying cause of SSOs. Untreated or incompletely treated sewage entering estuaries after a SSO can increase bacteria, nutrient, and toxin levels, potentially resulting in shellfish closures, algal blooms, fish kills, and contaminated water and sediment that can impair aquatic life.

1.2 Origination

The Division of Water Resources (DWR) raised this as a priority issue in coastal counties, and it was endorsed by the CHPP Steering Committee. In 2014, the Estuarine Policy Steering Committee raised SSOs as one of four emerging management and policy issues that should be addressed.[1] Additionally, the 2020 NC Climate Risk Assessment and Resilience Plan recommended wastewater infrastructure improvements be addressed for coastal resiliency.[2]

1.3 Background

Effective management of wastewater is critical to protection of surface waters, fish habitat, public health, and the economy. Pollutants entering estuaries degrade water quality, impairing its ability to support healthy fish habitat, fish populations, and fisheries. Untreated wastewater can enter surface waters when SSOs occur due to failures associated with collection infrastructure, lift stations, or wastewater treatment plants. Inflow and infiltration is a significant problem in coastal NC that results in raw wastewater entering estuarine waters.

A sanitary sewer or collection system is an underground pipe system used to convey wastewater to a treatment facility and is comprised of conventional gravity lines, pump stations, and force mains. Inflow and Infiltration, or I & I, is the term for groundwater and stormwater entering a sewer system. Inflow refers to the entry of stormwater into the sewage collection system during storm events, whereas infiltration refers to the movement of groundwater into the sewer pipe system. There are multiple mechanisms contributing to I & I (Figure X.1). Gutters connecting to lateral pipes (the pipe from an individual building to the roadside main line), uncapped sewer line cleanouts, faulty sewer manhole covers, and improper cross connections of stormwater lines with sewer lines are all possible ways stormwater can enter sewer lines. Groundwater can enter the sewer pipes through cracks, leaky pipe joints, deteriorated manholes, and broken lateral pipes.

Together, these two processes increase the volume and overload the sewage collection system,

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[1] Schiavinato, L. and X. Kalo. 2014. eds., 2014: Management Strategies for North Carolina's Estuarine Shoreline, UNC-SG-14-01, North Carolina Sea Grant, and NC Coastal Resources Law, Policy and Planning Center, Raleigh, NC.

[2] NCDEQ (NC Department of Environmental Quality). 2020. NC climate risk assessment and resilience plan. Impacts, vulnerability, risks, and preliminary actions. A comprehensive strategy for reducing North Carolina's vulnerability to climate change. Raleigh, NC. X p.

particularly during wet weather, which in turn can cause SSOs to occur.[3] Climate change may further exacerbate the problems with increased rainfall and higher groundwater levels. Nearly all sanitary sewer systems and receiving wastewater facilities in coastal NC are subject to issues and complications resulting from inflow and infiltration due to aging infrastructure, proximity to waterways, severe storms, and high ground water levels.

Sewer collection systems vary in age and construction materials. Older pipes and certain construction materials, such as metal and masonry, are more susceptible to deterioration. The degree and magnitude of I & I within a sewer collection system can be based on a number of factors. Along with system age, sewer line construction material, and poor construction methods, the following operational challenges can also contribute to I & I problems (D. May, DWR, personal communication):

- insufficient maintenance of lateral pipes connecting to sewer lines (responsibility typically lies with property owner)
- insufficient maintenance and clean out of main sewer lines (responsibility of facility owner, such as a municipality)
- removal of clean-out caps by property owners
- damage from road work (can result in increased flows)
- disposal of fats, oils, and greases down the drain, causing pipe blockages and subsequent overflows
- illicit connection of stormwater from roof drains, parking lots, etc., into the collection system

The severity of I & I is often a factor of groundwater table and weather conditions. Inflow often peaks during heavy or prolonged rainfall events. Chronic rainfall may result in an elevated groundwater table intersecting sewer pipes, resulting in higher infiltration rates.

Sewer lines, pump stations, and wastewater treatment plants (WWTPs) are designed for specific flows and peak flow volumes and rates. Contribution of flow from I & I is not a standard design component for most sewer systems and receiving wastewater systems. Consequently, flows in excess of the sewer system capacity may result in SSOs, which is a release of untreated or partially treated sewage from a sanitary sewer at unpermitted locations. These sewage spills often occur at manholes and pump stations when pumps cannot keep up with incoming flows. Excessive I & I can also result in reduced level of treatment at the receiving WWTP, discharge of insufficiently treated effluent to surface waters or land-application fields, overflows at WWTPs of untreated or insufficiently treated wastewater, and discharge of residual solids from WWTPs (D. May, DWR, personal communication).

The SSO spill volumes may range from hundreds to millions of gallons. Excessive flows at WWTPs may result in potential of discharge of residual solids depending on actions taken by facility operators. Discharge of residual solids creates potential for solids to settle on surface water sediments, with multiple water quality implications.

[3] Walch, M., M. Brosh, L. Lilly, J. Tribo, J. Whitehurst, B. Brumbaugh, D. Handy, M. Hoskins, K. Utt, R. Pitt, T. Spano, W. Katchmark. 2014. Recommendations of the expert panel to define removal rtes for the elimination of discovered nutrient discharges from grey infrastructure. Final panel report. Submitted to Watershed Technical Work Group, Chesapeake Bay Partnership.

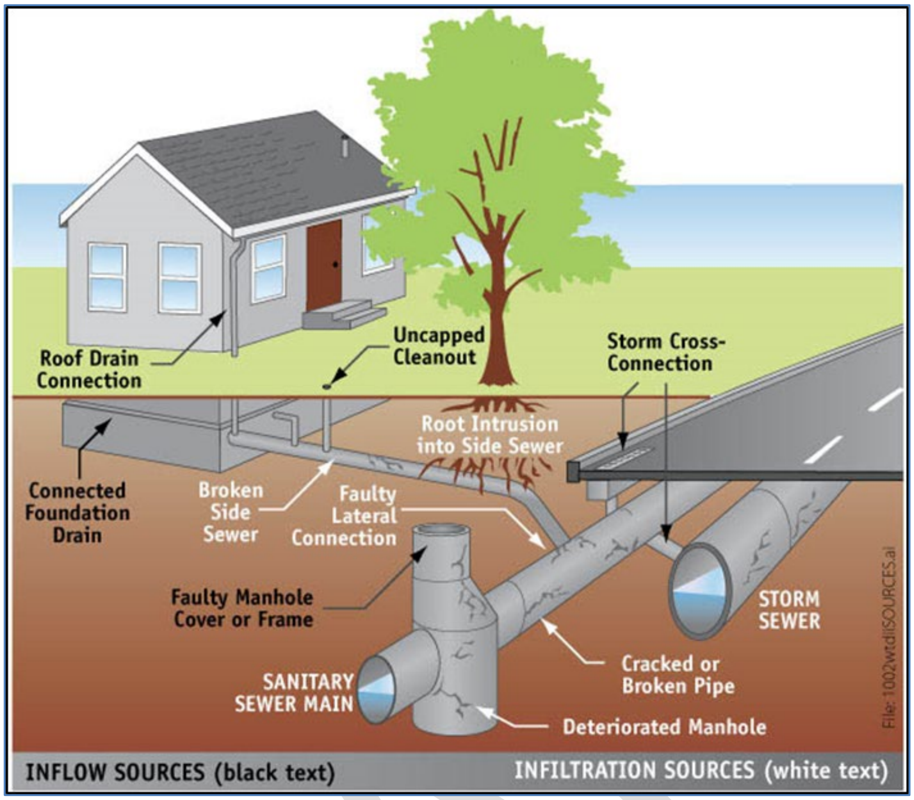

Figure X.1. Example of inflow and infiltration (I& I)pathways. (Photo credit: King County Dept. Natural Resource and Parks, Wastewater Treatment Division)

The location of discharging and non-discharging wastewater treatment facilities along coastal NC is widespread and consequently, so is the extensive network of collection lines carrying raw wastewater to those facilities (Figures x.2 and x.3). In 2020, there were 282 discharge wastewater treatment facilities and 295 non-discharge facilities permitted within the CHPP region and managed by the DWR (unpubl. data, DWR) (Table x.1 and x.2). Facilities with wastewater discharge permits release treated effluent directly from a pipe into surface waters. Facilities with non-charge permits apply treated effluent on land, retention ponds, or reuse it for other purposes such as irrigation.

Discharge facilities are categorized as industrial/commercial, municipal, domestic only, drinking water plants, water conditioning, and groundwater remediation. Municipal and domestic wastewater facilities (combined) are the most common type of facility. There are several categories of non-discharge wastewater facilities. The most common is wastewater irrigation, where treated wastewater is applied to land via spray irrigation, drip irrigation or other technology. High rate infiltration is increasingly permitted in coastal areas where the water table is high. With this method, groundwater is often lowered around a disposal area to increase the depth of “dry” soil under a retention area by installing perimeter sub-surface drainage pipes, wells, or ditching around the perimeter and discharging the clean groundwater to nearby surface waters. Treated wastewater is then discharged to a retention area with permeable soils, and allowed to seep into the ground. For each of these systems, particularly municipal systems, there are many miles of sewer lines beneath the ground transporting wastewater to a treatment plant.

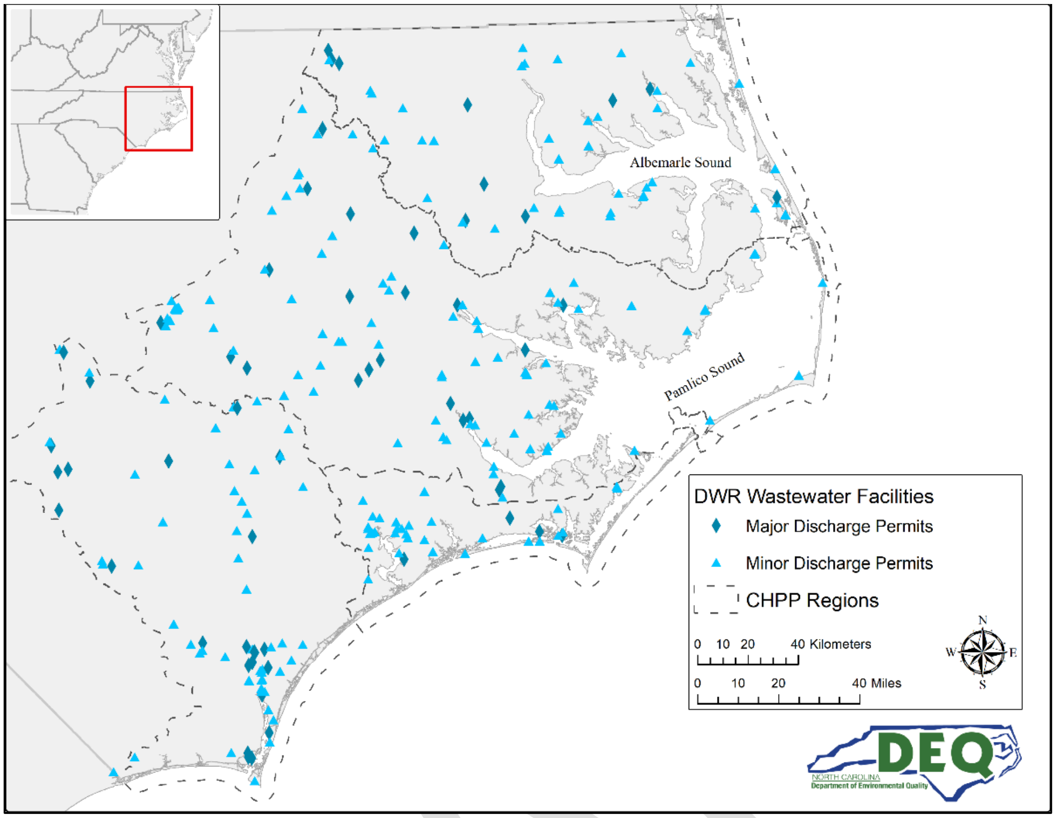

Figure X.2. Wastewater Discharge Facilities Located Across Coastal NC. Source: Source: DEQ ArcGis Online, 2020.

Table X.1. Numbers of NPDES discharge facilities by type within the four CHPP regions. Source: DEQ ArcGis Online, 2020.

Number of Facilities				Permit Type					
CHPP Region	Minor	Major	Total	Discharging 100% Domestic < 1MGD	Industrial Process & Commercial Wastewater Discharge	Municipal Wastewater Discharge, < 1MGD	Municipal Wastewater Discharge, Large	Water Plants and Water Conditioning Discharge	Ground water Remed. Discharge
1	40	11	51	5	10	9	8	19	0
2	89	23	112	7	37	17	16	33	2
3	33	4	37	16	3	3	2	12	1
4	53	29	82	9	30	14	14	12	3
Total	**215**	**67**	**282**	**37**	**80**	**43**	**40**	**76**	**6**

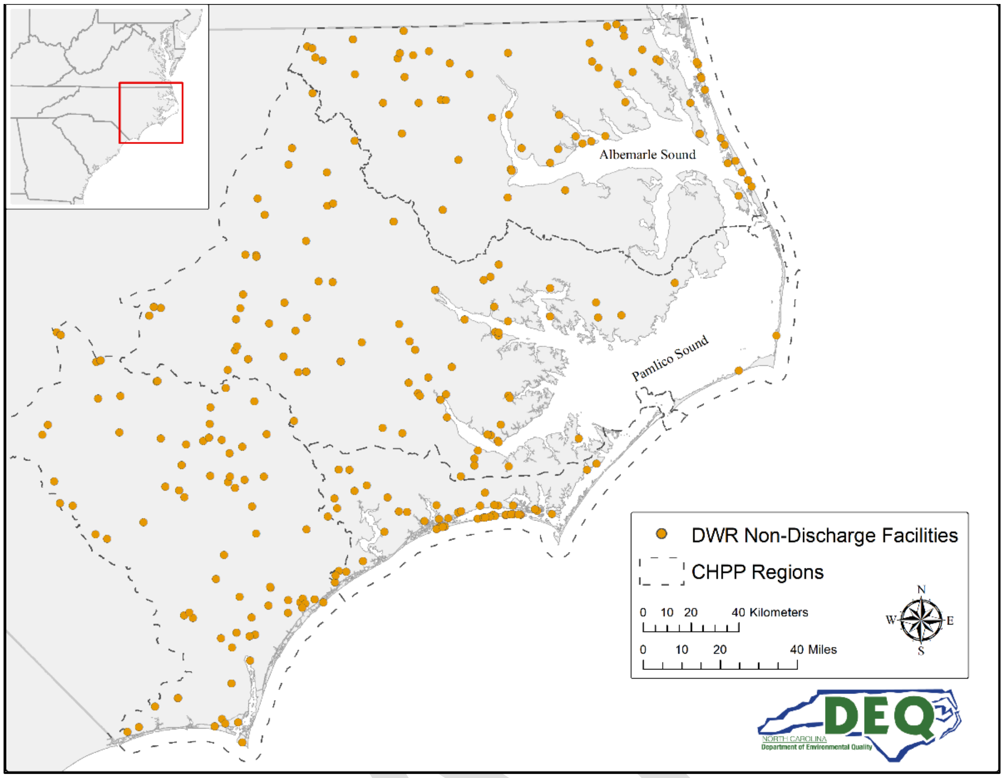

Figure X.3. Wastewater facilities with non-discharge permits located across coastal NC. Note: Identified facilities also include residual land application facilities and "other" types of non-discharge systems. Source: DEQ ArcGis Online, 2020.

Table X.2. Numbers of non-discharge permits by type within the four CHPP regions. Note: closed-loop recycle system, distribution of residual solids systems, and land application of residual solids systems pose potential for impacts to surface waters. Although such systems do not convey wastewater, they often address nutrient management needs and are referenced in the following table. Source: DEQ ArcGis Online, 2020.

Number of Facilities				Permit Type						
CHPP Region	Minor	Major	Total	Waste water Irrigation[1]	High Rate Infiltration	Reclaimed Water and Distribution[2]	Land Appl. Residual Solids[3]	Closed Loop Recycle	Distribution of Residual Solids	Other
1	15	52	67	25	18	6	11	2	2	3
2	44	46	90	41	4	16	18	3	7	1
3	13	41	54	11	30	5	5	1	2	0
4	31	53	84	32	9	11	17	7	7	1
Total	**103**	**192**	**295**	**109**	**61**	**38**	**51**	**13**	**18**	**5**

[1] Combined single family and other wastewater irrigation

[2] Combined reclained water and distribution

[3] Combined exempt and non-exempt from EPA 503 regulations for land application and disposal of residual solids

1.3.1. Effect on Water Quality

A major concern with SSOs that enter oceans, bays, estuaries, rivers, lakes, streams, or brackish waters is their direct impacts on water quality. Wastewater treatment plants and infrastructure are often sited in low-lying areas along the coast, since sewers are typically gravity-fed. Consequently, spills resulting from SSOs and WWTP operational complications often discharge to nearby surface waters.

Spills of untreated or partially treated sewage may convey or result in high bacteria levels to surface waters, elevated nutrient levels and loadings to surface water systems, depressed dissolved oxygen (DO) levels in surface waters, increased potential for algal blooms due to nutrient loading at chronic SSO locations, and stress or mortality of fish and other aquatic organisms. The unpredictable and random nature of SSOs makes them very difficult to monitor and study.[4] Prior investigations and case studies have helped characterize and quantify impacts to surface waters resulting from wastewater spills.

A study in Wilmington, NC monitored water and sediment quality following a sewer main break that discharged approximately three million gallons of raw sewage into the upper portion of Hewlett Creek[5], which dispersed throughout the creek and into the Intracoastal Waterway (IWW). Sampling found very high levels of fecal coliform bacteria (270,000 Colony Forming Units (CFU)/)/100 ml) in the creek initially. After three days, levels dropped below 100 CFU/100 ml in the channel and lower portion of the creek. However, in two tributaries, maximum counts remained high for five days, dropped slightly, then increased one week later after a rainfall. The increase after rain was attributed to runoff carrying residual sewage and resuspension from bottom sediment. Bacteria levels slowly decreased to normal levels over several more weeks. Fecal coliform bacteria in the sediment was also highly elevated and remained elevated for over a month, longer than the water column. The study found that the sediment served as a reservoir for fecal bacteria. Rainfall and experimental prop washing verified that bottom disturbance caused resuspension and fecal coliform to increase in the water column.

The biochemical oxygen demand (BOD) of the nutrient rich sewage caused severe hypoxia and several large fish kills two to three days after the spill. Dead organisms included American eels, flounder, mullet, bait fish, and birds. Nutrient concentrations in these sewage pipes are normally very high, approximately 40.2 mg/l total Kjeldahn nitrogen (TKN), 23.3 mg/l ammnonium (NH_4), and 5.3 mg/l total phosphorus (TP). Once in the creek, nutrient levels declined rapidly (1-1.5 days), being taken up by phytoplankton, resulting in several algal blooms. The decline in nutrients was also attributed to absorption by marsh plants, sediment and the sediment microbial community, benthic microalgae, macroalgae, and tidal flushing. The authors noted that the marsh community's ability to remove and cycle nutrients demonstrated the high value of conserving wetlands to improve water quality.[6] In addition to nutrients and bacteria, raw sewage can contain other materials hazardous to aquatic life, such as toxic chemicals, heavy metals, and endocrine disrupting chemicals. There is growing evidence that sewage discharges contribute to increasing harmful algal blooms (HABs) and changes in biodiversity and ecosystem health.[7]

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[4] Meyland, S.J., M. Lalor, R. Pitt. 1998. Monitoring and assessing the environmental and health risks of separate sanitary sewer overflows (SSOs). Presented at National Water Quality Monitoring Council National Monitoring Conference - Monitoring: Critical Foundations to Protect Our Waters. Reno, Nevada. July 7-9, 1998.

[5] Mallin, M.A., L.B. Cahoon, B.R. Toothman, D.C. Parsons, M.R. McIver, M.L. Ortwine, R.N. Harrington. 2007. Impacts of a raw sewage spill on water and sediment quality in an urbanized estuary. Marine Pollution Bulletin 54: 81-88.

[6] Ibid.

[7] Meyland et al. 1998, 6

Additionally, there are many pathogens present in sewage that can impact human health, and consequently shellfish harvest and recreational swimming activities.[8]

Sewage spills can cause significant localized acute impacts within the affected waterbody; however, their overall contribution to water quality in NC is less certain. To assess the prevalence and magnitude of I & I in coastal NC residential wastewater treatment systems, a study analyzed flows under different rainfall and temperature conditions using 2010-2011 data.[9] Of the 93 WWTPs analyzed, 92% exhibited a statistically significant flow response to rainfall, with increased flows averaging 12% more than rainless flows, with a maximum of 35%. The majority of the flow increase was attributed to infiltration rather than inflow.

The location of the systems with significant I & I occurred in both small and large municipalities throughout the coast, from Elizabeth City in the north, to Southport in the south. Central sewage treatment systems are often utilized in areas of high population density, such as cities and towns, as well as in areas where the groundwater table is too high for septic systems to function properly. Consequently, many of the wastewater collection pipes are sitting below ground, surrounded by groundwater. As pipes age and deteriorate, cracks in the pipes or joints allow groundwater to enter. Where the pipes are sitting in the groundwater, infiltration rates will be greater, particularly during wet periods. During dry periods, those same cracks can let wastewater leak out into the groundwater. Modelling predicted infiltration rates at over 40% where a two-inch rain event occurred after two weeks of dry weather. Modelling for a two-inch rain event occurring once a week for three weeks estimated average infiltration rates at 66%. Cumulative rain and lower temperatures drove significantly higher flows in the collection system suggesting that heavy rains in the cooler winter months are more likely to cause I & I problems.[10]

Deteriorating wastewater infrastructure plays a role in bacterial pollution, although stormwater runoff is considered the primary cause of water quality degradation.[11] Both SSOs and stormwater runoff occur with rainfall, complicating the ability to determine the contributing sources of fecal coliform concentrations. Similarly, where the groundwater table is low, wastewater can exfiltrate or leak out of sewer lines, and contaminate groundwater, which moves laterally to surface waters during rain events.[12] In urban settings, stormwater conveyances act as a conduit for sewage originating from leaking wastewater collection pipes.[13] [14] Studies in coastal NC comparing bacteria concentrations in septic and sewered watersheds showed both watershed types had increased bacteria counts in streams during rain events. The sewered watersheds had high increases due to leaky infrastructure or greater impervious

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[8] Meyland et al. 1998, 6

[9] Cahoon, L.B. and M.H. Hanke. 2017. Rainfall effects on inflow and infiltration in wastewater treatment systems in a coastal plain region. Water Science and Technology. 75(8):1909-1921. doi: 10.2166/wst.2017.072

[10] Cahoon, L.B. and M.H. Hanke. 2019. Inflow and infiltration in coastal wastewater collection systems: effects of rainfall, temperature, and sea level. Water Environment Research. 91:322-331. DOI: 10.1002/wer.1036.

[11] NCDEQ (North Carolina Department of Environmental Quality) 2016. North Carolina Coastal Habitat Protection Plan Source Document. Morehead City, NC. Division of Marine Fisheries. 475 p.

[12] Cahoon and Hanke 2017, 7

[13] Sercu, B., L.C. Van De Werfhorst, J. Murray, and P.A. Holden. 2009. Storm drains are sources of human fecal pollution during dry weather in three urban southern California watersheds. Environmental Science Technology. 43(2): 293-298. doi.org/10.1021/es801505p

[14] Sauer, E.P., J.L. VandeWalle, M.J. Bootsma, and S.L. McLellan. 2011. Detection of the human specific Bacteroides genetic marker provides evidence of widespread sewage contamination of stormwater in the urban environment. Water Research.45: 4081-4091.

surfaces.[15] [16] For a resilient system, managers must address multiple sources of pollution.

The coastal plain is more at risk to I & I than other regions of NC due to its low-lying geography and expansive hydrology. High groundwater levels, whether from rain or sea level rise (SLR), make wastewater infrastructure in coastal areas more at risk to infiltration, potentially resulting in more SSOs and improper treatment at the WWTPs.[17] The coastal plain is subject to higher average annual rainfall than other regions of NC and more extreme rainfall events, often associated with tropical storms. Climate change will exacerbate these conditions (see Climate Change Chapter for more information), and coastal wastewater collection systems may be increasingly vulnerable to effects of I & I and sewer spills.

Over the years, many incidents have occurred across coastal NC counties where elevated sewer system flows or other causes resulted in unpermitted discharges of wastewater or discharges of poorly treated wastewater to coastal waters and habitat (D. May, DWR, personal communication). Most of these SSOs can be traced back to the aging and failing water and sewer systems in the inner coastal region. A majority of NC's water systems are 40 years old or older, with many of them 60 to 70 years old. Some sewer lines in the towns of Columbia and Bellhaven are 90 and 100 years old, respectively. The average age of wastewater treatment plants in the state is approximately 40 years old, though many of them have undergone renovations to comply with current state and federal regulations. The NC section of the American Society of Civil Engineers gave NC a statewide grade of "C" due to its extensive wastewater infrastructure problems.[18]

The DWR requires that SSOs are reported to DWR by the permittee (15A NCAC 02B .0506 - Reporting Requirements). Specifically, the permittee shall verbally report by phone to a DWR staff member at the appropriate Regional Office, as soon as possible, but in no case more than 24 hours following first knowledge of the occurrence of either 1) any SSO and/or spill over 1,000 gallons to the ground, or 2) any SSO and/or spill, regardless of volume, that reaches surface water. These SSO incidents are tracked using an internal DWR database. The permittee is required to follow up with DWR by providing a written report within five days. It should be noted that the spill volumes in the database are estimated by the reporting party, can be difficult to estimate visually, and may vary in accuracy. From 2015 through 2019, there were 501 SSO incidents reported in the twenty coastal counties (Table x.3). The average sewer spill volume was estimated to be 50,170 gallons, median spill volume was 1,500 gallons, and maximum spill volume was 4 million gallons. In addition to estimating the volume of the spill, an estimated volume reaching surface waters is also provided. The total volume of wastewater reaching surface water was estimated to be in excess of 24 million gallons for this five-year period for NC's 20 twenty coastal counties. The data indicate that most of the spills reported are relatively small. The largest of the spill volumes, those that exceed approximately 33,000 gallons, represent 10% of the reported overflows for the five-year period. Brunswick, New Hanover, and Craven counties had the highest number of incidents during that time period (Figure X.4). In contrast, Onslow County had the highest total volume of sewage

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[15] Cahoon, L.B.. K.C. Hales, E.S. Carey, S. Loucaides, and K.R. Rowland. 2016. Multiple modes of water quality impairment by fecal contamination in a rapidly developing coastal area: southwest Brunswick County, NC. Environmental Monitoring Assessment. 188(89):1-13. doi.org/10.1007/s10661-015-5081-6

[16] Iverson, G., C.P. Humphrey Jr., M.H. Postma, M.A. Driscoll, A.K. Manda, and A. Finley. 2017. Influence of sewered versus septic systems on watershed exports of E. Coli. Water Air Soil Pollution. 228-237. DOI 10.1007/s11270-017-3426-1.

[17] Flood, J.F. and L.B. Cahoon. 2011. Risks to coastal wastewater collection systems from sea level rise and climate change. Journal of Coastal Research. 27(4): 652-660.

[18] Schiavinato and Kalo 2014, 1

spilled to surface waters, followed by New Hanover and Chowan counties (Figure x.5)

Table X.3. SSO incident data from the 20 coastal counties, 2015 – 2019. A dash is reflective of no information being available for the data type and may be a condition of potential reporting deficiencies in some cases.

Coastal County	No. of Reported Incidents (2015-2019)	Total Gallons of Wastewater Spilled to Surface Waters	No. of Incident Related to Storm Events	Total Gallons of Wastewater Spilled to Surface Waters Related to Storm Events
Beaufort	9	1,008,995	1	1,000,000
Bertie	22	1,549,600	2	1,000,000
Brunswick	101	883,072	4	20,650
Camden	0	0	-	0
Carteret	20	1,347,558	1	210,000
Chowan	19	2,748,141	-	0
Craven	81	791,147	4	87,300
Currituck	4	600	-	0
Dare	11	40,389	-	0
Gates	0	0	-	0
Hertford	15	109,062	4	81,122
Hyde	2	850	-	0
New Hanover	100	2,762,765	14	11,300
Onslow	47	10,299,536	-	0
Pamlico	18	130,949	3	40,149
Pasquotank	24	1,221,700	3	1,200,000
Pender	8	3,200	-	0
Perquimans	14	576,450	1	1,000,000
Tyrrell	0	0	-	0
Washington	6	11,275	1	10,000
TOTAL	501	23,485,289	38	4,660,521

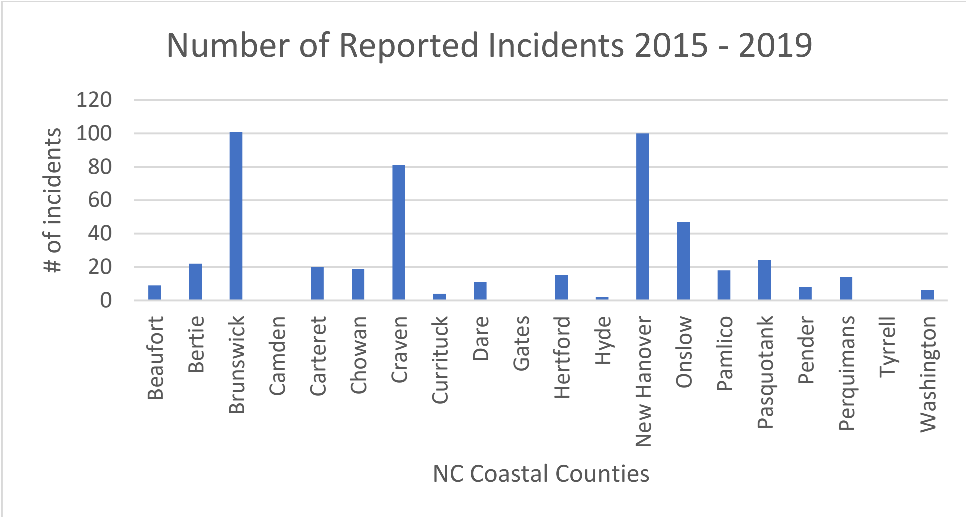

Figure X.4. Number of reported sanitary sewer overflow (SSO) incidents by NC coastal county from 2015 – 2019. Source: DWR database.

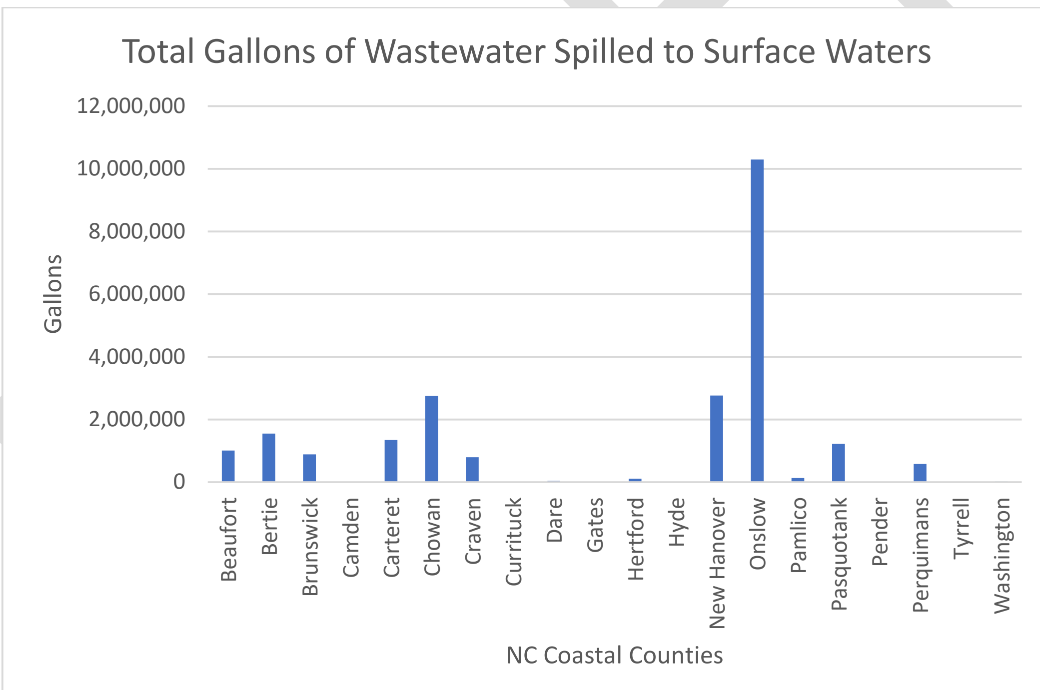

Figure X.5. Estimated wastewater volume in gallons spilled to surface waters for NC coastal counties, 2015-2019.

Data revealed that several coastal counties had no reports of SSOs over the five-year timeframe while other counties had what appear to be much higher instances of an SSO. Past experience of DWR staff indicates that it is unlikely that no SSOs occurred in those counties reporting zero SSOs (D. May, DWR, personal communication).

There can be many reasons a SSO is not reported or is failed to be identified; some examples include:

- Smaller collection systems may experience hydraulic loading for shorter duration and the operator is simply unaware of the occurrence.
- Problematic collection system segments can be in landscape positions where visual operations or reports from the public are infrequent due to lack of access.
- While some collection system operators actively seek out and target the identification of SSOs during severe precipitation events, other systems owners may have staffing issues that limit such proactive efforts.
- Operators and/or permittees of select systems may be unaware of the reporting requirements.

It is also the experience of DWR staff that counties with a higher population density and larger, more widely distributed collection systems tend to result in a higher likelihood of SSO incidents being reported. Both DWR and the permittee often receive notification of SSOs or a pump station alarm from adjacent homeowners and business. In addition, foot traffic along greenways having collection lines above ground results in routine and fast notification of infrastructure failures (SSOs). The identification and tracking of these events help target line cleaning and maintenance needs; Fat, Oil and Grease program implementation; and other I & I priorities.

Additional outreach, technical assistance, more intensive compliance oversight, and increased inspection frequency may result in a reduction in the number of SSO's and more accurate/robust reporting. The data provided is intended to help demonstrate the need to properly maintain, operate, and in some cases upgrade wastewater collection and treatment systems. Such action may result in fewer sewer spills to surface waters, resulting in less impact to receiving waters and coastal habitats.

Not all SSOs result in wastewater reaching surface waters. However, due to the vast hydrology of the NC coastal plain with numerous small creeks and ditches, it's likely that the sewage reaches surface waters directly or indirectly through runoff (D. Smith, DWR, personal communication). On a national scale, 10% of U.S. beach/swimming closures and advisories in 2012 were attributed to sewage spills and overflows.[19] This category includes combined sewer overflows, SSOs, breaks or blockages in sewer lines, and faulty septic systems. Combined sewer systems, where stormwater and wastewater are transported together in the same collection lines, do not occur in NC. Stormwater runoff, including agricultural sources, was the largest known source contributing to closures and advisories. Despite not being the major contributor, the Natural Resource Defense Council (NRDC) report notes that wastewater spills are an increasing concern due to climate change, and includes several strategies to improve the resiliency of wastewater infrastructure.

From 2005 – 2019, data from Division of Marine Fisheries (DMF) Shellfish Sanitation Section indicates that there were 19 recreational advisories reported (DMF Shellfish Sanitation, uppub. data) due to SSOs (Table X.4). This number only includes spills that resulted in a temporary shellfish closure or swimming advisory. These numbers are likely an underestimate of total sewage spills that reach coastal waters because those that occur in waters already closed or where the entire spill is within a safety buffer zone already established around permitted WWTP discharges are not included (S. Jenkins, DMF, personal communication).

[19] NRDC (Natural Resources Defense Council). 2013. Testing the waters. NRDC, Washington DC. 542 p. https://www.nrdc.org/sites/default/files/ttw2013.pdf

Since 2011, only one recreational advisory has occurred. Closures have declined in part due to a concerted effort to improve wastewater infrastructure in counties or municipalities that had repeated problems in the early 2000s, such as New Hanover, Carteret, and Onslow counties. While sewer spills result in localized water quality issues, they account for less than 1% of shellfish closures and swimming advisories (S. Jenkins, DMF, personal communication).

Table x.4. Sewage spill recreational advisories, 2005-2019 (DMF, Shellfish Sanitation office, unpub. data)

County	Number	Waterbodies Affected
Beaufort	1	Pamlico River near downtown Washington
Carteret	3	Town and Taylor creeks in Beaufort; Atlantic Ocean at Atlantic Beach
Craven	1	Neuse River between Wilkinson Pt and Pierson Pt, including Gatlin Creek and other creeks near New Bern
Hyde	1	Swanquarter Bay near Swanquarter
New Hanover	6	Hewlett, Bradley, and Futch creeks, ICW, Cape Fear River in Wilmington; Carolina Beach Yacht Basin
Onslow	3	Ward Creek, Swansboro; New River, Mill and Chaney creeks in Jacksonville
Pamlico	1	Neuse River between Wilkinson Pt and Pierson Pt, including Gatlin and other creeks near ???
Pasquotank/ Camden	3	Pasquotank River near Elizabeth City

1.3.2. Economic challenge

Problems with wastewater infrastructure contribute to a financial burden incurred by the sewer and wastewater system owner and economic impacts to the surrounding communities. Consequently, adequate funding and planning for proper maintenance and operation of wastewater infrastructure is sometimes not adequately provided. Increased flows associated with I & I result in increased volumes of wastewater to be managed and treated, translating into increased operational and system upkeep costs. In most cases, customers pay sewer fees based on the amount of water used over a time period or an established sewerage flat fee. Wastewater system owners may often be covering the added expense of managing, treating, and disposing of the additional volume of wastewater attributed to I & I while customers face increased rates. Because SSOs are not permitted, they are illegal and can result in regulatory agencies taking enforcement actions, which may include expensive fines when bodies of water cannot be used for drinking water, shellfish harvesting, fishing, or recreation, communities experience an economic loss. Remedial action may also be needed by owners in response to spills to minimize potential environmental impacts. The level of cost for such remedial response varies based on the characteristics of a spill. SSOs also impact local economies when they result in closure of beaches, impacting tourism and waterfront home values. Fishing and shellfish harvesting may be restricted or halted, in turn impacting production, supply, and distribution.

Aging infrastructure, particularly in low income areas, reduced available federal funding, high cost of infrastructure repair and replacement, and lack of strong capital improvement plans (CIPs) or asset management plans collectively contribute to making this issue economically challenging.[20] [21] Efforts to control I & I may be viewed as an ongoing continuous process, as opposed to a one-time project that will address all needs indefinitely into the future.

1.4 Discussion

Given the coastwide distribution of over 500 WWTPs, documented prevalence of I & I issues, and magnitude of SSOs, improvements to wastewater infrastructure are needed for long-term water quality management. This problem has been previously recognized as a priority to address. In 2006, the North Carolina Rural Economic Development Center (NC Rural Center) released a series of reports, as part of a Water 2030 Initiative, with data on public infrastructure and water supply. It concluded that approximately $17 billion in improvements were needed for water, sewer, and stormwater systems to keep pace with the growing population and repair of old infrastructure.

In 2010, a study on emerging estuarine issues was conducted by the NC Coastal Resources Law, Planning, and Policy Center, with financial support from Sea Grant and NOAA, and informational support from a steering committee. The study was done in response to public requests following a 2009 Ocean Policy Study, thus providing a comprehensive study of emerging management and policy issues for the entire NC coast. The Estuarine Policy Steering Committee selected SSOs as one of four key emerging natural resource issues in the coastal counties.[22] This was considered an emerging issue due to rapid development occurring on the inner coast and the expectation that infrastructure issues were likely to intensify with SLR. North Carolina is expected to be one of the top three most threatened areas from SLR in the U.S. as more than 2,000 square miles of the coast are less than three feet in elevation.[23]

The report had several recommendations related to SSOs. Two recommendations address "deemed permitted" collection systems. Deemed permitted collection systems are those with an average daily flow of less than 200,000 gallons per day (GPD) (15A 2T.0303). In the DEQ Washington Regional Office, approximately 50% of the wastewater systems were deemed permitted.[24] One recommendation of the report was that the NC Environmental Management Commission (EMC) and DEQ revise rule 15A 02T.0403 to require that a minimum of 10% of a deemed permitted collection system's lines be cleaned on an annual basis. This requirement exists for permitted systems but deemed permitted systems are exempt.

Regular cleaning of pipes can reduce SSOs. However, a better approach for these smaller systems would be to require collection lines be cleaned annually on a systematic basis (e.g. three to five years) reducing equipment mobilization cost. (D. Smith, DWR, personal communication). Further, because a deemed permitted collection system is not covered under an individually issued collection system permit, discussion may be needed to establish a mechanism to better capture such a need and ensure that collection system owners are aware of such a requirement.

Another recommendation of the Estuarine Policy Steering Committee report was for the EMC and DEQ to modify rules to require municipal wastewater collection systems with 100,000 or more GPD have a

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[20] Schiavinato and Kalo 2014, 1

[21] NCDWI (NC Division of Water Infrastructure). 2017. NC's statewide water ans wastewater infrastructure master plan. The road to viability. NCDEQ. Raleigh, NC. 104 p.

[22] Schiavinato and Kalo 2014, 1

[23] Albemarle-Pamlico Conservation and Communities Collaborative. 2009. Public listening sessions report: sea level rise and population growth in NC. Report 29. 62 p. https://digital.ncdcr.gov/digital/collection/p249901coll22/id/639601

[24] Schiavinato and Kalo 2014, 1

certified operator as an Operator in Responsible Charge (ORC). Existing EMC rules do not require an ORC for collection systems deemed permitted. Having an ORC would ensure that a qualified operator was responsible for operating, inspecting, and maintaining the system, potentially reducing SSOs and identifying problems proactively. While more oversight by an ORC would be helpful, there is a shortage of licensed wastewater and collection system operators in coastal and other regions of the state, and therefore an expansion of facilities required to have a designated licensed wastewater collection system operator could be challenging for some operations. As such, further evaluation may be warranted to assess implications of expanding the number of sewer systems requiring oversight by licensed wastewater operators or develop appropriate criteria for deemed permitted systems where an ORC should be required. Criteria could include a maximum GPD, history of problems, vulnerability of lines, SLR and storms, and risk to high quality waters and valuable coastal habitat. During the interim evaluation period, provisions within rule 2T .0403(c) provide a mechanism for the DWR to bring a deemed permitted collection system under an individual permit, in cases where it may be appropriate to do so. In cases where a deemed permitted sewer system experiences chronic compliance issues, including chronic SSOs, the operation may be required to apply for and come under an individual collection system permit. Conditions with the individual permit could provide a mechanism to require oversight of the system by a certified operator, as well as the necessity to conduct routine cleaning of sewer lines.

The report also recommended that the NC General Assembly put in place a dedicated fund for water and wastewater infrastructure maintenance and repairs. The report suggested establishment of a working group of experts to discuss and develop recommendations to address the issues associated with SSOs, as well as broader water and wastewater infrastructure issues, in NC's rural counties and municipalities. Finally, the report recommended that local governments focus on capital improvements planning and asset management planning, to aid in budgeting for improvements that will avoid and minimize the effects of wastewater collection system failures. While there is no dedicated funding for water and wastewater infrastructure operation and maintenance, some actions have since occurred to address the issues.

In 2013, the NC General Assembly, through G.S. 159G-70 created a nine-member State Water Infrastructure Authority (SWIA). Responsibilities include awarding both federal and state funding for water and wastewater infrastructure projects, establishing criteria to prioritize applications, and developing a state water infrastructure master plan. Additionally, the SWIA duties include assessing the state's water and wastewater infrastructure needs, evaluating the role of the state in funding needed infrastructure, assessing the adequacy of funding programs currently available to local governments and utilities and assessing the need for a troubled system protocol. The NC General Assembly also created the Division of Water Infrastructure (DWI) at that time to provide support to the SWIA.

Early in the SWIA work, it was realized that for the state to meet its water and wastewater infrastructure needs, it is crucial that individual utilities are, or are on a path to be, viable systems. Viability is defined as a system that functions as a long-term, self-sufficient business enterprise; establishes organizational excellence; and provides appropriate levels of infrastructure maintenance, operation, and reinvestment that allow the utility to provide reliable water services now and in the future, without reliance on grant funds. The SWIA addresses this and many other issues in its "Statewide Water and Wastewater Infrastructure Master Plan – The Road to Viability."[25]

The issue of I & I is more than just the physical condition and operation of a wastewater collection

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[25] NCDWI (NC Division of Water Infrastructure). 2017. NC's statewide water ans wastewater infrastructure master plan. The road to viability. NCDEQ. Raleigh, NC. 104 p.

system. No matter how resilient and sustainable the physical infrastructure is, its ability to serve customers reliably for the long-term ultimately depends on decisions made by the owner – usually elected officials – about how system needs are identified and funded, and the skill level of its utility employees. For example, decisions about water and sewer rates and fees impact the amount of revenue generated by a utility and its ability to keep the system well-maintained and make needed repairs in a timely manner. Decisions made about staff training impact the operation of the infrastructure components and system as a whole. Decisions about communicating with customers about the critical nature of infrastructure affects customer's understanding of and support for needed rates and fees. The organizational structure and management of a utility, from the elected officials to the operating staff, directly affects the quality of its physical infrastructure and its ability to maintain compliance.

Water and sewer utilities are intended to operate as self-sufficient business enterprises. As mentioned previously, this requires the ability to financially support the full cost of capital projects, replacement and renewal projects, as well as appropriate system operations and maintenance. Unfortunately, simply mandating that utilities fully fund infrastructure, operations and maintenance is not a realistic approach. As far as funding support, only a fraction of NC's infrastructure needs can be met with the level of funding currently available from state and federal subsidized funding sources, and increased funds from these sources does not appear likely.

Many WWTPs and sewer systems in the state were constructed years ago either with revenue from a large manufacturing customer base or with the help of federal grant funds, both of which have diminished considerably. In 1970, over half of NC's population lived in rural areas and supported farming and manufacturing including tobacco, furniture, and textiles. Today, the number and size of large water-using industries has declined and only one third of the state's residents live in rural areas. Wastewater treatment plants and sewers in many rural areas, originally built for large flows from manufacturing facilities, are now oversized for the much smaller domestic flows that remain. These rural utilities are still burdened with the upkeep and operation of these large systems, but now lack the significant sources of revenue that once paid for such work. In addition to decreasing population and industrial customers, water usage overall is declining, which also reduces revenues.

Some small utilities have not raised rates in years and continue to defer needed rehabilitation of their aging infrastructure. Other small utilities have worked to replace this revenue by raising water and sewer rates, and, as a result, some of the smallest, most economically distressed communities have some of the highest water and sewer rates in the state. These rates are unaffordable and unsustainable in the long-term. The U.S. Environmental Protection Agency (EPA) recognizes that pricing decisions involve consideration of equity as well as efficiency. Low-income households, especially those served by high-cost systems, may face affordability problems if prices are raised.[26] The growing issue of water and wastewater service affordability is also being elevated by the American Water Works Association and the Water Environment Federation.[27] Small utilities also face requirements to meet more stringent water quality regulations, especially regarding nutrient sensitive waters, which increases costs.

The SWIA recognizes that viability issues result from many different circumstances that are specific to each utility and require approaches tailored to individual needs. However, when utilities are not viable or are not on a path to become viable, other possible courses of action must be explored. The DWI administers two grant programs that provide funding designed to help utilities take the first steps toward viability. These options are best utilized in a proactive manner and well before a utility's

[26] https://www.epa.gov/sustainable-water-infrastructure/pricing-and-affordability-water-services#affordability

[27] https://www.awwa.org/Resources-Tools/Resource-Topics/Affordability

infrastructure and financial situation become critical.

- Asset Inventory and Assessment (AIA) Grants - support a utility as it examines the purpose and value of its infrastructure, and the processes it uses to determine when and how to spend infrastructure dollars. Outcomes include identifying the most critical projects and the ability to demonstrate and explain why they are critical, which will help gain support from governing bodies, customers, and stakeholders to make the needed investments. Funds are provided for a utility to:
    - Identify the water and wastewater infrastructure components that comprise its water and wastewater systems
    - Create an asset inventory
    - Determine the condition of these assets
    - Prioritize the most critical infrastructure needs
    - Develop a capital improvement plan (CIP) to fund the projects
- Merger/ Regionalization Feasibility Grants - investigate voluntary partnerships, such as consolidating two or more systems into one, that can result in improvements to physical infrastructure and organizational and financial management.

In addition to the above grants, permanent solutions can also be created when:

- Elected officials and utility governing boards explore potential advantages of a range of partnership solutions that might include regionalization, consolidation, shared management opportunities, contract operations, interlocal agreements, public-private partnerships, privatization, and other activities or arrangements; and
- Utilities reach out to other entities such as the North Carolina Rural Water Association, Southeast Rural Community Assistance Project, regional North Carolina Councils of Government, Department of State Treasurer, University of North Carolina at Chapel Hill School of Government Environmental Finance Center, the North Carolina League of Municipalities, the North Carolina Association of County Commissioners and the DWI to understand infrastructure issues and develop potential options.

The SWIA also administers other grant and loan programs to support construction of needed infrastructure repairs or modifications:

- Clean Water State Revolving Fund – provides low-interest loans to local governments to fund wastewater collection and treatment facility projects including the relocation of infrastructure outside of the 100-year and 500-year floodplains. Loans are also available for stormwater quality improvement projects, such as BMPs and stream restoration.
- State Wastewater and Drinking Water Reserve Programs – provides grants and loans for wastewater treatment and collection systems as well as drinking water treatment and distribution systems.
- Community Development Block Grant – Infrastructure – provides grants to local governments to address wastewater infrastructure needs in HUD qualified low to moderate income communities.

On July 1, 2020, Session Law (SL) 2020-79, “An Act to Improve the Viability of the Water and Wastewater Systems of Certain Units of Local Government…” was signed by Governor Cooper. SL 2020-79 requires review of local government units to determine if they are distressed due to issues in their water or wastewater enterprise fund and provides for a new Viable Utility Reserve (VUR) grant fund. A number of units of local government in coastal areas will likely be designated as distressed due to issues with their water/wastewater systems.

The goal of SL 2020-79 is to facilitate comprehensive, permanent solutions for distressed water or wastewater utilities through a process framework and grant funding to accomplish the solutions. Both the SWIA and the Local Government Commission of the Office of State Treasurer must approve the use of VUR grant funds. However, the initial appropriation of only $9 million for the VUR fund supports just the beginning of this process. A secure, reliable, on-going, and increased source of funding is needed for the long-term success of the new program. From January 2014, the first time awards were made to Local Government Units (LGUs), the SWIA has awarded more than 900 projects in the amount of approximately $1.9 billion. In 2019-2020, a total of $182 million of grant and loan funding was awarded, excluding the drinking water project funding.[28] Funding programs included 18 projects from the Community Development Block Grant-Infrastructure, 31 projects from the Asset Inventory and Assessment grant program, 10 from the Merger/Regionalization Feasibility Grants, 31 from the Federal-State Clean Water State Revolving Fund, and four from the State Wastewater Reserve. While this is a substantial amount of assistance, the DWI continues to receive more grant and loan funding requests from throughout the state than are available.

The NC Climate Risk Assessment and Resilience Plan[29] also recognized failing infrastructure and SSOs as a growing concern to coastal water quality. Climate change issues that can impact wastewater infrastructure include SLR, extreme heat, inundation and rainfall events, increased temperatures, flooding, storm surge, and dam failure. Flooding associated with extreme storm events can result in increases in I & I and more frequent SSO events. The frequency and magnitude of extreme storm events is expected to increase due to climate change. and lift stations Loss of power during storm events can also cause operation issues resulting in SSOs at wastewater treatment plants or lift stations.

To improve ecosystem and community resiliency, the plan suggests that state and local governments utilize policies or rules to encourage siting development, WWTPs, and other pollution sources away from riparian areas and floodplains. Also, utilities can continue to flood-proof assets such as WWTPs and upgrade sewer infrastructure to reduce the risk of I & I and SSO. The plan notes that improving wastewater management and maintaining wastewater infrastructure can help reduce the loading rates of nutrients and sediments into estuaries, resulting in more resilient conditions for submerged aquatic vegetation (SAV), other fish habitats, and coastal communities. When WWTPs are inundated and infrastructure is damaged, available federal funding could be utilized as much as possible to repair and reduce future flood risks. The plan sites a near-term priority as identifying and voluntarily moving WWTPs out of the floodplains.

The plan recommends that immediate focus is needed to develop strategic priorities for public and natural infrastructure improvements. Future climate conditions and resiliency should be integrated into current public investment decisions in local and regional water and transportation infrastructure improvements and other critical assets. By building resilience into infrastructure, risks for small businesses and communities are lowered.

As part of the EPA's Creating Resilient Water Utilities (CRWU) initiative, APNEP conducted the Climate Resilience Evaluation and Awareness Tool Exercise with the towns of Manteo and Columbia. Potential impacts of rising sea levels on wastewater infrastructure were examined using the EPA Climate Risk Evaluation and Assessment Tool (CREAT). The report provides engineering and financial

[28] NCDWI (NC Division of Water Infrastructure). 2020. Report on the water infrastructure fund and state water infrastructure authority. Fiscal year 2020. NCDEQ. Raleigh, NC. 183 p.

[29] NCDEQ 2020, 1

recommendations for realistic measures the towns might take to improve their resiliency to coastal hazards and flooding to consider for integration into their capital improvement planning processes.[30]

For many years, NRDC has provided an annual analysis of water quality by state. To deter increasing SSOs due to increasing SLR, extreme rain events, and flooding[31], recommended that wastewater utilities immediately implement climate-smart strategies, similar to what was recommended in the NC Climate Risk Assessment and Resilience Plan[32]. In addition to flood-proofing and relocating high-risk facilities where possible, other strategies included:

- Update water and wastewater emergency response and maintenance procedures to prepare for more common and more extensive coastal flooding of vulnerable infrastructure.
- Plan for alternative power supplies to support operations in case of loss of power.
- Install effluent pumping systems for wastewater treatment plants affected by SLR, and ensure the adequacy of emergency generator systems.
- Until vulnerable facilities can be relocated, build berms as a short-term protective measure.

The DWR emphasizes to utility owners the need for proper operation and maintenance of sewer lines to prevent many SSOs, but this also requires funding. Maintenance includes routinely inspecting sewer lines, and cleaning them at a frequency sufficient to address blockages from grease and fat, roots, and pipe deflections. Smoke testing, dye testing, and using cameras are examples of tools that can be used to detect sources of broken lines, obstructions, and illicit connections.

In 2017, as an incentive to correct illicit discharges from wastewater infrastructure, DWR approved a new nutrient reduction practice, "Design Specifications and Nutrient Accounting for Remedying Illicit Discharges to Surface Waters or Stormwater Systems". Illicit discharges were defined to include SSOs caused by I & I during wet weather, sewage leakage out of the pipe (exfiltration) during dry periods, and sanitary direct connections. Nutrient credits can be received for remedying such problems for compliance with applicable Nutrient Management Strategy Rules. This would only be applicable in NSW watersheds. Further information regarding Nutrient Practices and Crediting can be found at the following link maintained by DWR: https://deq.nc.gov/about/divisions/water-resources/planning/nonpoint-source-management/nutrient-offset-information#about-nutrient-offsets-and-trading. Topics including Stormwater Nutrient Accounting Tools, Approved Nutrient Reduction Practices, and Nutrient Offset and Trading information are covered at the referenced link.

Other actions DWR has recommended to help control I & I for sewer and wastewater systems in coastal areas include:

- Evaluate the feasibility of re-designing and re-engineering existing systems
- Evaluate and select sewer system designs that may be better suited for conditions experienced in coastal areas for new construction projects (e.g. vacuum sewer systems)
- Increase preventive maintenance of collection lines
- Pro-actively address potential problem areas within sewer lines and correct existing problems through repairing, replacing, or lining sections of the sewer line
- Charge and assess fees to customers at rates necessary to cover costs, including long-term expenses that may require extensive re-investment in the system when components have reached or

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[30] EPA (US Environmental Protection Agency) 2013. Climate Resilience Evaluation and Awareness Tool Exercise with Manteo and Columbia, North Carolina and the Albemarle-Pamlico National Estuary Partnership. EPA 817-B-13-002.E PA Office of Water (4608-T). 32 p.

[31] NRDC 2013, 11

[32] DEQ 2020, 1

exceeded the end of reasonable life cycle expectancies
- Explore establishment of alternative funding methods to support wastewater utility needs
- Expand funding ability from current state level resources
- Evaluate feasibility of modifications to ranking systems used to determine project funding eligibility, placing additional prioritization on projects located within environmentally sensitive coastal areas
- Explore whether current sewer and wastewater infrastructure regulations meet the needs of coastal areas and recommend updates if appropriate

1.5 Proposed Management and Research Options (source of previous recommendations are in italics; type of action is in blue)

1. Request adequate and recurring state appropriated funds needed for the viable utility reserve. (*SWIA 2019-2020 Annual Report*) (Funding)

2. Request the NC General Assembly modify legislation to allow SWIA flexibility in establishing grant conditions for programs under their authority, to ensure grant funds are used to help systems achieve long-term viability. *(SWIA 2019-2020 Annual Report)* (Legislative)

3. Within the funding programs under the purview of the SWIA, consider additional priority for projects with a direct benefit to sensitive estuarine waters, including SA waters, fish nursery areas, and impaired waters, particularly those adversely impacting estuarine fish and their habitat. (*SWIA 2019-2020 Annual Report – modified to be coastal specific*) (Policy)

4. Develop additional incentives to encourage improved maintenance of the collection system (e.g. incentivize owners and operators of wastewater lines for both existing systems and potential new systems to adopt construction designs that minimize the potential for sewer spills over the long term. (*Schiavinato and Kalo 2014, DWR staff*) (Policy)

5. Evaluate modifications of DWR rules to require deemed permitted collection systems under select criteria (e.g. 100,000 or more GPD) to have a certified operator as an Operator in Responsible Charge (ORC). DWR shall provide an update on this evaluation effort to the Water Quality Committee in approximately one year. (*Schiavinato and Kalo 2014, DWR staff*) (Potential rule making)

6. Investigate modification of DWR rules to require deemed permitted collection systems to be cleaned annually on a systematic basis (e.g. 3 to 5 years). The DWR shall provide an update on this evaluation effort to the Water Quality Committee in approximately one year. (*Schiavinato and Kalo 2014, DWR staff*) (Potential rule making)

7. Work with state and local governments in the coastal counties to develop policies or rules (within 15A NCAC 02T) regarding flood-proofing wastewater infrastructure; siting new and relocating existing infrastructure away from sensitive estuarine waters and floodplains; upgrading sewer infrastructure; and develop strategic priorities for public and natural infrastructure improvements. (*NC Risk and Resiliency Plan*) (Potential rule making)

8. Prioritize research on alternative wastewater collection system designs that may be better suited for coastal conditions (alternative sewer systems, composting toilets, etc). (*DWR, L. Cahoon, UNC-W*) (Research)

1.6 Authority

G.S. 143B-279.8. Coastal Habitat Protection Plans.

G.S. 143-215.1. Control of sources of water pollution. EMC - Permitting wastewater treatment plants.