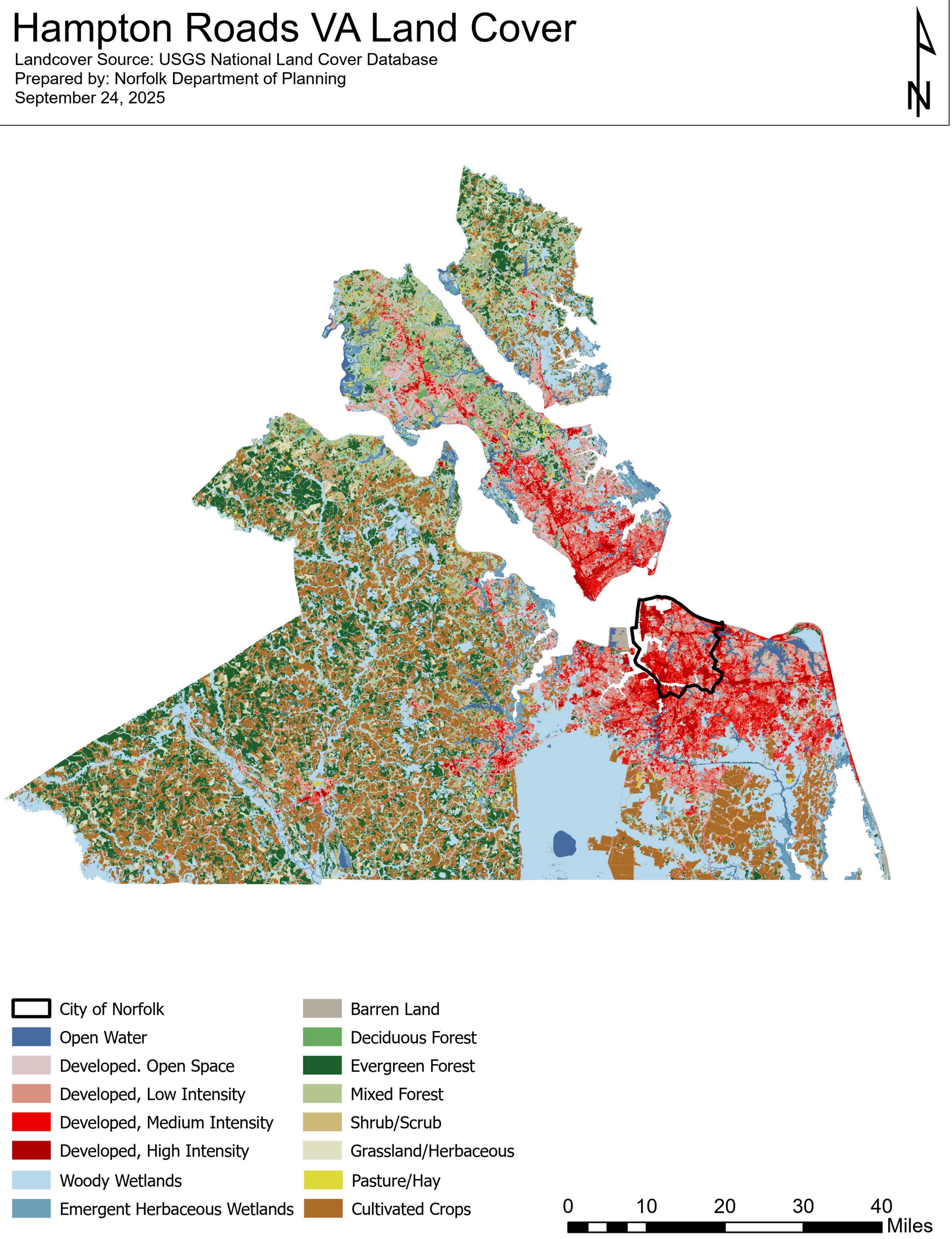
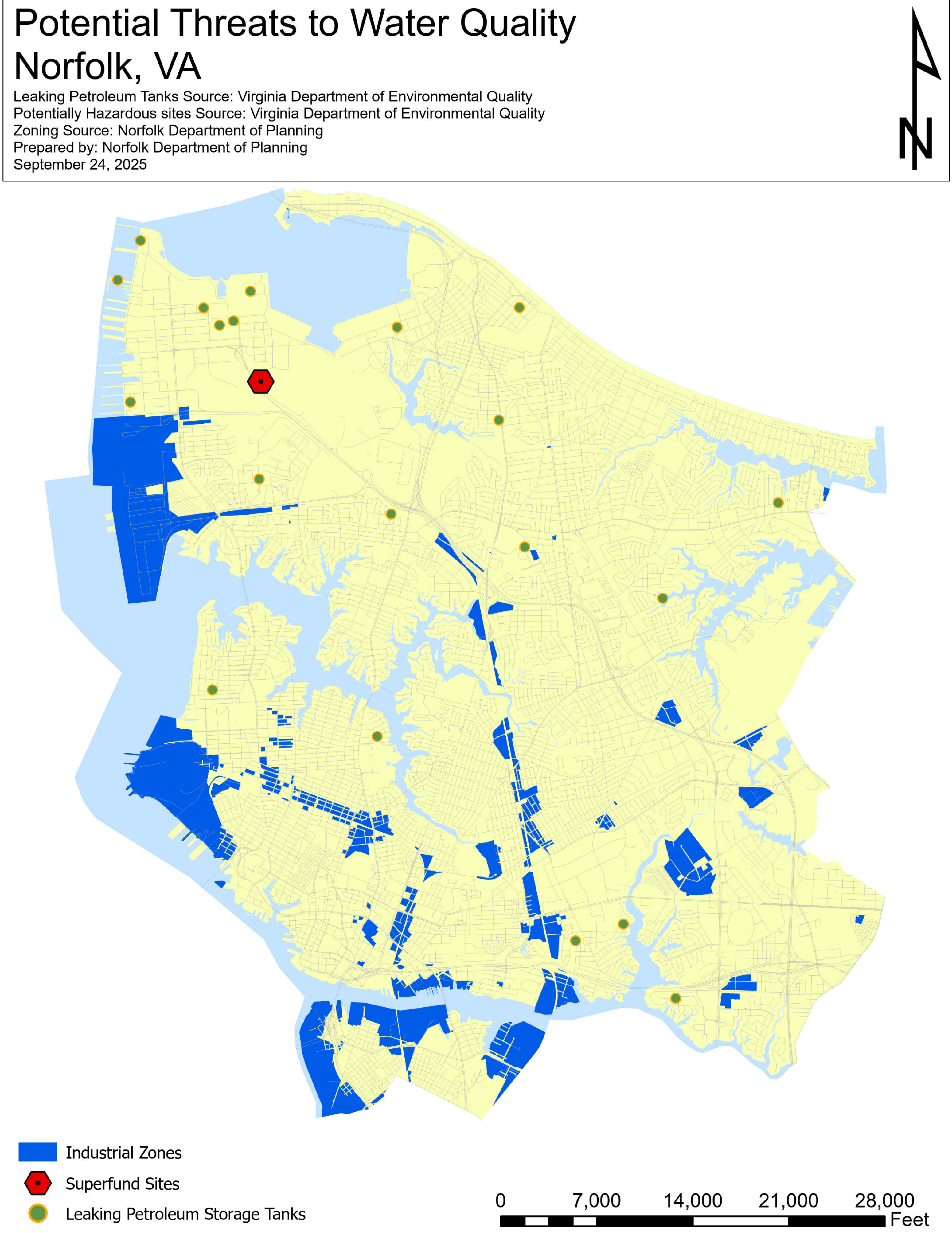
Hampton Roads VA Land Cover

Landcover Source: USGS National Land Cover Database
Prepared by: Norfolk Department of Planning
September 24, 2025



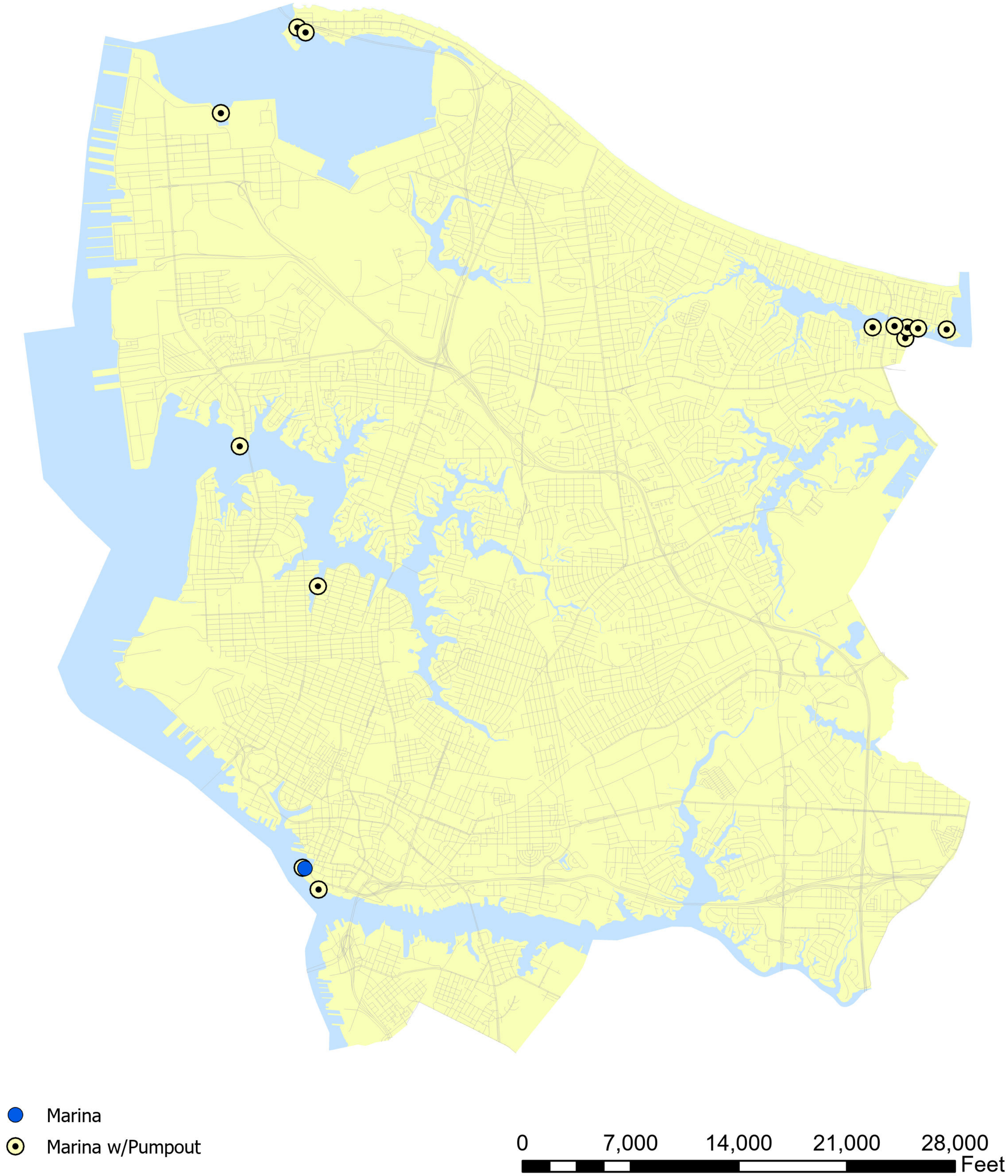
Potential Threats to Water Quality
Norfolk, VA

Leaking Petroleum Tanks Source: Virginia Department of Environmental Quality
Potentially Hazardous sites Source: Virginia Department of Environmental Quality
Zoning Source: Norfolk Department of Planning
Prepared by: Norfolk Department of Planning
September 24, 2025



Marinas Norfolk, VA

Marina Data Source: Virginia Department of Environmental Quality
Prepared by: Norfolk Department of Planning
September 24, 2025



CITY OF NORFOLK CHESAPEAKE BAY PRESERVATION AREA PROGRAM SUPPLEMENT

PHYSICAL CONSTRAINTS TO DEVELOPMENT

INTRODUCTION

The regulations of the Chesapeake Bay Preservation Act (CBPA) and the Chesapeake Bay Local Assistance Department (CBLAD) Checklist for Evaluation of Comprehensive Plans require that local comprehensive plans address existing natural limitations of the land that can act as physical constraints to development. These may include flood prone areas, highly erodible soils, highly permeable soils, wetlands, steep slopes, hydric soils, seasonally high water table, groundwater recharge areas, significant wildlife habitat areas, prime agricultural lands, and protected lands. An assessment of soils for septic tank suitability is also required. However, for an essentially built out City, such as the City of Norfolk, considering the majority of these physical constraints in its Comprehensive Plan is not appropriate because development patterns have been well established and the entire City is served by a public sewer system. Moreover, the full range of typical urban services is available throughout the city.

Available data supports the fact that Norfolk is essentially entirely developed and that little vacant land remains in the City. When an existing land use inventory was conducted for the City's Virginia Pollution Discharge Elimination System (VPDES) permit application in 1991, it was found that vacant land accounted for 8.6 percent of the City's existing land use (Table 1). When these figures were updated in 1999, it was found that only 1.5% of the City's existing land use consists of vacant land. These remaining vacant properties consist of relatively small, isolated parcels (Figure 1). Due to existing zoning and the surrounding development patterns, it is highly unlikely that existing physical constraints in these properties will prevent their development.

Table 1. Existing Land Use, City of Norfolk. From Norfolk VPDES permit data.

Land Use	1991	1999
Commercial	22.2%	22.6%
High-Density Residential	6.7%	7.7%
Institutional/Educational	7.0%	7.5%
Industrial	4.1%	5.6%
Multi-Family Residential	4.7%	2.5%
Recreational	6.6%	4.5%
Single-Family Residential	39.0%	48.0%
Vacant	8.6%	1.5%

Many of the physical constraints identified by the CBLAD Checklist are not applicable to long-term planning in the City of Norfolk and are not addressed here. However, as evidenced by its existing programs, flood prone areas, wetlands, coastal primary sand dunes and beaches are considered by the City to be important physical constraints to development. These are addressed below.

Figure 1. Existing Land Use

[figures available in Planning Department]

FLOOD PRONE AREAS

Flood prone areas are those sites in the City that are predictably subject to overflows from nearby water bodies. Development in flood prone areas can be potentially costly and hazardous. Several factors can determine the amount of damage caused by flooding, such as topography, rate of water rise, depth and duration of flooding, geographic orientation of the shoreline, and the amount of threatened development. Development in flood prone areas can worsen flooding by increasing the amount of impervious cover, which prevents the natural infiltration and absorption of water into the soil. The Chesapeake Bay Local Assistance Department (1989) notes that the benefits of preserving floodplains include enhancing water quality, allowing recharge of groundwater aquifers, reducing flooding, providing fisheries and wildlife habitat, providing recreational opportunities, and protecting historic lands.

In Norfolk, however, the flood prone areas in the City were developed before they were identified as “special flood hazard areas” and before the creation of federal and state floodplain protection programs. This historical development limits the opportunity to realize the full benefits of floodplain preservation. The City’s floodplain management effort will continue to focus on the identification, reduction, and mitigation of flood hazards within developed areas. There may also be some opportunities for targeted restoration of floodplains though buy-out and relocation programs.

Flood prone areas in the City of Norfolk were identified using digital floodplain information obtained from the Federal Emergency Management Agency (FEMA) (Figure 2).

Existing Floodplain Protection Policies

Development in flood prone areas is regulated by the City’s Floodplain/Coastal Hazard Overlay District. The Floodplain District applies to those areas of the City within the 100-year floodplain, as delineated on FEMA Flood Insurance Rate Maps. The Coastal Hazard District applies to those areas of the City located within V zones, as shown on Flood Insurance Maps, which in addition to being in the 100-year floodplain are potentially subject to wave damage, such as the Ocean View and Willoughby areas of the City. Development and redevelopment activities are prohibited in these Districts, except by permit. Development activities are required to meet strict building standards and to mitigate any resulting increased stormwater runoff that may potentially increase flooding problems.

Recently, the City began the process of developing a flood hazard mitigation plan that targets properties for acquisition. In addition, the City participates in the National Flood Insurance Program’s Community Rating System. Under this program, Norfolk currently possesses a Class 9 rating, which it obtained by implementing its Floodplain/Coastal Hazard Overlay District. The Class 9 rating allows Norfolk citizens to obtain a five percent reduction in their flood insurance premiums.

Figure 2. Floodplain

[figures available in Planning Department]

WETLANDS

Tidal wetlands are defined in Chapter 13 of Title 28.2 of the Code of Virginia and are classified as nonvegetated or vegetated wetlands. Nonvegetated wetlands are defined as *lands lying contiguous to mean low water and mean high water* and consist of intertidal flats, bars and beaches. Vegetated wetlands are defined as *lands lying between and contiguous to mean low water and an elevation above mean low water equal to the factor one and one-half times the mean tide range* and consist of what one typically considers a "wetland," such as marshes and swamps.

According to the Virginia Wetlands Management Handbook (1996), there are five major benefits of wetlands. First, wetlands are important sites of food and energy production for the marine ecosystem. Second, they provide important waterfowl and fish and wildlife habitat. Third, wetlands provide natural protection from shoreline erosion. Fourth, wetlands help to filter pollutants, such as sediment and nutrients, from urban runoff, minimizing impacts to local water quality. Finally, wetlands help to reduce flooding through their capacity to absorb large amounts of water.

A great amount of the City's wetlands have been lost or altered. As the City of Norfolk Tidal Marsh Inventory (VIMS, 1987) notes:

> *The tidal wetlands within the City of Norfolk have been subject to enormous development pressures historically. Since the turn of the century, entire creeks, e.g. Boush, Mason, Tarrant, Newton, Lamberts, Smith and Colley, have been either filled in or reduced to mere vestiges of nineteenth century areas.*

A recent article on wetland loss in the Elizabeth River basin noted that the amount of wetlands in the Elizabeth River was reduced by more than half between 1944 and 1977 (VIMS, 1999). The article also noted that wetland loss decreased significantly after the enactment of the state wetlands permit program in 1972.

The Shoreline Situation Report (VIMS, 1976) estimated that 40% of the City's shoreline had associated fringe marshes, 6% had extensive marshes and less than 1% had embayed marsh. The developed nature of Norfolk's shoreline is evident from the fact that the majority of its wetlands are fringe marsh, which are not as productive as embayed and extensive marshes. This is further supported by the fact that the U.S. Fish and Wildlife Service (USFWS) did not identify any "priority wetland areas" in the City of Norfolk in the Regional Wetlands Concept Plan (USFWS, 1990). In addition, the Chesapeake Bay Local Assistance Manual (CBLAD, 1989) did not identify any wetland areas in the City that have priority for protection.

A subsequent inventory of tidal marshes in the City of Norfolk can be found in the City of Norfolk Tidal Marsh Inventory (VIMS, 1987). At that time, the study found that there were 722 acres of tidal marsh in the City. The greatest concentration of tidal marsh in the City, over 360 acres or almost 50% of the City's tidal wetlands, was found associated with the headwaters of the Lafayette River. The findings of the Tidal Marsh Inventory are summarized in Table 2. The Tidal Marsh Inventory classified the City's tidal marshes into different types and groups according to their ecological value. Group One wetlands possess the highest ecological value because of their high productivity, wildlife utility, and close association with fish spawning and nursery areas. Group Five wetlands possess the lowest possible ecological value. Over 60% of the tidal wetlands in the City of Norfolk are Group One wetlands, indicating that they possess a very high ecological value (Figure 3).

For regulatory purposes, the delineation of wetland boundaries on a site should be performed using the Federal Manual for Identifying and Delineating Jurisdictional Wetlands (USACE, 1989). Available data, such as the USFWS National Wetlands Inventory (NWI) maps, can be used to identify general areas in the City that may potentially contain wetlands. NWI maps show the location of tidal and non-tidal wetlands according to a classification scheme developed by the USFWS (Figure 4). These maps show that there is a relatively small amount of isolated non-tidal wetlands in the City.

Table 2. Tidal Wetlands, City of Norfolk, Virginia. From City of Norfolk Tidal Marsh Inventory (VIMS, 1987).

System	Marsh Types	Group	Total (Acres)
Little Creek	-Saltmarsh Cordgrass -Black Needlerush -Saltbush	I, III, IV	127.2
Willoughby Bay	- Saltmarsh Cordgrass	I	7.6
Mason Creek	-Saltmarsh Cordgrass -Saltmeadow -Saltbush -Common Reed -Brackish Water Mixed	I, II, IV	55.5
Lafayette River	-Saltmarsh Cordgrass -Saltmeadow -Saltbush -Common Reed -Brackish Water Mixed	I, II, !V	362.4
Elizabeth River (North Shoreline)	-Saltmarsh Cordgrass	I	10.2
Broad Creek and Upper Elizabeth River	-Saltmarsh Cordgrass -Saltbush -Brackish Water Mixed	I, IV	134.1
Elizabeth River (South Shoreline)	-Saltmarsh Cordgrass -Brackish Water Mixed	I	25.1
Total			**722.1**

Existing Wetland Protection Policies

The City of Norfolk currently protects tidal wetlands through its Wetlands Ordinance. Under the Ordinance, any proposal to develop any vegetated or nonvegetated tidal wetland must obtain a permit from the local Wetlands Board. The Board works in conjunction with the Virginia Marine Resources Commission and the U.S. Army Corps of Engineers' Section 404 permit program in reviewing applications.

Figure 3. Tidal Marsh Inventory

[figures available in Planning Department]

Figure 4. NWI

[figures available in Planning Department]

In addition, tidal wetlands are protected as Resource Protection Area features by the City's Chesapeake Bay Preservation Area Overlay District. The District protects tidal wetlands by requiring a 100-foot buffer from development. The District also protects non-tidal wetlands that are contiguous or connected by surface flow to tidal waterways and wetlands as Resource Management Areas.

The Virginia Department of Environmental Quality is currently working to develop a state non-tidal wetlands protection program. Like the tidal wetlands protection program, proposed development activities affecting non-tidal wetlands would have to obtain a permit. The requirements to obtain this permit are unknown at this time.

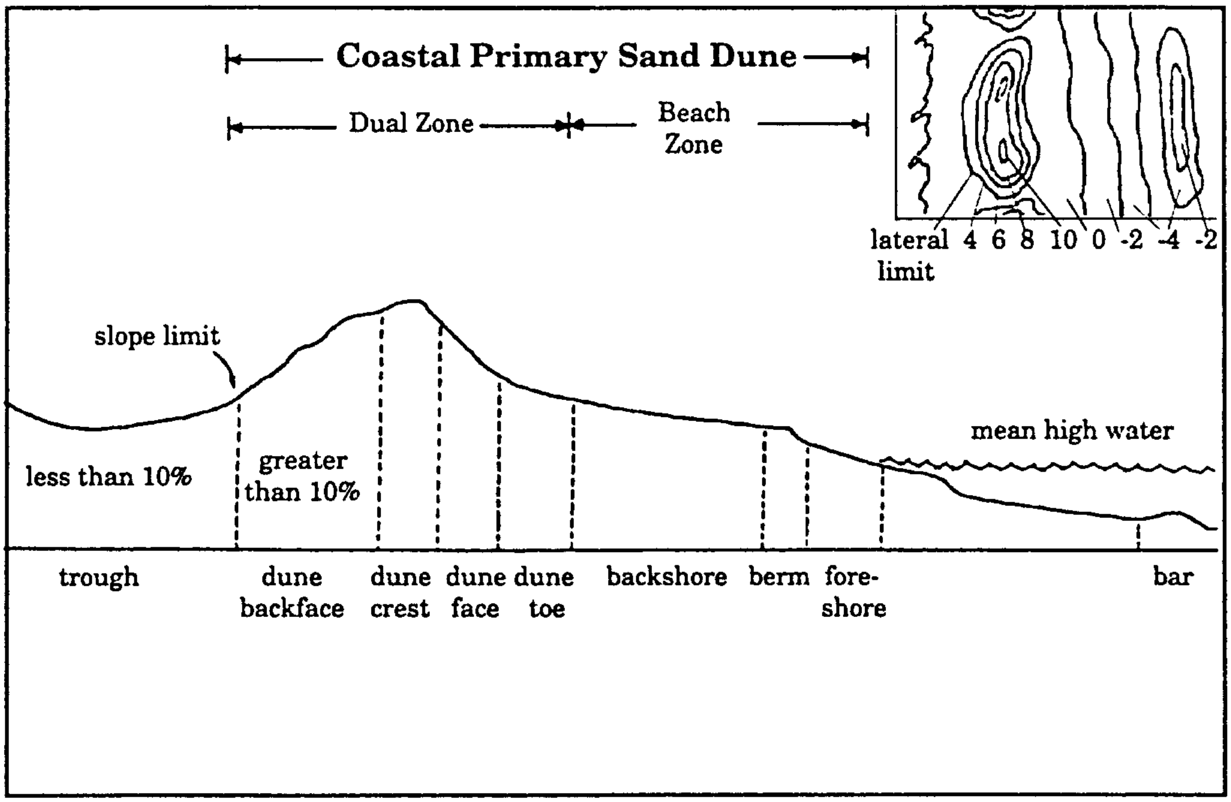


FIGURE 5. Jurisdictional Limits of Coastal Primary Sand Dunes. From <u>Virginia Wetlands Management Handbook</u>.

COASTAL PRIMARY SAND DUNES AND BEACHES

Under the Coastal Primary Sand Dune Protection Act, the coastal primary dune system consists of the beach from the mean high water line landward to the backside of the first dune, where the slope drops below ten percent (Figure 5). Coastal primary sand dunes in the City of Norfolk are found along the Ocean View shoreline.

According to the <u>Virginia Wetlands Management Handbook</u> (1996), there are four major benefits of preserving coastal primary sand dunes. First, they serve as protective features against flooding and erosion during coastal storms. Second, they serve as a supply of sand to nourish the fronting beach. Third, they provide habitat for coastal vegetation and wildlife. Fourth, sand dunes serve an important aesthetic function and add to the overall recreational experience of public beaches.

Existing Protection Policies

The City of Norfolk currently protects dunes and beaches through its Coastal Primary Sand Dunes Ordinance. Under the Ordinance, any proposal to alter any coastal primary sand dune in the City must obtain a permit from the Norfolk Wetlands Board.

SUMMARY AND CONCLUSIONS

Data indicate that the City is 98.5% built out and developed. Due to the highly developed nature of the City of Norfolk, a full physical constraints approach to development is not possible. Redevelopment is the primary building activity in the City. Through existing programs, redevelopment activities must comply with City ordinances that protect floodplains, wetlands, beaches and dunes.

SHORELINE EROSION

INTRODUCTION

Little natural unaltered shoreline remains in the City of Norfolk. Much of the shoreline in the City has been stabilized with structural controls. Because a great deal of the shoreline has been stabilized, shoreline and streambank erosion are not a very prevalent problem. Several of the shoreline stabilization structures are aging, failing and in need of maintenance. In addition, many of these structures were installed prior to the enactment of tidal wetland protection laws and their design may not be conducive to preserving wetlands. Addressing these issues is difficult because the vast majority of these shorelines are privately owned, with the exception of the Ocean View shoreline. The City currently operates an active shoreline management program in Ocean View.

ALTERED SHORELINE FEATURES

The Shoreline Situation Report: Cities of Chesapeake, Norfolk, and Portsmouth (VIMS, 1976) found at that time that approximately 50% of the City's shoreline was altered with shoreline stabilization structures, such as groins, riprap, or bulkheads. Subsequent shoreline data collected in 1993 from the low-altitude oblique aerial videography of the Hampton Roads Planning District Commission's Regional Shoreline Study (HRPDC, 1997) found that the percentage of hardened shoreline in the City was 46%. The discrepancy between the HRPDC study and the Shoreline Situation Report is due to different data collection methods. Both studies indicate that Norfolk possesses the highest percentage of altered shoreline in Hampton Roads. The Shoreline Situation Report estimated that only 4% of the shoreline in Norfolk is City-owned.

The Virginia Institute of Marine Science Wetlands Program monitors impacts to tidal vegetated and non-vegetated wetlands from permitted shoreline structures in Tidewater localities. During 1988 – 1999, approximately 217,500 ft^2 (5 acres) of tidal vegetated wetlands and 2,169,559 ft^2 (50 acres) of tidal non-vegetated wetlands were found to be impacted by permitted projects (VIMS, 2000). Annual permitted impacts during this time period are shown in Figures 6 and 7. According to VIMS, the reason for the large increase in permitted tidal non-vegetated wetland impacts in 1998 is a beach nourishment project undertaken at Ocean View (VIMS, 2001). The increase in impacts to vegetated wetlands in 1998-1999 is thought to be due to a housing development along the Lafayette River in 1998 and a wetlands restoration project in 1999.

FIGURE 6
Permitted Tidal Vegetated Wetland Impacts 1988 – 1999
City of Norfolk (VIMS, 2000)

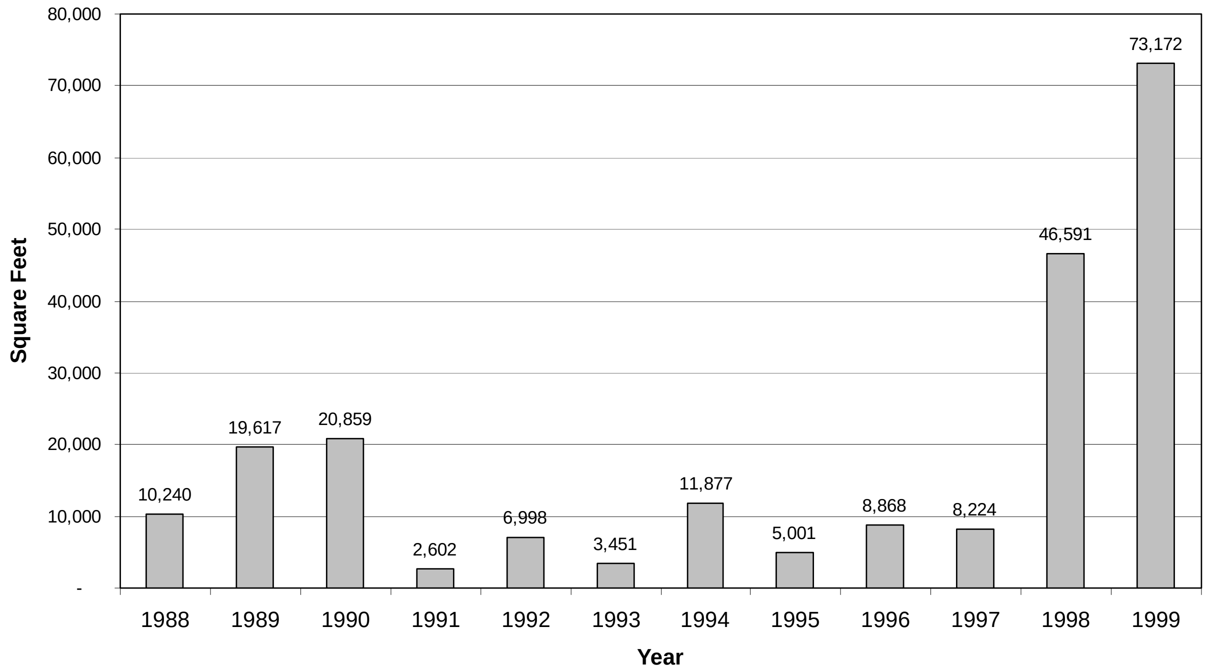


FIGURE 7
Permitted Tidal Non-Vegetated Wetland Impacts 1988 – 1999
City of Norfolk (VIMS, 2000)

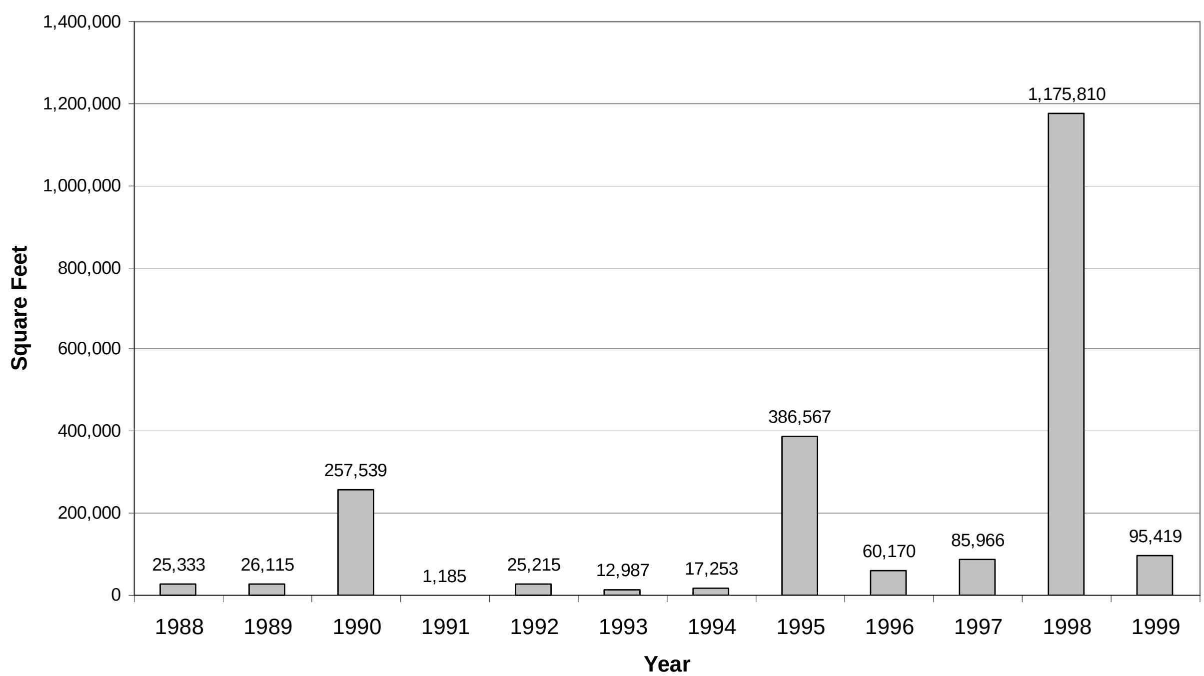
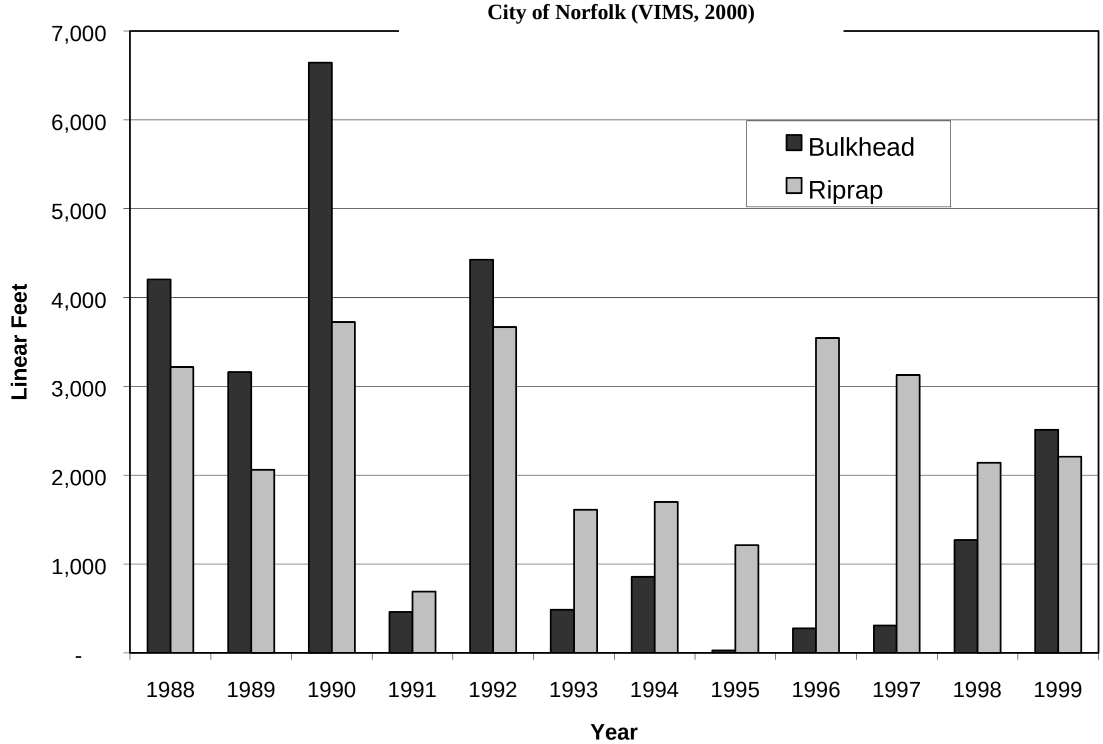


FIGURE 8

**Permitted Shoreline Structures
City of Norfolk (VIMS, 2000)**



The Virginia Institute of Marine Science Wetlands Program also monitors the length of permitted bulkheads and riprap in Tidewater communities. Data for the City of Norfolk indicates that during 1988 – 1999, approximately 10 miles of bulkhead and riprap was permitted. The data does not discriminate how much of this amount is a result of replacing failed structures. Of the 10 miles, 54 percent or 5.5 miles was riprap and 46 percent or 4.5 miles was bulkhead. Prior to 1993, the length of permitted bulkhead consistently exceeded the length of riprap (Figure 8). Beginning in 1993, however, it appears that this pattern reversed with permitted riprap consistently exceeding permitted bulkhead. Riprap is preferable to bulkheads because it minimizes structural reflection of wave energy, which can cause wetland loss. In addition, riprap can provide aquatic habitat and has a longer lifespan.

Significance for Planning

The cumulative impacts of placement of shoreline erosion control structures and water access points are generally not considered by local governments or permitting agencies; and, yet, such impacts can impact water quality and sensitive aquatic habitat. Inappropriate or unnecessary shoreline erosion control techniques can potentially exacerbate erosion at the site, and/or create an erosion problem on adjacent property or at downdrift or updrift areas. Additionally, certain shoreline erosion controls can create an unsuitable environment for the persistence of wetlands, submerged aquatic vegetation, and beaches. As a result, water quality and aquatic habitat can be degraded either locally or on a more regional scale. Boating activities and development of associated water access and use areas can also degrade water quality, exacerbate natural shoreline erosion rates, and potentially harm sensitive land and aquatic living resources found in those areas. Through comprehensive shoreline planning, inventories of unaltered and altered shoreline features can be combined with occurrences of observed environmental problems to see if any correlations exist. If correlations are found, appropriate actions can be identified.

EROSION RATES

The Shoreline Situation Report Cities of Chesapeake, Norfolk, and Portsmouth (VIMS, 1976) provides the most comprehensive shoreline erosion survey of the City to date. Though somewhat dated, the majority of erosion rates identified in the study still appear to be valid today. The Bank Erosion Study performed by VIMS (1992) apparently confirmed many of the erosion rates identified in the earlier shoreline situation reports completed for the Hampton Roads region. The Shoreline Situation Report notes that significant erosion is generally limited to the City's Ocean View shoreline. Ocean View has been stabilized with a series of groins and breakwaters. Prior to stabilization, however, the Shoreline Situation Report indicates that the historical erosion rate was 1.6 – 2.5 feet per year. This area is most vulnerable to wave energy due to the area's orientation and exposure to a large or long fetch, the distance over which the wind has an opportunity to create waves. The remaining shorelines of Norfolk appear to be generally stable; however, isolated cases of erosion may exist.

A more recent and more detailed examination of the Ocean View shoreline can be found in the City's Beach Management Plan (City of Norfolk, 1993). According to the plan, erosion rates along Ocean View range from 1.5 to 5.5 feet per year. In addition, the plan identifies three Critical Erosion/Storm Damage areas and recommends shoreline stabilization measures (Figure 9). One of these critical areas, the east end of Ocean View, has exhibited an erosion rate as high as 5 feet per year, threatening current redevelopment activities. This high erosion rate in east Ocean View is most likely caused by the jetties of Little Creek Harbor. The jetties prevent the natural flow of sand that moves east to west from reaching this area of Ocean View. In a cost-sharing agreement with the state, the City is currently in the process of stabilizing this area with a combination of breakwaters and beach nourishment. This work, however, is contingent upon the availability of state funding.

The Virginia Institute of Marine Science is currently in the process of updating the 1976 Shoreline Situation Report for the City of Norfolk. The report will contain updated information on isolated cases of shoreline erosion and identify locations of piers and docks and failing shoreline stabilization structures. Once this study is completed, its findings should be evaluated to arrive at more accurate shoreline hardening figures and identification of isolated incidences of shoreline erosion.

Figure 9. Shoreline Erosion

[figures available in Planning Department]

Significance for Planning

Erosion rate information has various applications for land use planning and decision-making. It can assist the local or regional planner in determining appropriate locations for future development and redevelopment, and the most appropriate methods for addressing erosion issues. For example, where data identifies a shoreline area to be in a state of "severe erosion" (greater than or equal to three feet per year), this information can be used to develop appropriate building setback policies and/or to direct shoreline development away from those areas to areas which are experiencing less intense erosion. Erosion rate information can also provide local wetlands boards with quantitative data upon which they can partially base permit approvals and denials, to suggest to the applicant the most appropriate erosion control options to address the problem, and to assess potential impacts on adjacent properties or properties downdrift or updrift, if those options are implemented.

SUMMARY AND CONCLUSIONS

Available information indicates that approximately half of the City's shoreline is hardened with shoreline stabilization structures. This represents the most hardened shoreline of any locality in the Hampton Roads Region. The City's shoreline is highly altered and little pristine areas remain.

The Shoreline Situation Report (VIMS, 1976) did not identify any severely eroding shorelines in Norfolk, as defined by the Chesapeake Bay Local Assistance Manual as eroding at a long-term historical erosion rate greater than 3 feet per year. The City's Beach Management Plan, however, notes that erosion along Ocean View can be over 5 feet in some areas. Critically eroding areas in Ocean View are being or have been stabilized with a combination of beach nourishment, breakwaters and groins, as guided by its Beach Management Plan. The City's inland shorelines appear to be generally stable, with some isolated cases of shoreline erosion. In these cases, it is difficult for the City to directly manage stabilization efforts because the shoreline is not owned by the City. Only about 4% of the shoreline in Norfolk is City-owned.

A recommended hierarchy of possible shoreline stabilization measures for low, moderate, and severely eroding shorelines is provided below. Since the City does not contain any severely eroding shoreline, perhaps with the exception of east Ocean View, only the hierarchy for areas with low and moderate erosion is applicable. The following ranking is consistent with the goals of the Chesapeake Bay Preservation Act and may help to guide recommendations on applications for installing new stabilization structures or replacing existing structures. It is important to note that although erosion control options are ranked individually, often a combination of erosion control methods is necessary. It is recommended that homeowners be encouraged to contact the Shoreline Erosion Advisory Service (SEAS) for a free consultation on an appropriate shoreline stabilization method for a site. The local SEAS Shoreline Engineer can be reached at 757-925-2468.

Areas with a Low Erosion Rate (< 1 ft/year)
1 = most preferable

1. Vegetative stabilization with/without bank regrading (if applicable)
2. Revetment
3. Bulkhead

Areas with a Moderate Erosion Rate (1 – 3 ft/year)
1 = most preferable

1. Vegetative stabilization (depending on site-specific conditions)
2. Beach nourishment
3. Revetment
4. Breakwaters
5. Groins
6. Bulkheads (depending on site-specific conditions)

Areas with a Severe Erosion Rate (> 3 ft/year)
1 = most preferable

1. Relocation
2. Beach nourishment
3. Revetments
4. Breakwaters
5. Groins
6. Seawall

Where shoreline stabilization is necessary, a unified area approach, rather than an individual site-by-site approach, is recommended. When such an approach is taken, individual costs can be lessened and worsening erosion problems for neighboring properties can be avoided. For more information on erosion control options, refer to Section V - Shoreline Erosion Control and Access Policy Options of the HRPDC Regional Shoreline Element of Comprehensive Plans, Part I: Guidance Manual (HRPDC, 1997). An additional source of information on shoreline erosion control options is Shoreline Management in Chesapeake Bay (Hardaway and Byrne, 1999). This publication is written in a format that is easy to understand, making it suitable for distribution to homeowners.

In a series of in-house studies titled Shoreline Erosion Control Guidelines by the Virginia Department of Conservation and Recreation (1993), it is stated that maintenance and establishment of marsh grasses should be considered as the first choice for shoreline erosion control in low energy areas with adequate site conditions. Generally speaking, for enhancing water quality and aquatic habitat, vegetative and non-structural forms of erosion control are preferred over other forms of shoreline stabilization. However, non-structural forms of erosion control are not effective at shoreline stabilization as wave energy increases and erosion becomes more severe. Along shorelines with less than 0.5 nautical miles of fetch, such as those on the City's interior creeks, marsh planting may be a viable form of shoreline erosion control. Along interior creeks where erosion is more severe, marsh plantings may be protected by a breakwater type of structure, such as a submerged sill, to protect the marsh toe. This approach has been shown to be successful throughout the Chesapeake Bay and may be a good approach to encourage in the City. Vegetative forms of shoreline stabilization may not be appropriate for boat docking facilities.

The City should continue to maintain existing erosion control measures along the City's Chesapeake Bay shoreline. This area is subject to high wave energy due to the long fetch resulting from the mainstem of the Chesapeake Bay. The City currently nourishes the beaches in this area with sand and stabilizes the beach fill with a series of groins and breakwaters. Beach nourishment is important in this area because it maintains the recreational beach, an important amenity. The structures help to maximize the lifespan of the beachfill.

INVENTORY OF OCEANOGRAPHIC SHORELINE CONDITIONS

BATHYMETRY

Information on bathymetry can be obtained from the National Oceanic and Atmospheric Administration (NOAA) Nautical Charts #1222, #12245, and #12253. Additional information can be obtained from ADC's Waterproof Chartbook of the Chesapeake Bay Maps #15, #33, and #38.

Digital bathymetric data was not readily available for this study. Generally speaking, the bathymetry of the Elizabeth River can be described as being relatively shallow. Outside of maintained navigation channels, reported depths at mean low tide in the nearshore areas of the River range from 1 – 4 feet. Bathymetry in Willoughby Bay is deeper, approximately 8 – 12 feet at mean low tide. The nearshore bathymetry in the Chesapeake Bay ranges from 2 – 4 feet and gradually increases to depths greater than 20 feet offshore. In the Willoughby area, however, the offshore area remains shallow due to the presence of a shoal known as Willoughby Bank.

Due to the concentration of industrial shipping and naval facilities in the Elizabeth River, there exist several federally maintained navigation channels. Information on navigation channels in the City of Norfolk was obtained from Navigation Management Plan for the Port of Hampton Roads (COE, 2000). At the entrance to the Elizabeth River is the Norfolk Harbor Channel, which extends south just past the Norfolk International Terminals (NIT). The channel is maintained to a depth of 50 feet and varies in width. At the entrance, the channel width is 1,000 feet and narrows upstream to 600 – 800 feet. While the entrance channel has not required maintenance since 1988, the remainder of the channel is dredged annually. Approximately 1 million cubic yards are dredged each year.

Continuing upstream from the Norfolk Harbor Channel is the Elizabeth River Channel, which extends to the confluence of the Eastern and Southern Branch. This channel is maintained to a depth of over 40 feet and a width of 750 feet. The Elizabeth River channel was last dredged in 1998. Approximately 400,000 cubic yards are dredged every five years.

FIGURE 10. Existing Navigation Channels. From Navigation Management Plan for the Port of Hampton Roads (COE, 2000).

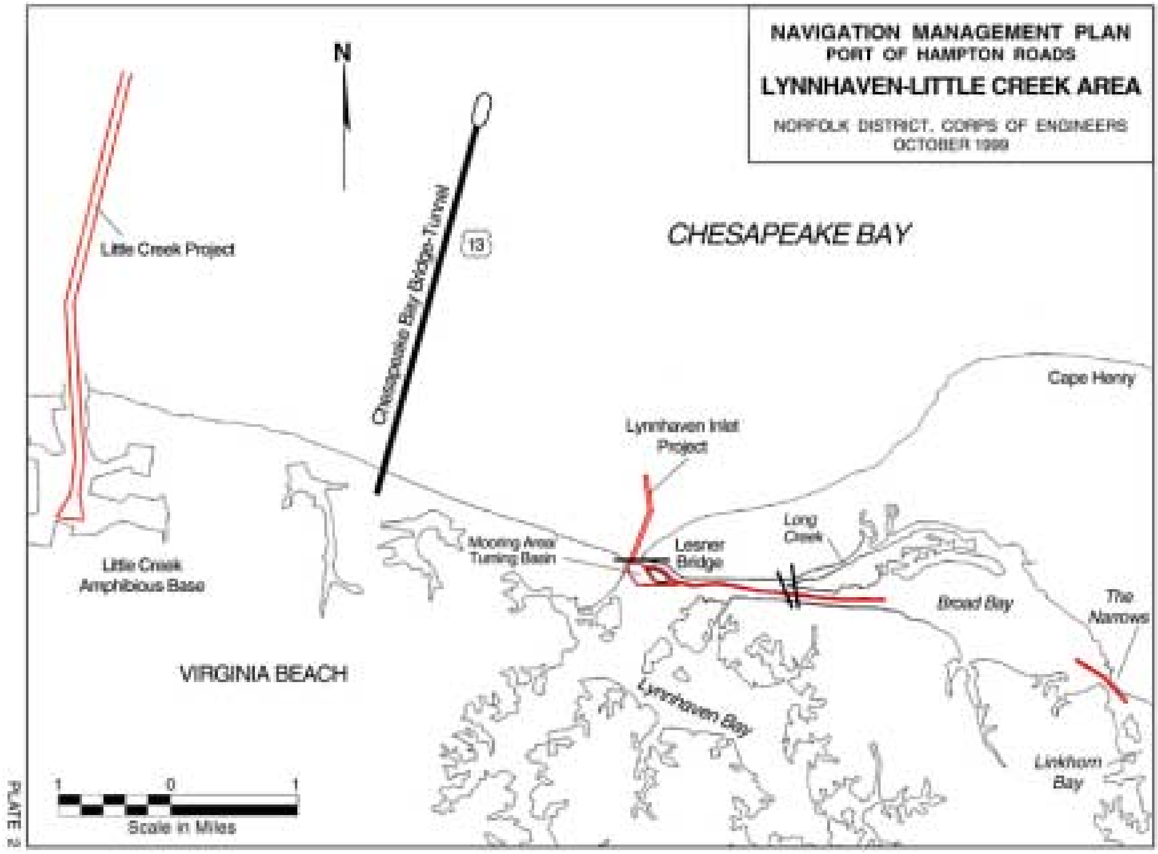
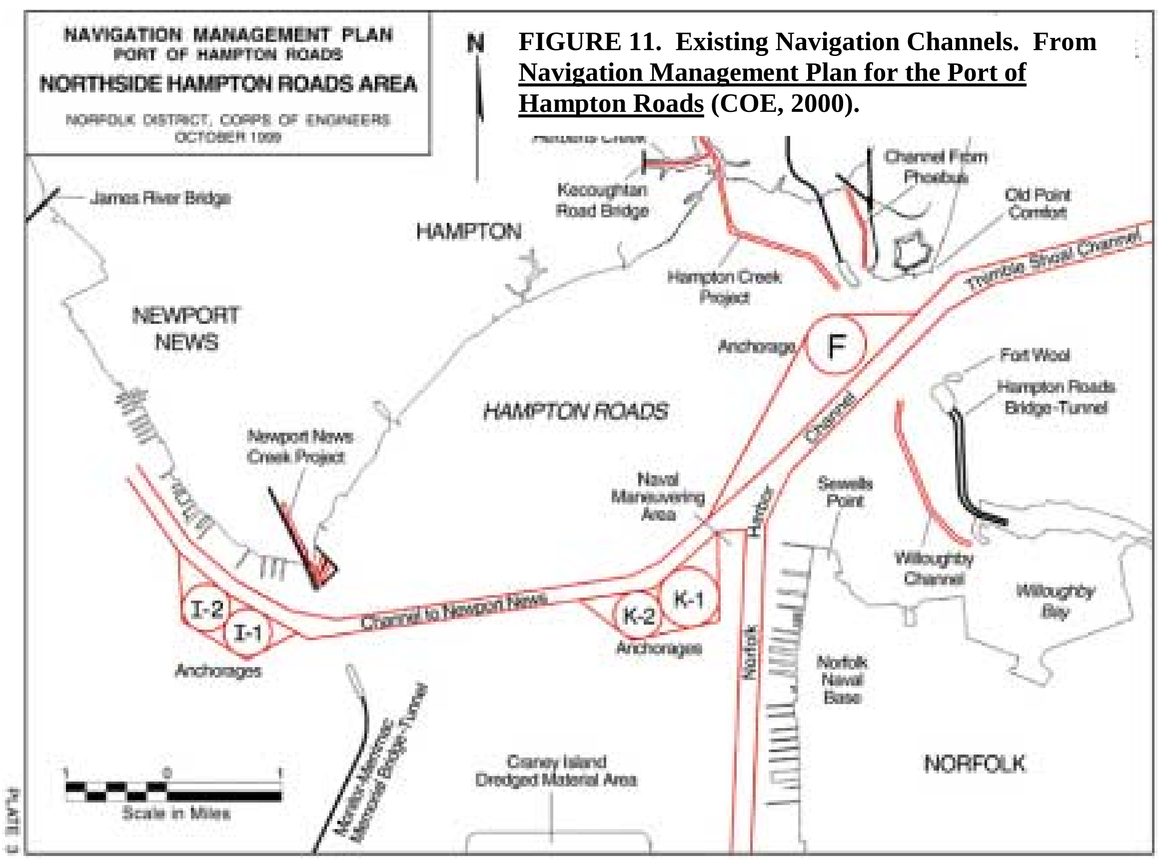


FIGURE 11. Existing Navigation Channels. From Navigation Management Plan for the Port of Hampton Roads (COE, 2000).



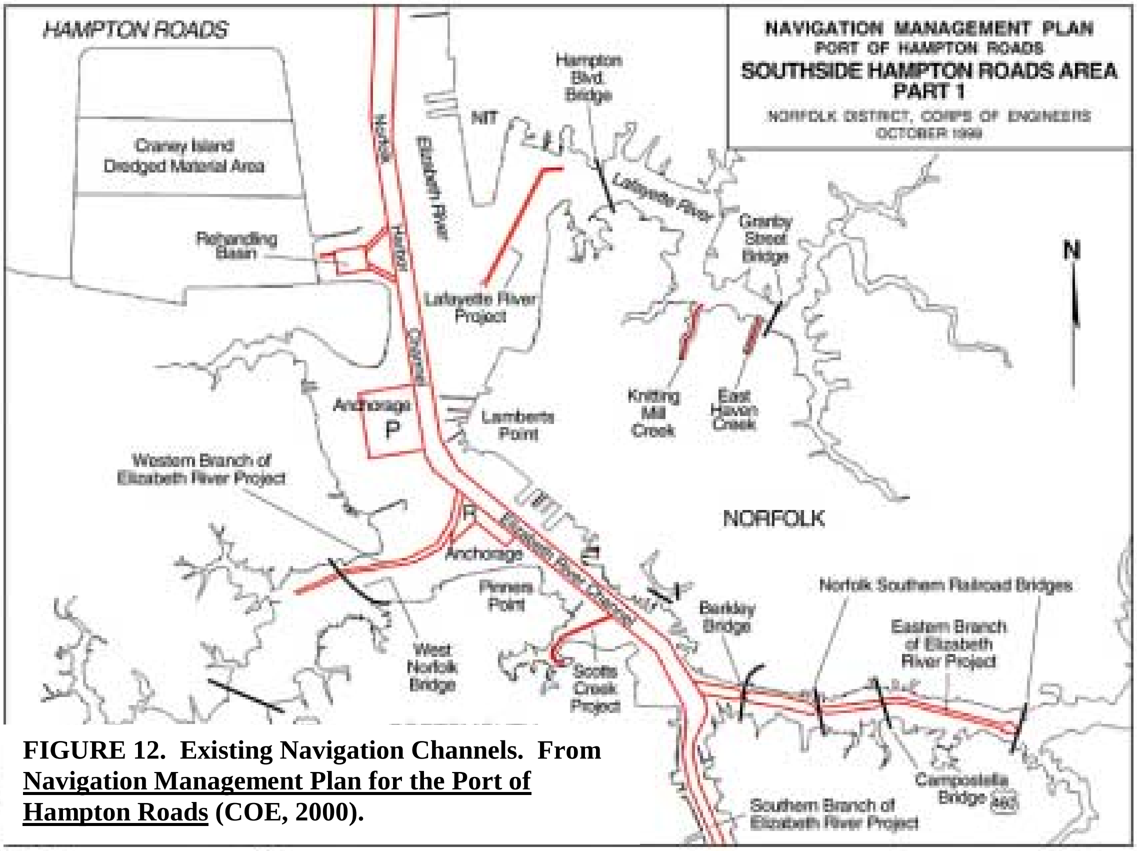


FIGURE 12. Existing Navigation Channels. From <u>Navigation Management Plan for the Port of Hampton Roads</u> (COE, 2000).

The navigation channel in the Southern Branch of the Elizabeth River is maintained to a depth of over 45 feet and a width of 450 feet. Like the Elizabeth River Channel, the maintenance dredging cycle is approximately every five years. The navigation channel in the Eastern Branch of the Elizabeth River extends from its confluence with the Southern Branch eastward to the Campostella Bridge. The channel in the Eastern Branch is maintained to a depth of 25 feet and a width of 500 feet. The channel narrows to 300 feet from the Norfolk Southern Railway Bridge to the Campostella Bridge. Regular maintenance dredging is not required in the Eastern Branch. The Eastern Branch was last dredged in 1989.

In Willoughby Bay, a federally maintained channel, known as the Willoughby Channel, extends from the tip of Willoughby Spit to the Hampton Roads Harbor. The Willoughby Channel is used by recreational and commercial boat traffic associated with the four marinas located at the tip of the Spit. The channel is maintained to a depth of 6 feet and a width of 200 feet; however, dredging is not required on a frequent basis. The channel was last dredged in 1994.

A federally maintained channel also exists at the entrance of the Lafayette River. The channel extends from the mainstem Elizabeth River to the Hampton Boulevard Bridge and is maintained to a depth of 8 feet and a width of 100 feet. Regular maintenance dredging of the

Lafayette River Channel is not required. This channel was last dredged in 1993. The Lafayette River is primarily used by recreational boat traffic associated with the residential development located along its waterfront.

The channel in Little Creek Harbor runs north to south and is maintained to a depth of 20 feet and a width of 400 feet. At its southern end, a turning basin is also maintained adjacent to the Naval terminals. The channel and turning basin are maintained by the Navy. In addition to significant use of the channel by naval vessel traffic, commercial and recreational boat traffic use is also significant. Commercial and recreational boat traffic originates from the several commercial marinas and seafood processing facilities located in the western portion of the Harbor.

In addition to federally maintained channels, City and privately maintained channels exist. The City has had an active dredging program in Pretty Lake since 1997 and is planning to begin a dredging program in Broad Creek. In the Lafayette River, the City is responsible for maintaining East Haven and Knitting Mill Creeks. Other creeks in the Lafayette River are maintained by waterfront homeowners. The most recently proposed private dredging project is found in Crab Creek. These channels are important for facilitating recreational boat traffic into and out of the Lafayette River that is generated by the concentration of waterfront residences along its shores.

FLUSHING CHARACTERISTICS AND CURRENT PATTERNS

Information on flushing characteristics and current patterns for waterways in Hampton Roads was collected for the HRPDC Regional Shoreline Study (HRPDC, 1997). The watershed of the Elizabeth River can be described as being relatively small and having limited freshwater inflow, low relief, low groundwater flow, and limited flushing. The tidal range in the Elizabeth River is approximately 2-3 feet, and the resulting tidal currents are relatively weak, reaching approximately 1 knot. Wind-generated currents help create a fairly homogenous, well-mixed system. Of these two forces, tidal exchange is the dominant mechanism for removing material from the system. Because the tidal currents are weak, pollutant residence times can be relatively long. Materials discharged in upstream areas are dispersed rapidly, but are removed from the system slowly.

It is believed that the orientation of some smaller tributaries of the James River and the large rate of water flow in the main stem serve to limit the flow of water in or out of the smaller tributaries. While mixing may occur at the mouths of these smaller tributaries, it is believed that flushing of these tributaries generally does not occur at a high rate. It has been documented that periodically freshwater flow from the James River intrudes into the mouth of the Elizabeth River, creating a saltwater wedge. This wedge, created by density differences between freshwater and saltwater, limits the capacity of the Elizabeth River to flush pollutants by restricting the outgoing flow from the Elizabeth River to the James River.

Like the Elizabeth River, circulation in Little Creek Harbor is tidally dominated. However, unlike the Elizabeth River, a strong vertical salinity stratification exists in Little Creek. This stratification facilitates a net flow of denser, saltier water into the harbor near the bottom and a net flow of fresher water out of the harbor near the surface. This circulation pattern greatly enhances flushing and removal of pollutants from Little Creek.

SUMMARY AND CONCLUSIONS

The Elizabeth River can be described as being a shallow water estuary. Outside of maintained navigation channels, reported depths at mean low tide in the nearshore areas of the River range from 1 – 4 feet. Bathymetry in Willoughby Bay is deeper, approximately 8 – 12 feet at mean low tide. The nearshore bathymetry in the Chesapeake Bay ranges from 2 – 4 feet and gradually increases to depths greater than 20 feet offshore. Due to industrial and private recreational interests, the City's waterways contain an abundance of federally, locally, and privately maintained navigation channels.

Due to a combination of natural and manmade conditions, the capacity of the Elizabeth River to flush pollutants is poor. Flushing is worse in headwater areas of the river. In contrast, flushing in Little Creek is good.

EXISTING WATER QUALITY DATA

INTRODUCTION

To assess the impacts that point and nonpoint source pollution may be having on water quality, the state conducts a statewide monitoring program. The location of water quality monitoring stations in the City Norfolk is shown in Figure 13. Interpretive waterbody specific water quality data can be found in the 1992 305(b) Virginia Water Quality Assessment Report (VWCB, 1993). Waterbody specific summaries were discontinued in subsequent 305(b) reports after 1992. When possible, the information presented below is updated with information obtained from the most recent 2000 Virginia Water Quality Assessment 305(b) Report (VDEQ, 2000), which also includes watershed assessment information. The Elizabeth River Project's State of the River 2000 also provides interpretations of recent water quality monitoring data.

THE MAINSTEM ELIZABETH RIVER

The VDEQ maintains one water quality monitoring station in the mainstem of the Elizabeth River, near the Norfolk International Terminals. Data from this station indicates that the mainstem supports state water quality standards. However, the 1998 305(b) Report notes the occurrence of tributyltin (TBT) at this site from the hull coatings of vessels that traffic and are serviced in this area. The 2000 305(b) Report confirms the exceedance of the state standard for TBT. Due to the presence of TBT, the Elizabeth River has been placed on the state Impaired Waters 303(d) Total Maximum Daily Load List. In addition, the Elizabeth River Project's State of the River 2000 notes the presence of contaminated sediment in this area.

Due to the historical pollution problems, the entire Elizabeth River, including the mainstem of the Elizabeth River, is condemned by the Virginia Department of Health for shellfish harvesting. As a result, the 1992 305(b) report notes that the fishable goal of the Clean Water Act is not supported in the mainstem of the Elizabeth River. The swimmable goal of the Clean Water Act is fully supported.

THE LAFAYETTE RIVER

The VDEQ maintains one water quality monitoring station near the mouth of the Lafayette River. Data from this station indicates support of water quality standards in this area. However, the state 1992 305(b) Report notes that cadmium was detected in a water column sample and that further samples were needed to determine the extent of contamination. The later 1998 305(b) Report found no violations of cadmium. The Elizabeth River Project's State of the River 2000 notes problems or borderline problems with sediment toxicity and metal concentrations in the sediment of the Lafayette River.

The shoreline land use of the Lafayette River is predominantly residential. Due to the historical pollution problems, the entire Elizabeth River, including the Lafayette

Figure 13. Location of Water Quality Stations

[figures available in Planning Department]

River, is condemned by the Virginia Department of Health for shellfish harvesting. As a result, the 1992 305(b) report notes that the fishable goal of the Clean Water Act is not supported in the Lafayette River. However, the swimmable goal of the Clean Water Act is fully supported.

THE EASTERN BRANCH OF THE ELIZABETH RIVER

The VDEQ maintains two water quality monitoring stations in the Eastern Branch of the Elizabeth River. One is located near the confluence with the mainstem of the Elizabeth River, and one is located in Broad Creek. These stations indicate that in general, water quality standards are met in the Eastern Branch, with exceptions. The station in Broad Creek has consistently recorded violations for fecal coliform bacteria, which is responsible for placing Broad Creek on the state Impaired Waters 303(d) Total Maximum Daily Load (TMDL) List. The source responsible for the bacteria is unknown at this time. In addition, the Eastern Branch is on the TMDL List for exceeding the state tributyltin standard. The source of tributyltin is the hull coating of commercial vessels that pass through and are serviced in the area. The fecal coliform violations in Broad Creek and the tributyltin violation in the Eastern Branch have caused them to be placed on the state Impaired Waters 303(d) Total Maximum Daily Load List. Several studies have also noted high levels of sediment contamination from the Berkley Bridge to the confluence with the mainstem of the Elizabeth River. These contaminants have accumulated in bottom sediments as a result of several decades of industrial shipyard activities in this area of the river.

The Elizabeth River Project's <u>State of the River 2000</u> notes problems with sediment toxicity and borderline problems with metal concentrations in the sediment of Broad Creek. In addition, the report notes borderline problems with the concentration of metals in the water and sediment column in the downstream area of the Eastern Branch. The downstream area of the Eastern Branch is also shown to have problems with toxicity in fish. Due to the pollution problems noted above, the entire Elizabeth River, including the Eastern Branch, is condemned by the Virginia Department of Health for shellfish harvesting. As a result, the fishable goal of the Clean Water Act is not supported in the Eastern Branch. According to the 1992 305(b) report, the swimmable goal of the Clean Water Act is fully supported for most of the Eastern Branch. However, approximately 30% or 0.5 square miles of the Eastern Branch fails to meet the swimmable standard.

THE SOUTHERN BRANCH OF THE ELIZABETH RIVER

The VDEQ maintains one water quality monitoring station in the Southern Branch of the Elizabeth River that is located within the City of Norfolk's boundaries. Observations recorded by this station are within state water quality standards. However, the metal concentrations in the sediment at this site have exceeded standards enough for DEQ to consider its support of state standards threatened. The Elizabeth River Project's <u>State of the River 2000</u> confirms problems with metals in the bottom sediment of this portion of the Elizabeth River.

Due to the historical pollution problems, the entire Elizabeth River, including the Southern Branch of the Elizabeth River, is condemned by the Virginia Department of Health for shellfish harvesting. As a result, the 1992 305(b) report notes that the fishable goal of the Clean Water Act is not supported in the Southern Branch. However, the swimmable goal of the Clean Water Act is fully supported.

LITTLE CREEK

Shellfish beds in this segment are considered to be nonproductive due to pollution associated with the U.S. Navy-Little Creek Amphibious Base. Within this waterbody, it has been established by the Virginia Department of Health (VDH) that it shall be unlawful for any person, firm, or corporation to take shellfish from this area for any reason. The closure is due to the buffer zones surrounding the outfalls for the Naval Amphibious Base and to nonpoint source (NPS) pollutants. Additional contributions to the degraded water quality in this watershed are attributed to extensive Naval ship docking and repair facilities.

The HRSD Chesapeake-Elizabeth sewage treatment plant (STP) occasionally discharges into Little Creek Cove during times of emergency bypasses, in extreme and infrequent weather events; however, the main outfall discharges to the Chesapeake Bay.

According to the 1992 305(b) report, the Clean Water Act (CWA) fishable and swimmable goals for this waterbody, which covers 1.24 square miles of surface water, are non-supported for the entire waterbody.

SUMMARY AND CONCLUSIONS

The primary pollution problems in the City of Norfolk are associated with the Elizabeth River. Surprisingly, the majority of the heavily developed Elizabeth River meets state water quality standards, although it is not by a great margin. Further, the Elizabeth River Project's State of the River 2000 notes that monitoring data reveals an improving trend for different water quality parameters of the Elizabeth River. The primary pollution issues in the Elizabeth River are associated with sediment contamination and tributyltin (TBT) associated with the hull coating of commercial vessels. In addition, Broad Creek has been classified as an impaired water by the state due to high levels of fecal coliform bacteria. The source of the bacteria is unknown at this time.

SENSITIVE LAND AND AQUATIC RESOURCES

Note: Natural resources are dynamic. The following information is the most current, comprehensive information that was available to the HRPDC at the time of study. Representation of data on maps in the various sources used is intended to serve as a guide to resource and species distribution and abundance, and should not preclude coordination with management officials on exact locations.

SUBMERGED AQUATIC VEGETATION (SAV)

Studies by VIMS indicate that the occurrence of SAV had not been formally documented within the waterways of the City of Norfolk until 1995 (VIMS, 2000). Beginning in 1995, the presence of a small amount of SAV has consistently been documented at the mouth of Little Creek by annual surveys. The most recent survey of SAV in Little Creek is shown in Figure 14. The persistence of SAV in Little Creek is surprising considering the surrounding land use and high levels of vessel traffic.

None of the City's waters were included in the Chesapeake Bay Program's Tier I SAV target restoration area. The Tier I target is restoration of SAV to areas currently or previously inhabited by SAV as mapped through regional and Bay-wide aerial surveys from 1971 through 1990. Refer to Part 1: Appendices--Appendix F-1 of the Regional Shoreline Element of Comprehensive Plans (HRPDC, 1997) for more information and a map and explanation of Tier I target restoration areas.

Significance for Planning

Local governments in Tidewater Virginia and other parts of Virginia's Coastal Zone need to recognize SAV beds as critical living resources that provide important fisheries habitat. Certain types of land use activities can contribute excessive pollutants, such as nutrients, sediments, pesticides, and metals, into adjacent waterways and, if uncontrolled, can degrade localized water quality conditions and SAV habitat. While impacts to SAV related to boating activities have been identified as a major problem, most state and federal agencies do not have policies regarding destruction of SAV by commercial and recreational boating activities. It is somewhat surprising that the SAV beds in Little Creek have persisted in light of the high amount of vessel traffic and the surrounding intense commercial, residential and military land use. These and all shoreline land uses in the City that are presumed to impact SAV will not change significantly in the foreseeable future because they have been legally established by the owners of shoreline property. Further, none of the City's waters have been included in the Chesapeake Bay Program's SAV restoration targets. These factors do not make SAV a significant issue to be addressed in long term planning in Norfolk. However, state and local stormwater management programs can indirectly address SAV by minimizing the amount of pollutants entering local waterways from surrounding land uses and potentially make the aquatic environment more favorable for SAV growth.

Figure 14. SAV

[figures available in Planning Department]

COMMERCIALLY- AND RECREATIONALLY- IMPORTANT FISHERIES

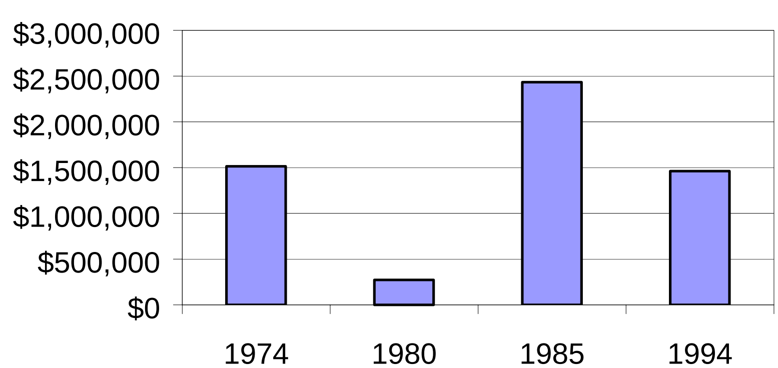
As a VIMS study of the Elizabeth River explained, "the commercially and recreationally important living resources have already been seriously impacted from the viewpoint of human utilization" (Priest, 1979). A 1983 State Water Control Board report notes that the commercially important fish species found in the Elizabeth River include river herring, shad, striped bass, white perch, catfish, menhaden, spot, and croaker. The report further notes that there are no significant spawning areas for these species in the Elizabeth River, although some tidal creeks may serve as limited spawning areas for forage fish, such as silverside, killifish, and goby. The report also notes that some studies have found that he Elizabeth River may serve as a nursery area for menhaden, spot, and croaker.

According to a recent federal permit application proposing to construct an artificial oyster reef in the Eastern Branch of the Elizabeth River, the National Marine Fisheries Service recognizes that the Elizabeth River contains Essential Fish Habitat for various life stages of 11 species of fish: windowpane flounder, bluefish, Atlantic butterfish, summer flounder, black sea bass, king mackerel, Spanish mackerel, cobia, red drum, dusty shark, and sandbar shark.

While the Elizabeth River is not used for commercial fishing, the City is located in relatively close proximity to the Chesapeake Bay and the Atlantic Ocean, which makes it an ideal location to support commercial fishing facilities. A VIMS publication, Virginia's Commercial Fishing Industry: Its Economic Performance and Contributions (Kirkley, 1997), reported that the City ranks fifth in the state for number of fishery species landed. In 1994, 48 species were landed at docks in the City. Summer flounder, the major species in terms of value, had a landed worth of $1,461,447. In the same year, commercial landings in Norfolk accounted for 180 full-time jobs.

The vitality of the commercial fishing industry fluctuates with changes in supply and demand, changes in climate, changes in aquatic ecology, and changes in fisheries management regulations. The fluctuating dockside value of landed fish for the City of Norfolk is shown in Figure 15.

FIGURE 15
Dockside Value of Fish Landings
City of Norfolk (Kirkley, 1997)



According to the VIMS publication, Saltwater Angling and its Economic Importance to Virginia (Kirkley and Kerstetter, 1997), recreational fishing contributes significantly to the Virginia economy. For the purpose of calculating expenditures and economic impacts, Norfolk is considered part of the Hampton Roads region of Virginia along with the

City of Hampton, the City of Suffolk, and York County. In 1994, recreational fisherman spent $70.5 million in the region. Of this, over half was spent on trip expenses (meals, lodging, charter boat fees), 13% was spent on equipment (rods, reels, tackle), and 35% was spent on boating expenses (fuel, oil, docking fees, launching fees, boat purchases). In turn, these expenditures generated $109.7 million in total sales, $61.7 million in income, and 2,468 person years of employment for the economy of Virginia. Data specific to the City of Norfolk is not available.

Virtually all of the City's waterways are condemned for shellfish harvesting. There are currently four condemnation areas identified by the Virginia Department of Health that affect the City:

- Shellfish Area Condemnation Number 60, Chesapeake Bay – Adjoining Little Creek
- Shellfish Area Condemnation Number 17, Little Creek
- Shellfish Area Condemnation Number 7, Hampton Roads
- Shellfish Area Condemnation Number 15, Chesapeake Bay at Entrance to Hampton Roads

It is unlawful for any person, firm or corporation to take shellfish from these areas for any purpose, except by permit granted by the Virginia Marine Resources Commission. The location of condemnation areas and leased shellfish grounds are shown in Figure 16.

Significance for Planning

Strategies should be developed by local governments and incorporated into local comprehensive planning efforts which address areas where land and water use activities, along with natural conditions, can have negative impacts on water quality conditions and, in turn, important fisheries habitats. Identification of commercially- and recreationally-important fisheries, their spawning and nursery areas, shellfish producing and management areas, and waterbodies which are closed to shellfish harvesting is an important first step in this regard. Although shellfish information is available from the Virginia Marine Resources Commission, fish habitat information is not. In other states, such as North Carolina, fish habitats are delineated on maps and provided to localities for use in their planning efforts. No such maps have been made available to Virginia Tidewater localities.

Further, the mobility and complex life cycle of fish species and complex ecology of tidal aquatic ecosystems add to the level of difficulty of addressing fish habitat protection. There is some uncertainty as to the exact locations of fish habitat and the magnitude of impacts from adjacent land uses, especially in tidal environments where pollutants can be transported into an estuary from a remote location by tidal currents. Despite this uncertainty, localities can properly implement programs that reduce the

Figure 16. Shellfish Leases

[figures available in Planning Department]

amount of pollutants known to impact fish habitat. Such programs include erosion and sediment control, Chesapeake Bay Preservation Act, and stormwater programs.

Unfortunately, a great amount of the City's fish habitat in the form of wetlands have been lost or altered. As the City of Norfolk Tidal Marsh Inventory (VIMS, 1987) notes: "The tidal wetlands within the City of Norfolk have been subject to enormous development pressures historically. Since the turn of the century, entire creeks, e.g. Boush, Mason, Tarrant, Newton, Lamberts, Smith and Colley, have been either filled in or reduced to mere vestiges of nineteenth century areas." A recent article on wetland loss in the Elizabeth River basin, notes that the amount of wetlands in the Elizabeth River was reduced by more than half between 1944 and 1977 (VIMS, 1999). The article also noted that wetland loss decreased significantly after the enactment of the state wetlands permit program in 1972. Thus, in a City such as Norfolk, the only approach available to protect fisheries consists of protecting and improving existing habitat and restoring lost habitat.

Several studies point to the strong influence that land use has on the quality of water in shellfish growing areas. Even relatively low levels of urban development yield high levels of bacteria, derived from urban runoff or failing septic systems. These consistently high bacterial counts often result in the closure of shellfish beds in coastal waters. Therefore, it is not surprising that most closed shellfish beds are in close proximity to urban areas. For example, all of the City of Norfolk's waterways are condemned for shellfish harvesting.

DESIGNATED NATURAL OR PROTECTED AREAS OF ECOLOGICAL OR CULTURAL SIGNIFICANCE

Due to the fact that the City of Norfolk is entirely developed, the presence of significant natural areas is limited. In the 1998 Virginia Water Quality Assessment 305(b) Report (VDEQ, 1998), hydrologic units or subbasins have been ranked according to the presence of wetland and aquatic natural heritage resources. The Elizabeth River watershed was given a "medium" ranking. Maps from the Division of Natural Heritage indicate that there are no habitats for any federal or state listed species in Norfolk.

According to the Virginia Department of Conservation and Recreation, Division of Natural Heritage, there are five general areas in the City where natural heritage resources are found (Figure 17). These are found in the Eastern Branch of the Elizabeth River, near the confluence with Broad Creek, the Lafayette River, Little Creek, Willoughby Spit, and an area between Tidewater Drive and Chesapeake Boulevard, just north of Little Creek Road. Natural heritage resources include amphibians, birds, fish, invertebrates, animals, non-vascular plants, vascular plants, reptiles, as well as unique ecological communities. A listing of these resources by name, rank, and status is included in Table 3. Figure 17 shows various one-minute blocks of different colors. The color indicates the highest legal protection status for natural heritage resources within that block. These blocks are intended to act as "caution flags" for natural heritage resources. The center of the blocks should not be interpreted as resource locations, and the blocks should not be considered buffer areas for resources reported within them. More specific information about these natural heritage resources and their locations can be obtained from VDCR. Information can also be obtained from the Natural Heritage Program home page at http://www.state.va.us/~dcr/vaher.html.

Table 3. Occurrence of Natural Heritage Resources in the City of Norfolk (VDCR-DNH, 2001).					
Common Name	**Scientific Name**	**State Rank**	**State Status**	**Last Observed**	**Quadrangle**
Peregrine Falcon	*Falco peregrinus*	S1	LE	1998	Norfolk South
Yellow-Crowned Night Heron	*Nyctanassa violacea*	S2	SC	1995	Little Creek
Black Skimmer	*Rynchops niger*	S2		1989	Norfolk North
Least Tern	*Sterna antillarum*	S2	SC	1989	Norfolk North
Pretty Dodder	*Cuscuta indecora*	S2?		1984	Little Creek
A Goldenrod	*Solidago tortifolia*	S1		1968	Little Creek
Spanish Moss	*Tillandsia usneoides*	S2		1969	Little Creek

S1 - Extremely rare; usually 5 or fewer populations or occurrences in the state; or may be a few remaining individuals; often especially vulnerable to extirpation.
S2 - Very rare; usually between 5 and 20 populations or occurrences; or with many individuals in fewer occurrences; often susceptible to becoming extirpated.
LE - Listed Endangered
LT - Listed Threatened
SC - Special Concern - animals that merit special concern according to VDGIF (not a regulatory

Significance for Planning

Natural areas serve as important reserves for rare organisms, they help maintain ecosystem stability, and provide important baseline information for long-term ecological monitoring. Local planning efforts should include careful consideration of identified natural areas. When planning near such an area, site development and access should be evaluated. VDCR officials stress that if a development proposal is being considered close to one of these areas, then the appropriate state or federal agency should be contacted for additional information.

SUMMARY AND CONCLUSIONS

Due to the history of development in the City of Norfolk, much of its sensitive aquatic resources have been destroyed. Some remnants of these resources have been identified. The headwater areas of the Elizabeth River are believed to provide fish habitat for significant species. The Virginia Institute of Marine Science has documented a persistent bed of submerged aquatic vegetation (SAV) within Little Creek Harbor. Finally, the Virginia Department of Conservation and Recreation – Division of Natural Heritage has identified five natural heritage areas within the City.

Figure 17. Natural Heritage Areas

[figures available in Planning Department]

ADJACENT EXISTING AND FUTURE LAND USE DESIGNATIONS

Land uses adjacent to the shoreline, both existing and proposed, are required by the Chesapeake Bay Preservation Act to be considered in comprehensive planning studies. In this regard, land and water use and water quality conflicts can be analyzed. Activities on the land and water invariably impact upon the utilization and quality of water resources. Potential impacts include increased nutrient, sediment, and pesticides carried in urban runoff and increased flows, which can cause streambank erosion.

In a developing locality, through the comprehensive planning process, local governments have the opportunity to direct conflicting land and water uses from sensitive natural resources. In Norfolk, however, this is very difficult. The City's shoreline is entirely developed. Most of the shoreline land use activities historically responsible for water quality problems and shoreline alteration were established long before environmental regulations were enacted. Because these land uses are well-established private uses, their relocation is usually not possible. In addition, some of these shoreline land uses represent significant industrial and commercial amenities which provide local, regional, and statewide economic benefits. Due to these factors, future land use depicted in Norfolk's Comprehensive Plan is going to be similar in level of development to existing land use. The primary means available for addressing water quality impacts from these land uses is to focus on maintenance, retrofits and implementation of state and local stormwater management programs. Generalized existing shoreline land use is provided in Figures 18 – 20. Existing City-wide land use is depicted in Figure 1.

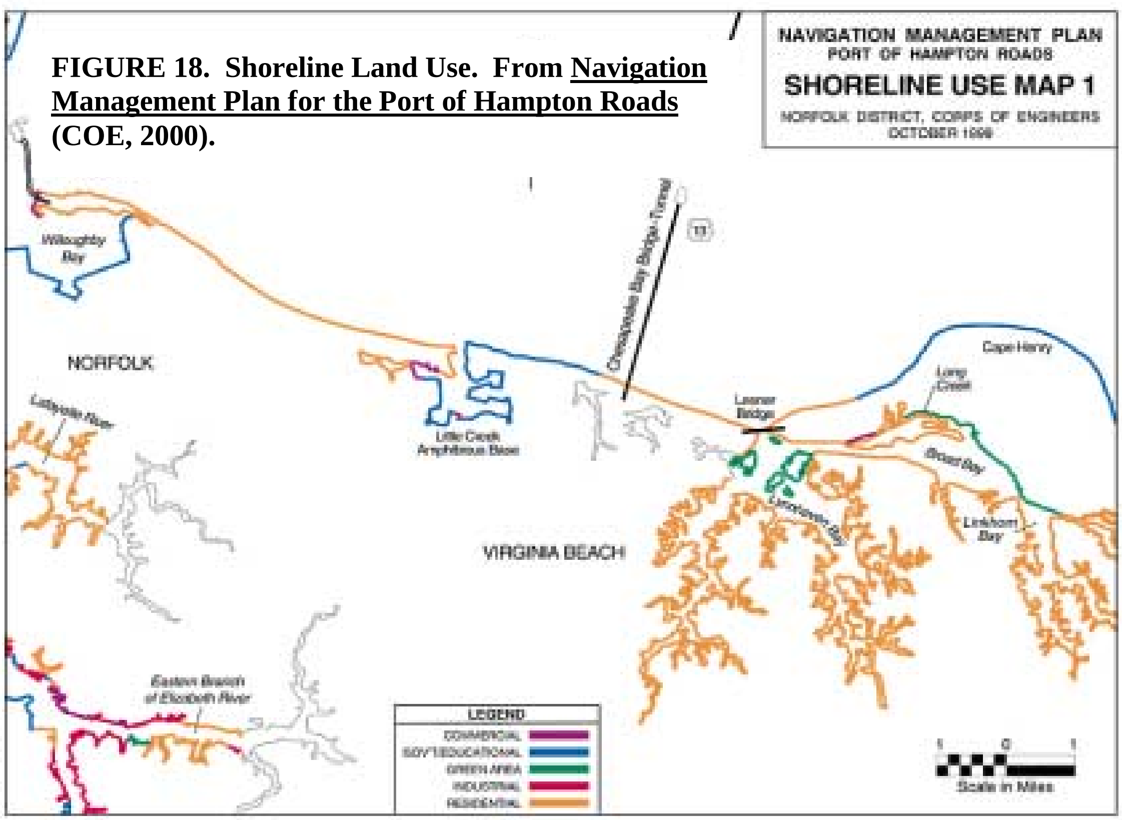


FIGURE 18. Shoreline Land Use. From <u>Navigation Management Plan for the Port of Hampton Roads</u> (COE, 2000).

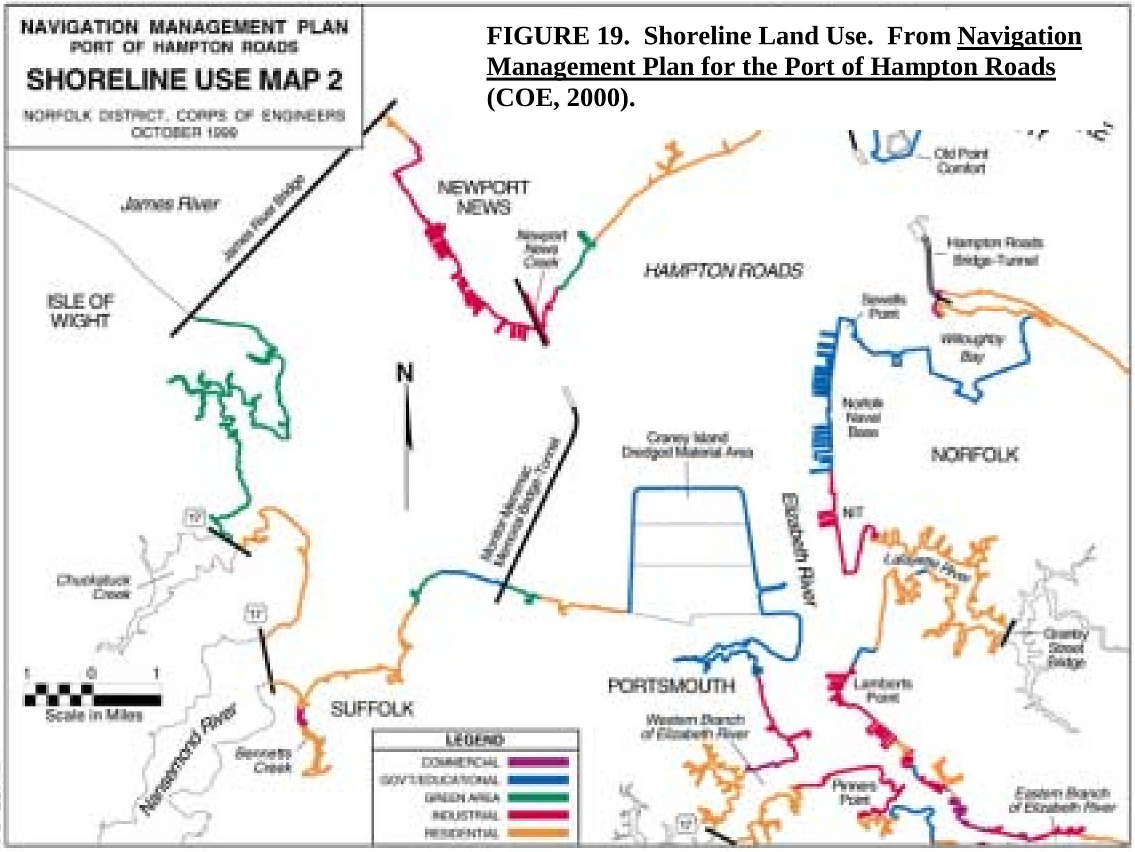


FIGURE 19. Shoreline Land Use. From Navigation Management Plan for the Port of Hampton Roads (COE, 2000).

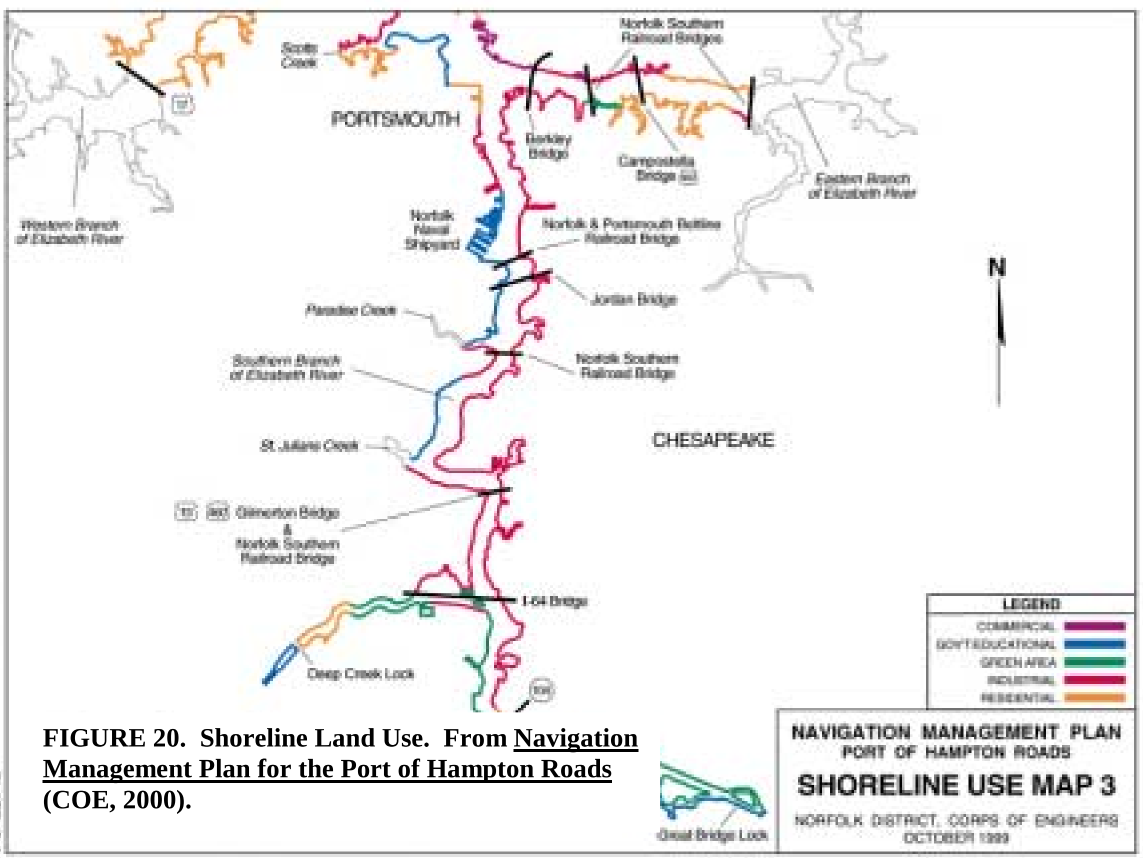


FIGURE 20. Shoreline Land Use. From Navigation Management Plan for the Port of Hampton Roads (COE, 2000).

SHORELINE ACCESS

INVENTORY OF SHORELINE ACCESS

Existing Private Piers and Docks

The Virginia Institute of Marine Science is currently updating the Shoreline Situation Report for the City of Norfolk, including an inventory of piers and docks. Once this data becomes available, it should be evaluated and incorporated into future planning activities, if it is deemed to be a relevant issue. The impact of private piers and docks is most likely not a relevant issue to the City of Norfolk due to the highly altered nature of its shoreline.

There are a limited number of scientific studies available that document direct significant impacts of private piers and docks on water quality and the aquatic ecosystem. Potential environmental impacts include shading and displacement of aquatic life, leaching of wood preservatives that are toxic to aquatic life, increased turbidity and other short-term impacts during construction, and other environmental impacts associated with boating activities. While the individual impact of private piers and docks may be minimal, the cumulative and collective impacts of individual piers and docks to the surrounding aquatic ecosystem may be significant, particularly in high densities.

The long recognized common law riparian right to wharf out is recognized in the Virginia Code. Title 28.2-1203(a) of the Code of Virginia allows owners of riparian or waterfront property to construct a non-commercial pier to access navigable water without obtaining a permit. While piers are not subject to permit regulations, the Virginia Marine Resources Commission does require an application to determine qualification for an exemption. While riparian property owners have the legally recognized right to construct a pier or dock to access navigable water, their impacts can be managed through siting and design requirements. Local governments can work with state permitting agencies to require or educate waterfront property owners about pier and dock design that will minimize environmental impacts. In a study entitled Dock Design with the Environment in Mind: Minimizing Dock Impacts to Eelgrass Habitats by Burdick and Short (1998), it was found that height above the water was the most significant factor in dock design affecting the health of submerged aquatic vegetation communities. The study found that ideally a pier or dock should be at least 3 meters above the submerged bottom, with a north to south orientation, and no more than 1 meter wide to minimize shading impacts to submerged aquatic vegetation. In addition to physical dimensions, alternative materials to chemically treated wood can be encouraged.

Historically, local governments have been reluctant to regulate individual private piers and docks because the existence of enabling authority to do so is unclear. In general, local governments can manage pier and dock density indirectly in two ways. Through zoning or subdivision ordinances, a local government can cluster development away from shorelines and retain the waterfront area as community open space and provide a community pier. In doing so, it is thought that any environmental impacts are easier to identify and control if activity is concentrated at one location. In addition, a local government can require a minimum lot size for waterfront lots, thereby reducing the concentration of piers and docks and dispersing their impact. However, these options are realistic options only in developing localities and usually not possible in cities like Norfolk that are entirely built out.

Existing Water Access Facilities and Water-Enhanced Recreation Areas

During the study period, a total of 36 marina facilities and 29 shoreline access points were identified in the City. Of the 36 marina facilities, 19 are available for private use only. Excluding these sites, there are a total of 46 shoreline access points available for use by the general public. In addition, there are several schools adjacent to water: Larrymore Elementary, Granby Elementary, Larchmont Elementary, Willard Elementary, Lindenwood Elementary and Lake Taylor Middle School. These facilities are shown in Figures 21 - 22. Tables 4 and 5 list these facilities, including the location of pump-out facilities. When compared to other localities in the region, the City of Norfolk has a relatively high number of shoreline access points.

Figure 22. Marinas

[figures available in Planning Department]

Figure 23. Shoreline Access

[figures available in Planning Department]

Table 4. Marina Facilities, City of Norfolk. Source: Virginia Department of Health, Boating Almanac, Vol. 4, 1993.						
Name	**Slips**	**Boats**	**Ramp**	**Restroom**	**Pumpout**	**Private Use Only**
American Legion Post 60 Marina	23	15		X	X	X
Bay Point Marina	316	181		X	X	
Clyde's Marina	44	36		X		
Cobbs Marina	95	57	X	X	X	
Colonnas Shipyard	16	4		X		X
Coopers Pier	20	9		X		
Cutty Sark Marina Inc.	98	85		X		
Eyeglass Point Pier	1	0				X
Knitting Mill Creek Yacht Club	14	1				X
Little Bay Beach & Boat Club Assoc,Inc.	9	6				X
Little Bay Harbor Marina	10	2				
Little Creek Marina, Inc.	392	317		X	X	
Lyons Shipyard	4	3		X		X
M.& V.W. Bay Marine Inc.	87	68		X	X	
Marine Hydraulics	4	6		X		X
Metro Machine	7	3		X		X
Municipal Pier	11	6		X	X	
Norfolk Yacht & Country Club	215	151	X	X	X	X
Norshipco Marine Sales	3	5		X		X
Old Dominion University (Rowing)	15	48		X		X
Old Dominion University (Sailing)	44	34		X		X
Otter Berth Waterside	36	12		X	X	
Pier Condominium	35	12			X	X
Pilot House Condominium	29	7			X	X
Norfolk Boat Works Inc.	8	4		X	X	X
Rebel Marine Service	69	67		X	X	
Tarmac America	6	6		X		X
Taylor's Landing	312	109		X	X	
Tidewater Boat Club	29	19		X		X
Todd Marine Service	19	5		X		X
U.S. Naval Station (Rec)	367	270	X	X	X	
Williams Pier	14	14				
Willoughby Bay Marina	358	281	X	X	X	
Willoughby Boat Club Condo	14	3			X	X
Willoughby Harbor Ltd.	289	184		X	X	
Freemason Harbor Condominium	35				X	X

Table 5. Shoreline Access Points, City of Norfolk. **Source: Chesapeake Bay, Susquehanna River and Tidal Tributaries Public Access Guide (Chesapeake Bay Program, 2000), the City of Norfolk, and Virginia Department of Game and Inland Fisheries.**

Access Point	Fee or Permit	Shoulder Parking	Limited Parking	Large Parking	Boat Ramp	Car Top Boat Only	Fishing	Swimming Beach	Hiking	Nature Study	Picnicking	Restrooms	Public
City Beach Park			x					x			x	x	x
Community Beach Park				x				x			x	x	x
Ocean View Beach Park			x					x				x	x
Sarah Constant Shrine Beach			x					x			x	x	x
Lafayette City Park				x	x				x		x	x	x
Lake Whitehurst	x			x	x		x				x	x	
Lakewood Park				x			x		x		x	x	x
Barraud Park					x		x		x	x	x	x	x
Northside Park				x					x	x	x	x	x
Tarrallton Park				x					x			x	x
Town Point Park					x							x	x
Virginia Zoological Park	x			x					x	x		x	x
Norfolk Botanical Gardens	x			x					x			x	x
East Ocean View Community Park				x			x					x	x
Harbor Park				x	x								x
Haven Creek Boat Ramp			x		x								x
Willoughby Boat Ramp				x	x							x	
45th Street Boat Ramp/Marina			x		x								
Villa Circle (Canoe Trail)		x				x							x
West Cove Court (Canoe Trail)						x							x
Piney Branch Court (Canoe Trail)						x							x
River Edge Road (Canoe Trail)						x							x
Lucile Avenue (Canoe Trail)						x							x
Mayflower Avenue (Canoe Trail)		x				x							x
Norview Avenue Bridge (Canoe Trail)						x							x
Granby Street Bridge (Canoe Trail)			x			x							x
The Hague Dog Park													x
Winona Dog Park													x

PROPOSED PUBLIC WATER ACCESS FACILITIES, SHORELINE RECREATION AREAS, AND FUTURE NEEDS ASSESSMENT

Part I: Guidance Manual, Section IV.B. of the Regional Shoreline Element of Comprehensive Plans (HRPDC, 1997) and its related appendices contain a discussion of shoreline and water access issues and a methodology for determining waterway appropriateness in meeting additional public shoreline and water access needs. Section V.B.1. and related appendices set forth policy options and implementation strategies for improving public access. The HRPDC Guidance Manual also contains information on potential environmental impacts of water access facilities and siting considerations, which is summarized below.

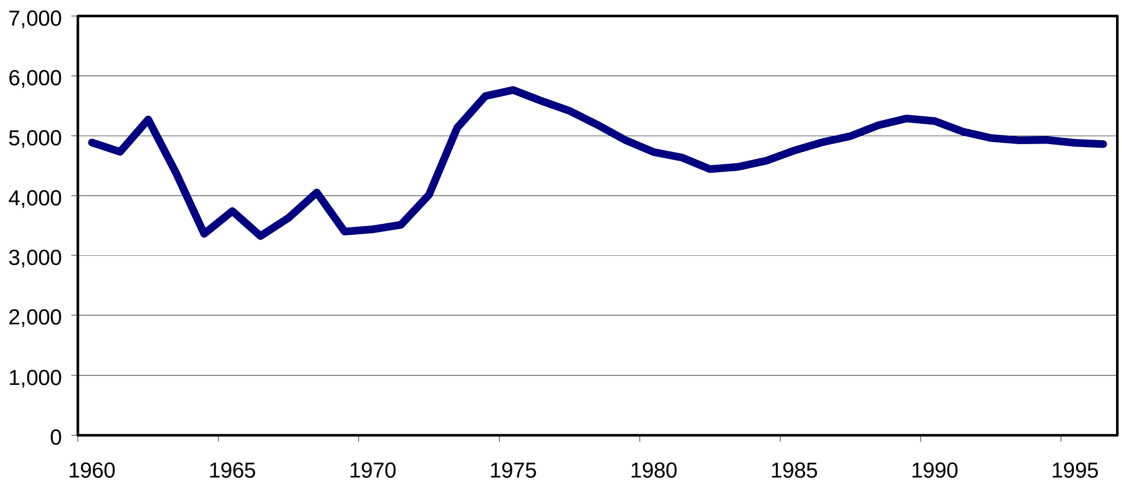
Water Quality Impacts from Shoreline Access

Part I: Guidance Manual, Section IV.B. and Appendix N of the Regional Shoreline Element of Comprehensive Plans (HRPDC, 1997) contains detailed information on potential environmental impacts of water access facilities. In summary, any form of shoreline access may potentially impact water quality in some way. The magnitude of the impact will depend on the type of access. The type of shoreline access that presents the greatest impact to water quality is marinas. Marinas can potentially impact water quality in the following ways:

- Re-suspension of bottom sediments by associated dredging and boating activities, increasing turbidity levels and releasing pollutants, such as bacteria, viruses, nutrients, heavy metals, oil and grease, and oxygen depleting substances;
- discharge of sanitary wastes from shoreside facilities and boats, which results in increased fecal bacteria levels and decreased dissolved oxygen levels;
- stormwater runoff from impervious surfaces associated with marina development can transport nonpoint source pollutants directly into receiving waters. These pollutants include sediment, bacteria, oil and grease, heavy metals, nutrients, detergents, and oxygen depleting substances;
- oil and fuel discharges associated with two-cycle boat engines;
- pollutants associated with boat maintenance activities. Pollutants include toxic substances associated with antifouling paints, oil contained in the bilge water, and runoff associated with boat washing activities; and
- associated piers, docks, and bulkheads may decrease water circulation and decrease aquatic habitat by blocking available light. Metals associated with the toxic substances used to treat timbers may leach into the surrounding waters.

The construction and operation of boat ramps will have many of the same impacts on water quality as marinas; however, they are usually much less significant. Boat ramp facilities are generally smaller in scale, accommodate less noxious uses, and usually require less encroachment on subaqueous land. Compared to marinas and boat ramps, non-motorized boating access, such as canoe/kayak access, presents few adverse impacts to water quality. Potential impacts from pier and bank fishing access are minimal, except perhaps for the installation and use of docks and piers and fish cleaning activities. Similarly, pedestrian shoreline access presents minimal impacts to water quality. A potential concern associated with pedestrian access may be stormwater runoff due to an increase in impervious surface associated with access facilities, such as buildings and parking lots.

FIGURE 23
Number of Regisered Boats
City of Norfolk (VDGIF, 1997)



Shoreline Access Needs Assessment

The City of Norfolk is almost completely developed and is experiencing a population decline. Since 1980, the population in Norfolk has decreased from 266,979 to 221,500 in 1998, a decrease of approximately 17% (HRPDC, 1999). According to data obtained from the Virginia Department of Game and Inland Fisheries (VDGIF), the number of registered boats has remained steady for almost twenty years (Figure 23). Despite its declining population and unchanging number of registered boats, Norfolk's location makes it a significant water recreation resource in the region because it readily provides access to the waters and beaches of the Chesapeake Bay. In addition, boaters find Norfolk attractive because of its close proximity to the Atlantic Ocean. A significant number of the users of Norfolk's access points come from surrounding communities.

Data from the VDGIF indicates that the annual number of boating accidents in the City ranges from four to nine per year. The City is typically included in the VDGIF top ten list of cities and counties with the most boating accidents in the state. The vast majority of boating accidents in Norfolk occur in the mainstem and Eastern Branch of the Elizabeth River.

Part II: Appendices-Appendix M of the Regional Shoreline Element of Comprehensive Plans (HRPDC, 1997) contains recreational needs projections by locality. Projections for the City of Norfolk are provided in Table 6 below.

Table 6. Projected Shoreline Recreation Needs for the City of Norfolk from Appendix M of the *Regional Shoreline Element of Comprehensive Plans* (HRPDC, 1997)

Activity	Estimated 1992 Activity Days	1992 Demand (Acres)	1992 Total Supply (Acres)	1992 Private Supply (Acres)	1992 Need (Acres)	Demand in 2000 (Acres)	Need in 2000 (Acres)	Demand in 2010 (Acres)	Need in 2010 (Acres)
Jet Skiing	11,700	183	570			179		175	
Lake Fishing	217,774	1,225	570			1,196		1,172	
Power Boating	499,100	12,030	570			11,748		11,508	
Sailboarding	8,454	73	570			71		70	
Sailing	77,183	1,336	570			1,305		1,278	
Salt Water Fishing	211,990	1,192	570			1,164		1,140	
Water Skiing	90,136	2,824	570			2,758		2,701	
Total Lake, River, and Bay Use	1,116,337	18,863	570	0	18,293	18,421	17,851	18,044	17,474
Canoe, Kayak, Jon Boat	84,122	21	0			21		20	
Rafting	9,737	2	0			2		2	
Stream Fishing	216,323	1,217	0			1,188		1,164	
Tubing	21,067	3	0			3		3	
Total Stream Use	331,249	1,243	0	0	1,243	1,214	1,214	1,189	1,189
Outdoor Beach Use and Swimming	1,852,153	133	53	0	80	130	77	127	74

Source: Regional Shoreline Element of Comprehensive Plans: Part 1: Appendices, HRPDC, February 1997.

The recreational needs projection for Norfolk indicates that the demand for powerboating, fishing and outdoor beach use and swimming significantly exceed the demand for other water-related activities.

The 1992 Virginia Outdoors Survey (VDCR, 1992) found that in the "urban corridor," of which Norfolk is a part, water-based recreational activities were the most popular among state citizens. Forty-six percent of survey respondents were found to engage in swimming/sunbathing, 58% engaged in power boating, 23% engaged in non-motorized boating, and 25% engaged in fishing. The demand for water-based recreation was made evident when the Outdoors Survey found that respondents felt that the most needed recreational amenity is access to water.

All available information indicates a high demand for water access, especially boating and beach access. In light of this, even though the City currently contains a relatively high number of shoreline access points, it seems appropriate that the City seek opportunities to provide additional access or improve existing access facilities, where possible. A primary limitation to establishing new access points is a lack of available land due to Norfolk's highly developed waterfront. Meeting the demand for additional access must be balanced with available resources and safety and environmental concerns. Increasing shoreline access beyond a certain level may increase the number of waterway use conflicts, resulting in a high level of accidents or environmental impacts in some areas.

Proposed and Potential Shoreline Access

The Chesapeake Bay Public Access Plan (Chesapeake Bay Program, 1990) noted the following about potential access areas in the City of Norfolk:

- The City plans to increase beach access and to build a public marina in East Ocean View. The new East Beach Marina will be located in this area and is scheduled to begin construction in 2001.

- The City proposes the establishment of a marina adjacent to Nauticus.

- The City proposes to establish a wetlands walkway adjacent to the tourist information center and the marshes bordering Willoughby Bay. (The walkway has since been constructed.)

- Potential water access areas include Bessie's Place (now Harbor Park) and the former landfill site in Lambert's Point.

- The City should improve the Haven Creek Boat Ramp and add an additional ramp at that location.

- The City should renovate and reopen the Grandy Park boat ramp.

Access developments since the publication of the Bay Access Plan need to be taken into consideration when examining the above observations.

Proposals made by the City of Norfolk for expanded access include:

- the construction of Lakewood Rowing Center at Lakewood Park, to include longhouses for storage and at least one pier;

- establishment of waterway trails with a total of 19 canoe/kayak access points; and

- renovation of the Grandy Village boat ramp as part of neighborhood redevelopment.

The locations of specific potential access points from the above sources are depicted in Figure 24.

The Virginia Outdoors Plan (1996) makes no specific references to the City of Norfolk, but it does contain some relevant recommendations. The plan suggests that military installations be evaluated for their potential to be used as joint recreational facilities, particularly for beach and water access. It also suggests the assessment of vacant land owned by Old Dominion University for recreational potential.

Shoreline Access Siting Considerations

Appendix N of Part I: Guidance Manual, Section V.B.1. of Regional Shoreline Element of Comprehensive Plans (HRPDC, 1997) contains information on potential environmental impacts of water access facilities and siting considerations. Siting guidelines are provided for marinas, boat ramps, canoe put-in/take-out facilities, shoreline pedestrian access sites, and fishing facilities. An additional source of siting guidelines is the Chesapeake Bay Areas Public Access Technical Assistance Report (Chesapeake Bay Program, 1999). Shoreline Development BMP's by the Virginia Marine Resources Commission (1994) provides siting considerations and recommended best management practices (BMPs) for boating facilities. In addition, the state is currently conducting a GIS-based marina siting study. These should be considered in evaluating proposed boat ramps or marinas.

Figure 24. Potential Access

[figures available in Planning Department]

Any activity that encroaches upon state-owned submerged land that lies below the mean low tide line requires a permit from VMRC. In granting or denying the permit, the Commission is required by state statute to consider the effects of the proposed project upon:

- Other reasonable and permissible uses of State waters and State-owned bottomlands, such as shellfish harvesting, fishing, navigation, and swimming
- Marine and fisheries resources
- Tidal wetlands
- Adjacent or nearby properties
- Water quality

Any proposed marina must also have a sewage treatment facilities plan approved by the Virginia Department of Health. The City of Norfolk Wetlands Board may also consider cumulative impacts to tidal wetlands associated with any proposed marina including pier shading, shoreline hardening, dredging, slumping, and boat wake induced erosion of adjoining wetlands.

General siting considerations recommended by VMRC include:

- The physical dimensions of the waterbody should be compatible with the size of the marina and type of vessel it is designed to accommodate.

- Marinas must have sufficient upland area to provide all necessary parking, stormwater management BMPs, fuel, and sanitary facilities without filling wetlands or subaqueous bottom.

- All marinas should be located in areas with good natural flushing.

- Marinas should not be sited close to areas of high natural resource value such as shellfish beds, SAV, and areas frequented by endangered species.

- The transfer or control of shellfish leases for the sole purpose of accommodating marina development is unacceptable.

- Projects that will result in a dense concentration of boats must be critically evaluated as to their impacts on natural resources; however, in densely populated areas, concentration of slips in a single facility may be justified to prevent disturbance of undeveloped shorelines.

- The Commission will require the applicant to demonstrate how best management practices will be incorporated into both the upland development plan associated with the facility as well as the required Erosion and Sediment Control Plan.

- The Commission may require that BMP structures be completed before any slips can be occupied.

VMRC also provides specific siting considerations:

- The number of slips is not predicated on the total number of units on the property.
- Required dredging for access channels should be limited to the minimum dimensions necessary for navigation and should avoid sensitive areas such as wetlands, shellfish grounds and submerged aquatic vegetation.
- Dredge material disposal areas for initial, as well as future maintenance needs, should be clearly defined and designated.
- Site specific stormwater management BMP's are required to minimize runoff from buildings and impervious surfaces.
- A solid waste disposal and recovery plan must accompany marina development plans.
- Sanitary facilities and pumpout facilities convenient to marina users should accompany development plans.
- Facilities incorporating boat maintenance operations shall include plans for collection and removal of maintenance by-products (sand blasting material, paint chips, etc.) before effluent enters adjoining waterways. Plans shall also make provisions for regular maintenance of these operations.

The Chesapeake Bay Area Public Access Technical Assistance Report (Chesapeake Bay Program, 1999) provides siting guidelines for boating access, beach and swimming access, pier and bank fishing, and natural area access. Desirable and undesirable site characteristics for each are summarized in Table 7.

Recently, the Virginia Department of Environmental Quality, Department of Conservation and Recreation, and the Virginia Institute of Marine Science have, through a cooperative effort, created the Virginia Clean Marina Program. The program offers individualized, on-site assistance to marina operators. In addition, the program expects to produce a best management practices manual for marinas and develop a clean marina award program. The program is being coordinated by VIMS and can be reached at 757-518-2000.

Table 7. Shoreline Access Siting Guidelines (Chesapeake Bay Program, 1999)		
Access Type	**Undesirable Site Characteristics**	**Desirable Site Characteristics**
Boat Ramp	• Too shallow or with inadequate area for intended use, requiring extensive dredging or filling • Low tidal range or flow and low flushing rates, such as dead end canals or upper reaches of tidal creeks • Location with poor water quality • Location at mouth of tidal creeks and other tributaries due to lower water quality and higher sedimentation rates • Location near designated fish or wildlife protection areas, shellfish beds, or SAV • Location which inhibits public access to navigable waters or hinders safe navigation by requiring structures that would extend into existing channels • Location near areas of heavy boating traffic.	• Easy access to open water, population centers, and necessary utilities • Accessible from existing roads and waterways • Location near existing state or federally maintained channels • High tidal range or flow and high flushing rates along the cutting side of the water body • Location in areas free of severe shoreline erosion or steep slopes • Compatibility with existing land and water uses • Location away from shellfish beds used for harvesting for human consumption • Access road that meets Department of Transportation secondary road standards • Variable turn-around area (size determined by design but must be able to accommodate a combined vehicle and trailer length of 40') • Buffer zone at shoreline for facilities which are not water dependent • 4 foot minimum width for walkways located apart from vehicular routes • Compatibility with local comprehensive plans
Swimming Beaches	• Slopes >15% and areas receiving heavy drainage • Areas with highly erodible soils and shorelines which erode >2 ft/year • Beaches requiring shoreline erosion control structures may cause downstream impacts • Wind and wave patterns which cause erosion and/or hazardous swimming conditions • Areas which historically receive intense storm activity • Locations near land uses or other conditions which have adverse effects on water quality • Location adjacent to SAV and shellfish beds • Beaches which have underwater hazards which cannot be corrected without grading or dredging	• Good transportation network and secondary road system to the site location • Location near the population need • Location near public water supply, sewage treatment, and other utilities • Accessibility from on-site to the beach resource • Beach areas receiving sand deposition • Natural protection for the beach resource such as a site protected by existing sand dunes or a location in a cove • Tidal and water currents safe for swimming • Locations that have not historically received severe storm activity • Good water circulation and flushing
Pier/Bank Fishing	• Too shallow or with inadequate area for intended use, requiring extensive dredging or filling • Low tidal range or flow and low flushing rates, such as dead end canals or upper reaches of tidal creeks • Slopes >15% and areas receiving heavy drainage • Areas with highly erodible soils and shorelines which erode >2 ft/year	• Good transportation network and secondary road system to the site location • Location near the population need • Location near public water supply, sewage treatment, and other utilities • Accessibility from on-site to the fishing resource • Natural protection for the fishing resource such as a site protected by existing vegetation or a location in a cove

Table 7. Shoreline Access Siting Guidelines (Chesapeake Bay Program, 1999)		
Access Type	**Undesirable Site Characteristics**	**Desirable Site Characteristics**
	• Wind and wave patterns which cause erosion and/or unacceptable fishing conditions • Locations near land uses or other conditions which have adverse effects on water quality • Areas with underwater hazards that cannot be corrected without grading or dredging	• Tidal and water current conditions which are acceptable for fishing • Locations that have not historically received severe storm activity • Good water circulation and flushing • Location free of severe shoreline erosion or steep slopes • Natural buffer zone along shoreline for facilities which are not water dependent
Natural Area Access	• Sensitive plant and animal habitats which would be disturbed by passive recreation activity • Natural areas which are extremely remote, and if developed as access points, would unnecessarily introduce human influences	• Natural areas which can provide educational and interpretive opportunities • Natural areas already coexisting with some level of human influence

SUMMARY AND CONCLUSIONS

Shoreline public access is one of the City's greatest resources. The location of the City makes it an ideal location to access the region's waterways for industrial shipping, recreational and commercial fishing, recreational boating, and swimming. For its size, the City has a great deal of shoreline access facilities. However, the demand for access is still higher than the available supply. Thus, the City should continue to seek opportunities to provide additional facilities or make enhancements to existing facilities. In the process, the City should seek to minimize potential water quality impacts from these facilities by paying attention to design features and siting them in appropriate areas.

EXISTING AND POTENTIAL POLLUTION SOURCES

INTRODUCTION

Comprehensive planning requirements of the Chesapeake Bay Preservation Act direct the City to identify existing and potential pollution sources to surface and ground water quality. These are addressed below.

PERMITTED DISCHARGES

The Virginia Department of Environmental Quality (VDEQ) currently administers the Virginia Pollution Discharge Elimination System (VPDES) program. This program is mandated by the federal Clean Water Act. Under this program, industrial, commercial and sewage treatment plant discharges to waterways must obtain a permit. Permit requirements establish effluent limitations for each significant pollutant found in the discharge. Effluent is monitored for compliance and penalties apply in cases where the standards are not met. Heavy metals, chlorinated compounds, and nutrients are some of the pollutants that are regulated.

Permitted facility discharge data was obtained from VDEQ for the City of Norfolk. These records indicate that there are 23 permitted facilities in Norfolk (Figure 25). The majority of these are port and shipyard facilities. The location of the outfall pipes that discharge wastes associated with these industrial activities is shown in Figure 26. Other major facilities that discharge into local waterways through outfall pipes include Norfolk International Airport and Sewage Treatment Plants operated by the Hampton Roads Sanitation District (HRSD). According to data obtained from VDEQ, there are over 350 outfalls in the City. Two hundred thirty nine, or approximately 65%, of these outfalls are associated with the Norfolk Naval Station. Thirty-six outfalls are associated with Norfolk International Airport, six outfalls are associated with the HRSD Virginia Initiative Plant, and the vast majority of the remaining outfalls are associated with shipyards.

LEAKING PETROLEUM STORAGE TANKS

Leaking underground and aboveground storage tanks pose a direct contamination hazard to both ground and surface water supplies. Leaking above and underground storage tanks can be a significant issue in aging cities, such as Norfolk. These storage tanks contain hazardous substances, such as petroleum, gasoline, diesel fuel, acetone, or kerosene. Over time, underground storage tanks can corrode and begin to leak. Small leaks in a tank are usually not detected, and have minimal impact on water resources if the leak occurs in shallow, well-aerated soils. Under these conditions, petroleum products will attach to clay and organic material in the soil and naturally occurring bacteria can decompose these products over time. Larger leaks or leaks in very permeable sandy soils do not provide an adequate barrier and can easily result in ground water contamination.

Figure 25. Permitted Discharges

[figures available in Planning Department]

Figure 26. Outfalls

[figures available in Planning Department]

The Department of Environmental Quality is charged with regulating underground storage tanks in Virginia. DEQ annually receives federal funds to clean up LUSTs. To prevent leaks from developing in the future, LUST regulations required that after December 22, 1998, all new tanks be made of non-corrodible materials and be equipped with overfill and spill prevention devices. Tanks in existence prior to that date were required to be replaced or retrofitted to meet the new standards by the deadline. Tanks are also required to possess leak prevention devices and monitoring equipment to help detect leaks. Underground storage tank regulations do not apply to residential underground storage tanks.

Leaking Underground Storage Tank data for the City of Norfolk was obtained from the Department of Environmental Quality. Currently, there are 271 aboveground storage tanks (AST's) and 388 underground storage tanks (UST's) in the City of Norfolk (Appendix B). On January 5, 2001 there were 85 open cases of leaking petroleum storage tanks reported by the Department of Environmental Quality (Figure 27). The DEQ considers a petroleum storage tank open if corrective actions identified for a documented leaking tank have not been completed.

SANITARY SEWER SYSTEM

The City's aging sanitary sewer collection system can be a potential source of pollution. Inflow and infiltration to the wastewater pipes can cause untreated wastewater to be released into the surrounding environment. Inflow is caused by improper stormwater drainage connections to the wastewater system, causing the capacity of wastewater pipes to be exceeded. In the same way, infiltration of groundwater through leaks causes pipes to be overloaded. This overloading causes the wastewater system to back up and may result in flooding containing untreated sewage. This overloading may also cause untreated sewage to reach the shallow groundwater aquifer or the surface drainage system from where it can be transported into local waterways. The City is currently in the process of systematically replacing failing portions of its wastewater system.

This issue is being addressed by pending federal sanitary sewer overflow regulations. The City is currently responding to these regulations through the Regional Directors of Utilities Committee of the Hampton Roads Planning District Commission.

CONTAMINATED SEDIMENT

Industrial development several decades prior to the enactment of environmental regulations has resulted in contamination of bottom sediments in the Elizabeth River. Toxic chemicals from shipyards, creosote plants, and shipping terminals located along the waterfront have been responsible for releasing toxic substances, which over time have accumulated in bottom sediments at harmful levels. Once accumulated in bottom sediments, they can be resuspended by dredging activities and by turbulence created by large vessels. Toxic substances of concern include heavy metals and polynuclear

Figure 27. Potential Threats to Groundwater and Surfacewater

[figures available in Planning Department]

aromatic hydrocarbons (PAHs), such as oil and creosote. These toxic substances can affect fish and bottom dwelling organisms, such as crabs and oysters.

The Chesapeake Bay Program has identified the Elizabeth River as a Region of Concern, indicating that contaminant concentrations in its bottom sediment are much higher than those in other areas of the Chesapeake Bay. Other designated Regions of Concern identified by the Bay Program include Baltimore Harbor and the Anacostia River. Sediment remediation efforts in the Elizabeth River are currently being coordinated through the Corps of Engineers Elizabeth River Restoration Study. A Project Steering Committee made up of local governments, local universities, the Hampton Roads Planning District Commission, the Virginia Department of Environmental Quality, the Virginia Marine Resources Commission and the Elizabeth River Project has been active in providing input into the Study. Recently, the Elizabeth River Project began its "Bottoms Up" campaign, which seeks to educate the public about sediment contamination issues and facilitate sediment remediation efforts in the Elizabeth River.

LANDFILLS

Non-Sanitary landfills and open dumps can allow for the percolation of contaminated water (leachate) through the soil to the aquifers below. Current regulations (Virginia State Regulations, Solid Waste Regulations, Subtitle D) by EPA require installations of sanitary landfills to conduct groundwater monitoring. According to the records of the Solid Waste Management Division of the Virginia Department of Environmental Quality, there are a total of nine known solid waste disposal facilities in Norfolk. These facilities may be classified as active, under enforcement action, inactive, or closed. There are an undisclosed number of facilities that do not have available data. Table 8 lists several different types of landfills, including construction and demolition debris, industrial wastes, sanitary wastes, solid and medical foreign wastes, tire piles, and materials recovery facilities.

Table 8. City of Norfolk Solid Waste Facilities		
Facility Name	**Type**	**Activity Status**
1. American Waste Industries Transfer Station	Solid and Medical Foreign Waste Transfer Station	Active
2. SPSA – Ballentine Transfer Station	Transfer Station	Active
3. Virginia Materials	Materials Recovery Facility	Active
4. Campostella Landfill	Municipal Landfill	Inactive
5. Lambert's Point – ODU	Non-Sanitary Landfill	Closed
6. Norfolk Naval Base Demolition Site	Construction and Demolition Debris	Closed
7. Norfolk Naval Base Salvage Fuel Site		Closed
8. Norfolk Naval Base – Waste Tire Operation Site	Tire pile	Closed
9. USA Ways Transfer Station	Transfer Station	Closed
Any non-sanitary landfills before 1975		Closed (complete data not available in searchable format)
Source: Virginia Department of Environmental Quality, Solid Waste Management Division, January 08, 2001		

WASTE LAGOONS/SURFACE WASTE IMPOUNDMENTS

Surface waste impoundments are used by industries, agricultural operations and municipalities for the retention, treatment and/or disposal of hazardous and non-hazardous liquid wastes. Surface impoundments can contaminate ground water through the percolation of liquid wastes to the aquifers below. The types of waste lagoons that currently exist in Norfolk are listed in Table 9.

Table 9. City of Norfolk Waste Lagoons/Surface Waste Impoundments		
Waste Lagoon Type	**Facilities**	**Description**
1. Hazardous Waste	None	N/A
2. Animal Waste	None	N/A
3. Sewage Waste	N/A	None on file with VDH, not currently tracked
4. Municipal Treatment Waste	None	Waste disposed of by HRSD
5. Industrial Treatment Waste	Two	Concrete operations that utilize surface impoundments as a primary settling basin. Water is treated and discharged to surface waters.

Source: Virginia Department of Environmental Quality, phone conversations, January 08, 2001

INEFFICIENT SEPTIC SYSTEMS

Inappropriate siting and poor design, construction and maintenance of septic systems can cause pollution of underlying ground water, as well as contribute to surface water pollution through run-off. Regular maintenance and proper usage of septic systems is important to ensure prevention of pollution of the City's water resources. Currently, all buildings are required to have city sewage service, unless indicated by the City of Norfolk that it is unable to provide such service to a location (cost or location reasons). At that time, they may have a private septic system installed on the property. The Norfolk Department of Utilities does not currently track private septic tank locations.

The Norfolk Department of Health (NDH) currently maintains paper files dating back to 1972 for all new septic systems installed and any repairs to existing systems. The NDH estimates that 500 private septic systems exist in Norfolk. This estimate does not include systems that are not recorded. NDH records approximately 5 new/repair private system incidents annually. Any Notices of Violation that are issued on these systems primarily occur through NDH inspections and reported incidents from the public. City Ordinance currently requires cases of failed septic systems to connect to the public sanitary sewer system within 30 – 60 days, if sewer is available.

PESTICIDES AND FERTILIZERS

Pesticides and fertilizers are used extensively in golf course and urban park management and residential lawn and garden care. Nitrogen in the form of nitrate is the fertilizer most commonly responsible for groundwater contamination. This is because nitrogen is highly stable and water-soluble and therefore leaches easily through the soil. Other commonly used fertilizers, like phosphorus and potassium, are less soluble and therefore have a tendency to bind to soil particles and not infiltrate into the ground water. In general, only half of the nitrogen applied is taken up in plants, the rest either runs off or enters the ground water (USGS, 1993).

Data to reflect the amounts of pesticides and fertilizers utilized, released and accumulated in Norfolk, as well as, the environmental impacts on ground water associated with accumulations has not been determined. The Virginia Department of Health does test annually for nitrate and phosphorus content in the ground water sources.

HAZARDOUS WASTE SITES

Sites that are included in the National Priorities List, administered by the Environmental Protection Agency, are designated by individual states as their single most serious uncontrolled waste sites, which pose an actual or potential threat to human health and the environment. The City of Norfolk has two NPL sites located at Little Creek Amphibious Base and Norfolk Naval Base, Sewell's Point Naval Complex (Figure 27).

HAZARDOUS WASTES

There are three types of Hazardous Waste Handlers: producers, transporters, and disposers. Hazardous wastes are classified as such because they display one or more of the following characteristics: ignitability, corrosivity, reactivity and toxicity. According to the Virginia Department of Environmental Quality, there are currently no hazardous waste disposal sites in Virginia. The Virginia Department of Environmental Quality provided a current list of the hazardous waste transporters located in Norfolk (Appendix C).

A study conducted by the Environmental Protection Agency in 1987 used black and white and color infrared aerial photographs to determine potential hazardous waste sites within the Elizabeth River area. Contamination problems related to intensive land use in the watershed throughout its history have made the Elizabeth River a prominent source of pollution entering the lower Chesapeake Bay. A total of 649 potential sites were identified and tracked with historical photographs, with over half of the sites discovered on the Norfolk South quadrangle. The site summary is provided in Appendix D.

HAZARDOUS MATERIALS

Potential ground water contamination problems from hazardous materials can occur from either accidental spilling or intentional dumping onto the ground. A facility that stores, uses or produces chemicals requiring Material Safety Data Sheets (MSDS) under the Occupational Safety and Health Administration hazard communication standard must provide a list of all those chemicals requiring reporting, grouped by hazard category, to the Local Emergency Planning Committee (LEPC) and the local fire department. All substances that meet certain thresholds established by EPA are included in the Extremely Hazardous Substances (EHS) list. The second list includes bulk storage facilities, such as suburban propane tanks.

The City of Norfolk Fire Department currently maintains a list of all facilities that require permits for Hazardous Materials. Appendix E reflects a list of all facilities in Norfolk that store or use hazardous materials.

ABANDONED WELLS

Improperly sealed abandoned wells can provide a direct conduit for surface run-off carrying pollutants to enter ground water aquifers. Abandoned wells may also be used as convenient sites to illegally dispose of potentially hazardous wastes that can enter the ground water system directly. Currently, Department of Health, Office of Water Programs and Norfolk Department of Health do not formally track abandoned wells. Owners are required to notify VDH when the well becomes inactive, and then proceed with an abandonment process (filling and capping). If the abandonment process is complete, a form is submitted to VDH, but the tracking of records for completions of well abandonment are not currently maintained by VDH or NDH.

BORROW PITS

Mining activities pose a significant threat to ground water and surface water quality by creating toxic products, disrupting aquifers, affecting the movement and recharge of groundwater, causing land subsidence, and completely altering the landscape. According to the Hampton Roads Planning District Commission's 1995 Borrow Pit Management Strategy Study, there are currently no abandoned, closed, or operational Borrow Pits located within the City of Norfolk that pose a potential threat to the ground water, and Norfolk's city code prohibits borrow pit operations within it's boundaries.

NONPOINT SOURCE POLLUTION

Nonpoint source pollution in the City of Norfolk consists exclusively of urban runoff. Pollution in urban runoff is addresses by the state Virginia Pollution Discharge Elimination System (VPDES). Under the VPDES program, cities with populations greater than 100,000 are required to obtain a permit to discharge stormwater runoff from their municipal separate storm sewer systems (MS4s). Generally speaking, an MS4 is essentially the drainage system within the City that eventually discharges into a local waterway. MS4 permits require cities to implement a stormwater quality management program. Norfolk's stormwater management program currently consists of an active public stormwater education effort, monitoring the discharge from stormwater outfalls for pollutant levels, maintaining the City's drainage system, and installing or retrofitting stormwater facilities that improve the water quality of runoff. Unlike other VPDES permits, effluent limitations are not currently imposed on MS4 permits due to the variability of natural causes that are outside of the control of a local government, such as rainfall.

Pollutant loads from the existing land use in Norfolk were estimated in the Regional Stormwater Loading Study (CH2MHill, 1999). Estimating stormwater pollutant loads is required by Norfolk's Virginia Pollution Discharge Elimination System (VPDES) permit. Estimated nitrogen and phosphorus loads from the sub-watersheds of the City are shown in Figures 28 - 32. The locations of the sub-watersheds of the City are shown in Figure 39. The pollutant loads were estimated using calculated Event Mean Concentrations and the EPA simple method, which is the same model used to comply with the Chesapeake Bay Preservation Act to calculate pollutant loads from proposed development projects. Pollutant loads predicted by this model are proportional to the level of imperviousness and rainfall. Thus, according to the model, those sub-watersheds that have relatively high levels of impervious surface also export a relatively high level of pollutants. As expected, the pollutant loads estimated for those watersheds of the City that contain a high level of commercial, industrial, and or institutional development are higher than its other watersheds.

The Regional Stormwater Loading Study found that runoff coming from only 12 percent of the City was treated by best management practices. This is largely a result of the fact that a great majority of the City was developed long before stormwater best management practices were required by environmental regulations. Retrofitting existing developed areas with stormwater best management practices (BMPs) is very expensive and the needed funds are typically not available. As a result, retrofitting the City is a slow process. Currently, the most feasible way to retrofit areas of the City with BMPs is during redevelopment activities.

FIGURE 28

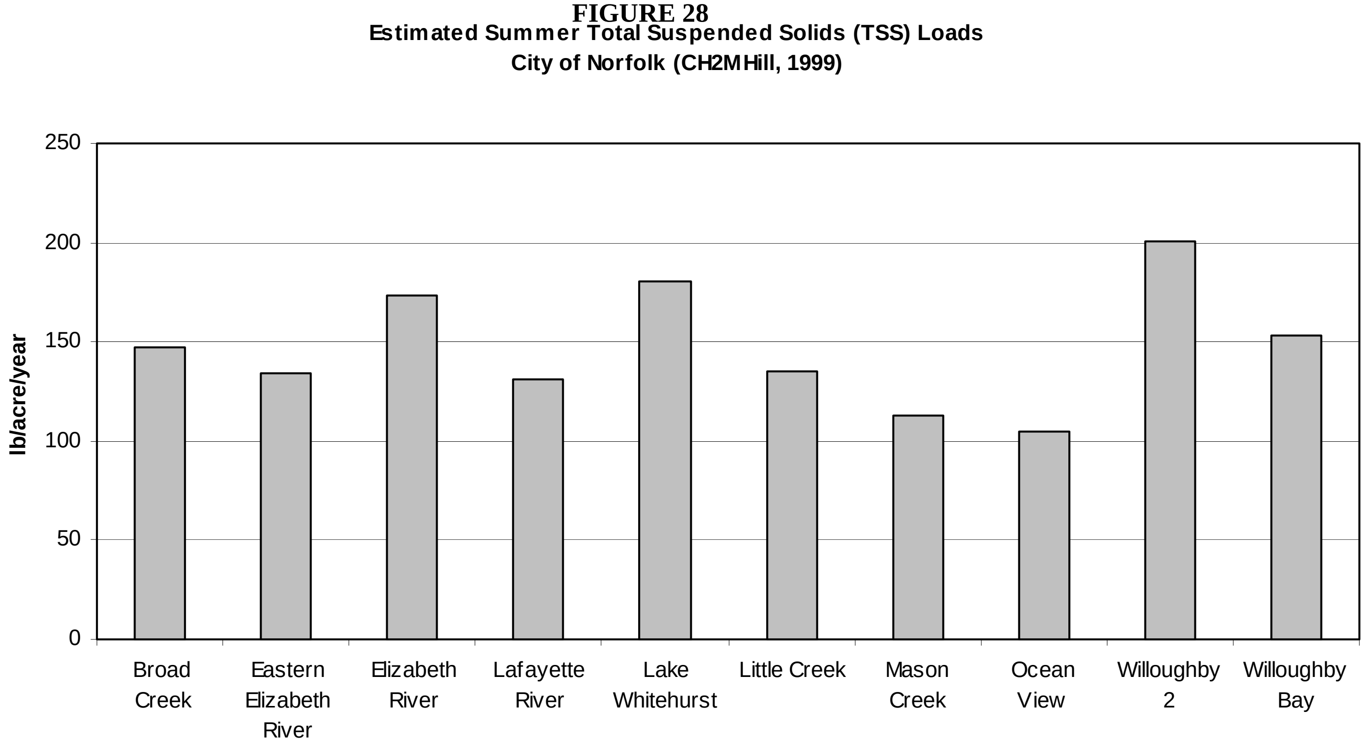


FIGURE 29

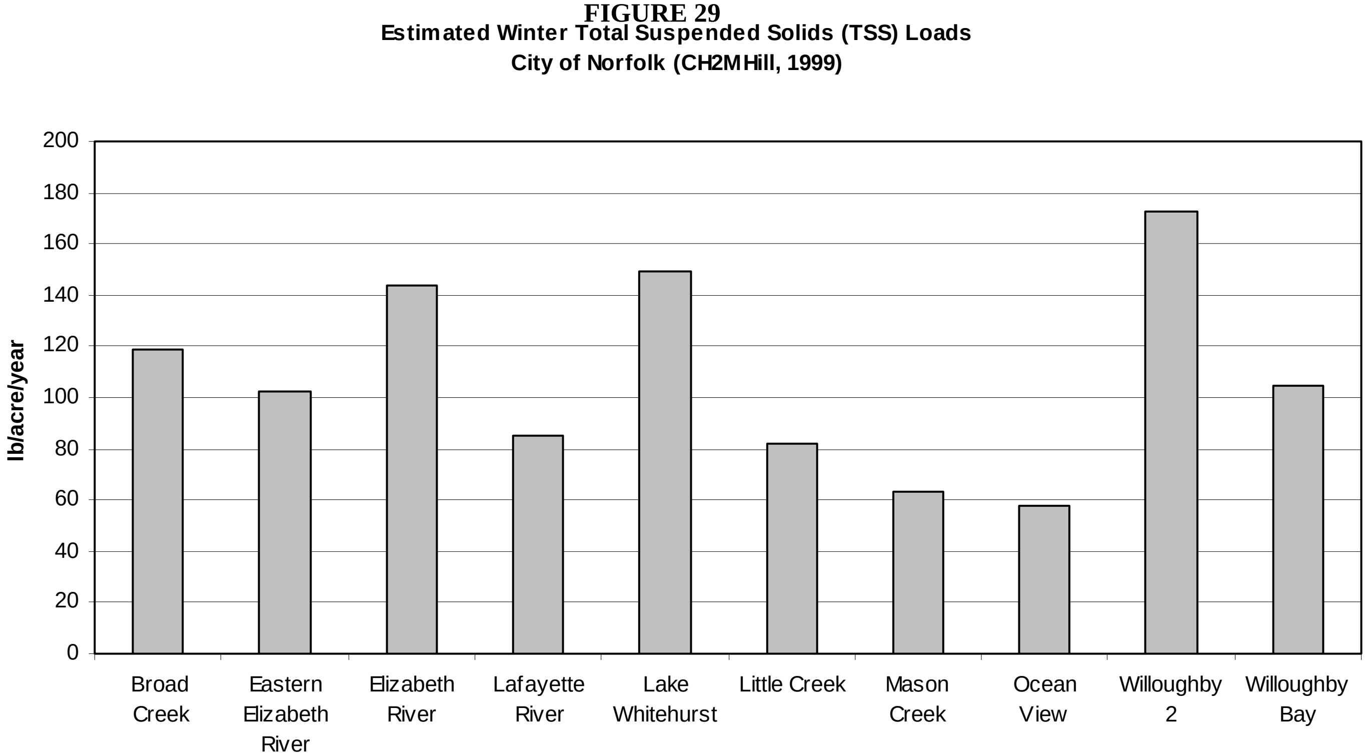


FIGURE 30

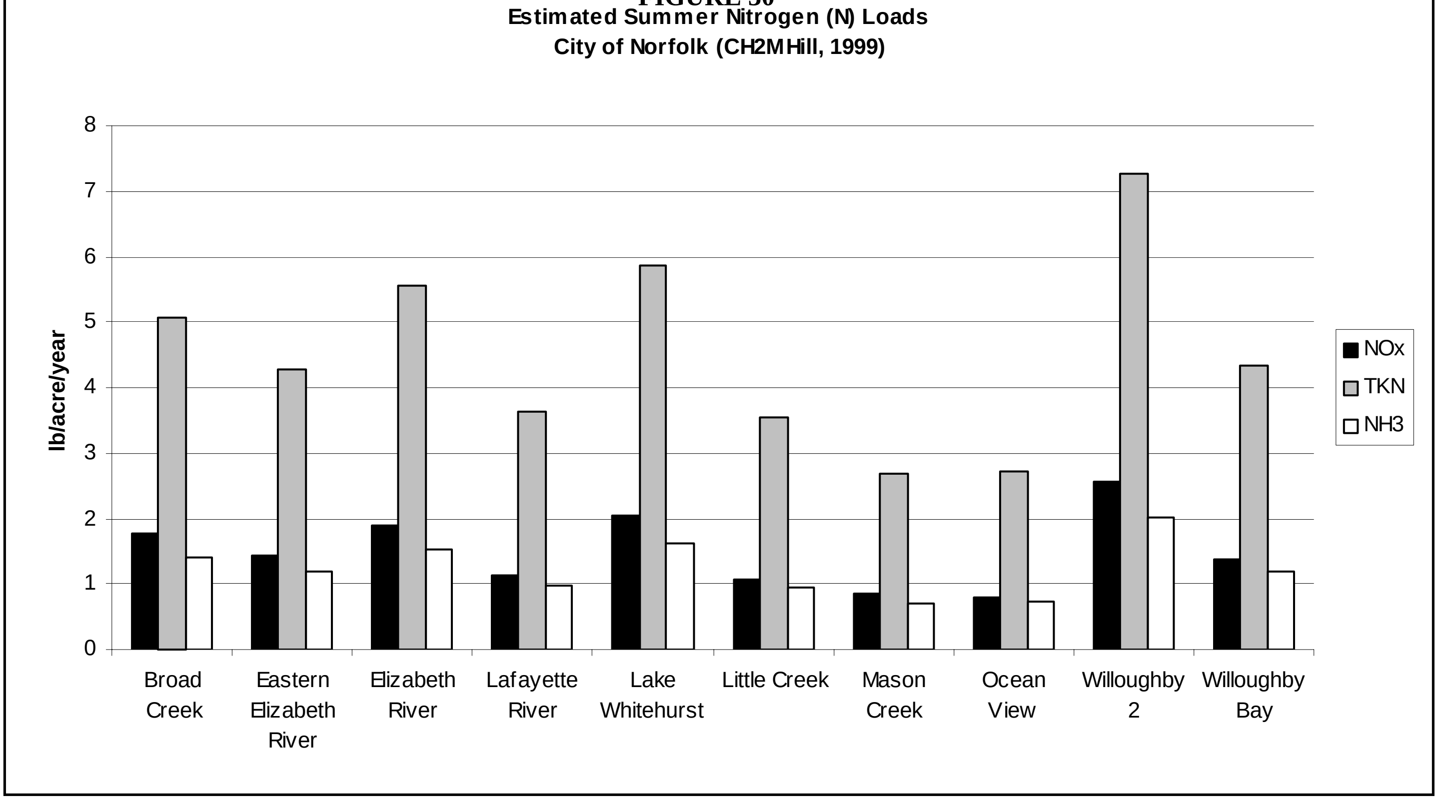


FIGURE 31

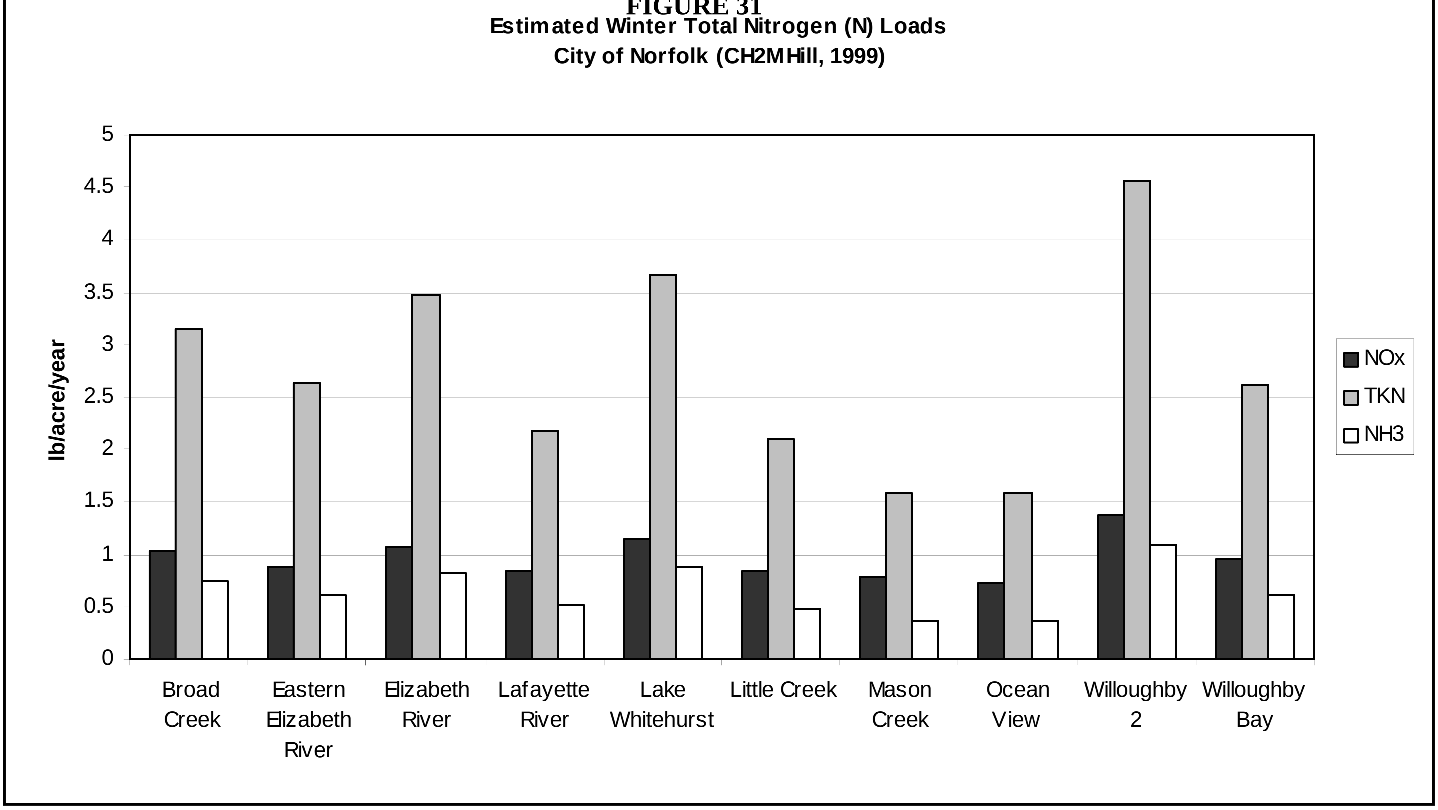
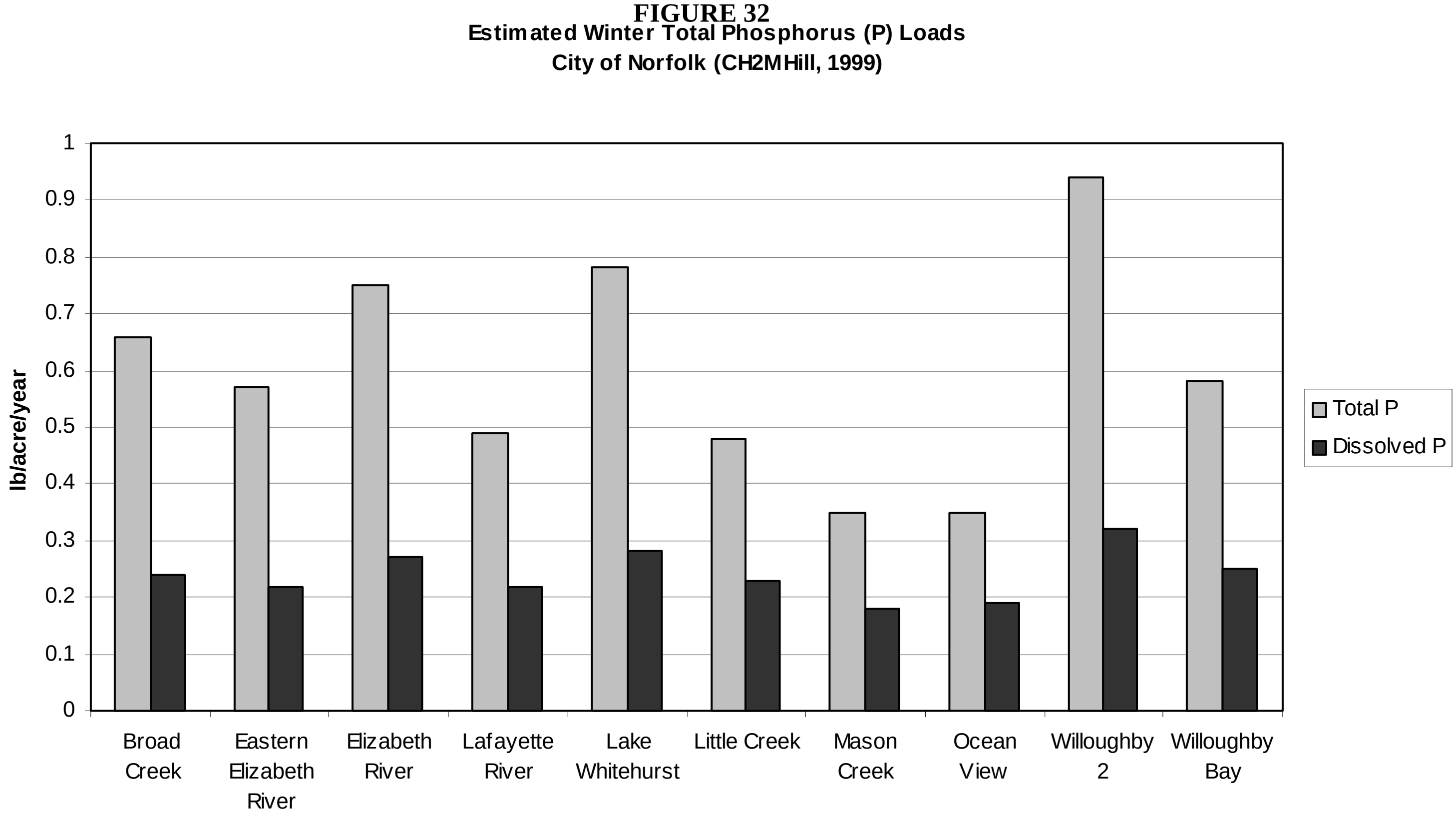


FIGURE 32


Estimated Winter Total Phosphorus (P) Loads
City of Norfolk (CH2MHill, 1999)
lb/acre/year
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Broad Creek
Eastern Elizabeth River
Elizabeth River
Lafayette River
Lake Whitehurst
Little Creek
Mason Creek
Ocean View
Willoughby 2
Willoughby Bay
Total P
Dissolved P

PROTECTION OF POTABLE WATER SUPPLY

INTRODUCTION

Clean potable water resources are critical to the physical and economic health of the community as well as the natural environment. In order to protect and manage the City's water supply resources, a basic understanding of the natural system is needed. Because many activities have the potential to severely degrade the water quality and quantity of the City's water resources and pose health threats to City residents, this section focuses on the nature of the City's ground and surface water supply. In addition to characterizing the water resources, a preliminary range of water resource management options will be explored for their suitability to protection efforts in Norfolk.

GROUND WATER RESOURCE CHARACTERIZATION

The following section contains a description of the groundwater system in the City of Norfolk. Information is provided on groundwater terminology and the hydrologic cycle.

Ground Water Terminology

An *aquifer* is a rock or sediment in a geologic formation or group of formations, which is sufficiently saturated with water and sufficiently permeable to transmit economic quantities of water to wells or springs. A *confining unit* is a geologic formation or formations above or below an aquifer, which has a sufficiently low permeability to impede the flow of water between aquifers. An *unconfined aquifer* or (water table aquifer) is an aquifer in which there is no confining unit between the top of the aquifer and the land surface. A *confined aquifer* is an aquifer in which there is a confining unit between the top of the aquifer and land surface. In a ground water system with multiple aquifers, such as that below Norfolk, the confined aquifers are separated from each other by confining units (Figure 34).

Hydrologic Cycle

An understanding of the ground water system beneath the City of Norfolk begins with the hydrologic cycle. The hydrologic cycle describes the continuous movement of water above, on, and below the surface of the earth. The three basic ground water components of the hydrologic cycle are the introduction of water to the ground water system, movement of water within the ground water system, and discharge of water from the ground water system. Figure 33 illustrates the hydrologic cycle of the Virginia Coastal Plain.

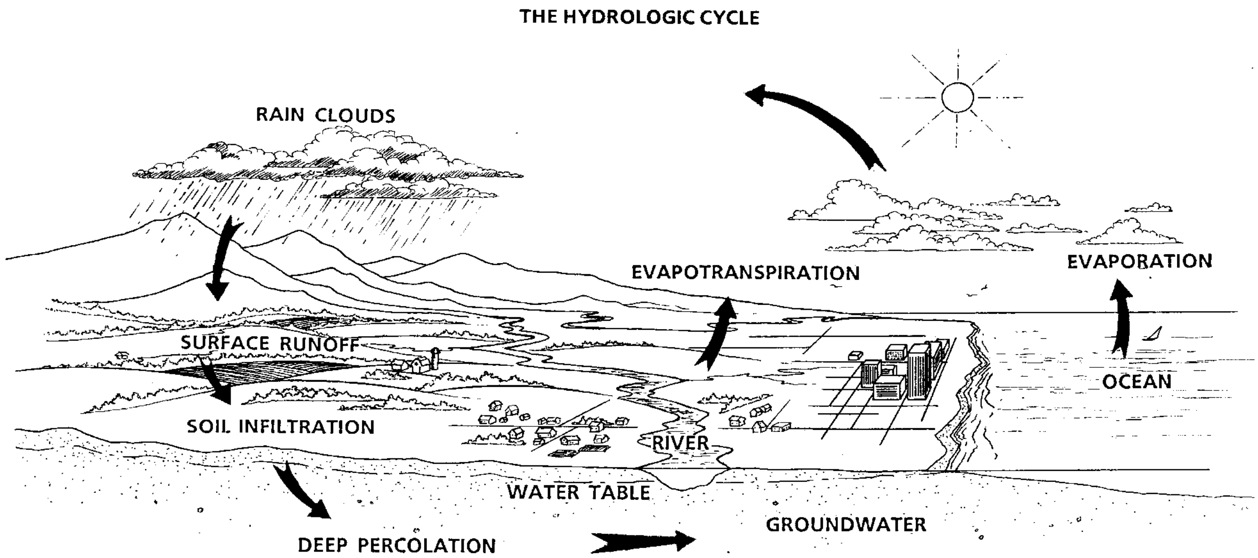


FIGURE 33. Hydrologic Cycle of the Coastal Plain. Source: Adapted from Virginia Water Resources Research Center, Threats to Virginia's Groundwater.

The hydrologic cycle begins with precipitation. Rainwater infiltrates the ground and percolates downward into the soil and into the saturated zone of the upper most aquifer, known as the water table aquifer. Water moves both downward and laterally through this aquifer in response to gravitational forces toward discharge areas such as seeps, springs, streams, the Chesapeake Bay, or Atlantic Ocean. Water that moves downward in the water table aquifer eventually encounters a less hydraulically conductive (permeable) confining unit, such as a clay and/or silt soil layer. These confining units partially impede downward movement of ground water, which encourages the lateral movement of water through the aquifer. Some of the water, however, will permeate through the confining layer downward into an underlying aquifer. These saturated soil units below the confining units are called confined aquifers.

Water in confined aquifers also moves both laterally and vertically in response to pressure gradients and gravitational pull towards discharge areas. Confining units again impede vertical movement of water within a confined aquifer and the process is continuously repeated as water moves throughout the entire layered sequence of sediments.

Fresh ground water flowing easterly eventually encounters salty ground water as it approaches the coast. Density differences and pressure gradients force the fresh water upwards. The upward moving fresh water is impeded by the confining units but eventually discharges into the Chesapeake Bay or Atlantic Ocean. Water evaporates from these surface water bodies and forms clouds, which in turn produce precipitation to continue the hydrologic cycle. (Laczniak and Meng, 1988).

Ground Water Framework

The City of Norfolk is located within the Virginia Coastal Plain Physiographic Province, which extends from the Fall Line in the west, to the Atlantic Ocean in the east, to the Maryland border in the north, and to the North Carolina border in the south. The surface of the Virginia Coastal Plain consists of a series of broad gently sloping, highly dissected north-south trending terraces bounded by seaward facing escarpments, which represent ancient shorelines. The subsurface is characterized by wedge shaped unconsolidated sedimentary deposits that, in general, slope (dip), and thicken towards the east. These deposits consist of clay, silt, sand, and gravel, with variable amounts of shell material. In some localized areas, cementation of shell beds can form thin lithified (rock) strata. The unconsolidated sediments overlay a crystalline bedrock basement that also slopes gently to the east.

Many different depositional environments existed during the formation of the Virginia Coastal Plain deposits. In general, the stratigraphic section (vertical profile) consists of a thick sequence of non-marine (riverine and alluvial) sedimentary deposits overlain by a thinner sequence of marine (near shore beach, estuarine, and delta) sediments. The ground water flow system in the Coastal Plain of Virginia is a multi-aquifer system as mentioned above. Studies have identified at least nine major water bearing hydrogeologic units (aquifers) in the Virginia Coastal Plain (Hamilton and Larson, 1988; Laczniak and Meng, 1988; Harsh and Laczniak, 1990). Figure 34 illustrates the general vertical distribution of the aquifer system of the Virginia Coastal Plain.

Chesapeake Bay Impact Crater

Approximately 35 million years ago a meteor impacted area adjacent to the present-day mouth of the Chesapeake Bay. The USGS is currently involved in a major study of the impact crater and its effect on the ground water system in Southeastern Virginia. The southwestern portion of the outer rim of the crater intercepts the northeastern portion of the City (Ocean View area). The impact disrupted the aquifer system, and studies currently in progress will yield a more accurate picture of the ground water system in this part of the state.

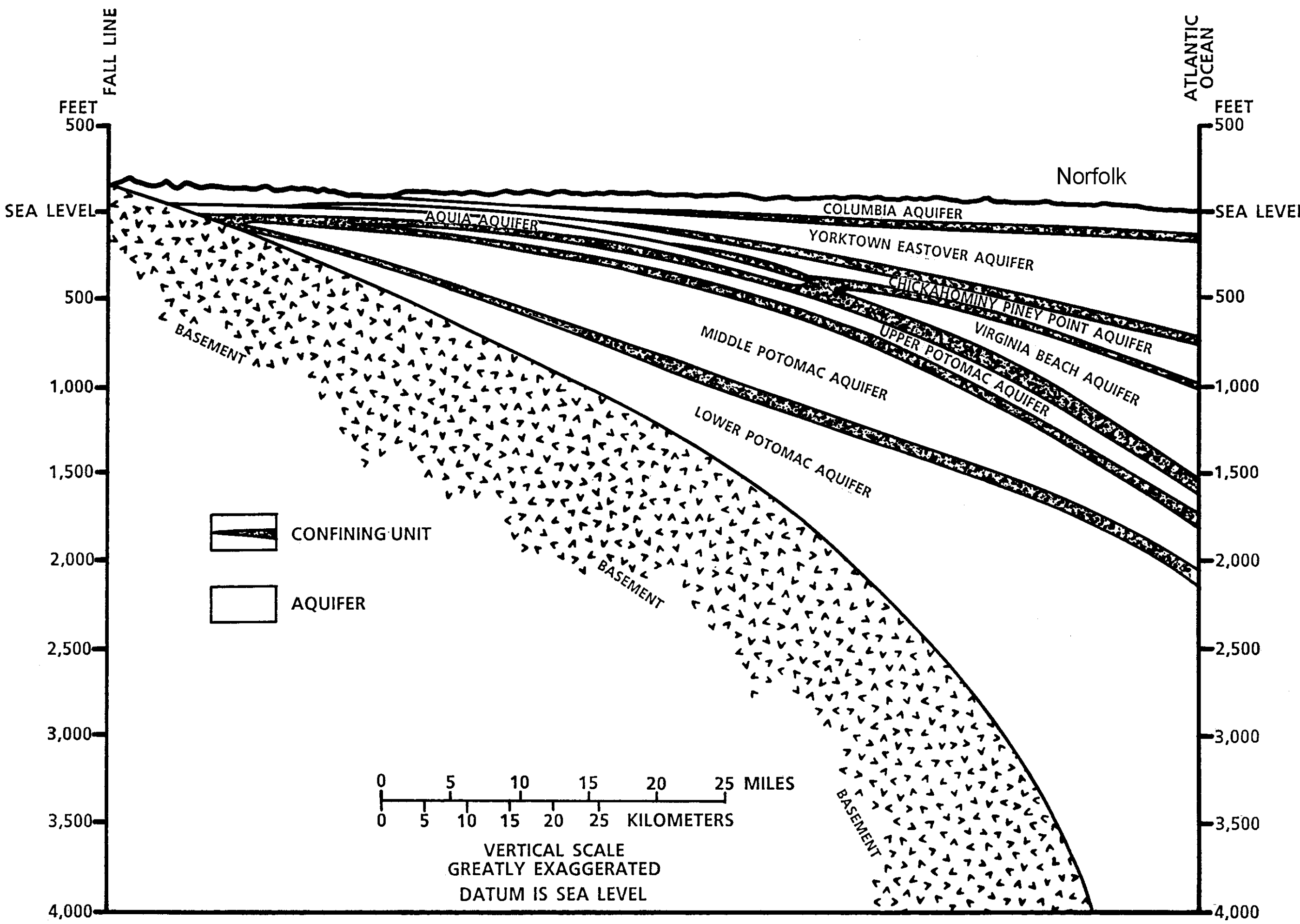


FIGURE 34. The Hydrogeology of Southeastern Virginia. Source: USGS Report, Hydrogeology and Analysis of the Ground Water Flow System in the Coastal Plain of Southeastern Virginia, 1988.

As illustrated in Figure 34, the ground water framework beneath the City of Norfolk is comprised of one unconfined aquifer and seven major confined aquifers. The confined aquifers are separated from aquifers above and below by confining beds (except in the area within the Chesapeake Bay Impact Crater). The following paragraphs provide a general description of the aquifers identified beneath the City of Norfolk from youngest to oldest (top to bottom):

Columbia Aquifer

The Columbia Aquifer is the uppermost aquifer and is unconfined throughout its extent. The Columbia Aquifer consists of the sandy surficial deposits above the Yorktown Confining Unit. This aquifer is characterized by interbedded very coarse gravel channel deposits that fine upwards into silts and clays. The Columbia aquifer is used primarily for domestic water supplies (drinking water and irrigation), especially in the eastern region of the Virginia Coastal Plain.

Yorktown-Eastover Aquifer

The sediments of the Yorktown-Eastover Aquifer are characterized by the interlayered, thick to massively bedded shelly sands separated by thinner clay beds. The Yorktown-Eastover Aquifer is separated from the Columbia aquifer by the Yorktown Confining Unit. Beneath Norfolk, it overlies the St. Mary’s and Calvert Confining Units. In cross section, the Yorktown-Eastover Aquifer is wedge shaped sloping (dipping) and thickening to the east.

Numerous wells penetrate the Yorktown-Eastover Aquifer throughout the Virginia Coastal Plain. Some light industries and many domestic users use this water-supply source. Well yields have been reported ranging from 20 to 250 gallons per minute (gpm) (Harsh and Laczniak, 1990).

Chickahominy-Piney Point Aquifer

The Chickahominy-Piney Point Aquifer is characterized by black and white sands containing glauconite, shells, and dark silty clay inter-dispersed throughout the sands (Meng and Harsh, 1988). The Chickahominy-Piney Point Aquifer overlies the Nanjemoy-Marlboro Confining Unit and is overlain by the Calvert Confining Unit.

Numerous wells penetrate the Chickahominy-Piney Point Aquifer in the Virginia Coastal Plain. Many light industries, small municipalities, and domestic users use this as a water-supply source. Reported well yields for the Chickahominy-Piney Point Aquifer range from 20 to 250 gpm (Harsh and Laczniak, 1990).

Virginia Beach Aquifer

The Virginia Beach aquifer is a confined aquifer found in the eastern end of the Coastal Plain only and contains no outcrop area. The sediments found in this aquifer consist of fine- to medium-grained glauconitic sand, mixed with thin layers of clay and shell material. This aquifer is capable of producing generally good quality water for domestic and industrial uses, although it has been found to be salty in some areas. The top of this aquifer can be found between 800 to 1100 feet beneath the City. The Virginia Beach Aquifer is mostly overlain by the Chickahominy-Piney Point aquifer at its eastern end under the City of Virginia Beach.

Aquia Aquifer

The sedimentary deposits of the Aquia Aquifer consist of a continuous, elongate-lens shaped sand body. It is limited in its extent pinching out towards the east beneath the City of Norfolk. It overlies the Upper Potomac Confining Unit and is overlain by the Nanjemoy-Marlboro Clay Confining Unit.

Numerous wells drilled in Virginia penetrate the Aquia Aquifer. Many light industries, small municipalities, and private residencies use the aquifer. The Aquia Aquifer is capable of supplying large quantities of water in the northern two-thirds of the Virginia Coastal Plain. In the Hampton Roads region, the Aquia Aquifer is not commonly used as an aquifer because the deposits are much finer grained, commonly containing a limy-mud matrix and thin limestone beds (Meng and Harsh, 1988).

Upper Potomac Aquifer

The Upper Potomac Aquifer is separated from the Aquia Aquifer by the Upper Potomac Confining Unit. The Upper Potomac Aquifer is comprised of stratified sands and clays. The sands have been characterized as white micaceous, very fine to medium quartz with shell material. The Upper Potomac Aquifer overlies the Middle Potomac Confining Unit.

Most light industries and municipalities in the central region of the Virginia Coastal Plain use the Upper Potomac Aquifer. This aquifer is capable of producing large quantities of good water suitable for most uses. Reported well yields range from 25 to 350 gpm (Harsh and Laczniak, 1990).

Middle Potomac Aquifer

The Middle Potomac Aquifer is the second deepest and thickest confined aquifer in the hydrogeologic framework and the sedimentary deposits are believed to be late Early Cretaceous in age (Meng and Harsh, 1988). The Middle Potomac Aquifer consists of interlensing medium sands, silts and clays of differing thickness. The clays in the upper portion of the aquifer are laminated and massive. It lies directly above the Lower Potomac Confining Unit and is overlain by the Middle Potomac Confining Unit.

Most of the industries and municipalities throughout the western half of the Virginia Coastal Plain use this aquifer, sometimes in combinations with the underlying aquifers. The aquifer is capable of supplying large quantities of water but generally lies too deep for all but large industrial and municipal applications. Well yields from this aquifer are reported to be as much as 750 gpm (Harsh and Laczniak, 1990).

Lower Potomac Aquifer

The Lower Potomac Aquifer is the lowermost confined aquifer beneath the City of Norfolk. It is characterized by thick, interbedded sequences of angular to subangular, medium to very coarse-grained sand, clayey sand, and clay with interbedded gravel (Harsh and Laczniak, 1990; Hamilton and Larson, 1980; Meng and Harsh, 1988). The lithologic heterogeneity and discontinuous nature of the sediments in this unit makes correlation or tracing of individual sand and clay layers extremely difficult, even over relatively short distances. It lies entirely on the bedrock basement and is overlain throughout its extent by the Lower Potomac Confining Unit.

Table 10. City of Norfolk Ground Water Sources		
Intake Name (Number)	**Depth (ft)/Aquifer/Location**	**Primary Uses**
Well No. 1 (181-00200)	949/Middle Potomac/Western Branch Reservoir, Suffolk, VA	Replenish surface water sources
Well No. 2 (181-00201)	1020/Middle Potomac/Lake Prince, Suffolk, VA	
Well No. 3 (181-00202)	1183/Middle Potomac/Lake Burnt Mills, Suffolk, VA	
Well No. 4 (181-00203)	912/Middle Potomac/Lake Prince, Suffolk, VA	
Navy Well No. 1 (181-00204)	980/Middle Potomac/US Naval Communications Station, Suffolk, VA	
Navy Well No. 2 (181-00205)	503/Middle Potomac/ US Naval Communications Station, Suffolk, VA	

Source: Virginia Department of Health, data provided for Hampton Roads Source Water Assessment Program, January 27, 2000, and Virginia Department of Environmental Quality Well Data, 1995.

Only a few deep stratigraphic test wells and high capacity production wells penetrate the Lower Potomac Aquifer in the Virginia Coastal Plain (Meng and Harsh, 1988). The aquifer is capable of supplying large quantities of water but generally lies to deep for all but large industrial applications. Well yields from this aquifer are reported to be as much as 700 gpm (Harsh and Laczniak, 1990).

SOURCES OF GROUND WATER FOR NORFOLK

Norfolk does not own or operate municipal drinking water wells within the City boundaries. However, Norfolk currently owns and operates six ground water withdrawal wells that are located within the jurisdictional boundaries of the City of Suffolk. Table 10 lists general information regarding each well, and Figure 35 illustrates the location of each well.

Data from the Department of Environmental Quality indicates that in 1995, there were approximately 51 non-municipal public and private ground water wells in Norfolk. Appendix A lists information on wells shown in Figure 36.

The Virginia Department of Health currently does not have any community or non-community water systems on file within the City of Norfolk. There may be an undisclosed number of ground water wells that are not on file.

Figure 35. Municipal Well Locations

[figures available in Planning Department]

Figure 36. Non-Municipal Well Locations

[figures available in Planning Department]

GROUNDWATER QUALITY

The City of Norfolk currently does not have an on-going initiative to collect data on ground water quality before treatment. The Virginia Department of Health (VDH) does conduct periodic water quality tests on all ground water sources in Virginia. Data can be obtained for water quality parameters including volatile, inorganic and metal content, alkalinity, radiological content, and annual sanitary surveys.

The United States Geological Survey developed a compilation of existing data reflecting ground water quality of the Coastal Plain in 1993. The following sections summarize the general quality of five of the major confined aquifers.

Figure 37 depicts the distribution of hydro-chemical facies (part of the aquifer that is differentiated by other parts by changes in chemical composition) in the Coastal Plain discussed below.

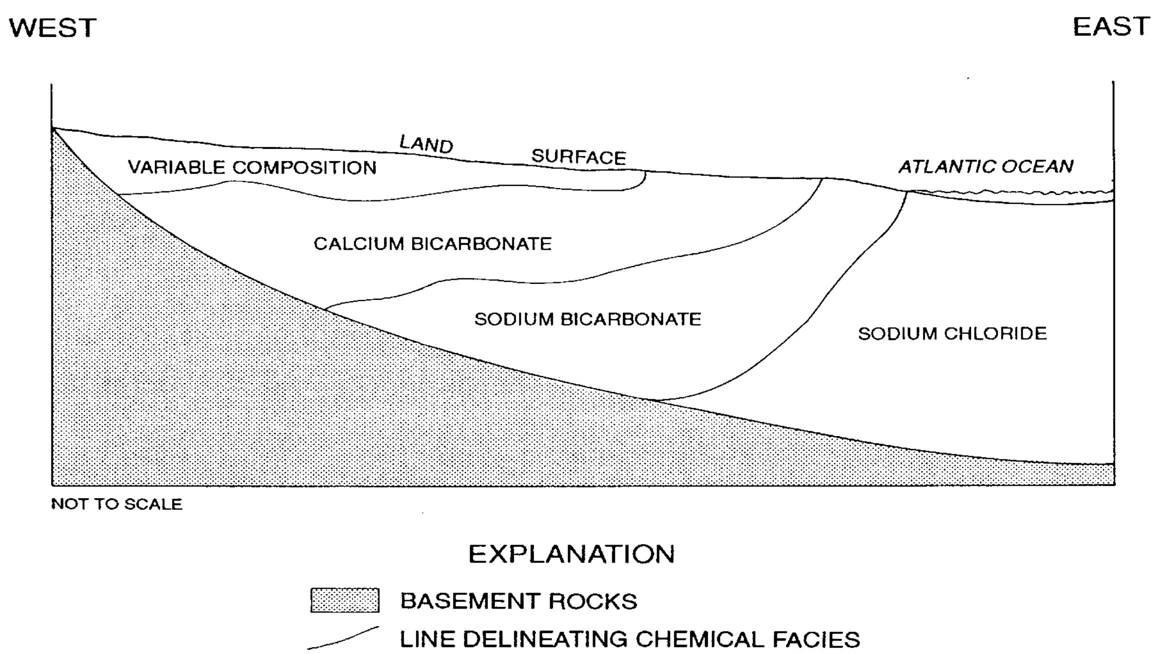


FIGURE 37. Distribution of hydro-chemical facies in the Coastal Plain Physiographic province of Virginia. Source: USGS Report "Quality of Ground Water in the Coastal Plain Physiographic Province of Virginia", 1993.

Threats to ground water quality are addressed in a previous section, "Existing and Potential Pollution Sources."

Yorktown-Eastover

Water of this aquifer is primarily a hard, calcium bicarbonate type, with a zone of soft sodium bicarbonate type water located in the east-central part of the aquifer (USGS, 1993).

Chickahominy-Piney Point

Water of this aquifer is primarily of the sodium bicarbonate type but evolves to a sodium chloride type in the extreme eastern portion of the aquifer. Water from the aquifer in the central part of the Coastal Plain Physiographic province is slightly basic, fresh, soft, and concentrations of sodium, dissolved solids, and fluoride decrease to the west. Toward the east, water becomes slightly acidic, moderately hard to very hard, and slightly saline to moderately saline. Concentrations of sodium, chloride, alkalinity, and sulfate increase toward the east. Dissolved solids concentrations exceed 500 mg/L in most of the eastern part of the aquifer. Sodium concentrations exceed 20 mg/L throughout most of the aquifer. (USGS, 1993)

Upper Potomac

Transitions in chemical facies are evident from calcium carbonate in the west to sodium bicarbonate in the central part, and then to sodium chloride in the east. The water is slightly basic (pH greater than 7.0) throughout this aquifer. Dissolved-solids concentrations exceed the 500 mg/L USEPA SMCL (United States Environmental Protection Agency Secondary Maximum Contaminant Level) in the eastern part of the aquifer. Fluoride concentrations exceed the 4 mg/L USPEA MCL in the south-central part of the aquifer and exceed the 2 mg/L USEPA SMCL throughout much of the rest of the aquifer. Concentrations of chloride exceed 250 mg/L USEPA SMCL in the eastern part of the aquifer. Hardness decreases from west to east and becomes moderately hard to very hard in the southeast. (USGS, 1993)

Middle Potomac

The distributions of constituent chemical concentrations reflect the progression of ground water along the flow path, interaction with sediment minerals, and mixing with saltwater. The high concentrations of sodium, chloride, sulfate, and dissolved solids in the eastern zone have been attributed to ancient seawater intrusion, and subsequent incomplete flushing of this seawater, and to diffusion from deep offshore evaporitic basins (Meisler and others, 1988). Concentrations of dissolved solids exceed the 500 mg/L USEPA SMCL in approximately the eastern third of the aquifer. Sodium concentrations exceed 20 mg/L throughout most of the aquifer. Fluoride concentrations exceed the 4.0 mg/L USEPA MCL in a large part of the southern Coastal Plain and exceed the 2.0 mg/L USEPA SMCL throughout much of the central and eastern parts of the aquifer. Chloride concentrations exceed the 250 mg/L USEPA SMCL in the eastern part of the aquifer. Hardness values exhibit no distinct pattern. (USGS, 1993)

Lower Potomac

Available data for the lower Potomac aquifer indicate that water-quality patterns are generally similar to regional patterns for the middle Potomac, with key differences most likely resulting from the greater age, increased distances along ground water flow paths, less completely flushed connate seawater, and proximity to underlying bedrock of the lower Potomac aquifer and saltwater compared to the middle Potomac aquifer. Calcium-carbonate type water is not common in the lower Potomac aquifer. Chemical facies transitions from sodium bicarbonate to sodium chloride type waters are found farther west in the lower Potomac aquifer. Dissolved-solids concentrations exceed the 500 mg/L USEPA SMCL in about the eastern third of the aquifer. Sodium concentrations exceed 20 mg/L throughout most of the aquifer. Chloride concentrations exceed 250 mg/L USEPA SMCL in about the eastern half of the aquifer. The water is soft throughout the western half of the aquifer, increasing to very hard in the east (USGS, 1993).

GROUNDWATER RECHARGE AREAS

Ground water recharge areas are defined as areas where water moves downward from the water-table aquifer through confining units to the confined aquifers (Hamilton and Larson, 1988). Several flow boundaries exist on the Coastal Plain (limit the movement of the aquifers either laterally or vertically): Fall Line to the West and the granitic basement beneath the system. Within these boundaries, there are several means to which the groundwater system underlying and utilized by Norfolk accomplishes recharge:

Vertical recharge zones

Vertical recharge occurs for the water table aquifer (unconfined Columbia aquifer) from precipitation events. According to a study done by USGS (1988), in southeastern Virginia, approximately one-half of the precipitation returns to the atmosphere as evapo-transpiration from the land, surface waters and vegetation. The remainder is overland flow or infiltration into the ground to recharge the water-table aquifer and some deeper, confined aquifers. Vertical recharges were simulated in a study by the USGS (1988), and Norfolk shows potential vertical recharge to the Lower Potomac, Middle Potomac, Upper Potomac, Virginia Beach, Chickahominy Piney-Point and Yorktown-Eastover aquifers. Exact locations of recharge zones within Norfolk is not possible due to a lack of available data and the extent of impervious surfaces that may overlie recharge areas. Therefore, focusing protection efforts on specific recharge areas in Norfolk would be difficult to implement.

Due to the hydrogeologic framework of the Coastal Plain, aquifers that are utilized by Norfolk recharge in areas located outside of the City's jurisdictional boundaries, where they outcrop (exposed) at the surface, in this case, towards the Fall Line. Table 11 presents a generalized description of where each aquifer within the Coastal Plain outcrops.

Table 11. Aquifer outcrop/exposure locations (direct recharge zones)	
Aquifer Name	**Outcrop Location**
Columbia	Unconfined through-out extent
Yorktown-Eastover	Along broad area, west of Smithfield, parallel to Fall Line
Chickahominy Piney-Point	Along major stream valleys in West
Aquia	Along major stream valleys in West
Virginia Beach	Confined through-out extent
Upper Potomac	Confined through-out extent
Middle Potomac	Confined through-out extent
Lower Potomac	Confined through-out extent

Source: United States Geological Survey, *Hydrogeology and analysis of the Ground-water flow system in the Coastal Plain of Southeastern Virginia*, 1988, pp. 31 – 33.

WATER USAGE AROUND RECHARGE AREAS

Since specific recharge zones cannot be identified within the City from available data, the water usage surrounding such recharge zones also cannot be determined. If an initiative to identify ground water recharge zones is developed, the data can be compared to water usage data tracked by the Virginia Department of Environmental Quality using latitude and longitudinal coordinates.

SURFACE WATER RESOURCE CHARACTERIZATION

SOURCES OF SURFACE WATER IN NORFOLK

Norfolk owns and operates ten reservoirs, which encompass 4,221 acres of land and have a storage capacity of 15,632 billion gallons (City of Norfolk, 2000). The reservoir system consists primarily of two groups of lakes. The first group, the Western Lakes, is located in the City of Suffolk and Isle of Wight County and includes the Nottoway River and Blackwater River Pumping Stations, Lake Prince, Lake Burnt Mills, and Western Branch Reservoir. The second group, the In-Town Lakes, is located in Norfolk and the City of Virginia Beach and includes Stumpy Lake, Lake Lawson, Lake Smith, Little Creek Reservoir, Lake Whitehurst, and Lake Wright. The total area of the watershed in the In-Town System is approximately 23 square miles (City of Norfolk, 1996). Lake Wright and Lake Whitehurst are both located in the northeastern corner of the City adjacent to Virginia Beach border. The watersheds of Lake Wright and Lake Whitehurst are split between Virginia Beach and Norfolk. Lake Taylor is an unofficial part of the In-Town Reservoir System that is not currently used as a source of water. Stumpy Lake was also part of Norfolk's reservoir system but has been sold to the City of Virginia Beach.

The location of surface water intakes are shown in Figure 38.

RESERVOIR WATER QUALITY

The City's reservoir system primarily suffers from eutrophication problems as a result of high phosphorus concentrations. Stormwater runoff is the major source of phosphorus loading. The nutrient loading causes the reservoirs to fluctuate between eutrophic and hypereutrophic conditions, as measured according to Carlson's trophic state index. Water-quality problems in eutrophic reservoirs include algal blooms throughout the growing season; taste and odor problems from the excessive algae growth, and fish kills from periods of low dissolved oxygen. Eutrophication can result in loss of reservoir volume, increased trihalomethane (THM) precursors, and increased treatment costs to control taste and odor problems. Norfolk is currently using duckweed-harvesting equipment in some of the In-Town lakes to remove excess vegetation that has resulted from eutrophication. The harvesting has been undertaken in response to requests by local residents (HRPDC, 1997).

Threats to surface water quality are addressed in a previous section, "Existing and Potential Pollution Sources." According to data obtained from DEQ, there is one permitted discharge to Lake Whitehurst, the Norfolk International Airport.

CURRENT AND FUTURE LAND USE ACTIVITIES

The bulk of the land in the water supply watersheds located within the City of Norfolk is developed. Current land use categories represented in the watersheds include residential, commercial, and institutional. Figure 39 depicts the location of drainage basins and the most

Figure 38. Surface Water Intakes

[figures available in Planning Department]

Figure 39. Land Use with Drainage Basins

[figures available in Planning Department]

recent land use data available for the City of Norfolk. This land use data in the water supply watersheds is being updated for the entire HRPDC region through the Hampton Roads Source Water Assessment Program. This data can be utilized for future regional watershed protection and management efforts.

WATER USAGE OF SURFACE WATERS

Recent data on water usage of the City's reservoirs is provided in Table 12.

Table 12. Surface Water Usage for 2000 in Millions of Gallons (City of Norfolk, 2001)

Month	Lake Prince	Western Branch 1	Western Branch 2	Lake Wright	Stumpy Lake	Black-water R.	Notto-way R.	System Demand
Jan	689	704	538	305	0	0	108	2,176
Feb	286	1,133	538	99	0	0	0	2,000
Mar	304	1,335	557	4	0	0	0	2,100
Apr	303	1,230	582	0	0	52	0	2,054
May	310	1,359	597	93	0	0	0	2,291
Jun	301	1,313	562	124	0	0	0	2,249
Jul	313	1,421	610	98	0	0	0	2,394
Aug	292	1,431	575	94	0	0	0	2,367
Sep	317	1,409	541	29	0	0	0	2,243
Oct	326	1,450	547	0	5	0	0	2,274
Nov	329	1,379	486	0	0	0	40	2,109
Dec	347	1,359	497	0	0	0	133	2,103
Total	**4,115**	**15,523**	**6,628**	**845**	**5**	**52**	**281**	**26,360**

GROUND WATER AND SURFACE WATER RELATIONSHIPS IN NORFOLK

Ground water and surface water relationships are defined here as the potential and current interaction of ground water with surface water. Norfolk is located in the South Eastern Virginia Groundwater Management Area, where the Chesapeake Bay and other important surface water bodies receive ground water that discharges directly from the Coastal Plain of Virginia. Groundwater recharge occurs primarily by the downward percolation of water through the unsaturated zone during and after a precipitation event. Most groundwater that is discharged eventually contributes to stream flow. Ground water in coastal areas can also discharge directly to estuaries. In the Coastal Plain of Virginia, the lower reaches of most of the rivers and streams are affected by tides, and many coastal basins discharge directly to estuaries.

Ground water and surface water relationships in Norfolk primarily exist through surface water discharge, ground water recharge, tidal mixing, and current or future channel dredging.

Ground Water and Surface Water Discharge/Recharge Relationships

Ground water from the confined and unconfined aquifers all contribute to the discharge into surface waters in and around Norfolk. Data does not currently exist to determine aquifer discharge locations or rates.

During pre-pumping conditions in Southeastern Virginia, a hydraulic equilibrium existed in the groundwater system. Recharge to the total system equaled discharge to the surface waters (USGS, 1998). Movement of water within the aquifers was primarily lateral from the Fall Line in the west to the surface waters, Chesapeake Bay, and Atlantic Ocean in the east. Introduction of wells alters the groundwater to surface water relationships in the following manners (Figure 40):

I. Non-pumping well: ground water flow and recharge to stream is the same as pre-well conditions; height of water in well is same as water table.
II. Pumping well, low pumping: ground water flow and recharge to stream is disrupted with a cone of depression surrounding the well, and a reduction in storage of water within aquifer equal to the amount being pumped out.
III. Pumping well, moderate pumping: ground water flow and recharge to stream is disrupted, with cone of depression surrounding well, and a reduction in storage of water within aquifer and reduction of recharge to stream equal to the amount being pumped out.
IV. Pumping well, high pumping: ground water flow and recharge to stream is disrupted, with cone of depression surrounding well, and a depletion of storage of water and reversal of stream recharge to ground water equal to the amount being pumped out.

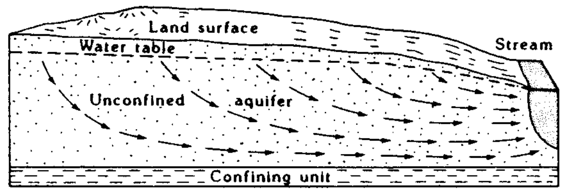


Figure 23.1--Ground-water flow for prepumping conditions; ground water discharging to stream

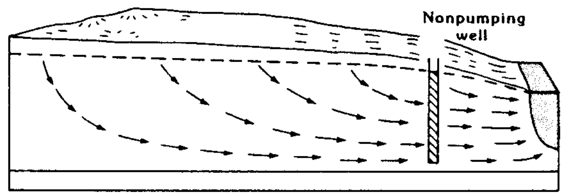


Figure 23.2--Ground-water flow for nonpumping conditions; ground water discharging to stream

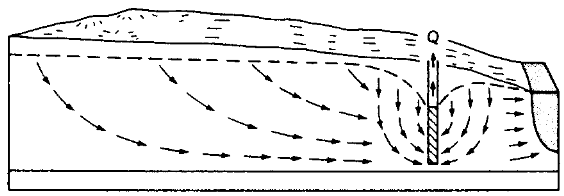


Figure 23.3--Ground-water flow for pumping conditions; reduction in storage equals pumpage

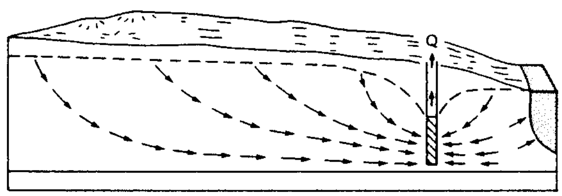


Figure 23.4--Ground-water flow as pumping continues; reduction in storage and reduction in ground-water discharge to stream equals pumpage

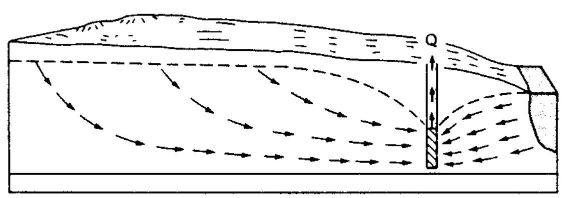


Figure 23.5--Ground-water flow as pumping continues; reduction in ground-water discharge to stream and inducement of stream water into the ground-water system equals pumpage

FIGURE 40. Direction of ground-water flow for pre-pumping and pumping conditions and sources of water derived from a well. Source: USGS Report "Hydrogeology and Analysis of the Ground-Water flow system in the Coastal Plain of Southeastern Virginia".

Currently, there is no data to determine if the above conditions apply at any of the groundwater withdrawal wells owned by Norfolk. As well, there is no data to determine if privately owned ground water withdrawal wells within the city boundaries are having an impact on ground water/surface water relationships.

Ground Water and Surface Water Relationships Resulting from Channel Dredging

Currently, there is no data that reflects dredging activities reaching the top altitudes of the confined aquifers in the ground water system. Potential concern could be raised for the channel dredging activities in the Elizabeth River. Currently, the top of the Yorktown-Eastover aquifer is reported at an average depth of 70-80 feet below land surface of the City of Norfolk. Although the reported depth of 70 – 80 feet does not reach the average depth of the channels along the mainstem of the Elizabeth River of 50 – 55 feet, consideration needs to be made for the infiltration of the Yorktown aquifer into the above confining unit due to hydraulic head. Potentially, the hydraulic head level of the Yorktown aquifer is at or above that of the river channels. This would increase the potential for leakage of the Yorktown-Eastover aquifer directly into the Elizabeth River. If pumping lowers the hydraulic head there is a potential for downward percolation of pollutants into the Yorktown-Eastover aquifer. Further studies and data need to be collected to determine the actual depths of the Yorktown aquifer in areas along the river channels.

Ground Water and Surface Water Relationships Due to Tidal Mixing

During times of ebb tide (low), the ground water contributes to the surface water in normal, lateral conditions but during times of flood tide (high) the surface water may interface with the discharging ground water causing brackish (salty) conditions along shorelines. Influence of the brackish water will decrease further inland from the shorelines, except under conditions where ground water withdrawal encourages encroachment.

WATER SUPPLY DEMAND

Most of Norfolk has access to public water supply. All new buildings have mandatory connection to the city's water distribution system unless it is unfeasible for the city to supply water to a particular location. In that instance, private water systems are allowed. Additionally, the city supplies water to other area jurisdictions for potable water supply. In 2000, the demand on the City's water supply system averaged 72.00 million gallons per day. Data on recent water usage is provided in Table 12. The current system has the capacity to meet current and expected demand. These figures reveal that a rapid increase in demand for water in Norfolk is unlikely in the future. The 2000 Census reveals that from 1990 to 2000, Norfolk's population decreased from 261,229 to 234,403, approximately a 10% decrease. Census data also reveals that population growth in the Hampton Roads region has been modest, less than 1% a year.

An accurate number for the supply of water being retrieved from the private ground water withdrawal wells is currently not available.

SUMMARY AND CONCLUSIONS

Available data indicates that there is a sufficient amount of water supply available to meet projected demand in Norfolk. Several of the City's reservoirs are eutrophic due to high nutrient inputs from stormwater. Pollutant load analyses conducted for the City's VPDES stormwater permit indicate that the Lake Whitehurst watershed contains one of the highest nutrient loads from stormwater runoff. Managing stormwater inputs to the City's reservoirs is complicated by the fact that their watersheds are situated within several local jurisdictions that are outside the control of the City. Likewise, the City's wells are located in other communities. Therefore, regional coordination of local governments is critical to managing the quality of Norfolk's reservoirs and wells.

Since there is also no comprehensive ground water quality monitoring data currently available for the City, contamination problems and their possible sources cannot be detected. Thus, the main threat to the ground water resources underlying the City of Norfolk is essentially a lack of information on the quantity and quality of ground water resources within the City, the uses of the water, and the relationships of ground water to surface water sources.

EXISTING WATER RESOURCE PROTECTION POLICES/PROGRAMS

FEDERAL PROGRAMS

The nature of federal water protection law is fragmentary in nature. There is no one main surface water or ground water law, but rather a host of different laws that include water quality protection provisions outright, or general environmental protection provisions that can be applied to water resources. The U.S. Environmental Protection Agency (EPA) has primary jurisdiction over federal activities relating to water quality. A list of federal laws and their relevance to ground water protection are outlined below.

FEDERAL LAW	RELEVANCE TO WATER QUALITY PROTECTION
Safe Drinking Water Act	Authorizes EPA to establish drinking water standards; requires state underground injection control programs; requires federal review of federally assisted projects overlying sole source aquifers; requires states to develop wellhead protection programs; and provides funding for demonstration programs designed to identify critical aquifer protection areas. Amendments to the law in 1996 require states to implement Source Water Assessment Programs to identify the most significant potential sources of contamination for each public water system.
Resource Conservation and Recovery Act	Authorizes EPA to regulate the storage, transportation, treatment, and disposal of solid and hazardous wastes to prevent contaminants from leaching into ground water from municipal landfills, underground storage tanks, surface impoundments, and hazardous waste disposal facilities. Bans open dumps.
Comprehensive Environmental Response, Compensation, and Liability Act (Superfund)	Authorizes EPA to clean up contamination caused by chemical spills or hazardous waste sites that pose threats to the environment.
Federal Insecticide, Fungicide, and Rodenticide Act	Authorizes EPA to control the availability of pesticides that have the ability to leach

FEDERAL LAW	RELEVANCE TO WATER QUALITY PROTECTION
	into ground water. Also gives EPA authority to review environmental effects associated with pesticide use.
Toxic Substances Control Act	Authorizes EPA to control the manufacture, use, storage, distribution, or disposal of toxic chemicals that have the potential to leach into ground water supplies. Requires manufacturers to register chemicals, submit periodic reports, and meet labeling and packaging requirements.
Clean Water Act	Authorizes EPA to make grants to the states for the development of ground water protection strategies as well as authorizes a number of programs to prevent water pollution from a variety of sources. Establishes permit programs for wetlands, industrial, municipal, and stormwater discharges (NPDES).
Hazardous Materials Transportation Act	Authorizes the Department of Transportation (DOT) to establish regulations for the transportation of hazardous materials, including hazardous wastes.
Hazardous Liquid Pipeline Safety Act	Authorizes DOT to establish regulations for the interstate and international movement of hazardous liquids by pipeline (and their storage incidental to such movement).
Coastal Zone Management Act	Authorizes the National Atmospheric and Oceanic Administration (NOAA) to assist states with funding to develop and implement programs to manage the use of land and water in the coastal zone.
National Environmental Policy Act	Requires evaluation and study of federal actions for their potential adverse effects on the environment.

Implications for State and Local Government

Federal laws tend to be broad in scope and focus on controlling potential sources of pollution contamination on a national basis. Rather than mandating specific remedies for local application, federal laws provide for general water quality protection activities and delegate the development of implementation strategies for these programs to the states and localities. Examples of federally prescribed programs include stormwater programs, wellhead protection programs and state ground water protection strategies.

STATE WATER QUALITY PROGRAMS

In Virginia, the first legal mandate to protect water quality lies in Article XI, Section 1 of the Virginia Constitution, which declares that it is a policy of the Commonwealth "to protect its atmosphere, lands and waters from pollution, impairment, or destruction, for the benefit, enjoyment, and general welfare of the people of the Commonwealth." The State Water Control Law was enacted in 1946 to carry out this mandate as it pertains to the protection of "state waters." State waters as defined in the law includes both surface water and ground water. The Virginia Water Control Board (VWCB) was created to enforce and administer the law. Below is a brief outline of programs that deal in some way with water quality protection.

Ground Water Management Act

In 1973, Virginia General Assembly adopted the Virginia Ground Water Act, which authorized the VWCB to establish ground water management areas along with a permitting system for withdrawals in such areas. In such areas, ground water supplies are in danger of being overdrawn or polluted. Currently, there are two ground water management areas: one on the Eastern Shore and a second in Eastern Virginia, which includes the City of Norfolk.

As part of its national Ground Water Protection Strategy, the EPA awarded a grant to the Commonwealth to develop its own ground water protection strategy. In response to the availability of new funding and an increasing awareness of the need for more effective ground water protection tools, the state created the Virginia Ground Water Protection Steering Committee in 1986 to assess current problems, identify program needs and set priorities for new ground water protection programs. The GWPSC is chaired by the DEQ staff and is comprised of representatives from a number of state agencies whose programs affect ground water quality.

Due in large part to the findings of the USGS studies conducted for the HRPDC, the 1992 General Assembly adopted the Ground Water Management Act of 1992 and repealed the 1973 Ground Water Act. The new legislation established criteria for the creation of ground water management areas and requires persons who withdraw more than 300,000 gallons a month to obtain permits. The Act requires that previously exempted agricultural ground water withdrawals obtain ground water withdrawal permits. The Act was amended January 1, 1999, to include specific requirements for agricultural ground water withdrawal permits.

In addition to administering its own ground water programs, the state has the responsibility of administering several federal programs as well. Although the SWCB has primary responsibility for ground water protection for Virginia, a number of different state agencies administer a variety of federal and state mandated programs that directly or indirectly address ground water.

Chesapeake Bay Preservation Act

The Chesapeake Bay Preservation Act (CBPA) requires local governments in Tidewater, Virginia to incorporate general water quality protection measures into their comprehensive plans, zoning ordinances, and subdivision ordinances. Localities in Tidewater must establish programs that define and protect lands which, if improperly developed, may result in substantial damage to the water quality of the Chesapeake Bay and its tributaries. The Act requires local governments to exercise their police and zoning powers to protect the quality of state waters by enforcing stormwater runoff and shoreline buffer standards. State waters are defined as including all waters on the surface or under the ground, wholly or partially within or bordering the Commonwealth. Norfolk's Chesapeake Bay Preservation Act program is discussed in more detail in a subsequent section.

To implement the Bay Act, each locality must adopt a Chesapeake Bay Preservation Area Program, based on the Chesapeake Bay Preservation Area Designation and Management Regulations which were adopted by the Chesapeake Bay Local Assistance Board in 1989 and amended in 1991. In response to these regulations, the City of Norfolk adopted its Chesapeake Bay Preservation Area Overlay District. An additional requirement of the Act is that local governments adopt a comprehensive plan or plan amendment to incorporate water quality protection measures consistent with the goals and objectives of the Bay Act.

The passage of the Chesapeake Bay Preservation Act and its implementing regulations marks the first time that Virginia local governments have been required to explicitly address water quality protection through the comprehensive planning process. Specifically, the Bay Act Regulations require local governments to "establish an information base from which to make policy choices about future land use and development that will protect the quality of state waters." Among other things, this information base is to address marine resources, shoreline erosion problems and the location of erosion control structures. The Regulations require local governments to establish policy statements in their comprehensive plans on a range of issues critical to water quality protection. According to the regulations of the Chesapeake Bay Preservation Act, the localities of Tidewater, Virginia must examine and adopt policies concerning physical constraints to development, potable water supply, shoreline erosion, waterfront access, and redevelopment.

Erosion and Sediment Control Law

In 1973, Virginia passed the Erosion and Sediment Control Law. This law requires local governments to adopt and enforce a local erosion and sediment control ordinance. Local ordinances require land disturbing activities, such as construction, to implement runoff controls that minimize the amount of floodwaters and sediment discharged into local waterways from development and redevelopment sites greater than 10,000 square feet. In designated Chesapeake Bay Preservation Areas, the Erosion and Sediment Control Law applies to development sites greater than 2,500 square feet. The Erosion and Sediment Control Law also requires local programs to have state certified program administrators, plan reviewers, and inspectors.

Stormwater Management Act

In 1998, the Virginia General Assembly enacted the Virginia Stormwater Management Act. The Act provides local governments with the enabling legislation to voluntarily adopt a local stormwater management ordinance and program. To be deemed consistent with the Act, the local stormwater program must at a minimum address flooding and stream channel erosion. In addition, a locality is strongly encouraged to address water quality protection in its stormwater program. To protect water quality, the local ordinance must establish that post-development levels of pollution leaving a site must not exceed pre-development levels. In redevelopment, post-development levels must be 10% less than pre-existing levels. The City of Norfolk adopted a consistent Stormwater Management Ordinance in 1996.

Under the Act, for the first time state agency projects are required to meet stormwater quantity and water quality standards.

Virginia Pollution Discharge Elimination System (VPDES)

Under the federal Clean Water Act, any discharge to surface waters must obtain a permit. This permit program is usually administered by the states. In Virginia , the VPDES program is administered by DEQ. Any discharge from a municipal treatment or industrial facility must apply for a permit. The permit establishes limits for certain pollutants. The facilities are required to implement monitoring programs to verify that pollutant levels contained in the discharge are within the prescribed limits.

In addition to municipal treatment and industrial facilities, localities with populations greater than 100,000 must obtain a VPDES permit to discharge stormwater runoff from their drainage outfalls. A permitted locality must develop and implement a stormwater management plan. The City of Norfolk's Stormwater Management Program is discussed in more detail in a later section.

Construction activities greater than five acres must obtain a VPDES permit and ensure that stormwater runoff controls are being implemented during and after construction. In 2003, under the Phase II Stormwater Regulations, recently adopted by EPA, construction sites greater than one acre will be required to obtain a permit. Under the new regulations, municipalities located within an urbanized area, determined by Census data, must obtain a stormwater permit.

Chesapeake Bay Program and Tributary Strategies

The Chesapeake Bay Program is a partnership between the states of Virginia, Maryland, Pennsylvania, the District of Columbia, and the U.S. Environmental Protection Agency (EPA) to reduce pollution in the Chesapeake Bay. In 1987, the Bay Program partners signed an agreement to achieve a 40% reduction in the amount of nitrogen and phosphorus going into the Bay by the year 2000. In 1992, the Chesapeake Bay Agreement was reevaluated and reaffirmed the 40%

reduction goal. However, because scientific evidence revealed that the lower tributaries, such as the James River, did not directly contribute to the water quality problems of the mainstem Chesapeake Bay, the 40% nutrient reduction goal did not apply to these rivers. Instead, individual reduction goals for these tributaries would be established at a later date, based on further studies of their water quality and living resource conditions. To that end, in 1995 the state began to develop Tributary Strategies for the lower Bay tributaries.

The Elizabeth River and Little Creek watersheds are included in the James River Tributary Strategy. The James River Tributary Strategy establishes a goal of reducing the amount of sediment going into the James River basin by 9% from 1985 levels. In addition, the Strategy calls for capping the level of nutrients going into the lower James River at 1996 levels. To achieve these goals, the Strategy identifies several potential implementation options. Implementation of these options is voluntary. To encourage voluntary implementation, the state established a grant program known as the Water Quality Improvement Fund.

The Chesapeake Bay Program also administers a Chesapeake Bay Partner Community Award Program. To receive the award, a local government must achieve a series of benchmarks that demonstrate its commitment to protecting the water quality of the Bay. The City of Norfolk is recognized as a Silver Chesapeake Bay Partner Community. To receive silver status, the City had to demonstrate it is active in promoting public awareness of Chesapeake Bay protection efforts.

Source Water Assessment Program

As a result of new requirements in the 1996 amendments to the Safe Drinking Water Act, states are now implementing Source Water Assessment Programs (SWAPs), which build on existing wellhead protection programs. In these assessments, states will identify the most significant potential sources of contamination for each public water system – whether served by ground water or surface water. These assessments, which should be completed for all public water systems in each state by 2003 and made available to the public, will provide valuable information for communities on priority drinking water protection needs.

The Virginia Department of Health (VDH) is responsible for administering the program. The City of Norfolk is included in the SWAP currently underway through the Hampton Roads Planning District Commission and VDH Eastern Virginia Field Office.

Private Well Regulations

VDH also administers the State's Private Well Regulations that became effective in September 1990. Prior to that only public water supply wells and private wells constructed during the installation of a new or repaired septic system were regulated. The main purpose of the regulations is to insure all private wells are located, constructed and maintained in a manner that does not adversely affect public safety, health, or ground water resources. These regulations also specify well abandonment procedures. VDH implements the program through the use of such tools as subdivision plan review, site feasibility studies, system design, regulatory inspections, sanitary surveys, and required enforcement actions.

Wellhead Protection Program

The Wellhead Protection Program (WHPP) is a pollution prevention and management program used to protect ground water sources of drinking water. The Safe Drinking Water Act established the WHPP in 1986. The law specifies that certain program activities, such as delineation, contaminant source inventory, and source management be incorporated into state wellhead protection programs that are approved by EPA prior to implementation. WHPPs are the foundation for many of the SWAPs required under the 1996 Safe Drinking Water Act amendments.

Since 1986, EPA has approved 50 WHPPs, including Guam and Puerto Rico. Virginia has not yet submitted a program, but does voluntarily submit biennial reports on wellhead protection program progress.

Underground Storage Tank (UST) Program

The DEQ administers this Resource Conservation and Recovery Act (RCRA) program which is supported by federal funds and matching state funds. Regulations have established design standards for new tanks and reporting requirements for existing tanks. Regulations apply to all UST systems, which consist of one or a combination of tanks that are used to contain an accumulation of regulated substances, and the volume of which is 10% or more beneath the ground. The UST regulations do not apply to the following systems:

1. Farm or residential tanks of 1,100 gallons or less capacity used for storing motor fuel for noncommercial purposes;
2. Tanks used for storing heating oil for consumption on premises where stored, except for tanks having a capacity of more than 5,000 gallons for storing heating oil;
3. Septic tanks;
4. Pipeline facilities regulated under the Natural Gas Pipeline Safety Act, the Hazardous Liquid Pipeline Safety Act, or under comparable state laws;
5. Surface impoundments;
6. Storm water or waste water collection system;
7. Flow-through process tanks;
8. Liquid traps or associated gathering lines used in gas production or other gathering operations; and
9. Storage tanks situated in an underground area, such as a basement, cellar, shaft, tunnel, or similar situation, where the storage tank is situated upon or above the surface of the floor.

UST owners must certify that existing tanks in use are not leaking and ensure that those that do are replaced with new tanks. If a tank has been found to be leaking, the owner must take immediate action to limit damage to the environment, report the leak to DEQ, and develop and carry out a plan of remediation for the site. The durability of new tanks and requirements for leak detectors are included in the Virginia Building Code, so any new installation must receive a building permit from a local building official.

As of December 22, 1998, all existing UST systems must comply with one of the following requirements:

1. New UST system performance standards found in 40 CFR Part 280.20.
2. Performing upgrade requirements found in 40 CFR Part 280.21, including interior lining changes, cathodic protection, piping upgrades and spills and overfill prevention equipment.
3. All closure requirements found in 40 CFR Part 280.21.

The DEQ maintains records on some 74,000 regulated USTs at 25,000 facilities in Virginia. The UST program maintains a computer database of all UST information and tracks the reporting of installations, upgrades, repairs, and closures.

Leaking Underground Storage Tank (LUST) Program

The LUST side of the UST program is involved in correcting leaks from underground storage tanks. DEQ regional office staff performs initial investigations and direct owners/operators to take appropriate remediation activities. Regional office staff review all required reports and issue corrective action plan (CAP) permits as needed. Although inclusion in this list does not necessarily mean there is an active leak at the facility, it does mean that steps required to clean up the site are currently underway.

Aboveground Storage Tank (AST) Program

DEQ administers regulations relating to the 9,968 presently registered ASTs. State law requires that AST facilities with an individual capacity greater than 660 gallons or an AST facility with an aggregate capacity of 1,230 gallons to be registered with DEQ. AST facilities with a capacity greater than 25,000 are required to have an Oil Discharge Contingency Plan. The plan identifies sensitive resources and outlines steps to be taken in case of a leak or spill. State regulations require these facilities to conduct regular inspections and incorporate several design features to prevent leaks or spills before they occur. AST facilities with an aggregate capacity of at least one million gallons must implement a ground water monitoring program.

Waste Permitting Activities

RCRA addresses water quality issues at both permitted and non-permitted land-based waste disposal units. Information is maintained for non-hazardous solid waste disposal sites and is divided into two sectors. The term “sites” refers to facilities with most facilities having more than one regulated unit. There are a total of 47 units among 29 facilities in Virginia.

The first sector, “Base Program Correction Action” sites are permitted units required to perform corrective action if the ground water concentrations exceed established ground water protection standards. The second sector is “Non-permitted Land Disposal Facilities (LDF)” where continued operation of the facility is contingent upon removal or decontamination of contaminated media. In instances where the LDF is closed, ground water monitoring is required to demonstrate that closure performance standards are met. When standards are not met, the site is issued a Post Closure Permit and corrective action is taken.

Ground water contamination statistics are also maintained by the DEQ's Federal Facilities Restoration and Superfund Office. The Federal Facilities Restoration activities include Department of Defense (DOD) installations (Army, Navy, Air Force, Defense Logistics Agency, and Formerly Used Defense Sites) and a NASA installation for a total of 33 installations. Currently eight federal facilities are listed on the National Priority List (NPL) and 25 non-NPL sites. The City of Norfolk has two NPL sites located at Little Creek Amphibious Base and US Norfolk Naval Base, Sewell's Point Naval Complex.

Pesticide Disposal Program

With funding from EPA's Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and Clean Water Act (Sections 319 Non Point Source and 106 Ground Water Protection) grant programs, the Virginia Department of Agriculture and Consumer Services and Virginia Pesticide Control Board have conducted a highly popular Pesticide Disposal Program. As of October 1997, more than 240 tons of unwanted pesticides have been collected from 1,455 agricultural producers, pesticide dealers, and commercial pest control firms located in 83% of Virginia's counties and cities and disposed of safely.

Pesticide and Ground Water Management Plan

In response to the EPA Pesticides and Ground Water Strategy, the Virginia Department of Agriculture and Consumer Services formed a task force in 1992 to draft a Generic State Management Plan (GSMP) for pesticides in ground water. The task force comprised of four representatives from GWPSC, four from the agricultural community, a member from the Board of Agriculture, one from the Virginia Pesticide Control Board, and representatives from the water user community. The completed plan was submitted to EPA Region III and received concurrence in 1995. The Plan established a graduated response plan for pesticides detected in ground water, a process for developing pesticide specific management plans, and a graduated response approach for managing pesticides identified as potential threats to ground water.

EPA's proposed rule "Pesticides and Ground Water State Management Plan Regulation" would restrict the use of certain pesticides by providing states with the flexibility to protect the ground water in the most appropriate way for local conditions. EPA is proposing to restrict the legal sale and use of five pesticides that have been identified as either "probable" or "possible" human carcinogens, including alachlor, atrazine, cyanazine, metolachlor, and simazine. The labels of these pesticides would be changed to require use in accordance with an EPA-approved state management plan.

Ground Water Protection Steering Committee

The Virginia Ground Water Protection Steering Committee (GWPSC), established in 1986, continues to meet bi-monthly as a vehicle for sharing information, for directing attention to important ground water issues, and for taking the lead on ground water protection initiatives that require an interagency approach.

REGIONAL WATER RESOURCE PROGRAMS

Since the watersheds of Norfolk's reservoirs and waterways cross jurisdictional boundaries, continued regional communication and cooperation is essential for the success of water supply resource protection. Below is a brief summary of regional water quality protection initiatives.

Hampton Roads Planning District Commission

The City of Norfolk participates in various regional programs that have been identified by regional advisory committees of the HRPDC, which are comprised of staff from member localities, HRPDC, state agencies, and the private sector. Current regional water resource projects that Norfolk benefits from include:

Cooperative Regional Ground Water Management Program - Continuing Studies

On behalf of the member localities, the HRPDC administers a cooperative, cost sharing agreement with the USGS to continue to develop and refine the regional ground water model and related ground water database for Eastern Virginia. Under this program, the USGS is responsible for the collection of field data, computerization of the data, refinement of the existing Coastal Plain Model (CPM) and computer evaluation of the data. This project encompasses four discrete, but mutually supportive, elements:

- Water Level Network
- Comprehensive Ground Water Chloride Study
- Hydrogeologic Framework Study
- Coastal Plain Model 2000

Regional Ground Water Management Program-Mitigation Administration Water Technical Assistance

The member localities provide funding for the HRPDC to support staff with ground water hydrology and computer modeling expertise to provide ground water technical support to the member localities. This project includes the following activities:

- Hampton Roads Regional Ground Water Mitigation Program
- Technical Assistance
- Local Ground Water Studies
- Ground Water Education
- Administrative Support and Coordination for the Cooperative Ground Water Programs with the USGS

Hampton Roads Source Water Assessment Program

The HRPDC is under contract to the VDH to evaluate surface water sources of drinking water and land use activities that constitute potential threats to their quality for the Hampton Roads area. As part of this project, the HRPDC staff will incorporate the SWAP data generated by the VDH for the community ground water systems into a regional database. This database will be updated as needed and will be used to prioritize surface water and ground water protection activities in the Hampton Roads area.

Regional Stormwater Management Program

Established formally in 1996 by the Regional Stormwater Management Committee, this program focuses on activities that support permit compliance efforts of the six communities with VPDES Stormwater System Permits, regional education and training, and technical assistance to the region's small non-MS4 communities.

Regional Chesapeake Bay Committee

This committee is coordinated by the HRPDC and its membership includes state and local government representatives responsible for implementing the Chesapeake Bay Preservation Act. The Committee facilitates regional cooperation on Bay Act implementation efforts.

Lower James River Watershed Roundtable

The HRPDC is responsible for coordinating the efforts of the region's local governments and other stakeholders in implementing the state's nutrient and sediment reduction goals, as specified in the James River Tributary Strategy, through the Lower James River Roundtable. The Commonwealth has chosen to use the Lower James River Roundtable, and other Roundtables around the state, to communicate to and gather input from major stakeholders on Virginia's nutrient and sediment reduction efforts under the Chesapeake Bay Program.

HR STORM

The Hampton Roads Stormwater Education Committee, established in 1997, is the Public Information and Education Subcommittee, which grew out of the efforts of the Hampton Roads Regional Stormwater Management Committee. The Hampton Roads Planning District Commission has been working together with the sixteen localities to develop a regional effort focusing on stormwater education.

Hampton Roads Water Efficiency Team

The Hampton Roads Water Efficiency Team's (HR WET) mission is to develop and implement a regional approach to promoting efficient water use throughout Hampton Roads. The HR WET program has established the following goals: raise public awareness of the region's water supplies and the need to use them efficiently with the objective of changing habits, not lifestyles, regarding water use; reduce per capita water consumption by increasing the number of people using water more wisely.

HR CLEAN

The Hampton Roads Clean Communities program is a regional coalition of local government litter prevention and recycling coordinators. The purpose of HR CLEAN is to promote litter control, recycling, beautification, and general environmental awareness through educational projects designed to reach all sectors of the region's communities.

Hampton Roads Environmental Crimes Task Force

This regional task force is chaired by the City of Norfolk and seeks to coordinate the enforcement of environmental crimes in the region. Membership of the Task Force includes federal, state, and local enforcement agencies.

Elizabeth River Watershed Action Plan

The Elizabeth River Watershed Action Plan was developed by the Elizabeth River Project in cooperation with state agencies and representatives from the region's citizens, businesses and local governments. The Plan presents 18 action items to restore the Elizabeth River. Action items address stormwater runoff, riparian buffers, habitat enhancement, public access, pollution prevention, sediment contamination and derelict vessels.

Elizabeth River Restoration Study

The City actively participates on the Steering Committee established to guide the formulation and implementation of the Corps of Engineers Elizabeth River Restoration Study. Members of the Committee include federal, state, and local governments, the HRPDC, academia, citizens, and the Elizabeth River Project. The Committee identified sediment remediation and wetland restoration as priority initiatives for the Study.

LOCAL WATER RESOURCE PROGRAMS

At the local level, the City has implemented a range of water quality protection ordinances in an effort to minimize the impact of current and future land development on water quality, including:

- Environmental Offenses Ordinance
- Erosion & Sediment Control Ordinance
- Sewer Usage Ordinances (Public and Private)
- Solid Waste Ordinance
- Stormwater Management Ordinance
- Water Supply Ordinance
- Wetlands and Coastal Primary Sand Dunes Ordinance
- Chesapeake Bay Preservation Area Overlay District

- Tree Ordinance

While the topic of protecting the City's potable water supply is not contained in its own section of the General Plan, the City does establish policies that address protection of its potable water supply, source quantity, and water demand.

Current Water Quality Policies of General Plan

- Enhance water quality in the Chesapeake Bay and its tributaries
- Comply with the Federal Clean Water Act for stormwater discharges
- Encourage greater integration and coordination of various water quality activities at the regional, state and federal levels
- Encourage increased financial support from state and federal governments for mandated programs to protect the quality of state waters
- Support additional research at the federal and state levels on approaches to improve water quality
- Increase education and public awareness of various water quality issues
- Incorporate technical advancements into water quality protection efforts

Other current policies of General Plan

- Examine the reuse potential of currently underutilized industrial properties along the waterfront (Economic Development, ED-16)
- Support regional efforts to develop public transit and alternative transportation modes (Environmental Quality, EQ-12)
- Protect, enhance, restore, and manage wetlands, beaches, sand dunes, forests, and other ecosystems including remaining waterfowl and wildlife habitats (Environmental Quality, EQ-14)
- Develop, promote, and manage a greenway and open space preservation program throughout the city which provides protection to open space and environmental sensitive areas (Environmental Quality, EQ-15)
- Increase public education on environmental issues (Environmental Quality, EQ-16)
- Evaluate the policies of the 2000 plan in relation to existing or new environmental conditions and intervening technological advances (Environmental Quality, EQ-16)
- Explore alternative resources for the generation of energy which will lessen negative impacts on air and water quality (Environmental Quality, EQ-18)
- Implement landfill disposal alternatives including waste minimization and reuse, recycling, and resource recovery (Environmental Quality, EQ-19)
- Provide efficient collection practices, adequate disposal facilities and intermediate facilities which incorporate state-of-the-art technologies that maximize protection to the environment and minimize local budgetary impacts (Environmental Quality, EQ-20)
- Introduce water as an amenity to inland developments (Community Design, CD-13)

In addition to the above policies, the City of Norfolk supports its mission for the protection of its water resources from nonpoint source pollution by the following water quality initiatives currently on-going in the City.

Site Plan Review

The City's Zoning Ordinance requires that all development and redevelopment activities, with the exception of single-family homes, submit a site plan. The site plan review process requires submittal of a landscape plan, an erosion and sediment control plan, and a stormwater management plan. If the activity affects a Chesapeake Bay Preservation Area, a water quality impact assessment and tree protection permit may be required. During the site plan review process, the applicant is made aware that the responsibility for maintaining privately owned stormwater best management practices lies with the property owner and is required to sign a maintenance agreement. The agreement is recorded at the courthouse.

Chesapeake Bay Preservation Area Overlay District

The Chesapeake Bay Preservation Area Overlay District of the City's Zoning Ordinance applies to all lands within the City identified as Chesapeake Bay Preservation Areas. Chesapeake Bay Preservation Areas include designated Resource Protection Areas (RPAs) and Resource Management Areas (RMAs). Designated RPAs within the City include:

- Tidal wetlands;
- Nontidal wetlands connected by surface flow and contiguous to tidal wetlands or tributary streams;
- Tidal shorelines; and
- 100-foot vegetated buffer area located adjacent to and landward of any of the above features, and along both sides of any tributary stream.

The City's Zoning Ordinance defines RMAs as lands "that if improperly used or developed, has the potential for causing significant water quality degradation of for diminishing the functional value of the resource protection area." The RMA encompasses an area defined by the boundaries of a lot or parcel containing RPA features.

The Overlay District prohibits development within designated RPAs, with the exception of water dependent uses and redevelopment activities. All development and redevelopment sites containing RPA features must meet established performance standards. These standards require that development projects use stormwater best management practices to ensure that the post-development nonpoint source pollution from the site does not exceed predevelopment levels. For redevelopment, post-development nonpoint source pollution must represent a 10% decrease from pre-existing levels. In addition, the District requires projects to minimize land disturbance, preserve existing vegetation to the maximum extent practicable, and minimize impervious cover.

Erosion and Sediment Control Ordinance

The City's Erosion and Sediment Control Ordinance requires any land disturbing activity greater than 10,000 square feet to obtain a permit. If in a Chesapeake Bay Preservation Area, the land disturbing activity must have a permit if it is greater than 2,500 square feet. In order to obtain a permit, one must submit an erosion and sediment control plan. The plan must specify how the applicant proposes to minimize the amount of sediment from leaving the construction site, in accordance with state standards. In addition, the plan must detail how the applicant proposes to minimize downstream channel erosion after construction is complete. The City regularly conducts site inspections to see if on-site erosion and sediment controls are installed and maintained properly.

Norfolk Stormwater Management Program

In 1987, Congress passed an amendment to the Clean Water Act (CWA) requiring municipal separate storm sewer systems (MS4) serving populations greater than 100,000 to obtain a permit. Generally speaking, an MS4 is essentially the City drainage system that prevents flooding by discharging stormwater into local waterways. Subsequently, in 1990, the U.S. Environmental Protection Agency (EPA) promulgated what has become known as the Phase I Stormwater Regulations. Under these regulations, the City of Norfolk was required to obtain a Virginia Pollution Discharge Elimination System (VPDES) permit to discharge stormwater runoff draining from its jurisdiction. Unlike VPDES permits for point source discharges, the MS4 permit did not establish effluent limits but required each regulated local government to develop a stormwater management program that reduces pollutants being discharged in their runoff to the maximum extent practicable.

In 1991, the City of Norfolk established its Environmental Stormwater Management Program. The City was one of the leaders in the state to develop a municipal stormwater management program and stormwater utility fund. The stormwater utility is funded by fees assessed on residential and non-residential properties. These fees are based on the property's contribution to stormwater runoff resulting from the amount of impervious area it possesses. The stormwater utility fund supports several activities of Norfolk's Stormwater Management Program. These include:

- Storm water quality projects for pollution reduction
- Cleanup of illegal dump sites
- Street sweeping
- Detection of illicit (non-stormwater) discharges and connections to the stormwater system
- Inspection and maintenance of Best Management Practices (BMPs)
- Review of site plans
- Inspection of construction sites for erosion and sediment control
- Protection and preservation of wetlands and other shoreline natural resources
- Public education and information for pollution prevention
- Flood reduction projects

The City's Stormwater Management Ordinance requires the installation and maintenance of stormwater best management practices, mandated by the site planning and Chesapeake Bay Preservation Area components of the Zoning Ordinance. In addition, the Ordinance prohibits the discharge of debris, chemicals, and wastewater into the City's drainage system.

Inspections are an important aspect of the City's Stormwater Management Program. Currently, the City inspects approximately 350 stormwater BMPs on a regular basis. Dry or wet ponds are inspected twice a year. All other BMPs are inspected once a year. If a deficiency is identified during an inspection, the owner of the BMP is notified and corrective measures are identified. If an owner fails to respond within 30 days, a notice of violation is issued. If an owner fails to respond to a notice of violation, a summons is issued. The City Norfolk tracks BMP inspections and reports using a database system. In addition, the City of Norfolk Stormwater Program was recently presented with a Virginia Municipal League award for its "Business Partners for Clean Water" program.

For Lakes Sake 2000

In 2000, the first lake appreciation day was held in cooperation with the City of Norfolk Department of Utilities, Virginia Lakes and Watersheds Association, Virginia Cooperative Extension, Department of Conservation and Recreation, Virginia Department of Game and Inland Fisheries, Hampton Roads Water Efficiency Team, Norfolk Environmental Stormwater Management, Norfolk Environmental Commission and Norfolk Botanical Gardens. The purpose of the event is to increase citizen awareness of the importance of the City's reservoirs in daily life as the source of drinking water, recreation and environmental protection. The City plans to continue this initiative annually.

Lake Smith/Lake Lawson Initiative

This initiative addresses non-point source pollution concerns within the Lake Smith/Lake Lawson watershed. The goals of the initiative are: promote non-point source pollution prevention through information and education; co-sponsor teacher workshops; promote the use of urban and agricultural nutrient management and best management practices; sponsor watershed lake clean-ups; and promote watershed understanding through public meetings.

Norfolk Environmental Commission

The Norfolk Environmental Commission is a volunteer citizen advisory board appointed by the Norfolk City Council. Affiliated with the national Keep America Beautiful organization, its stated mission is to lead citizens towards environmental stewardship by educating, altering attitudes, changing behaviors and reducing pollution and waste. The Commission established the Ernie Morgan Environmental Action Center (EAC) in 1998 to provide education programs, resources and opportunities for citizen action and collaboration, and to instill confidence and commitment in citizens for responsible action on behalf of our urban environment. EAC accomplishes these tasks through interactive exhibits, environmental information resources and outreach programs.

Norfolk Environmental Crimes Task Force

The Norfolk Environmental Crimes Task Force coordinates the enforcement of environmental crimes in the City. The Task Force is made up of members of several City agencies including fire, police, planning, public health, Commissioner of Revenue and stormwater. Of these agencies, the fire and police departments have primary enforcement responsibility. Since 1988, the fire and police departments have issued summons for approximately 1,000 cases and collected over $350,000 in fines. The Task Force meets on a monthly basis and is tasked with revising existing environmental ordinances, creating new environmental ordinances, discussing ongoing investigations, and identifying areas where enforcement can be improved. In addition, they have also established a 24-hour phone line to report illegal dumpers, established a program to recoup from the responsible parties the cost of responding to emergency spills, and set up a hazardous materials inspection program for facilities that store or use hazardous materials. Task Force members are also involved in giving presentations to school groups and civic leagues. In recognition of its exemplary efforts, in 1996 the Task Force received a U.S. Environmental Protection Agency Partnership Award for its superior coordination with local officials and the community to prepare for and prevent environmental emergencies.

WATER QUALITY IMPROVEMENTS THROUGH REDEVELOPMENT

INTRODUCTION

Runoff from developed areas, due to increased imperviousness, can potentially degrade local water quality. Paved areas cannot absorb rainwater and the resultant runoff can transport pollutants and toxic substances into local waterways. As of December 31, 1999, existing land use data developed for the City's Virginia Pollution Discharge Elimination System (VPDES) permit indicated that almost 99 percent of the City was developed. The City of Norfolk possesses the highest amount of impervious surface of any locality in Hampton Roads.

Typically, older urban areas, such as the City of Norfolk, were developed prior to the enactment of environmental regulations that require water quality protection measures in their design. In these cases, redevelopment provides the primary means of making significant water quality improvements. During redevelopment of these older areas, water quality improvement measures such as stormwater best management practices (BMPs) and shoreline restoration activities can be incorporated.

The City currently addresses construction and post-construction runoff through its site planning requirements, stormwater management and erosion and sediment control ordinances and Chesapeake Bay Preservation Area Overlay District. Under these local ordinances, redevelopment activities are required to implement measures that treat the runoff leaving a site during and after construction. In addition, the Chesapeake Bay Preservation Overlay District requires that redevelopment result in a 10 percent decrease in nonpoint source pollution from preexisting levels.

In cooperation with the Elizabeth River Project (ERP), the City has conducted wetland restoration projects at Birdsong Wetlands and Pescara Creek. In addition, as part of the Corps of Engineers Elizabeth River Restoration Study, three wetland restoration sites in the City have been identified: Grandy Village, ODU drainage canal, and Somme Avenue. Restoring these wetlands will provide water quality benefits to the City's waterways.

INTENSELY DEVELOPED AREAS (IDAs)

The Chesapeake Bay Preservation Act regulations give local governments the option to designate Intensely Developed Areas (IDAs). The intent of IDAs is to identify designated redevelopment areas where the concentration of development is desired. In designating IDAs, local governments are directed to examine development patterns within Chesapeake Bay Preservation Areas. Areas of existing development and infill sites, where little of the natural environment remains may be designated as IDAs provided they are characterized by one of the following at the time of local program adoption:

- Development has severely altered the natural state of the area such that it has more than 50% impervious surface

- Public sewer and water is constructed and currently serves the area by the effective date of the regulations. This condition does not include areas planned for public sewer and water
- Housing density is equal to or greater than four dwelling units per acre

The predominant development pattern in Norfolk is characterized by redevelopment and infill development, with little natural vegetation remaining. In such a setting, full protection of the 100-foot buffer is not practical or feasible in all cases. The Chesapeake Bay Preservation Act recognizes this by allowing greater flexibility in meeting the Resource Protection Area buffer requirements in designated IDAs. To better reflect the City of Norfolk's development patterns and help achieve the intent of the Bay Act to concentrate development in already developed areas, the City should consider expanding its IDA designation to residential areas.

Currently, only five shoreline areas are identified as IDAs in the City's Zoning Ordinance. Land uses in or near these IDAs are primarily characterized by heavy industrial activities, shipping and ship repair industries, or marinas. Parts of downtown Norfolk are also incorporated into an IDA as is part of a former landfill site on Forty-fourth Street behind Old Dominion University. Officially, the City defines its five IDAs as the following:

- **a. Elizabeth River and its Tributaries**. From the intersection of the western shoreline of Moseley Creek and Westminster Avenue to the intersection of Forty-Ninth Street and the Elizabeth River. Includes Lamberts Point Terminal and Waterside.
- **b. The Southern and the Eastern Branch of the Elizabeth River and its Tributaries**. From the city limit on the eastern branch to the city limit on the southern branch. Includes the Norfolk waterfront across the Elizabeth River from Waterside.
- **c. The Lafayette and Elizabeth Rivers**. From the western boundary of the Lochhaven subdivision to the southern boundary of the Norfolk Naval Base. Includes the Norfolk International Terminals.
- **d. Little Creek**. The westerly and northerly shoreline of Little Creek from the shoreline terminus of the western entrance channel jetty to the Shore Drive bridge and the southerly shoreline of Little Creek from the Shore Drive bridge to the Norfolk city limit. Includes the marina-dominated shoreline at the entrance to Little Creek Harbor.
- **e. Willoughby Bay**. From the western shoreline terminus of Bayville Street to the southern shoreline terminus of 15th View Street. Includes the marina-dominated shoreline on Willoughby Bay, at the end of Willoughby Spit.

These IDAs are shown in Figure 41. Each of these designated IDAs is analyzed below for existing conditions and potential redevelopment opportunities.

Figure 41. IDAs

[figures available in Planning Department]

A. Elizabeth River and its Tributaries

Existing Shoreline Conditions

This designated IDA includes the Lamberts Point Terminal and Waterside areas of the City. According to DEQ records, there are currently ten permitted industrial facilities that discharge effluent to the Elizabeth River along this shoreline (Table 13). The outfalls from these facilities are concentrated at the Lamberts Point Terminal and shipyard facilities near the Campostella Bridge. DEQ records also indicate that there are three active cases of leaking petroleum storage tanks a quarter of a mile or less from the shoreline (Table 14). These are located at Eagletons and the Econo Gas Station on Boush Street and the Norfolk Southern Tower (Figure 27). Virginia Department of Health records indicate seven boat docking facilities in this area (Table 4). All of the commercial marinas along this shoreline are equipped with boat sewage pumpout capability.

Table 13. Permitted Discharges (DEQ, 2000)

Permit Number	Name
VA0081281	HRSD Virginia Initiative Plant
VA0003409	Norfolk Southern Railroad
VA0054828	Norfolk Oil Transit
VA0005860	VDOT Midtown Tunnel
VA0003263	J.H. Miles and Company, Inc.
VA0085855	Lyon Shipyard, Inc.
VA0004405	Norshipco-Brambleton
VA0004260	Tarmac America, Inc.
VA0004391	Colonnas Shipyard, Inc.
VA0089222	C&M Industries, Inc.

Table 14. Leaking Above Ground and Underground Storage Tanks (DEQ, 2000).

Pcnumber	Name	Location
19992284	Econo Gas Station	759 Boush Street
20005157	Eagletons	430 Boush Street
20005107	Norfolk Southern Tower	3 Commercial Place

Water Quality Improvement Opportunities

Potential wetland restoration sites identified by the Corps of Engineers Elizabeth River Restoration Study in this area include the Old Dominion University Drainage Canal north of Lamberts Point, the former landfill site at Lamberts Point, the Harbor Park shoreline, and a filled in wetland site along the shoreline at the Granby Village public housing complex. After further investigation, however, wetland restoration at the Harbor Park shoreline and former landfill site at Lamberts Point were deemed infeasible due to site constraints and/or regulatory concerns. The City continues to be very active in its support for restoration of the remaining sites that are included in the Elizabeth River Restoration Study.

The state DEQ is responsible for overseeing the closure of leaking petroleum storage tanks. The City should work with DEQ so that active cases of leaking underground storage tanks are contained and closed.

B. The Southern and the Eastern Branch of the Elizabeth River and its Tributaries

Existing Conditions

This shoreline IDA is characterized primarily by industrial development including several ship building and repair facilities and the Ford Motor Plant. According to DEQ records, there are currently seven permitted industrial facilities that discharge effluent to the Elizabeth River within this IDA (Table 15). DEQ records also indicate that there are five active cases of leaking petroleum storage tanks in close proximity to the shoreline (Table 16 and Figure 27). Virginia Department of Health records indicate that there are five boat docking facilities in this area. All of these are associated with industrial shipbuilding and repair facilities and are not appropriate for recreational boat pumpout facilities (Table 4).

Table 15. Permitted Discharges (DEQ, 2000)

Permit Number	Name
VA0089168	Sealift Drydock
VA0053813	Colonnas Shipyard
VA0073091	Metro Machine Corporation
VA0087556	Tarmac America, Inc.
VA0089141	Marpol, Inc.
VA0005851	VDOT – Downtown Tunnel
VA0004383	Norshipco-Berkley
VA0090255	Center for Advanced Ship Repair

Table 16. Leaking Above Ground and Underground Storage Tanks (DEQ, 2000).

Pcnumber	Name	Location
19860093	Colonnas Shipyard	400 East Indian River Road
19992385	Norshipco-Berkley	750 West Berkley Avenue
19982215	Norshipco-Berkley	750 West Berkley Avenue
19992386	Norshipco-Berkley	750 West Berkley Avenue
19982296	Norshipco-Berkley	750 West Berkley Avenue

Water Quality Improvement Opportunities

Potential wetland restoration sites identified by the Corps of Engineers Elizabeth River Restoration Study in this area include a site in Steamboat Creek and two sites east of the Campostella Bridge, at Campostella Heights. However, these sites have been dropped from the Study. Private property concerns prevented the two sites at Campostella Heights from being included. The site at Steamboat Creek was not included because it was found that it was already a functioning wetland and only needed very minor improvements.

The Corps of Engineers Elizabeth River Restoration Study also identified a sediment restoration site at the Campostella Bridge, along the southern shoreline of the Eastern Branch of the Elizabeth River. The City continues to be very active in its involvement and support for the remediation of this site as included in the Elizabeth River Restoration Study.

C. The Lafayette and Elizabeth Rivers

Existing Conditions

This IDA includes the entirely industrial shoreline of the Norfolk International Terminal (NIT), which is owned and operated by the Virginia Port Authority (VPA). The NIT is the largest facility operated by the VPA and is the central focus of future plans to expand the shipping industry in Virginia. The land and shoreline are owned by the state. As a result, the City of Norfolk is limited in its jurisdiction to control potentially environmentally impacting activities occurring in the NIT.

Water Quality Improvement Opportunities

The manner in which redevelopment is conducted at the NIT is ultimately the responsibility of the state. Along with other state agencies, the City regularly comments on development and redevelopment proposals for the NIT through the state Environmental Impact Review process. Through this process and others, the City has the opportunity to encourage the adoption of pollution prevention activities and water quality improvement measures.

D. Little Creek

Existing Conditions

This IDA consists of the concentration of commercial marinas along the Little Creek shoreline east of the Shore Drive bridge. There are a total of seven marinas representing over 1,300 slips (Table 4). Two of the seven marinas lack boat sewage pumpout facilities, Clyde's Marina and Cutty Sark Marina.

Water Quality Improvement Opportunities

Redevelopment opportunities in this area consist primarily of installing pumpout stations at those marinas that currently lack them. The marinas in this area could also be examined for encouraging the adoption of pollution prevention practices and the need for installation of stormwater best management practices. The newly created Marina Technical Assistance Program at the Virginia Institute of Marine Science will be helpful in this effort.

E. Willoughby Bay

Existing Conditions

This IDA shoreline consists of the concentration of commercial marinas along the Willoughby Bay shoreline on Bayville Street. There are four marinas representing over 700 slips (Table 4). Two of these marinas lack boat sewage pumpout facilities: Willoughby Bay Marina and Coopers Pier. DEQ records indicate that the Willoughby Bay Marina contains an active case of a leaking petroleum storage tank.

Water Quality Improvement Opportunities

Redevelopment opportunities in this area consist primarily of installing pumpout stations at those marinas that currently lack them. DEQ should ensure that the leaking petroleum storage tank is contained and closed in as timely and an effective manner as possible. This area could also be examined for encouraging the adoption of pollution prevention practices and the need for installation of stormwater best management practices. The newly created Marina Technical Assistance Program at the Virginia Institute of Marine Science will be helpful in this effort.

OTHER WATER QUALITY IMPROVEMENT OPPORTUNITES

Regulatory Measures

Runoff from approximately 12% of the City is treated by stormwater best management practices (BMPs) (CH2MHill, 1999). This is a result of the fact that the majority of the City was developed prior to the enactment of water quality regulations. Because of the high level of development of the City, the primary limitation to installing additional BMPs is finding available land. Without available land, the primary means of water quality improvements available to the City consist of maintaining the existing stormwater infrastructure and incorporating stormwater BMPs in redevelopment activities, as required by regulatory programs. Redevelopment activities within the City of Norfolk are required to comply with the City's Erosion and Sediment Control Ordinance, Stormwater Management Ordinance and site planning requirements, and the Chesapeake Bay Preservation Area Overlay District of its Zoning Ordinance. These programs require that redevelopment activities adopt water quality improvement measures in their design through the use of stormwater best management practices. In addition to existing regulatory programs, some urban cities in the region have developed a regional BMP banking system. This option is discussed further in the Urban Retrofits section.

Voluntary Efforts

The City of Norfolk Stormwater Program administers a successful voluntary awards program, "Business Partners for Clean Water." This program recently received an award from the Virginia Municipal League. In addition, the City of Norfolk supports the efforts of the Elizabeth River Project (ERP). ERP has been very successful in encouraging private industries and military facilities along the river to voluntarily implement pollution prevention practices, habitat restoration activities and stormwater best management practices through their River Stars program. The River Stars program formally recognizes those organizations along the river that undertake habitat improvement and/or water quality improvement measures. Recent recipients of the River Star award include NORSHIPCO, the Ford Motor Company manufacturing plant, Colonna's Shipyard, NOVA chemicals, the Hampton Roads Regional Jail, Metro Machine, Southern States Coop, Naval Station Norfolk, and the People for the Ethical Treatment of Animals (PETA) office.

Urban Retrofits

The City currently coordinates urban retrofit projects through its Stormwater Management Plan (1994). The plan evaluates all of the City's major stormwater ponds and presents recommendations for their enhancement. Since completing the plan, two stormwater ponds, Lake Scott and Lake Modoc, have been dredged to improve their water quantity and water quality functions.

Due to its high level of urban development, the typical approach of using individual on-site BMPs to treat stormwater is not as effective in the City of Norfolk. Obstacles to requiring site specific BMPs in Norfolk include a limited availability of land, high pollutant removal and maintenance costs, and incompatibility with redevelopment and infill development activities. A more effective approach to implement in Norfolk may be a regional BMP credit system, which has been used successfully by other Hampton Roads localities. Under this approach, areas currently served by individual on-site BMPs would be served by a series of constructed regional stormwater facilities. In addition, proposed redevelopment and infill development activities would have the option of paying for pollutant removal credits by using a regional facility to meet stormwater runoff requirements associated with the Chesapeake Bay Preservation Act and Virginia Pollution Discharge Elimination System requirements. A regional stormwater facility credit system has many benefits, such as requiring less land for stormwater facilities, a greater ability to maintain a limited number of regional facilities as opposed to several individual facilities, increased pollutant removal effectiveness, and being more compatible with existing development in the City of Norfolk.

Brownfields

Another promising method for achieving water quality improvements through redevelopment includes the redevelopment of brownfield sites. The U.S. EPA defines brownfields as "abandoned, idled, or under-used industrial and commercial facilities where expansion or redevelopment is complicated by real or perceived environmental contamination" (US EPA, 2001). The goal of brownfield development programs is to cleanup these sites, thereby eliminating risks to public health and the environment and making them available to contribute to local economic development efforts.

There are several obstacles to overcome in developing brownfield sites. Cleanup costs are often uncertain and depending on the level of contamination can be significant. Ultimate legal responsibility for cleanup is also uncertain due to the complicated nature of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and associated court rulings. Sometimes, the ownership of the abandoned brownfield site can be hard to determine. In addition, it can be difficult to obtain financing from lending institutions for brownfields development projects due to real or perceived contamination problems. Thus, brownfield development programs typically try to clarify these issues and reduce the cleanup liability for potential investors.

To clarify some of the uncertainty surrounding brownfield redevelopment, the Department of Environmental Quality (DEQ) administers Virginia's Brownfields/Land Renewal Program. This program offers free site screenings to local governments, which include researching the history of the property in question, reviewing any existing reports or records associated with the property, and collecting samples and conducting laboratory analysis to determine whether contamination exists. If contamination exists, then a risk assessment is performed to identify feasible cleanup options. Currently, there is no state funding program available for implementing cleanup options.

While DEQ does not offer funding to remediate brownfields, it seeks to encourage brownfield cleanup through the Voluntary Remediation Program. The Program seeks to create a streamlined process through which a brownfield site can be cleaned up voluntarily and liability issues can be reduced. Through the Program, DEQ works with interested parties to develop a suitable cleanup plan. Once the cleanup plan has been implemented, a "certification of satisfactory completion of remediation" is issued. Once the certification is issued, the site is granted immunity from future enforcement action by DEQ, unless new issues are identified that were not addressed by the cleanup plan.

At the federal level, the U.S. EPA administers a revolving loan fund for cleaning up contaminated brownfields. Under this program, a local government can use EPA funds to administer a low-interest rate loan program to facilitate cleanup efforts. In addition, in 1997, a federal brownfields tax incentive was created. Under this tax program, the costs incurred to cleanup a brownfields site are considered deductible business expenses. In order to qualify for the tax deduction, the taxpayer must receive a "qualified contaminant site" certification from DEQ.

Because brownfields development would assist the City of Norfolk in achieving its environmental and community development goals, it should consider the possibility of taking advantage of the above programs to encourage brownfields development within the City. A first step might be to work with state and federal agencies, neighborhoods, environmental organizations, such as the Elizabeth River Project, and potential developers to identify and prioritize potential brownfield development sites.

SUMMARY AND CONCLUSIONS

Under the regulations of the Chesapeake Bay Preservation Act the entire shoreline of the City of Norfolk may qualify for Intensely Developed Area (IDA) designation. Expansion of the City's IDA designation should be considered in recognition of the fact that the City of Norfolk, in its entirety, is an area targeted for redevelopment and infill development.

Currently, the City has five shoreline reaches designated as IDAs. Along these reaches, potential water quality improvement measures in these areas include correcting open cases of leaking petroleum storage tanks, installing boat pumpout facilities, and stormwater retrofits. In addition, the Corps of Engineers Elizabeth River Restoration Study has identified potential wetland restoration sites in one of these IDAs.

The vast majority of building activity in the City of Norfolk is redevelopment and infill development. The City's site planning, Chesapeake Bay Preservation Area, erosion and sediment control, and stormwater management requirements ensure that all major redevelopment activities will result in net improvement to water quality. Restoration and retrofitting of existing commercial and industrial sites is occurring through the efforts of the Elizabeth River Project. Publicly owned major stormwater facilities are systematically being retrofitted by the City of Norfolk's Stormwater Management Program. To further enhance the City's stormwater management efforts, the City should consider the potential advantages of implementing a regional stormwater facility credit system.

In addition, the City should consider brownfields development as a means to achieve community development goals and obtain water quality improvements through redevelopment.

REFERENCES

Burdick, D.M. and Short, F.T. Dock Design with the Environment in Mind: Minimizing Dock Impacts to Eelgrass Habitats. An interactive CD-ROM published by the University of New Hampshire, Durham, NH. 1998.

CH2MHill, Regional Stormwater Loading Study. Prepared for the HRPDC Regional Stormwater Management Committee. Herndon, VA. September 1999.

Chesapeake Bay Local Assistance Department. Chesapeake Bay Local Assistance Manual. Richmond, VA: CBLAD, 1989.

Chesapeake Bay Program. Chesapeake Bay Area Public Access Plan. Chesapeake .Executive Council. Annapolis, MD: CBP, December 1990.

Chesapeake Bay Program. Chesapeake Bay & Susquehanna River and its Tidal Tributaries: Public Access Guide. Annapolis, MD: CBP, 2000.

Chesapeake Bay Program. Chesapeake Bay Area Public Access Technical Assistance Report. Annapolis, MD: CBP, 1999.

City of Norfolk. General Plan of Norfolk. Department of City Planning and Codes Administration. Norfolk, VA.

City of Norfolk. Beach Management Plan, City of Norfolk. Department of City Planning and Codes Administration, Bureau of Environmental Services. Norfolk, VA. January 1993.

City of Norfolk. personal communication, David Rosenthal, March 14, 2001.

Elizabeth River Project. State of the River 2000. Norfolk, VA: ERP, 2000.

Hamilton, P.A., and Larson, J.D. Hydrogeology and Analysis of the Ground-water Flow System in the Coastal Plain of Southeastern Virginia. US Geological Survey Water-Resources Investigation Report 87-4240, 1988.

Hampton Roads Planning District Commission. Borrow Pit Management Study. Chesapeake, Virginia: HRPDC, January 1995.

Hampton Roads Planning District Commission. Groundwater Protection Handbook for Southeastern Virginia. Chesapeake, Virginia: HRPDC, January 1990.

Hampton Roads Planning District Commission. Regional Shoreline Element of Comprehensive Plans. Part I: Guidance Document. Chesapeake, VA: HRPDC, February 1997.

Hampton Roads Planning District Commission. Regional Shoreline Element of Comprehensive Plans. Part II: Appendices. Chesapeake, VA: HRPDC, February 1997.

Hampton Roads Planning District Commission. Water Supply Watershed Management in Hampton Roads. Chesapeake, VA: HRPDC, 1997.

Hampton Roads Planning District Commission. Hampton Roads Data Book. Chesapeake, VA: HRPDC, 2000.

Hardaway, C.S., G.R. Thomas, B.K. Fowler, C.L. Hill, J.E. Frye, and N.A. Ibison. Results of the Vegetative Erosion Control Project in the Virginia Chesapeake Bay System. *Proceedings of the Twelfth Annual Conference on Wetlands Restoration and Creation*. 985.

Hardaway, C.S., G.R. Thomas, J.B. Glover, J.B. Smithson, M.R. Berman, A.K. Kenne. Bank Erosion Study. Gloucester Point, VA: VIMS. 1992.

Hardaway, C.S. and R.J. Byrne. Shoreline Management in Chesapeake Bay. Virginia Institute of Marine Science: Gloucester, VA. 1999.

Harsh, J.F., and Laczniak, R.J. Conceptualization and Analysis of Ground-water Flow System in the Coastal Plain of Virginia and Adjacent Parts of Maryland and North Carolina. US Geological Survey Professional Paper 1404-F, 1990.

Kirkley, J. Virginia's Commercial Fishing Industry: Its Economic Performance and Contributions. Gloucester Point, Virginia: VIMS, 1997.

Kirkley, J. and Kerstetter, D. Saltwater Angling and its Economic Importance to Virginia. Gloucester Point, Virginia: VIMS, 1997.

Laczniak, R.J., and Meng, A.A. III. Ground-water Resources of the York-James Peninsula of Virginia: US Geological Survey Water Resources Investigation Report 88-4059, 1988.

Meng, A.A. III, and Harsh, J.F. Hydrogeologic Framework of the Virginia Coastal Plain. US Geologic Survey Professional Paper 1404-C, 1988.

Priest, Walter I. III. A Resource Atlas and Existing Conditions Report on the Southern Branch of the Elizabeth River. Gloucester Point, VA: VIMS, 1979.

Priest, Walter I., III, Lyle M. Varnell, Thomas A. Barnard, Julie G. Bradshaw, Kirk J. havens, Carl Hershner, Pamela Mason, and William L. Roberts. Wetlands Program Technical Report No. 99-2. *VIMS Shoreline Permit Database Impacts and Alterations Summary 1988 –1992*. , Gloucester Point, Virginia: VIMS, February 1999.

Priest, Walter I., III. "Historic Wetland Loss in the Elizabeth River." The Virginia Wetlands Report. Virginia Institute of Marine Science, Virginia Wetlands Program. Gloucester Point, VA: VIMS, Summer 1999.

Southeastern Virginia Planning District Commission. The Waters of Southeastern Virginia. Volume I: An Analysis of Water Access Needs. Chesapeake, VA: SVPDC, June 1988.

Southeastern Virginia Planning District Commission. The Waters of Southeastern Virginia. Volume II: A Regional Waterways Guide. Chesapeake, VA: SVPDC, June 1988.

U.S. Army Corps of Engineers. Navigation Management Plan for the Port of Hampton Roads. Norfolk, VA: USACE, February 2000.

U.S. Environmental Protection Agency. Brownfields Glossary of Terms. http://www.epa.gov/swerosps/bf/glossary.htm#brow. 2000.

U.S. Fish and Wildlife Service. Regional Wetlands Concept Plan, Emergency Wetlands Resource Act. Newtown Corner, MA: USFWS, October 1990.

U.S. Geological Survey. Quality of Ground Water in the Coastal Plain Physiographic Province of Virginia. Reston, VA: USGS,1993.

U. S. Geological Survey. Ground-Water Discharge from the Coastal Plain of Virginia. Reston, VA: USGS, 1994.

Virginia Water Control Board. Elizabeth River Data Characterization. Richmond, VA: VWCB, 1983.

Virginia Water Control Board. Virginia Water Quality Assessment for 1992 305(b) Report to EPA and Congress. Richmond, VA: VWCB, 1992.

Virginia Department of Environmental Quality. 1998 Virginia Water Quality Assessment 305(b) Report. Richmond, VA: VDEQ, 1998.

Virginia Department of Environmental Quality. 2000 Virginia Water Quality Assessment 305(b) Report. Richmond, VA: VDEQ, 2000.

Virginia Department of Conservation and Recreation. Critical Natural Areas, Exemplary Wetlands, and Endangered Species Habitats in Southeastern Virginia. Richmond, VA: VDCR-DNH, March 18, 1992.

Virginia Department of Conservation and Recreation. Virginia Nonpoint Source Pollution Watershed Assessment Report. Richmond, VA: VDCR, July 1997.

Virginia Department of Conservation and Recreation. 1992 Virginia Outdoors Survey. Division of Planning and Recreation Resources. Richmond, VA: VDCR-DPRR, undated.

Virginia Department of Conservation and Recreation. The 1996 Virginia Outdoors Plan. Division of Planning and Recreation Resources. Richmond, VA: VDCR-DPRR, undated.

Virginia Institute of Marine Science. City of Norfolk Tidal Marsh Inventory. Gloucester Point, Virginia: VIMS. 1987.

Virginia Institute of Marine Science. Shoreline Situation Report, Cities of Chesapeake, Norfolk, and Portsmouth. Gloucester Point, Virginia: VIMS. 1976.

Virginia Institute of Marine Science. Shoreline Erosion in Tidewater Virginia. Gloucester Point, Virginia: VIMS. 1978.

Virginia Institute of Marine Science. Virginia Wetlands Management Handbook (2nd Edition). Wetlands Program. Gloucester Point, VA: VIMS. January 1996.

Virginia Institute of Marine Science. Tidal Wetlands Impact Data. http://www.vims.edu/rmap/wetlands/cgi-bin/index.htm. 2000

Virginia Institute of Marine Science. Bay Grasses in Chesapeake Bay and Delmarva Peninsula Coastal Bays. http://www.vims.edu/bio/sav/. 2000

Virginia Institute of Marine Science. personal communication, David O'Brien, July, 2001.

Virginia Marine Resources Commission. Shoreline Development BMP's: Best Management Practices for Shoreline Development Activities Which Encroach In, On, or Over Virginia's Tidal Wetlands, Coastal Primary Sand Dunes and Beaches, and Submerged Lands. Newport News, Virginia: VMRC, 1993.