United States Department of Agriculture

Natural Resources Conservation Service

Report No. RI-TP-2006-1

Flood Plain Management Study: Pocasset River Watershed, Providence County, Rhode Island

Prepared by the USDA Natural Resources Conservation Service In Cooperation with:

City of Cranston
Town of Johnston
Rhode Island Department of Environmental Management
Northern Rhode Island Conservation District
Rhode Island Emergency Management Agency

Cover Photo: Truck driving through a flooded street during a 2001 storm event, looking north on Fletcher Avenue in the City of Cranston, Rhode Island. (Rhode Island NRCS file photo)

ABSTRACT

The Pocasset River Flood Plain Management Study (FPMS) is the first phase in the development of a Watershed Plan to mitigate flooding and the associated damages caused by flooding along the Pocasset River. The FPMS is comprised of two documents: RI-TP-2006-1 and RI-TP2006-2. The RI-TP-2006-1, commonly referred to as the "Popular Report", sets forth the current and future conditions relating to flooding in the Pocasset River Watershed and provides alternatives to mitigate the flooding. The popular report also contains the revised Flood Plain Maps and Cross-Sections for the existing and future flooding condition. The RI-TP-2006-2, commonly referred to as the "Technical Report", provides a detailed analysis of the methods used and assumptions made to develop the Hydrology and Hydraulics for the computer models used in the analysis.

The "Popular Report" is comprised of six main sections: Section 1.0, Introduction; Section 2.0, Project Setting; Section 3.0, Watershed Problems and Opportunities; Section 4.0, Hydrology and Hydraulics; Section 5.0, Formulation and Development Options; and Section 6.0, Conclusions.

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1.0 INTRODUCTION

The Pocasset River Flood Plain Management Study was initiated because of a storm event that occurred in August of 1999. The USDA Natural Resources Conservation Service (NRCS) was contacted by the Town of Johnston to determine if there were federal funds available to restore several eroded stream banks along the Pocasset River and Simmons Brook. The Rhode Island State Office of NRCS requested funds for two projects through the Emergency Watershed Program (EWP). These two projects were the restoration of the stream bank at Morgan Mill Road on the Pocasset River and the stabilization of the stream bank on Simmons Brook located at St. Rocco's Church. Both projects were successfully completed in cooperation with the Town of Johnston.

In March of 2000, the Town of Johnston requested federal assistance for watershed protection and flood prevention under the provisions of the Watershed Protection and Flood Prevention Act (Public Law 83-566) for the Pocasset River Watershed[1]. Although the Town of Johnston made the application, the policy of NRCS is to address flooding problems on a watershed basis. A large portion of the City of Cranston lies within the Pocasset River Watershed. The City of Cranston was contacted and they requested to become part of the study. A small portion of the watershed is within the City of Providence and, while they are not a formal applicant, this portion of the watershed was included in the study.

Documented flooding has occurred throughout the watershed since the 1950's and in recent years has become increasingly more common. Development in the watershed has not only increased the frequency, but also the intensity and duration of flooding events. This has resulted in higher damages to residential, commercial, and industrial property throughout the watershed. This report, known as the "Popular Report," documents the existing conditions within the watershed, provides updated Flood Plain maps for present and future land use conditions, and states potential solutions to mitigate or prevent damages from future flooding.

[1] Participation of NRCS in the Pocasset River Flood Plain Management Study is in accordance with Federal Level Recommendation 5(b) of "A Unified National Program for Flood Plain Management," March 1986, Federal Emergency Management Agency, and Section 6 of Public Law 83-566. The principles contained in Executive Order 11988, Flood Plain Management, are addressed in this part.

2.0 PROJECT SETTING

2.1 SIZE

The Pocasset River watershed covers 13,200 acres or 20.6 square miles. The river is approximately 10 miles long. There are two main tributaries that enter the Pocasset River, Dry Brook and Simmons Brook.

2.2 LOCATION

Named for the watershed's main tributary, the Pocasset River Watershed is located in the southeast corner of Providence County, Rhode Island. It covers 20.6 square miles or 13,200 acres. There are three municipalities located in the watershed, all having independent-governing bodies: the Town of Johnston, the City of Cranston, and the City of Providence. The Town of Johnston comprises approximately 70 percent of the watershed, the City of Cranston 29 percent, and the City of Providence slightly less than 1 percent.

2.3 SOCIAL AND ECONOMIC CONDITIONS

Watershed Population: 8,533
Number of Farms: 15

Total Population[1]

Johnston 28,195
Cranston 79,269
Rhode Island 1,048,319

Population Over 65[2]

Johnston 8.9%
Cranston 17.3%
Watershed 21.1%
Rhode Island 4.5%

Per Capita Income[3]

Johnston $21,440
Cranston $21,978
Rhode Island $21,688
Nationwide.................... $33,050

Median Home Value[4]

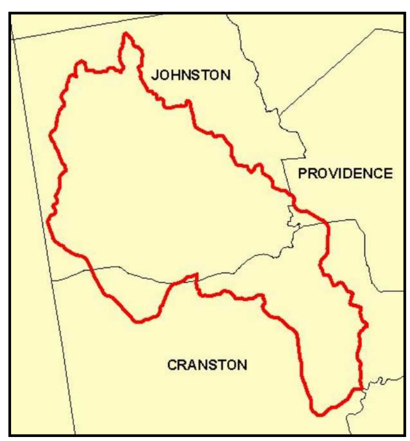
Johnston $131,700
Cranston $122,500
Rhode Island $133,000

Unemployment[5]

Johnston 4.7%
Cranston 4.8%
Rhode Island 5.6%

Map 1 - Locus by County

Map 2 - Locus by Town



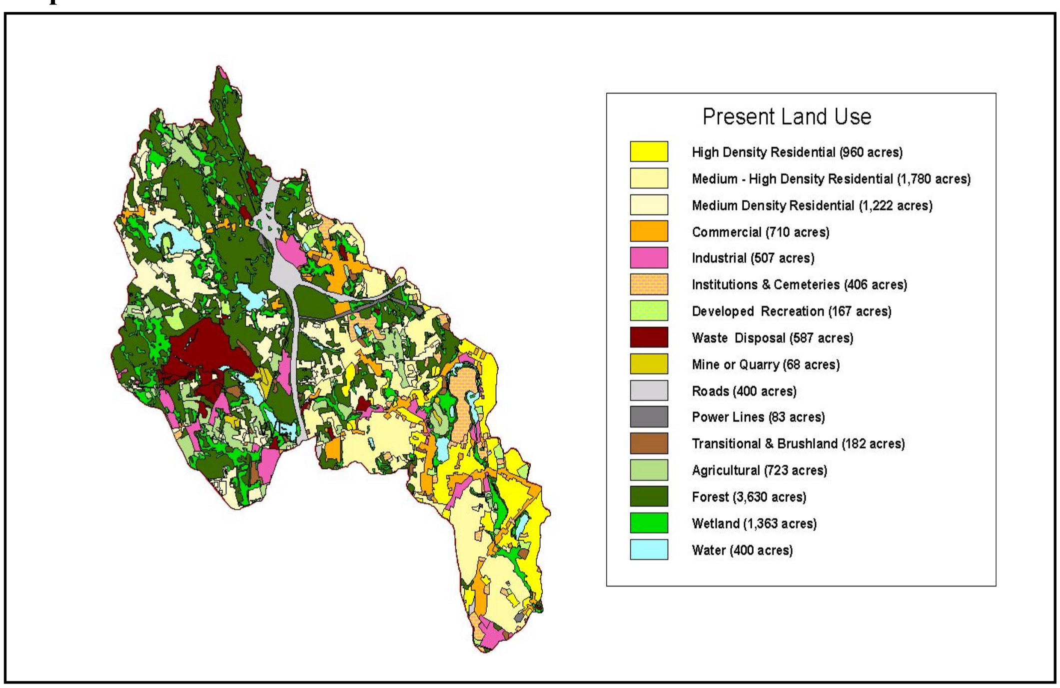
2.4 LAND COVER AND USE

Land use in the Pocasset River Watershed varies significantly from the headwaters located in the western portion of the City of Cranston and the Town of Johnston to the outlet located in the southeastern portion of the watershed in Cranston.

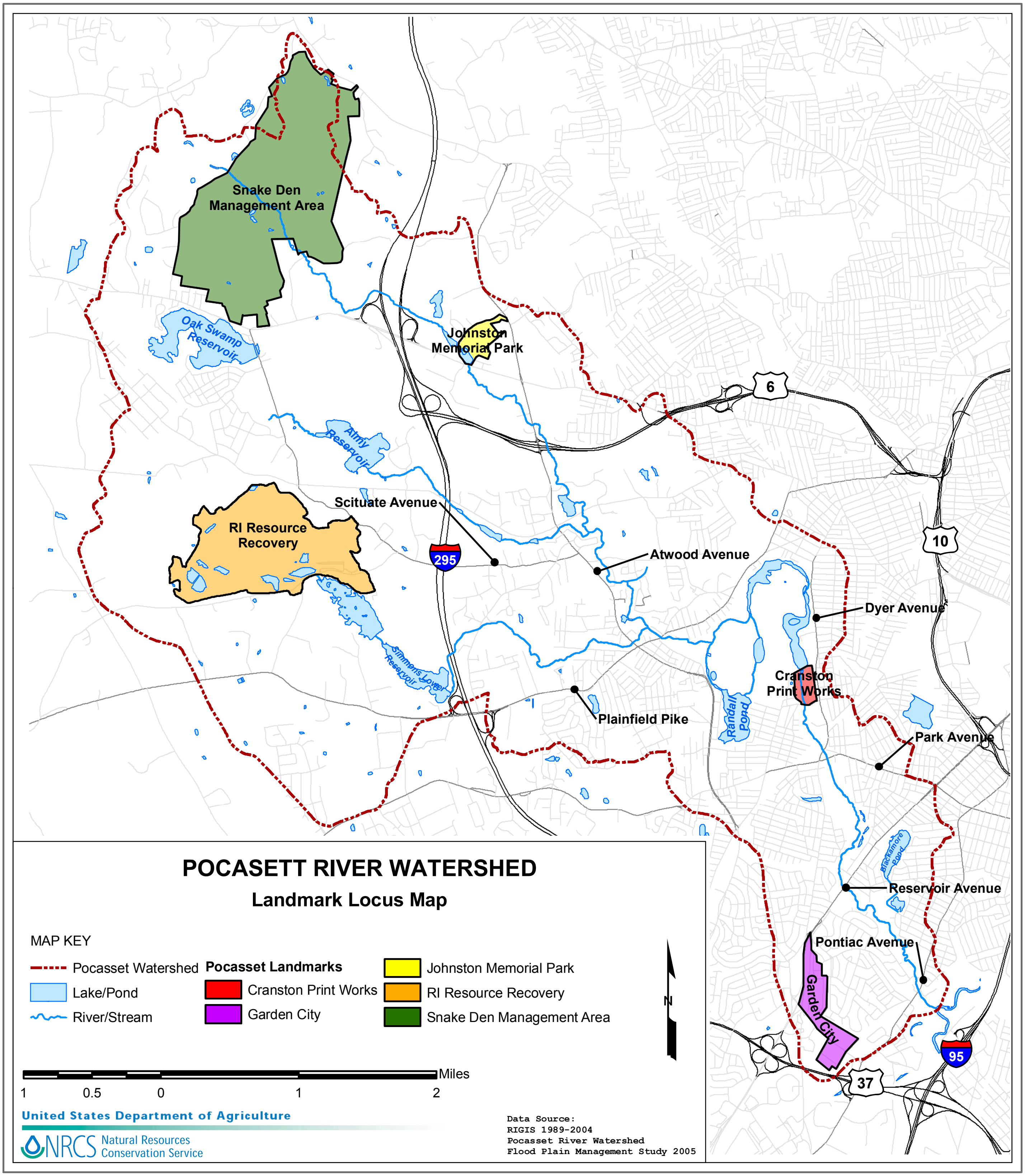
The western portion of the watershed, west of Interstate 295, is the least densely settled area within the study limits. The predominant cover type is forest with some farms located in the western most areas. There are some residential developments within this area and an increase in this type of development is the current land use trend. The most significant land use in this portion of the watershed is the Rhode Island Resource Recovery Corporation (RIRRC) facility and many privately owned commercial enterprises located at the northwestern end of Upper Simmons Reservoir. The RIRRC is the disposal site for most of Rhode Island's solid waste. Neighboring states also dispose of waste at the RIRRC facility. Significant industrial development is proposed for this area and for the surrounding property owned by RIRRC. New exchange ramps have been added to Interstate 295 to facilitate entry to the RIRRC property and potential industrial development.

East of Interstate 295 there is a wide range of land uses including commercial, industrial, and residential developments. Most of the open space found in this section of the watershed is located within the Flood Plain of the Pocasset River and its tributaries. Major commercial areas can be found along Route 5 in the Town of Johnston north and south of Route 6 and on Route 5 in the City of Cranston at the intersection of Park Avenue. Another significant commercial district is located in the Garden City area of Cranston. Industrial developments are scattered throughout this portion of the watershed in industrial parks and historic mills along the river.

Map 3 - Present Land Use[6]



Map 4 - Landmark Locus Map



2.5 TOPOGRAPHY AND SOILS

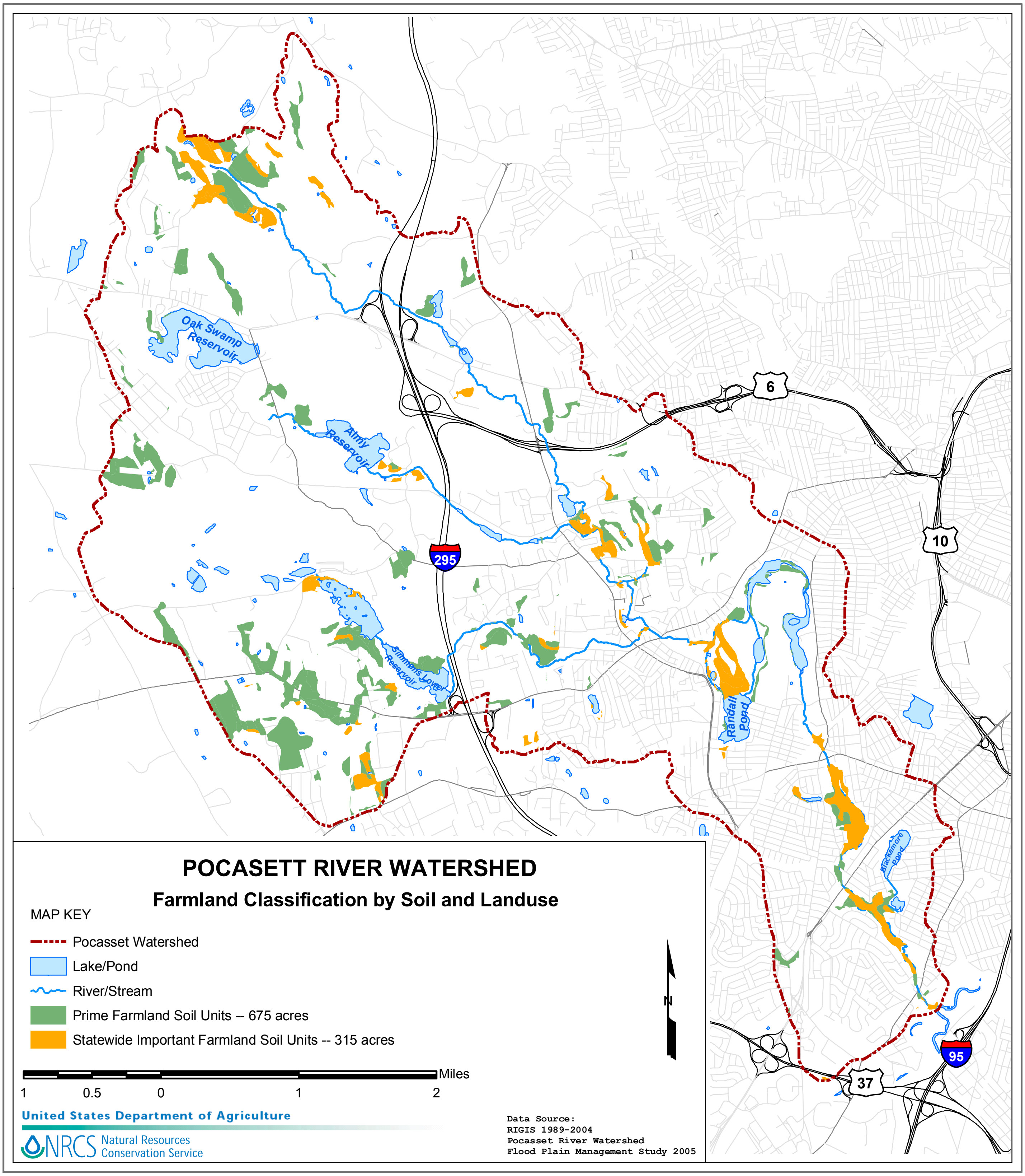
The watershed is located in Major Land Resources Area 144A, "New England and Eastern New York Upland, Southern Part". The watershed consists of glaciated uplands with relatively low hills separated by narrow valleys. The northern portion has bedrock-controlled topography with short steep slopes and wetlands in the low areas. Most of the City of Cranston portion consists of glacial outwash plains and terraces. The stream channels and ponds in the headwaters of the Pocasset River have an elevation of approximately 300 feet above sea level. At its terminus at the confluence with the Pawcatuck River, the elevation is about 5 feet. Most of the hills in the headwaters section of the watershed have an elevation of 400 to 500 feet.

The majority of the watershed consists of well drained to poorly drained sandy soils developed in stony ablation till. These soils are friable and have moderate to rapid permeability. Along the western edge are areas of soil formed in dense till. Approximately 12 percent of the watershed area consists of these slowly permeable soils. A roughly equal area consists of soils formed in water sorted stratified glacial drift (outwash). Most of these soils are located in the City of Cranston portion of the watershed and are devoted to urban uses. Many areas near the river are developed and consist of soils that have been manipulated by humans. Areas of cuts and fills (Udorthents) are common close to the stream channel, especially in the lower portions of the watershed.

Prime Farmland soils: Prime farmland is land that has the best combination of physical and chemical characteristics for producing food, feed, forage, fiber, and oilseed crops and that is available for these uses. It has the combination of soil properties, growing season, and moisture supply needed to produce sustained high yields of crops in an economic manner if it is treated and managed according to acceptable farming methods. In general, prime farmland has an adequate and dependable water supply from precipitation or irrigation, a favorable temperature and growing season, an acceptable level of acidity or alkalinity, an acceptable content of salt or sodium, and few or no rocks.

Map 5 shows the location of Prime and State-wide important farmland soil map units in the Pocasset Watershed. Two methodologies for determining the location and acreage of these soil map units were employed for this study. One method was to use the existing "official" soil survey data and calculate the acreage for the watershed based on that data. The problem with this method is the existing soil survey maps were produced in the 1970's and includes areas where the land use has since changed to urban uses which do not meet the definition of prime farmland. Using this method the acreage of Prime and Important farmland is 1,937 and 624 respectively. The second method was to query the RIGIS 1995 land use maps that were queried to show only the open space related land use classifications, the prime and important soil map units were then re-calculated to show only those areas that may still meet the definition of prime and important soil map units (although the land use maps are still 12 years old). Based on this method the acreage of prime and important soil map units is 675 acres of Prime Farmland soils and 315 acres of State-wide Important soils. Most of the prime farmland soils are located in the NW and western part of the watershed.

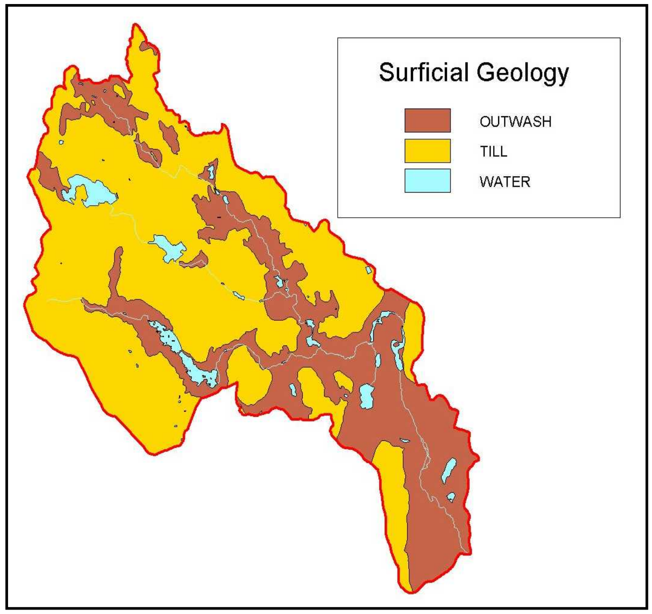
Map 5 - Farmland Classification By Soil and Landuse



2.6 GEOLOGY[7]

All of what is now Rhode Island was once covered by glacial ice sheets several thousand feet thick during the Pleistocene epoch, which began 2.5 to 3 million years ago. As the glacier moved south, it scoured and picked up older glacial deposits, bedrock, and soil. The final deposition of glacial material occurred during the Wisconsin glaciations 10,000 to 12,000 years ago. As the glacier melted and receded, it deposited unconsolidated material consisting mainly of unsorted glacial till and beds of alluvial-sorted sand gravel and silt (glacial outwash). Glacial till is the most extensive of these deposits found in Rhode Island and makes up about 65 percent of the Pocasset River Watershed. Large deposits of outwash located along the Pocasset River and Simmons Brook make up 34 percent of the watershed. .

Map 6 - Surficial Geology



2.7 FORESTRY[8]

While approximately 59 percent of Rhode Island is covered by forest, only about 30 percent of the Pocasset River Watershed is forested. The majority of forested areas in the Pocasset Watershed are found west of the Interstate 295 corridor. The Rhode Island Department of Environmental Management's Snake Den Management Area, consisting of 774 acres, makes up one of the largest blocks of contiguous forest in the Pocasset River Watershed. Commercial forestry is not a major concern when properly managed, but permanent loss of forested cover due to development is a likely contributor to the increased flooding in the watershed.

2.8 STREAM RESOURCES

The Pocasset River begins in the northwestern portion of the Town of Johnston. This area is home to the state-owned Snake Den Management Area and a number of large agricultural operations, resulting in a mostly undeveloped landscape. The river flows southeast through the Town of Johnston until it passes under Interstate 295. From there it flows east along Route 6 and enters the Johnston Memorial Park. It leaves the park flowing to the south under Route 6, then turns to the southeast towards Route 5. The river crosses under Route 5 approximately one-half mile south of Route 6. The river then flows to the south towards the City of Cranston where it flows under Plainfield Street. The river then meanders through the City of Cranston until it reaches the Cranston Print Works. From the Print Works, the river flows to the south until it discharges into the Pawtuxet River just southeast of Pontiac Avenue. The Pawtuxet River flows to the east 1.7 miles and discharges into Narragansett Bay at Pawtuxet Cove.

The Pocasset River has two major tributaries: Simmons Brook and Dry Brook. The Simmons Brook Watershed has an area of 6.9 square miles and is located solely in the

Town of Johnston. It discharges into the Pocasset River just north of Plainfield Street along the border with the City of Cranston. Dry Brook has a watershed area of 3.2 square miles and is located just south of Route 6 in the Town of Johnston. The brook flows east until it enters the Pocasset River just south of Central Avenue and east of Atwood Avenue (Route 5). Both stream channels are relatively narrow and steep.

There are two major man-made impoundments located in the upper reach of Simmons Brook. Lower Simmons Reservoir is 45 acres in size and is located just west of Interstate 295. Upper Simmons Reservoir consists of 50 acres and is located at the upper end of Lower Simmons Reservoir. The reservoirs were constructed around 1840 during the industrial revolution as water supplies for the Cranston Print Works. As the textile industry in New England waned, the dams and their impoundments were turned over to local lake associations or the local municipalities.

Simmons Brook Watershed is also the home of the Rhode Island Resource Recovery Corporation's (RIRRC) State Landfill. RIRRC operates the RI State Landfill and recycling facility. The RIRRC owns approximately 585 acres within the watershed, including a majority of the property surrounding Upper Simmons Reservoir.

There are several man made reservoirs located along Dry Brook. Two of the largest reservoirs are Oak Swamp and Almy. Oak Swamp Reservoir is located in the upper reach of the watershed. It is approximately 111 acres in size and has a drainage area of 1.06 square miles. A majority of the shoreline on Oak Swamp has been developed. Properties initially were most likely summer cottages that were eventually converted to year-round residential housing. The Oak Swamp dam is owned by the Town of Johnston. There is a lake association that oversees its management.

Almy Reservoir, also known as Jillson Reservoir, is 54 acres in size. There are only a few houses located on the shore of the reservoir and they are adjacent to the existing dam. The two reservoirs were built as water supplies for the Cranston Print Works sometime around 1860 and were deeded over to the Town of Johnston around 1960. Currently, both reservoirs are used for recreational fishing and boating.

2.9 WETLANDS[9]

According to the US Fish and Wildlife Service's National Wetlands Inventory, there are 1,822 acres of wetlands in the watershed consisting of:

- 119 acres emergent wetlands
- 1,149 acres forested wetlands
- 303 acres lacustrine open water
- 83 acres of palustrine open water
- 140 acres of scrub shrub wetland
- 28 acres of riverine open water

2.10 CLIMATE[10]

In Rhode Island, the seasons are influenced by the moderating effect of the Atlantic Ocean. In winter, the average temperature is 30 degrees F and the average daily minimum temperature is 20 degrees. The lowest temperature at Kingston on record was minus 18 degrees. The lowest temperature at Providence on record was -9 degrees. In summer, the average temperature is 70 degrees and the average daily maximum is 80 degrees. The highest recorded temperature was 99 degrees.

Total annual precipitation is approximately 43 inches per year. Of this, 22 inches or 45 percent usually falls between April and September, which includes the growing season for most crops. In two years out of ten, the rainfall during this time is less than 18 inches. Total annual precipitation is nearly always adequate for crops commonly grown in this area. The most amount of rainfall on record for one day in Providence is 5.39 inches while 6.48 inches is the highest on record at Kingston. Thunderstorms, most of which occur in summer, on average take place twenty-one days a year.

In winter, the ground is frequently covered with snow. On average, nineteen days have at least one inch of snow on the ground, but the number of such days varies greatly year to year. Average seasonal snowfall is 36 inches.

The average relative humidity in mid-afternoon is about 55 percent. Humidity is higher at night, and the average at dawn is about 75 percent. The prevailing wind is from the southwest. Average wind speed is highest, 13 miles per hour, in April.

2.11 EXISTING FLOOD PLAIN MANAGEMENT

The communities of Johnston and Cranston both have existing ordinances for the regulation of development in "Special Flood Hazard Areas" of flood plains. The Special Flood Hazard Areas are defined by the Federal Emergency Management Agency's Flood Insurance Rate Maps, Flood Hazard Boundary Maps and Floodway Maps for the respective community. The purposed of these ordinances is minimize hazards to persons and damage to property from inland flooding, to protect floodways from encroachment and to maintain the capacity of flood plains to retain and carry off flood waters.

Development within a Special Flood Hazard Area is regulated by both communities. The Johnston ordinance states that 'No water course may be altered in a manner that results in a decrease in the water carrying capacity of the water course and no land will be graded or altered in such a manner as to increase base flood levels within the Town of Johnston during the occurrence of the base flood discharge." Additionally the ordinance states "Within the regulatory floodway no encroachment, including fill, new construction, substantial improvements to an existing structure or other development shall be permitted that will result in any increase in base flood levels within the community…" The City of Cranston's ordinance has similar language and provides the same type of protection

3.0 <u>WATERSHED PROBLEMS AND OPPORTUNITIES</u>

3.1 FLOODING

The major flooding-related problems identified by local governments, community organizations and residents include loss of property value, damage to residential, commercial and industrial properties, increase in local government cost and damage to roads and bridges. Other losses include decreased property value in flood prone areas and loss of potential sites for commercial and industrial development.

Flooding in the Pocasset River Watershed has been a problem since the 1950's, according to residents living within the river's flood plain and newspaper accounts gathered during the initial investigations. In 1979, a storm on January 31 caused "The Great Flood of 79". Local newspapers reported an excess of $900,000 in damages from the flood, with Fletcher Avenue being one of the harder hit sections of the City of Cranston. The fire department had to respond to over 250 water emergencies. In 1982, a storm of just under six inches of rainfall caused some of the most serious flooding in the history of the City.

The City was declared a disaster area by the then Governor J. Joseph Garrahy. There was 1.5 million dollars of damages within the City.

Anecdotal accounts have suggested that the severity and frequency of flooding has increased over the past twenty years. In March 2001, two significant flood events occurred within a ten-day period. The two storms occurred on March 21 and March 30 and had rainfall amounts of 3.11 and 2.88 inches, respectively, as measured at the T.F. Green Airport.

A number of areas have been significantly affected by flooding during these last two floods (see Map 7, Areas of Flooding Concern). Atwood Avenue in the Town of Johnston is impacted just south of the intersection of Atwood Avenue (Routes 5) and Hartford Pike (Route 6) where the Pocasset River passes through a bridge on Route 5. There are eleven properties that were flooded, including a commercial development, which contains a supermarket, a commercial storefront, and several restaurants. Economic losses in this area have included a reduction in business, increased police and fire costs, and direct property damage. Stream bank scouring has occurred, causing business owners to attempt installation of stabilization practices.

Another area impacted by flooding is located at the intersection of Central Avenue and Atwood Avenue, where Dry Brook discharges into the Pocasset River. The FM Global office park is located just northeast of the intersection and outlying buildings owned by FM Global have been flooded. Additionally, the Rotary Drive neighborhood has up to thirteen properties that could potentially be impacted during a major flood event.

Photo 1 - Flooding in commercial district on Atwood Avenue, Town of Johnston

The Morgan Mill Road Industrial Park has experienced instances of severe flooding. There are approximately nine light industrial facilities located in the park. In 1999, flooding caused damage to Morgan Mill Road and the bridge that crosses the Pocasset River and the associated riverbanks. The Town of Johnston requested Emergency Watershed Program (EWP) funding to restore the riverbanks. Funding was provided through NRCS, and a stone revetment was installed. Flooding still occurred in March of 2001 but no damage resulted, (due to the bank being protected from erosion by the revetment). Flooding directly impacts two industrial buildings located adjacent to the Pocasset River even during minor events. The other industrial buildings located here are impacted because Morgan Mills Road is usually closed during storm events.

Map 7 - Flooding Areas

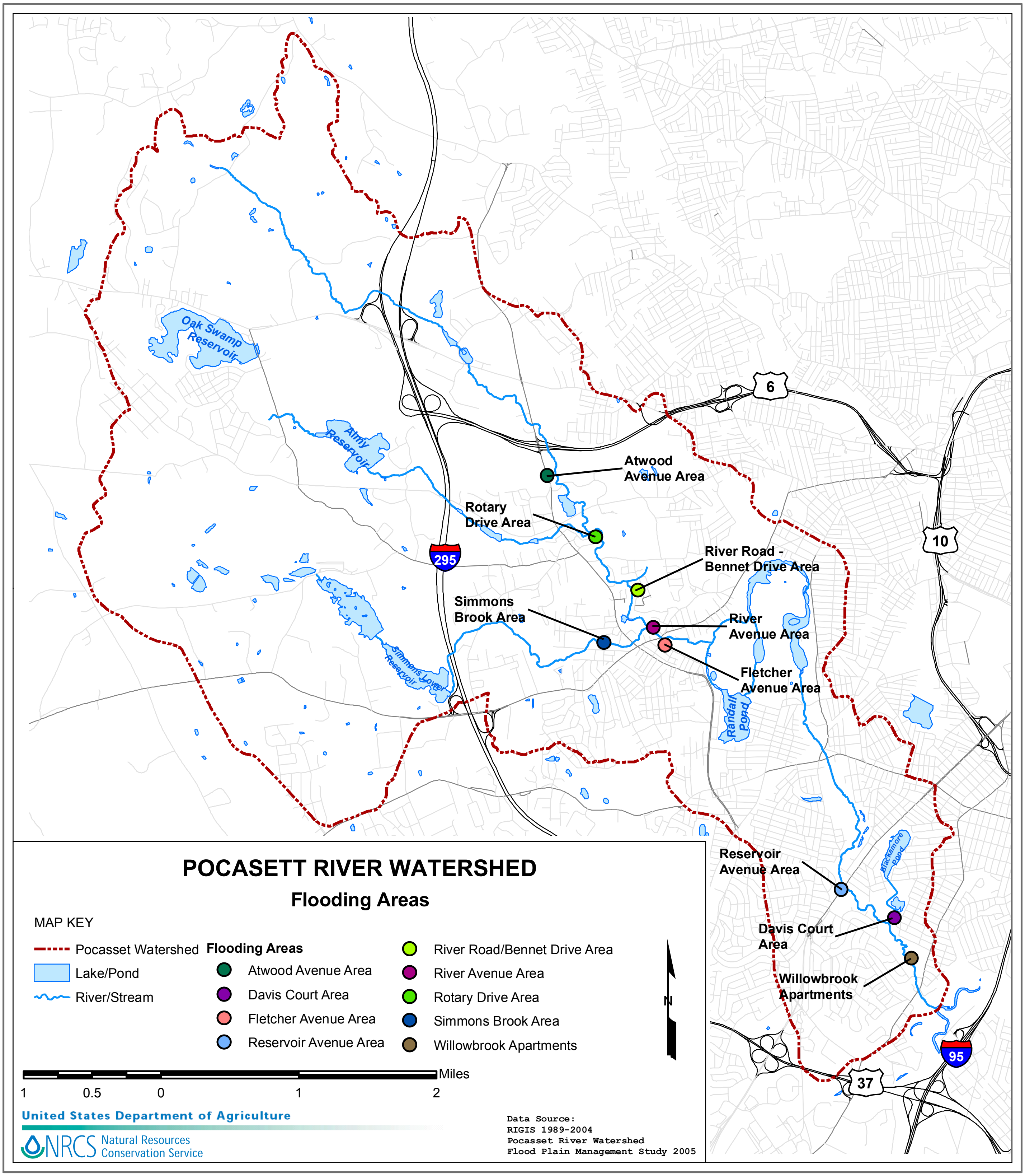


Photo 2 - Flooding at a Mill Complex on Simmons Brook west of Atwood Avenue, Town of Johnston

South of Morgan Mill Road is the residential community made up of River Drive, Melody Lane, and South Bennett Drive. Many of the homes are located adjacent to the River or adjacent to a large flood plain wetland located on the river. In excess of thirty two residential properties can be impacted during a storm event. Additionally, Park Place Apartments across the river experience frequent flooding. There are 78 residential units in this development. The floods of 2001 caused significant damage to these areas including loss of property and riverbank erosion resulting in substantial cleanup costs.

Photo 3 - Flooding in the River Avenue and Bennet Drive Neighborhoods, Town of Johnston

South of the River Drive community is River Road, located on the Cranston-Johnston border adjacent to the intersection of Route 5 (Atwood Avenue) and Route 14 (Plainfield Street). This is the area where Simmons Brook enters the Pocasset River. Flooding causes significant impacts to both commercial and residential properties located in the area adjacent to River Road, as well as properties located along Simmons Brook. There are three residential and three commercial properties impacted during storm events. Losses from the 2001 floods included: damage to residential properties; loss of industrial materials; stream bank erosion; clean up costs; and loss of production time. At least one industrial mill complex located on Simmons Brook still has vacant areas due to previous flood damage.

Flooding in 2001 was severe enough in this area to cause stream bank erosion along Simmons Brook. Again, the Town of Johnston applied for EWP assistance through NRCS. A portion of Simmons's Brook adjacent to St. Rocco's parking lot needed to be stabilized and construction was completed in October of 2002.

Photo 4 - Flooding of Residential Property on River Road, Town of Johnston

The most impacted area along the Pocasset River is Fletcher Avenue located in City of Cranston just south of Plainfield Street. There are thirty two commercial and industrial properties affected during major flood events. The area is a mixture of industrial, commercial, and residential properties. There are many varied operations in the industrial park including: a food processing company, the City of Cranston school bus garage, auto body shops and polishing operations. The industrial park is located within the flood plain of the Pocasset River. This area sustains some of the highest losses due to flooding. Losses include property damage, temporary loss of housing, loss of business, loss of wages and loss of development potential.

Photo 5 - Flooding in industrial area of Fletcher Avenue, City of Cranston

The last area on the Pocasset River with significant flooding problems is located just upstream of Reservoir Avenue and extends to Pontiac Avenue. The area is made up of a number of streets including: Knollwood Avenue, Davis Court, Myrtle Street, Autumn Street, and Sheridan Street. There are 45 homes, 216 apartments and 9 commercial buildings that can be impacted by flood events. These neighborhoods are mainly residential with some commercial property along Reservoir Road damages include: damage to buildings; loss of personal items; increased police and fire assistance; and cleanup cost. The periodic flooding also decreases property values.

There are other areas within the watershed where flooding causes damages. While these areas are not highlighted here, they will be included in the final plan for flood mitigation.

3.2 WATER QUALITY[11]

The Pocasset River starts in the Snake Den State Park located in the Town of Johnston, RI. The river meanders through rural land in the headwaters, then through suburban and highly urbanized regions until its confluence with the Pawtuxet River. Although water quality throughout the river has not been thoroughly characterized, it is influenced by stormwater runoff from paved residential areas, industrial sites, and highways. In addition, the state's Central Landfill is located on a tributary to the Pocasset River.

Leachate from the landfill to the nearby tributary has been a concern for a number of years and is being addressed under the federal Superfund Program. Groundwater and surface water in the area are being monitored quarterly under the Record of Decision.

In 1989, Rhode Island Department of Environmental Management (RIDEM) contracted the US Geologic Service to conduct sampling at 13 river stations throughout the state. The Pocasset River was sampled at one station on two dates, September 22, 1989 and November 30 1989, for this project. Physical water quality parameters (DO, temperature, pH, hardness), bacteria (fecal coli form), nutrients and metals were analyzed. This study indicated that the river had bacteria levels that exceeded the swimming criteria.

In 1990, the three communities along the Pawtuxet River (West Warwick, Warwick, and Cranston) contracted Applied Science Associates to characterize selected water quality parameters within the Pawtuxet River as part of the facilities planning studies for the upgrades at the wastewater treatment facilities.

The mouth of the Pocasset River at Pontiac Avenue was sampled during this study. During this project, analyses were conducted for total and dissolved metals, nutrients, and physical water quality parameters. Results indicated exceedances of total copper and total lead criteria and elevated nitrate levels.

From November 1993 to December 1994, the River Rescue project conducted a water quality monitoring study of the Pawtuxet River. The mouth of the Pocasset River at Pontiac Avenue was sampled monthly under this study. The River Rescue project was a collaborative effort between Citizens Bank, the University of Rhode Island, the Coastal Resources Center, and the Rhode Island Sea Grant. The project was designed to collect water quality data on the urban rivers in the Providence area using trained citizen volunteers as field scientists. Physical parameters and total metals were analyzed under the Pawtuxet River Monitoring Project. Results of this study indicated exceedances of total copper and total lead criteria in the Pocasset River.

The water quality data collected from the studies detailed above were used to list the Pocasset River as impaired for bacteria, total copper and total lead on Rhode Island's 1994, 1996, and 1998 List of Impaired Waters. Under Section 303(d) of the Clean Water Act, states are required to identify waters for which existing required pollution controls are not stringent enough to achieve State water quality standards. These waters are referred to as water quality limited or impaired. Once a waterbody is identified as impaired, Section 303(d) requires that water quality restoration plans, also known as Total Maximum Daily Loads (TMDL), be developed for each pollutant causing the impairment. These restoration plans describe the non-point source and point source pollution controls necessary for the waterbody to meet water quality standards.

In 1998, the TMDL Program in RIDEM's Office of Water Resources conducted a monitoring project of waterbodies that were listed as impaired for total metals. Since the state had recently adopted water quality criteria for dissolved metals, the more bio-available form of metals, it was necessary to determine if each of these waterbodies was actually impaired and exceeding the new dissolved metals criteria. The TMDL staff monitored the Pocasset River at Pontiac Avenue in September, November and December 1998 and April and July 1999. The samples were analyzed for dissolved copper and lead. The data showed no violations of dissolved copper criteria, but three out of the five samples exceeded the chronic dissolved lead criteria. The results of this study were used to remove dissolved copper from the list of impairments on the Pocasset River.

The Pocasset River remains on Rhode Island's 2002 List of Impaired Waters for bacteria (fecal coliform) and dissolved lead. The river is currently targeted for development of a water quality restoration plan for these pollutants in 2008-2012. Regular monitoring on the Pocasset River and all waters of the state will be addressed in the statewide Monitoring Strategy that is currently under development.

3.3 CULTURAL RESOURCES

Background file searches and preliminary field investigations were conducted for the watershed area. The historic background and file search was conducted at the Rhode Island State Historic Preservation Office (SHPO) and the Rhode Island Historical Society. The research discovered that no historic properties listed on or eligible for listing on the National Register of Historic places are known to exist within the "Area of Potential Effect" (APE) for the potential mitigation alternatives. There are known archaeological sites and historic properties within the watershed but none are within the APE and would not be affected by potential mitigation alternatives.

Much of the APE is in heavily disturbed urban area that has a low potential of finding any intact buried archaeological materials. The area along and within the river channel has seen heavy disturbance from construction and the likelihood of intact deposits in this area is very remote. This holds true for the areas to be impacted by the proposed dikes, as they are in areas of heavy urban construction and these areas have been altered.

The areas to be impacted by the proposed dike would be looked at more closely if the dike alternative becomes the selected alternative. At that time, NRCS in consultation with the SHPO will decide what, if any, affected areas may need further cultural resources field investigations.

3.4 RECREATION

Recreation along the Pocasset River is primarily limited to fishing. Most of the river is not accessible for canoeing or kayaking. Because there is limited access to the river, there is little or no hiking along the river. There are some opportunities for hiking and bird watching in the Snake Den Management Area that is located in the northwestern portion of the watershed. Oak Swamp Reservoir is used for fishing and recreational boating, while limited fishing takes place in Almy Reservoir that is located east of Oak Swamp on Dry Brook. Recreational fishing also takes place in both Upper and Lower Simmons Reservoirs.

There are opportunities for cycling in the watershed. Recently the new Washington Secondary Bike Path was completed by Rhode Island Department of Transportation. The bike path travels through Cranston, West Warwick, and Coventry. It also connects with the Providence Bike Path.

3.5 WILDLIFE

The Pocasset River and its associated riparian corridor provides significant wildlife habitat throughout the watershed. There is also significant wildlife habitat provided by all the reservoirs and impoundments found throughout the river and its tributaries.

Observations during field inventories indicate an abundance of wildlife in the shallow wetlands within the Pocasset River, Cranston Print Works Pond, Upper and Lower Simmons Reservoirs, Almy Pond and Pocasset Pond. Wading birds such as great blue herons, green herons, and egrets are somewhat common in the spring, summer, and fall.

Waterfowl such as wood ducks, mallards, and other dabblers are sometimes found in abundance in the shallow wetland areas surrounding the impoundments. Muskrats are also common in these areas.

Terrestrial wildlife is quite common in the uplands surrounding the river and its impoundments. Throughout the City of Cranston and Town of Johnston, the river and surrounding uplands is the only significant habitat found in the commercial, residential, and industrial areas.

Consultation with the U.S. Fish and Wildlife Service in Concord, New Hampshire indicated that no federally-listed endangered or threatened species under their jurisdiction were known to occur in the watershed area. The Rhode Island Department of Environmental Management Natural Heritage Program indicated only one State Endangered species (Wild Clematis) is located in the northern portion of the watershed.

3.6 FISHERIES[12]

The Pocasset River is used by the public extensively as a recreational warm water fishery. The main river, its tributaries, and associated reservoir are all fished. Data collected by the RIDEM indicates a variety of fish species inhabit these waters. Fish species collected include long nose dace, white sucker, American eel, red fin pickerel, bluegill, and golden shiner. Large mouth bass, perch, and other species are found in the reservoirs located throughout the watershed. During collection of engineering survey data for development of the hydrology and hydraulic models, NRCS staff encountered local citizens fishing in the reservoirs. Residents indicated that they fish in both the river and the reservoirs, and some eat the fish.

There is potential for restoration of anadromous fisheries in the Pocasset River. Anadromous fish that would be targeted for restoration are blue back herring, alewives, and chad. Successful restoration of these fisheries in the Pocasset River is solely dependent on restoration of fish passage on the lower Pawtuxet River. Currently, access to the Pawtuxet River by anadromous fish is not possible because of the dam located at the confluence with Narragansett Bay in Pawtuxet Village. The RIDEM, in partnership with the Pawtuxet River Authority, National Oceanic and Atmospheric Administration, United States Fish & Wildlife Service (USFWS), Save the Bay, NRCS, Environmental Protection Agency and other agencies, is working to provide passage through the lower Pawtuxet dam.

Once this passage is completed, anadromous fish will have access to the Pocasset River up to the Cranston Print Works' dam. This will open up approximately three river miles of potential spawning area or beyond if modifications to the dam are made.

3.7 WETLANDS

Wetlands perform a number of significant functions and values to communities. Wetlands slow the flow of storm water by temporarily storing and slowly releasing it downstream. When a wetland is eliminated, storm water moves faster, increasing the amount and duration of flooding. This raises the potential for damages to both life and property downstream from the loss. Wetlands provide sediment removal, as well as chemical and nutrient absorption. Wetland plants play a large role in that they utilize excess nutrients for growth, as well as some other potentially harmful substances. These issues are important to this watershed in particular, considering that the Rhode Island Resource Recovery Landfill is upstream of a large community of people. Wetlands are valuable habitat for wetland dependent wildlife species like amphibians, reptiles, various kinds of songbirds and waterfowl, as well as some upland species like white tailed deer, raccoons, rabbits, and squirrels. Wetlands provide recreational opportunities such as fishing, hiking, photography, boating, hunting, skating, and general exploring. They provide educational opportunities for nearby schools.

In the Pocasset River Watershed, the most important function in relation to this study is floodwater retention and attenuation. The destruction and alteration of wetlands throughout the watershed over time has had a significant negative impact on the degree and duration of flooding.

According to the National Wetlands Inventory produced in 1975 by the USFWS, there are 1,822 acres of wetland in the 13,200 acre Pocasset River Watershed. This was determined by photo interpretation in 1978 using the definition stated in Cowardin et al. (1979). There are 119 acres of emergent/wet meadow wetlands, 1,149 acres of forested wetlands, 303 acres of lacustrine open water, 83 acres of palustrine open water, 140 acres of scrub shrub wetland, and 28 acres of riverine open water.

A current issue, as well as from the past, is the loss of wetland due to filling and draining for development. Various neighborhoods, as well as shopping centers, business and roads, have encroached on the wetlands year after year. The construction of Interstate 295, the Rhode Island Resource Recovery Landfill and the continuing commercialization of the Town of Johnston and the City of Cranston are all large contributors to the wetland loss.

In 2001, NRCS conducted a study to determine the estimated loss of freshwater wetlands in the Pocasset River Watershed. The goals of the analysis were to quantify the impact of wetland loss on flooding and the potential for incorporating wetland restoration projects into the flood mitigation plan. Methods used included aerial photo interpretation (1939, 1970, and 1997 photos) analysis of National Wetlands Inventory maps, analysis of the Soil Survey of Rhode Island and various field techniques.

NRCS found that a significant amount of wetland acreage has been lost. Since 1939, there has been a net loss of 537 acres of wetlands. There were 419 acres lost between 1939 and 1970 and 188 acres between 1970 and 1997, for a total of 607 acres, representing a 25 percent loss of the 2,409 acres of wetland existing in 1939. Forested wetlands suffered the largest loss of 488 acres, or 20 percent of the wetlands present in 1939. There were approximately 70 acres of wetlands created during the same period (1939-1997). The increase was primarily due to alterations caused by development adjacent to or within natural wetland areas, such as the impoundment of existing streams or riverine wetlands where roads or highways were constructed. In some areas, increased impervious areas have increased runoff and altered the moisture regime of the wetland.

4.0 HYDROLOGY AND HYDRAULICS

The goal of this study is to determine the extent and severity of flooding within the Pocasset River Watershed, develop new flood plain maps for the Pocasset River, and developed potential alternatives that will reduce damages due to flooding. To accomplish these tasks, NRCS has developed two computer models that simulate the Hydrology and Hydraulics within the Pocasset River Watershed, the River and its flood plain. The hydrology model determines how much runoff comes from the watershed during a rainfall event and gets into the river. The hydraulic model determines how the water flows in the River and its associated flood plain. The hydraulic model results will be used to develop the flood plain maps. A detailed explanation of the "Hydrology and

Hydraulics can be found in the Pocasset River Flood Plain Management Study "Technical Report" that was released as part of this study.

4.1 HYDROLOGIC ANALYSIS

The hydrologic analysis for the Pocasset River was completed using the NRCS TR-20 (Technical Release-20) model. The model was used to determine peak runoff for each sub-area within the watershed. The model can determine volume of runoff from each sub-area, develop a runoff hydrograph for each sub-area, and route the runoff hydrograph through the stream's reaches and reservoirs.

The watershed was originally divided into 12 sub-areas (Map 8) but was later divided into 25 areas (Map 9) to refine the model. The sub-areas were chosen based on similar land use, topography and a definable outlet. SCS Runoff Curve Number (CN) method was used to represent runoff from each individual sub-area. A CN was developed for each sub-area. The major factors that determine CN are hydrologic soil group (HSG), cover type, treatment, hydrologic condition, and antecedent moisture condition. Travel time (Tt) and time of concentration (Tc) was computed for each sub-area. Tt is the time it takes for water to travel from one location in the sub-area to another. Tt is a component of Tc that is the time for runoff to travel from the hydraulically most distant point of the watershed to a point of interest. The TR-20 model was used to route runoff hydrographs through structures and reservoirs within the watershed. Surveying data was collected by NRCS engineering staff to develop stage-storage discharge relationships for each structure or reservoir. Reservoirs that were routed include Oak Swamp Reservoir, Almy Reservoir, Pocasset Pond, Upper Simmons, Lower Simmons, and Cranston Print Works Pond.

TR-20 provides as output: volume of runoff, peak discharge at various points in the watershed, hydrographs of either discharge or elevation versus time for structures; and many other pieces of related information. The peak discharges are used in the US Army Corps of Engineer's Hydrologic Engineering Center River Analysis System (HEC-RAS) hydraulics program to calculate water surface elevations. TR-20 can provide some water surface elevations but the backwater profile provided by HEC-RAS is more accurate since it is based on actual survey data and not on representative stream reaches.

4.2 HYDRAULIC ANALYSIS

The HEC-RAS model was used to perform the hydraulic analysis of the Pocasset River and its tributaries to estimate the water surface elevation for the selected storm intervals. The depth of flooding will be used to develop new flood plain maps and determine average annual damages for the watershed.

Originally, information for the hydraulic model was taken from the Flood Insurance Study (FIS) for the City of Cranston, RI (Community Number 445396) and the FIS for the Town of Johnston, RI (Community Number 440018). Model geometry from the two FIS were from HEC-2 and Water Surface Profile (WSP-2) input files and from surveys performed by the Rhode Island staff during January through and April 2001. No evidence was located in the text for the above flood insurance studies that indicates either model was calibrated with any known or observed high water marks.

In 2001 and 2002, a contract was let to secure aerial flight data in the form of a digital terrain model (DTM) of the watershed. The original hydraulic model geometry described above was abandoned in favor of a hydraulic model developed using the recent DTM in conjunction with computer technology (ArcView GIS 3.2, HEC-RAS version 3.1.1) that would enable the presentation of flood inundation mapping of the watershed. Survey information completed by the Rhode Island staff in 2001 was also used in this model to enhance the geometry presented at bridge and culvert crossings as well as to verify and adjust the channel bottom elevations of the data extracted from the DTM. The geometry used from the aerial flight data did not extend below the surface of the water.

Very limited data was available for the hydraulic calibration of the HEC-RAS model. The rainfall distribution for the storm of record dated 21-22 March 2001 was run through the TR-20 program and the subsequent flow values were input into HEC-RAS. The storm of record was from the Providence, R.I. Airport, WBAN # 14765 (cumulative total equals 2.59 inches) and was adjusted hourly by RIBCON OBSERVERS DAILY PRECIPITATION MARCH 2001 where the Johnston, R.I. gage recorded 0.31 inch and 3.11 inches for the 21st and 22nd March 2001 respectively. High-water marks were surveyed from where the Pocasset River splits upstream of the Pocasset Cemetery in the City of Cranston to a point in the Town of Johnston near the Morgan Street Bridge. Two points were also surveyed in Simmons Brook and two upstream of the Garden City Bridge and 1 point near the Pontiac Ave. Br. in the lower reach of the Pocasset River (Cranston Lower Reach). The survey was conducted based upon photographic evidence and, uncertainty exists as to whether the water was in recession at the time of the survey and whether the high water marks in some cases were influenced by sources such as obstructions rather than the high water of the Pocasset River.

At most of the locations where water marks were surveyed, the computed water surface is within one-half foot of the storm of record and quite closer in many cases. At the locations on Simmons Brook, the difference is larger. This difference may be due in part to an erroneous location in the HEC-RAS model of the high water mark as well as the uncertainty of the timing when the water stage was measured. During the flood event used to calibrate the HEC-RAS model, the R.I. staff observed a blockage comprised of trees and debris downstream of the high water mark. Blockages are not typically included in hydraulic modeling and are not part of the final model. The model was rerun to simulate the blockage and results showed that the computed water surface elevation closely agreed with the observed high water mark.

4.3 MODEL RESULTS

The following tables show existing and future flooding conditions for various locations in the watershed:

Table 1 - Peak Discharge, Present Condition

	Peak Discharge (CFS) for Recurrence Interval			
Location	**2 Yr**	**10 Yr**	**100 Yr**	**500 Yr**
Atwood Ave.	152	401	832	1091
Route 6	152	401	831	1090
Central Ave.	286	547	1068	1395
Morgan St.	307	585	1038	1316
Morgan Mill	394	748	1249	1573
Plainfield Pike	580	1126	1926	2846
Print Works Dam	394	827	1774	2618
Print Works Crossing	494	949	1814	2666
Haven Ave.	509	969	1814	2680
Dual Arch Bike Path	521	985	1827	2693
Dyer Ave.	525	976	1842	2715
Park Ave.	538	988	1844	2719
Reservoir Ave.	550	1005	1847	2723
Garden City	676	1243	2116	2733
Pontiac	745	1278	1860	2735
Outlet Dry Bk.	62	159	334	458
Outlet Simmons Bk.	447	948	1787	2340

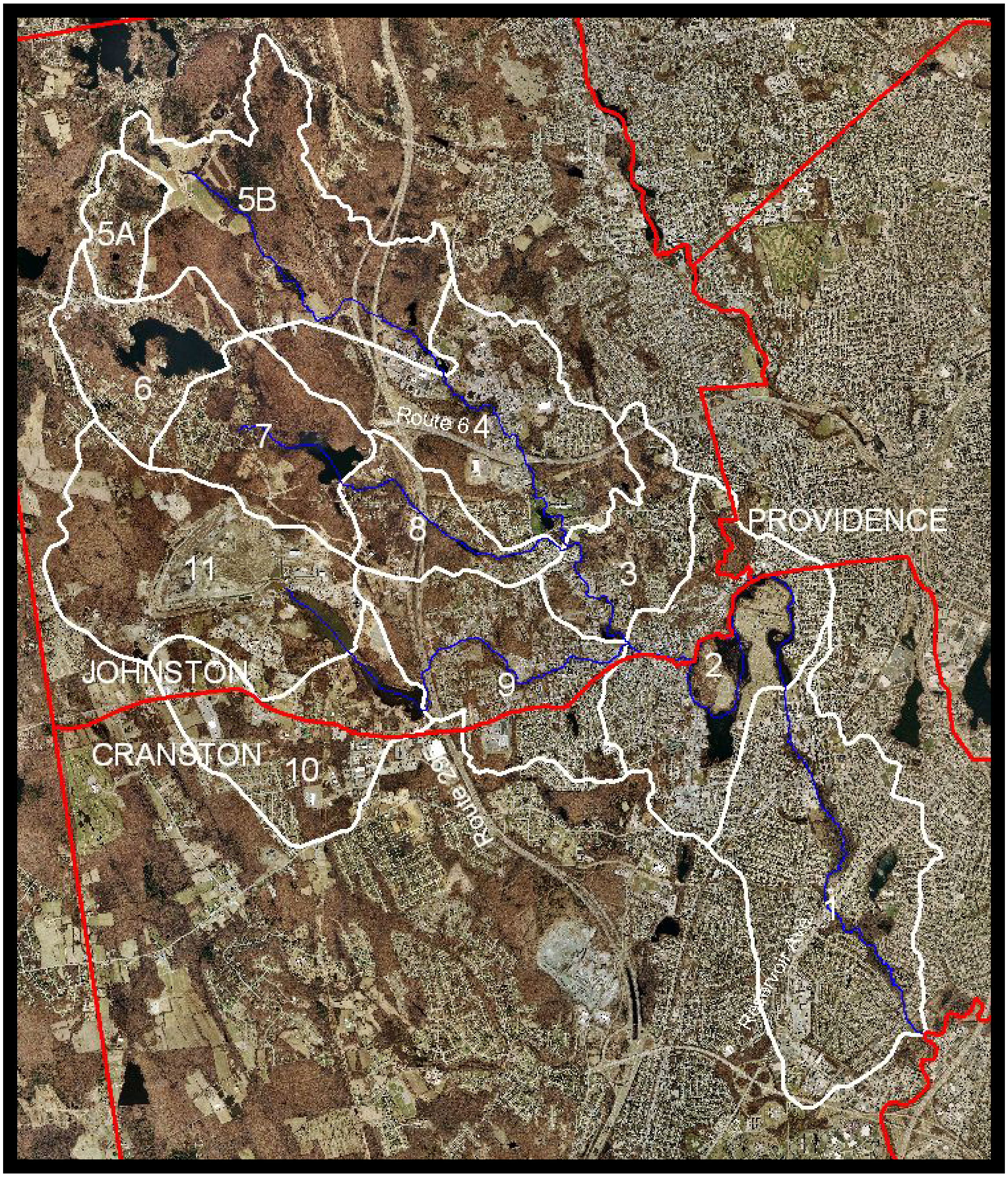
Table 2 - Peak Discharge, Future Condition

	Peak Discharge (CFS) for Recurrence Interval			
Location	**2 Yr**	**10 Yr**	**100 Yr**	**500 Yr**
Atwood Ave.	344	640	1027	1346
Route 6	344	640	1027	1345
Central Ave.	447	660	1328	1695
Morgan St.	468	691	1264	1606
Morgan Mill	592	887	1470	1864
Plainfield Pike	783	1292	2419	3312
Print Works Dam	546	1022	2243	3091
Print Works Crossing	564	1052	2284	3154
Haven Ave.	568	1058	2292	3164
Dual Arch Bike Path	572	1063	2299	3174
Dyer Ave.	583	1076	2312	3183
Park Ave.	585	1078	2314	3188
Reservoir Ave.	586	1080	2316	3192
Garden City	718	1284	2370	3180
Pontiac	779	1306	2268	3074
Outlet Dry Bk.	100	216	412	543
Outlet Simmons Bk.	589	1138	2019	2586

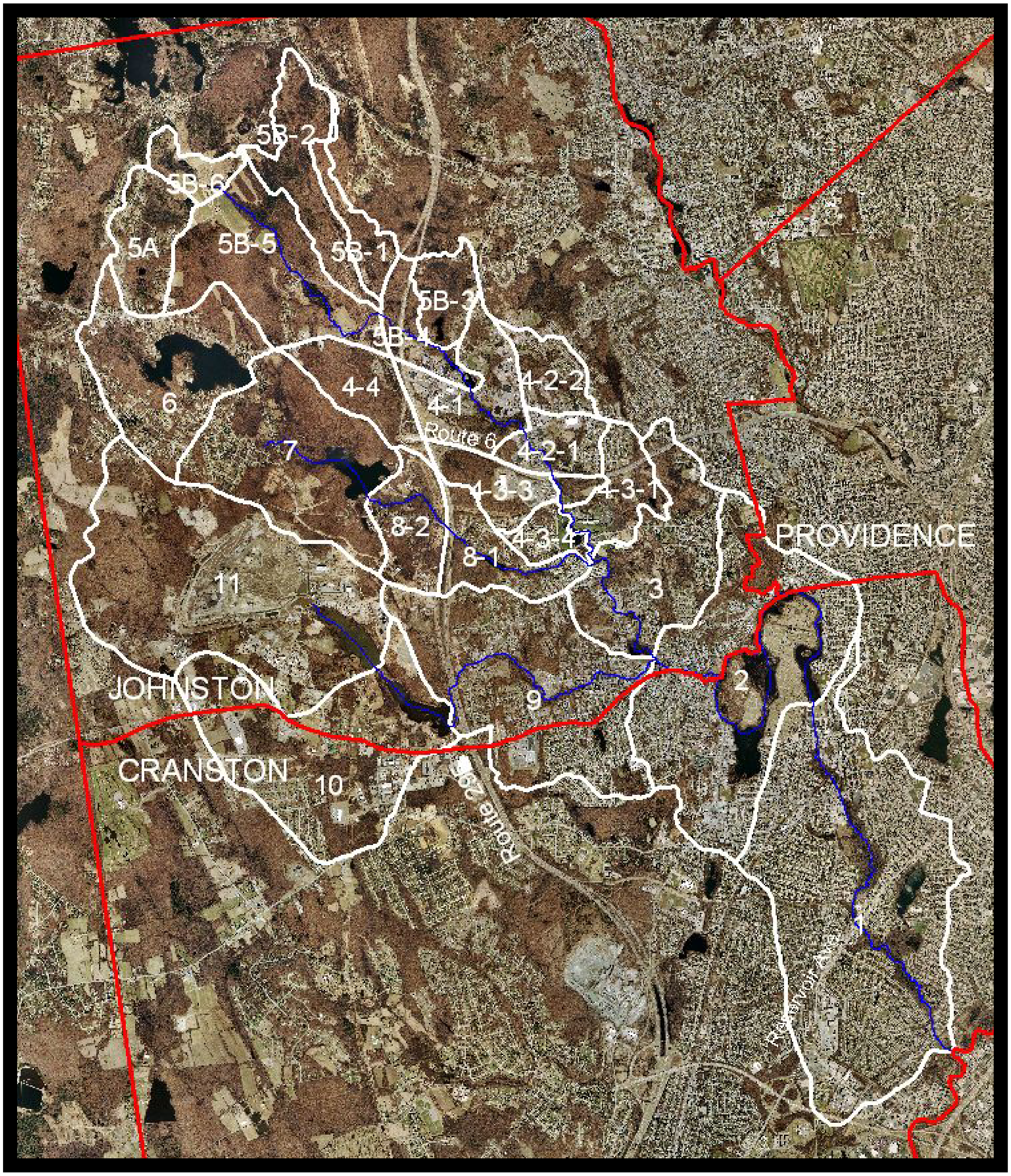
Table 3 - Volume of Runoff Passing Each Channel Location

	Volume of Runoff Passing (acre-ft)	
Location	**100 Yr Present**	**100 Yr Future**
Atwood Ave.	575	697
Route 6	709	841
Central Ave.	868	1035
Morgan St.	1524	1809
Morgan Mill	1566	1855
Plainfield Pike	2998	3495
Print Works Dam	3649	4124
Print Works Crossing	3681	4156
Haven Ave.	3710	4186
Dual Arch Bike Path	3789	4266
Dyer Ave.	3792	4282
Park Ave.	3816	4294
Reservoir Ave.	4114	4598
Garden City	4388	4879
Pontiac	4408	4899
Outlet Dry Bk.	613	729
Outlet Simmons Bk.	1351	1543

Map 8 - Initial Study Sub Areas (12 Sub Areas)



Map 9 - Final Study Sub Areas (25 Sub Areas)



5.0 FORMULATION AND DEVELOPMENT OF FLOOD MITIGATION OPTIONS

5.1 FORMULATION PROCESS

The formulation process is used to determine potential options that may or may not mitigate flooding within the watershed. The goal of the process is to develop a comprehensive list of options. The formulation process is a public process by which information regarding flooding throughout the watershed is collected to determine the extent of the problems. The local communities, residents and businesses were encouraged to participate in the initial formulation process. These participants provided information on the location and severity of flooding, potential causes of flooding and possible alternatives that could be investigated. NRCS also collected information from landowners to determine what types of alternatives may be acceptable to individual landowners or groups of landowners. As an example, businesses located in the Fletcher Avenue Industrial Park were not opposed to buy outs if they could possibly find similar facilities in the local area. They also indicated that installation of floodwalls would also be acceptable and that some may be willing to provide easements on the land needed. The information collected was used to develop an initial list of potential alternatives.

The list of options were developed with input from personnel from the Natural Resources Conservation Service (NRCS) National Water Management Center, the NRCS New England Interdisciplinary Resource Technical Team, the NRCS Rhode Island State Engineer, and planning staff from NRCS offices in Rhode Island, New Jersey, and New York. Once the initial list was developed, the potential alternatives were sent for review to the Rhode Island Department of Environmental Management, Rhode Island Emergency Management Agency, United States Environmental Protection Agency, United States Army Corps of Engineers and the United States Fish and Wildlife Service. These agencies were given a tour of the watershed so they would understand the severity of the flooding. Additional alternatives were suggested by some of the agencies and these were added to the list. As this study goes into the Watershed Plan development phase, additional scoping meetings will be held to begin development of the Environmental Impact Statement. Alternative mitigation plans included in any future Watershed Plan developed for the Pocasset River may be a combination of the various alternatives suggested below.

5.2 ALTERNATIVES EVALUATED

During the formulation process, some degree of evaluation was provided for the following alternatives:

- No Action Alternative
- Voluntary move, flood proofing, or Property Acquisition
- Redesign and rebuild existing industrial reservoirs for flood retention
- Floodwalls or dikes
- Restore watershed wetlands
- Stormwater basins
- Bridge/road modifications, and floodway installation
- Channel modification (dredge the channel)
- Flood plain ordinances and Stormwater management
- Early flood warning system.

5.3 MINIMUM STANDARDS TO BE ACHIEVED

Preliminary data were developed for each alternative. NRCS staff held a number of formulation meeting and field tours throughout the development of the "Flood Plain Management Study" between 2001 and 2004. NRCS staff was present during the storm events on March 21, 2001 and March 30, 2001. Both events resulted in significant flooding outside of the undeveloped areas of the flood plain and caused significant damages within the watershed. Based on the in field experience, input from the public and the extensive time spent working within the watershed on the project, an initial list of alternatives were developed. Each alternative was considered alone and in various combinations in an effort to meet the sponsor's and the public's objectives. Alternatives were developed that would maximize flood damage reductions using the 100-year flood conditions based on the existing "Comprehensive Land Management Plans" for the Town of Johnston and City of Cranston.

The 100-year flood was selected in the formulation process because it is consistent with the communities' objectives. A 100-year evaluation period is being used because this is the planned life expectancy and minimum engineering standard for many of the improvements being considered. Using the 100-year storm event addresses the criteria used in the National Flood Insurance Program, Federal Emergency Management Agency programs, and flood plain ordinances. The Natural Resources Conservation Service interim standard "Flood-Proofing Measure" being reviewed by the RI Emergency Management Agency is based on the 100-year event. Other floods, of greater or lesser intensity, may also be considered in the formulation of reasonable alternatives for any future Watershed Plan.

Alternatives recommended in any future PL 83-566 Watershed Plan will have to meet the following four general tests as outlined in the Water Resources Council's Economic and Environmental "*Principles and Guidelines* "(P&G) (1983):

1. ***Completeness*** **–** the extent to which a given alternative plan provides and accounts for all necessary investments or other actions to ensure realization of the planned effects.
2. ***Effectiveness*** – the extent to which an alternative plan alleviates the specified problems and achieves the specified opportunities.
3. ***Efficiency*** **-** the extent to which an alternative plan is the most cost effective means of alleviating the specified problems and realizing the specified opportunities, consistent with protecting the Nation's environment.
4. ***Acceptability*** **–** the workability and viability of the alternative plan with respect to acceptance by State and local entities and the public and compatibility with existing laws, regulations and public policies.

5.4 DETAILS OF ALTERNATIVES

The Natural Resources Conservation Service is recommending that the following list of alternatives be further investigated if the Sponsors agree to go forward with development of a full Watershed Plan for the project. Development of the full Watershed Plan will include analyzing the impacts of the alternative using the Technical Release 20 (TR-20) developed by the NRCS and HEC-RAS developed by Army Corps of Engineers (ACOE) hydrology and hydraulics computer models. Preliminary estimates of the costs of the alternatives and a cost benefit analysis to determine if the alternatives are justifiable will be analyzed using the ACOE Flood Damage Analysis (HEC-FDA) model.

(POTENTIAL ALTERNATIVES ARE NOT LISTED IN ANY PREFERENTIAL ORDER)

5.4.1 NO ACTION ALTERNATIVE

This alternative represents conditions that will prevail and become increasingly pervasive if no steps are taken to reduce flood damages. In fact, the future or build-out computer model, which utilizes the comprehensive plans for each community, shows a significant increase in flooding if development continues according to these plans. Indications are that this development trend will occur and is occurring at an increasing rate.

The increase in flood level from present to future build-out conditions for various cross sections along the river are shown in the following table.

Table 4 – Headwater Elevations, Present Condition

		Headwater Elevation ft (NAVD 88)				
Location	**Station**	**Channel invert**	**2 Yr**	**10 Yr**	**100 Yr**	**500 Yr**
Atwood Ave.	42,872.41	119.7	122.4	125.0*	125.8	126.1
Route 6	41,834.10	113.2	116.3	119.6	122.9	123.7
Central Ave.	37,864.17	93.9	99.8	101.3	103.1	103.4
Morgan St.	34,783.68	87.8	93.2	95.4	98.0	99.5
Morgan Mill	33,493.92	77.0	85.2	86.3	87.1	87.5
Plainfield Pike	29,814.77	70.0	77.4	79.7	84.0	85.4
Print Works Dam	17,476.61	62.0	66.7	67.2	68.2	69.0
Print Works Crossing	16,680.42	44.2	50.5	52.4	53.5	55.0
Haven Ave.	16,124.49	43.1	47.8	49.3	51.4	53.7
Dual Arch Bike Path	14,486.61	36.9	42.8	44.7	47.2	50.3
Dyer Ave.	14,105.5	36.4	41.1	42.7	45.1	48.7
Park Ave.	13,682.40	32.6	39.3	40.7	42.7	46.0
Reservoir Ave.	7668.66	19.8	26.1	27.6	30.9	31.9
Garden City	1685.30	11.0	19.3	21.7	25.9	27.4
Pontiac	1161.72	8.6	17.3	19.9	22.2	23.2
Confluence Dry	36,623.31	91.7	95.3	96.5	98.6	100.0
Confluence Simmons	30,433.19	73.3	78.1	80.0	84.1	85.5

*Shading indicates flow over the road

Map 10 - Selected Station Locations

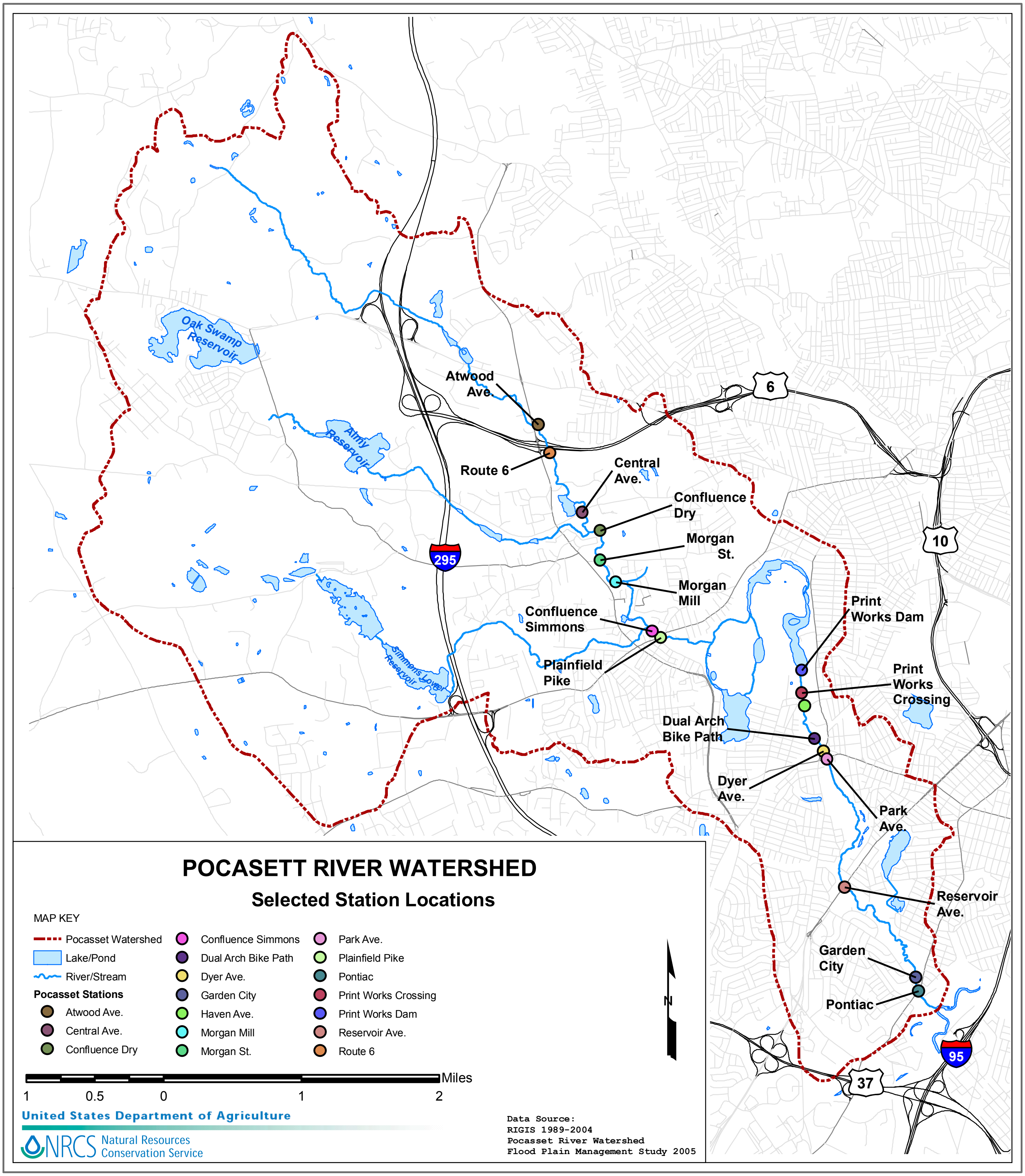


Table 5 – Headwater Elevations, Future Condition

		Headwater Elevation (NAVD 88 ft.)				
Location	**Station**	**Channel invert**	**2 Yr**	**10 Yr**	**100 Yr**	**500 Yr**
Atwood Ave.	42,872.41	119.7	124.8*	125.5	126.1	126.3
Route 6	41,834.10	113.2	118.9	121.9	123.6	124.4
Central Ave.	37,864.17	93.9	100.5	102.3	103.3	103.6
Morgan St.	34,783.68	87.8	94.2	96.3	99.2	100.6
Morgan Mill	33,493.92	77.0	85.9	86.5	87.4	87.8
Plainfield Pike	29,814.77	70.0	78.3	80.3	85.0	85.8
Print Works Dam	17,476.61	62.0	66.8	67.4	68.7	69.2
Print Works Crossing	16,680.42	44.2	50.9	52.5	54.1	56.0
Haven Ave.	16,124.49	43.1	48.0	49.7	53.2	55.5
Dual Arch Bike Path	14,486.61	36.9	43.1	45.0	48.7	51.1
Dyer Ave.	14,105.5	36.4	41.3	43.1	46.8	49.1
Park Ave.	13,682.40	32.6	39.5	40.9	45.2	47.1
Reservoir Ave.	7668.66	19.8	25.9	27.5	31.9	33.4
Garden City	1685.30	11.0	19.7	22.0	26.7	28.1
Pontiac	1161.72	8.6	17.7	20.1	22.7	23.3
Confluence Dry	36,623.31	91.7	96.0	97.1	99.6	101.0
Confluence Simmons	30,433.19	73.3	78.8	80.6	85.1	85.9

*Shading indicates flow over the road

5.4.2 VOLUNTARY MOVE, ELEVATE, FLOOD PROOF, OR VOLUNTARY BUYOUT (NON STRUCTURAL MEASURES)

Nonstructural measures can consist of individual property flood proofing, property elevation or property removal and are used in place of structural measures. They are measures implemented to protect an individual property. The level of protection (flood proofing or elevating versus removal) is determined by the location of a specific property and whether it is located in a High Hazard Area (HHA). The HHA criteria are determined by the Local Sponsors and are usually based on the Flood Proofing Measure adopted by the Local Sponsoring Organizations. The NRCS has developed a Flood Proofing Measure specifically for the Pocasset River that can be adopted by the local sponsors.

5.4.3 REDESIGN AND REBUILD EXISTING INDUSTRIAL RESERVOIRS FOR FLOOD RETENTION

Initially, members from the NRCS, National Water Management Center, Rhode Island NRCS State Conservation Engineer, and RI NRCS staff visited the watershed to review the problems and provide potential solutions. After touring the watershed and seeing the sprawling development throughout the area, it was determined that new flood retention reservoirs were not possible. However, NRCS staff did see a potential opportunity for re-development of existing industrial reservoirs into flood retention reservoirs. Some benefits to this alternative would be the rehabilitation of dams that pose a potential risk to property and life and installing one or two larger reservoirs as opposed to numerous smaller basins (reduced installation and maintenance cost), potential re-establishment of stream base flow (dry reservoirs) to a more natural condition. Some of the costs associated with this alternative are loss of potential recreational opportunities in the reservoirs, loss of some wetland function and value, and potential loss of historic structures (stone dams).

The reservoirs that were considered were Upper Simmons, Lower Simmons, Almy, and Cranston Print Works Dam. Cranston Print Works was eliminated because the cost of building a dam that meets NRCS standards in this location would be prohibitive both from and engineering and economic prospective. In addition, the Print Works Dam is in relatively good condition and provides an excellent opportunity to view an example of a granite dam built during the industrial revolution. Another alternative that will be looked at is modification of the existing pipe spillway at the Print Works Dam; this alternative will be detailed in another section.

The initial analysis of this alternative consisted of running the hydrology and hydraulic models without the sub-areas represented by Upper Simmons Reservoir, Lower Simmons, and Almy Reservoirs. This method is crude but did provide feedback as to the potential effectiveness of these alternatives. The results generated by the models, using this method, indicated that installation of the reservoirs in their existing location would have little or no effect on the existing peak flows in the areas where flooding occurs. They do, however, reduce the total volume that discharges during a storm event and therefore reduce the duration of peak flooding.

Potential does still exist for use of Upper and Lower Simmons Reservoirs for controlling storm water from the potential development of the areas surrounding the landfill (i.e. the Industrial Park Buffer). The comprehensive plans developed by the Town of Johnston show this area being zoned as commercial and industrial use. If future expansion of the landfill and development of the industrial buffer are foreseen, then some type of measures will be needed to control additional runoff. Presently, the Rhode Island Resource Recovery Corporation (RIRRC) has applied for a wetlands permit in order to complete an expansion at the Johnston landfill. Part of their plan will be installation of storm water controls including a detention basin. It may make more sense to install one large basin that could service the entire area of sub-areas 10 and 11. Some of the benefits of this type of solution are reduced maintenance, and the ability to remove accumulated sediments from Simmons Reservoir.

5.4.4 DIKES OR FLOODWALLS

Dikes and floodwalls have been successfully used for many years to protect entire neighborhoods, commercial, and industrial areas from flooding. Dikes are typically made of earthen material and take up more land than do floodwalls. Dikes are usually used in areas that are less densely settled and have lower property values because they require a larger area for their footprint. Floodwalls are usually made of concrete or sheet piling and take up significantly less room than dikes. In most cases, they can be placed away from the river to prevent encroachment into existing wetlands. Both dikes and floodwalls will require pumping stations to prevent overland runoff from collecting behind the structures and causing isolated flooding of the protected areas. The local community will be responsible for maintaining both the structures and pumping stations.

The initial analysis of the hydraulic models indicates a number of areas that could benefit from installation of floodwalls. Dikes have been ruled out because they would require significant land resources for installation and may not be justified either economically or environmentally. It is highly likely that dikes would require significant encroachment on the river's existing flood plain wetlands.

The following are a list of the potential location of floodwalls within the Pocasset River:

Davis Court/River Terrace/Willow Brook

These areas are located upstream from the Garden City Bridge. Significant flooding occurred in this area in the 2001 floods. Future condition models show large areas that will be flooded by the one percent storm. A floodwall seems to be the only feasible alternative for this area. Not all properties in this neighborhood would be protected by the floodwall. Presently, it may not be possible to protect the entire neighborhood because of the runoff from Randall Pond. The runoff flows through a series of buried pipes that run through the neighborhood. Provision would need to be made to either route the runoff around the area into the Pocasset or provide a significantly large pumping stations behind the floodwall.

Reservoir Avenue (Nursery Area)

This floodwall would protect the area North West of the bridge over the Pocasset River on Reservoir Avenue. The floodwall would protect both commercial and residential properties. Several properties may have to be acquired to site the floodwall. Additional analysis will have to be completed if this alternative is selected to determine both downstream and up stream impacts.

Industrial Park on Dyer Avenue

This floodwall will protect the industrial buildings located in the industrial park on Dyer Avenue, just north of the Cranston bike path. It may be possible to individually flood proof each impacted building. Additional analysis should be completed if the plan is implemented.

Fletcher Avenue (Industrial Park)

Fletcher Avenue is one of the most well-known areas to be impacted by flooding. The industrial park has approximately 20 businesses that have been damaged or have the potential for damages during the one percent chance storm. Residential properties located across Fletcher Avenue from the industrial park also sustain damage and will be protected by a floodwall. Some properties adjacent to the Plainfield Street Bridge may need to be removed in order to site the floodwall. Additional analysis should be completed if this alternative is selected to determine both downstream and upstream impacts.

Park Plaza

Park Plaza apartments are located north of Plainfield Street and east of Atwood Avenue on the Pocasset River. A floodwall would provide protection to all of the buildings that make up Park Plaza. If this alternative is selected, additional analysis will need to be completed to determine downstream and upstream impacts and impacts to the River Drive/Melody Court Neighborhood.

Rotary Drive

Rotary Drive is located just south of the confluence of the Pocasset River and Dry Brook. Access to this residential neighborhood is from Atwood Avenue. A floodwall would provide protection to all properties in the neighborhood.

5.4.5 RESTORATION OF WATERSHED WETLANDS

Numerous studies have concluded that wetlands have many functions and values that are important to the public. Flood storage in wetlands can provide protection and mitigation from flooding within a watershed. The loss of wetlands throughout a watershed can increase flooding and increase the potential for damage and loss of life. In the Pocasset

River Watershed, there has been a loss of 607 acres of wetland since 1939. This equates to a 25 percent loss of wetlands within the watershed.

Protection of wetlands can be an effective tool used to prevent an increase in flooding within a watershed, however, restoration of lost wetlands can be hard to justify economically. Restoration projects completed by NRCS in Rhode Island have averaged $80,000 per acre of wetland created or restored. This cost does not include the cost of purchasing the land that will be required for the restoration. It is also difficult to quantify their potential effectiveness, since many factors influence flood storage in wetlands. These factors can include the type of wetland, location within the landscape, and size.

Though restoration of a significant portion of the lost wetlands within the Pocasset Watershed may not be a feasible option to mitigate flooding, there will be opportunities to restore some Flood plain wetlands if other mitigation measures are implemented. These restorations should be incorporated into any plan to mitigate flooding.

5.4.6 INSTALLATION OF STORM WATER BASINS TO CONTROL FLOODING

Installation of storm water basins to control flooding is an accepted practice used by many communities. These basins are usually installed in new developments and may be required by local storm water management ordinances. All new developments in the Pocasset River Watershed should be required to implement a storm water management plan to reduce increased volumes of runoff that are caused by increased impervious area. The plans should try to reduce impervious area and mitigate for increased runoff.

NRCS was asked to consider installation of regional storm water detention facilities in place of the reservoirs. Regional detention facilities would be effective if properly located, but may be unrealistic in the Pocasset River Watershed. The cost of installation would likely exceed the economic benefits gained mainly due to the cost of purchasing the land required for the basins. The rule of thumb for estimating the storage needed to have any reduction in flooding is one inch over the entire watershed. This would add up to 1100 acre feet of storage. Since the average basin is 5 feet deep there would need to be about 300 acres of basins. Recent cost of constructing these types of projects average $100,000 per acre. So the construction cost would exceed 30 million dollars. The basins would have to be located in areas that are already developed to be effective and it is unlikely that many of the current owners would be willing to relocate. Additionally, it would be necessary for a local entity to be responsible for the maintenance and repair of the installed basins.

5.4.7 BRIDGE, CULVERT MODIFICATION OR FLOODWAYS

Bridge or culvert modification has the potential to provide some flood relief in areas where water is impounded due to undersized culverts and bridge crossings. Bridges and culverts may have been adequate when installed, but as flooding has increased the potential for impounding water has increased. Some channel work or floodway installation may be required just upstream and downstream of the bridges or culverts because development along the banks of the river has restricted channel size in these areas.

Present and future condition models were reviewed to determine if major bridges and road crossings were impounding water that either caused flooding or increased the depth of flooding in a particular area. Comparison of the water surface profiles for the 2-year, 50-year, and 100-year storm events for both existing and future conditions model is a simple method to determine which bridges or road crossings should be analyzed. The profiles indicated eight locations that could be modified to obtain flood relief. The locations were Garden City Bridge, Reservoir Avenue Bridge, Park Avenue Bridge, Dyer Avenue Bridge, Plainfield Street Bridge, Morgan Mill Road Bridge, and Morgan Avenue Bridge. The dilapidated railroad trestle south of Pontiac Avenue was also removed to see if it had the potential to reduce upstream flooding.

Significant flooding occurs in the Simmons Brook area west of Atwood Avenue. The cause of the flooding appears to be an undersized culvert beneath the industrial building that straddles the river. An analysis will be complete to determine if an additional by-pass culvert can be installed to provide adequate capacity during peak runoff periods.

5.4.8 CHANNEL MODIFICATION (DREDGE THE CHANNEL)

This alternative was discussed by many people attending the public meetings that were held prior to start of the study and after the initial list of alternatives were developed. This alternative is in essence "pulling the drain stopper out." Though this may seem to be a logical remedy for the flooding in the watershed, it will provide little, if any, relief. The dredging would provide a minimal amount of storage even if it were completed for the whole length of the river (18 miles). The project would be costly and permitting of such an endeavor would be highly unlikely. There would be potentially significant impacts to fish habitat throughout the reach of the river.

There should be some opportunity to provide for better flow through clearing and snagging some portions of the Pocasset River and its associated tributaries. Urban rivers are very susceptible to the creation of debris dams. These can be created when trees along the banks of the river fall over. Several have been found during development of this study that can have the potential for creating a new or exacerbating an existing flooding problem. A monitoring system should be developed to identify these blockages when they occur and remove them in a timely manner.

5.4.9 STORM WATER MANAGEMENT AND FLOOD PLAIN ORDINANCES

Storm water management ordinances have been effective in preventing impacts due to development in watersheds throughout the United States. Storm water management ordinances have been adopted by many communities in Rhode Island including the City of Cranston. Restrictions imposed might be reductions in impervious area, mitigation of runoff, requirements for no increase in peak flows and/or compliance with flood plain management and National Flood Insurance Program requirements with this alternative.

Flood Plain Management Ordinances are implemented through state permitting programs such as the Rhode Island Department of Environmental Management, Wetlands Permitting Program.

5.4.10 EARLY FLOOD WARNING SYSTEM

An automated flood warning and response system will benefit all parties along the Pocasset River, Simmons Brook, and Dry Brook. The system should be part of all alternatives, especially individual property flood proofing (residential), commercial property flood proofing, floodwalls, and dikes. The system would alert residents and the community so they can prepare for potential flooding events. Tasks that may need to be initiated include readying pumping stations, installing low opening enclosures, and moving vehicles from areas prone to flooding. The early flood warning system would consist of automatic rain gauges and stream gauges. They would be solar operated or with backup power if electrically operated from the power grid. All instruments would be tied into the RIEMA office in the City of Cranston and to both municipalities. An emergency response plan would be developed and coordinated with each municipality and the RIEMA. Notification of the potential flooding would be through the local municipalities, state agencies and the local media.

6.0 REPORT CONCLUSIONS

Flooding in the Pocasset River watershed has been an on going problem since the 1950's. Most areas throughout the watershed are contributing to the flooding problem. Continued development within the watershed has increased both the severity and frequency of flooding. The communities of Johnston and Cranston will need to implement a watershed wide approach to mitigate and prevent additional flooding in the future.

The following are recommendations to provide relief from existing and future flood impacts:

1. **Complete development and implementation of the Watershed Plan:** NRCS will continue to assist the communities in finalizing the development of the Watershed Plan. The communities can apply for funding through the Watershed Protection and Flood Prevention Act (Public Law 83-566).

2. **Develop and implement a Storm Water Management District:** The communities should work together to develop and implement a Storm Water Management District for the Pocasset River Watershed. Rhode Island enacted legislation in 2002 to allow communities to establish "Stormwater Management Districts".

3. **Control Runoff from Impervious Areas:** The communities should continue to work with the Rhode Island Department of Environmental Management to limit runoff volumes from newly developed areas and decrease runoff from existing developments. Therefore, it is recommended that communities control both peak runoff discharge rates and total runoff volumes from areas that will be re-developed or newly developed.

4. **Early Flood Warning System:** The communities should work with the Rhode Island Emergency Management Agency and the National Weather Service to begin installation of both stream gauging and rainfall gauging stations. These gauges will become the basis for developing an "Early Flood Warning System" for the Pocasset River.

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[1] *Total Population*. United States Census Bureau. 2000. Summary File 3 (SF 3) - Sample Data P1.

[2] *Population 65 Years and Over*. United States Census Bureau. 2000. Summary File 3 (SF 3) - Sample Data P11 - Household Type (Including Living Alone) By Relationship for the Population 65 Years and Over.

[3] *Per Capita Income in 1999 (Dollars)*. United States Census Bureau. 2000. Summary File 3 (SF 3) - Sample Data, P82.

[4] *Median Value (Dollars) For All Owner-Occupied Housing Units*. United States Census Bureau. 2000. Summary File 3 (SF 3) - Sample Data H85 - Owner-Occupied Housing Units.

[5] *Sex By Employment Status For The Population 16 Years And Over [15]*. United States Census Bureau, 2000, Summary File 3 (SF 3) - Sample Data P43 - Population 16 Years And Over.

[6] *Land Use and Land Cover*. Rhode Island Geographic Information System. 1995.

[7] *Glacial geology of Rhode Island*. Rhode Island Geographic Information System from USGS classification and mapping. 1965.

[8] *Trends in Rhode Island Forests: A Half-Century of Change.* Northeastern Research Station and Rhode Island Department of Environmental Management Division of Forest Environment. 2002.

[9] *National Wetland Inventory.* US Fish and Wildlife Service, 1977.

[10] *Soil Survey of Rhode Island.* United States Department of Agriculture, Soil Conservation Service, 1981. Climate, page 1.

[11] *TMDL To Monitor Waterbodies Listed As Impaired For Total Metals.* RI Department of Environmental Management Office Of Water Resources. 1998.

[12] RI Department of Environmental Management, Division of Fish and Wildlife.

7.0 GLOSSARY

Aerial Flight Data - Data and photography taken from special flight instruments during flyovers.

Anadromous Fish – Fish that migrate upstream from the sea to breed in freshwater.

Antecedent Moisture Condition (AMC) – Same meaning as ARC (AMC is the older term.)

Antecedent Runoff Condition (ARC) - The index of runoff potential before a storm event. It estimates the existing soil moisture condition by using the rainfall received in the 5 days prior to the storm event of interest. (Updated term)

Attenuation - Lessening in amount, force, or value.

Backwater - Water backed up or retarded in its course as compared with its normal or natural condition of flow.

Calibrate - See hydraulic calibration.

CFS – Cubic feet per second, the typical units of flow measurement.

Channel Flow - Where flow converges in gullies, ditches, and natural or man-made water conveyances (including pipes not running full.)

Channel Slope - The steepness of the channel expressed as a percent.

Confluence - The point of juncture of two or more streams.

Conservatism - As related to this flood study – tending to err on the safe side of design values (structures will be larger/stronger than may be required.)

Contour Interval - The numerical value between adjacent contour lines that indicates the accuracy level to which the topographic survey was taken.

Cross Section - The shape of a channel or stream viewed across its axis. This area includes adjacent flood plains.

Culvert - Metal, concrete, or plastic pipe put under the road that is crush resistant and conveys water.

Curve Number - See Runoff Curve Number.

Discharge - The quantity of water flowing at a given point, usually expressed in CFS.

Flood routing – Computation of the changes in the amount of stream flow as a flood moves downstream or through reservoirs or structures.

Flood plain - Normally dry land adjacent to a body of water such as a river, stream, lake, or ocean that is susceptible to inundation by floodwaters.

Floodwalls - A constructed barrier of resistant material, such as concrete, masonry block, or sheet pile designed to keep water away from a structure.

Flow Regimes - The type of flow: sub-critical, critical, or supercritical.

Groundwater - Water in the ground that is in the zone of saturation and from which wells and springs draw their water sources.

Headwaters – The upper parts of a river drainage system.

Homogenous - Material characterized by properties that are identical everywhere.

Hydraulic Calibration - The process of using historical data in a model to verify design assumptions and parameters as an accuracy check.

Hydraulic Capacity - The maximum flow that a particular stream, channel or structure is capable of carrying.

Hydraulic Model – A model to determine velocity and elevation of flows

Hydrograph - A graphical representation of stream discharge plotted versus time.

Hydrologic Soil, Group (HSG) - Classification system of soils developed by NRCS based on the permeability and infiltration rates of the soils. 'A' type soils are primarily sandy in nature with a high permeability while 'D' type soils are primarily clayey in nature with a low permeability.

Hydrology - The applied science concerned with the waters of the earth, their occurrences, distribution, and circulation through the unending hydrologic cycle of: precipitation, consequent runoff, infiltration, and storage; eventual evaporation; and so forth.

Hydrology or Hydrologic Model – A model used to determine the amount of flow at a given location.

In-Channel Hydraulic Structures - Physical structures directly in the flow path that affect the rate and direction of water conveyed through a channel.

Ineffective Flow Areas - Areas not contributing to flow in the downstream direction. They are typically located near structures (bridges & culverts) or in a very wide flood plain.

Inlet conditions - The flow conditions around an inlet that primarily relate to elevation, quantity, and velocity of flow and type of structure.

Inline Structure - See in-channel hydraulic structures.

Inundate - To cover completely with water; especially flood waters.

Land Cover Soil Complex - The classification of a selected land area for runoff potential, which relates the land type to the Hydrologic Soil Group (HSG).

Mitigate - To make or become less severe or intense.

Outlet - The exit point for a body of water or structure where waters are released.

Photogrammetry - The use of aerial photography in the production of maps and charts.

Reach – Any designated length of a river selected for design and/or evaluation.

Recession curve - The receding portion of a hydrograph showing the decreasing rate of runoff following a period of rain or snowmelt.

Runoff - Water that enters a stream during and after a storm. May consist of surface runoff and groundwater flow.

Runoff Curve Number - A dimensionless number of 100 or less that relates runoff to the soil-cover complex of the watershed. Higher numbers mean greater runoff.

Sensitivity Analysis - A series of computer model runs where selected parameters are changed to test the variability of output data to the input data.

Shallow Concentrated Flow - Begins where sheet flow converges to form small rills or gullies and swales.

Sheet flow - Flow that occurs overland in places where there are no defined channels and the floodwater spreads out over a large area at a uniform depth.

Stage - The level of the water surface above a given datum at a given location.

Stage Discharge Relationship - A graph showing the relation between the gage height, usually plotted as ordinate, and the amount of water flowing in a channel, expressed as volume per unit of time.

Stage Storage Relationship – Storage versus elevation.

Storage - Water artificially impounded in surface or underground reservoirs for future use.

Sub area - A watershed that is a portion of a larger watershed.

Subcatchment - A smaller area within a defined watershed. Also known as sub area.

Topography - Graphic representation of the surface features of a place or region on a map, indicating their relative positions and elevations.

Tributary - A stream or river that flows into a larger stream or river.

Unsteady Flow - A characteristic of a flow system where the magnitude and/or direction of the specific discharge changes with time.

Vertical Datum - Established elevation reference.

Water surface elevation - The vertical elevation value of the stream surface at a given location and point in time.

Water Table – Elevation or depth of the phreatic surface of a zone of saturation, where the body of ground water is not confined by an overlying impermeable zone.

Watershed - A defined land area drained by a river, stream, or drainage way, or system of connecting rivers, streams, or drainage ways such that all surface water within the area flows through a single outlet.

Weir - A wall or plate placed in an open channel to regulate or measure the flow of water.