Governor's Narragansett Bay and Watershed Planning Commission

Nutrient and Bacteria Pollution Panel

Initial Report

March 3, 2004

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Panel Charges
Short-term Charges: By March 2004, as part of the Commission's Phase I Strategic Plan, develop an initial nutrient and bacteria reduction strategy, addressing all major sources, that identifies the initial steps necessary to meet the following long-term goals:

- By 2010, reopen 25 percent of areas now closed to swimming;
- By 2010, reduce the number and frequency of beach closures by 50 percent;
- By 2010, reduce the number of days shellfish areas are closed by 50 percent, and reopen 2,000 acres;
- By 2015, restore Greenwich Bay and the Blackstone, Woonasquatucket, [and Wood-Pawcatuck] Rivers to fishable and swimmable condition; and
- By 2020, restore the Seekonk, Moshassuck, Providence, and Pawtuxet Rivers, Upper Bay, and Mount Hope Bay to fishable and swimmable condition.

NUTRIENT POLLUTION -- Recommendations

- Provide Best Practicable Treatment to remove 40-50% of nitrogen from RI WWTFs that discharge to the upper bay or its tributaries; Complete planned upgrades at MA WWTFs in watershed and conduct analyses on need for additional reductions
- Complete sewering work in Warwick, East Greenwich, and Warren; Mandate tie-ins
- Improve stormwater management --- Implement infiltration measures and other techniques that have proven more effective than end-of-pipe treatment
- Reduce atmospheric deposition
- Reduce nutrient flux from septic systems --- Require denitrification in watersheds where septic-derived nitrogen is a major water quality impairment; Maintain septic systems; Preserve and restore riparian buffers
- Improve public understanding of nutrient pollution and good practices -- Clean up after pets; Manage fertilizer and manure properly
- Monitor changes in loads and impacts

BACTERIA POLLUTION -- Recommendations

- Complete CSO projects (Fall River, NBC, Worcester, Newport) and assess effectiveness
- Complete sewering work in Warwick, East Greenwich, and Warren; Mandate tie-ins
- Strengthen beach licensing -- Require beaches to eliminate food sources for waterfowl
- Improve stormwater management --- Implement municipal and state stormwater management plans; Implement measures prioritized in TMDLs for Greenwich Bay, Palmer, Barrington, and Narrow Rivers and Green Hill Pond and plans to be done for Blackstone, Woonasquatucket, & Kickamuit
- Maintain septic systems --- Phase out high-risk cesspools; Establish municipal onsite management programs
- *Encourage "no discharge" by boaters (*One panel member insisted this read "enforce".)
- Investigate and eliminate sources at beach areas --- Scarborough Beach, Bristol Town Beach, Easton's Beach
- Complete and implement restoration plans for the Blackstone River, Woonasquatucket River, Tidal Pawcatuck and Little Narragansett Bay, Seekonk, Moshassuck,and Providence Rivers and Mount Hope Bay

Narragansett Bay Nutrient Pollution

- **The Issue**

Excessive nutrient loading or eutrophication is one of the most significant problems facing estuaries worldwide[1]. Narragansett Bay, although relatively well-mixed and less susceptible than other estuaries to eutrophication, exhibits an increasing array of symptoms – low dissolved oxygen, fish kills, eelgrass loss, macroalgae blooms, benthic community changes, and a shift from benthic to pelagic as the dominant fish community in the Bay[2].

- **Sources**

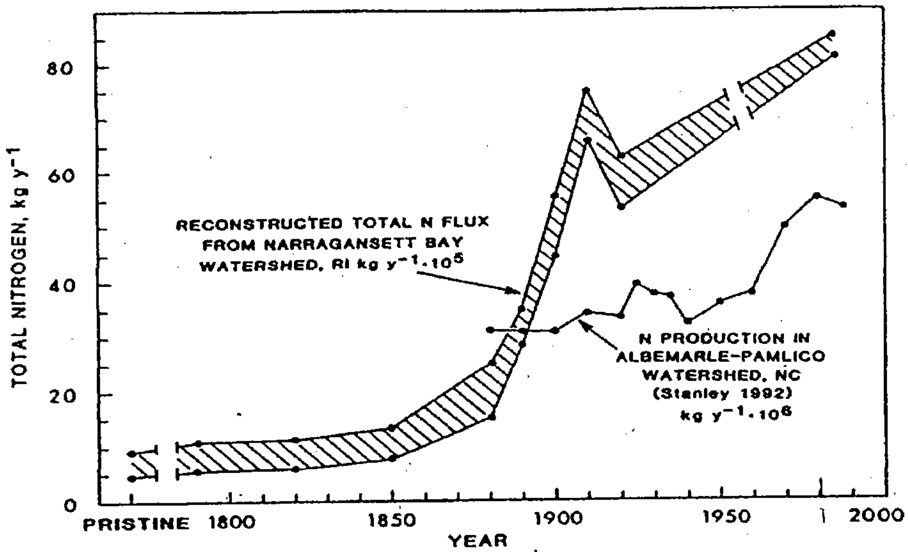
9100 metric tons/yr (9100 x 10^3 kg N/yr) is the most commonly used estimate of total nitrogen loading to Narragansett Bay[3]. Reflecting the measurement methods, this estimate was composed as follows:

	NO_2+NO_3	NH_4	DIN	DON	PN	total	%
	(all units of metric tons/yr)						
Atm. Dep.	266	78	336	78	----	420	5
River/stream	2478	1582	4060	1344	168	5600	62
Urban runoff	~56	~182	238	252	28	518	6
WWTFs	87	1904	1988	420	140	2562	28
Totals	2884	3752	6622	2100	336	9100	

Most nutrient loading (approximately 60%) was shown to enter through the upper Bay, particularly through the Providence/Seekonk Rivers.

Other analyses[4] show general agreement regarding total loading but decompose the "river/stream" component to provide more insight into sources by recognizing that it is, in large part, due to wastewater treatment facilities (WWTFs) and atmospheric deposition. Alexander et al. (2001) estimated that 62% of the total came from point sources, 19% from non-agricultural nonpoint sources, 6% from fertilizer and 3% from livestock in addition to the 10% from atmospheric deposition. Castro et al. (2001) estimated 73% of their total loading figure came from human sewage (through WWTFs and Individual Sewage Disposal Systems (ISDSs)), 13% from atmospheric deposition, 10.5% from agricultural runoff, and 3% from urban nonpoint sources. The analysis reported by Roman et al. (2000) estimated that wastewater treatment facilities contributed 73% of the nitrogen load, atmospheric deposition 23%, and agriculture 4%. RIDEM (2000)[5] estimated that WWTFs contributed 66% of the total nitrogen to Upper Narragansett Bay; rivers and runoff (not including WWTFs) 30%, and direct atmospheric deposition 4%. Moore et al. (in press), using a similar but higher resolution technique than Alexander et al. (2001), estimated that total nitrogen load from the Providence/Seekonk River was 68% municipal wastewater, 15% atmospheric deposition, 14% runoff from developed lands, and 3% runoff from agricultural lands. All these analyses agree that wastewater treatment plants are the major source of nitrogen to the Bay.

Nutrient loading to Narragansett Bay has increased by more than a factor of five since historical times and continues to increase, although at a slower rate. Dissolved inorganic nitrogen, the most biologically-available form of nitrogen, alone has increased by a factor of five[6]. Bay watershed population, the major factor driving loading, has doubled since 1900[7] and, although slowed in the recent decade, is predicted continue to increase at 0.5-0.6% annually in the coming years. Suburban and rural communities, particularly coastal communities, are projected to grow more rapidly.



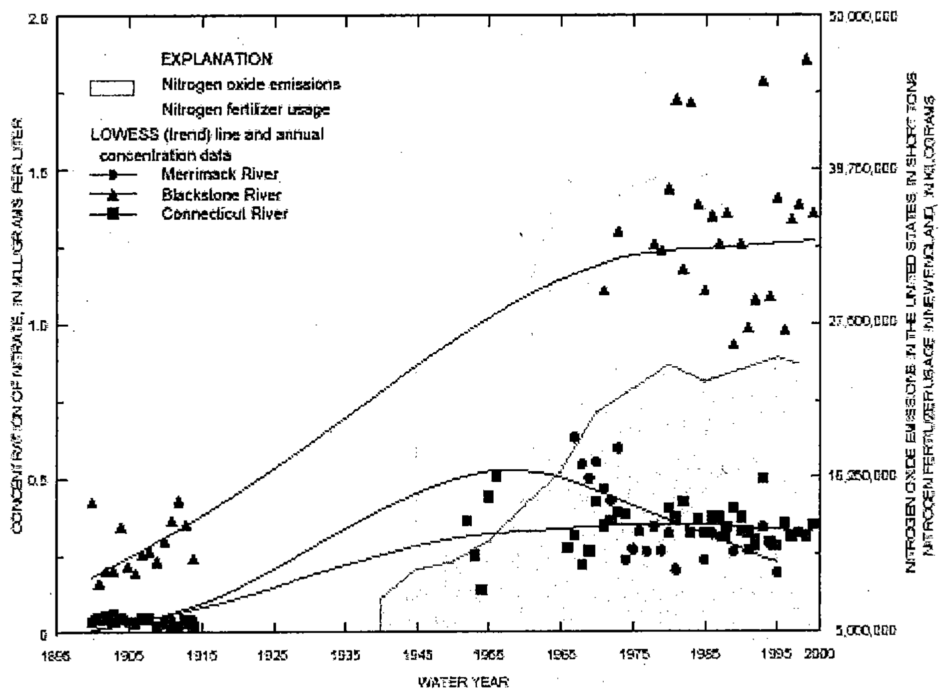


Figure 10. Trends in annual nitrate concentrations in the Merrimack, Blackstone, and Connecticut Rivers from 1900-2000, annual nitrogen oxide emissions in the United States from 1940-98, and annual agricultural usage of nitrogen fertilizer in New England from 1945-91 (Annual nitrogen oxide emissions data from the U.S. Environmental Agency, 2000b; annual nitrogen fertilizer usage data from Alexander and Smith, 1990, and Alexander, R.B., U.S. Geological Survey, written commun., 2001).

Significant loading enters through coves, harbors, and embayments along the periphery of the mid-Bay – Greenwich Bay, the Palmer River, Mt. Hope Bay, etc. Portions without strong circulation show indications of nutrient pollution and are designated as impaired by nutrient pollution[8]. These areas may be strongly connected to overall Bay loading, importing rather than exporting, nutrients from the Bay[9]. Concerns have also been raised in lower Bay areas such as Wickford Harbor. In the case of Wickford Harbor, which has no point source discharge, 75% of the nitrogen loading was estimated to come from groundwater, 20% from surface runoff, and 5% from direct atmospheric deposition[10].

The Rhode Island salt ponds also have been recognized as suffering from eutrophic conditions since 1980 or before[11]. Although these ponds are not part of the Bay by most definitions and fed by different nutrient sources, their ecological stresses and response has some similarities to areas of the Bay.

- **Impacts**

Dissolved oxygen levels are reduced by decomposition of blooms fueled by excess nutrients. Low dissolved oxygen affects the survival and growth of most marine animals[12]. Significant hypoxic or even anoxic conditions occur in the Providence River, Greenwich Bay, Mt. Hope Bay, and other areas throughout the warm summer months. A volunteer dissolved oxygen "strike team" conducted synoptic surveys during critical summer times over the past four years. Those data, together with data from continuous monitors on several buoys, show that low oxygen conditions extend from the Providence/Seekonk River into the upper Bay, particularly with moderate stratification associated with neap tides, at times covering about a third of the total Bay area[13]. Low oxygen conditions were more extensive during the hot, drought summer of 2002 than the cooler, wetter summer of 2001. Hypoxic extent was the greatest ever measured in August of 2003, extending from the upper Bay to south of the Jamestown bridge[14].

Fish kills due to low oxygen occur occasionally and their pattern mirrors the distribution of nutrient loading[15]. The largest fish kill in more than 100 years, involving more than a million juvenile menhaden, occurred in Greenwich Bay in August of 2003[16]. Low dissolved oxygen, caused by nutrient pollution, was the cause.

Eelgrass has virtually disappeared from the upper Bay. Today, no significant eelgrass beds occur north of Jamestown, and none remains in Greenwich Bay and the Palmer River. Initial analysis of aerial mapping of eelgrass beds in July 1996 revealed only 100 acres remaining in the Bay[17]. Disease and hurricane disturbances are partly responsible but excess nutrients, by reducing penetrating light levels, has played a role in historical losses and continued failure of replantings in the upper Bay. Nixon et al. (2001)[18] reviewed published papers on 30 estuarine ecosystems and data from mesocosm experiments. They noted that "There does seem to be a consensus that seagrasses do not survive in shallow waters receiving large inputs of inorganic nutrients, especially nitrogen. ... Our experiments suggest that these indications (of deteriorating health) begin to appear with inorganic nutrient enrichment exceeding 2 mmol N/sq m/day." As an example, eelgrass areas in RI coastal ponds decreased 41% over the last three decades and the decrease appears to be linked to nitrogen loads from septic systems[19].

Macroalgae, such as the green sea lettuce *Ulva*, often thrives in high nutrient loading conditions and outcompetes other submerged vegetation. The ecological structure of an area can be altered by such changes as has happened in Waquoit Bay on Cape Cod[20]. Macroalgae is relatively dense in shallow coves in Greenwich Bay and similar areas around Narragansett Bay. High water temperatures can cause sudden die-off of macroalgae resulting in noxious odors and dangerous hydrogen sulfide emissions from decomposing vegetation such as accumulated off Conimicut Point in 2003[21].

Benthic communities in the upper bay exhibit patterns of nutrient overenrichment – shallow apparent redox-potential discontinuity, high apparent oxygen demand, and low-order benthic successional stages[22]. Hypoxic and anoxic events may be contributing to the observed shift from benthic to pelagic species as the dominant community in the bay[23]. Studies have also shown that Rhode Island salt marshes are being altered by increased nutrient levels[24].

High nutrient inputs raise primary production levels and fisheries yield typically increases[25]. However, with increasing loading, a maximum point is reached followed by a decline in various components of fisheries[26]. Turning points are difficult to identify because multiple factors are involved in complex systems and data are limited but the Black Sea, the Baltic, and other areas around the world provide examples of eutrophication-driven degradation[27]. The Black Sea is exhibiting recovery after recent loading decreases. Long Island Sound, since initiating nutrient reduction efforts, has seen its hypoxic zone shrink in extent and duration and its total fish biomass increase[28]. Nitrogen loading to Sarasota Bay has been reduced by 47% since 1990. Seagrass acreage has increased by at least 18% and the Bay now supports 110 million more fish, 71 million more crabs, and 330 million more shrimp than in 1988[29].

Temperature increases, such the 1 to 2 C increase monitored in Narragansett Bay since the 1960s, appear to interact with effects of nutrient-overenrichment in ways that increase the impact of either alone on the ecosystem[30]. In addition to damage to estuarine systems, excess fixed nitrogen in the environment is linked to many other problems – acid rain, ground-level ozone, unhealthy nitrate levels in drinking water, freshwater eutrophication, etc[31].

- **Strategy**

Our objective is to eliminate eutrophication effects, particularly episodes of low dissolved oxygen, in areas where it occurs and prevent its development in other areas susceptible to nutrient pollution. This should reduce the risk of fish kills such as occurred in 2003 and other shifts in the ecological structure of the Bay. Contributing factors are many and complex but nutrient pollution plays a major role and it is the prime factor that is directly controllable.

Our strategy is to focus first on reduction of nutrients associated with human wastes (through WWTFs and ISDSs), the largest fraction of nitrogen load to the Bay of all sources. WWTFs are the most directly manageable of all sources, technology is available for reducing their contributions, and implementation of reductions at WWTFs is generally more cost-effective than at other sources. Susceptible coves, harbors, and embayments around the periphery of Narragansett Bay can be affected by a mix of local sources and tailored reduction efforts may be required.

- **Goals and Reduction Measures**

Fluxes from rivers and watersheds and, perhaps, between portions of the Bay have more impact on nutrient pollution than on bacteria pollution. This is particularly true for the Providence/Seekonk Rivers and Upper Bay, which receives input not only from the immediate watershed but also from the Blackstone, Ten Mile, Woonasquatucket, Moshassuck, and Pawtuxet Rivers. Consequently this paper first reviews general goals and reduction measures, then considers the specific goals assigned to the panel.

Potential overall nutrient reduction goals are bounded on the upper end by reductions so large as to be unreasonable to accomplish and on the lower end by reductions so small reductions as to be unlikely to have detectable effects. On the upper end, returning to pre-industrial levels of nitrogen loading (particularly DIN) would require a nitrogen loading reduction of about 80%[32]. Such a large reduction might be impossible to achieve but there is little or no indication that it is either necessary or desirable. On the lower end, loading reductions of 10% or perhaps even 20% may not produce change distinguishable from normal interannual variation. In between, reducing nutrient levels to a threshold that would be expected to allow eelgrass to survive (2 mmol N/sq m/day)[33] would require a reduction of about 50%. (Note that greater percentage reductions would be necessary to reach this target in areas north of Prudence Island.)

-- Upgrade Waste-Water Treatment Facilities (WWTFs) – Most WWTFs in the Narragansett Bay watershed perform only secondary treatment which does little to remove nutrients. RIDEM estimated that advanced treatment at WWTFs discharging to the upper Bay loading would reduce total upper Bay loading by 35%[34]. New permits requiring upgrades have been issued for some of these plants and construction has begun at several locations (see attached table).

-- Reduce Combined Sewer Overflows (CSOs) – Four major CSO projects are in progress or planned or in progress in the Bay area – Narragansett Bay Commission, Fall River, Worcester, and Newport. CSO projects are primarily aimed at reducing pathogens and, without advanced treatment at WWTFs, will not reduce nutrient loading. Coupled with the planned facility upgrades, however, the return on the CSO investment is increased by reducing the nutrient content of runoff that would otherwise overflow. The nutrient reduction is estimated to be less than 0.5% of the overall loading.

-- Improve Individual Sewage Disposal Systems (ISDSs) or replace with sewer connections (to WWTFs with nitrogen removal treatment) – 37% of RI's population is served by ISDSs and it has been estimated that about 15% of these are failing or ineffective. Even properly functioning septic systems, unless specially designed, do little to remove nitrogen. Their impact depends on the amount of attenuation along flowpaths. No systematic estimates are known but, as a rough guess, if defective systems were replaced with properly maintained, effective systems or sewer connections (to plants with effective nutrient removal), total Bay loading might be reduced by 5-10%. Older systems, especially cesspools, are very often inadequate. MA title V regulations help eliminate failed systems when they are within the groundwater contribution area of an embayment or tributary. RI is considering legislation to phase out high-risk cesspools. Cities and towns in both states are adopting municipal wastewater management plans and community septic system loan programs to ensure inspection and maintenance. Advanced, nutrient-removing septic systems or sewering is particularly important in areas close to the Bay or where there is a direct groundwater connection. RI CRMC requires advanced systems that remove nutrients in some areas.

-- Improve stormwater management – Urban runoff contributes an estimated 6% of the Bay's nitrogen loading[35]. In areas like Wickford, surface runoff carries about 20% of the nitrogen load to the Harbor (groundwater carries the other 80%)[36]. Most communities in the Bay watershed are in the process of producing stormwater management plans. Stormwater discharges are coming under a permit system. In RI, provisions were enacted in 2002 to allow establishment of stormwater management districts but, to date, no such structures have been set up. Nutrient loads at stormwater outfalls have not commonly been measured and, thus, priority actions are difficult to identify. End-of-pipe stormwater management measures are generally not effective in reducing nutrient loads, particularly nitrogen. Source reductions, volume attenuation measures, and infiltration basins are more likely to be effective.

-- Restore wetlands and riparian areas – Both wetlands and riparian areas can be effective in removing nutrients before they flow into the Bay. Overall Bay effects of historical losses or restoration potential have not been estimated. RI has established a coastal zone buffer program and techniques have been developed to identify characteristics of sites throughout the watershed that are most effective for denitrification[37].

-- Promote nutrient management plans and best management practices for agriculture, lawns, and golf courses, particularly to reduce fertilizer and manure losses to the environment.

-- Encourage "no discharge" boating – All marine waters of RI are designated as a "no discharge" area. Although these discharges are relatively small in the overall context of the Bay, they may be important in small, concentrated areas. Pumpout stations need to be easily accessible, their use needs to be encouraged by the boating community and marinas, and enforcement increased by harbormasters, the state, and the Coast Guard where there are indications of problems.

-- Reduce atmospheric deposition -- Direct atmospheric deposition to the Bay constitutes about 5% of the load[38]. Direct plus indirect deposition has been estimated to be 10-14% of the load[39]. Clean air efforts have not substantially reduced nitrogen oxide (NO_x) emissions but increased efforts are being mandated to reduce ground level ozone and fine particulate matter, both of which are connected to NO_x emissions. Overall, if NO_x emissions were reduced by 50% by 2030 (as intended by federal legislative proposals), nitrogen loads to the Bay might be reduced by 5-7%.

The focus of this initial report is on goals assigned to the panel. These goals direct attention to specific areas. Other areas which might stand out as particularly important in a more comprehensive analysis have not been addressed here. Examples include the Palmer River, the Taunton River, Wickford Harbor, and the Coastal Ponds.

1. <u>By 2015, restore Greenwich Bay and the Blackstone, Woonasquatucket, [and Wood-Pawcatuck] Rivers to fishable and swimmable condition.</u>

Because this panel's charge is nutrient and bacteria pollution and this paper is focused on nutrient aspects, attention is on "fishable", meaning meeting dissolved oxygen criteria. Reducing nutrient pollution should restore other ecosystem characteristics, such as habitat and community structure, that are critical to fishability. However, note that fully achieving fishability may require other actions not related to nutrient pollution such as removing dams, meeting temperature standards, and eliminating toxics.

Note also that eutrophication in marine waters is usually controlled by nitrogen, whereas, in freshwaters, eitrophication is controlled by phosphorus. Pollution reduction efforts should address both local and downstream effects and, thus, be concerned with both nitrogen and phosphorus in freshwater areas.

A. Greenwich Bay

Greenwich Bay was the site of the large fish kill in 2003. The fish kill was due to hypoxia or insufficient oxygen. Many factors were involved but the major controllable factor was nutrient pollution[40]. Low oxygen conditions in Greenwich Bay have been the subject of intensive study. Granger et al.[41] reported a daily minimum of 2.1 mg/l in Greenwich Cove based on continuous measurements from June 1 to September 31, 1997. Out of over 1,900 measurements of dissolved oxygen in all parts of Greenwich Bay, less than 5% showed concentrations less than 2 mg/l. While oxygen concentrations in the outer bay and in Warwick Cove were almost always greater than 2 mg/l, concentrations below 2 mg/l were common in near bottom water in the inner bay and in Greenwich Cove.

Granger et al.[42] estimated total loading to Greenwich Bay to be between 135 and 234 metric tons per year. Streams and groundwater were estimated to contribute between 41 and 60 metric tons/yr, the East Greenwich WWTF 29 metric tons/yr, direct atmospheric deposition 15 metric tons/yr, and import from the main part of Narragansett Bay 50 to 130 metric tons/yr. Urish and Gomez[43], examining primarily groundwater input, estimated the load to be 133 metric tons/yr. The draft Greenwich Bay Special Area Management Plan (SAMP) estimated nitrogen loading to be 185 metric tons/yr. More recent estimates for the Greenwich Bay SAMP show Narragansett Bay waters contributing 45%, septic systems 24%, atmospheric deposition on the watershed 9%, atmospheric deposition on the bay 8%, lawn fertilizer 4%, and boat heads <1%[44]. In the fish kill report[45], RI DEM estimated septic systems contributed 51%, the WWTF 40%, lawns 7%, roof and road runoff 2%, and direct atmospheric deposition <1%. These figures are conditions such as during the fish kill (dry weather, mid-summer, in the western part of the bay) rather than the annual averages estimated for the SAMP.

Development of a TMDL for nutrients in Greenwich Bay has been initiated by RI DEM but has not yet been completed. Subsequent to initiation of the TMDL work, CRMC initiated development of the SAMP. RI DEM and CRMC are coordinating efforts so that the water quality chapter for the SAMP, still in development, may serve as an equivalent plan to address nutrients. A permit has been issued calling for the East Greenwich WWTF to limit discharge of nitrogen to 5 mg/l. Construction is expected to be completed by March, 2006. The project is on the CWFA PPL. Warwick and East Greenwich are extending sewer lines through the well-established and fairly dense communities bordering Greenwich Bay. In Warwick, tie-ins are mandated on a schedule that will extend to 2010-2012. Despite large bond issues and assistance from the CWFA, resources may not allow all appropriate areas identified in the SAMP to be sewered. The Potowomut area, because of its separation from the rest of Warwick, is a particular problem. Also some areas directly on the bay cannot be sewered because they could be inundated during storms. Special design and maintenance may be required for wastewater systems in these areas.

Stormwater BMPs are recommended and prioritized in both the pathogen TMDL[46] and the SAMP for Greenwich Bay. In many areas, the minimum (generally non-structural) actions required under phase II of national stormwater regulations are sufficient. Eighteen stormwater outfalls (nine state owned and nine city owned) have been included on DEM's TMDL implementation list for capital projects. The proposed bond issue could help support the cities' costs. State costs may be substantially covered by federal assistance for stormwater pollution abatement in connection with DOT projects retrofitting roadway drainage systems. Priorities were determined based on the bacteria loads contributed rather than nutrient loads. Reexamination, considering both stream inputs and direct bay discharges, may be necessary. Stormwater designs should be selected with a strong preference for source reduction, upland flow attenuation, and infiltration rather than end-of-pipe systems which have limited effectiveness in reducing nutrients. Preservation of buffers around the bay and its tributaries will help reduce nutrients and manage stormwater.

Waterfowl, wildlife, and domestic pets contribute nutrients to the bay. Residents can help reduce these inputs by picking up after pets, not feeding birds, and maintaining uncut vegetation along the shore.

Boat discharges are not a large portion of the total load but they could be a significant factor in some areas if regulations are not adhered to. "No discharge" should be all boaters' practice not just a regulation. A survey in 2003 found 4018 boats in Greenwich Bay with about 2500 expected to have heads (marine sanitation devices). Ten pumpout facilities, including one pumpout boat, are available in the bay. Boaters, marinas, and enforcement officials should increase effort to ensure that pumpouts are available and used and discharges eliminated.

→ extend sanitary sewers to all areas where needed in the Greenwich Bay watershed;
require tie-in to sewers where available;
complete upgrade to East Greenwich WWTF;
improve pump-out access and ensure compliance with no-discharge requirement;
reduce stormwater discharges to Greenwich Bay and their nutrient loads;
preserve, create, and maintain vegetated buffers;
improve public understanding and awareness of pollution issues and good practices (including not feeding birds);
monitor water quality changes

B. Blackstone River

The Blackstone River was the subject of intense study, including water quality modeling, in the early 1990s[47]. WWTFs, particularly two major facilities in Worcester and Woonsocket, were found to strongly influence water quality. This is consistent, from the nutrient perspective, with findings of Boyer and others[48] that human sewage is the primary contributor to nitrogen loading in the Blackstone. Advanced treatment (nitrification), implemented in the mid 1980s at the Upper Blackstone Water Pollution Abatement District (UBWPAD) facility in Worcester, made a significant improvement in dissolved oxygen concentrations in the river[49]. However, during dry weather large diurnal swings in dissolved oxygen continue in impoundments in the river. In reaches directly below the Woonsocket WWTF, instream nitrification governs oxygen profiles causing a sag in dissolved oxygen that often extended to the mouth of the river in Pawtucket, RI. In wet weather, the ability of the UBWPAD facility is overwhelmed and the plant discharges significant levels of ammonia depleting oxygen in conversion to nitrate. The two major WWTFs are responsible for roughly 51% of the total ammonia and 20% of nitrates in the river[50].

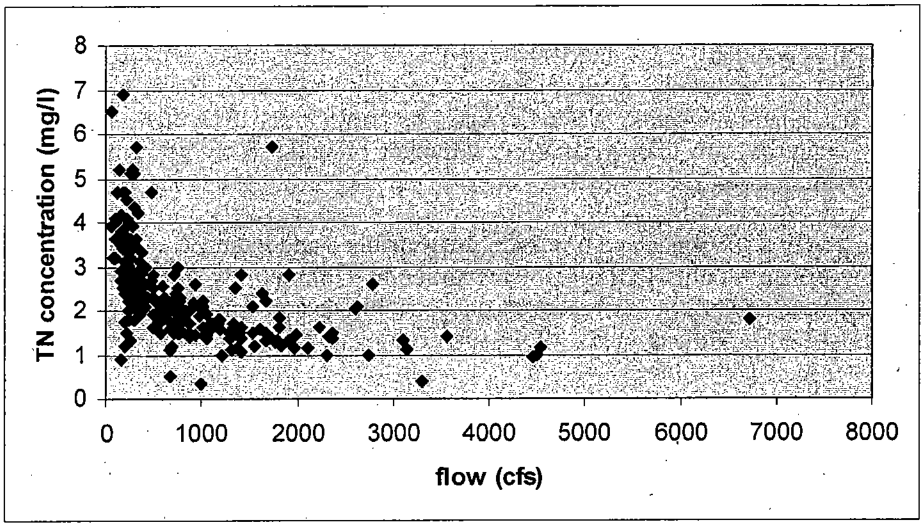
Six WWTFs discharge directly to the mainstem Blackstone River and four others discharge to tributaries. The WWTFs in the watershed all have permits limiting phosphorus discharges. The permits generally require nitrogen monitoring and include limits for ammonia-nitrogen based on the need to control the oxygen demand associated with nitrification. The Woonsocket WWTF also has a seasonal (April 1 – October 31) permit limit of 10 mg/l on total nitrogen discharge. Plant modifications were completed in 2001 and, although the facility experienced compliance problems in 2002, the limit was met in 2003. Permits for the Blackstone WWTFs have been designed so that, when upgrades are completed and facilities are in compliance, dissolved oxygen standards in the river should be met. Designs for these facilities generally include provisions for nitrogen and additional phosphorus removal should those be needed.

Both Worcester and NBC CSOs discharge to the Blackstone. An extensive CSO abatement program in Worcester was done in the 1980s, reducing overflows to a single outfall. Ongoing work to upgrade the UBWPAD facility should reduce present activations from 24 to about 7 per year. NBC's CSO reduction project will address outfalls to the Blackstone River in phase 3 but completion will not be until 2022. CSOs are not a major delivery mechanism for nutrients.

Many communities in the watershed are not sewered but no estimates have been made of the contribution of septic systems to nutrient loading. Municipal onsite management plans are beginning to be adopted. Glocester has a proposed management plan on the CWFA PPL and Cumberland has one under study. The Blackstone watershed in MA and RI will be the site of a National Decentralized Wastewater Demonstration Program. Some communities are installing sewers. Burrillville, for instance, has sewering proposals on the CWFA PPL.

Worcester is a phase I community in EPA's stormwater management program. There are 8 MA and 5 RI phase II communities in the watershed and all have proposed or are developing stormwater management plans. Although the TMDL is not complete, RI DEM identified the likely need for stormwater management measures for 16 areas in the watershed on its TMDL implementation list (8 state and 8 local). No loading estimates are available and, although pollution reductions are expected, quantification will be difficult.

The Blackstone River is a significant contributor to nutrient loading of the Seekonk and Providence Rivers and Upper Narragansett Bay. Concentrations as measured by USGS at Manville, RI are often above 2 mg/l (see figure). The EPA recommended nutrient criterion for this area is 0.71 mg/l total nitrogen as a median annual value (and 31.25 ug/l for total phosphorus).



→ complete planned upgrades at MA WWTFs on the Blackstone and conduct analyses on the need for additional reductions;
seek the best nitrogen removal performance from present and planned MA WWTFs, and conduct an interstate study of attenuation to determine how much of the nitrogen from MA WWTFs reaches RI and the Bay;
complete Worcester and NBC CSO projects;
monitor effectiveness of these projects as well as stormwater and onsite wastewater management efforts.

C. Woonasquatucket River

There are few data in headwater streams of the Woonasquatucket River. Several reservoirs in the upper reaches have elevated trophic conditions due to nutrients (primarily phosphorus). The dissolved oxygen conditions along the river generally meet water quality standards with the exception of the segment downstream of the Smithfield WWTF. Oxygen levels recover further downstream and remain high until Waterplace Park[51].

Smithfield WWTF is the only treatment plant discharging to the river. The discharge permit issued in 2001 for the plant calls for ammonia to be less than 2.7 mg/l, phosphorus to be less than 0.2 mg/l, and nitrogen removal is required (to levels consistent with the modifications necessary to achieve the ammonia limit). Facilities planning is underway and completion might be expected in 2007. The WWTF upgrade is included on the CWFA PPL. Smithfield also has extensive sewering included on the CWFA PPL. Phase 2 of the NBC CSO project, to be completed by 2014, should eliminate (?) overflows to the Woonasquatucket River. Stormwater management projects under phase II or DEM's TMDL implementation list are not targeted at nutrient reduction but may assist. The Woonasquatucket has an active watershed council helping to spur and guide efforts to achieve fishable/swimmable goals (see their plans and progress at http://www.state.ri.us/dem/programs/bpoladm/suswshed/actindex.htm).

→ complete Smithfield WWTF upgrade and ensure reduction in nitrogen load;
complete phase 2 of NBC CSO project;
monitor water quality and take action to prevent additional nutrient loads

D. Wood-Pawcatuck River

The Wood-Pawcatuck River generally meets nutrient-related water quality standards except in the tidal portions (and some ponds and brooks upstream such as Yawgoo and Barber ponds and Chickashen Brook because of eutrophication driven primarily by phosphorus). The tidal Pawcatuck is listed as impaired by low dissolved oxygen. Granger[52] found low oxygen conditions in CT portions of Little Narragansett Bay.

RI DEM has completed TMDLs for ponds and brooks in the watershed and included estimates of stormwater management measures on its TMDL implementation list. Preliminary work toward TMDLs for the tidal Pawcatuck and Little Narragansett Bay was initiated but has been suspended due to staff shortages at RI DEM. Although the TMDL is not complete, RI DEM identified the likely need for stormwater management measures for 10 areas in the watershed (5 state and 5 local) and included these on its TMDL implementation list. A community ISDS repair program for Westerly is included on the CWFA PPL. Charlestown and South Kingstown have programs in place. Three other communities in the watershed (Hopkinton, Richmond, and Exeter) have municipal onsite treatement system management plans under study.

The Westerly WWTF has been issued a permit calling for less than 5.5 mg/l ammonia and a design target of less than 12 mg/l nitrogen. The upgrade project was completed in October, 2003. The watershed delivers large quantities of nutrients to the tidal Pawcatuck River and Little Narragansett Bay. Nitrate flux appears to be decreasing despite a population increase in the watershed of nearly 40% over the past 20 years[53].

→ monitor changes in the tidal Pawcatuck and watershed to determine if further actions are necessary

2. <u>By 2020, restore the Seekonk, Moshassuck, Providence, and Pawtuxet Rivers, Upper Bay, and Mount Hope Bay to fishable and swimmable condition.</u>

The Providence and Seekonk Rivers and the Upper Bay are sufficiently tightly coupled to be considered as a single unit. The Moshassuck and Pawtuxet Rivers (as well as the Blackstone and Woonasquatucket Rivers considered above and the Ten Mile River) drain to the Providence/Seekonk. Mt. Hope Bay can be considered separately.

A. Moshassuck River

The Moshassuck River is not listed as impaired by dissolved oxygen conditions. Dissolved oxygen concentrations measured by River Rescue generally met the regulatory standard of greater than 5.0 mg/l and over 60% saturation. Sources of pollution consist largely of CSOs and nonpoint pollution. No WWTFs discharge to the Moshassuck. CSOs are to be dealt with through a combination of separating sewers and connections to the storage tunnel as part of phase 2 to be completed by 2014. Lincoln, now approximately half sewered, has development of a wastewater facilities plan on the CWFA PPL.

→ preserve status as unimpaired by low oxygen or nutrients

B. Pawtuxet River

The main stem of the Pawtuxet River is listed as impaired by low dissolved oxygen and nutrients. The upper reaches of the river supply drinking water and meet fishable standards. Several ponds in the lower watershed (Roger Williams Park Ponds, Mashapaug Pond, and Spectacle Pond) are listed as impaired by low oxygen, excess algal growth, and phosphorus.

RI DEM has addressed the main stem impairment by issuing discharge permits that constitute a control action equivalent to a TMDL. Three WWTFs discharge to the Pawtuxet River. Together these plants constitute the majority of nutrient loading to the river. All the plants now have total nitrogen limits of 8 mg/l, including not more than 2 mg/l of ammonia nitrogen. Phosphorus is limited to 1 mg/l. The West Warwick plant is due to complete construction of upgrades to meet these permit limits in July, 2005. The Warwick plant improvements should be completed by September, 2004. The Cranston plant is currently achieving the ammonia limit and additional upgrades for phosphorus and nitrogen should be completed in 2007. These projects are on the CWFA PPL or have been supported in the past. Sewers and interceptors for Coventry, West Warwick, and West Greenwich are also on the CWFA PPL. Johnston has established a municipal onsite treatment system management plan and three other communities (Scituate, Foster and Coventry) are considering such plans. Other communities in the Pawtuxet watershed are largely sewered. Stormwater management actions in 5 areas of the watershed (all state responsibility) are also included on DEM's TMDL implementation list. Eleven of the twenty largest outfalls identified by RI DOT (by mass of pollutants discharged) discharge to the Pawtuxet River. RI DOT's I-95 Stormdrain Retrofit Project has prioritized work in the Pawtuxet watershed – with the five largest outfalls targeted for construction of retrofit BMPs.

→ monitor changes as WWTF upgrades are completed and determine if further action needed

C. Providence/Seekonk River and Upper Narragansett Bay

The Seekonk River, the Providence River, and Upper Narragansett Bay are listed as impaired by low dissolved oxygen and nutrients. Dissolved oxygen conditions are affected by nutrient inputs from the Blackstone, Ten Mile, Woonasquatucket, Moshassuck, and Pawtuxet Rivers and WWTFs at Bucklin Point, Fields Point, and East Providence.

For the Providence/Seekonk Rivers and Upper Bay, RI DEM has adopted a goal of reducing nitrogen loadings from RI WWTFs by 45%. This is based on reexamination of observed and experimental data, together with analysis of performance of available technology. If treatment plant loadings constitute 66% of river and upper Bay loadings and all are reduced by 45%, overall loading would be reduced by 30%. Improvements to RI facilities to provide advanced treatment are included on the CWFA PPL (except East Providence, Woonsocket, and Warren).

→ provide best practicable treatment for nitrogen removal at WWTFs discharging to the Providence/Seekonk (and Ten Mile) Rivers;
ensure that action is taken to reduce nitrogen loading from the Blackstone, Woonasquatucket, and Pawtuxet Rivers as outlined above;
complete NBC CSO project

F. Mt. Hope Bay

MA and RI portions of Mt. Hope Bay, as well as the tidal Taunton and Cole Rivers, are listed as impaired by low dissolved oxygen and nutrients. Dissolved oxygen studies have been conducted since 1972 by New England Power Company and Marine Research, Inc.[54], Brown University in 1972-73, MA CZM since 1999[55], and Narragansett Bay volunteer surveys since 1999[56]. Summer hypoxic conditions were found most frequently along a zone near the northern shore, particularly near the mouths of the Lee and Cole Rivers. 1972-73 studies found hypoxic conditions over a broad area of Mt. Hope Bay but a review of 1972-98 data found that low dissolved oxygen conditions were less prevalent in the mid-bay waters near Spar Island than at the sampling locations nearer to Brayton Point. Dissolved oxygen concentrations less than 4 mg/l occurred in these waters every year but three (1987, 1996, and 1997) and occasionally represented greater than 20% of the June-August readings.

Both states recognize impairment of these waters as a condition requiring a TMDL but work has not yet started. The MA Estuaries Project has proposed a three-year data collection effort, extending as far inland as Brockton, starting next summer if funding is approved. This effort would produce a TMDL Tech Report. MA DEP has also developed a preliminary scope of work for the Taunton River leading to development of a nutrient TMDL. An assessment effort is planned as phase IIB of the Fall River CSO project. Although the CSO project is not aimed at nutrient reduction, this assessment may afford a significant opportunity to assess the condition of all major pollutants.

The major nutrient sources to Mt. Hope Bay are the Taunton River and wastewater (and CSO) discharges from Fall River. Additional river inputs come from the Cole, Lee, Kickamuit, and Quequechan Rivers. Nixon et al.[57] estimated 1638 metric tons/yr discharged from the Taunton River and 434 metric tons from the Fall River WWTF, totaling 2072 metric tons/yr loading to Mt. Hope Bay. Isaac[58] estimated 1297 metric tons/yr based on his "river method" (781 metric tons/yr from nonpoint sources and 514 metric tons/yr from point sources). He estimated 1920 metric tons/yr using a "land use" method (720 metric tons/yr from nonpoint sources and 1200 metric tons/yr from point sources including Brockton, Taunton, and four other WWTFs in the Taunton watershed in addition to the Fall River plant.

The Fall River WWTF does not have nutrient removal requirements but is monitoring nutrients. The facility is in the midst of an upgrade to increase capacity from 50 to 106 MGD to reduce CSOs. Fall River's CSO project, including increased plant capacity, will greatly reduce overflows but not nitrogen loading. Other treatment plants in the watershed do not now have nitrogen limits. (The Brockton plant, in a major upgrade, is being designed to remove nitrogen). Most facilities (except Fall River and Somerset) have limits on ammonia discharges. Present phosphorus limits are 1.0 mg/l at Brockton, Bridgewater, and Mansfield and 0.2 mg/l at Middleboro. MA DEP does not regard septic systems as a significant source for this watershed although there may be localized effects in some areas. MA and RI communities in the watershed are on schedule with respect to stormwater management plans and permitting.

→ conduct a comprehensive bi-state assessment of nutrient pollution in Mt. Hope Bay to determine the extent of nutrient removal required for WWTFs discharging to Mt. Hope Bay and the Taunton River; examine other sources to determine if additional actions are necessary

Status of Nutrient Removal at WWTFs in RI (updated 1/04)

	WWTF	Advanced Treatment Status	Permit or Mod	CA or CA Mod	Facility Plan		Prelim. Design		Final Design		Complete Const	
					Due	App.	Due	App.	Due	App.	Due	Comp.
1	BRISTOL	Nitrogen Not Evaluated	7/28/99									
2	BURRILLVILLE	Ammonia (8.9), Nitrogen (Max extent)	9/7/00	2001		12/02	NA		NA		NA	
3	CRANSTON	Ammonia (2), Nitrogen (8), Phosphorus (1)	6/1/00	2000	12/31/01 (N & P)	7/03			2/04			
4	EAST GREENWICH	Nitrogen (5)	9/28/01	2001		9/00	2/1/02	4/17/02	8/1/03 rec'd 7/31/03	10/14/03	3/06	
5	EAST PROVIDENCE	Nitrogen	9/27/91									
6	JAMESTOWN	Not Anticipated	9/25/00									
7	NARRAGANSETT	Ammonia (32)	3/29/00									
8	NARRAGANSETT BAY COMM-BUCKLIN	Ammonia, Nitrogen (design target of 8)	12/31/90			11/97		NA		9/01	9/06	
9	NARRAGANSETT BAY COMM-FIELDS	Ammonia, Nitrogen	9/30/92									
10	NEW SHOREHAM	Ammonia (11.2)	5/2/00		1/16/03 rec'd 2/21/03							
11	NEWPORT	Nitrogen Not Evaluated	11/10/97									
12	RIEDC/QUONSET	Nitrogen Not Evaluated	12/30/99									
13	SMITHFIELD	Ammonia (2.7), Nitrogen (max extent) and Phosphorus (0.2)	6/8/01	2001	12/8/01	12/02	6/03 rec'd 5/29/03					
14	SOUTH KINGSTOWN	Not Required	5/7/01									
15	WARREN	Ammonia, Nitrogen	11/26/96									
16	WARWICK	Ammonia (2), Phosphorus (1), Nitrogen (8)	6/1/00	4/26/01		4/97		3/99	12/99	10/19/01	8/19/04	
17	WEST WARWICK	Ammonia (2), Phosphorus (1), Nitrogen (8)	6/1/00	2000		4/97		3/99	3/01	4/18/02	7/05	
18	WESTERLY	Ammonia (5.5), Nitrogen (design target of 12)	3/11/97	2002		3/00	8/30/01	11/01	7/02	4/5/02	10/03	10/03
19	WOONSOCKET	Ammonia (2) Nitrogen (10), Phos (1)	6/14/00	2000		3/00		NA		7/00	9/01	9/01

Narragansett Bay Bacterial Pollution

- **The Issue**

Bacteria (and viruses and protozoa) in Bay waters can present a danger to public health. Because of that threat, bathing and shellfishing uses of the Bay are limited in some areas. Much progress has been made eliminating these microorganisms that cause illnesses. The public is well protected from the epidemics of typhoid and cholera such as occurred in the 1800s. However, the esthetic and recreational value of the Bay, as well as its value as a shellfishing ground, continues to be reduced because of bacterial pollution.

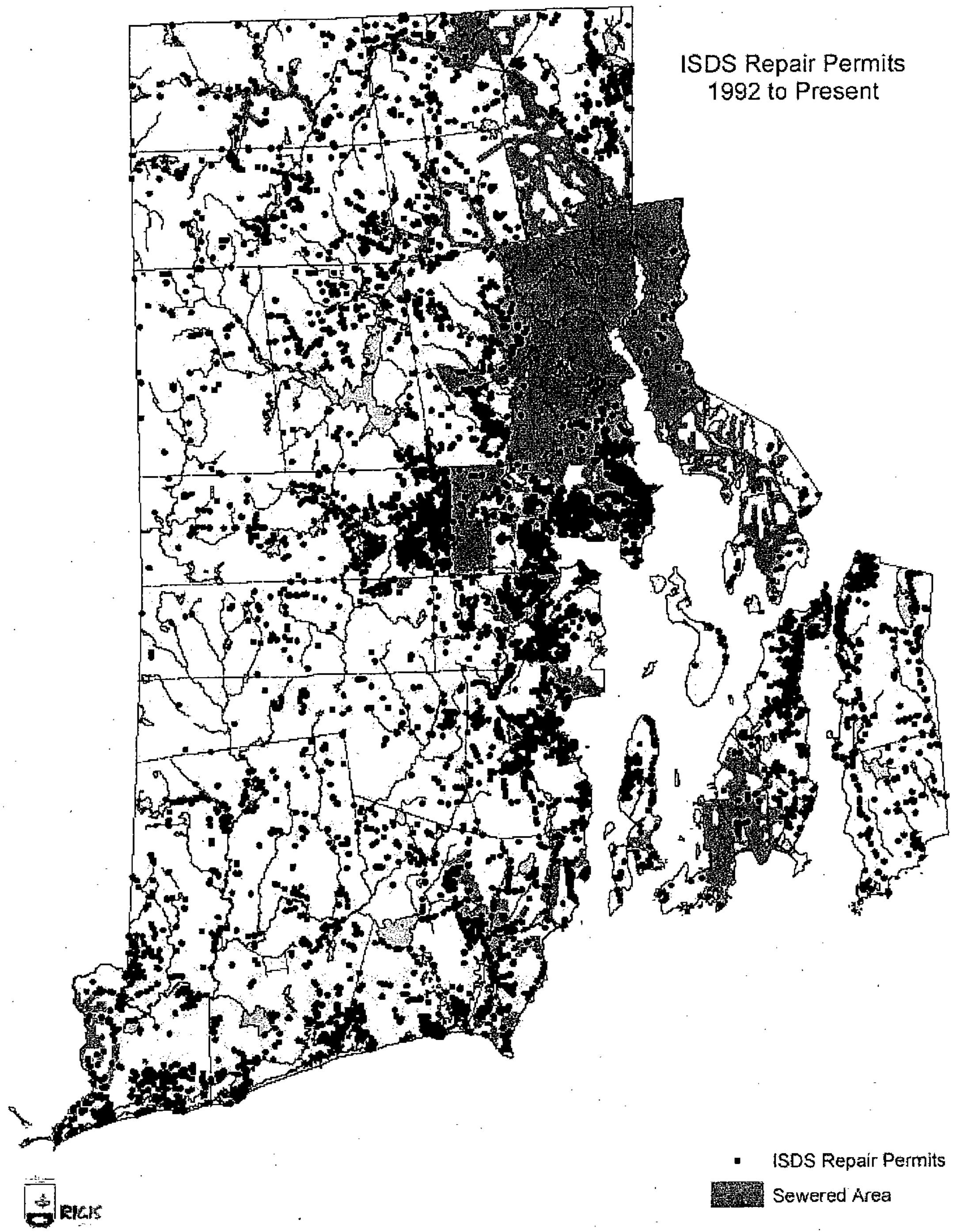
- **Sources**

Most bacteria that present a threat to human health are associated with the feces of warm-blooded animals. (Naturally occurring *Vibrio* species can cause human illness through shellfish consumption but outbreaks are rare in Narragansett Bay.) Escherich in 1885 determined that a group of bacteria, which he termed "coliform bacteria", were always detected in high concentrations in human feces. The thermotolerant (capable of growing at the elevated temperature of 44.5 C) subgroup of coliform bacteria has been shown to be more specifically related to coliform bacteria in feces of humans and warm-blooded animals and is called "fecal coliforms". Current efforts are switching to use of enterococci organisms as the standard for detection of risk in recreational waters[59]. All of these standards are indicators rather than comprehensive assessments of all pathogens but, in addition to being more practical, they should be increasingly precise and reliable.

In recent years, combined sewer overflows (CSOs) have been the major source of fecal coliforms to the Bay. CSOs were estimated to contribute 80% of fecal coliforms entering the Providence/Seekonk River during wet weather and precipitation events[60]. Annual fecal coliform loads from the CSOs were nearly four orders of magnitude (i.e. a factor of 10,000) higher than loads from wastewater treatment facilities (WWTFs) and approximately 200 times the estimated annual loading from separate storm drains[61]. CSOs were estimated to be responsible for 96% of the fecal coliforms entering Mt. Hope Bay in wet weather[62].

WWTFs typically are required to limit discharges of fecal coliforms to 200 organisms/100 ml as a monthly average and 400 organisms/100 ml as a daily maximum (both expressed as geometric means). At such levels, WWTFs are rarely a major source of bacterial pollution. However, because of the possibility of by-passes due to equipment failure or other events, restrictions are placed on the use of Bay waters in the vicinity of WWTFs.

Cesspools and failed septic systems can be a significant source of bacterial pollution. 37% of RI's population is served by Individual Sewage Disposal Systems (ISDSs) (see map). Inspection of over 1200 septic systems in the Greenwich Bay area found 12% of systems in violation. Wet weather increases transport of bacteria from cesspools and septic systems as well as many other sources. More than 150 storm water outfalls have been identified along Greenwich Bay, its coves,



RI DEM has completed five TMDLs for fecal coliforms in rivers draining to Narragansett Bay – the Barrington, Runnins, Palmer, Narrow, and Hunt Rivers – as well as for the Saugatucket River which drains to Point Judith Pond. Two other fecal coliform TMDLs have been submitted to EPA for final approval – the Sakonnet River and The Cove at Island Park – and another fecal coliform TMDL for Greenhill and Ninigret Ponds has been submitted for preliminary review. Lastly, a fecal coliform TMDL for Greenwich Bay waters has just been released for public comment. Sources in some cases have been identified (along with corrective actions) but, in other cases, sources remain elusive. An analysis of coliform contamination in Buttermilk Bay, MA illustrates many sources and techniques applicable to the Narragansett Bay watershed[63]. RI HEALTH is attempting to develop a capability for RNA fingerprinting to identify sources of bacterial pollution. The MA DEP recently released a draft TMDL, including RNA analysis of sources, for Massachusetts portions of the Palmer River[64]. RI DEM completed identification of bacteria sources in Green Hill Pond using polymerase chain reaction in July of 2003[65].

- **Impacts**

Beaches are closed when bacteria standards are not met. RI HEALTH, with support from EPA, conducts a risk-based beach monitoring program at all licensed beaches in the state. The standard for fecal coliforms in saltwater is 50/ml MPN (most probable number with not more than 10% of samples exceeding 500); enterococci must be less than 35/ml MPN (geometric mean). In Massachusetts, beach monitoring programs are conducted by municipalities. RI beaches in were closed more than four times as often in 2003 than in 2002 – a total of 454 days in 2003[66].

The interstate shellfishing industry is regulated under the FDA's National Shellfish Sanitation Program to maintain national health standards. Both MA and RI conduct bacteriological monitoring of shellfish waters in order to maintain certification of these waters for shellfish harvesting for direct human consumption. The standard for fecal coliforms is 14/ml MPN (geometric mean with not more than 10% of samples exceeding 49). Harvesting is permitted in approved areas and prohibited in closed areas. Other areas are conditionally approved on a seasonal basis (reflecting potential pollution from boats) or on a rainfall-related basis. Closures are also imposed as stock management measures unrelated to water quality conditions. Collectively, areas that are not approved are termed "restricted". The percent approved area in RI waters has fallen from 68% of bay in 1985 to 63% in 2003. Most of the change reflects administrative decisions to reduce any possible risk to human health by, for instance, setting larger restricted areas around WWTFs.

The transition in standards (from fecal coliforms to enterococci) and the differences between shellfish (set by FDA) and bathing beach (set by EPA) procedures will cause some technical disagreements but have generally been consistent regarding use or closure.

- **Strategy**

Bacteria pollution reduction efforts should focus on eliminating or reducing wet weather delivery. CSO reduction projects have been initiated and need to be completed. Storm water management efforts are beginning and should be targeted to relieve swimming and shellfishing limitations. Cesspools should be phased out and septic systems properly maintained. Most dry weather flows of bacteria pollution (except WWTFs) are illegal and should be eliminated when discovered. Corrective action for sources related to beach closures, regardless of weather conditions, should be given high priority.

Most municipalities in the watershed are now required by state and federal regulations to seek permits for municipal separate storm sewer systems (MS4s). Applications must include a storm water management plan that addresses six minimum measures as well as TMDL and other water quality restoration plan requirements. Municipalities are asked to give priority to illicit discharge detection and elimination efforts in areas that impact beaches.

Older Individual Sewage Disposal Systems (ISDSs), especially cesspools, are often inadequate. MA Title V regulations help eliminate failed systems that may be impacting embayments and tributaries. RI should adopt a plan to phase out high risk cesspools. Many cities and towns in both states support municipal septic system management plans and are adopting community septic system loan programs to help ensure proper maintenance of existing septic systems.

- **Goals and Reduction Measures**

The focus of this initial report is on goals assigned to the panel. These goals direct attention to specific areas. Other areas which might stand out as particularly important in a more comprehensive analysis have not been addressed here.

1. <u>By 2010, reopen 25% of areas now closed to swimming</u>

The RI HEALTH advises against swimming (primary contact recreation) north of Conimicut Point. This includes a number of sites that, historically, have been used as beaches, including Gaspee Point and Crescent Park (Riverside). Phase 1 of the NBC CSO project should be completed by 2007. (The NBC CSO project is included on the Clean Water Finance Agency Project Priority List (CWFA PPL).) Bacterial loading to the Providence/Seekonk River is expected to be reduced by 40%. The complete NBC CSO project is expected to be completed in 2022, reducing bacterial loading by 95-98%. Monitoring at sites north of Conimicut Point in the late 1980s suggested that, with reductions in bacterial loading, some of these beaches might be reopened for swimming. In fact, samples from the Riverside beach never exceeded EPA criteria[67]. More extensive monitoring in 1999 showed beach water quality standards were met at 11 upper Bay sites close to 50% of the time but, in 2000, only 44% of samples met standards[68]. Modeling reported in the CSO Environmental Assessment[69] estimated that, even with completion of all phases of the CSO project, water quality at Gaspee Point and Crescent Park would fail to meet standards 25-30% of the time. Those estimates may be pessimistic about conditions at completion given that other improvements, such as at the Bucklin Point WWTF, were not considered. Urban residents indicate unmet demand for beach recreation, particularly at nearby locations[70]. RI DEM designates uses of Providence/Seekonk River areas to include primary and secondary contact recreation.

Data for the NBC CSO project environmental assessment[71] indicate that conditions in the Seekonk River and Providence River north of Fields Point fail to meet swimming water standards even in dry weather. On completion of phases of the CSO project, beach reopenings may be most likely in the area between Fields Point and Conimicut Point.

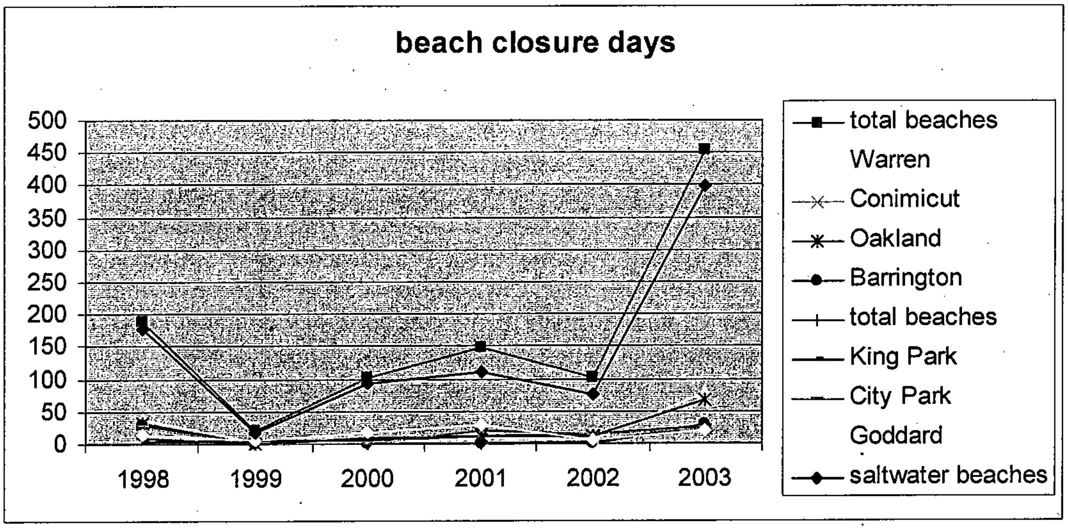
No beaches in Mt. Hope Bay or elsewhere Narragansett Bay other than the upper Bay are regarded as "closed". Significant reductions in bacteria counts are expected in Mt. Hope Bay with completion of the second phase of the CSO project there by the end of 2004. Projections of water quality at potential swimming areas do not appear to have been made.

→ The only closed beaches in Narragansett Bay are north of Conimicut Point. The post-phase 1 assessment of effectiveness of the NBC CSO project should include a focus on actual and potential swimming water quality in this area and limitations by both CSO and non-CSO sources. This aspect of the assessment should be done in cooperation with RI HEALTH and the city planners of East Providence, Warwick and/or Barrington. Achieving the goal of reopening by 2010 areas now closed to swimming, if possible, will require concerted effort based on this assessment.

2. <u>By 2010, reduce the number and frequency of beach closures by 50%</u>

RI HEALTH has collected consistent water quality data at 122 licensed beaches (including 72 saltwater beaches) since 1999. 2003 was a particularly bad year – 454 closure days including 397 days at saltwater beaches. It may be most reasonable to interpret the goal with reference to a 5-

year average of saltwater beach closures – 174 days of closure. The goal would then be to reduce beach closures by 87 days. (Three beaches in the Massachusetts portion of Narragansett Bay report swimming water quality to EPA. The only closures reported at these beaches in 2003 were 2 days at Pierce Beach on the Taunton River.)



Sanitary surveys and investigations, involving multiagency cooperation, have been conducted at several beaches that suffered numerous closures[72]. Identified or potential sources included stormwater discharges, boats, seagulls and other waterfowl, CSOs, treatment plants and pump stations (failures), as well as river influences, and residential and industrial areas.

A two-pronged strategy is suggested. First is to focus on areas with most closures – 8 beaches have accounted for 81% of saltwater beach closure days since 1998. RI HEALTH, in conjunction with other state and local agencies, has identified sources contributing to bacterial pollution at these beaches[73].

-- Warren Town Beach – closed 78 days in 2003

Investigations in 2003 found an overflow discharging onto the beach from a forced main sewer line in disrepair. The town slip-lined the pipe and bacteria counts at the beach were reduced dramatically. The beach may see some further improvement with the completion of the NBC CSO phase 1 by 2007. Implementation of water quality restoration plans (TMDLs) for the Palmer and Runnins Rivers should also help. RI DEM's TMDL implementation list includes work on 3 state stormwater outfalls, livestock BMPs, and public education. A TMDL for the MA portion of the Palmer River has been completed and the draft is available for public comment. Other bacteria sources noted in the sanitary survey include a large number of boats, birds, the Warren WWTF, a seafood processing plant, and residences.

→ eliminate food sources for birds on the beach, encourage "no discharge" by boaters, pursue implementation of TMDLs particularly on the Palmer River, and monitor to determine if closures are eliminated by 2007. If not, stormwater discharge on the beach should be removed or treated.

-- Conimicut Point – closed 67 days in 2003

Investigations have not identified nearby sources, other than seagulls. Conditions may improve substantially with completion of Warwick sewering (and tie-ins) and phase 1 of the NBC CSO project by 2007

→ prohibit feeding of birds near the beach, eliminate other food sources, encourage sewer tie-ins, and monitor improvement with CSO project completion.

-- Oakland Beach -- closed 66 days in 2003

Investigations showed stormwater runoff, boats, and seagulls as nearby sources. Improvements are expected as Warwick sewering is completed and stormwater management measures identified as priorities in the Greenwich Bay TMDL are implemented. Stormwater management measures for the general area are included on DEM's TMDL implementation list. Some control measures identified in the TMDL as planned or existing (by RI DOT or the towns), particularly swirl separators, are not likely to be effective in reducing bacteria loads.

→ pursue actions on priority discharges identified in Greenwich Bay TMDL, ensure that control measures to be implemented are selected to reduce bacteria loads, encourage sewer tie-ins, prohibit feeding of waterfowl near the beach, encourage "no discharge" by boaters, and monitor conditions to determine if additional actions are needed.

-- Barrington Town Beach – closed 28 days in 2003

Investigations showed stormwater runoff and seagulls as nearby sources. NBC's CSO discharges may also be a source.

→ prohibit feeding of birds near the beach, eliminate other food sources, and monitor improvement with CSO project completion.

-- Bristol Town Beach – closed 26 days in 2003

Stormwater with high fecal content from a wetland swale as well as waterfowl have been identified as nearby sources. NBC's CSO discharges may also be a source.

→ determine source of high bacteria in the wetland swale, provide disinfection if necessary, control waterfowl population at this beach by eliminating food sources, and monitor improvement with CSO project completion.

-- King Park Swim Area – closed 26 days in 2003

Nearby sources include CSO discharges from the city of Newport, boat discharges, waterfowl, and stormwater. Stormwater separation, already installed, should be completed. Inspections have found boater discharge violations and fines have been imposed.

→ complete stormwater separation, continue enforcement of "no discharge" from boats, control waterfowl population at this beach by eliminating food sources, and monitor improvements to determine if additional action needed.

-- City Park Beach (Warwick) – closed 23 days in 2003

Stormwater runoff, boats, and seagulls have been identified as nearby sources. Conditions at this beach are similar to those at nearby Oakland Beach described above.

→ pursue actions on priority discharges identified in Greenwich Bay TMDL, ensure that control measures to be implemented are selected to reduce bacteria loads, encourage sewer tie-ins, prohibit feeding of waterfowl near the beach, encourage "no discharge" by boaters, and monitor conditions to determine if additional actions are needed.

-- Goddard Park – closed 21 days in 2003

Stormwater runoff, boats, and seagulls are also identified as nearby sources at this heavily used beach. Conditions will benefit from the same actions that benefit Oakland Beach and City Park Beach on the north side of Greenwich Bay. However, being on the south side of the bay, Goddard Park is further from sewering work. It is further from priority stormwater management measures in Brush Neck Cove but closer to measures recommended for Greenwich Cove.

→ pursue same actions as above.

Secondly, there should be a special focus on lower Bay/South County beaches to preserve public expectation. Because of heavy use, Scarborough may be particularly important.

-- Scarborough – closed 6 days in 2003

Stormwater from three nearby outfalls has been identified as the primary source. Investigations of sources of the high bacterial counts have been inconclusive. Inadequate sewage disposal facilities were found at a nearby campground and action is being taken to eliminate that possible source. RI HEALTH and RI DEM await the results of microbial source tracking conducted in September of 2003. Further investigation, possibly including additional microbial source tracking, is needed to identify causes of high counts at the other outfalls.

→ conduct additional source investigations and analyze alternative solutions, including reduction, infiltration, or treatment of stormwater discharges or relocation of pipes.

-- Easton's Beach – closed 3 days in 2003

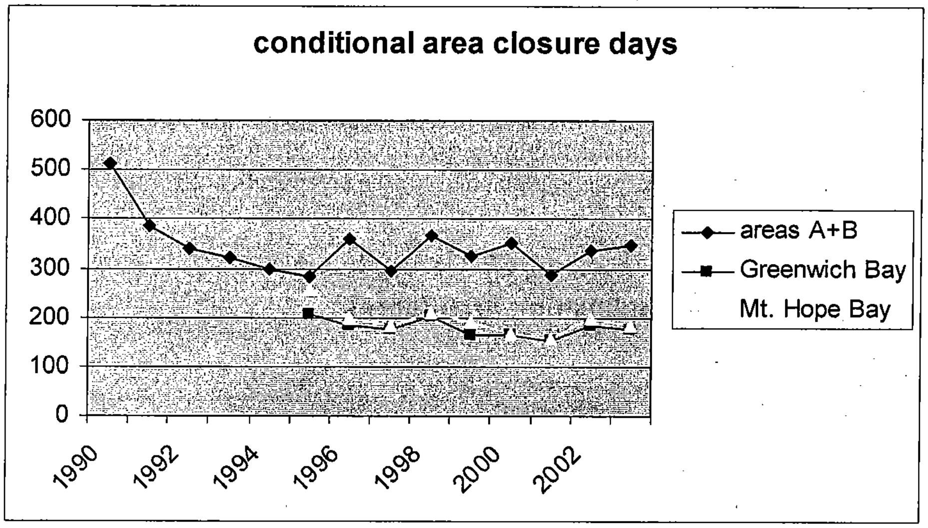
Nearby sources include a pump station, stormwater, and waterfowl. A pump failure during the 2003 swimming season forced a beach closure. Waterfowl food sources (trash and extensive piles of seaweed) should be removed from this beach. Sources of bacteria in the drainage ditch along Memorial Boulevard need to be identified.

→ correct pump station problems, remove food sources from the beach, and investigate other sources of bacteria

In addition, to preserve public confidence, predictive models for closure should be developed so that waiting for test results will not leave the public at risk.

3. <u>By 2010, reduce the number of days shellfish areas are closed by 50% and reopen 2,000 acres.</u>

Four areas of the Bay are subject to conditional closure: Areas A and B in the upper Bay, the main part of Greenwich Bay, and portions of Mount Hope Bay/Kickamuit River[74]. Operating rules now call for closure of Area A for 7 days after a ½ inch rainfall or a 0.5 million gallon by-pass. Areas A and B are closed for 7 days after a 1 inch rainfall and 10 days after a rainfall of more than 3 inches. Greenwich Bay and Mount Hope Bay/Kickamuit River are closed for 7 days after a rainfall of ½ inch or more. Greenwich Bay is also closed for portions of the winter season as a management measure to limit harvest. Water samples are collected and analyzed on a monthly basis. Closure rules are adjusted based on the geometric mean of 30 samples at each of the sampling stations in an area. Conditionally closed areas in the Bay total 14,663 acres (with an additional 1,239 acres closed seasonally). Prohibited areas total 33,191acres (26,809 acres in RI and 6,382 acres in MA).

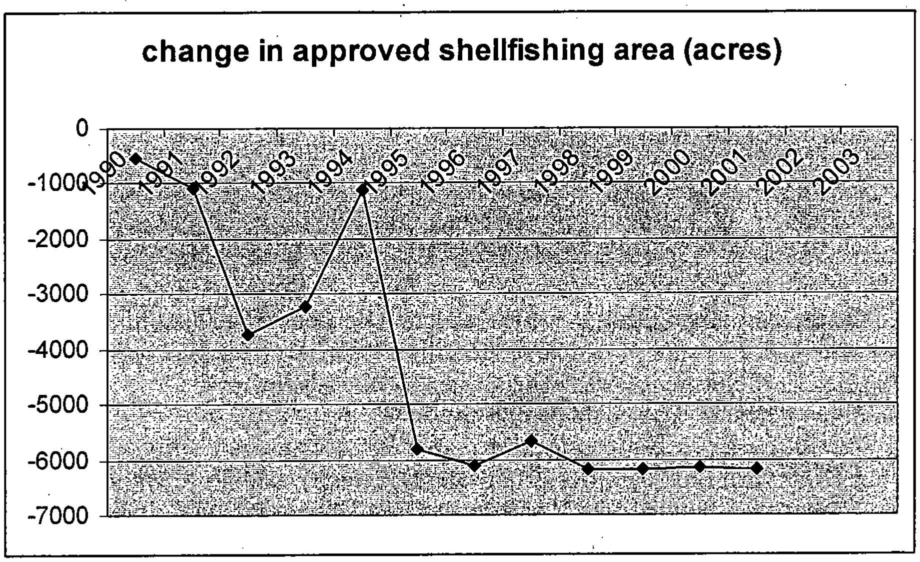


Phase 1 of the NBC CSO project should result in a 40% reduction in bacterial loading to the upper Bay. Acre-days of shellfish closure should be reduced by 41% in Area A (5461 acres) and 77% in Area B (3978 acres)[75]. If closure rules can be adjusted to take advantage of these improvements, the number of closure days could be reduced 56%.

The bacteria TMDL for Greenwich Bay identifies stormwater and wastewater (from septic systems) as the major sources of pollution. Both Warwick and East Greenwich are extending sewer lines. In Warwick, tie-ins are proposed to be mandated on a schedule that will extend to 2010-2012. Storm water best management practices (BMPs), ranging from education efforts through upland flow attenuation measures to infiltration basins, are recommended and areas prioritized. RI DEM has identified 18 stormwater outfalls (nine state owned, nine city owned) as priorities for stormwater management measures. (These are included on DEM's TMDL implementation list.) The proposed bond issue could help support the cities' costs. State costs may be substantially covered by federal assistance for stormwater pollution abatement in connection with DOT projects retrofitting roadway drainage systems. Warwick's extensive sewering project has taken advantage of synergy with roadbuilding work. (The sewer project in included on the CWFA PPL.) Compliance with "no discharge" rules for boats is also important to ensuring improvement of water quality.

The aim of the TMDL is to restore the designated use of Greenwich Bay as a shellfishing area – both the 1,716 acre conditionally closed area in the main part of the bay and the 680 acres of permanently closed areas in the main bay and coves designated for shellfishing. Management closures as well as precautionary closures in marina areas and in the vicinity of the WWTF would remain but implementation of the TMDL should make it likely that 50% of the conditionally closed area could be reopened.

Conditionally closed areas in the Mount Hope Bay/Kickamuit River area are along the western shore off Bristol. They may improve substantially with completion of the Fall River CSO project although no detailed estimates are know to have been made. The project is expected to reduce fecal loading to Mount Hope Bay by 75%. Phase I, increasing the capacity of the WWTF from 50 to 106 MGD, is complete. Phase IIA, a main storage tunnel and screening and disinfection facility for the north system, should be completed by December, 2004. Phase IIB, to be completed by September 2005, will evaluate the project's effectiveness and examine costs and benefits of additional measures. Interstate cooperation during this phase may enable a comprehensive assessment of water quality and shellfishing management in the area. RI completed its 12-year cycle shoreline survey for shellfishing impacts in 2002. RI DEM has pathogen TMDLs under development for the Kickamuit Reservoir and Upper Kickamuit River. Septic systems, storm drains, and other possible sources have been identified. Farm BMPs as well as storm water BMPs are likely to be needed. Warren, the major RI community in the Kickamuit watershed, is about 70% sewered and has additional sewering on the CWFA project priority list. Concerted effort by RI DEM to complete TMDL analyses underway and planned for the area can benefit from and complement the Fall River CSO evaluation effort and other MA pollution control activities.



TMDLs have been completed to address permanently closed areas of the Palmer, Barrington, and Runnins Rivers – accounting for a total of 1658 acres. Additionally, draft bacteria TMDLs have been completed for the Sakonnet River at Portsmouth Park and The Cove at Island Park and Greenhill Pond and Tockwotten Cover area of Ninigret Pond – encompassing another 813 acres. Implementation of these TMDLs is included on DEM's TMDL implementation list and should contribute toward the goal of reopening 2,000 acres.

Permanently closed areas of Narragansett Bay include 35 locations in RI and 5 in MA. The largest areas are in Providence/Seekonk River (5,508 acres) and Mt. Hope Bay (including the Kickamuit, Lee, Cole, and Taunton Rivers -- 4,844 acres in RI and 6,382 acres in MA for a total of 11,226 acres). As a result of the CSO projects, some portions of these areas may be upgraded in their use designation and opened conditionally, however no detailed estimates have been made. Many other areas of the Bay are closed as a precaution because of the presence of marinas, docks, and treatment facilities and reopening is unlikely. Changes in extent of approved areas in recent years has largely reflected these precautionary closures.

→ Shellfishing area closure days are likely to be reduced by about 50% by 2010 through completion of the NBC and Fall River CSO projects, sewering, and stormwater management in Greenwich Bay and BMPs in the Kickamuit watershed. Achieving the goal of reopening 2,000 acres is most likely through interstate cooperation in Mt. Hope Bay, a concerted effort to correct sewage disposal problems in Portsmouth Park and Island Park, and implementation of stormwater management and other BMPs in the Palmer, Barrington, and Narrow Rivers and Green Hill and Ninigret Ponds.

4. By 2015, restore Greenwich Bay and the Blackstone, Woonasquatucket, [and Wood-Pawcatuck] Rivers to fishable and swimmable condition.

Because this panel's charge is nutrient and bacteria pollution, "fishable" and "swimmable" are interpreted in this context. Thus "swimmable" means meeting bacteria standards for swimming. "Fishable" means meeting dissolved oxygen criteria and, in locations where shellfishing is a designated use, meeting bacteria standards for shellfishing. Dissolved oxygen issues are addressed in a companion paper on Narragansett Bay nutrient pollution.

A. Greenwich Bay

Greenwich Bay is a shellfishing area and has three licensed swimming beaches (Goddard Park Beach , Oakland Beach, and City Park Beach). Conditions and improvement actions to achieve both fishable (shellfishing) and swimmable standards with respect to bacteria are discussed above.

B. Blackstone River

Many segments of the Blackstone River and its tributaries are listed as impaired due to pathogens. The Blackstone is not a shellfishing area. Bacteria sources include CSOs, WWTFs, ISDSs, stormwater, and illicit discharges.

Developing a water quality restoration plan or TMDL for the mainstem Blackstone is a high priority for RI DEM but has not yet been completed. MA DEP also lists the mainstem Blackstone as in need of a TMDL.

The major sources of bacteria load to the Blackstone River are CSOs. Both Worcester and NBC CSOs discharge to the Blackstone. An extensive CSO abatement program in Worcester was done in the 1980s, reducing overflows to a single outfall. Ongoing work to upgrade the UBWPAD facility should reduce activations from 24 at present to about 7 per year. NBC's CSO reduction project will address outfalls to the Blackstone River in phase 3 but completion will not be until 2022.

Six WWTFs discharge directly to the mainstem Blackstone River and four others discharge to tributaries. Except in the event of bypasses or failures (such as with the power failure at the Upper Blackstone facility in October, 2003), these plants should not contribute large bacteria loads.

Many communities in the watershed are not sewered but no estimates have been made of the contribution of septic systems to bacteria loading. Municipal onsite management plans are beginning to be adopted. Glocester has a proposed management plan on the CWFA PPL and Cumberland has one under study. The Blackstone watershed in MA and RI will be the site of a National Decentralized Wastewater Demonstration Program. Some communities are installing sewers. Burrillville, for instance, has sewering proposals on the CWFA PPL.

Worcester is a phase I community in EPA's stormwater management program[76]. There are 8 MA and 5 RI phase II communities in the watershed and all have proposed or are developing stormwater management plans. Though the TMDL has not been completed, stormwater management projects for 16 areas in RI's portion of the watershed are identified as likely to be needed and included on DEM's TMDL implementation list (8 local and 8 state). No loading estimates are available and, although pollution reductions are expected, quantification will be difficult.