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CONTROLLING POLLUTION FROM ON-SITE SEWAGE DISPOSAL SYSTEMS IN BUZZARDS BAY: A PLAN FOR EVALUATING PROGRAM OUTCOMES

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by
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Sometimes when it is late at night and very quiet, I open the bathroom door and look at it. Like the most deadly of enemies, it appears utterly defenseless, an impotent mass of porcelain and steel. But I know that someday soon it will turn on me, and I will not emerge the winner.

OK, this is not entirely true. It's not really the toilet that has my eyeball bulging through the bathroom door keyhole. It's what I know lies deep in the black earth below it--the septic system. I have no idea what a septic system actually does. But I do know that it is very, very important.

I had hoped to live a life without coming into intimate contact with a septic system, to squander my remaining days dancing giddily upon subterranean town-maintained sewer systems and sophisticated urban plumbing arrangements, to flush with wild abandon. But as the new owner of three cottages on a lake in Vermont, those carefree days are gone. Life has begun in earnest. I tremble to flush in my own home.

Sally Jacobs
The Boston Globe
October 6, 1989

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I. INTRODUCTION AND PROBLEM STATEMENT

Approximately half of the residents of the Buzzards Bay watershed use cesspools or septic systems to dispose of sanitary wastes.[1] This has resulted in what is becoming a public health threat as well as a major nutrient enrichment problem, especially in poorly flushed embayment areas. These on-site systems, many of which are poorly maintained, allow contaminants to reach surface waters, groundwater, and eventually the coastal waters where bacterial and viral pathogens threaten the public health of the people using the bay.[2] These pathogens are transmitted to humans through the consumption of shellfish and by direct contact with the waters through swimming or other water contact sports. Excessive nitrogen inputs cause significant environmental degradation and may also pose health risks to humans, especially young children.

The Buzzards Bay Project (BBP), one of the programs of the National Estuary Program funded by the states and the Environmental Protection Agency (EPA), is attempting to address these issues as part of its recently completed Comprehensive Conservation and Management Plan (CCMP). A number of action steps have been developed to address the problem of increasing levels of pathogens and nutrients in the bay from on-site systems.

Following a description of Buzzards Bay and its primary pollution problems, I will review the technical operations of septic systems, the plan to address the pathogen/nutrient problem under the BBP, other suggestions which could be successful in achieving the goals of the program, the importance and difficulty of measuring environmental success, and finally the issues which must be considered if one were to carry out an evaluation research project for this septic system action plan.

The literature review for such a research project includes: 1) government documents on estuary pollution and the management of pollution programs published by the EPA, NOAA (National Atmospheric and Oceanographic Administration), Massachusetts state and local environmental agencies, and agencies from other states; 2) scientific reports on groundwater, surface water, and estuary pollution; 3) technical reports on Best Management Practices (BMPs) and septic system operations; 4) historical information on the Buzzards Bay area; 5) journal articles on evaluating environmental programs; and 6) writings on the methodology of evaluation research. Personal interviews were also conducted with Joseph Costa, Director of the Buzzards Bay Project, George Loomis of URI's Natural Resource Sciences Department, Jens Sorensen of University of Rhode Island, Robert Bowen of the University of Massachusetts (Boston), and Rich LaPan and Steven Schimmel of EPA's EMAP program.

II. HISTORY AND BACKGROUND

According to a recent report by the EPA, there are some disturbing problems impacting estuarine and near coastal waters of the United States. These problems include: "...water masses that do not contain sufficient oxygen to sustain living resources; an accumulation of toxic contaminants that threaten humans, fish, and shellfish populations; a decline in the amount and quality of ecologically important habitat (e.g. wetlands and submerged aquatic vegetation); evidence that many restoration and mitigation efforts have not replaced losses of critical habitats; an increase in the frequency and persistence of algal blooms; a decrease in water clarity; an increased number of closures of beaches, shellfishing grounds, and fisheries because of pathogenic and chemical contamination; and an increased incidence of human health problems from consumption of contaminated shellfish and from swimming in contaminated waters."[3] As a result of these problems, one-third of the nation's shellfish beds have been closed, more than half of the original wetlands in the contiguous U.S. have been lost since the European settlement, a fourth of the nation's monitored estuaries have elevated levels of toxic substances, and many coastal areas have experienced significant economic hardship due to the destruction of these resources.[4]

The most prevalent pollutants in estuaries are nutrients and pathogens, and in the U.S., the primary sources of estuarine pollution are: municipal discharges, resource extraction, storm sewers and runoff, land disposal of wastes, and agriculture.[5]

While many policies and procedures have been developed to address point source pollution from such sources as sewage treatment plants, resource extraction sites, and industrial discharge pipes, the problem of nonpoint source (NPS) pollution has received much less attention.

According to a BBP report, the Buzzards Bay estuary is experiencing three significant pollution problems: health risks from pathogens associated with the improper treatment or disposal of human wastes; excessive nutrient inputs to the Bay; and contamination of fish, shellfish, and lobsters by toxic substances.[6] The first two of these primarily result from NPS sources and will be discussed in this paper.

What is NPS pollution? According to the federal government, NPS pollution is pollution that is: 1) generated by diffuse land use activities (not identifiable activities); 2) conveyed to waterways through natural processes such as storm runoff or groundwater seepage rather than deliberate controlled discharge; and 3) not susceptible to "end of pipe" treatment but rather must be addressed by changes in land management or process practices.[7]

According to one estimate, nonpoint source pollution is responsible for "73% of the oxygen demanding loadings, 84% of nutrients, 98% of bacteria counts, and 99% of suspended solids in the nation's waters."[8] Nonpoint source pollutants enter surface waters as a result of a number of processes including urban stormwater runoff, groundwater flow, runoff from agricultural and ranching activities, and from discharges from pleasure boats to these waters. NPS pollutants can be generally categorized as: sediments, pathogens, toxins, and nutrients. Of these, Buzzards Bay is most greatly impacted by pathogens and nutrients.[9]

In 1988, the Massachusetts Division of Water Pollution Control tested streams and coastal waters for coliform bacteria, nutrients, and metals. Of the 61.4 miles of Buzzard Bay tributaries, 100% exhibited excessive levels of coliform bacteria and 9% contained excessive levels of nutrients. In addition, of the 21.6 square miles of Buzzards Bay coastal basin tested, 88% had bacterial problems, 16% had high levels of nutrients, and 31% exhibited high levels of metals or toxins.[10]

The pathogen problem has resulted in the closing of shellfish beds and swimming beaches in Buzzards Bay. The greatest danger from pathogens is that they pose a health risk to those coming into contact with them. Swimmers, and eaters of contaminated shellfish, are particularly vulnerable to diseases from these types of pollutants which enter estuaries not only via sewage treatment plant effluent, but also from such non-point sources as vessel sanitary wastes, subsurface disposal systems, stormwater runoff, wildlife and waterfowl wastes, and domestic animals.

The most common health impacts resulting from swimming in contaminated water are ear, eye, and skin infections as well as respiratory diseases. In addition, if water is ingested while swimming, gastrointestinal infections are also possible.[11]

Consumption of contaminated seafood can cause acute gastrointestinal disorders, including such serious diseases as cholera and infectious hepatitis.[12]

Excessive nutrients, primarily from anthropogenic sources, often pollute estuaries and have been identified as a serious problem for embayments of Buzzards Bay. These contaminants degrade water quality, destroy fish and plant habitat, and may exacerbate the pathogen problem. The primary sources are "septic systems, sewage facilities, atmospheric inputs, and fertilizers which are used on lawns, golf courses, and agricultural areas."[13] One of the major estuarine problems resulting from excessive amounts of nutrients is eutrophication. This occurs when algae growth is stimulated, and in extreme circumstances results in anoxic events and fish kills. The increased turbidity caused by the algal blooms prevents sunlight from reaching submerged vegetation such as eelgrass which begins to disappear. The loss of these valuable nursery areas results in a reduction of certain fish populations. When the algae die and decompose, there may be serious depletion of oxygen in the waters causing fish kills and the death of benthic organisms.[14]

In a study which included drainage areas of sections of Buzzards Bay, there was evidence of a synergistic effect where nitrogen enrichment actually contributed to the survival of fecal coliforms and promoted the growth of certain harmful bacteria.[15] An additional health concern regarding high nitrogen levels is danger to babies who can suffer "blue baby syndrome" when they ingest drinking water with a high nitrogen content.

In contrast to other types of pollutants, the impact of nitrogen loading is primarily confined to the smaller, bordering embayments rather than to the central portion of the bay. Most embayments experiencing this problem receive the nitrogen inputs from local groundwater and stream discharges.[16] One of these nitrogen-sensitive embayments (Buttermilk Bay) receives approximately three-quarters of its nitrogen load from septic systems in the surrounding drainage basin. Throughout the bay, septic systems contribute nineteen percent of the total nitrogen inputs. [17]

The quantities of these various pollutants are increasing as the population in the surrounding communities rapidly expands. The Buttermilk Bay report indicated that this particular bay was close to surpassing its carrying capacity for nitrogen and that other areas within the bay have experienced eutrophication.[18] In addition, various habitat areas are also experiencing stress such as the eelgrass beds on both sides of Buzzards Bay, the important shellfish (bay scallop, oyster, soft-shelled clam and quahog) beds used for commercial fisheries, and bathing beaches throughout the Bay.[19] For every habitat impacted or destroyed, there is the accompanying loss of income, increased threats to public health, and environmental degradation which impacts the Bay's ability to serve as a valuable resource.

As is common with most U.S. estuaries, initial attempts to clean up Buzzards Bay have focussed on reducing point source inputs. Nevertheless, there are a number of things that can be done to control NPS pollution. Technology-based solutions including such measures as installing storm drains, boat pump-out facilities, and denitrifying septic systems are often implemented with significant results. These "best management practices" also include changes that are not technological in nature such as requiring the use of setbacks or buffers from sensitive areas, planting cover vegetation to reduce erosion and sedimentation, or limiting the use of fertilizers and pesticides by homeowners or golf courses.

The Buzzards Bay Project under its CCMP has included a number of such preventive practices some of which are specifically targeted at addressing the problems caused by faulty or poorly sited on-site sewage disposal systems.

III. BUZZARDS BAY WATERSHED DESCRIPTION

Buzzards Bay can be described as a moderately large, tidally dominated estuary which is located in southeastern Massachusetts. It is 28 miles long, averages approximately eight miles in width, and has a mean depth of 36 feet. It is close to 228 square miles in size, it contains over 210 miles of coastline, and the drainage basin covers 426 square miles.[20] The eastern shore is drained primarily by groundwater and the western shore is drained by a number of small to moderate river basins. Although it is a well-mixed estuarine system, Buzzards Bay is not well-flushed and it traps many of the pollutants entering the waters.[21] The numerous small embayments within Buzzards Bay are particularly impacted by these trapped contaminants.

The coastal zone of Buzzards Bay contains a variety of important habitats including "salt marshes, tidal streams, eelgrass beds, tidal flats, barrier beaches, rocky shores, and a number of subtidal habitats."[22] It is an important area for tourism and beach recreation, shipping, scientific research, effluent discharge, boating, and recreational fishing and shellfishing. It is also a significant economic resource for the commercial fishing and shellfishing fleets.

A Massachusetts Audubon report estimates New Bedford's annual loss of shellfish due to pollution from combined sewer outfalls (CSOs) to be over $13 million.[23] In addition, Massachusetts' $800 million annual saltwater fishing industry has suffered greatly from reports of coastal pollution in the Buzzards Bay area.[24]

It has been estimated that the population of the drainage area of Buzzards Bay increased by 49% between 1950 and 1986.[25] Presently the population numbers close to 250,000 and this number will continue to increase at a rapid rate in the years to come. This population increase has strained the system both in terms of increased levels of pollution and increased tensions among competing users of the resources of the bay.

In spite of this growth, much of the land surrounding the bay remains undeveloped with as much as 60% classified as forest.[26] However, the areas adjacent to the shoreline are more developed and many more coastal areas have been zoned for future residential development. The largest city bordering the estuary is New Bedford, with a population of nearly 100,000. This densely populated urban center has contributed significantly to the pollution problems in the bay and at the same time its citizens have been impacted greatly by these contamination problems.

The eastern shore of Buzzards Bay is part of Barnstable County, the fastest growing county in New England. Along with the increased pathogen levels, rapid population growth and increased shoreline development have contributed to high nutrient levels in portions of the bay.

An estimated 491,600 lbs/year of nitrates enter the groundwater kettle ponds and coastal bays each year on Cape Cod and this represents a 25% increase since 1980.[27] A similar rate of increase has likely occurred in Buzzards Bay. Residential development, much of it using inadequate septic systems and cesspools which would not be permitted under present standards, contributes greatly to this problem.

Some of the particular impacts on Buzzards Bay from the increasing amount of contaminants reaching its waters include the closure of swimming beaches, decline in the eelgrass acreage, contaminated lobsters and areas closed to lobstering, increased frequency of algae blooms in smaller embayments, decline in finfish populations, and the closing of shellfishing areas.[28] The total acreage of shellfish beds closed in Buzzards Bay as of March 1, 1990 was 15,320.[29] The primary reason for these closures is the presence of a high levels of pathogens which are linked to increased septic system effluent and stormwater runoff. As the cleanup of point source pollution in the watershed continues to make headway, the importance of examining the problems associated with nonpoint sources is becoming the primary focus in efforts to cleanup this important estuary.

One of the most comprehensive studies of the sources and impacts of pathogenic pollutants and nutrient enrichment in a coastal embayment was conducted in the northern end of Buzzards Bay in the Buttermilk Bay embayment.

The shoreline of Buttermilk Bay has been developed and includes light commercial industry, seafood restaurants, and residential development ranging from one house to every two acres to eight houses per acre.[30] In addition, there are twenty direct stormwater discharge sites.[31]

Until 1984, water quality in Buttermilk Bay had been considered very good, but during that summer all areas were closed to shellfishing due to high bacterial pathogen levels.[32] The following year Mr. George Heufelder of the Barnstable County Health and Environmental Department began a study of the causes of this problem, focusing on stormwater runoff, septic system effluent, wildlife, marinas, fresh water inputs, and point-source discharges. He concluded that the primary cause of the bacterial contamination of the shellfish beds was runoff from roads following rainstorms.[33] However, with regards to the impact on the shellfish beds from septic systems, Dr. Heufelder found that both bacterial and viral pathogens were able to reach the bay from individual sewage disposal systems via the groundwater from great distances in the area's sandy soils. He also discovered that these contaminants can survive in the wrack line along the shore for up to three weeks during the summer.[34]

Another harmful impact was attributed to the increased levels of nitrogen introduced by ISDS into the groundwater and eventually to surface waters. He found that increased bacteriological contamination could be linked to higher levels of nutrients which are supplied to bacteria and viruses from ISDS effluent.[35]

IV. NATIONAL ESTUARY PROGRAM

In order to proceed with an effective approach to clean up "estuaries of national significance" in the United States, the National Estuary Program (NEP) was established as part of the Water Quality Act of 1987. Section 320 of the act authorizes the EPA to develop comprehensive plans for these estuaries through the convening of management conferences with the goals of "protecting and improving water quality and of enhancing the living resources in these environmentally sensitive areas."[36]

To achieve these goals, the NEP attempts to establish partnerships among federal, state, and local governments, to increase public participation in pollution control activities, and to promote basinwide planning.[37]

The primary purposes of the Management Conferences are to: assess trends in water quality, natural resources, and uses of the estuary; collect, characterize and assess data on toxins, nutrients, and natural resources to identify the causes of environmental problems; develop the relationship between the in-place loads and point and nonpoint loadings of pollutants in the estuary and the potential uses of the particular area, water body, and natural resources; develop a Comprehensive Conservation and Management Plan (CCMP) that recommends priority corrective actions and compliance schedules to assure that the designated uses of the estuary are protected; develop plans for the coordinated implementation of the plan; to monitor the effectiveness of the plan; and to review all federal financial assistance programs and development projects for consistency with this plan.[38]

The NEP process is carried out in four phases: the planning phase where the management framework is established; the characterization and problem definition phase; the creation of a management program; and the implementation phase.[39]

Once the management framework is in place, the characterization phase is implemented in an attempt to discover the sources, impacts, and possible corrective measures which can be developed to reduce the impact of point and nonpoint pollution in the estuary. This involves gathering scientific data which can help in the understanding of historical trends in the estuary as well as an assessment of its present condition. During the characterization phase, scientists rely primarily on historical data and their goal is to gather information on "pollutant sources to the estuary, circulation of material in the estuary, distribution of chemicals in estuarine waters and sediments, distribution of biological organisms in the estuary, rates of biological processes, factors important to human and environmental health, and geographic areas of special importance."[40] This phase forms the basis for developing the goals and objectives for the particular estuary program.

Action plans are developed to address particular priority problems in the estuary based on established goals and objectives. There may be a number of action plans for each estuary program ranging from steps to control stormwater runoff to the establishment of bylaws and new regulatory programs to address land-use issues.

V. THE BUZZARDS BAY PROJECT

One of the first estuaries to receive funding under the NEP was Buzzards Bay. The Buzzards Bay Project (BBP) was begun two years prior to the 1987 act as a state program with support from the EPA and the Massachusetts Executive Office of Environmental Affairs. The project established a management structure, began to identify and research water quality problems in the bay, and started to develop a management plan to address these problems. The BBP identified three types of pollution problems in the bay: high levels of pathogens (bacterial and viral), excessive nutrient inputs, and the presence of toxic substances.[41] By 1990, a draft CCMP was completed and released for public comment. The final plan which includes eleven specific action plans is expected to be approved during 1991. Included as one of these action steps is a plan to address the problem of pathogen contamination and nitrogen overloading in areas of Buzzards Bay due to on-site, sub-surface septic disposal systems. On-site sub-surface sewage disposal systems contribute significantly to the pathogen levels and the nutrient inputs, and to a lesser extent to the input of toxic substances.

In addition to the primary goals of addressing the problems associated with pathogens, excessive nutrients, and toxins, the BBP is attempting to educate and involve the public in this cleanup effort. Once the studies have been completed and the remediation measures begun, the public must begin to view themselves as important participants in saving this estuary. Many measures will only be effective if the public becomes aware of specific actions they can take to reduce inputs of contaminants into the bay.

MASSACHUSETTS ISDS REGULATIONS

In Massachusetts the requirements regarding the sub-surface disposal of sanitary sewage are promulgated in the State Environmental Code (Title 5) of the Code of Massachusetts Regulations (310 C.M.R. 15.00). The stated goal of these regulations is to "provide minimum standards for the protection of public health and the environment when ISDS are used for the disposal of sanitary sewage."[42] It establishes standards regarding the suitability of the soil for treating liquid wastes, allowable percolation rates, the restricted distance in which an ISDS can be placed in relation to surface water supplies or watercourses, and the use of specific types of toilets, leaching areas, and septic tanks. For example, ISDS can only be located where there is "at least a four foot depth of naturally occurring pervious soil beneath the entire area of the leaching facility; percolation rates of greater than 30 min/inch are considered impervious and unsuitable for ISDS use; ISDS cannot be located within 50 (or 100) feet of surface water depending on the type of system; and privies, chemical toilets, humus toilets, and other new system designs are not permitted unless they undergo thorough examination and prove to be no more damaging to the environment than standard septic systems."[43] Under this code, general ordinances and bylaws may be enacted by local governments to conserve health; to prevent overcrowding of land; to provide for the water supply, drainage of sewage, open space and conservation of natural resources; and to prevent blight and pollution of the environment.[44]

Title V allows towns to place restrictions on nutrient loading levels for new subdivisions, to enact "pooper scooper" regulations in nearshore areas, to restrict the conversion of seasonal cottages to year-round homes if the ISDS is not properly upgraded, to require sewer hookups for growth in densely populated areas, to require system inspection at time of sale to a new owner, and to create "surface water districts" where certain activities may be prohibited or require a permit.[45] The Town of Falmouth enacted subdivision regulations that require an environmental impact analysis to assess the expected increase of nutrients to the watershed from any new development in sensitive areas. The carrying capacity of the receiving waters and cumulative impacts from other activities in the watershed are important considerations as part of this analysis.[46] The Town of Chatham, which does not drain into Buzzards Bay, requires the inspection of ISDS systems by a registered engineer or sanitarian prior to real estate transactions.[47]

Title V also allows Boards of Health to adopt more stringent standards in order to adequately address local conditions and specific water quality issues. It is allowable under the statute for these local boards to order property owners to clean or repair their ISDS and to establish mandatory pumping or inspection schedules for residences under their jurisdictions.[48] Some municipalities (Bourne, Carver, and Plymouth) have established regulations requiring upgrading of pre-Title V systems when the system needs repairs or if they are being altered in any way, and Bourne has placed restrictions on locating ISDS in any "hazard-prone area" or in soil with less than six feet clearance above groundwater supplies.[49]

A 1989 Buzzards Bay Technical Report noted that although some towns had exercised their authority under Title V to better regulate pollution from ISDS and other nonpoint sources, most had done little and excessive pathogens and nutrients continued to be a problem.[50]

The EPA issued a design manual which included a number of recommendations regarding the management of on-site systems. According to the EPA, in order for ISDS management to be effective, there must be: "validation of site evaluation, a review of system design, certification of operation and maintenance, supervision of system construction, assistance provided for rehabilitation, a public education component, and adequate monitoring and enforcement capability."[51] Systems must be designed and sited properly, monitored for proper operation, and adequately maintained so that failures can be prevented.

One of the primary problems plaguing current ISDS management practices is that the responsibility for operating and maintaining the system has been left to the owner.[52] Unless authorities establish standards, educate the public, and verify that owners are caring properly for these systems, there will continue to be problems.

The EPA suggested instituting an operating permit system whereby an owner could not use a system unless he could certify that it is properly operating and maintained according to the local regulations. Additional suggestions include randomly inspecting systems in sensitive areas and passing legislation which authorizes local governments to require "repair, replacement, or abandonment of improperly functioning systems."[53]

IV. SEPTIC SYSTEM OPERATIONS

On-site septic systems (or ISDS--Individual Sewage Disposal Systems, if used for a single residence) are soil-based wastewater treatment systems consisting of a septic tank, the absorption area, and the surrounding soil.[54] ISDS also includes systems without tanks such as cesspools or seepage pits in which minimal treatment takes place prior to discharge to the soil. The proper performance of a septic system is dependent upon many factors including "design of the unit, characteristics of wastes, rate of hydraulic loading, climate, areal geology and topography, physical and chemical composition of the soil mantle, and care given to periodic maintenance."[55]

In conventional septic systems a "buried, watertight tank receives wastewater from the home, separates solids from the liquid, provides limited digestion of organic material, stores the solids, and permits the liquid to discharge for further treatment and disposal."[56] The absorption area distributes the effluent to the soil where "physical, chemical, and biological wastewater treatment processes occur."[57]

In order for the system to adequately remove harmful pathogens from the wastewater, all components of the system must be properly functioning. The tank and pipes must be properly designed, located and maintained, and the soil must be suitable for leaching the sewage.

Important considerations are the groundwater elevation and the presence of bedrock or impervious materials. An unsaturated zone below the drainfield is necessary for proper aeration and for slowing the rate of travel of the effluent. Slow travel permits the die-off of bacteria and viruses, and decomposition of organic materials.[58] The EPA Design Manual for OSDS recommends a water unsaturated soil depth beneath absorption systems from 24-48".

For proper operation the soil cannot be too shallow nor prone to saturation. It must be permeable enough to allow liquids to pass through but not so permeable that they flow through so quickly that no cleansing takes place. Certain materials that may cause damage or clogging must not be allowed to enter the system (disposable diapers, oil and grease, paints, paint thinners, etc.), and systems must be regularly pumped and inspected.[59]

If these conditions are met, ISDS are capable of providing adequate treatment of sewage, but if not, many problems can arise in such disposal systems.

One estimate is that of the approximately 17 million systems in the United States, only 40% function in a proper manner.[60] The reasons for this, according to Canter and Knox, are that the operation and maintenance of ISDS is largely unregulated and is left to the judgment of the system owner. Also, it is often difficult to detect problems prior to experiencing an overt system failure where effluent surfaces.[61] In addition, many older systems are still being used despite the fact that they have exceeded their functional life spans. Septic system problems are also common in densely developed coastal areas where the carrying capacity of the drainage area for on-site systems is exceeded.

Pathogenic contamination from septic systems can occur as a result of overt system failure, from septic system overflow pipes, and through groundwater flow.[62]

When there is an overt system failure, soils can no longer receive additional effluent and sewage collects on top of the system and may break out onto the surface of the ground where it is transported to receiving waters. Surfacing of effluent is usually the result of a clogged leaching field caused by inadequate preventive maintenance (i.e. removal of grease). Heavy rains may also contribute to system overflow where the septic systems are not well-designed or inadequately maintained.[63]

Overflow pipes, which are now illegal to use, were designed to direct septic overflow toward a major water body, ditch or stream. These are also a source of pathogenic pollution.[64]

Pathogenic bacteria and viruses are also present in groundwater because of intrusion of sewage from on-site systems. Unless natural soil processes occur as these liquids percolate through the soil, these contaminants will enter the groundwater and move eventually to surface waters and estuaries. The process by which bacteria and viruses become attached to the surface of soil particles is called absorption. However these organisms are not permanently attached and are often released during heavy rainfall.[65]

According to Cogger, bacterial and viral survival is prolonged when "saturated and anaerobic conditions are present beneath the absorption trenches."[66]

It is also possible for bacteria and viruses to move great distances through soil and to exist for extended periods of time. In a study by Rahe, it was found that fecal coliform bacteria moved two feet downward and 50 feet laterally in just one hour in western Oregon in saturated soil.[67] Another study showed that coliform bacteria survived for more than one month under cool saturated conditions. Enteric bacteria have been found to survive up to 100 days in saturated soils, and viruses have been found to migrate up to 600 feet from their source.[68] A 1990 study in Narragansett Bay found human viruses viable in groundwater up to 200 feet downgradient from a septic system source.[69] Viruses are also more resistant to environmental change and have longer life spans in soil than bacteria.[70]

Seasonal vacation communities face an additional obstacle in the effective disposal of septic system effluent. Because of "intermittent occupancy, an effective biological clogging material is not completely developed as part of the soil absorption system."[71] Because of this, wastewater is not evenly distributed within the drainfield and does not receive adequate treatment to remove harmful pathogens. Loomis et al. concluded that seasonally occupied shoreline systems may need to meet more rigorous design and siting standards.[72]

Even where soils are suitable for treating the pathogens in effluent they may not be able to adequately treat nitrates especially where housing density is high. Nitrates present another serious problem especially for groundwater supplies. It is a highly soluble product of the aerobic degradation of wastewater, and is readily transported to groundwater.[73]

Usually nitrate is simply treated by being allowed to enter the groundwater where it becomes diluted. However there are more and more examples of nitrate levels higher than EPA allowed levels. This concerns not only public health officials but natural resource managers who have witnessed falling dissolved oxygen levels, eutrophication episodes, and increased fish and shellfish kills.

The EPA estimates that "the average person produces waste containing 10 lbs. of nitrogen each year and as much as half of this amount may eventually leave the leaching field in a highly soluble form to enter the groundwater".[74] This is especially true in outwash soil.

In other studies, nitrate was found to exceed EPA groundwater standards (10mg/l)as much as 100 feet downgrade from on-site systems operating in well-drained sands, and to reach unhealthful levels over 300 feet from an on-site system in sandy soil."[75] The greatest obstacle to reducing nitrate concentrations in coastal areas is increased population density. The BBP recommends controlling nitrogen inputs by managing growth, reducing fertilizer use, and promoting treatment technology capable of reducing nitrogen from septic system effluent through a de-nitrification process.[76]

At the present time, efforts to limit development density appear to be the most common approach to address the problem of excessive nitrate loading. Lower housing density allows for the effective dilution of this contaminant to acceptable levels in groundwater and coastal areas. However, recently there have been increased efforts to develop technological solutions to reduce contaminants from septic system effluent.

A number of unconventional systems have been developed in an attempt to reduce pathogen and/or nitrate levels, including mound systems, aerobic units, and dual systems.

The mound system is simply a pile of sand built up above the natural soil where the septic tank effluent is pumped and allowed to seep down through it. It is fairly effective, requires little maintenance, but it can be two to three times more expensive than a standard septic system.[77]

A significantly more costly and technically much more complicated aerobic system removes much more of the oxygen demanding substances and suspended solids while also greatly reducing bacteria and other dangerous organisms. Regular ongoing maintenance is required and the possibility of system failure is greater if the system is not properly maintained.[78]

Dual systems separate toilet wastes (blackwater) from other household wastewater (graywater). The graywater enters the septic system for treatment while the blackwater is separated out for separate treatment. These systems are also more expensive and require more maintenance.[79]

The University of Rhode Island Department of Natural Resources Science has done considerable work with denitrifying on-site sewage disposal systems. "Denitrification is the reduction of nitrate to a gaseous nitrogen compound by bacteria under anaerobic conditions in the soil."[80] A septic system can be modified to become a denitrification system by establishing anaerobic conditions and adding an energy source. Patterned after the RUCK system, URI-NRS' buried sand filter/greywater systems have recently been assessed in a field laboratory and in two full-scale systems in Charleston, R.I.[81] Their findings indicate that "the combination of a buried sand filter and an anaerobic tank using greywater as a carbon source can remove approximately 50% of the nitrogen in household wastewater prior to discharging to a soils absorption field."[82] The study, according to the authors, supports the concept of dividing the household wastestream into greywater and blackwater components. When a rock tank was used as the anaerobic environment and greywater constituted at least 40% of the total wastestream, denitrification rates of 100% were observed.[83]

One final factor to consider when regulating for septic system use is that human activities may cause the water table to rise over time as runoff is concentrated in smaller areas of land than would be available under natural conditions.[84]

Efforts to control the pollution of embayments by septic system effluent must include more than technological fixes to reduce the flow of pathogens and nutrients. Many communities are establishing comprehensive land use regulations as a vital component of their pollution control effort. There may need to be restrictions placed on the number of homes per acre, other areas may be restricted from any development, and in some areas the amount of impervious surface should be limited to allow for proper land drainage. Overlay districts, building moratoriums, more stringent site plan reviews or permits for sensitive areas, cluster housing, bylaws regulating activities contributing to erosion and sedimentation, wetland protection districts, and "no salt" areas are all common approaches toward achieving this goal.

During the spring of 1991, three Buzzards Bay communities initiated a more comprehensive strategy and placed on local ballots the issue of establishing Nitrogen Overlay Districts as a means of limiting development densities in sensitive, nutrient impacted areas. Under these revised zoning by-laws, "nitrogen management issues must be considered prior to the granting of any special permit or variance."[85] For one town, minimum lot sizes were increased to 70,000 sq. ft.

Before summarizing the recommendations for improving ISDS management for the Buzzards Bay drainage area it may be useful to examine a few approaches which have proven effective in other areas.

The Narragansett Bay Project, also an NEP program, convened an ISDS task force in order to issue recommendations as to how to best address the problems associated with these systems. The impetus for looking at this issue was a study completed for the Narrow River watershed that presented data showing that this area was developed beyond its carrying capacity and is experiencing an ISDS failure rate of 65%.[86] Many of these septic systems were built for seasonal use and failed once the cottage was converted to year-round use.

The task force report focused on the need to regulate for cumulative impacts by revising local zoning ordinances. Specific recommendations for ISDS use included: requiring regular septic system pumping; more aggressive enforcement of ISDS codes; establishing specific siting and design criteria for new systems in critical areas; updating standards pertaining to variances and system additives; allowing certain innovative technologies; devising new criteria for determining site suitability and system sizing; and spelling out maintenance responsibility of owners.[87]

One of these recommendations for controlling pathogens involved the regulating of the density of septic systems within a critical zone. Restrictive site controls such as mandatory 150 foot setback from sensitive areas, four foot separation from the bottom of the septic leaching field and groundwater supply, and lot size controls have all been instituted.[88]

In some of the densely developed areas of Rhode Island's salt pond region, high levels of nutrients and bacterial contaminants have been traced to ISDS which predate state-enforced siting and design standards. Many of these systems are also approaching their expected life span. The special area management plan for this region calls for ongoing public education activities, regular maintenance programs, the upgrading of inadequate systems, the extension of sewer services to densely developed areas surrounding these ponds, and the establishment of buffer zones along the perimeters of these ponds.[89] The Coastal Resources Management

Council also began testing the feasibility of utilizing denitrifying systems as a means of reducing the levels of these contaminants in the salt ponds.

Another successful subsurface sewage management program in Idaho follows a three-pronged approach of: establishing policies promoting sound environmental practices; limiting residential sprawl; and negotiating sewage management agreements (SMAs) which govern the permitting of septic tanks in the watershed.[90]

This rapidly growing area with highly permeable soil began to experience high levels of nitrate in its drinking water. Under each SMA, "goals, policies, and programs to prevent damage from septic tank leachate" are established based on the particular circumstances of each community. Once a critical level of population growth is reached, there would be an agreement under the SMA to either construct sewer hookups for new development or to not grow any further. The SMA is "a civil contract negotiated and periodically renewed between town governmental entities that distributes enforceable duties and obligations to each as a way of reaching a goal or providing a service."[91]

RECOMMENDATIONS FOR ISDS USE

There are a number of steps which can be taken in order to better manage the use of ISDS in the Buzzards Bay watershed and to lessen their impact on the estuary. Local ordinances and bylaws (as well as state regulations) must be changed, current land use practices must be altered, self-regulation of septic systems must be ended, new technologies must be developed, programs designed to carry out regulatory mandates must be better funded, staffed and administered, and the public must become much better educated on their role in protecting the bay from NPS pollution, particularly from ISDS.

Such a comprehensive approach requires a more regionalized focus while at the same time places emphasis on the individual steps that can be taken by all to meet the goal of a cleaner bay. It may not be enough for some surrounding towns to enact bylaws to protect against excessive pathogens or nutrients if adjacent towns continue to contribute increasing levels of pollutants into the watershed. Some regulations such as prohibitions against cesspools and system additives, or requirements that system design, siting, and installation be carried out by qualified individuals could be applicable to all towns of the watershed. Hydrologists and sanitarians should be responsible for determining the suitability of soil and the water table level for ISDS use. Similarly, regulations pertaining to mandated inspection and/or maintenance requirements for ISDS should be codified and applicable to all watershed communities. The EPA recommends either mandatory inspections of systems no less than every two years or mandatory pump-out of systems every 3-5 years. They also recommend separation of greywater from blackwater.[92]

The Massachusetts Audubon Society has recommended that Title V (State Sanitary Code) be amended to include "stricter soil surveys prior to allowing use of an ISDS" and that "setback requirements from surface waters, wetlands, and wellheads be increased."[93] This code could also be made more flexible by allowing the use of innovative ISDS technologies to reduce pathogens and nitrates.

If a significant part of the problem is that there are numerous faulty systems which are currently undetected, an enforcement effort will be needed to compliment any strengthening of the regulations. At a minimum, systems would be required to be inspected when there is a change in ownership of a residence, or when a residence is being converted from seasonal to year-round use. Upgrading of an ISDS would be required if the current system is: a cesspool or seepage pit; a system being used beyond its operating life span; or if any additions to the size of the home would overtax the current capacity of a system. Operating permits could be required prior to using the system. Variances to ISDS regulations should be the exception rather than the rule.

Random inspections by town health or engineering officials should also be instituted in order to detect illegal or faulty systems, and violators should receive fines.

A major public education effort should accompany the strengthening of the regulations. Homeowners, as well as developers, businesses, and the real estate industry need to become aware as to how these systems operate, the impacts they are having on the groundwater and estuary, and what they can do to help solve the problem. The laws should be clearly explained, particularly those applying to system inspection, pumping, and ongoing maintenance.

Financial assistance should be made available (if possible) to towns and homeowners in order to ease the financial burden these changes may impose. Incentives may also be utilized such as are used in South Kingston, R.I. which offers rebates to encourage pumping.

Alternatives to conventional systems such as the mound, aerobic, RUCK, dual, or other denitrifying models should be tested and tried in this watershed, and where no ISDS system can safely be used there should be mandated sewer hookups.

Changes in land-use management approaches could also have an effect in reducing pollution levels. Designating some areas as being in need of special protection such as the salt pond region of Rhode Island or ACEC (Areas of Critical Environmental Concern) in Massachusetts can be the first step in developing a protective management plan. Nitrogen overlay districts, septic management districts, or sewage management agreements have all proven effective in limiting development pressures and reducing contaminant levels. For nitrogen in particular, zoning restrictions pertaining to minimum lot size can have an important impact on oxygen levels in embayments.

Just as important is to support and encourage the local boards of health to work within their broad mandates to protect public health and natural resources through stronger local ISDS ordinances and bylaws.

Finally, it will be critical to carefully gather data, monitor changes, and evaluate outcomes for any programs or technological improvements that have been implemented in the Buzzards Bay watershed so that effective strategies may be replicated.

VII. MEASURING ENVIRONMENTAL SUCCESS/PROGRAM EVALUATION

How can we measure environmental success for a program that attempts to address the problems associated with NPS pollution in Buzzards Bay, particularly the effects of septic system effluent on coastal embayments?

One of the ways progress is measured is through the utilization of program evaluation. Program evaluation is introduced into the process during the goal setting stage and its purpose is to allow environmental ment in the program and

to determine what improvements should be made."[94] It is a means of providing information about program outcomes which allows management to ascertain whether or not it has been successful in reaching its goals.

Basically, program evaluation can be divided into two general categories: process evaluation and outcome evaluation. Process evaluation "describes and determines the effectiveness of how well the program steps were carried out according to the prescribed policies, programs, and action steps", while outcome evaluation "examines the end results (or program outcomes) and attempts to assess whether or not the program contributed to these results."[95]

Process evaluation would require an examination of such management activities as the interpretation and enforcement of environmental regulations pertaining to a program, the adequacy of funding levels, program implementation efforts and intergovernmental coordination, and the degree of public awareness and acceptance of the program.[96] For an ISDS management program, process evaluation may focus on such components as the number of permits or variances issued, whether or not towns hired qualified staff such as hydrologists, sanitarians or health agents, number of faulty systems discovered and corrected, the adequacy of the public education efforts of surrounding towns, number of systems inspected by health agents, and a review of the degree of success or failure of any new bylaws, land-use regulations, or enforcement techniques.

In this paper, I have focussed on outcome evaluation rather than on an evaluation of the process. Specifically, will the programs implemented to reduce pathogens and nitrates from septic systems result in reduced contaminant levels in the embayments of Buzzards Bay, the safe harvest of shellfish resources, and a reduction in the number of swimming beach closures?

Sorensen and McCreary list two key conditions that must exist in order for a program to be evaluated: "an adequate post-implementation time period to allow a program to reach maturity and a set of indicators for measuring performance."[97]

Virginia Tippie, formerly of URI's Center for Ocean Management Studies, has written about the importance of establishing measurable criteria with regards to environmental program goals. She described the process of an evaluation research project as consisting of four key components: 1) program goals must be defined; 2) measurable evaluation criteria must be formulated; 3) data must be collected and organized; and finally, 4) the results are evaluated. The specific criteria or "monitoring indices must be acceptable to the public and able to be measured quantitatively."[98]

For environmental protection programs, Tippie recommends long term time-series data to assure that changes in water quality are due to program action steps. Such indices as shellfish bed closures and acreage of wetlands or seagrass beds should be used.[99]

One of the most important studies on developing "meaningful and measurable criteria" for purposes of evaluating coastal area programs was by Englander, Feldmann, and Hershman in 1977. They proposed that criteria used for evaluating programs should be developed based on a review of the goals of the program which can be "expressed in legislation, delineated in administrative guidelines, the attitudes of coastal zone managers, or the statements of coastal zone problems that led to the passage of legislation." Of these, the authors feel that the fourth may be most useful in developing criteria for program evaluation.[100]

These authors also point out additional difficult evaluation issues such as: the problem of causation or linking environmental outcomes and program actions; the inadequacy of baseline data in which to make comparisons between past and present conditions; and the difficulty in identifying and utilizing meaningful and measurable criteria.[101]

The EPA's Office of Water developed a strategic plan which described long term ecological goals for the nation's waters (including estuaries) that can serve as a beginning point in measuring program success. These goals are: increased number (or acreage) of shellfish beds open for harvest; a decline in the number of fishing bans and health advisories; a decrease in the extent of low oxygen "dead zones", maintenance of (or increase in) the extent and productivity of critical habitats, especially wetlands; and the maintenance of the biotic integrity of invertebrate and fish communities.[102] This listing of ecological goals could be very useful to those designing an evaluation program for ISDS management in Buzzards Bay. In order to address the issue of contaminants in swimming areas, another tool might be tracking "beach closure days". In addition, as a measure of severe nitrogen problems, information should be gathered from public health departments on cases of babies suffering from nitrogen related illnesses.

Some of these indicators, such as acreage of open shellfish areas, which rely on periodic sampling for viruses and bacteria are easier to measure. Others such as the biotic integrity of fish communities require an assessment of species diversity, dominance, and ratio of pollutant-tolerant species to pollutant sensitive species in order to develop a theory on the environmental health of the estuary.[103]

The condition of these shellfish beds and swimming beaches are directly related to the water quality of these estuarine areas. Such contaminants as bacterial and viral pathogens, and excessive amounts of nitrogen must be quickly identified in these areas so that precautionary measures can be taken. Since it is quite difficult and prohibitively expensive to test for all possible contaminants, other means of testing for water quality must be pursued.

Currently the most common approach is to examine "indicator species" which are defined as either the most sensitive or most commercially important species in an area.[104]

According to Wilson, "indices simplify a complex mass of data by selecting a component or components from the data mass such that any change in the selected component mirrors the change in the system as a whole."[105] The three components of the estuary system most often assessed for pollutants are the water column (which shows actual levels of contaminants present), the sediments (which are useful because they may "integrate pollutants over time to reflect exposure to that pollutant"), and organisms (which also integrate and concentrate pollutants over time but are somewhat more difficult to gather than sediments)[106]. Water samples are the most common means of testing shellfishing and bathing beach areas, but sediments and shellfish must also be tested to assure that contamination levels are not approaching critical levels in the organisms.

Total and fecal coliform levels are often used in determining whether or not shellfish areas or swimming beaches should be closed. These bacteria are assumed to indicate the presence or potential presence of human pathogens and although this indicator concept may not be 100% accurate, it is much less expensive and time-consuming than testing for all possible viral and bacterial contaminants.

It is important to note that there has been much criticism of existing water quality standards which are used to classify shellfish and bathing areas. In a progress review of the Narragansett Bay Project in 1990, concern was expressed over the fact that while waters are being tested for bacterial indicators, viral pathogens are actually the cause of most swimming and shellfish associated diseases.[107] The research currently being conducted by EPA and NOAA may result in standardized environmental indicators which can supplement or replace existing indicators and lead to greater assurances regarding the use of shellfish and swimming areas.[108]

Experiences of other estuary programs can be valuable in developing a monitoring and evaluation program for Buzzards Bay. The Chesapeake Bay program has implemented a "water quality and living resource monitoring program" which focusses on changes in environmental quality over time.[109] One of the important components of the Chesapeake Bay program has been the development of monitoring programs for the smaller systems within large estuarine systems. Their "watershed monitoring" model attempts to determine whether or not BMPs designed to control NPS inputs from agriculture and stormwater projects are effectively reducing pollutant loads from Chesapeake streams.[110] The actual installation of each BMP is tracked and the information gathered includes: BMP location by county and subwatershed, BMP type, acres served by the BMP, the number of animal units served, tons of manure stored, tons of soil saved per acre, pounds of nutrients saved per acre or ton, total cost of the BMP, and costs to farmers or homeowners.[111] This tracking of each BMP and of the efficiency of each in reducing levels of sedimentation and nutrients could be practiced in the Buzzards Bay embayments to assist in the evaluation of the effectiveness of septic system action plans.

In a study funded by the Narragansett Bay Project (NBP), the importance of establishing a "permanent, consistent monitoring program for water quality, fish and shellfish resources, nearshore habitat and wetland conditions" was emphasized as a key component of the successful management of this resource.[112] This report stressed the interdependencies of bay processes and concluded that it is necessary to "identify and evaluate linkages between individual and cumulative impacts and ecosystem function, where "watershed inputs can be linked to waterbody effects."[113] The NBP and other NEP programs rely on the establishment of water quality goals that can be used to assess the degree of failure or success of pollution control measures over time. This type of predevelopment/postdevelopment assessment of water quality in sensitive estuary areas relies heavily on ongoing and precise monitoring activities and appears to be the best approach in determining whether or not actions have been successful.

THE BUZZARDS BAY PROJECT MONITORING PLAN

The recently developed monitoring plan for the Buzzards Bay Project under the CCMP calls for ongoing review of the action plans that address the problems of pathogen contamination and excessive nutrients in the bay. Particular attention will be focused on the condition of the 27 embayments within the bay in order to assess the effectiveness of the action plans and to measure environmental trends.[114]

The BBP Monitoring Plan regarding pathogen contamination has been designed to assess whether or not management actions have: 1) lessened the levels of fecal coliform bacteria or other indicator organisms in the water and in shellfish, 2) reduced the number of shellfish resource areas closed due to pathogen contamination, 3) reduced the number of beaches closed due to pathogen contamination, and 4) lessened the amount of time that shellfish areas and bathing beaches are closed. Various trends pertaining to these indicators will also be monitored over time.[115]

Fecal coliform bacteria will be the primary indicator for monitoring pathogen contamination. Records of beach and shellfish area closures will also be an important component of this monitoring plan.

Regarding nutrient enrichment, the plan calls for the examination of the impact of management strategies (action plans) on the levels of nitrogen in the coastal embayments, and of nitrogen loading trends in the embayments as well as in the central portion of the bay.[116]

According to the BBP Monitoring Plan, measuring for nutrient loading and its effects requires an examination of "levels of dissolved inorganic nitrogen, particulate organic nitrogen and dissolved oxygen, as well as water transparency, chlorophyll a levels, periphyton growth, macroalgal abundance, flushing rates of the embayments, temperature and salinity."[117]

Shellfish abundance and density may also be important parameters to measure as are changes in acreage of salt marsh and submerged aquatic vegetation in the bay.

One of the detrimental impacts from excessive nutrients entering the bay is the loss of eelgrass, a resource which plays an important ecological role in Buzzards Bay. In a study by Costa for the BBP, it was discovered that "land-based sewage disposal, development activities, and residential and agricultural fertilizer application" have contributed much of the nutrients that have lead to reduced eelgrass acreage.[118] Because of its sensitivity to pollution, Costa proposed using eelgrass as an indicator species for changes in water quality in Buzzards Bay.[119]

Estimates of nitrogen inputs from groundwater and sewage treatment plants have been made for the entire bay but much less is known about nutrient loading and flushing time for individual embayments. The BBP Monitoring Plan recommends examining watershed land-use patterns for each embayment to estimate nutrient inputs from groundwater, and combining this with nutrient data from surface water discharges to arrive at a total estimate for each embayment.[120] Most monitoring efforts for nutrient levels will occur during the summer months when eutrophication is most likely to occur and will include water samples from a minimum of five sites in each embayment.[121]

Because pathogens and especially nitrogen may take quite some time to reach embayments because they are moving via groundwater flow, it will be necessary to develop a groundwater monitoring component in order to effectively monitor the impact of septic system mitigation measures. Nelson and Ward (1982) suggested two basic objectives with regard to system failure detection: "the detection of temporary overloads of high pollutant concentrations in groundwater; and the detection of permanent overloads of high concentration."[122]

Canter and Knox recommend that the testing location be in the "upper portion of the saturated zone directly beneath the field lines of the treatment system", and that the parameters to be measured include bacteria, viruses, and nitrates. Fecal coliforms and fecal streptococci would be possible indicators of bacterial and viral pathogens, and nitrate levels could be monitored to detect potential nutrient loading in the embayments of the watershed.[123]

The implementation of the BBP Monitoring Plan will provide information on an ongoing basis regarding the pathogen and nutrient loading levels for the bay as a whole and for each of the 27 embayments. This feedback information will be important in assessing whether on not the BBP is reaching its stated goals or whether adjustments in strategies are needed. In order to evaluate the impact of the septic system action plan on pathogen and nutrient levels in particular embayments, an evaluation research project will be required.

Prior to presenting a proposed program evaluation for ISDS management under the BBP, it may be useful to examine some of the issues pertaining to data gathering, and to review some of the data currently available and of use to BBP managers.

DATA NEEDS AND AVAILABILITY

The importance of comprehensive data gathering and of assuring its accuracy in a manner as thoroughly and systematically as possible cannot be overstated. Unless data gathering techniques result in unbiased and comprehensive data, it will be impossible to determine whether or not the policies and programs which are implemented are having the desired impact in reducing pollution.

Once an estuary pollution problem has been identified, there is a need for additional data on the current condition as well as for data on the changes in the estuary over some past period of time. Historical information may be available to allow determination of how the estuary once was, but just as important is to document the current baseline condition against which future changes can be assessed. Once this baseline condition is established, "conditions must be closely monitored in order to gather data on changes over time as a result of activities directed at a particular problem."[124]

The CCMP for the BBP recommended that sanitary surveys be conducted in each drainage area contributing to an embayment. These surveys would include information on the pollution sources, meteorological factors, hydrogeographical factors that may affect pollutant distribution, and an assessment of water quality.[125] This data would be gathered as part of the NEP "characterization" process.

Data collection for such an ambitious undertaking as an NEP program does not become less important once the characterization phase is completed and baseline data is in place. Data gathering must be an ongoing activity and is a key component of the monitoring and evaluation process. Unless new data is gathered and analyzed on the changing condition of the estuary, it will be impossible to assess the success or failure of action plans to reduce pollution and restore the estuary to a less contaminated condition.

The evaluation of action plans to control problems from septic systems or any other NPS problem will not require the BBP or surrounding towns to design and implement entirely new scientific data gathering experiments in all instances. Much information is currently being collected and should be utilized. In addition, much historical data exists and could be accessed rather than using 1991 as the starting point.

Under the National Ocean Pollution Planning Act of 1978, NOAA is required to coordinate marine pollution research, development, and monitoring activities funded by the federal government. NOAA "studies and makes recommendations on the implications of marine pollution to human health and on trends in the status of marine ecosystems."[126] NOAA scientists also collect data on fish landings and monitor trends and declines in the stocks of several commercially valuable fish and shellfish.[127]

Recently the National Oceanic and Atmospheric Administration, in conjunction with the EPA, has begun a research partnership under the Environmental Monitoring and Assessment Program. EMAP was designed as an integrated federal program which includes not only the EPA and NOAA, but the U.S. Fish and Wildlife Service, the U.S. Forest Service, and the U.S. Geological Survey. Its goal is to "assess and document the status and trends in the condition of the nation's sensitive environmental areas including estuaries and coastal waters."[128] To implement this program, data is being gathered in a standardized manner, over large geographic scales, and for long periods of time.

For estuarine areas, NOAA and the EPA will be the primary agencies involved. These agencies will be "gathering data to assess the regional extent of coastal environmental problems, measuring changes in the extent of these problems, evaluating associations between ecological condition and pollutant exposure, and assessing the effectiveness of pollution control actions and environmental policies."[129]

EMAP data which may be useful to the BBP includes dissolved oxygen levels, water temperature, salinity, turbidity, chlorophyll a, chemical analysis of bottom samples, and tissue chemical analysis, pathological assessment, and population structure of finfish in the bay.[130]

With regards to point, non-point, and riverine sources of pollutants in coastal areas, NOAA's Coastal Pollutant Discharge

Inventory (NCPDI) is a database which includes this information for the East Coast of the United States. Discharges extending from the heads of estuaries seaward, including such categories of pollutants as oxygen demanding materials, particulate matter, nutrients, heavy metals, petroleum hydrocarbons, chlorinated hydrocarbons, pathogens, sludges, and wastewater have been approximated for the period 1980-1985.[131]

In their 1990 Report to the Congress on Ocean Pollution, Monitoring, and Research, NOAA reported on the development of a database on the quality of the nation's shellfish growing waters. Information included data on "the sources of pollutants affecting harvest-limited waters, trends in classification from 1971 through 1985, and current and historic landings." [132]

NOAA also has issued reports containing information pertaining to the susceptibility to, and status of, nutrients in the nation's estuaries. Such important and useful information as rate of freshwater inflow, flushing and dilution rates, and estimated nutrient loadings are all collected and analyzed.[133]

Currently the shellfish survey data is being updated for the coastal states and this new information will include the change in acreage since 1985, the reasons for the changes, and the sources of pollution.[134]

The National Status and Trends Program for Marine Environmental Quality began in 1984 with a goal of developing an information base to quantify the "current status and long term trends in concentrations of key contaminants, and in biological indicators of contamination effects on living resources in the coastal and estuarine environment."[135]

Currently NOAA classifies shellfish waters as: 1) approved for harvest, 2) conditionally approved, 3) restricted, or 4) prohibited.

In Massachusetts, the Division of Marine Fisheries (DMF) monitors fecal coliform bacteria in coastal waters and in shellfish. Over 300 sites in approximately 59 shellfishing areas are sampled five times per year, and additional samples are gathered during rain events where runoff can increase levels of pathogen pollution.[136] Waters are tested for temperature, salinity, ph, and fecal coliforms. The DMF also records shellfish area and beach closings. The Department of Environmental Protection (Division of Water Pollution Control) conducts periodic surveys of water quality conditions and classifies shellfish growing waters in Massachusetts.[137]

One of the important tasks for those monitoring water quality in the bay will be to coordinate the collection of data (particularly on coliform bacteria levels) generated by the various governmental agencies in the area including U.S. FDA, Massachusetts DEP, and the local boards of health.

With regards to the Buzzards Bay area, the Shellfish Sanitation Section of the Massachusetts Department of Environmental Protection (DEP) has been sampling these waters for coliform bacteria since 1975 in order to classify shellfish growing areas. Since 1987, testing is conducted five times per year in addition to the tests conducted immediately following periods of heavy rainfall.[138]

The Department of Environmental Quality Engineering (now DEP) began collecting water quality and wastewater discharge data on Buzzards Bay in 1971 and it includes much data on coliform bacteria in the bay as well as in individual embayments for the past 20 years.[139]

The U.S. FDA studied water quality in two Buzzards Bay embayments during 1972 as part of its classification of shellfish areas and in 1981 tested for coliform levels at a number of sites on the eastern shore of Buzzards Bay.[140] The town of Bourne has been testing for fecal coliform in Buttermilk Bay for a number of years and also samples storm drain effluent.[141] The shellfish Constable of Marion monitors fecal coliform in Marion harbor "during swimming months and in shellfish areas as needed", and the Wareham Board of Health collects similar data at ten public beaches twice a month from May through September.[142]

Rhode Island tests the water at 34 bathing beaches just prior to the bathing season and beaches "susceptible to various bacterial inputs are monitored as often as once per week."[143]

It appears that a significant amount of water quality data has been collected in Buzzards Bay (and in some of its embayments) and that much data is still being gathered. Continued monitoring of these parameters will be important in assessing the impact of action plans for ISDS, but it will be necessary to supplement this data with new studies. Groundwater sampling in areas where faulty systems have been repaired or where innovative technologies have been instituted, stream water quality sampling in previously untested areas throughout the watershed, and embayment sampling for indices not previously gathered should all be implemented.

Some of this important data can be gathered by citizens as part of the citizen monitoring component of the BBP.

CITIZEN MONITORING

Because of the enormity of the task of monitoring each of the 27 embayments of Buzzards Bay, it will be important to establish a citizen monitoring component as part of this plan.

Precedents for successfully using citizen volunteers can be found in the Chesapeake Bay NEP and in a number of smaller monitoring efforts including two such programs in Rhode Island.

The Chesapeake Bay program developed a citizen water quality testing program to augment the NEP data gathering effort and to learn more about the water quality in some of the smaller tributaries. Under this program, five water quality factors (water and air temperature, ph, turbidity, salinity, and dissolved oxygen) were measured weekly. This was supplemented by general observations of the site regarding amount of debris, presence of fish kills, odor, oil slicks, and water color. Data is then entered into a computer file. Results of this citizen effort have been positive and it is an important part of the projects monitoring efforts.[144]

Since 1985, 30 volunteers have monitored water quality every other week from May through October for seven Rhode Island salt ponds. Along with gathering data on the same factors as in the Chesapeake Bay program, the "Salt Pond Watchers" also take samples for nutrient concentrations and chlorophyll as well as concentrations of fecal coliform bacteria.[145]

The Rhode Island Watershed Watch utilizes citizens trained by the University of Rhode Island Department of Natural Resource Sciences to gather water samples on a weekly or biweekly basis at 26 freshwater locations throughout the state. A second component of this program involves the assessment of non-point sources of pollution through shoreline surveys. Visual observations of water and shoreline conditions, of possible non-point sources of pollution, and of current uses of these water bodies and surrounding shores are summarized on data sheets and used to map each location.[146]

Along with providing information valuable to the monitoring efforts of local programs, these citizen programs help to educate the public about water quality issues.

VIII. ACTION PLAN DEVELOPMENT, IMPLEMENTATION, AND ASSESSMENT

The EPA's Office of Water published "A Primer for Establishing and Managing Estuary Projects" in 1989 which outlined a process for developing action plans for particular priority problems. The manual clearly describes a process in which action plans to address a problem (such as the impact of septic system effluent) may be effectively developed, implemented, and evaluated. Beginning with the problem identification and goal setting steps, it also addresses important considerations such as: what management activities are possible under current manpower, budgeting, and political constraints; who is responsible for what activities to be completed by when, for what cost and to be carried out according to which procedures; the importance of monitoring results and costs; and the need to evaluate the effectiveness of the action plans in achieving improved environmental quality so that redirection of the plan may occur if necessary.[147]

In order to attain the expressed goals of improved estuarine water quality and enhanced conditions for living resources for an estuary such as Buzzards Bay, numerous interrelated action plans must be developed, funded, implemented, monitored, and evaluated. For each of the priority problems (including pathogens and excessive nutrients), there will need to be a number of individual steps taken which will hopefully reduce the occurrence and impact of these contaminants. Just as the implementation of NPDES system has contributed to a reduction in point source inputs of pathogens, toxins, and nitrogen, programs must be established for the various non-point sources of these pollutants.

There are numerous NPS inputs and regardless of the fact that some sources such as stormwater runoff contributes greater amounts of pollutants overall, the use of septic systems contributes significantly to the problems of contaminated seafood, closing of swimming beaches, and problem associated with nitrogen impacted embayments.

The action plan described in the BBP CCMP to reduce the problem of pathogenic pollution from septic system effluent contains the following recommendations: 1) the Massachusetts DEP should amend Title V so that the provisions pertaining to upgrading Pre-Title V systems, ongoing inspection and maintenance of septic systems, setback requirements near sensitive areas, and the granting of siting variances are addressed and strengthened; 2) better enforcement of the regulations which do adequately address the problem; 3) new amendments to Title V which more adequately address the problem of viral pathogen transport from septic systems; 4) Board of Health regulations should be strengthened so that more and better qualified staff are hired, certified inspections are required following major repairs, sale of a house or when converting from seasonal to year-round use, and that system placement regulations are adopted especially for sensitive resource areas.[148]

To this list of recommendations, the following steps should be considered: 1) Massachusetts DEP and surrounding towns should undertake a comprehensive public education campaign to teach homeowners, businesses, and government officials about the health dangers and financial impact to the region from increased levels of pathogens in the embayments and groundwater and what can be done to prevent it; 2) a state and local effort should be undertaken to detect faulty systems contributing to this problem; 3) increased utilization of pilot programs (such as NODs and SMAs) and innovative systems (such as those which separate blackwater and greywater) throughout the drainage area to reduce contaminants flowing from septic systems; 4) institution of fines as penalty for use of faulty systems; and 5) the implementation of program evaluations for various mitigation measures and individual BMPs.

With regards to the management of nitrogen in sensitive embayments, the CCMP recommends that municipalities adopt nitrogen-loading bylaws or health regulation, and that the Massachusetts DEP "regulate cumulative impacts of nitrogen...by developing nitrogen specific criteria for state water quality standards."[149] It also calls for DEP to promote "the development and acceptance of cost-effective alternative technologies for denitrification". The CCMP again points out the difficulty in effecting change in the embayments if the current state sanitary code remains as it is. It recommends that the DEP amend Title V to address the weaknesses in the provisions pertaining to setbacks from resource areas, variances in sensitive areas, and the use of denitrifying septic systems.[150]

The CCMP also includes recommendations that are more general in nature such as greater state enforcement of regulations extending sewer hookups, more assistance for local boards of health, qualified health agents to administer the program in each town, and certified inspections at the time of conversion or sale of a home.[151]

It appears that there are a number of possible ways to approach this problem. The specific steps taken will depend on a combination of political, budgetary, scientific, and administrative factors. The questions remains, how will we know if we are having any success in dealing with this problem?

In order to evaluate the impact of these action steps on the environmental quality of Buzzards Bay, especially its smaller embayments, a number of considerations must be pondered. First, there will be a number of simultaneously occurring action plans being carried out which will likely affect pathogen and nutrient levels in each embayment. The impact from such activities and mitigation measures as stormwater remediation projects, marina boat pump-out projects, changes in fertilizer application practices, wastewater treatment plant improvements, increased use of setbacks, vegetated buffers and other land-use practices, etc. must be considered. Second, it will be important to evaluate the implementation process for the septic system action steps in order to determine which activities were carried out according to design and could actually be affecting the water quality. Third, during the initial information gathering or characterization stage, it will be important to develop meaningful estimates of inputs of pathogens and nitrogen from other sources such as stormwater runoff, cranberry bogs, boat pump-out wastes, farms, golf courses, landfills, parking lots, wastewater treatment plants, etc., so that calculations can be made regarding septic system inputs. Fourth, adequate time must be allowed for steps to be implemented and for outcomes due to these steps to occur. Fifth, it will be important to select meaningful and measurable criteria by which to evaluate program outcome. Sixth, much effort must be expended on coordinating activities and developing cooperation among the numerous federal, state, and local governmental bodies as well as nongovernmental units and citizens' groups. Lastly, those assessing the program must be aware of natural processes such as sea level rise and increased CO_2 levels, or anthropogenic changes such as rapid residential development, significant population increases, deforestation measures, etc. which could overwhelm any septic system management improvements.

ACTION PLAN SUMMARY

I believe that the action plan for septic system management in Buzzards Bay should initially focus on three key program components: public education, detection and repair (or shutdown) of presently malfunctioning or poorly sited systems, and the changes needed in the state sanitary code and in local government regulations.

Homeowners, businesses, and those in the construction and real estate industries are often unaware of the extent of the problems associated with septic system effluent and even more ignorant of what they can do to solve these problems. Simply making the public aware of proper operating, maintenance, and inspection procedures could effect some change in pathogen and nutrient levels in Buzzards Bay embayments.

Detection of faulty or poorly sited systems in the drainage area is a bit more complicated and could be part of a sanitary survey of the region or of a particular embayment. It would be valuable to gather information on the types and ages of the systems, particularly those that are not functioning, poorly located, cesspools, or hooked up to illegal overflow pipes. Additional valuable information would include total area population, soil and water table data, location of sensitive resource areas and surface water/groundwater resources, data on cottage conversions and septic system variances, number of people contributing to each septic system, etc. Program managers would also need to determine the uses and condition of particular embayments, additional contributing sources of pathogens and nutrients, and any other action plan, BMPs, or mitigation measures being implemented in a particular area.

Simultaneously, local communities would be encouraged to enact protective bylaws and ordinances, hire qualified public health agents and engineers, test innovative systems, monitor land use practices, and increase enforcement of all regulations pertaining to septic systems.

It is also important to continue to examine results of ongoing studies such as those of NOAA, EPA, DEP and the Buttermilk Bay study, and to utilize this data in addressing this problem.

The action plan should be implemented in all the municipalities of the watershed and there should be some flexibility to allow for unique circumstances faced by each local government agency.

The Buzzards Bay Monitoring Plan listed the criteria which will be utilized to evaluate whether or not conditions in the bay have been improved (with regards to pathogens) as a result of actions taken. These indicators include: 1) reduced levels of fecal coliform (or other bacterial or viral indicators) in the water and in shellfish; 2) reduced numbers of shellfish resource areas closed due to pathogen contamination; 3) reduced numbers of beaches closed due to pathogens; and 4) reduction in the amount of time that shellfish and bathing beaches are closed.[152] This information could be supplemented with data from sediment and groundwater samples as well as from reports of viral or bacterial illnesses from health departments.

Excessive nitrates do not often result in the closing of a swimming beach or shellfish area. Additional criteria must be developed in order to assess improvement in water quality with regards to this contaminant. And, although extreme events such as fish kills from excessive nitrogen or reports of young children suffering ill health effects may be important to document, important indicators of the excessive nutrient problem is best gathered through water sampling and analysis. Embayments should be sampled to determine levels of dissolved inorganic nitrogen, particulate organic nitrogen, dissolved oxygen, as well as for transparency, chlorophyll a, periphyton, and macroalgal growth.[153] Much of this data can be gathered through citizen monitoring efforts and will be most useful during the summer months when nutrient levels increase in New England.

Other useful data can be gathered from sampling groundwater of the embayment drainage area and from monitoring the growth or decline in acreage of submerged aquatic vegetation.

With the development of action plan activities for septic system management and the establishment of criteria in which to assess changes in water quality and in the resources of Buzzards Bay embayments, the issue becomes: can an evaluation research project be designed that will link changes in embayment conditions with the implementation of this program to improve the management of septic systems in the drainage area?

IX. EVALUATION RESEARCH PROJECT

Evaluation research has been defined by Weiss as a methodology which 1) examines the effects of policies and programs on their targets in terms of the goals they are meant to achieve; 2) assesses the extent to which goals are realized by utilizing objective and systematic methods; 3) looks at factors associated with successful or unsuccessful outcomes; and 4) assists decisionmakers in making wise choices among future courses of action.[154]

Evaluation research is most effective when it is integrated with other steps in the policymaking process rather than used strictly as a method to account for what has happened in the past. From the initial program planning stages, through the implementation stage, evaluation research should play an important role. This approach often uncovers unanticipated problems and may be useful in suggesting mid-course changes for programs being implemented. It is also important that early in the policy process, consideration be given to how proposed goals and objectives can be measured. This helps an agency design programs where measurement and evaluation of outcomes is possible.

When information gathered prior to the start of a program is compared with new information following its implementation, one is often able to assess the success or failure of program activities. The challenge according to Brewer and DeLeon is to be able to successfully attribute these outcomes to program activities rather than to other influences.[155]

This problem of linkage is particularly difficult in environmental mitigation programs such as this proposed septic system management plan. Burroughs and Lee conducted an evaluation research study of a pollution control program in Narragansett Bay and wrote of the difficulty in attributing the changes in water quality to the program activities as opposed to "other forces working in the environment."[156] For the Buzzards Bay program, these forces would include not only other mitigation activities occurring within the watershed, but also the variety of naturally occurring hydrogeological and meteorological changes which may occur. Rutman has outlined an approach which can be useful in beginning an evaluation research study and for addressing the linkage issue. First, identify the primary users of the evaluation study and determine how they view the objectives and activities; second, collect and synthesize this information and develop a model depicting the intended resource inputs, program activities, intended impacts and assumed causal links; and third, determine if the program represented by the model is feasible and useful to evaluate.[157] The evaluator should then attempt to get agreement from the intended users of the evaluation on the program activities and measures, and finally develop plausible, testable assumptions linking program activities to program outcomes".[158]

The CCMP of the BBP has identified the key problems of the estuary, and the proposed action plan for septic system management outlines specific program activities and intended impacts. The next step in the evaluation research process is to "develop plausible, testable assumptions linking program activities to program outcomes."

The evaluation research project begins with the formulation of a question. This is followed by the impact hypothesis which will be tested using this methodology. The question is: would the implementation of a basinwide program to reduce levels of pathogens and nutrients from on-site septic disposal systems result in a reduction of these contaminants in the embayments utilized for shellfishing and swimming in Buzzards Bay? The impact hypothesis is: a program which is effective in educating the public about on-site septic system impacts, operations, inspection, and necessary maintenance practices; identifying and repairing (or eliminating) malfunctioning or poorly-sited systems; and changing outdated and ineffective sanitary code regulations, local bylaws and ordinances, and public health regulations, will result in a reduction in pathogen levels and nutrient levels in these embayments and an improvement in the condition of shellfish resources and swimming beaches.

Once the impact hypothesis has been developed, and meaningful and measurable indicators in which to assess program outcomes have been selected, alternative explanations or rival hypotheses must be examined in order to test the validity of this hypothesis.

Cook and Campbell have identified thirty-five potential rival explanations regarding the validity of an evaluation study. These are categorized into four general types of validity.[159] The first, internal validity, requires a close examination of all alternative explanations for the impacts of an activity. This will be particularly important in evaluating on-site septic system management because of the various mitigation measures being implemented and the numerous sources of these contaminants in the embayments.[160]

External validity issues include whether or not the results of the evaluation research study can be applied in other locations. It may be that program outcomes were a result of unique circumstances within the particular embayments rather than due to program implementation alone.[161]

Care must also be given to the data gathering and analysis steps of the process in order to protect against problems related to statistical conclusion validity. Selection of sample size and other statistical techniques must be carefully carried out to prevent problems in this category of validity.[162]

The primary concern with regards to validity in this study is with internal validity.

Bowen et al. described some of the ways of addressing the difficulty of testing for rival explanations through the use of time-series data, control groups, and randomization. In order to present "the strongest possible causal interpretation for an impact hypothesis, there needs to be strong empirical support and an apparent refutation of all rival explanations."[163]

It should be possible to develop such an evaluation for selected embayments utilizing time-series data collected over the past several years. It may also be possible to utilize a control group if there are two somewhat similar embayments, one of which incorporates the proposed action plan activities and one that does not.

Selection of the embayments for this evaluation research study will be a critical step and could be the deciding factor in the success or failure of the study.

There are great differences among the 27 embayments of the Buzzards Bay basin and some of these areas should be eliminated from consideration for this study. Large urban embayments (such as New Bedford Harbor), areas already hooked up to sewer systems, embayments heavily impacted by toxins, wastewater treatment plant effluent, agricultural fertilizer and chemicals (such as those surrounded by cranberry bogs), or those impacted significantly by stormwater runoff should not be selected. Embayments destroyed beyond recovery or those without any shellfish or swimming areas should also be eliminated. Embayments selected also should not include areas targeted for other significant action plan projects such as stormwater remediation or boat pump-out projects.

The ideal embayments may be those that are primarily surrounded by non-sewered, moderate to densely populated residential development; experiencing problems with their shellfish resources and swimming beaches due to pathogen pollution and excessive nutrients; not significantly impacted by other pollution sources (with the exception of average stormwater runoff) nor targeted for other mitigation measures; and in which water quality, shellfish bed and beach closing data is available for the past several years.

There are a number of embayments fitting this description in this area and closer examination of the sanitary survey data could aid in the selection process. The Buzzards Bay Project has also collected data on "embayment volume, depth, flushing time, and the ratio of land-drainage area to water volume" as part of their examination of embayments that may be susceptible to adverse effects from nitrogen loading.[164]

Because of the great difficulty in determining with precise accuracy the levels of pollutants contributed by all of the on-site septic systems of an embayment's watershed, the additional contaminants from other pollution sources, the degree to which action plan activities or other mitigation measures have impacted the contaminant levels in the embayment, and the impact of naturally occurring processes on embayment pollution, it is unlikely that all of the components of an ideal experiment can be replicated. Warren noted the difficulty in evaluating a program which is directed at a problem that has "multiple causation" where no single factor causes the problem and no single program activity will fix the problem."[165] This however does not mean that such evaluations are not useful or possible, only that they are difficult and may need to incorporate techniques which vary from what is common with ideal experiments. For this project, a quasi-experimental design approach could be implemented along with the mini-evaluation approach utilized by the Chesapeake Bay Program.

The quasi-experimental designs include such experimental practices as the use of time-series and comparison groups.[166] With the quasi-experimental approach, "one variable (in this case the management of on-site septic systems) is manipulated through the apparatus of government with the hope that the desired changes (in the embayments) will ensue."[167]

According to Caparaso, in order for a quasi-experiment to be successful, a number of elements of an ideal laboratory experiment should be applied. First, "the independent variable must shift enough through a known manipulation to produce a reasonable expectation of a change in the dependent variable; second, the effect of the change of the independent variable on the dependent variable must go beyond that produced by chance alone; and third, plausible rival hypotheses must be examined and ruled out to support the case for a causal relationship."[168] The first element would seem to indicate that a significant number of people would need to change their practices with regards to septic system use. Many faulty and poorly sited systems would need to be repaired or moved, and regulatory changes would have to be approved and implemented in order for there to be an impact on the individual embayment. Element number two points toward the need for a longer term experiment in order to rule out chance. Regarding the third element, prudent selection of the embayments utilized for the experiment will be important as will an understanding of what impact other mitigation measures, natural processes, or such trends as population growth could have on embayment water quality.

The other component of this evaluation research project which would be vital in the building of valid causal influences is the use of mini-evaluations similar to the practice of the Chesapeake Bay Program. If a number of micro-activities could be shown to reduce pathogens and nutrients from OSDS, then it can be inferred that fewer contaminants will be entering the embayments. The Chesapeake Bay model tracks the effectiveness of each BMP that has been installed to reduce agricultural and stormwater runoff. The information gathered includes "BMP location by county and subwatershed, BMP type, areas served by each BMP, number of animal units served,...tons of soil saved per acre", etc., and the goal is to determine the efficiency of each BMP in reducing sediment and nutrients.[169]

For Buzzards Bay embayments, a similar type of mini-evaluation could be implemented for septic systems. For example, when a malfunctioning system is located, samples of leaching field soil and/or groundwater could be tested for bacteria, virus, and nitrate levels. Once the system is repaired and adequate time is allowed for the new system operate correctly, samples could again be taken and compared. Similar mini-evaluations could be carried out where denitrifying systems are installed or where systems have been shutdown and prohibited from operating. Results of these experiments could provide evidence of the value of more effective septic system management practices and their importance in cleaning up the embayments.

Another important consideration in evaluating such a program is that some attention must also be focused on the implementation of the program activities. While the primary focus may be on the desired outcome (less contaminated water and resources), it is important to know whether or not action plan activities were implemented in order to link them to program outcomes. Unless managers can point to the effective implementation of education, enforcement, repair, maintenance and inspection projects, etc., and provide evidence of their impact through such practices as mini-evaluations; it will be difficult to support their hypothesis or to rule out rival hypotheses. Also, if a program does not produce positive outcomes the reason may be due to implementation problems rather than inadequate program design.

So, what conclusions can be deduced following an evaluation research study which discovers a reduction in the number of acres of contaminated shellfish areas and a reduction of beach closure days?

It may be impossible to attribute the entire reduction of pollutant levels to this action plan, but it appears that by utilizing the successful results of the mini-evaluations and by presenting evidence which rules out significant impact from rival hypotheses, one may conclude that these action plan activities have been effective and do support the impact hypothesis. As Brewer and DeLeon concluded in Foundations of Policy Analysis, "often about the only thing one can say with any confidence is that such-and-such a policy or program has had some positive relationship (or negative relationship) to intended goals."[170] Furthermore, the authors state that "sound choices can often be made if such general statements are known to be valid in the large, even though specific cause-effect sequences are not well-understood and precise data describing the context are not available."[171]

X. SUMMARY

The use of ISDS in the Buzzards Bay watershed continues to seriously impact both swimming and shellfishing activities while at the same time posing a threat to public health. Bacterial and viral pathogens, as well as excessive nitrogen, are the primary contaminants of concern; and measures to control their associated impacts have been somewhat ineffective especially in some of the smaller embayments.

The Buzzards Bay Project has begun to develop action plans to address these problems, but there are a number of obstacles to overcome. There is little public awareness of the magnitude of the septic disposal problem, and each homeowner basically monitors his/her own system. It is not until a serious problem occurs that homeowners are required to take action. In addition, each town is operating under different regulations and by-laws when it comes to handling septic system operation.

While Massachusetts' statutes exist which will allow for the initiation of tougher standards at the local level, the surrounding municipalities have enacted strong local ordinances in only a limited number of cases.

Solving the problems caused by pathogens and excessive nutrients in the bay requires more than improved ISDS management by the local communities. To effectively control the introduction of these contaminants into this estuary a comprehensive program needs to be developed to address the entire range of point and nonpoint source pollutant inputs into the watershed. The

Comprehensive Conservation and Management Plan of the BBP is an attempt to reach this goal. Both technological solutions and regulatory changes must be introduced and implemented. A watershed-wide view must be adopted with each individual BMP or regulatory improvement seen as contributing toward the goals of the BBP. The action plan pertaining to ISDS management in this watershed has been developed as an important component of this comprehensive strategy.

With regards to ISDS management, focus should shift from a reliance on self-monitoring by individual homeowners to a more comprehensive approach relying on public education, identification and repair of faulty or poorly sited systems, regulatory modifications, and ongoing evaluation of results.

Effective governance of septic system use in Buzzards Bay will require a more regionalized approach which incorporates consideration of cumulative impacts within an embayment and which develops ISDS action plans for each sub-watershed.

New technologies must be tested and introduced, and scientists must continue monitoring embayments to gather important data.

Improved land use management practices must be adopted including such techniques as Nitrogen Overlay Districts, Sewage Management Agreements, and mandatory setback and buffer zones adjacent to sensitive areas.

Once comprehensive action plan activities have been implemented, it is important that a method to evaluate program results is carried out. Is the ISDS program effective in meeting the goals of reduced contaminant levels and an improvement in the condition of swimming beaches and shellfish resources?

To answer this question, it will be necessary to monitor the implementation of program components, to gather and analyze data on water quality and condition of natural resources, and to evaluate whether or not the ISDS program has resulted in improved conditions.

In the final chapter of this paper, a method of conducting such an evaluation for selected embayments was proposed. A formal evaluation of outcomes utilizing the methodology of evaluation research with a quasi-experimental design may be an effective approach to answering the question of whether or not the program met its goals. What one could hope to conclude is that the implementation of the ISDS action plan activities contributed to improvements in water quality and a reduction in closures of shellfish beds and swimming beaches.

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