STORMWATER MANAGEMENT PLAN
FOR THE HEN COVE, BARLOW'S LANDING
AND POCASSET RIVER WATERSHEDS
IN BOURNE, MASSACHUSETTS

PREPARED FOR:

The Town of Bourne
Board of Selectmen

PREPARED BY:

GALE ASSOCIATES, INC.
8 School Street
Weymouth, MA 02189

DRAFT REPORT
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TABLE OF CONTENTS

Executive Summary

Barlows Landing, the Pocasset River and the northern portion of Hen Cove are currently closed to shellfish harvesting because fecal coliform densities in these waters frequently have exceeded 14 MPN/100 ml; the Massachusetts water quality standard for shellfish growing waters. Gale Associates, Inc. was retained by the Town of Bourne to investigate the significance of storm drain discharges in causing these closures since some portions of these the study areas exhibit elevated coliform densities following storm events.

The objectives of this study were to locate and document storm drain systems within the three watersheds, to determine which discharges are contributing to the closure of shellfishing waters, and to recommend measures to reduce fecal coliform loading, from these discharges, to shellfishing waters.

Storm drain structures and their interconnections were identified within the three watersheds and plotted on the Town's 200-scale planimetric maps. Effluent from outfalls which discharged either indirectly, into tributaries, or directly into shellfishing waters during three storm events was sampled and analyzed for fecal coliform bacteria in order to determine which drainage systems are contributing to shellfish bed closures and as an aid in prioritizing these systems for mitigation. Stormwater runoff entering the uppermost and lowermost catch basins within each of these drainage systems, as well as the intermediary basins of the larger drainage systems, was sampled and analyzed for fecal coliform and fecal streptococcus bacteria in order to determine the entry points of fecal contamination into these systems and to distinguish between human and nonhuman sources where possible. The potential for septic leachate to infiltrate these systems was also investigated in an effort to identify general areas in which groundwater sources of fecal coliform bacteria may be contributing to the contamination of drainage discharges.

Data collected in this study suggests that all of the storm drain systems sampled can potentially serve as vehicles for the 3ransport of fecal contamination, primarily of nonhuman origin, from the watershed to shellfishing waters. The degree of impact which a drainage discharge imparts to coastal waters in terms of fecal coliform loading, is dependent upon the frequency and magnitude of effluent contamination, the proximity of the outfall to shellfishing areas and the frequency and volume of flow discharged from the outfall. The magnitude of effluent contamination varied between the outfalls sampled as well as between storm events for the same outfall. The data collected in this study suggests that this may be attributable to the variability in the magnitude of the contamination of stormwater runoff entering these drainage systems. Since these entry points of fecal coliform loading to drainage systems vary between storm events, mitigation measures aimed at controlling watershed sources of fecal contamination to drainage systems must address all entry points into all drainage systems.

The reduction of fecal coliform loading to shellfishing waters can most effectively be accomplished by controlling loading to these areas from drainage discharges rather than controlling the sources of loading to drainage systems. The Town of Bourne has enacted regulations which pertain to the reduction of animal waste deposition and septic leachate contamination of groundwater and surface water. Although these regulations may reduce nonpoint source loading of fecal coliform bacteria to nearshore waters, they have not been effective in reducing fecal coliform loading to storm drain systems. Other methods of source control currently being implemented by the Town are wrackline removal, which does not affect loading to drainage systems, and street sweeping and catch basin cleaning. The latter two mitigation measures, however, may reduce fecal coliform loading to shellfishing waters, and their continuance is recommended as a maintenance component of the stormwater management plan for the three watersheds. In addition, structural alterations to storm drain systems are recommended as the most effective, long-term solution to reducing fecal coliform loading, from drainage systems, to shellfishing waters. These alterations involve reductions in the volume and frequency of flow from drainage systems as well as the conversion of concentrated, surface discharges to diffuse, subsurface discharges.

Documentation of Storm Drain Systems

The shorelines of Hen Cove, Barlows Landing and the Pocasset River were walked at low tide in order to locate storm drain outfall pipes and road swales which discharge into these waters. Subsequently, a reconnaissance of all roads in the three watersheds was conducted in order to identify all upgradient drainage structures including catch basins, leaching basins, manholes and interconnecting pipes. The locations of these structures were then recorded on the 1972 Town of Bourne 200-scale planimetric maps for use in producing an existing conditions drainage system plan for each watershed.

Catch basin gratings and manhole covers were removed in order to identify interconnections between drainage structures and to gather the existing conditions information contained on the "drainage checklist" sheets. These sheets are referenced by their structure identification codes, which appear on the drainage plans entitled "Stormwater Management Plans" (October 20, 1988), and are available for review at the Engineering Department. Information contained on these sheets includes: Interconnections between drainage structures, structure depth, pipe depth and size and general conditions. Pipe locations which remained unresolved following a second field investigation were presented to personnel from the Bourne Highway Department. Pipe locations remaining unresolved by the Highway Department are indicated on the "Stormwater Management Plans" as dotted lines.

Subdrainage areas within each watershed were also delineated on the "Stormwater Management Plans" and their boundaries verified by noting drainage patterns during storm events. Planimetry was used to determine the surface area of each watershed and its subdrainage area.

Effects of Storm Drain Discharges on Shellfish Bed Closures

The effects of storm drain discharges on the closure of shellfish resource areas were evaluated by two methods. Three years of bacteriological data, collected by the Special Assistant to the Bourne Board of Health (1) and the Shellfish Section of the Department of Environmental Quality Engineering (2), was reviewed in order to determine whether any portions of the study areas exhibited a pattern of elevated fecal coliform densities following wet weather conditions. Additionally, a stormwater runoff sampling program was conducted in order to quantify fecal coliform bacterial loading, through the existing storm drain systems, to coastal waters and their tributaries.

Stormwater Runoff Sampling Program

Stormwater entering and exiting drainage systems which discharged either indirectly, via watercourses, or directly into the waters of Hen Cove, Barlows Landing and the Pocasset River was sampled during storm events which occurred on August 24, October 22 and November 28, 1988. Samples were collected, aseptically, in sterile containers at the locations indicated on the "Storm Water Runoff Sampling Station Plans". Bacteriological analyses were conducted by the Morrell Associates, Inc. bacteriology laboratory. All samples were processed within ten (10) hours of collection. Fecal coliform and fecal streptococci bacterial densities were determined by the membrane filter technique in accordance with Method 909C and Method 910B, respectively (3).

Entry Points of Fecal Contamination into Storm Drain Systems

Surface entry points of fecal contamination into storm drain systems were identified by sampling road runoff entering the uppermost and lowermost catch basins with each drainage system. Additional sampling stations, such as basins located near road intersections and medially-located basins within the larger drainage networks, were also sampled. Catch basin locations from which road runoff samples exhibited fecal coliform densities greater than 100/100ml were interpreted as contamination entry points. The streptococci bacterial densities of these samples were used as verification of these fecal contamination entry points.

The potential for septic leachate, containing fecal coliform bacteria of human origin, to infiltrate storm drain systems was assessed by reviewing information available on the hydrogeology of the area and through consultation with the Bourne Health Agent. Housing density (dwellings/acre) was calculated for each subdrainage area to evaluate leachate infiltration potential with respect to drainage system locations. Additionally, drainage outfall pipes were observed during August for dry weather flow and catch basins were examined for illegal connections to septic systems.

Differentiation Between Types of Fecal Contamination Source

The fecal streptococcus bacterial densities of road runoff samples were used as an aid in differentiating between human and nonhuman types of fecal contamination sources. Although fecal coliform/fecal streptococcus ratios may provide information on possible sources of fecal contamination, under certain circumstances these ratios may yield deceptive results.

Road runoff is generally very turbid and may contain toxic leachate substances. Both factors may inhibit the growth of fecal coliform bacteria, thus producing erroneous FC/FS ratios. Furthermore, FC/FS ratios should not be used to differentiate between contamination sources when fecal streptococcus densities are less than 100/100ml since at low densities a streptococcal species which is also associated with vegetation, insects and certain soil types generally predominates. Differention between nonhuman sources of fecal contamination may be accomplished, however, by conducting costly biochemical tests to isolate particular streptococci species. For these reasons, FC/FS ratios were used only as an aid to source identification. Additional information used to differentiate between loading sources consisted of observations of potential contamination sources during each storm event and by reference to the "Stormwater Runoff Sampling Station Plans" which show the locations of licensed dogs in each subdrainage area. Stormwater runoff samples characterized by FC/FS ratios of less than 0.7 were interpreted as contamination from nonhuman sources of fecal contamination and samples with ratios greater than 4.4 were interpreted as human sources of fecal contamination. Ratios between these numbers were interpreted as comtamination from both source types.

Prioritization of Drainage Systems for Remediation

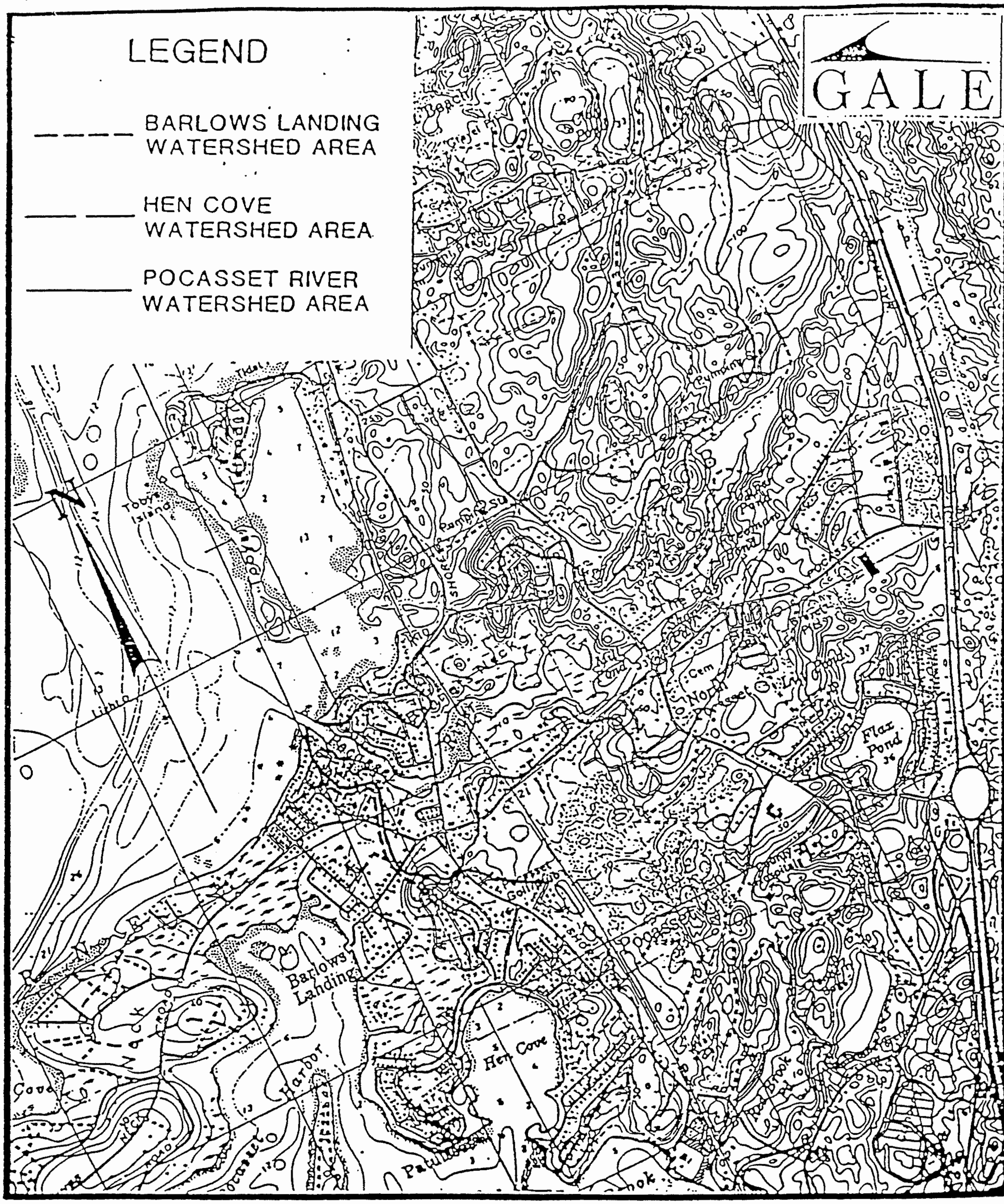
Effluent from storm drain outfall pipes which discharged into coastal waters and their tributaries during three storm events sampled and analyzed for fecal coliform bacterial discharges from submerged and other inaccessible outfalls were characterized by sampling stormwater existing the lowermost catch basin of the drainage system. Discharges characterized by fecal coliform densities greater than 100/100 ml on at least one occasion were considered contaminated. These drainage systems were then ranked according to the magnitude of impact that their discharges inpart to shellfishing waters. Ranking criteria included: the magnitude and frequency of effluent contamination, the magnitude and frequency of the systems outflow and the proximity of the outfall to shellfishing areas.

Overview

The limits of the watersheds which drain into the Pocasset River, Hen Cove and Barlows Landing, which are approximately 474.2 acres, 153.6 acres, and 322.9 acres in size, respectively, are delineated in Figure 1. Table 1 summarizes the land use data, shown in Figure 2, for each watershed.

The Hen Cove watershed is the smallest, but most densely developed of the three areas studied and the Pocasset River watershed, although the largest, is the least urbanized. Developable land within the three watersheds is limited, mainly due to the large amount of wetland area. Development within the watersheds is primarily residential, with the exception of some commercial areas within the Pocasset River watershed. Existing dwellings consist mainly of summer residences which have been converted to year-round homes. Most of the developed areas are located within the 100-year floodplain, which is approximately 15 feet above sea level, and some areas are located within velocity zones. The depth to groundwater is 10 feet or less within all three study areas with the exception of that portion of the Pocasset River watershed which is located upgradient from Shop Pond. The depth to groundwater in this area ranges from 20-40 feet (4).

Data collected in this study indicates that storm drain discharges do contribute to the contamination of shellfishing waters located within the three study areas. The degree of impact, in terms of fecal coliform loading, which a discharge imparts to these waters is dependent upon the proximity of the outfall to a shellfishing area, the magnitude and frequency of effluent contamination and the frequency and volume of flow from the outfall.



WATERSHED MAP

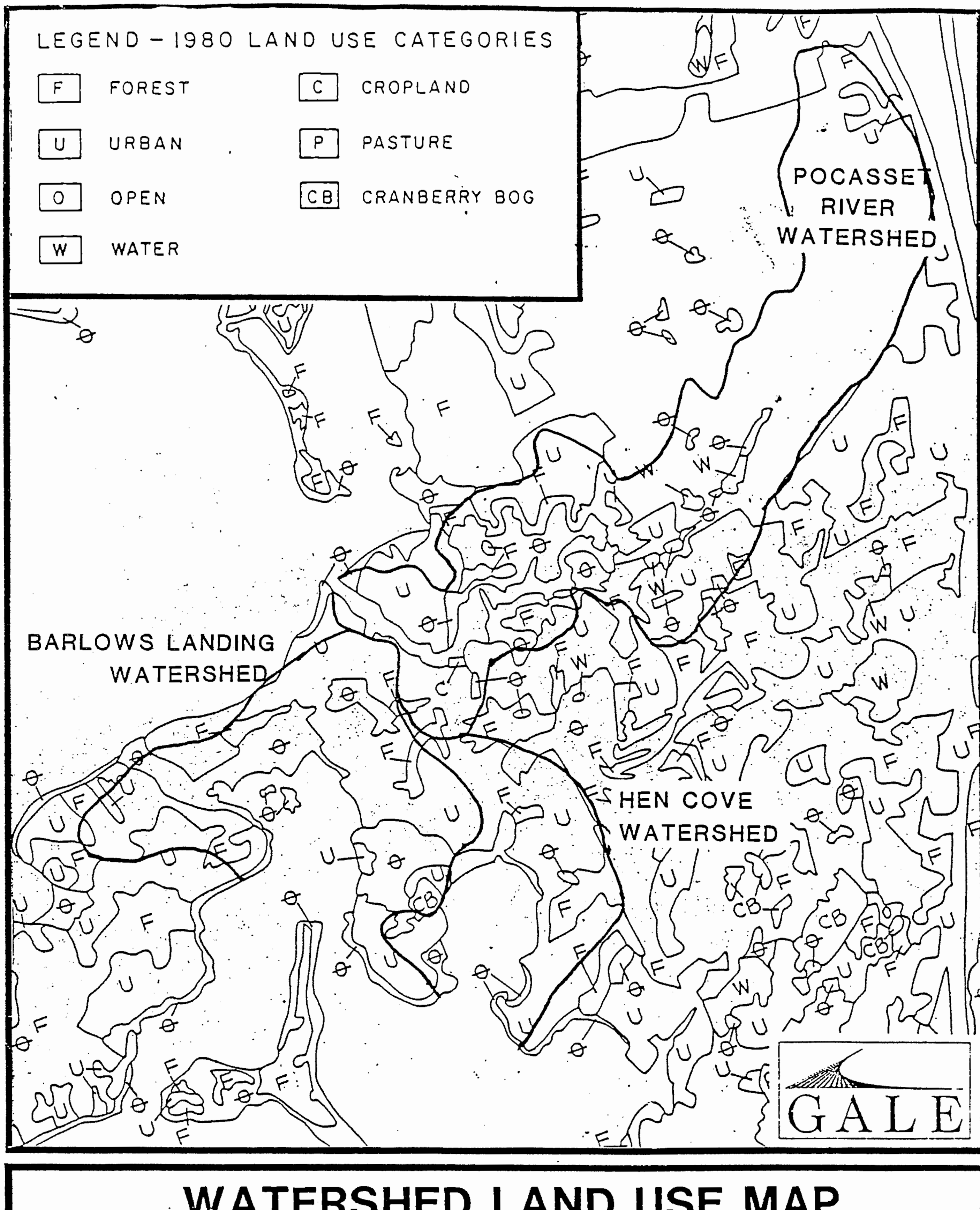
BOURNE MASSACHUSETTS

1" = 2083'

FIGURE 1

Table 1. Percent Land Use Types by Watershed for 1980

	Watershed		
	Hen Cove	Barlow's Landing	Pocasset River
Forest	5	15	55
Urban	90	63	30
Open (Wetland)	5	20	14
Cranberry Bog		2	
Cropland			1
Watershed Area (Acres)	153.6	322.9	474.2



WATERSHED LAND USE MAP

BOURNE, MASSACHUSETTS

1" = 2083'

FIGURE 2

Fecal contamination was present in the effluent of most of the outfalls sampled, however, the magnitude of contamination varied between outfalls. The magnitude of contamination also varied between storm events for the same outfall. The data indicates that this may be attributable to the variability in the magnitude of the contamination of stormwater runoff entering the drainage systems. The results of a study conducted in the Buttermilk Bay area of Bourne suggest that the degree of development within a subdrainage area may be a factor which affects the magnitude of fecal coliform loading to storm drain systems (5).

Watershed sources of fecal coliform loading to drainage systems may be of either human or nonhuman origin. FC/FS ratios for the stormwater runoff samples indicate that most of this fecal contamination is of nonhuman origin. Dog wastes, contained in runoff from private lawns and driveways, are suspected as the major source of fecal coliform loading to storm drain systems, although mapping of the locations of dwellings with licensed dogs produced an underestimate of the dog population size within each watershed. According to the Director of the Bourne Department of Natural Resources, the dog population increases in the summer with the return of seasonal residents to their coastal dwellings. The Town has enacted regulations pertaining to the reduction of dog waste deposition and distributed fact sheets relating dog wastes to the contamination of coastal waters, however, these regulations have not been effective in eliminating fecal coliform loading to drainage systems as is evidenced by the data gathered in this study. This is probably due to the fact that these regulations are difficult to enforce and pertain only to wastes deposited on beaches and other public areas. Most of the dog waste which enters storm drain systems is transported via stormwater runoff from private lawns and driveways.

Human sources of fecal contamination are not suspected as major contributors of fecal coliform loading to drainage systems. No direct connections between catch basins and septic systems were discovered and dry weather flows from drainage outfalls were not contaminated. FC/FS ratios of stormwater runoff into drainage systems also indicated that the surface entry of human sources of fecal coliform bacteria was rare in the three study areas. Septic systems located within low-lying areas, however, may surcharge during some storm events and cause leachate containing fecal coliform bacteria to flow into nearby drainage systems. The data suggest that this may be happening in the Barlows Landing watershed. Other studies have documented the increased entrainment of fecal indicator organisms in groundwater following storm events. Elevated fecal coliform densities in standing water sampled from catch basins during dry weather suggests that these areas may serve as reservoirs of fecal contamination which are transported to coastal waters during storm events. Conditions in the reservoirs may even promote fecal coliform growth in that they are often moist, nutrient-rich environments which are not directly exposed to sunlight. This contamination may be attributable to the septic leachate infiltration of drainage systems which are located within the water table or it may be attributable to regrowth of fecal coliforms, contained in residual stormwater runoff, in the basins. The potential for septic leachate to infiltrate storm drain systems could not be evaluated in this study because detailed groundwater contour maps of the study areas do not exist and groundwater sampling was not conducted. The presence of fecal contamination in the groundwater and the standing water of leaching basins at Taylers Point, in Bourne, suggests that septic leachate may infiltrate drainage systems located in the water table (6). Continued efforts by the Health Agent to enforce the Town bylaws which pertain to the upgrading of septic systems, particularly in the Barlows Landing watershed, to meet Title V requirements will aid in reducing fecal coliform loading, from human sources, to drainage systems.

Discussions of fecal coliform loadings to shellfishing areas from particular drainage discharges, are presented by watershed in the following sections.

Pocasset River

The limits of the Pocasset River watershed, storm drainage systems and their subdrainage areas, and the stormwater runoff sampling stations are shown on Sheets 38, 39, 43 and 44 of the "Stormwater Runoff Sampling Station Plans". DEQE sanitary monitoring statons as well as dwellings with licensed dogs are also indicated on these plans. Fecal coliform and fecal streptococcus densities for the samples collected during the three storm events are presented in Table 2. The area, runoff rate and housing density of each subdrainage area within the watershed is presented in Table 3.

Although it is the largest of the three areas studied, the Pocasset River watershed is the least urbanized. Approximately 55% of this 475-acre area is forested and another 14% consists of wetland and other undevelopable land. Although there are several storm drain systems which discharge directly into the river, the majority of the systems discharge into tributaries or into vegetated areas located far away from the shoreline of the river. Distinguishing between elevated fecal coliform densities in the river which are a result of cumulative loading from upstream sources and those which are attributable to localized sources is difficult because this is dependent upon the flushing characteristics of the river. Therefore, the impacts imparted to the river from each discharge were evaluated for the entire river rather than for a particular area within the river.

All of the Pocasset River is currently closed to shellfish harvesting. The most productive shellfish habitat is the area which is west of the railroad bridge. Data collected in this

TABLE 2. FECAL COLIFORM AND FECAL STREPTOCOCCI BACTERIA PER 100ml. OF STORMWATER (POCASSET RIVER)

STATION	8-24-88 FECAL COLIFORM	8-24-88 FECAL STREP	8-24-88 RATIO FC:FS	8-24-88 POLLUTION SOURCE*	10-22-88 FECAL COLIFORM	10-22-88 FECAL STREP	10-22-88 RATIO FC:FS	10-22-88 POLLUTION SOURCE*	11-28-88 FECAL COLIFORM	11-28-88 FECAL STREP	11-28-88 RATIO FC:FS	11-28-88 POLLU SOUR
PR19-CB	<100				100				<100			
PR19	300	200	1.500	B					3,400	<100		
PR16-O					100				<100	2,800	0.036	
PR20	200	100	2.000	B					<100	4,700	0.021	
PR16	1,100	400	2.750	B					100	600	0.167	
PR70	100	1,100	0.091	N								
PR78-S	100								100	300	0.333	
PR78	1,000	900	1.111	B					100	200	0.500	
PR79-O									<100			
PR79-S	100											
PR79	1,900	400	4.750	H								
PR43	100	3,500	0.029	N								
PR41-O	41,000				900				400			
PR60	<100	800	0.125	N	1,400	2,500	0.560	N	400	300	1.333	
PR57	100	4,900	0.020	N								
PR50	100	900	0.111	N	600	1,800	0.333	N	<100	<100		
PR41	300	2,200	0.136	N	2,800	2,300	1.217	B	200	500	0.400	
PR39-O	6,800											
PR40	100	200	0.500	N								
PR37-O	9,200											
PR36	2,100	23,000	0.091	N								
PR35-S									300	5,200	0.058	
PR35-CB					200							
PR33-S					100	500	0.200	N	300	4,900	0.061	
PR32	300	500	0.600	N								
PR30	1,800	2,400	0.750	B	200	500	0.400	N				
PR33	9,700	33,000	0.294	N	3,400	4,900	0.694	N	1,400	5,600	0.250	
PR35	100	500	0.200	N								
GC-S									100	600	0.167	
PR22-O	28,000				1,200							
PR22-CB									200			
PR22	15,000	1,200	12.500	H	1,500	7,700	0.195	N	<100	100	1.000	
PR11					300	2,400	0.125	N	100	300	0.333	
PR14-O	2,900				4,100	7,200	0.569	N	100			
PR14-CB	5,600											
PR13-CB					1,600							
PR14	3,300	9,100	0.363	N	8,100	10,000	0.810	B	600	700	0.857	
PR4-O									<100			
PR4-CB	36,000											
PR1	5,900	13,000	0.454	N								
PR4	1,800	27,000	0.067	N								
PR3									<100	<100		
PR26-O					100				300			
PR26	100	2,800	0.036	N								
SP-S					100	300	0.333	N	<100	100	1.000	
MP-S					6,200	2,700	2.296	B	100	600	0.167	
HF-S									>1,000,000	>1,000,000	1.000	

* H-HUMAN, N-NON-HUMAN, B-BOTH
O-STORM DRAIN OUTFALL SAMPLED
S-SURFACE WATER SAMPLED
[illegible]

TABLE 3. SURFACE AREAS, RATES OF RUNOFF & HOUSING DENSITIES OF SUBDRAINAGE BASINS WITH STORM DRAIN DISCHARGES INTO THE POCASSET RIVER

SHEET	SUBDRAINAGE BASIN ID #	DRAINAGE AREA (Acres)	RATE OF RUNOFF Q10 (cfs)	HOUSING DENSITY (Dwellings/Acre)
39	PR41	4.32	11.70	0.69
	PR43	0.13	0.38	0
	PR47	7.10	14.72	0.56
	PR78	2.21	6.41	0
	PR79	0.32	0.93	0
	PR89 (swale)	0.80	2.32	1.25
38	PR 4	0.68	1.97	4.41
	PR14	0.55	1.60	0
	PR16	5.51	13.41	1.63
	PR19	0.43	1.25	0
	PR73	0.28	0.81	0
	PR70	3.60	10.45	1.11
	PR35	56.08	79.24	0.12
	PR39	17.17	32.30	0.99
	PR37	8.32	17.97	0.60
43	PR22	6.10	16.52	1.48
	PR26	1.00	2.71	1.00

Data Reference: Stormwater Management Plan, 10/20/88 (Aerial photography, April 18, 1972).

study indicates that low level fecal contamination was present in the river upstream from this area (Stations PR78-S and PR79-S) during storm events. Storm drain discharges located upstream from shellfishing areas are PR78-0, PR79-0, PR35-0 and PR41-0. Outfalls PR78-0 and PR79-0 are located the furthest upstream.

Stormwater runoff from these two small subdrainage areas is discharged onto a heavily vegetated hillside and only enters the river as diffuse, overland runoff during high intensity storm events. Thus, effluent from these two drainage systems is not suspected as a significant source of fecal contamination. More likely sources are septic leachate breakout from the hillside, dog wastes contained in lawn runoff and waterfowl wastes originating from upstream wetland areas. Effluent discharged from outfalls PR41-0 and PR35-0 is causing fecal contamination of the river upstream from the shellfish beds. Effluent discharged into Mill Pond, from outfall PR41-0, was contaminated during all three storm events and is probably the major contributor to elevated fecal coliform densities at the outlet of this impoundment. Nonpoint sources of contamination from waterfowl wastes and septic leachate may also contribute to the contamination of this pond. A horse farm is located between the outlet of Mill Pond and the PR35-0 outfall. Although runoff from the stable (HF-S) was highly contaminated, no direct flow of this runoff into the river was observed. Effluent from PR35-0, however, was contaminated during two storm events. This system drains the largest subdrainage area within watershed. Most of this area consists of golf course greens, and as a result, has the highest rate of runoff of all the wastershed subdrainage areas. Stormwater was observed spewing from catch basin PR35 during the November storm event. Overland runoff and outflow from the golf course ponds enters the intermittent stream shown on Sheets 38 and 43 during storm events. This stream enters the PR35 drainage system at catch basin PR33 and is discharged through a subsurface pipe into the saltmarsh area behind the church. This saltmarsh area contains a network of mosquito ditches which drain into the river through a pipe located on the east side of the railroad bridge. DEQE data indicates that outflow through this pipe has been contaminated following storm events. Data from this study suggests that the sources of fecal contamination to this drainage system are dog wastes contained in stormwater runoff which enters catch basin PR33 and fecal material from the waterfowl on the golf course ponds. Additionally, nonpoint source contamination from septic leachate may enter the mosquito ditch area since ponding in the vicinity of the church's septic system was observed during storm events.

Outfalls PR22-0 and PR26-0 discharge into a tributary which flows into the section of the river between the railroad bridge and the car bridge. According to data collected by DEQE, this tributary was grossly contaminated on November 2, 1988 when sampled within one day of a storm event. Data collected during this study indicates that both of these drainage discharges are contributing to the contamination of the tributary. Drainage system PR22 has a greater impact on the fecal coliform load than does system PR26. The subdrainage area for system PR22 is six times the size of the PR26 drainage area and consists of commercial land use types. The magnitude of effluent contamination and the volume of effluent discharges through outfall PR26 is greater. Discharges from this outfall, located on the northern shore of the river, also contribute to elevated fecal coliform densities in the section of the river. However, the magnitude of contamination from this outfall is low.

The most densely populated portion of the Pocasset River watershed is the area to the west of the Shore Road car bridge, however, stormwater runoff from most of this area enters the river as overland runoff. Stormwater is discharged into the river directly through drainage outfalls PR14-0 and PR4-0, as well as via several boat ramps. Outfall PR14-0 discharges during most storm events because its subdrainage area is the small section of Shore Road between the car bridge and Barlows Landing Road, which has a high rate of runoff.

Erosion of the embankment below this outfall has created a direct connection between the discharge and the river. Effluent from this outfall imparts one of the most significant impacts to the river, in terms of fecal coliform loading from storm drain systems, as a result of the magnitude of its contamination and the frequency with which it flows. Although the PR4 subdrainage area contains the most dwellings per acre, runoff from this small area only enters the river directly during storms of high intensity. Thus, drainage discharges from this outfall impact this section of the river to a lesser extent. Although the flushing characteristics of the river are generally poor, discharges from these two drainage systems would receive the greatest amount of dilution since they are located cloest to the river mouth.

reduce volume of water

Hen Cove

The limits of the Hen Cove watershed, storm drainage systems and their subdrainage areas, and the limit of the area closed to shellfishing are delineated on Sheets 43 and 47 of the "Stormwater Management Plans". The locations of DEQE sanitary monitoring stations and dwellings with licensed dogs are also indicated on these plans. Fecal coliform and fecal streptococcus densities for samples collected during the three storm events are presented in Table 4. The area, rate of runoff and housing density of each subdrainage area within the watershed is presented in Table 5.

Although Hen Cove has the smallest watershed of the three study areas, it is the most densely populated. Approximately 153.6 acres of predominately urban land drains into the embayment. Stormwater runoff from the southeastern portion of the Patuisset area, less than 10% of the entire watershed, enters the cove directly as overland runoff following its discharge through two 4-inch PVC pipes. It is rather the eastern half of Hen Cove that is impacted by stormwater discharges.

Stormwater runoff is discharged directly into the eastern half of the embayment through four drainage outfalls (HC4-O, HC3-O, HC1-O and HC24-O), three bituminous concrete swales and a boat ramp which is located on Bellbuoy Road. Stormwater discharges also enter the cove indirectly via outfall HC62-O, which flows into a shallow pond located east of Island Drive before reaching the cove at the HC7 culvert, and via a subsurface discharge (HC6-O) from catch basin HC6.

Based on elevated fecal coliform densities at Stations 10 and 5, the DEQE closed Hen Cove to shellfishing on November 24, 1988, based on bacteriological data collected at additional sampling stations, to include a 49-acre area which lies within a line extending from Wabash Avenue to Hill Street (Sheet 47).

TABLE 4. FECAL COLIFORM AND FECAL STREPTOCOCCI BACTERIA PER 100ml. OF STORMWATER (HEN COVE)

STATION	08-24-88 FECAL COLIFORM	08-24-88 FECAL STREP	08-24-88 RATIO FC:FS	08-24-88 POLLUTION SOURCE*	10-22-88 FECAL COLIFORM	10-22-88 FECAL STREP	10-22-88 RATIO FC:FS	10-22-88 POLLUTION SOURCE*	11-28-88 FECAL COLIFORM	11-28-88 FECAL STREP	11-28-88 RATIO FC:FS	11-28-88 POLLUTION SOURCE*
HC64	21,000								<100			
HC65	50,000								2,800			
HC62-O	3,600				1,100				200			
HC62-CB	4,100											
HC62-SWALE									200			
HC45	<100	2,900	0.034	N	3,300	1,200	2.750	B	1,500	15,000	0.100	N
HC54	<100	11,000	0.009	N	700	1,900	0.368	N	200	4,600	0.043	N
HC62	1,700	25,000	0.068	N					100	500	0.200	N
HC49					400	200	2.000	B	<100	700	0.142	N
HC47	600	14,000	0.043	N								
HC7	700				1,600	1,100	1.455	B	1,200			
HC6-O	1,200				300							
HC6-CB	800				1,200							
HC5									200	400	0.500	N
HC6	6,700	15,000	0.447	N	1,900	1,500	1.267	B	<100			
HC4-O	12,000								<100			
HC4	1,100	6,800	0.162	N					<100	<100		
HC3-O					100							
HC57-CB	1,200											
HC3-CB									1,300			
HC26	<100	2,700	0.037	N					500	2,100	0.238	N
HC25	200	1,300	0.154	N					<100	300	0.333	N
HC57	1,800	1,800	2.250	B								
HC3									2,700	3,300	0.818	B
HC22									100	700	0.143	N
HC1-O	3,500				700							
HC1	4,700	15,000	0.313	N					100	900	0.111	N
HC24-O									800			
HC24-CB	54,000											
HC24	19,000	38,000	0.500	N					<100	800	0.125	N

* H-HUMAN, N-NONHUMAN, B-BOTH
O-STORM DRAIN OUTFALL SAMPLED
S-SURFACE WATER SAMPLED
CB-INSIDE OF CATCH BASIN SAMPLED

TABLE 5. SURFACE AREAS, RATES OF RUNOFF & HOUSING DENSITIES OF SUBDRAINAGE BASINS WITH STORM DRAIN DISCHARGES INTO HEN COVE

SHEET	SUBDRAINAGE BASIN ID #	DRAINAGE AREA (Acres)	RATE OF RUNOFF Q10 (cfs)	HOUSING DENSITY (Dwellings/Acre)
47	HC24	14.40	29.87	0.69
	HC2	12.58	23.04	2.86
	HC58	0.92	2.67	2.17
	HC64	2.73	5.46	7.69
43	HC4	0.39	1.13	7.69
	HC6	1.10	3.19	25.45
	HC7	45.54	53.08	0.79
	HC62	21.76	37.60	1.38
	HC65	2.78	5.66	3.60

Data Reference: Stormwater Management Plan, 10/20/88 (Aerial photography, April 18, 1972).

Other storm drain discharges which impact the closed shellfishing area are outfalls HC6-O and HC4-O. Both outfalls discharge from catch basins located on Bellbuoy Road, which extends around the perimeter of Hen Cove, and as a result is a popular road for people to walk their dogs. Nonhuman sources of fecal contamination contained in stormwater runoff enter catch basins HC6 and HC4. Fecal contamination of human origin, from septic systems located on the hill above catch basin HC5, may be also infiltrating the HC6 drainage system. It should be noted that outfall HC6-O is a subsurface discharge and is therefore a diffuse or nonpoint source of contamination.

Drainage outfalls HC24-O, HC3-O and HC1-O are located outside the closure area, however, the effluent from these three outfalls was also contaminated on at least one occassion. The latter two outfalls discharge onto Cedar Point Beach and are submerged at high tide. Data collected by the Town during ten sampling events did not indicate contamination of the overlying water at this beach, however, few samples were collected following storm events. The frequency of contamination of the cove from these discharges is dependent upon storm intensity and tidal conditions. Contamination from outfall HC1-0 would occur more frequently than it would from outfall HC3-0 since this drainage system consists mostly of impervious road area. Outfall HC24-0 would impact coastal waters on an infrequent basis; during long duration storms as that which occurred on November 28, 1988.

Barlows Landing

The limits of the Barlows Landing watershed, storm drainage systems and their subdrainage areas, and the stormwater runoff sampling stations are shown on Sheets 42, 43, 37 and 38 of the "Stormwater Runoff Sampling Station Plans". The location of the DEQE sanitary monitoring stations as well as dwellings with licensed dogs are also indicated on these plans. Fecal coliform and fecal streptococcus densities for samples collected during the three storm events are presented in Table 6. The area, rate of runoff and housing density of each subdrainage area within the watershed is presented in Table 7.

Barlows Landing is a shallow embayment located between Hen Cove and Wings Neck. The 323-acre watershed is twice the size of that which drains into Hen Cove but is not as densely populated; primarily as a result of the large amount (22 acres) of wetland area concentrated within the northern and southeastern portions of the watershed.

Stormwater runoff is discharged directly into the embayment through three drainage outfalls (BL24-0, BL21-0 and BL20-0) and via a boat ramp which is located at Barlows Landing Beach. Effluent from drainage outfalls BL35-0, BL54-0 and BL57-0 enters the northeastern portion of the embayment indirectly; via a tributary which originates near the intersection of North Shore Road and Wings Neck Road. Stormwater also enters the embayment indirectly through drainage outfalls BL6-0, BL9-0 and BL5-0. These outfalls discharge into the mosquito ditch network of the saltmarsh area located southeast of the embayment.

TABLE 6. FECAL COLIFORM AND FECAL STREPTOCOCCI BACTERIA PER 100ml. OF STORMWATER (BARLOWS LANDING)

STATION	08-24-88 FECAL COLIFORM	08-24-88 FECAL STREP	08-24-88 RATIO FC:FS	08-24-88 POLLUTION SOURCE*	10-22-88 FECAL COLIFORM	10-22-88 FECAL STREP	10-22-88 RATIO FC:FS	10-22-88 POLLUTION SOURCE*	11-28-88 FECAL COLIFORM	11-28-88 FECAL STREP	11-28-88 RATIO FC:FS	11-28-88 POLLUTION SOURCE*
BL24-CB	5,200								<100			
BL24	100	100	1.000	B					<100	800	0.125	N
BL54-O	31,000								1,100			
BL63-CB									100			
BL54-CB									5,200			
BL54-S					140,000	38,000	3.684	B	5,500	20,000	0.275	N
BL54	4,700	21,000	0.224	N					800	600	1.333	B
BL63									300	<100		
BL32-CB	12,000											
BL21-CB					4,800				9,100	300	30.333	H
BL46	100	3,600	0.028	N								
BL43	2,400	17,000	0.141	N								
BL42	4,300	22,000	0.195	N					200	1,600	0.125	N
BL29	27,000	40,000	0.675	N	3,200	25,000	0.128	N	400	3,500	0.114	N
BL32	500	14,000	0.036	N								
BL21	1,000	12,000	0.083	N					<100	3,700	0.027	N
BL6-CB	34,000				6,300				300			
BL6-SWALE									100			
BL12	1,300	1,600	0.813	B					100	700	0.143	N
BL6	12,000	200	60.000	H	4,000	1,200	3.333	B	<100	1,200	0.083	N
BL9-CB	28,000				2,100				100			
BL9	19,000	1,200	15.833	H	1,000	5,300	0.189	N	300	1,400	0.214	N
BL5-O									100			
BL5-CB	300				500				100			
BL5	3,900	8,300	0.470	N					<100	<100		
BL57-O									100	12,000	0.008	N
BL53									6,400			
BL36-S					13,000	11,000	1.182	B	<100	5,100	0.020	N
BL35-S					12,000	10,000	1.200	B	500	6,400	0.078	N

* H-HUMAN, N-NON-HUMAN, B-BOTH
O-STORM DRAIN OUTFALL SAMPLED
S-SURFACE WATER SAMPLED
CB-INSIDE OF CATCH BASIN SAMPLED

TABLE 7. SURFACE AREAS, RATES OF RUNOFF & HOUSING DENSITIES OF SUBDRAINAGE BASINS WITH STORM DRAIN DISCHARGES INTO BARLOWS LANDING

SHEET	SUBDRAINAGE BASIN ID #	DRAINAGE AREA (Acres)	RATE OF RUNOFF Q10 (cfs)	HOUSING DENSITY (Dwellings/Acre)
38	BL54	9.37	17.14	3.74
	BL57	2.60	5.81	1.92
43	BL5	0.73	2.12	2.06
	BL9	3.83	11.12	1.04
	BL6	15.16	31.45	1.85
	BL21	18.60	35.99	1.83
42	BL24	6.42	14.35	0.16

Data Reference: Stormwater Management Plan, 10/20/88 (Aerial photography, April 18, 1972).

Based on elevated fecal coliform densities at Stations 3, 3A, 3B and 3C, the DEQE closed all of Barlows Landing to shellfishing, on July 16, 1987, as part of the Wings Neck to Scraggy Neck closure. Sanitary data collected by the Town of Bourne, during 1986, suggests that stormwater runoff contributes to elevated fecal coliform densities in Barlows Landing. Fecal coliform densities in the vicinities of Barlows Landing Beach and in the tributary which flows beneath Kenwood Road exceeded 14 MPN/100ml 54 percent (7/13 samples) and 100 percent (6/6 samples) of the time, respectively, when these areas were sampled within two days after a rain event.

Three storm drain outfalls (BL35-0, BL54-0 and BL57-0) discharge into the Kenwood Road tributary. Effluent from BL54-0 was grossly contaminated during two storm events and that from BL57-0 exhibited a low level of contamination (100FC/100ml) on the single occasion that it was sampled. Effluent from outfall BL35-0 could not be sampled because this outfall is submerged, however, fecal coliform densities in the overlying water (BL35-S) indicated that contamination was present in this area. FC/FS ratios of tributary samples collected downstream from these three discharges suggest contamination from human and nonhuman sources. FC/FS ratios of runoff which drains into the BL54 drainage system suggest that septic leachate in this densely-populated, low-lying area may be entering this system through surface flow. Elevated fecal coliform densities in the tributary during dry weather periods, however, indicate that stormwater is not the only fecal contamination source. Potential nonpoint loading sources include waterfowl, wildlife and septic systems.

Effluent samples collected during this study and by the Town of

Bourne, from outfalls BL21-0 and BL20-0 indicate that these two discharges contaminate Barlows Landing Beach. Since dry weather contamination has historically been present in the beach area, however, nonpoint source loading is also implicated. FC/FS ratios of stormwater runoff entering drainage system BL21 suggest that the source of fecal contamination from surface flow is of nonhuman origin. There are at least four dwellings with dogs located within this subdrainage area.

Although drainage discharges to Barlows Landing Beach and the Kenwood Road tributary contribute the greatest degree of impact to Barlows Landing, in terms of fecal coliform loading from storm drain discharges, it should be noted that effluent from outfalls BL5-0, BL24-0, BL6-0 and BL9-0 also contribute to this contamination. Discharges from these outfalls impact the embayment to lesser degrees depending on the proximity of the outfall to shellfishing areas and its frequency and volume of flow.

Overview

The Town of Bourne has addressed the reduction of fecal coliform loading to shellfishing waters by enacting bylaws aimed at controlling both human and nonhuman loading sources. Although these mitigating measures may reduce the amount of nonpoint source loading to nearshore waters, they have not been effective in reducing loading to storm drain systems. Although FC/FS ratios indicate that the fecal contamination entering drainage systems is primarily of nonhuman origin, bylaws pertaining to the reduction of animal waste deposition have not eliminated loading from these sources to drainage systems. Regulations pertaining to the reduction of dog waste deposition are difficult to enforce and pertain only to wastes deposited in public areas. Wastes deposited on lawns, driveways and other private areas are not subject to these regulations and yet these portions of the watershed are probably the major sources of fecal contamination to storm drain systems. Therefore, the most effective, long-term solution to the reduction of fecal coliform loading to shellfishing areas, from drainage systems, should emphasize control at the outfall rather than the source. This can be accomplished through the implementation of structural alterations to drainage systems; primarily through the reduction of the frequency and volume of the flow from the outfall, and where technically feasible, converting point source discharges to diffuse, subsurface discharges.

In addition to the structural alterations discussed in the following section, it is recommended that all bituminous concrete road swales which direct runoff into wetland areas be converted to vegetated swales where technically feasible. The following nonstructural mitigating measures should also be implemented in order to reduce fecal coliform loading to shellfishing areas.

A regularly scheduled catch basin cleaning and street sweeping program should be conducted in the three watersheds as a maintenance component of the stormwater management plan. At a minimum, street sweeping of all roads in the watershed should be conducted in May and in November, after the leaves fall, in order to remove solids which have accumulated on the road surfaces. Catch basin cleaning of all basins in the watersheds should be conducted immediately following street sweeping activities. Additionally, the basins should be inspected on a quarterly basis for sediment accumulation and cleaned as needed. These inspections should be conducted on a monthly basis during the summer. Although most of the areas within the watersheds are developed, the enactment of a bylaw to control stormwater runoff into wetland areas is also recommended. The Town of Wellfleet's stormwater runoff bylaw is presented in the appendix.

Structural Alterations to Drainage Systems

Implementation of the following drainage system alterations will offer the most effective, long-term solution to reducing fecal coliform loading, via storm drain systems, to the waters of the three study areas. The alterations fuction in reducing the flow rate and volume of stormwater being discharged to these areas by increasing the infiltration capacities of the targeted drainage systems. The resultant increase in stormwater detention time will allow for the attenuation of fecal coliform bacteria, reduce nutrient, pollutant and sediment loading to coastal waters and reduce erosion and sediment resuspension at the discharge point. Although the majority of the existing drainage structures are of dry block construction, which offers some degree of leaching, infiltration would be greatly enhanced by the conversion of these structures to leaching catch basins. The cost of a leaching catch basin is estimated at $1,500.00. In some instances, however, high groundwater elevations would require that leaching trenches be installed rather than leaching catch basins. The estimated cost of a leaching trench is $7.00 per linear foot. If a sedimentation basin is required, the estimated cost is $2,500.00. Additional alterations may include some or all of the following:

1. Construction of additional leaching catch basins within the drainage system.
2. Installation of leaching trenches between drainage structures.
3. Conversion of the outfall pipe to a perforated subsurface pipe.
4. Installation of sedimentation basins.

Typical details of a leaching catch basin, leaching trench and sedimentation basin are included in the Appendix. Deep observation test holes and percolation tests must be performed at the location of each leaching and sedimentation basins prior to installation, to confirm soil permeabilities and to establish maximum groundwater elevations.

Representatives from Gale Associates have met with Representative Cahir and Senator Rauschenbach to discuss the availability of funds for these structural alterations. A committee has been formed to award construction grant monies, approximately 5 million dollars, which were appropriated as part of the Transportation Bond Issue. Submission of this report along with the grant application should establish the Town of Bourne as a high priority for this funding.

POCASSET RIVER WATERSHED

Drainage Outfall (PR14-0)

Drainage Structures PR13, PR14 and approximately 750 LF of Shore Road pavement and shoulder area contribute to outfall PR14-0.

- Replace existing structures with new leaching basins. (would reduce stormwater discharge).
- Install a rip rap swale at outfall PR14-0. (this should stabilize the embankment)

Drainage Outfall (PR4-0)

Drainage structures PR2, PR3 and PR4 contribute to outfall PR4-0. Flow out of outfall PR4-0 was observed to only occur under intense storm conditions.

- Replace structures PR3 and PR4 with new leaching basins (would reduce stormwater discharge).

Drainage Outfall (PR16-0)

Drainage structures PR20, PR17 and PR16 contribute to outfall PR16-0.

- Install an additional leaching basin downgradient from PR16 (would decrease stormwater discharge).

Drainage Outfall (PR35-0)

The golf course and intermittent stream, drainage structures PR33, PR34 and PR35 with the possibility of drainage structures PR29, PR30 and PR31 connect to outfall PR35-0.

- Reduce surface runoff from the golf course by converting the existing pond to a detention pond and vegetating the existing outlet from the pond to the intermittent stream.

- Replace drainage structures PR29, PR30 and PR31 with leaching basins if found to be connected to outfall PR35-0 (would decrease stormwater discharge).

Drainage Outfall (PR42-0)

Drainage outfall PR42-0 is the outfall of a complex storm drain system which begins on County Road at drainage structure PR60. The system consists of interconnecting drain manholes and catch basins along County Road. Stormwater flows towards outlet manhole PR42, discharges through PR42-0 and then flows into a concrete sediment box and into Mill Pond. Catch basins PR60, PR59, PR58, PR57, PR55, PR53, PR50, PR59, PR44, PR45 and PR43 all connect into this sytem.

- Replace the existing catch basins with leaching basins. (would reduce stormwater discharge).

Drainage Outfall (PR91-0)

Drainage structures PR92 and PR91 contribute to drainage outfall PR91-0.

- Replace structure PR92 with a leaching basin. (would reduce stormwater discharge).

Drainage Outfall (PR78-0)

Drainage structure PR78 contributes to outfall PR78-0.

- Replace structure PR78 with a leaching basin. (would reduce stormwater discharge).

HEN COVE WATERSHED

Drainage Outfall (HC1-0)

Drainage structures HC1 and HC58 contribute to outfall HC1-0. Drainage structure HC1 appears to be constructed within the water table.

- Remove drainage structure HC1, HC58 and outfall HC1-0 and direct stormwater runoff through a vegetated swale.

Drainage Outfall (HC24-0)

Drainage structures HC17, HC18, HC19 & HC24 contribute to outfall HC24-0. HC19 appears to be an existing drywell.

- Reconstruct structures HC17, HC18 & HC24 as leaching basins (would reduce stormwater discharge).

Drainage Outfall (HC6-0)

Construct two leaching basins at the lower end of Park Avenue. (This would reduce stormwater discharge from Park Avenue to Bellbuoy Road and ultimately, Hen Cove).

- Remove outfall HC6-0 and direct stormwater runoff through a vegetated swale.

Drainage Outfall (HC3-0)

Drainage structures HC2, HC3, HC22, HC23, HC25, HC26 & HC57 contribute to outfall HC3-0.

- Replace the existing structures with leaching basins (would reduce stormwater discharge).

Drainage Outfall (HC4-0)

Drainage structure HC4 contributes to outfall HC4-0.

- Replace structure HC4 with a leaching basin. (would reduce stormwater discharge).

Drainage Outfall (HC62-0)

Drainage structures HC49, HC48, HC47, HC45, HC46, HC56 & HC62 contribute to outfall HC62-0.

- Replace the existing structures with leaching basins (would reduce stormwater discharge).

Drainage Outfalls (HC64 & HC65)

Drainage structures HC64 & HC65 consist of 4 inch PVC pipes which direct road runoff into the salt marsh.

- Remove the existing PVC pipes and replace each pipe with a vegetated swale to the salt marsh.

BARLOWS LANDING WATERSHED

Drainage Outfall (BL54-0)

Drainage structures BL54, BL63 & BL66 contribute to BL54-0 which discharges into the stream that flows beneath Kenwood Road.

- Reconstruct the structures as leaching basins (would reduce stormwater discharge).

- Install perforated pipe between structures (would reduce stormwater discharge).

- Install a sediment trap immediately downgrade from BL54 (would reduce stormwater sediment discharge).

Drainage Outfall (BL21-0)

BL21-0 is the outfall pipe of a large closed storm drain system which begins at the intersection of North Shore Road and Barlows Landing Road. The system is made up of a series of interconnecting drain manholes and catch basins located on Barlows Landing Road that ultimately connect to structure BL21. Stormwater then discharges through a corrogated metal pipe which runs beneath the Barlows Landing Beach jetty and is submerged at high tide.

- Reconstruct BL29, BL30, BL37, BL40, BL42, BL43, BL44, BL47 & BL49 as leaching basins (would reduce stormwater discharge).

- Construct two additional leaching catch basins on Barlows Landing Road between existing structures BL44 and BL46 (would further decrease stormwater discharge).

- Install a sediment trap immediately downgrade of BL21 (would reduce stormwater sediment discharge).

- Install perforated pipe between the BL21 sediment trap and the outfall (would further reduce stormwater discharge).

- Replace structure BL21 with a sediment trap and direct stormwater runoff through a vegetated swale.

Drainage Outfall (BL6-0)

Drainage structures BL6, BL7, BL8 & BL12 contribute a relatively large runoff area which outlets through 250$\pm$ LF of pipe to BL6-0.

- Reconstruct the structures to leaching basins (would reduce stormwater discharge).

- Install perforated pipe between the structures (would further reduce stormwater discharge).

- Install a sediment trap immediately downgrade of BL6 (would reduce sediment discharge).

Drainage Outfall (BL9-0)

- Reconstruct existing structure BL9 as a leaching basin (would reduce stormwater discharge).

- Install a sediment trap immediately downgrade of BL9 (would reduce sediment discharge).

- Install perforated pipe between the BL9 sediment trap and the outfall (would further reduce stormwater discharge).

Drainage Outfall (BL24-0)

Drainage structure BL24 is on the beach and frequently filled with sand.

- Remove and direct parking lot flow overland.

Drainage Outfall (BL5-0)

Structure BL5 appears to be in the water table and septic leachate contamination is suspected.

- Install perforated pipe between the structure and the outfall (would reduce stormwater discharge).

Drainage Outfall (BL57-0)

Drainage structures BL57, BL52, BL53, BL50 & BL51 contribute to outfall BL57-0 which discharges into the stream that flows beneath Kenwood Road.

- Reconstruct the structures as leaching basins (would reduce stormwater discharge).

- Construct additional leaching basins between existing structures BL57 and BL53 (would further reduce stormwater discharge).

Drainage Structure (BL35)

Structure BL35 appears to be in the water table and is frequently clogged which causes surcharge into the street.

- Install perforated pipe between BL34 and BL35 (would reduce stormwater discharge).

References

(1) Bourne Board of Health. 1985-1988. Water quality monitoring program reports.

(2) Massachusetts Department of Environmental Quality Engineering. 1985-1988. Data files pertaining to fecal coliform densities in the waters of the Pocasset River, Hen Cove and Barlows Landing.

(3) APHA. 1985. Standard methods for the examination of water and wastewater. American Public Health Association. 1268 pp.

(4) Cape Cod Planning and Economic Development Commission. 1988. Plan of water table contours and public water supply well zones of contribution.

(5) Barnstable County Health and Environmental Department. 1987. Bacteriological monitoring in Buttermilk Bay. 77 pp.

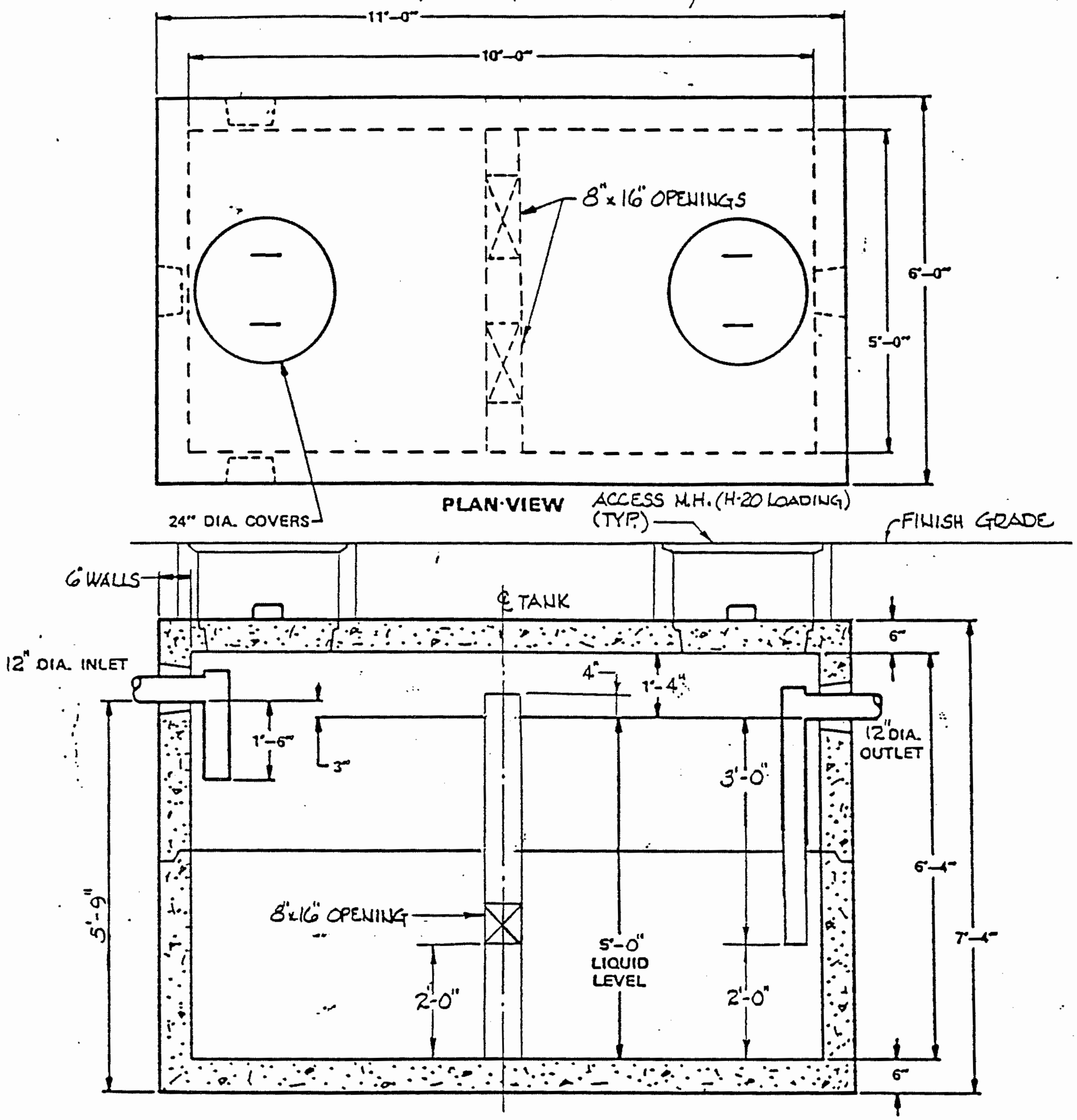
(6) Bourne Board of Health. 1981. Water quality monitoring report, Taylor's Point, Bourne, Massachusetts.

Wellfleet Stormwater Runoff Bylaw

Section 30. In order to protect the quality of the waters of the harbor and other wetlands within the Town limits, no road or other surface shall be regraded, constructed, or maintained in such a manner as to divert or direct the flow of runoff, defined as including storm water or any other surface waters, excepting natural pre-existing water courses, into any wetland, as defined in Massachusetts General Laws Chapter 13, S. 40. Uncontaminated runoff shall be directed in such as way as to recharge the groundwater within the lot where it originates and in such a manner as not to alter natural runoff into any wetland, nor to cause erosion, pollution or siltation into or towards any wetland.

PRECAST SEPTIC TANK. ST 5 X 10—2. 2,000 GAL/HEAVY DUTY-H-20 LOADING

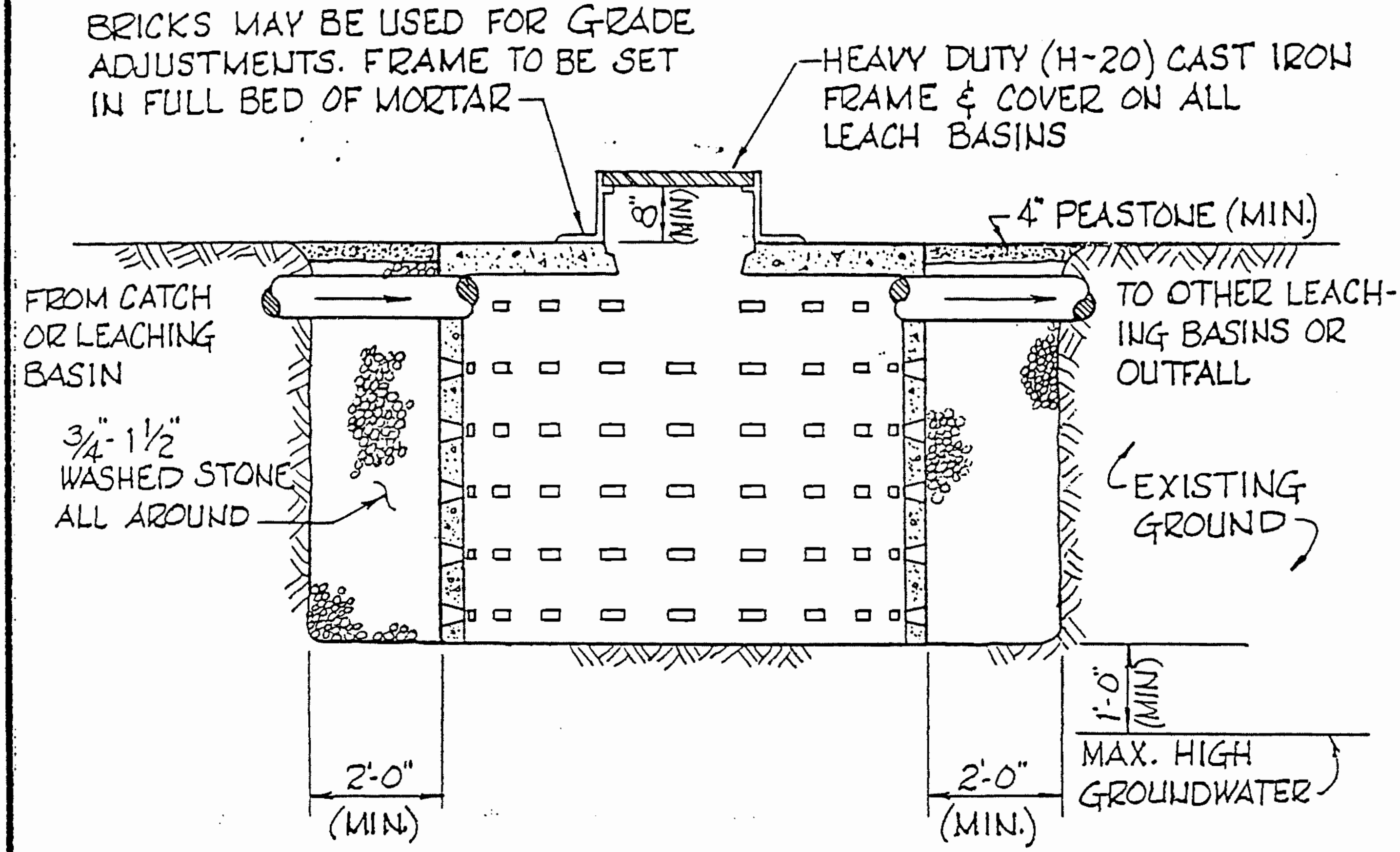
(AS MANUFACTURED BY ROTONDO & SONS, INC.
OR AN APPROVED EQUAL)



CROSS SECTION VIEW

PROPOSED GAS/OIL SEPARATOR AND SEDIMENT TRAP

GALE ASSOCIATES INC. 8 SCHOOL STREET WEYMOUTH, MASS. 02189	DATE: 1·31·89
	DRAWN: KWE
	CHECKED: ABT
	SCALE: NO SCALE
	JOB NO.: 5276



NOTES

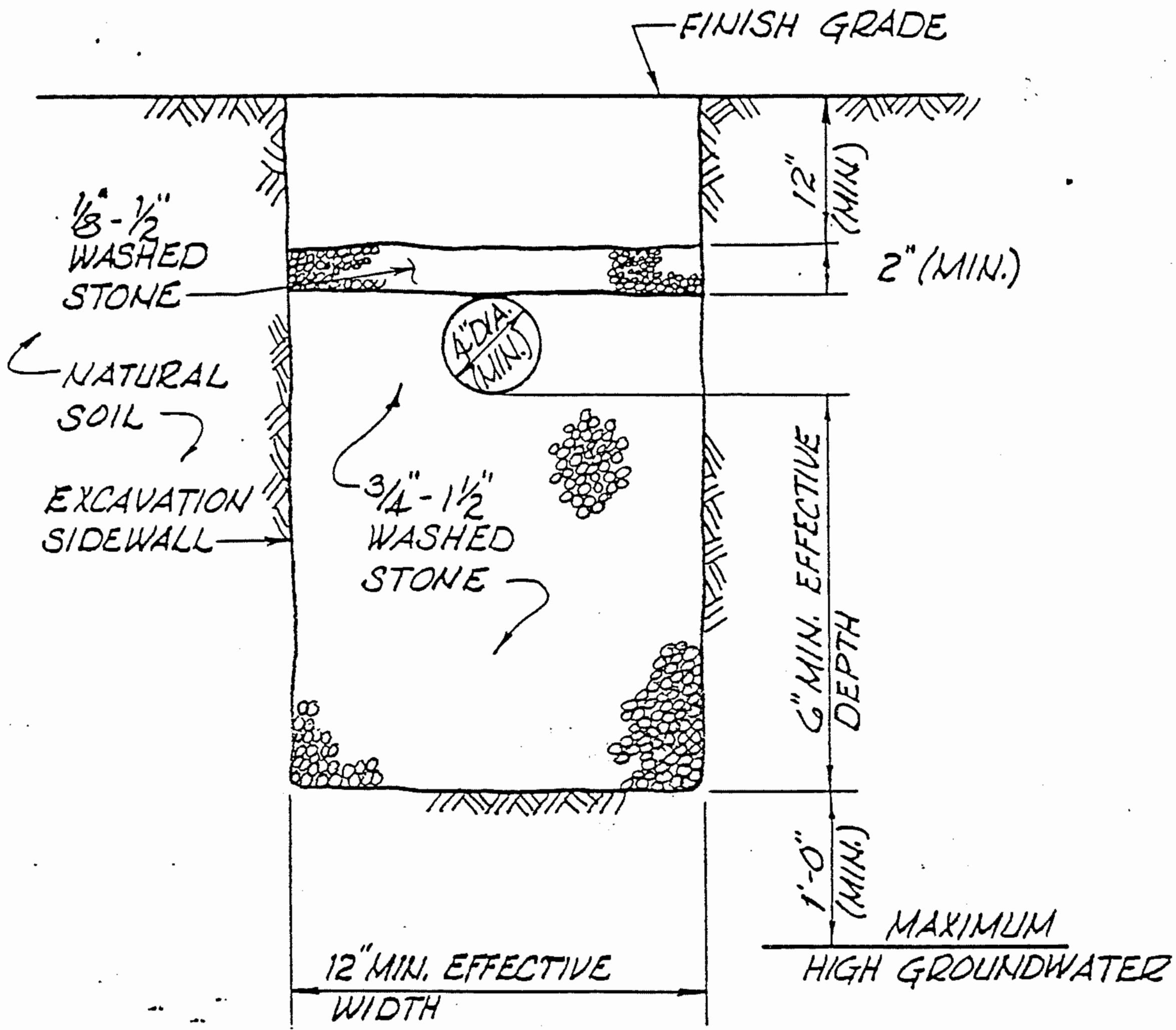
1. ALL JOINTS TO BE MORTARED.

2. 2' MAX. CHIMNEY HEIGHT ON BASINS.

LEACHING BASIN DETAIL

(H-20 LOADING)

GALE ASSOCIATES INC. 8 SCHOOL STREET WEYMOUTH, MASS. 02189	DATE: 1·31·89 DRAWN: KWE CHECKED: ABT SCALE: NONE JOB NO.: 5276



TYPICAL LEACHING TRENCH DETAIL

GALE ASSOCIATES INC. 8 SCHOOL STREET WEYMOUTH, MASS. 02189	DATE: 1·31·89 DRAWN: KWE CHECKED: ABT SCALE: NONE JOB NO.: 5276