Buzzards Bay Geographic Response Plan for Oil-Spill Mitigation

<u>**Based on research coordinated by**</u>

The Coalition for Buzzards Bay

December 2004

Prepared by Miles O. Hayes, Todd M. Montello, Linos Cotsapas, and Mark White, Research Planning, Inc.

TABLE OF CONTENTS

Page

LIST OF FIGURES

Figure **Page**

LIST OF TABLES

Table **Page**

LIST OF SUMMARY SHEETS

ACKNOWLEDGMENTS

The Coalition for Buzzards Bay coordinated the project through a grant from the Massachusetts Environmental Trust and funding and support from the Massachusetts Department of Environmental Protection. Additional planning and implementation support was provided by Massachusetts Coastal Zone Management, the National Oceanic and Atmospheric Administration, The United States Coast Guard, The Buzzards Bay Project National Estuaries Program, Massachusetts Maritime Academy and the ten municipalities surrounding the Bay. Ben Bryant of The Coalition for Buzzards Bay was the project coordinator. The protection strategies presented in this document were arrived at collectively by a field team consisting of the authors and of several different local experts who made recommendations. During review of the first draft of this report and during a workshop held on 2 August 2004 in Bourne, MA, additional input and local knowledge were provided. The advice and local knowledge of these associates contributed significantly to the work. Additional input and reviews were provided by:

The Coalition for Buzzards Bay Steering Team members:

Captain Peg Brandon – Massachusetts Maritime Academy

Captain Stephen Chmiel – New Bedford Fire Department

Joe Costa –Buzzards Bay Project

Dan Crafton – Massachusetts Department of Environmental Protection

Dave Janik – Massachusetts Division of Coastal Zone Management

Steve Lehmann - National Oceanic and Atmospheric Administration

LCDR Richard Klein - Marine Safety Office Providence, United States Coast Guard

Chief Charles Klueber – Bourne Fire Department

Richard Packard – Massachusetts Department of Environmental Protection

Mark Rasmussen – The Coalition for Buzzards Bay

Matthew A. Rudick – Marine Safety Office Providence, United States Coast Guard

Chief Ron Scott – Mattapoisett Fire Department

As well as Technical Support by:

Charles Bradley – Marion Harbor Master

Chief Richard Guerzoni – Marion Fire Department

Asst. Chief Allen Denham – Marion Fire Department

Gary Sherman – Westport Shellfish Constable

Chief Stephen Motta – Westport Fire Department

Deputy Brian Legendre– Westport Fire Department

Mike O'Rielly – Dartmouth Conservation Commission

Steve Mello – Dartmouth Harbor Master

Chief Timothy Francis – Fairhaven Fire Department

Jeff Osuch – Fairhaven Town Manager

Gary Golas – Fairhaven Harbor Master

Dave Peterson – Mattapoisett First Responder

Michael Botelho – Mattapoisett Town Office

Chief Robert McDuffy– Wareham Fire Department

Chief Howard Anderson – Onset Fire Department

Mike Parola – Wareham Harbor Master

George Weinert – Bourne Department of Natural Resources

Gregg Fraiser – Falmouth Harbor Master Office

Bob Spiro – Falmouth Harbor Master Office

Chuck Martinsen– Falmouth Department of Natural Resources

Weatherly Dorris – Quissett Harbor

Chip Morse – Quissett Harbor

Jay Hess – Naushon Island Trust

Seth Garfield – Gosnold

Allen Wilder- Gosnold

Steve Hurley – MA Division of Fisheries and Wildlife

At Research Planning, Inc. (RPI) of Columbia, South Carolina, numerous Geographic Information Systems (GIS) staff, and graphics staff were involved with the development, compilation, and digitization of the GIS data hardcopy output. Mandie Minton, Greg Whitson, Chris Locke entered, processed, and produced the GIS data and hardcopy products under the supervision of Mark White, GIS Director. Christine Lord compiled most of the information on the Principal Resources at Risk section. Cartographic design and graphic art production was provided by Joe Holmes and Wendy Early completed the final word processing and assisted in report production.

INTRODUCTION

A number of key areas of Buzzards Bay are the focal points for designing strategies to protect the vital resources of the area's coastal ponds and bays, islands, marshes, and tidal flats. Therefore, this project was commissioned by The Coalition for Buzzards Bay to develop potential protection strategies for 43 selected locations, some with multiple sites, occurring along the coastline of the Bay (Table 1; Fig. 1). The discussion of each of these locations included in this report alludes to the range of conditions that might occur at the site; however, the proposed protection strategies are based on our best professional judgment of what would work under average wave and tide conditions. The diagrams that accompany the proposed protection strategies are schematic representations of boom placement, collection points, anchor points, and skimmer locations. The symbols used to depict booms are not necessarily shown to true scale. The actual length of boom segments will be determined by local conditions at the time of the spill. The proposed strategies should not be interpreted as the only workable protection scheme. Each spill will be time, place, and circumstance specific. Therefore, the strategy finally used to protect the inlet will have to be chosen at the time of the spill.

The field study of the Buzzards Bay coast was carried out between 29 May and 2 June 2004. On 29 May, Miles O. Hayes and Todd Montello of RPI and Ben Bryant of The Coalition for Buzzards Bay conducted an overflight of all but two of the locations at low spring tide and over 200 oblique color aerial photographs were taken from altitudes of 800 to 1,500 feet. These photographs are supplemented by medium resolution true color vertical aerial photography downloaded from the Massachusetts Geographic Information Systems (MassGIS) website (www.mass.gov/mgis/).

The Buzzards Bay Geographic Response Plan (BBGRP) is a study that will require periodic updates as additional information on the area becomes available or as if changes are made. Such updates should be coordinated by The Coalition for Buzzards Bay whose web site will also host the study at: WWW.SaveBuzzardsBay.org/BBGRP.htm. Some of the first steps to be undertaken could involve the following:

- Local responders should investigate all strategies. Information regarding shore access points, sediment availability, current strengths, anchor points and other information that may help execute the strategy should be added to the BBGRP.
- The report should be used by local first responders to coordinate their efforts in the critical first hours of an oil spill and should be used as a communication tool to work with the State and Federal Authorities who will be allocating resources.

TABLE 1. Locations for which protection strategies were developed.

INLET NUMBER/ NAME	INLET CLASS *	GEOM/PHIC CLASS**	INLET NUMBER/ NAME	INLET CLASS *	GEOM/PHIC CLASS**
1. Richmond Pond	D	3	25. Pocasset River System	C	4
2. Westport River System	A	2	26. Red Brook Harbor System	B	4
3. Allens Pond	B	1	27. Squeteague Harbor	B/C	2
4. Slocums River System	A/B	4	28. Rands Harbor	C	5
5. Little River System	B	4	29. Fiddlers Cove	C	5
6. Salters Pond	D	3	30A. Wild Harbor River	B/C	4
7. Apponagansett Bay	B	4	30B. Wild Harbor	C	5
8. New Bedford Outer Harbor	B	4	31. West Falmouth Harbor	C	5
9. West Island System and Causeway	B/C	4	32A Little Sippewisset Marsh	B	1
10. Nasketucket Bay	A	4	32B Great Sippewisset Marsh	A/B	1
11. Brandt Island Cove	C	4	33. Quissett Harbor	C	4
12. Mattapoisett Harbor System	A	4	34. Weepecket Islands	B/C	6
13. Upper Aucoot Cove	B/C	4	35. Quicks Hole Pond	D	3
14A. Ram Island	B/C	6	36. Cuttyhunk Pond	C	5
14B. Bird Island	B/C	6	37. West End Pond	D	3
15. Sippican Harbor	B	4	38. Penikese Island Rookery	B/C	6
16. Wings Cove	B/C	4	39A. Hadley’s Harbor	B/C	4
17. Weweantic River System	A	4	39B. Hadley’s Harbor	D	3
18. Wareham River System	A	4	39C. Hadley’s Harbor	B/C	4
19. Bourne Cove	B/C	2	39D. Hadley’s Harbor	B/C	4
20. Little Harbor	B/C	2	39E. Hadley’s Harbor	B/C	4
21. Widows Cove	B/C	4	40. Tarpaulin Cove	D	3
22. Onset Bay System	A	4	41. Pasque Island Marsh	B/C	2
23. Buttermilk Bay System	A	4	42. West Beach	D	3
24. Back River System	B	4	43. Silver Beach	D	3

* See Table 2 for Inlet Class scale.
** See discussion of Geomorphic Class (pages 12-14).
1) Classic Tidal Inlets
2) “Half Inlets”
3) Natural Temporary Washover Channels into Coastal Ponds
4) River Mouth Entrances and Natural Coves and Bays
5) Harbors
6) Islands

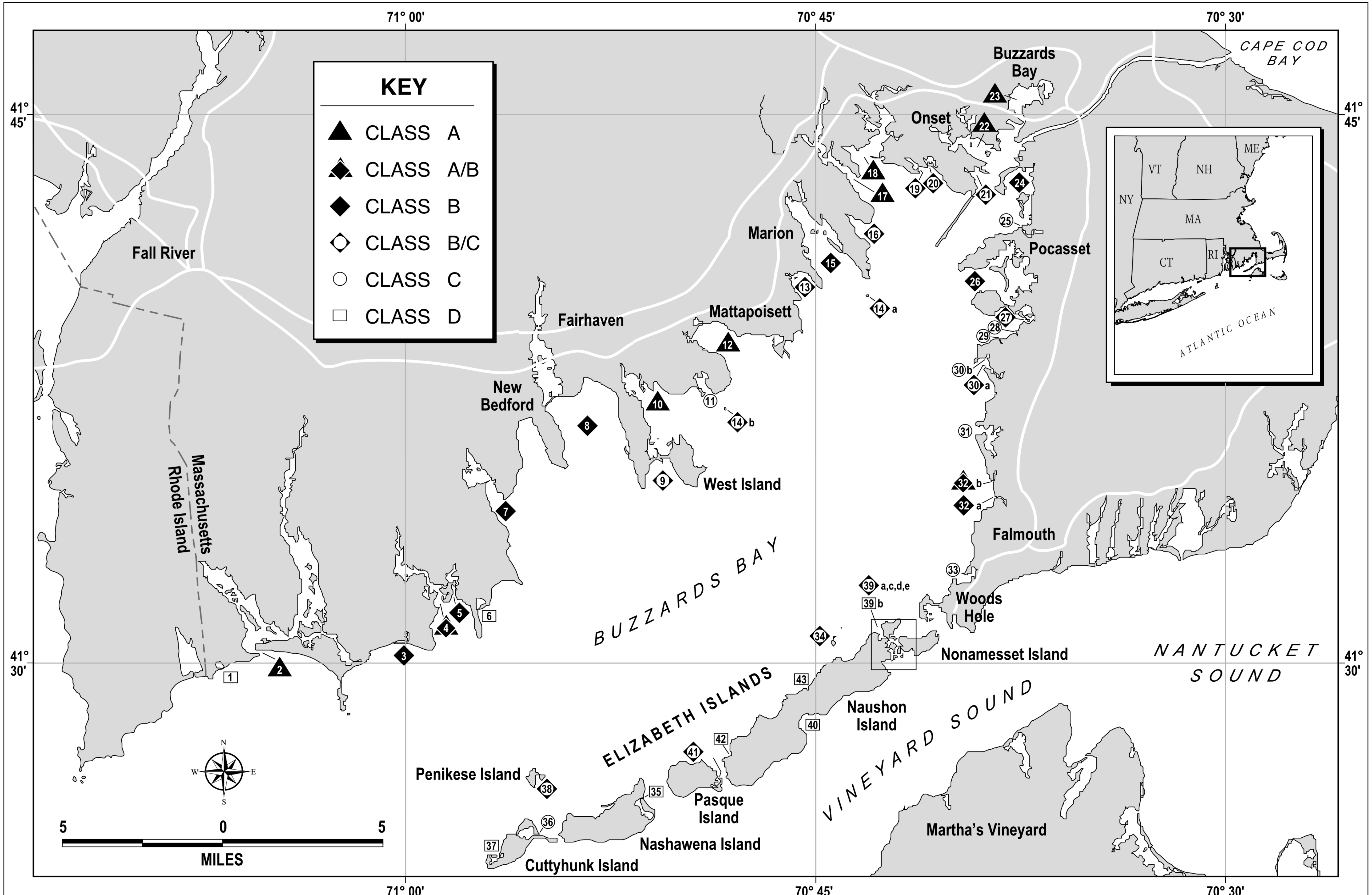

FIGURE 1. Coastal locations for which protection strategies have been devised.

- Towns should identify additional areas to protect, such as marinas, and work with those businesses to maintain their own supply of protection boom. Any additional protection strategies should be added to the plan.
- Communication protocols for mutual aid and for Unified Command should be added to the report.
- Permanent anchor points on shore can be established, and GPS locations of apex anchors in the Christmas tree formations should be determined.
- There are several operational-type parameters (including but not limited to: currently available spill resources, staging areas of such resources, specific location of primary and secondary anchor sets and points, discharge of skimmed material, disposal of contaminated debris, etc.) that should be expanded upon by The Coalition for Buzzards Bay and/or the various towns in the area, upon consultation with responders.

The proposed protection strategies emphasize flood-tidal conditions only, because the basic assumption is that the strategy be designed to deal with spilled oil coming to the site from the open waters of the Bay. These proposed potential strategies are based on the information at hand on waves and tidal currents. Where such data are missing, inferences based on the geomorphology were used. It would be helpful if site-specific current studies were carried out in some of the more difficult areas in order to fine-tune the proposed strategies. Furthermore if primary permanent anchor points are to be located, then this should be done after appropriate tide/current studies are conducted.

Sediment dikes (recommended at several sites) were identified as potential strategies only where it was determined that there were sufficient quantities of sediment available locally to render this strategy feasible.

At several sites where strategies were developed culverts were present. Though culverts were identified at some locations, additional culverts may exist at these as well as other sites that were not identified. Where possible, culverts should be closed to prevent inflow of oil.

Though only deflection and protection booms are discussed in this report, additional boom types, such as snare boom, may be used in various protection scenarios based on availability of materials and resources during an actual spill event. The first responders or clean-up contractors in the area can advise on the availability of such resources.

The following elements are included in the discussion of most of the individual locations:

- Location summary sheet, which includes Inlet Class (based on degree of difficulty of protection), brief summaries of principal resources at risk, preliminary/potential protection strategies, geomorphology, resources required, contact information for local, state, and federal entities/individuals who may be contacted in the event of spills, and other comments as necessary. Note that the list of contacts is not intended to be an exhaustive list of all potential contacts for a particular site, but rather a list of potential contacts identified during the fieldwork and the subsequent reviews.
- Vertical aerial photograph (in color) of the location, as well as at least one supplementary oblique color aerial photograph and a ground photograph (where available) of one of the most critical collection points.
- Preliminary/potential protection strategy (for flood conditions) is printed in color on the photograph.
- Collection point summary table, which includes a brief discussion of the collection points and possible staging areas plus comments concerning the type of equipment to be used at each collection site.
- Strategy implementation table, which prioritizes the order of strategy implementation.

PROTECTION STRATEGIES USED

In making a decision on a protection strategy, the following hierarchy of controls dictated the final strategy:

1) Physical process of the location
2) Protection priorities
3) Effectiveness of response

If the waves were assumed to be too large or tidal currents too strong for booms to function in certain parts of the area, the strategy called for fall back to more protected sites. The potential effectiveness of response was also given careful consideration. The probable effectiveness of a response would be controlled by such factors as access, particularly to collection points, types of equipment required, and logistics support required.

Several additional assumptions that affected the final decision on a particular protection strategy include:

- When oil is on the water, the first priority is containment and the second is recovery.

- Following guidelines established by the U.S. Coast Guard Strike Team, we conclude that deflection booms are the best means of controlling oil in the vicinity of tidal inlets or other areas of constricted flow because of the common occurrence of tidal currents greater than 0.7 knots, the threshold velocity for entrainment of oil past a boom set at 90° to the current (see diagram in Figure 2).

- The preferred method of recovery is to divert oil to a collection point along shore where the oil can be collected from the water surface. Trapping oil against vertical pilings, concrete seawalls, or protection boom is desirable. It is also possible to use as collection points fine- to medium-grained sand beaches, which are easily cleaned and penetration of oil into the sediment is minimal. Coarse-grained sand, shell and gravel beaches, riprap, tidal flats, and marshes should not be used as collection points except as a last resort. Where workable collection points are not available on land, open water skimmers are recommended.

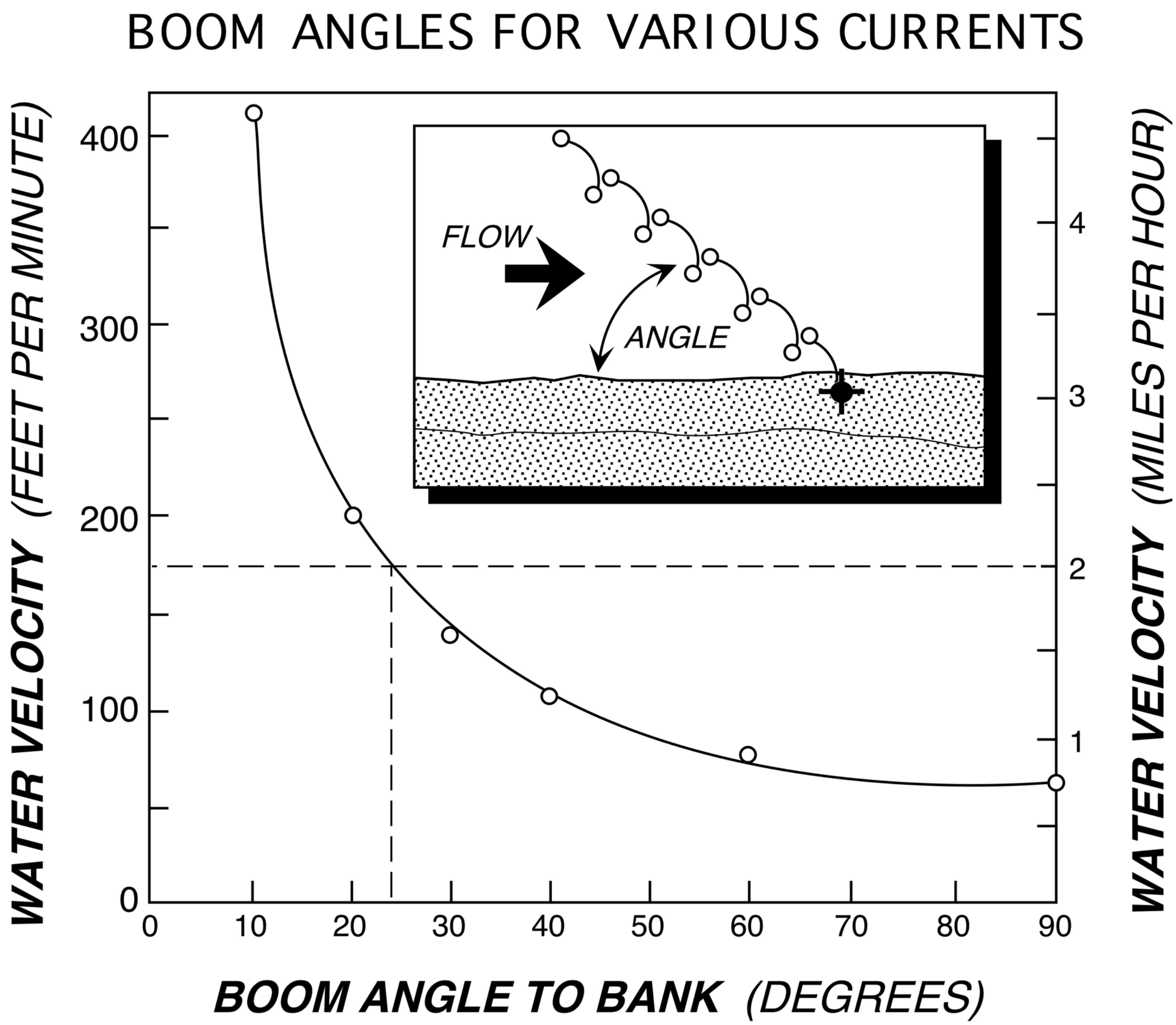

FIGURE 2. Angles to set booms to avoid entrainment of the oil based on water current velocity in miles per hour (courtesy of U.S. Coast Guard Strike Team).

- Entrainment of the deflection booms will occur, unless they are set at very small angles to the current, if the current velocity exceeds about 3.5 knots. Large waves also may cause both entrainment and splashover, depending upon the physical configuration of the boom.

- Except in the case of the offshore islands, the protection strategies depicted relate only to spills located seaward of the areas of concern, and the strategy recommended applies only to flood-tide conditions.

An example of how one of the protection strategies is presented graphically is given in Figure 3. In that example, the inlet at the entrance to the Westport River System (location no. 2; Fig. 1), it was assumed that it would usually be necessary to fall back inside the inlet for the first line of defense. This is because of anticipated flood currents of up to four (4) knots in the entrance channel and the potential for wave action in the entrance during stormy conditions. Two lines of collection boom are designed to divert oil to sand and gravel beaches (CP-1 and CP-8) on either side of the inlet during the early stages of the rising tide (discussed further below). These two deployments would not work under heavy wave conditions. Further inside the inlet, two sites were chosen as the primary collection points (first line of defense) on land (collection points CP-2 and CP-7 on Fig. 3) for oil coming through the inlet throat. Both of these collection points are sand and gravel beaches. These primary collection points have contingency back-up deflection boom to two more land-base collection points (CP-3 and CP-6) and two open water skimmers (CP-4 and CP-5), should entrainment occur at the first line of defense. The black arrows on Figure 3 indicate the probable path of surface oil during the flood tide. Some of the critical recommended anchor points for the boom are also shown, but many more anchors would be needed. Although we have calculated the lengths of boom required for these strategies, the exact length of the segments of boom to be used during the actual spill response will be determined by local conditions.

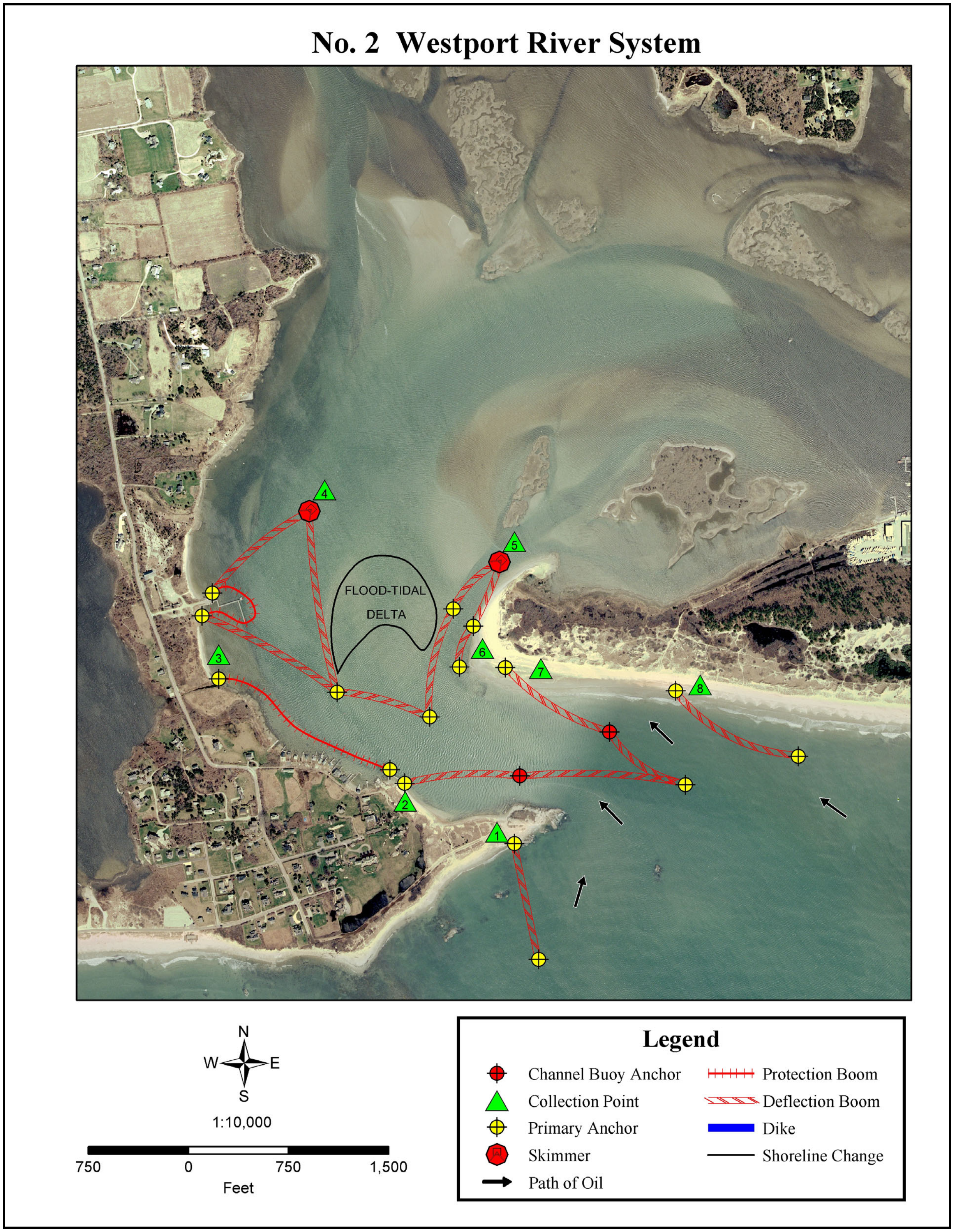

FIGURE 3: Strategy for Westport River System (no. 2).

CLASSIFICATION OF PROTECTION SITES

The sites selected for protection on the coast of Buzzards Bay were classified on the basis of the degree of difficulty for containment and recovery of spilled oil once it reaches the site. This ranking, which is summarized in Table 2, is on a scale that ranges from A to D, with the locations classed as A's being the most difficult, and, consequently, the most expensive ones to deal with. The occurrence of the different locations, by class, is illustrated in Figure 1. In Buzzards Bay, seven sites were classified as A, one of which is illustrated in Figure 3 (Westport River System). The other six locations in this class are large coves and river entrances located along the northwestern shoreline of the bay between New Bedford and the Cape Cod Canal. Two locations, Slocums River System (no. 4) and Great Sippewisset Marsh (no. 32B), were classified A/B, because it was thought that changing hydrodynamic conditions (e.g., large waves, high spring tides) would significantly increase the difficulty of protecting these locations (changing the ranking from class B to class A). Eight locations were ranked as B, 17 as B/C, 8 as C, and 8 as D.

TABLE 2. Proposed ranking scale for the sites on the Buzzards Bay shoreline selected to be protected, based on estimated degree of difficulty for containment and recovery of spilled oil.

A.	Extremely difficult because of large size and extreme physical conditions. Large expense because of magnitude of resources to protect.
B.	Difficult because it is subject to strong currents and/or large waves. Significant amount of resources to protect.
C.	Less difficult because of smaller tidal prism and relatively weak tidal currents.
D.	Inlet channel can be closed with sediment dike under normal adverse conditions.

TIDAL INLETS—GENERAL

Origin

In the classic sense, tidal inlets are channels that divide barrier islands into segments. They are subject to reversing tidal currents, and are conduits for the volume of water that flows in and out of the bay/estuarine system landward of the inlet during a tidal cycle, called the tidal prism. Tidal inlets on the sandy coastal plains of the eastern USA are usually formed by either of two mechanisms:

(1) Storm-generated scour channels (resulting inlets are usually shallow and prone to rapid migration); and

(2) Closure of estuarine entrances by growth of sand spits (resulting inlets usually deep and fixed in place).

Morphology

As shown in Figure 4, a typical tidal inlet in a barrier island setting consists of a deep channel between the adjacent sand spits, called the inlet throat, and lobate-shaped sand bodies on either side of the inlet, called tidal deltas. The sand deposit on the landward side of the inlet, the flood-tidal delta, is typically composed of sheet-like lobes of sand with seaward-sloping ramps on their seaward sides covered by landward migrating waves of sand. In some places, the flood-tidal delta is a very complex array of channels, sand flats and salt marshes (well-developed flood tidal deltas occur at the Westport River System (strategy no. 3; see Fig. 3), and Buttermilk Bay System (strategy no. 23). The sand deposit on the seaward side of the inlet, the ebb-tidal delta, is built seaward by ebb-tidal currents, but waves mold the outer margins into an arcuate shape and build landward migrating intertidal bars (swash bars) on the delta surface. The tidal flow on the ebb-tidal delta is horizontally segregated, with the main ebb channel, which usually projects perpendicular to shore off the inlet throat, being dominated by ebb-tidal currents. Shallower, flood-dominant channels (marginal flood channels) flank both sides of the ebb-tidal delta (see Figure 4). The marginal flood channels are important in oil-spill response because the first waters to enter the inlet during the rising tide flow down these channels, even as residual ebb-tidal currents are flowing out the main ebb channel. This allows for a period of time (one hour or so) when any oil heading landward would be moving only down the marginal flood channels, during which time it could possibly be diverted to the adjacent beach, rather than allowing it to enter the inlet and the highly sensitive pond/bay behind it. A small ebb-tidal delta is present just outside the entrance to the Back River System (strategy no. 24).

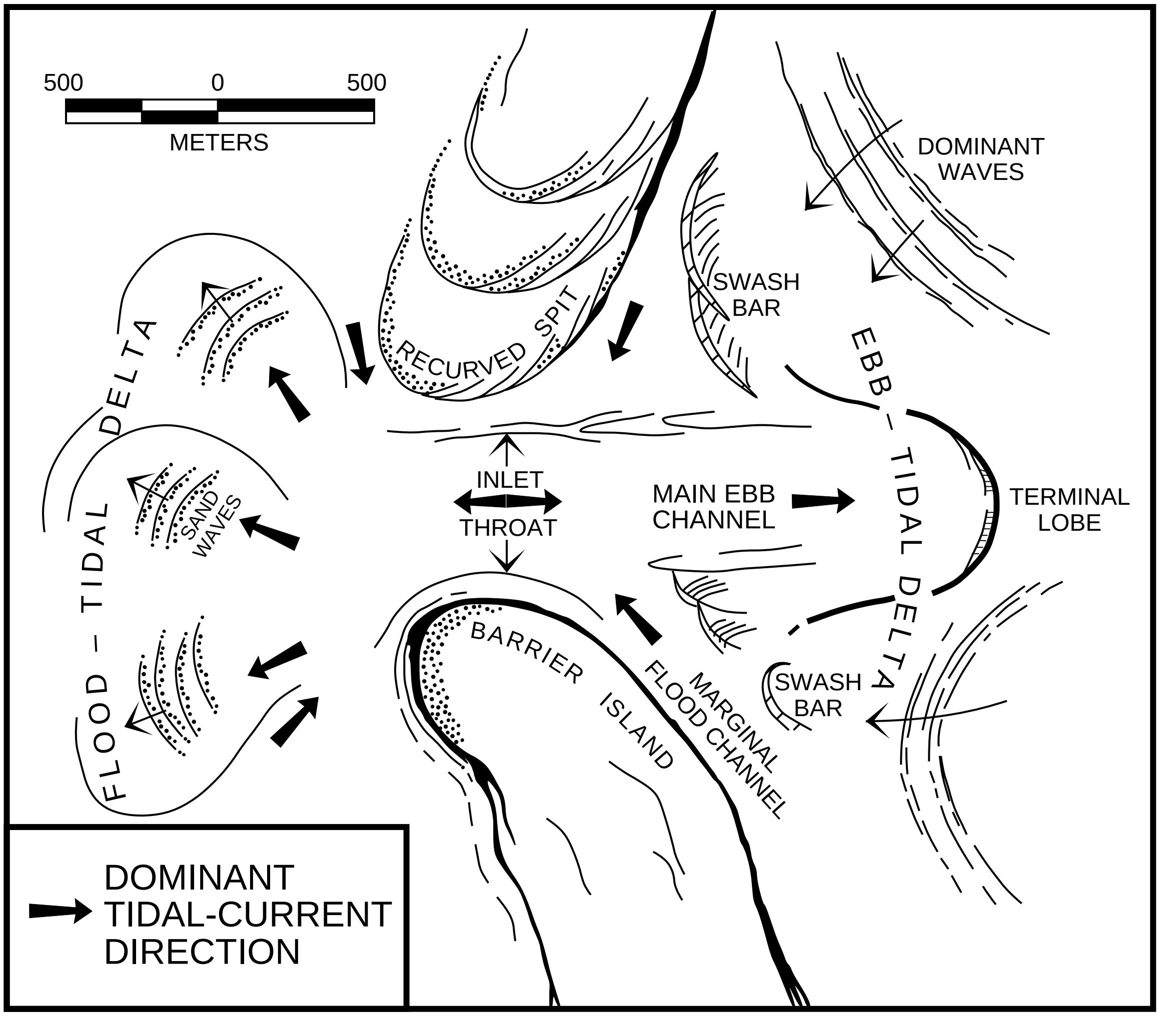

FIGURE 4. General model showing the morphological components of a typical tidal inlet.

Very few inlets in nature have tidal deltas of equal size as is depicted in Figure 4. Most inlets, including those in Buzzards Bay, are either flood-dominated or ebb-dominated. Flood dominated systems are most common where the bay/ pond complex landward of the inlet is open water. In this instance, the flood-tidal delta is usually much larger than the ebb-tidal delta. On the other hand, if the area landward of the inlet is a complex system of sinuous tidal channels, tidal flats, and salt marshes, the inlet tends to be ebb-dominated and the ebb-tidal delta is much larger than the flood-tidal delta. The inlets at Little and Great Sippewisset Marsh (strategy nos. 32A and 32B) are both ebb-dominated.

SITES TO BE PROTECTED ON SHORELINE OF BUZZARDS BAY

Introduction

The areas to be protected in Buzzards Bay are highly variable. Only three of the 52 sites discussed in this report [Allens Pond (strategy no. 3) and Little and Great Sippewisset Marsh (strategy nos. 32A and 32B)] conform to the morphological pattern described in Figure 4, which is based on the typical tidal inlets found along barrier islands of the Southeast and Gulf Coast shorelines of the USA. However, the Buzzards Bay coastline is an indented, rocky coast that was intensely glaciated during the ice ages. Major barrier islands, per se, are uncommon along this shoreline, and there are many rocky headlands and intervening valleys flooded by sea water during the most recent sea level rise, creating a very irregular and complex shoreline. Consequently, a variety of shoreline indentations that receive ocean flow through relatively narrow constrictions and contain sensitive coastal resources, such as marshes and tidal flats, occur along the coast. These indentations have been treated as "tidal inlets" in this project. The different types of "inlets" or "Geomorphic Classes" include: (a) classic tidal inlets (3 sites); (b) "half inlets" (5 sites); (c) natural temporary washover channels into coastal ponds (8 sites); (d) river mouth entrances and natural coves and bays (25 sites); and (f) harbors (5 sites). Four island sites were also selected.

Classic Tidal Inlets

As noted above, only three of the locations surveyed are in this category.

With respect to oil-spill response, man-modified inlets are typically easier to deal with than natural systems (of the same size), because of the ease of access to land-based collection points. On the down side, narrowly constricted jetties normally accentuate tidal currents a great deal, which usually necessitates operating landward of the jetties to collect oil.

"Half Inlets"

The irregular outline of the shoreline caused by valleys carved during lowered sea level, indentations caused by glacial processes such as ice-block basins, and so forth, has been straightened over time by barrier spits built across these indentations, or embayments. This has only occurred in areas where sediment is available and waves are large enough to generate longshore sediment transport. If the longshore transport is strong, a single spit will build most the way across the embayment so that the entrance channel abuts an adjacent upland, which is commonly underlain by bedrock. This process results in a "half inlet" configuration.

A total of five of the inlets surveyed are in this group. The Westport River System (illustrated in Figure 3), a classic example of this type of inlet, is ranked as class A, because of strong currents, the large size, the magnitude of resources needing protection, and the difficulty of the proposed strategy. The other four inlets are classified as B/C, usually classed greater than C because of the possibility of storm wave activity or strong currents during spring tides, or the presence of extensive tidal flats seaward of the entrance [as is the case at Bourne Cove (no. 19) and Little Harbor (no. 20)].

Natural Temporary Washover Channels Into Coastal Ponds

Eight of the sites have temporary channels of this type. Some of these channels may be opened artificially on occasion. At all of these sites, we recommend that the channels be closed temporarily by the construction of sediment dikes in the event of a spill. At a few of the sites, finding enough sediment in the vicinity of the channel to complete the job could be a problem at certain times of the year (e.g., after storms).

River Mouth Entrances and Natural Coves and Bays

A total of 27 of the study sites were either river mouth entrances or natural coves that were flooded with marine water during the last sea level rise. None of these entrances contain major barrier spits, thus they tend to be relatively deep at the entrance, and, as a rule, currents are not very strong in the outer reaches of the bay. However, there may be constrictions further inside the bay which have strong, complex current systems. Six of the seven sites classified as the most difficult (class A) are of this type. All six are located on the northwestern shoreline of the Bay and all are large with extensive natural and human resources in need of protection.

Harbors

Five of the areas surveyed were classified as harbors. These were either manmade harbors or highly modified natural harbors. All of these sites were classified as C, because of their relatively small size, lack of a large tidal prism, relative simplicity of the protection strategy, and minimal natural resources to protect.

Islands

Primarily because of the presence of important bird nesting and feeding areas, four island systems were selected. All four of these areas were classified as B/C, or higher than C because of the potential for waves to disrupt the strategy.

Tidal Current Data

Meaningful tidal current information on the study sites in Buzzards Bay is relatively scarce. Our field observations documented currents of 3-5 knots during peak flood in a few localities. We believe our protection strategies are conservative enough to accommodate the stronger currents where they occur, by either: (a) falling back inside the inlet to where the currents are weaker; (b) aligning booms at low angles and proper lengths; or (c) providing sufficient backup protection.

BOOM REQUIREMENTS

Approximate measurements of the footages of boom required for the strategies designed for the Buzzard Bay study sites are given in Table 3. The totals include all of the back-up boom configurations shown on the strategy diagram. Deflection boom is boom segments set up at an angle to the current flow, cascade style, so as to divert the oil to a collection point down current. Protection boom is established around areas designated for protection, such as salt marshes and marina entrances.

TABLE 3. Approximate footages of boom required for the potential protection strategies presented for the Buzzards Bay coast. Refer to Figure 1 for site names and locations.

		FEET OF BOOM	
INLET NAME	**CLASSIFICATION**	**DEFLECTION**	**PROTECTION**
1. Richmond Pond	D	-	-
2. Westport River System	A	12,140	2,380
3. Allens Pond	B	2,290	320
4. Slocums River System	A/B	3,140	-
5. Little River System	B	3,050	-
6. Salters Pond	D	-	-
7. Apponagansett Bay	B	6,720	2,970
8. New Bedford Outer Harbor	B	17,420	2,900
9. West Island System and Causeway	B/C	6,890	-
10. Nasketucket Bay	A	20,850	6,900
11. Brandt Island Cove	C	3,830	4,320
12. Mattapoisett Harbor System	A	19,010	4,460
13. Upper Aucoot Cove	B/C	6,520	4,520
14A. Ram Island	B/C	1,560	3,700
14B. Bird Island	B/C	1,550	3,130
15. Sippican Harbor	B	17,970	9,240
16. Wings Cove	B/C	6,030	3,350
17. Weweantic River System	A	9,740	13,860
18. Wareham River System	A	14,710	4,080
19. Bourne Cove	B/C	3,200	5,320
20. Little Harbor	B/C	3,110	4,540

TABLE 3. Continued.

INLET NAME	CLASSIFICATION	FEET OF BOOM: DEFLECTION	FEET OF BOOM: PROTECTION
21. Widows Cove	B/C	3,990	2,570
22. Onset Bay System	A	12,800	-
23. Buttermilk Bay System	A	8,090	920
24. Back River System	B	5,070	-
25. Pocasset River System	C	1,760	1,040
26. Red Brook Harbor System	B	11,450	4,510
27. Squeteague Harbor	B/C	3,650	1,190
28. Rands Harbor	C	1,240	420
29. Fiddlers Cove	C	1,340	520
30A. Wild Harbor River	B/C	2,000	-
30B. Wild Harbor	C	1,580	740
31. West Falmouth Harbor	C	3,290	1,060
32A. Little Sippewisset Marsh	B	3,200	400
32B. Great Sippewisset Marsh	A/B	6,000	-
33. Quissett Harbor	C	5,170	240
34. Weepecket Islands	B/C	2,450	10,320
35. Quicks Hole Pond	D	-	-
36. Cuttyhunk Pond	C	2,390	-
37. West End Pond	D	-	-
38. Penikese Island Rookery	B/C	1,100	7,440
39A Hadley's Harbor	B/C	1,210	-
39B. Hadley's Harbor	D	-	-
39C. Hadley's Harbor	B/C	1,080	130
39D. Hadley's Harbor	B/C	2,780	360
39E. Hadley's Harbor	B/C	2,210	2,840
40. Tarpaulin Cove	D	-	2,630
41. Pasque Island Marsh	B/C	1,110	850
42. West Beach	D	-	730
43. Silver Beach	D	-	860

EXPLANATION OF TERMS USED

The following provides explanations and definitions for the terminology used in the discussion of protection strategies for the study sites.

Beach Morphology

The typical beach morphology found in New England is illustrated in Figure 5. Sand beaches are normally planed off flat during storms. Gravel beaches typically are steeper and have a steep berm at the high-tide line.

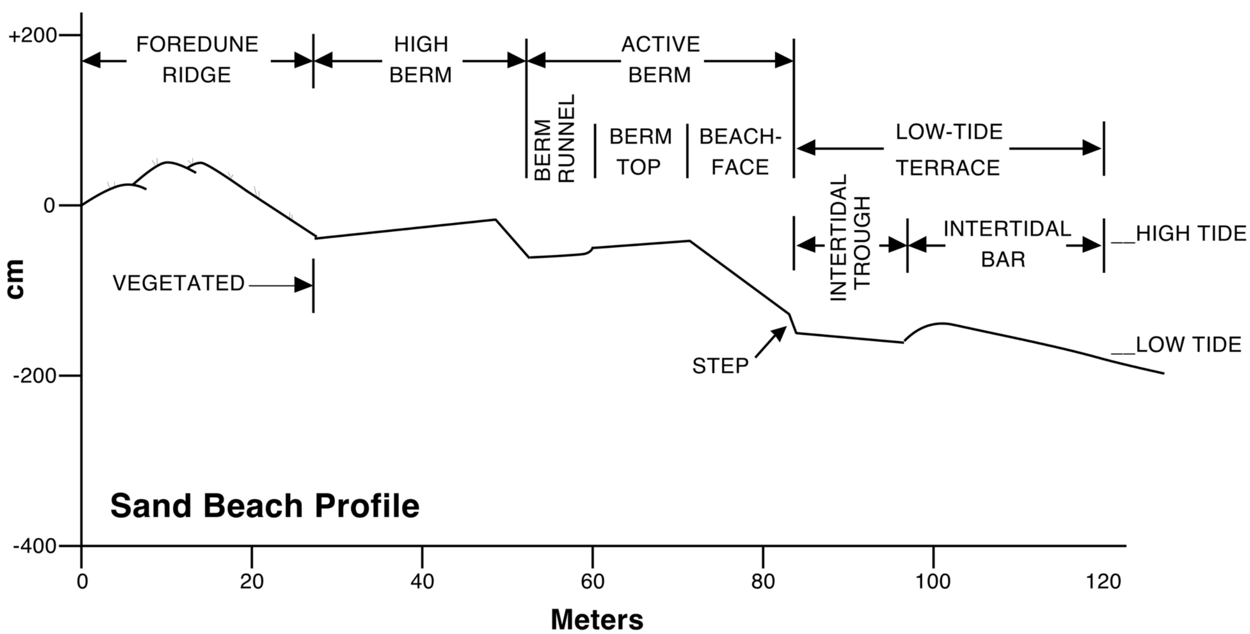

FIGURE 5. Nomenclature used for the sand beaches.

Coastal Sediments

Coastal sediments are classified into three general categories according to the dominant size of the individual clasts: (1) gravel, mean size greater than 2.0 mm;
(2) sand, mean size between 0.0625 and 2.0 mm; and (3) mud, mean size less than 0.0625 mm.

Other Commonly Used Terms

Some additional terms that are used in the descriptions of the study sites are defined as follows:

Anchor point. Stabilized position to which the line of booms is attached.

Berm (on a beach). A wedge-shaped sediment mass built up along the shoreline by wave action. Typically has a relatively steep seaward face and a gently sloping landward surface. A sharp crest (berm crest) usually separates the two oppositely sloping planar surfaces on the top of the berm. There are frequently two berms present, a high berm, the most landward, oldest berm, and an active berm, the most seaward and most recently activated berm (Figure 5).

Class of study site. Ranking of study site based on degree of difficulty for containing and collecting spilled oil within the site (see Table 2).

Collection point. Zone along the shoreline where oil is directed so it can be collected from water surface or cleaned up. An example would be a hard-packed, fine-grained beach from which oil contamination can be readily recovered.

Deflection boom. A floating barrier designed to direct the flow of oil to a suitable collection point so that it can be recovered. The boom is set at an oblique angle to the primary flow direction. The angle is dependent on the velocity of the currents.

Ebb-tidal delta. Lobate accumulation of sand at the seaward margin of the primary entrance channel to a tidal inlet. Formed as a result of deceleration of ebb-tidal currents. Modified by waves.

Flood-tidal delta. Lobate accumulation of sand at the landward margin of the primary entrance channel to a tidal inlet. Formed as a result of deceleration of flood-tidal currents.

Geomorphic class. Type of study site based on its geomorphic evolution (e.g., washover channels; river mouth entrance).

Groin. A shore protection structure built perpendicular to the shoreline, intended to trap littoral drift and retard erosion of the shore (W.F. Baird, pers. comm.).

Inlet throat. The deepest portion of the channel that connects the ocean to the mainland water body in a tidal inlet complex. Deep scour is the result of the accelerated flow of ebb- and flood-tidal currents in the constricted entrance channel.

Intertidal boom. Boom designed to lay on intertidal surface at low tide and to prevent entrainment of oil under the boom on a rising tide.

Jetty. A structure extending into a body of water, designed to provide access to an onshore berth (W.F. Baird, pers. comm.).

Knot. A unit of speed in navigation equal to one nautical mile per hour (1.852 km/h) (W.F. Baird, pers. comm.).

Longshore sediment transport. Sediment moved on the beach and in the nearshore zone by currents generated by breaking waves.

Main ebb channel. Deep channel through ebb-tidal delta, scoured by ebb-tidal currents, that projects seaward directly away from the inlet throat (see Figure 3).

Marginal flood channel. Component of ebb-tidal delta resulting from horizontal segregation of tidal current flow. Ebb-tidal delta usually has two marginal flood channels which are oriented obliquely to the main ebb channel and roughly parallel to the adjacent beaches (see Figure 3).

Protection boom. Boom designed to keep oil away from some feature, such as a fringing salt marsh. Not designed specifically for deflection or collection.

Riprap. A layer of randomly placed cobble- to boulder-sized fragments of rock designated to prevent erosion or scour of a structure, embankment, or foundation (W.F. Baird, pers. comm.).

Salt marsh. Growth of herbaceous plants subject to inundation of salt water during a tidal cycle.

Seawall. A structure separating land and water areas, designated primarily to prevent erosion and other damages due to wave action (W.F. Baird, pers. comm.). Usually vertical and composed of concrete.

Skimmer. Mechanical device designed to float on water and remove oil or oily water mixtures from the water surface.

Spit. Linear inter- or supratidal sediment body built by wave action. Typically composed of multiple curving beach ridges that project away from the dominant wave approach direction.

Tidal channel. Permanent channel located within the intertidal zone that serves as a conduit for the rising and falling tide. These channels usually migrate slowly.

Tidal prism. The total volume of water that flows into and out of a bay, harbor, or estuary during one tidal cycle.

Tide. The periodic rising and falling of the water that results from gravitational attraction of the Moon and Sun and other astronomical bodies acting upon the rotating Earth (W.F. Baird, pers. comm.).