A Narragansett Bay Estuary Program Report

Photo-Interpretation of Buffer Zones, Coastal Wetland Potential Restoration Sites, and Hardened Shorelines in the Narragansett Bay Estuary Rhode Island and Massachusetts

Narragansett Bay Estuary Program

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A. INTRODUCTION

The Natural Resources Assessment Group (NRAG) at the University of Massachusetts, Amherst, entered into agreement with the U.S. Fish and Wildlife Service's (FWS) National Wetlands Inventory (NWI), Northeast Region, in cooperation with Rhode Island Department of Environmental Management, Narragansett Bay Program (NBP) and Save the Bay, Inc. to provide stereoscopic aerial photointerpretation of land use and land cover in buffer zones, potential coastal wetland restoration sites and hardened shorelines in the Narragansett Bay project area.

NRAG is a technical services group in the Department of Plant and Soil Sciences at the University of Massachusetts, specializing in the inventory of wetlands, upland vegetation and land use using remote sensing techniques for use in digital data sets.

Coastal wetlands, deepwater habitats and coastal resource features for the Narragansett Bay estuary were inventoried by NRAG in 1996, to include maps of submerged aquatic vegetation (SAV), primarily eelgrass. That inventory is the base data for the analyses in this project.

As part of a comprehensive coastal habitat analysis, additional work conducted by NRAG includes trend analysis of coastal wetlands and the 500-foot buffer zones for the era 1950's through 1990's, and selected areas for the 1930's era.

The University of Rhode Island, Environmental Data Center (URI/EDC) was contracted for the digitizing of this data.

B. STUDY AREA

Narragansett Bay occupies eastern Rhode Island and the upper Mount Hope Bay/Taunton River portions of southeast Massachusetts. Limits of the project area were defined in part by geography, the limits of brackish waters and bay hydrogeomorphology. See Fig. 1.

Approximately 540 miles of shoreline was covered, located on portions of 13 US Geological Survey 1:24,000 scale topographic maps: Providence, East Providence, Somerset, Assonet, East Greenwich, Bristol, Fall River, Wickford, Prudence Island, Tiverton, Narragansett Pier, Newport and Sakonnet Point.

C. METHODS

1. Aerial Photography and Data Preparation

Source imagery was 1:40,000 scale true color transparencies flown in the summer of 1996 and 1:12,000 scale of the same type, season and year, flown by the James W. Sewell Company of Old Town, Maine.

Photointerpretation of buffer zones and potential wetland restoration sites was at 1:40,000 scale. The 1:12,000 scale was stereoscopically reviewed as a collateral source; for example, locating small stands of tall reed (*Phragmites australis)* not detectable at 1:40,000 scale; to clarify problematic areas due to shadows or overexposure on the 1:40,000 imagery; and for the hardened shorelines mapping.

For the buffer zone and restoration analysis, photography was data-prepared with Grafix Wet Media DuraLar .004 gauge 9-inch by 9-inch mylar overlays, affixed with drafting tape at each corner. Mylar overlays were pin-registered at four corners and identifying notations were made in black India ink.

Photo mylars with buffer zone and restoration photointerpretation were generated separately, each overlaying mylars containing the base wetland data photointerpreted in 1996.

2. Transfer

Photointerpreted data was transferred onto selected frosted mylar manuscripts at 1:24,000 scale, containing previous (rectified) data layers to ensure accuracy and consistency during transfer. Manuscripts were prepared for NRAG's use by the URI/EDC.

The manuscript for transferring land use/land cover (LULC) data in the buffer zone contained digital linework from the base wetlands layer and a 500-foot buffer zone boundary. The buffer boundary was measured landward from the most inland edge of coastal wetland or coastal feature. Buffer zone data was transferred by NRAG onto these manuscripts using a Bausch & Lomb stereo zoom transfer scope (ZTS).

The manuscript for transfer of potential wetland restoration sites contained color-differentiated polygon linework from the base wetland layer and the buffer zone layer. Transfer of potential restoration sites was a combination of attributing base wetland polygons, breaking out new polygons within base polygons, placing arcs adjacent to base wetland and/or buffer zone polygons and ZTS of new polygons.

Hardened shorelines were reviewed stereoscopically on the 1:12,000 scale imagery and transferred directly to 1:24,000 scale frosted mylar manuscripts (prepared by URI/EDC) overlaying USGS stable base topographic maps. Linear delineations of these features were made on 1:12,000 overlays on an as-needed basis, primarily for clarifying breaks separating the different types. The manuscripts contained digital base wetlands overlaying USGS stable base maps to allow consistent transfer of hardened shoreline features.

Point locations of field sites were transferred onto or near base wetland polygons and were coded for site identification.

Following transfer and digitizing, URI/EDC provided proof plots to NRAG for quality control and consistency checks between the various layers.

3. Minimum Mapping Units

Minimum mapping units (MMU's) targeted for this project were:

- 0.5 acre for LULC in the buffer zone
- 0.5 acre for potential coastal wetland restoration sites, except for monocultural stands of *P. australis*, where the MMU was .25 acre
- approximately 125 linear feet (LF) minimum for restoration arcs
- approximately 125 LF to 250 LF for hardened shoreline arcs, varying with the feature (See Section C4c.)

For conspicuous fill materials in coastal wetlands, the targeted MMU may be under 0.5 acre at the discretion of the photointerpretor.

4. Classification

A. Wetlands

Estuarine and marine resources and freshwater wetlands within the 500 foot buffer zone have been classified according to *Classification of Wetlands and Deepwater Habitats of the United States* (Cowardin et al., 1979; reprinted 1992) and following the US Fish & Wildlife Service's NWI mapping standards.

B. Land Use/Land Cover in the Buffer Zone

Land Use and Land Cover classification of uplands in the 500-foot buffer zone was modified from Anderson (1976) to address the needs of this project. The hierarchical classification allows uniformity at Levels 1 and 2 yet can be customized to suit project needs using Levels 3 and 4. We classified land use/land cover to either Level 2 or 3, selecting categories considered significant in characterizing the 500-foot buffer zone for three main reasons:

- As natural buffers functioning as wildlife habitat, mitigation of potential erosion and sedimentation, mitigation of potential runoff and leachates and bank stabilization
- As man-made sources of potential external impacts to coastal wetland resources.
- To document development in proximity to tidally restricted wetlands where tidal hydrology may be restored.

Please consult Anderson (1976) for detailed information on land use/land cover classification.

As mentioned, freshwater wetlands and water bodies within the 500-foot buffer zone were classified by Cowardin et al. (1979). Table 1 lists buffer zone land use/land cover codes customized for this analysis.

Table 1. *Land Use/Land Cover in the 500-foot Buffer Zone* (Anderson, 1976).

Level 1	Level 2	Level 3
1 Urban or Built-up Land	11 Residential	111 Single Family
		112 Multi-family
		113 Mobile Home Parks
		114 Lawns (includes non-residential lawns)
		115 Other (e.g., military barracks)
	12 Commercial and Services	121 Commercial and Institutional Structures (plazas, malls, schools, universities, military bases)
		122 Recreational structures (e.g., beach pavilions, water slides)
		123 Marinas
		124 Junkyards
		125 Paved surfaces associated with commercial and services
		126 Unpaved surfaces (sandy parking lots in beach areas)
		127 Wharves, piers & shipyards
	13 Industrial	
	14 Transportation, Communications and Utilities (includes lighthouses) (for roads, map 4-lane highway corridors; no 2-lanes)	
	15 Industrial & Commercial Complexes	
	16 Mixed Urban or Built-up Land	
	17 Other Urban or Built-up Land	171 Golf courses
		172 Cemeteries
		173 Other (zoos, urban parks, ski areas, forts)
		174 Landfills
2 Agricultural	21 Cropland	
	22 Orchards, Nurseries, Vineyards, Ornamental Horticulture)	
	23 Confined Feeding Operation	
	24 Pasture and Hayfields	
	25 Other	
3 Rangeland	31 Herbaceous Cover	
	32 Shrub and Brush Cover	
	33 Mixed	
4 Forest	41 Deciduous Forest Cover	
	42 Evergreen Forest Cover	
	43 Mixed	
5 Water, and 6 Wetlands	Use Cowardin (1979) for freshwater wetlands in the buffer zone**	
7 Barren Land	71 Dry Flats	
	72 Beaches (classified under Cowardin, 1979)	
	73 Sand Areas other than Beaches (dunes, backdunes)	
	(Note: Dunes were mapped on original wetlands layer as "D")	
	74 Bare exposed rock	
	75 Strip Mines, Quarries and Gravel Pits	
	76 Mixed Barren Land	
	77 Transitional (active earthwork)	

Note: **Freshwater wetlands within the 500-foot buffer zone classified under Cowardin (1979) included palustrine wetlands, some of which were tidally-influenced freshwater hydrology and others strictly freshwater types.

C. Potential Wetland Restoration Sites

Potential coastal wetland restoration sites were identified by use of Cowardin et al. (1979) classification combined with codes customized for the analysis by USFWS (R. Tiner, pers.comm.) in coordination with NRAG staff.

With reference to the scope of work for this project (R. Tiner, *Narragansett Bay Ecosystem Mapping Project: Coastal Wetland Restoration Site Identification and Trends Analysis of Coastal Wetlands and their Buffers,* 2/15/00) NRAG used conventional photointerpretation techniques to identify and map potential coastal wetland restoration sites of three basic types:

1) Sites of former estuarine wetlands that may be suitable for restoration (Type 1A); filled former wetland, effectively drained former wetland, and farmed former wetland.
2) Existing freshwater wetlands and impoundments that were estuarine wetlands and may be suitable for restoration (Type 1B).
3) Existing estuarine wetlands that are functionally impaired in some way (Type 2) due to on-site alterations (i.e., tidally-restricted, diked/impounded, ditched, spoil deposition, excavated, and farmed/hayed) and due to off-site activities (i.e., agricultural runoff, erosion/deposition, impervious surface runoff, sand/gravel extraction, turf runoff and potential leachates)…monocultural stands of *Phragmites australis* will be mapped when the stand is at least 0.25 acres in size.

Mapping of Type 1A sites was based on photointerpretable evidence of fill, effectively drained wetlands or farmed wetland soils assessed as previously supporting estuarine wetland, with collateral reference to USDA Natural Resources Conservation Service's *Soil Survey of Rhode Island* (1981) and *Soil Survey of Bristol County, Southern Part* (1981).

Mapping of Type 1B sites was based on photointerpretable evidence of alteration that potentially changed conditions from estuarine to freshwater; for example, resulting from a restricted road crossing, a dike or a dam. A change in vegetative cover and/or inundation is assessed and classifiable as tidally influenced freshwater or freshwater (Cowardin, 1979). Where mapping units can be compared, soil surveys (USDA/NRCS, 1981) were consulted to support photointerpretation. Potential external impacts were also assessed for Type 1B sites.
If wetlands landward of a restriction, diking or damming exhibit no photointerpretable change to freshwater conditions, they were classified as altered Type 2 estuarine wetlands and not Type 1B sites.

Mapping of Type 2 Internal sites (those impaired by on-site alterations) was based on a), photointerpreted classification using Cowardin (1979) modifiers for ditching, diking and other impoundments, and excavating; and b), photointerpretable evidence of restriction, vegetation change and minor filling.

Assessment of ditched coastal wetlands was generally highly photointerpretable and common in the project area. In most cases, ditching is for mosquito control. Other instances include small canals or dug out channels.

Excavated coastal wetlands were also photointerpretable, but not common.

Assessment of tidally-restricted wetlands was not based solely on presence of the "h" (diked/impounded) modifier in NWI classification. Restriction is indicated by photointerpretable man-made structures crossing coastal wetlands (e.g., dams, dikes, road crossings, railway beds abutments and old cart paths) which potentially impede tidal exchange in coastal wetlands landward of the structures. Photointerpretable scour (open water) on the upstream side may or may not be present. Upstream vegetation change may or may not be evident. Culvert collapse or malfunction may or may not be present. Roadbed fill and causeways qualify as restriction irrespective of open water flow conditions at the culvert, and/or vegetation change. That is, any marsh crossed by apparent roadbed fill or a causeway qualifies as tidally-restricted, even if the culvert appears functional and water in the tidal creek flows freely. This is based on the premise that tidal exchange across the length of causeway or roadbed is impaired.
The open water component of a restricted wetland area may or may not be designated as restricted habitat, based on photointerpretable stagnation and/or scour. In many cases, open water appears to circulate freely through a functional culvert or restriction and will not be designated as restricted, whereas wetlands surrounding the open water are designated restricted based on the crossing itself.
Distinguishing tidally-restricted wetlands from *severely* tidally-restricted wetlands was primarily based on photointerpretable *Phragmites* at greater than 30% cover, as compared to other restricted wetlands lacking significant cover of this plant.

Estuarine wetlands impaired by off-site activities were selected as Type 2/External sites "..only when virtually unbuffered (a 100-foot woody buffer lacking.)" (Tiner, Scope of Work, 2/15/00). Presence of a 100-foot woody buffer was based on photointerpreter judgment at 1:40,000 scale. Some Type 2/External sites may have woody buffers slightly greater than 100 feet due to photo shadowing or other conditions affecting estimates of buffer width. Additionally, there may be cases where woody vegetation is developing in the buffer since date of overflight (4 years).
Assessment of potential external impacts is limited to *photointerpretable* sources in proximity to coastal wetlands. Impairment by external sources such as point source discharges, chemical contaminants in groundwater, and suspended sediments are not photointerpretable and aren't within means of this project.

Table 3 lists the classification developed for estuarine wetland restoration analysis. Appendix A is a memorandum providing additional mapping procedures for identifying potential restoration sites.

Table 2. *Codes describing potential coastal wetland restoration sites in the Narragansett Bay project area* (from R. Tiner, 2/15/00).

Type 1A sites
1fph = fill/*Phragmites*-dominated
1fsp = fill/dredged spoil
1d = effectively drained

Type 1B Sites
1su = submerged
1w = palustrine wetland (formerly estuarine)
1x = excavated palustrine wetland (formerly estuarine)

Type 2 Sites/ Internal
(existing estuarine wetland with on-site alterations)
2r = tidally restricted
2rs = severely tidally-restricted
2d = significant ditching
2h = diked/impounded
2f = minor filling
2fs = minor filling/dredged spoil
2v = vegetation change/*Phragmites*-dominated
2vi = vegetation change/Iva
2x = excavated

Type 2 Sites /External
(existing estuarine wetlands with potential impacts from off-site activities)
2Elf = landfills
2Eis = impervious surfaces
2Ela = lawns
2Egc = golf courses
2Ein = industrial plants
2Ejk = junkyards
2Edf = dairy farms
2Ecr = cropland
2Esg = sand & gravel operations
2Ees = erosion & sedimentation (as from earthwork or bank erosion)

Type 1B Sites with Potential External Impacts
1Elf = landfills
1Eis = impervious surfaces
1Ela = lawns
1Egc = golf courses
1Ein = industrial plants
1Ejk = junkyards
1Edf = dairy farms
1Ecr = cropland
1Esg = sand & gravel operations
1Ees = erosion & sedimentation
(Note: Type 1B sites with internal impacts are coded by Cowardin (1979) classification)

D. Hardened Shorelines

Codes for hardened shorelines were developed by NRAG in coordination with FWS (R. Tiner, pers. comm.), and with reference to definitions in RI Coastal Resources Management Program Sect. 300.7 A., Definitions (RICRMP, As Amended, 1979). As such, mapped hardened shorelines are mostly in agreement with regulatory terms, with the exception of some additional definitions (Table 3).

The hardened shorelines are linear features. Artificial jetties and groins that are polygonal features at 1:40,000 scale were previously mapped and classified under Cowardin (1979). Wharves and piers that are polygonal features at 1:40,000 scale were mapped as Land Use/Land Cover in the 500-foot buffer zone. Where the structure that forming a hardened shoreline is polygonal, a *linear* feature was mapped and coded to follow the seaward edge of the structure.
Naturally occurring rocky shores were mapped as polygonal features with the previous Bay inventory.

Table 3. *Hardened shoreline classification for the Narragansett Bay project area.*

Code	Feature	Definition (* ref. RICRMP, 1979)
BK	Bulkheads	(*) "…a wood, steel or concrete structure built to retain or prevent wasting and collapse of a bluff into the sea…provides limited protection from waves."
SW	Seawall	(*) "…a massive, stand alone structure of placed or dumped stone, concrete or steel sheetpile..often have curved or stepped face designed to withstand the direct onslaught of ocean waves."
JT	Jetty	(*) "…usually of dumped stone (rubble mound) that retard the migration of a tidal inlet (breachway) in order to provide safer passage for boats in and out of coastal lagoon and estuaries."
GR	Groin	(*) "..structure built of rock, steel, timber or concrete that extends across a beach into tidal waters and is used to entrap sand in the longshore transport system, generally perpendicular to shoreline's coastal trend."
RR	Revetment	(*) "..built to armor a sloping shoreline face Usually composed of one or more layers of stone or concrete riprap…blankets and generally conforms to contours or a coastal feature."

Table 3. (continued)

Code	Feature	Definition (*ref. RICRMP, 1979)
BW	Breakwater	(*) "..either exposed or submerged. Protects a shore, harbor, anchorage or basin by intercepting waves…sometimes placed parallel to open shoreline to retard force of incoming waves to headland and barrier beaches."
PP	Permanent Pier	Solid stone or concrete piers not suspended by piles and blocking water circulation.
OSP	Other Significant Piers	Large piers or wharves supported by either solid fill or large piles; type of support cannot be verified through photointerpretation.

5. Fieldwork

a. Data Collection

NRAG conducted two sessions of fieldwork: one prior to photointerpretation (July 16-17 and 19-20, 1997) and one subsequent to photointerpretation (May 23-25, 2000). The 1997 field data was collected by plot method. The 2000 field data used NWI rapid assessment method modified for the project.

Fieldwork was designed for the collection of reference wetland data within four categories of disturbance: relatively undisturbed or near pristine, moderately disturbed, severely disturbed and severely tidally restricted. Data on reference wetlands with varying levels of degradation is expected to be useful in developing restoration plans. Undisturbed or near-pristine reference wetlands may be considered the model for long term restoration goals. The other three categories represent wetland conditions that can result from disturbance(s).

Appendix B is a plant list developed from fieldwork in the project area. Appendix C contains the field data sheets for reference wetlands and severely tidally restricted wetlands collected for this project. Appendix D contains field data sheets generated with the original wetlands inventory, the base data layer for this work.

b. Site Selection

Selection of field sites was based on accessible coastal wetlands within four categories of disturbance. Sites on posted private lands were not accessed; other sites not posted were not accessed if crossing private land was required and the owners could not be contacted.

Subjectivity exists in selecting reference wetlands. We categorized relatively undisturbed, moderately disturbed and severely disturbed reference wetlands by presence/absence of disturbance factor(s), the apparent severity of disturbance(s), and presence/absence of buffering vegetation. We also considered disturbance categories within context of overall development in this estuary.

Coastal wetlands relatively free of human disturbance were categorized as undisturbed. This generally means lacking disturbance factors within or external to the wetland likely to alter wetland plant community composition and/or tidal regime. Relatively undisturbed sites are buffered with native woody vegetation along most or the entire boundary. This was a judgment, in that the length of buffered edge was not quantified.

Many coastal marshes in the project area are ditched for mosquito control, and this was considered when categorizing reference wetlands. As a result, some ditched wetlands were categorized as relatively undisturbed. The number and condition of ditches, the extent of hightide bush *(Iva frutescens*), and presence/absence of other disturbance factors differentiated relatively undisturbed and moderately disturbed ditched wetlands.

Moderately disturbed reference wetlands were generally those with single impairment such as significant ditching or fragmentation, and which are relatively unbuffered (in part or entirely) from potential impacts. Tidally restricted coastal wetlands without significant cover of *P. australis* may also be ranked as moderately disturbed.

Severely disturbed reference wetlands usually have multiple sources of impairment, a significant cover of invasive species such as *P. australis,* and/or are largely unbuffered with native woody cover.

Severely tidally restricted wetlands usually have road crossings or other structures impairing tidal exchange, often with apparent culvert malfunction. A significant cover of invasive plants, primarily *P. australis*, appears to result from restriction; however, invasion by *P. australis* appears related to many types of disturbance(s) and is not limited to tidally-restricted wetlands.

Appendix B1 presents field data documented for 58 reference wetlands and 18 severely tidally restricted wetlands. Field data for 42 wetlands observed through rapid assessment (NWI data form) was obtained in 1996 for the previous coastal habitat inventory, and these are included here again in Appendix B2.

D. RESULTS:

Following summarizes the results of field data collected on reference wetlands and severely tidally restricted wetlands. Users interested in acreage summaries for the restoration and trends analysis are referred to the summary report(s) to be prepared by US Fish & Wildlife Service.

Table 4 lists reference wetlands by disturbance category with classification, dominance type and quadrangle location. Table 5 is list of severely tidally restricted sites, the restricting structures and the quadrangle location.

Table 4. *Selected reference wetland field sites in the Narragansett Bay project area, July 1997 and May, 2000.*

A. Relatively Undisturbed (18 sites)

Site #	*Classification*	*Dominance Type*	*Quadrangle*
R3	E2EM1P	*Spartina patens*	Tiverton
R4	E2EM1N	*S. alterniflora*, tall	Tiverton
R5	E2EM1N	*S. alterniflora*, tall	Tiverton
R7	E2EM1P	*S. alterniflora*(short)/*S. patens*	Tiverton
R13	E2EM1Pd	*S. patens/S. alterniflora*,short	Narragansett Pier
R14	E2EM1Pd	*Juncus gerardii*	Narragansett Pier
R15	E2EM1N	S. alterniflora, short	Narragansett Pier
R16	E2EM1P6	*S. patens/Scirpus pungens/Panicum virgatum*	Narragansett Pier
R18	E2EM1N	*S. alterniflora*, short	Prudence Island
R22	E2SS1P	*Iva frutescens*	Narragansett Pier
R33	E2EM1P	*S. patens*	Narragansett Pier
R34	E2EM1Pd	*S. patens/S. alterniflora*, short	Narragansett Pier
R37	E2EM1Pd	*S. patens*	Wickford
R42	E2EM1P6	*Scirpus validus*	East Greenwich
R43a	PSS1/EM1R	*Acer rubrum/Typha angustifolia*	East Greenwich
R43b	E2EM1P	*S. patens*	East Greenwich
R43c	E2EM5P	*Phragmites australis*	East Greenwich
R45a	E2EM1P	*Distichlis spicata*	East Greenwich
R45b	E2EM5P	*Phragmites australis*	East Greenwich
R45c	E2EM1P6	*Typha angustifolia*	East Greenwich
R49	E2EM1P	*S. patens*	East Providence
R54	E2EM1Pd	*S. patens*	Narragansett Pier

B. Moderately Disturbed (18 sites)

R1	E2EM1Pdh	*J. gerardii*	Sakonnet Point
R6	E2EM1P	*J. gerardii*	Tiverton
R8	E2EM1Pd	*J. gerardii/S. alterniflora*, short	Newport
R10	E2EM1Pd	*S. patens*	Newport
R12	E2EM1Ph	*S. alterniflora*, short	Newport
R17	E2EM1Pd	*S. patens/S. alterniflora,* short	Prudence Island
R23	E2EM5/1P6	*P. australis/T. angustifolia*	Narragansett Pier
R24	E2EM1Pd	*S. patens*	Bristol
R32	E2EM1Pd	*S. patens*	Narragansett Pier
R35	E2EM5P	*P. australis*	Wickford
R36	E2EM1Ph	*S. patens*	Wickford
R38a	E2EM1P	*S. patens*	East Greenwich
R38b	E2EM5P	*P. australis*	East Greenwich
R39a	E2EM1Pd	*S. alterniflora*, short	East Greenwich
R39b	E2SS1Pd	*Iva frutescens*	East Greenwich

Table 4. (continued)

R40	E2EM5/1P	*P. australis/S. patens*	East Greenwich
R41	E2EM1N	*S. alterniflora*, tall	East Greenwich
R51	E2SS1Pdh	*I. frutescens*	Bristol
R52	E2EM1Pd	*J. gerardii*	Bristol
Severely Disturbed (21 sites)			
R2	E2EM1P6dh	*T. angustifolia*	Sakonnet Pt.
R9	E2EM1P6h	*T. angustifolia*	Newport
R11	E2EM1Pdh; E2EM5Ph	*J. gerardii; P. australis*	Newport
R19	E2EM5P	*P. australis*	Prudence Is.
R20	E2EM1/5P6h	*T. angustifolia/P. australis*	Narragansett. Pier
R25	E2EM1Ph	*S. alterniflora*, short	Bristol
R26	E2EM1/SS1Ph	*S. patens/I. frutescens*	Bristol
R27	E2EM1/5Ph	*S. patens/P. australis*	Bristol
R28	E2EM5P6h	*P. australis*	Bristol
R29	E2EM1Ph	*S. alterniflora*, short	Wickford
R30	E2EM1Ph	*S. patens/S. alterniflora*,short	Wickford
R31	E2EM1Ph	*S. alterniflora*, short	Wickford
R46	E2EM1N6h	*S. alterniflora*, tall	E. Providence
R47	PEM5Rh	*P. australis*	E. Providence
R48	PEM5Rh	*P. australis*	E. Providence
R50	E2EM1Pd	*S. patens/Distichlis spicata*	Bristol
R53	E2EM1/5P6h	*T. angustifolia/P. australis*	E. Providence
R55	E2EM1P	*S. alterniflora*, short	Tiverton
R56a	E2EM1P6h	*T. angustifolia*	Tiverton
R56b	E2EM5P6h	*P. australis*	Tiverton
R57a	E2EM1Pdh	*S. patens*	Sakonnet Pt.
R57b	E2EM1P6dh	*T. angustifolia*	Sakonnet Pt.
R58	E2EM5P	*P. australis*	Wickford

Site R54 (E2EM1P) at Sheffield Cove in Jamestown is representative of relatively undisturbed salt marsh in the project area. The marsh is dominated by salt meadow grass *(Spartina patens*) in association with spike grass (*Distichlis spicata*). Short form smooth cordgrass (*S. alterniflora*) is common, with lesser amounts of sea lavender *(Limomium carolinianum),* common glasswort *(Salicornia europaea)* and seaside goldenrod (*Solidago sempervirens*). A zone of switchgrass (*Panicum virgatum*) bands upper limits. The marsh is not significantly ditched, is well buffered by native woody upland cover, and is not subject to invasive species colonization. Beavertail Road is at its southern end, where impervious surface runoff appears minor due to a narrow, elevated buffer.

A typical moderately disturbed wetland (R8) is found at Sachuest National Wildlife Refuge in Middletown (E2EM1Pd). Black grass (Juncus gerardii) and short form smooth cordgrass dominate this ditched marsh. Other species include common glasswort, salt meadow grass, switchgrass and marsh orach (*Atriplex patula).* An unimproved road and a salt pond levee restrict the marsh. Invasive tall reed

(P. australis) is present along a ditch, but does not dominate. A stand of narrow-leaved cattail (*Typha angustifolia*) is at the northwest corner of the marsh.

An example of severely disturbed marsh in the project area is site R55 (E2EM1P), a marsh dominated by short form smooth cordgrass in association with salt meadow grass, with lesser amounts of spikegrass and tidal pools. Invasive tall reed bands upper limits of the marsh. To the north, an old dump apparently filled part of this marsh, presenting potential leachate impacts. The dump is now vegetated with upland shrubs. To the south end, there is additional shrub-covered fill material, and parts of this shrub area appear to be ditched freshwater wetland. This freshwater wetland may be former salt marsh with shallow fill. Residential development is to the east side. To the west is impervious road runoff (Boyd Lane). This road fragmented the marsh, creating a restricted tall reed and narrow-leaved cattail brackish marsh landward of the road. Culvert malfunction appears to contribute to restricted conditions.

Twelve severely disturbed wetland field sites are also severely tidally restricted. Cross-reference site numbers are noted in the field data.

Table 5. *Selected severely tidally restricted coastal wetland field sites in the Narragansett Bay project area, May, 2000.*

Site #	*Restriction(s)*	*Quadrangle*
STR1	road, culvert	Narragansett
STR2	road, bridge, rail bed	E. Providence
STR3	old dam	Wickford
STR4	road, bridge, culvert, rail bed	E. Providence
STR5	road, bridge	Bristol
STR6	road, culvert	Newport
STR7	road, culvert	Newport
STR8	road, culvert	Tiverton
STR9	road, culvert	Tiverton
STR10	road, culvert	Sakonnet Point
STR11	road, bridge, dike	Newport
STR12	road, culvert	Newport
STR13	road, culvert	Narragansett Pier
STR14	road, culvert	Bristol
STR15	road, bridge, culvert	Bristol
STR16	dikes, promontory	Wickford
STR17	road, bridge	Wickford
STR18	road, bridge	E. Providence

Two severely restricted sites (STR1, STR13) located at Wesquage Pond in Narragansett appear remediable by culvert invert repair. The road crossing these sites appears heavily used to access to high-density residential development and a seasonal beach area. Beyond repairing the existing culvert, restricted wetland communities (*P. australis* and

T. angustifolia, dominants) may benefit from placing additional culverts and/or enlarging existing culverts.

STR3 is a remote restriction (unused old dam). Removal of the dam may curb the spread of *P. australis* at the south end of the salt marsh; however, *P. australis* at this location may be in response from external impervious surface runoff (development along US Route 1A). The *S. alterniflora* (short) dominance type landward of the restriction includes a relatively broad area of tidal flats and pannes (*Salicornia* sp.), possibly indicating of increased ponding as compared to the seaward community type (site R37).

The restriction at Silver Creek in Bristol (STR4) might be improved by investigating an apparent culvert elevation problem under the bridge. At incoming high tide, water level in the rectangular culvert appeared too high.

At Hazard Road (STR7) in Newport, an unimproved road restriction appears easily remedied. The roadbed fill seems to be sunken and washed over by tides, and the stone culvert is collapsed. The road does not appear to be well used by the public. Ponding is evident on both sides of the restriction, and *P. australis* has invaded. We did not observe residential development directly abutting these wetlands.

A collapsed culvert at Boyd Lane in Portsmouth (STR8) appears to aggravate roadbed fill restriction. Fragmented salt marsh landward of the restriction is presently dominated by brackish invasive species (*P. australis* and *T. angustifolia*). The seaward marsh (R55) is
S. alterniflora short-form with interior open water and algae bed, which may be evidence of ponding resulting from restriction.

A pipe outlet to Sakonnet Harbor appears submerged, potentially aggravating tidal exchange in wetlands at Haffenreffer Refuge (RIDEM), site STR10. The wetlands are restricted by roadbed fill. The pipe runs approximately 125 linear feet beneath the road.

At upper Wickford Cove in North Kingstown, there appears to be multiple, relatively unused restrictions (earthen dikes and a long promontory); see STR 16.

CONCLUSIONS

The Natural Resources Assessment Group previously inventoried coastal wetlands and deepwater habitats in estuarine and marine environments for RIDEM and STB in 1996. That digital data layer was used as the base for the specialized analyses presented here: land use/land cover in the 500 foot buffer zone, identification of potential coastal wetland restoration sites, and mapping of hardened shoreline.

Land use/land cover in the buffer zone is intended to provide managers with information about potential external impacts to coastal wetlands and bay waters, presence/absence of natural woody buffer zone cover, and the location of residences and other structures potentially affected by restored tidal hydrology.

Identification of potential restoration sites is intended to be a first screening of wetlands with photointerpretable signs of degradation. Determination of these sites as viable restoration candidates is ultimately field-based, as partially exemplified by the data collection on severely tidally restricted sites. Prioritization of viable restoration sites is enabled with collateral data such as public/private ownership, presence of endangered/threatened species, location in the flood zone, historic significance and/or any other information deemed pertinent to restoration site prioritization. It is noted that coastal wetlands showing non-photointerpretable signs of degradation (for example, known contamination determined from water quality sampling) may be viable restoration sites and prioritized. Users are referred to the potential wetland restoration site matrix, developed from this data and supplemented by collateral information. Matrix construction is a cooperative effort between RIDEM, Save the Bay and U.S. Fish & Wildlife Service.

The hardened shorelines data is intended to assist resource managers in assessing marsh accretion and sea level rise, restoration of tidal regimes, marine transport and navigation, and various other coastal zone dynamics such as flooding, storm surge, currents and erosion/deposition.

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REFERENCES

Anderson, J.R., E.E. Hardy, J.T. Roach and R.E. Witmer. 1976. *A Land Use and Land Cover Classification System for Use with Remote Sensor Data.* U.S. Geological Survey Professional Paper 96A. U.S. Government Printing Office, Washington, D.C. 28 pp.

Cowardin, L.W., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. *Classification of Wetlands and Deepwater Habitats of the United States.* U.S. Fish and Wildlife Service, Washington, D.C. FWS/OBS-79/31.

APPENDIX A:
Memorandum on Restoration Methodology

APPENDIX B:

Plant List
of
Species Observed at Field Sites
Narragansett Bay Project Area
August 1996 through May 2000

1. Emergent Plants

Scientific Name	Common Name
Amaranthus cannabis	Water Hemp
Agalinis maritimus	Saltmarsh False-Foxglove
Agropyron pungens	Stiff-Leaf Quackgrass
Agrostis stolonifera	Creeping Bent Grass
Alnus rugosa	Speckled Alder
Asparagus officianalis	Garden Asparagus Fern
Aster novae-angliae	New England Aster
Aster novi-belgii	New York Aster
Aster puniceus	Annual Saltmarsh Aster
Atriplex patula	Halberd-Leaf Saltbush
Atriplex sp.	Saltbush
Baccharis halimifolia	Sea Myrtle
Bidens connuta	Purple-Stem Beggar-Ticks
Bidens frondosa	Devil's Beggar-Ticks
Cabomba caroliniana	Carolina Fanwort
Carex sp.	Sedge
Cephalanthus occidentalis	Common Buttonbush
Ceratophyllum sp.	Hornwort
Convolvulvus sepium	Hedge Bindweed
Cuscuta sp.	Dodder
Cyperus filicinus	Slender Flatsedge
Distichlis spicata	Seashore Saltgrass
Eleocharis rostellata	Beaked Spike Rush
Eleocharis sp.	Spike Rush
Elymus riparius	Riverbank Wild Rye
Elymus virginicus	Virginia Wild Rye
Festuca rubra	Red Fescue
Glaux maritima	Sea Milkwort
Hibiscus moscheutos	Swamp Rose Mallow
Impatiens capensis	Spotted Touch-Me-Not
Iva frutescens	Marsh Elder
Juncus canadensis	Canada Rush
Juncus gerardii	Saltmeadow Rush
Juniperus viginiana	Eastern Red Cedar
Leersia oryzoides	Rice Cutgrass
Lilaeopsis chinensis	Eastern Lilaeopsis
Limomium nashii	Northern Sea Lavender
Ludwigia palustris	Marsh Seedbox
Lycopus virginicus	Virginia Bugleweed
Lythrum salicaria	Purple Loosestrife
Myrica pensylvanica	Northern Bayberry
Nymphaea odorata	White Water Lily
Panicum virgatum	Switchgrass

Parthenoscissus quinquifolia	Virginia Creeper
Phalaris arundinacea	Reed Canary Reed
Phragmites australis	Common Reed
Plantago maritimum	Seaside Plantain
Pluchea purpurascens	Saltmarsh Camphor-Weed
Polygonum arifolium	Halberd-Leaf Tearthumb
Pontedaria cordata	Pickerel Weed
Potomogeton sp.	Pondweed
Ptilimnium capillaceum	Mock Bishop-Weed
Puccinellia maritima	Seaside Alkalai Grass
Ranunculus sp.	Buttercup
Rosa palustris	Swamp Rose
Rosa rugosa	Saltspray Rose
Rumex crispus	Curly Dock
Rumex verticillatus	Swamp Dock
Sagittaria latifolia	Broad-Leaf Arrowhead
Salicornia europea	Slender Glasswort
Salicornia virginica	Virginia Glasswort
Samolus parviflorus	Water Pimpernel
Scirpus sp.	Bulrush
Scirpus americanus	Olney's Bulrush
Scirpus fluviatilis	River Bulrush
Scirpus pungens	Three-Square Bulrush
Scirpus robustus	Saltmarsh Bulrush
Sium suave	Hemlock water-Parsnip
Solanum dulcamara	Bittersweet Nightshade
Solidago sempervirens	Seaside Goldenrod
Sparganium sp.	Bur-Reed
Spartina alterniflora	Saltmarsh Cordgrass
Spartina patens	Saltmeadow Cordgrass
Spartina pectinata	Slough Grass
Suaeda linearis	Annual Seepweed
Suaeda maritima	White Seepweed
Teucrium canadense	American Germander
Toxicodendron radicans	Poison Ivy
Triglochin maritimum	Seaside Arrow Grass
Typha angustifolia	Narrow-leaved Cattail
Typha latifolia	Broad-leaved Cattail
Vitis labrusca	Fox Grape
Zizania aquatica	Annual Wild Rice

2. Aquatic Plants

Scientific Name	Common Name
Agardhiella sp.	Red Weed
Ascophyllum nodosum	Knotted Wrack
Champia parvula	Barrel Weed
Chondrus crispus	Irish Moss
Codium fragile	Deadman's Fingers
Enteromorpha sp.	Hollow Green Weeds
Eudesme virescens	Brown Slime Weed
Fucus sp.	Rockwed
Fucus vesiculosus	Rockweed
Gracilaria tikvahiae	Graceful Red Weed
Phycodrus rubens	Sea Oak
Polysiphonia sp.	Tubed Weeds
Ruppia maritima	Widgeon Grass
Sargassum filipendula	Sargassum
Sphaerotrichia divaricata	Slippery Tangleweed
Stilophora rhizoides	Rough Tangle Weed
Ulva lactuca	Sea Lettuce
Zostera maritima	Eelgrass

APPENDIX C:

Field Data Sheets
for
Reference Wetlands,
Collected July 1996 and May 2000

APPENDIX D:

Field Data Sheets for the Original Wetlands Inventory,
August – October, 1996