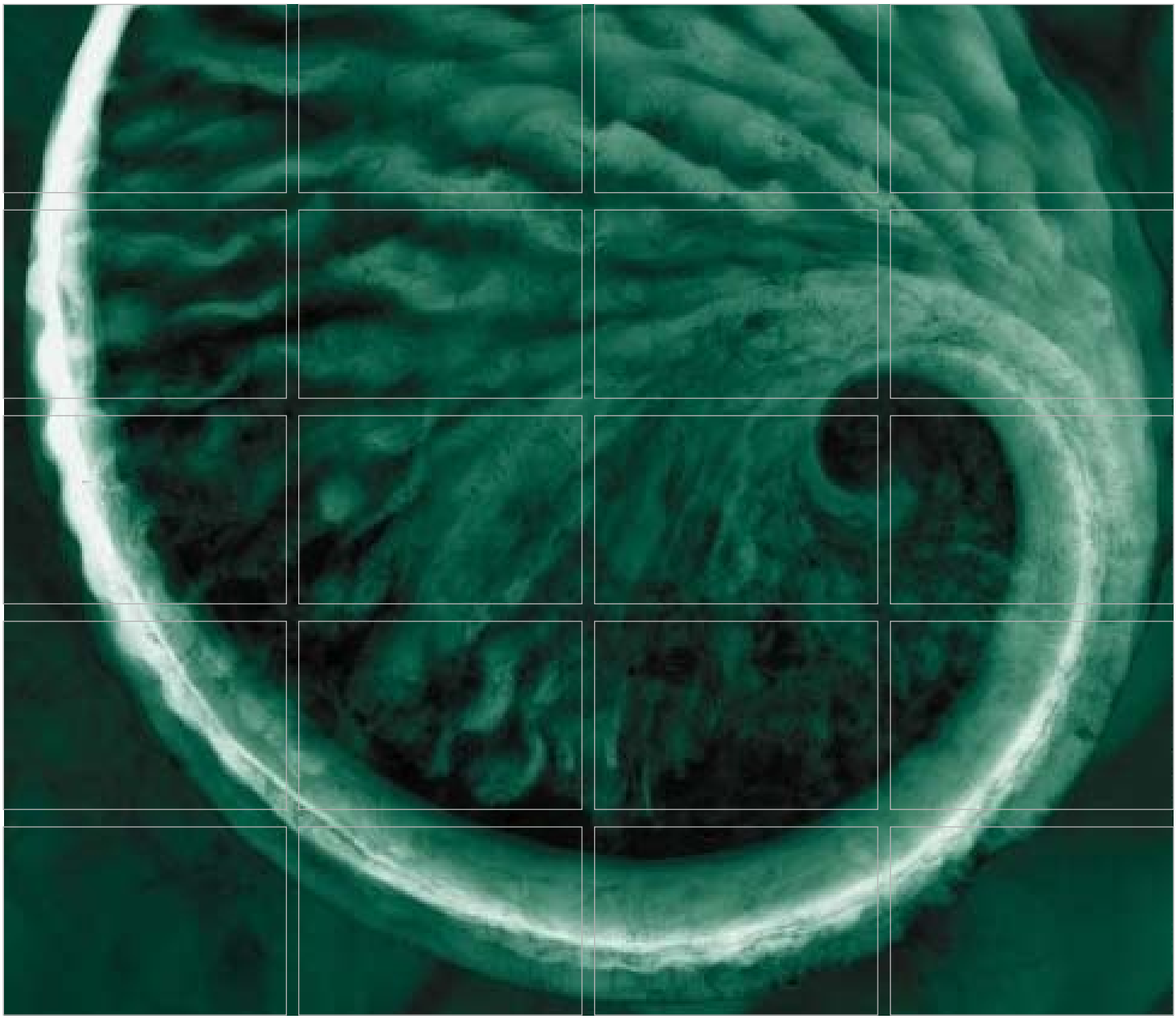

2006 Wetland Restoration Monitoring Report

Raytheon Company

Former Raytheon Facility
430 Boston Post Road
Wayland, Massachusetts

USACE Permit No. 200300294
MADEP File No. 322-533

15 December 2006

ERM

Delivering sustainable solutions in a more competitive world

FINAL REPORT

Raytheon Company

2006 Wetland Restoration Monitoring Report

430 Boston Post Road

Wayland, Massachusetts

15 December 2006

USACE File #200300294

DEP File #322-553

ERM Reference: 0043034

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1.0 PROJECT OVERVIEW

Environmental Resources Management (ERM) has prepared this 2006 Wetland Restoration Monitoring Report to present third-year monitoring results for the wetland remediation site at the Former Raytheon Facility at 430 Boston Post Road in Wayland, Massachusetts (Site; Figure 1). This report is prepared in accordance with the 3 August 2006 regulatory guidance letter by the U.S. Army Corps of Engineers (USACE) entitled, "Minimum Monitoring Requirements for Compensatory Mitigation Projects Involving the Creation, Restoration, and/or Enhancement of Aquatic Resources." (USACE; 2006) It also meets the applicable permit condition requirements of the USACE, the Massachusetts Department of Environmental Protection (DEP), and the Wayland Conservation Commission (Commission). Project information is listed below.

USACE Permit No.: 200300294
DEP and Wayland Order of Conditions File No.: 322-553
Permittee: Raytheon Company, 880 Technology Park Drive, Billerica, MA
Consultant: ERM, Attn: John Drobinski, 399 Boylston Street, 6th Floor, Boston, MA
Telephone: 617-646-7800
Date Wetland Restoration Complete: 24 February 2003
Wetland Monitoring Dates: 16 May 2006, 18 August 2006, 6 October 2006
Inspected by: Ann McMenemy and Philip London (ERM)
Site Directions: Route 20 West (Boston Post Road) from Interstate 95/Route 128 (Exit 26)

This project involved restoring the approximately two-acre remediation area by re-establishing the hydrology, topography, and the emergent marsh community disturbed by the excavation and removal of contaminated soils in 2003 and 2004. Site activities in 2006 have included three wetland monitoring events, invasive species management control work, and planting additional buttonbush (*Cephalanthus occidentalis*). The third-year monitoring results by ERM reveal that the remediation area has not achieved several of the Commission's permit requirements due to the further colonization of barnyard grass (*Echinochloa crusgalli*) and revegetation issues. The 2005 annual monitoring report concluded that all of the standards for success required by the USACE were met within two growing seasons, except for 75 percent survivorship of herbaceous plants installed in 2003 (Woodlot, 2005). Raytheon is currently evaluating additional restoration activities for the wetland remediation area to meet the project's permit conditions and standards of success.

2.0 REQUIREMENTS

Special Condition No. 5 of the USACE Section 404 Permit requires that mitigation be performed in accordance with the project's *Regulatory Permit Application for Wetland Impacts Resulting from Remediation of Oils, Hazardous Materials in Sudbury River Floodplain Wetlands, Wayland, Massachusetts* (Plan; ERM, 2003). The goal of the Plan is to produce an emergent marsh community with native herbaceous species consistent with the conditions historically found in the Sudbury River floodplain. The presence of exotic and invasive species is to be minimized.

The standards for success were established in the Plan to ensure that the project can be objectively evaluated to determine if it is developing into the desired resource type and providing the expected functions. The following table identifies which standards of the Plan and additional permit requirements in the Wayland Order of Conditions (OOC) have been met based on the results of the 2006 monitoring results.

Parameter	**Standards for Success**	**Achieved**
Hydrology	Final grading of the remediation project area must be consistent with the original contours.	Yes
Soils	The soils used for restoration shall be a mixture of sand, loam, silt, and clay and 12% organic matter.	Yes
Vegetation	1. *Percent areal cover*: The remediation project area must attain at least 75% areal cover of native, non-invasive species within two growing seasons. The OOC also requires 90% or more areal coverage of wetland vegetation for three consecutive growing seasons. 2. *Survivorship of Planted Stock*: The herbaceous plantings have a 75% survival; planted buttonbush shrubs have an 80% survival within two growing seasons. The OOC also requires 100% survival of the buttonbush for three consecutive growing seasons. 3. *Invasive species*: To be controlled with reasonable measures. 4. *Erosion control*: All slopes within and adjacent to the mitigation sites are stabilized.	Yes No No; Yes No Yes Yes
Wildlife Use	Wetland and aquatic-dependant species must utilize the site.	Yes

3.0 SUMMARY DATA

ERM wetland and soil scientists conducted wetland monitoring on 16 May, 18 August, and 6 October during the 2006 growing season. Wetland monitoring involved collecting data on vegetation, soils, hydrology, and wildlife. Data collection was consistent with the methodology used by Woodlot Alternatives, Inc. (Woodlot) during the 2004 and 2005 monitoring events (Woodlot 2004 and 2005).

The figures attached to this report collectively show the location of the compensatory mitigation site relative to other landscape features, its boundaries, habitat types, locations of photographic reference points, sampling data points, and other features pertinent to the mitigation plan. The locations of the photographs are depicted on Figure 3.

3.1 HYDROLOGY

Pre- and post-remediation topographic elevations were previously surveyed and found to be consistent with the original contours (Woodlot 2004). Based on field observations, hydrologic conditions range from shallow inundation to seasonal saturation depending on the season and location within the remediation project area. In May 2006, ERM observed a majority of the remediation area inundated with 12 to 18 inches of standing water (Photograph 1). In August and October 2006, the flood waters of the Sudbury River had subsided, and surface saturation was observed throughout the remediation area, except for several small pockets of standing water and about four to six inches of flowing water in the swale.

3.2 SOILS

On 6 October 2006, ERM augured three holes to a depth of 30 to 35 inches to document the soil characteristics, including texture, organic content, soil layers, Munsell matrix colors, and Munsell redoximorphoric colors, size, and abundances of depletions and concentrations. The soil boring locations are shown on Figure 3; descriptions can be found in Table 1.

The soil profile descriptions show the constructed soil surface layers ranging from 22 inches or greater in depth and consisting of sandy loam and fine sandy loam textures high in organic matter content. The wetland soils of the remediation area were manufactured off site by Agro-source,

Inc. to ensure the proper organic matter content and textures consistent with the composition of floodplain soils (ERM; 2003). These soils are too young to display hydric soil morphology. However, the frequently flooded nature of these soils for a long duration during the growing season is consistent with the definition of a hydric soil (New England Hydric Soils Technical Committee; 2004).

3.3 VEGETATION

3.3.1 Areal Vegetative Cover

On 18 August 2006, ERM collected vegetation data using 25 one-meter square plots. The plots were randomly spaced throughout Areas A, B and C of the remediation area (Figure 2). Data collected in each plot included a list of species present, estimated percent areal cover by species, and percent areal cover of bare ground and water for each plot. The data was tabulated and averaged across the plots (see Table 2 for results).

The 25 data plots, when extrapolated to the entire site, yield the following results with respect to areal coverage: 51 percent coverage by non-invasive wetland vegetation, 28 percent coverage by invasive species, and 21 percent coverage of bare ground. The 2005 annual monitoring results indicated that the remediation project area had attained 75 percent areal cover of native, non-invasive wetland species within two growing seasons, thereby meeting the USACE-defined success standard for percent areal coverage (Woodlot; 2005). The difference between the 2005 and 2006 data can be attributed to a change in the distribution of the randomly-spaced plots and the further spread of barnyard grass. The 2005 monitoring report also indicated that invasive plants, including cattails (*Typha spp.)*, purple loosestrife (*Lythrum salicaria*), and barnyard grass, averaged about 20 percent of the areal coverage; while ERM's 2006 results show this coverage increasing to about 28 percent.

3.3.2 Planted Stock Survivorship

The data collected on 18 August 2006 suggests that the survivorship of planted herbaceous stock remains less than 75 percent. The 18 August 2006 monitoring procedures included meander surveys to identify plants present in the remediation area but not recorded in the 25 vegetation plots (Table 3). The results of the data plots and meander surveys reveal that only 11 of the 19 wetland plant species installed in 2003 remain. Rice-cut grass (*Leeria oryoides*) had the highest areal coverage of this group, averaging about 23 percent. Plant species installed in 2003, but not observed during the 2006 surveys, include northern blue flag (*Iris*

veriscolor), cardinal flower (*Lobelia cardinalis*), and marsh fern (*Thelypteris palustris*). These species alone account for approximately 25,000 of the 65,100 or 38 percent of the total plants that were originally planted.

The Commission requires the survival of 25 planted buttonbush for three consecutive growing seasons. These shrubs were planted in the northern portion of Area C, generally along the intermittent swale. The 18 August 2006 survey found 14 of the 25 buttonbush remaining in thriving condition. On 5 September 2006, ERM planted 11 additional buttonbush in the same general area. The shrubs were 3 to 4 feet tall and purchased from Garden in the Woods, a nursery located in Framingham, Massachusetts.

3.3.3 Invasive Species

ERM conducted invasive species control measures on 5, 11, and 12 September 2006 for purple loosestrife and barnyard grass, which continued the maintenance practices conducted during the 2005 growing season. Purple loosestrife seed heads were cut in and around the entire remediation area, collected in plastic bags, and then disposed of off site. The barnyard grass seed heads were cut to the ground in Area C to reduce the possibility of this seed being carried by wind to southern portions of Area C.

On 6 October 2006, ERM classified the vegetative composition of the remediation area into five categories based on wetland classification and dominance of invasive species, and then field estimated the areal extent of each category (Figure 3). This mapping was done to provide a better understanding of the distribution of invasive species at the Site. Based on this mapping, it is estimated that barnyard grass comprises 25 percent or more of the vegetative composition in about 60 percent of the remediation area. Cattail and purple loosestrife are encroaching into the remediation area from adjacent areas outside of the project area; however, neither is dominant in any project location. Common reed (*Phragmites australis*) is not present in the remediation area.

3.3.4 Erosion

The upland areas disturbed during the remediation project have been reclaimed and planted with upland trees and shrubs, and seeded with an erosion control seed mix. The 2005 annual monitoring report indicated that the survival of upland trees and shrubs was approximately 94 percent, including site access areas and the area along the edge of the embankment leading to the wetland floodplain (Woodlot; 2005). ERM's 2006 monitoring work confirms that the upland plantings have a high

degree of survival, and that no associated erosion problems exist in the remediation area.

3.4 WILDLIFE USE

Wildlife observations in the remediation project area are presented in Table 4. Wetland-dependent species observed during the 2006 monitoring work include Red-winged Blackbird (*Agelaius phoeniceus*), Great Blue Heron (*Ardea herodias*), and Green Frog (*Rana clamitans*). On 18 August 2006, ERM observed an approximately 10-inch long fish in the impoundment at outfall OF-2. The wildlife sightings confirm that the remediation area is meeting its success standard of supporting wetland and aquatic-dependent species.

4.0 CONCLUSIONS

The monitoring data collected in 2006 indicate that the wetland remediation project is not meeting the standard for success for areal coverage of native, non-invasive species, and the survivorship of planted stock. These deficiencies can largely can be attributed to the further colonization of barnyard grass throughout the remediation area. Barnyard grass is a summer annual grass that has a Facultative Upland indicator status, therefore, besides being an invasive plant, it is also not a wetland plant. This grass can be controlled over time through early season cutting/mowing; however, the continued cutting of barnyard grass will likely take years to show progress in portions of the remediation area where it dominates, as viable seeds are already present in the soil in great quantities. This situation is demonstrated by the further colonization of this species from past growing seasons.

Consistent with the 2003 Plan and Special Condition 69 of the Commission's OOC, restoration activities will be evaluated to determine the best alternative to meet the standards for success. Special Condition 69 requires the development of a formal restoration plan for the Commission's approval if the restoration work is not successful after three growing seasons.

5.0 REFERENCES

Environmental Resources Management. 2003. "Regulatory Permit Application for Wetland Impacts Resulting from Remediation of Oils, Hazardous Materials in Sudbury River Floodplain Wetlands, Wayland, Massachusetts," 6 February 2003.

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Woodlot Alternatives, Inc. 2004. "The Wetland Remediation Site at the Former Raytheon Facility, Wayland, Massachusetts, 2004 Wetland Restoration Monitoring Report," December 2004.

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Tables

Table 1
Soil Profile Descriptions
Former Raytheon Facility
Wayland, Massachusetts

Test Pit Designation	Depth	Horizon	Color	Texture	Redoximorphic Features		Depth to Saturation	Depth to Groundwater	Comments
					Color	Size			
1	0"-35"	AC	10YR 2/1	Sandy Loam	-	-	Surface	6"	1-5% gravels; 5Y 5/1 silt deposits.
2	0"-35"	AC	10YR 2/1	Sandy Loam	-	-	Surface	Surface	1-5% gravels.
3	0"-22"	AC	2.5Y 2.5/1	Fine Loamy Sand	-	-	Surface	Surface	
	22"-23"	Cg	2.5Y 5/2	Loamy Fine Sand	-	-			Original alluvial sand lens.
	23"-30'+	Oab	10YR 2/1	Sapric	-	-			Original layer.

Notes:
"Original" indicates soils that were not disturbed by the remedial excavation.
All data collected by ERM on 18 August 2006.

Table 2
Summary of Random Vegetation Plot Surveys
Former Raytheon Facility
Wayland, Massachusetts

Plant Species	Common Name	Origin	Wetland Indicator Status	Area C Plots																		Area B Plots			Area A Plots		Species Occurrence In Plots	Total Cover In Plots (%)	Average Cover Per Plot (%)
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25			
Acorus americanus	Sweet flag	V	OBL																			30		25		5			3	60	2.4
Alisma plantago-aquatica var. parviflorum	Lesser water-plantain	P	OBL							20	2																		2	22	0.9
Bidens cernua	Nodding bur-marigold	S	OBL	3	5	5	3	1					3			1				1		10	T						9	32	1.3
Carex/Scirpus	Sedge	V	FACW												3														1	3	0.1
Cephalanthus occidentalis	Buttonbush	P	OBL																T										1	0	0
Cyperus eragrostis	Umbrella sedge	V	OBL	3	7	5	2						5				15	5		15	5	10	25					15	12	112	4.5
Digitaria sp.	Crabgrass	V	UPL																T										1	0	0.0
Echinocloa crus-galli	Barnyard grass	V	FACU	3	3	5	10	15	15	10		3	80	5	10	85	45	55	5	22	50	30	40	10		95			21	596	23.8
Eleocharis obtusa	Spike rush	P	OBL									3			T	1	1			1								5	5	11	0.4
Leersia oryzoides	Rice cut-grass	P	OBL	75	50	78	75	40		15	3	3		90			30	40		60	5				10				14	574	23.0
Ludwigia palustris	Water purslane	V	OBL							20	15				T									50				45	5	130	5.2
Lythrum salicaria	Purple loosestrife	V	FACW	10	25			4	5	20	20	3	3	1	T					1	T	5							13	97	3.9
Penthorum sedoides	Ditch stonecrop	V	OBL		10				30										T										3	40	1.6
Polygonum sp.	Smartweed	P	FACW																								5		1	5	0.2
Polygonum coccineum	Water smartweed	P	OBL						5																				1	5	0.2
Polygonum lupathifolium	Willow-weed	V	FACW+										1																1	1	0
Polygonum persicaria	Lady's thumb	V	FACW																		T							1	2	1	0
Sagittaria latifolia	Common arrowhead	P	OBL						25		15										5								3	45	1.8
Salix nigra	Black willow	V	FACW+							10																			1	10	0.4
Scirpus atrovirens	Black bulrush	V	OBL			7																							1	7	0.3
Scirpus tabernaemontanii	Soft-stemmed bulrush	P	OBL				5					3																	2	8	0.3
Sium suave	Water-parsnip	V	OBL				5															15			90				3	110	4.4
Sparganium americana	Bur-weed	V	OBL							5	25								25										3	55	2.2
Typha xglauca	Hybrid cattail	V	OBL																									7	1	7	0.3
Vegetative forb	Various	S and/or V	N/A									2			T												30	10	4	42	1.7
Thatch/bare ground				6	0	0	0	40	20	0	20	83	8	4	87	13	9	0	70	0	35	15	20	15	0	0	65	17	-	527	21.1
Saturated to surface				Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No			
Standing Water (inches)				0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Total % Vegetative Cover for Plot				**94**	**100**	**100**	**100**	**60**	**80**	**100**	**80**	**17**	**92**	**96**	**13**	**87**	**91**	**100**	**30**	**100**	**65**	**85**	**80**	**85**	**100**	**100**	**35**	**83**			***79***
Total % Hydrophytic (Non-invasive) Cover for Plot [1]				81	72	95	90	41	60	70	60	11	9	90	3	2	46	45	25	77	15	50	40	75	100	5	35	76			***51***
Total % Invasive Species Cover for Plot				13	28	5	10	19	20	30	20	6	83	6	10	85	45	55	5	23	50	35	40	10	0	95	0	7			***28***

Notes:
P = Planted.
S = Seeded.
V = Volunteer.
UPL = Obligate upland species, < 1% occurrence in wetlands.
FACU = Facultative upland, 1-33% occurrence in wetlands.
FAC = Facultative, 34-66% occurrence in wetlands.
FACW = Facultative wetland, 67-99% occurrence in wetlands.
FACW+ = Facultative wetland, greater occurrence than FACW.
OBL = Obligate wetland, greater than 99% occurrence in wetlands.
T = Species occurs in trace amounts.
1 = Excludes barnyard grass, purple loosestrife, and cattail.

Table 3
Summary of Plant Meander Surveys
Former Raytheon Facility
Wayland, Massachusetts

Plant Species	Common Name	Origin	Wetland Indicator Status
Acer rubrum	Red maple	V	FAC
Bidens frondosa	Beggars-tick	V	FACW
Carex lupulina	Hop-sedge	V	OBL
Eupatorium perfoliatum	Boneset	S	FACW+
Lemna gibba	Duckweed	V	OBL
Pontederia cordata	Pickerel weed	P	OBL

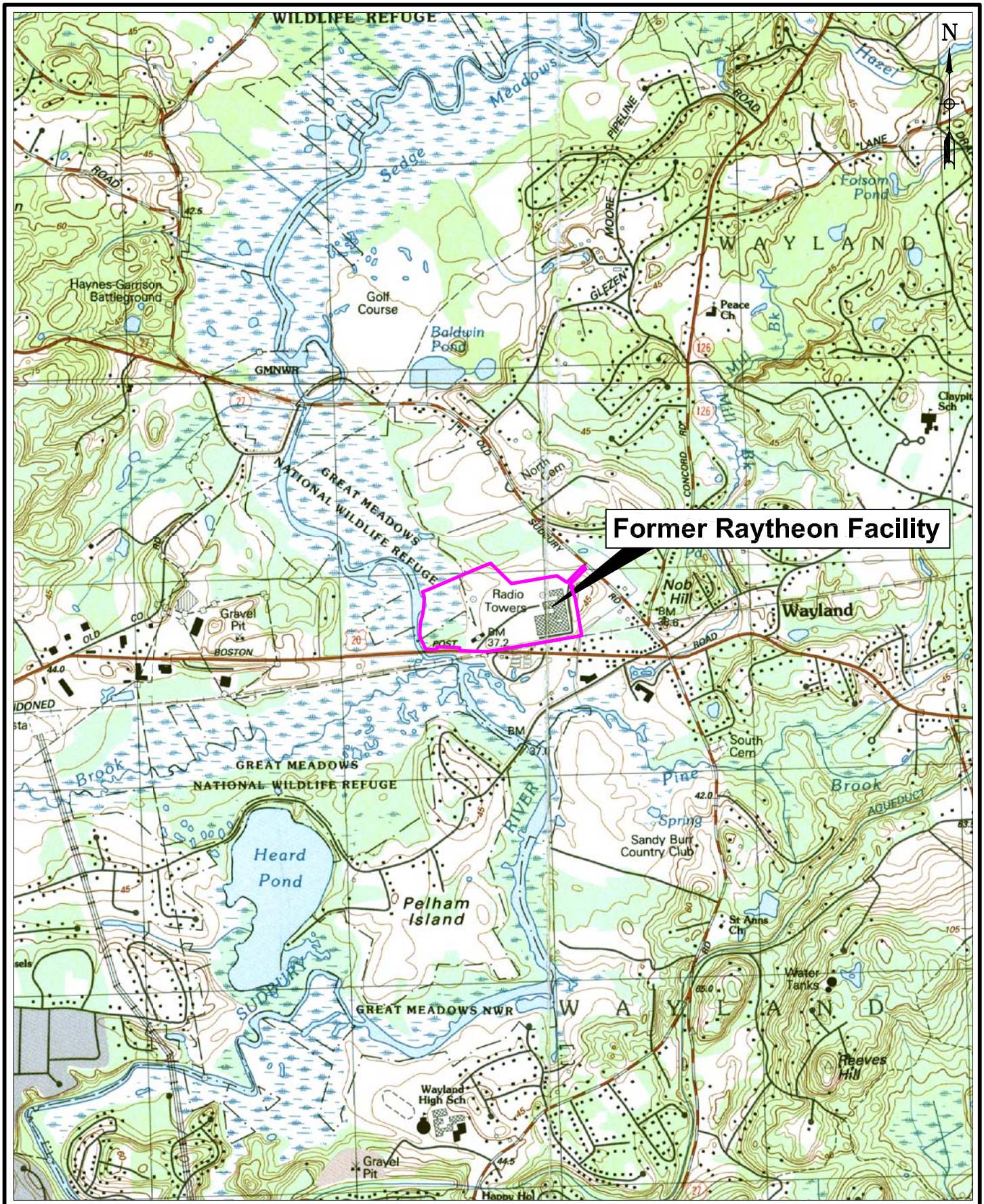
Notes:
P = Planted.
S = Seeded.
V = Volunteer.
FAC = Facultative, 34-36% occurrence in wetlands.
FACW = Facultative wetland, 67-99% occurrence in wetlands.
FACW+ = Facultative wetland, greater occurrence than FACW.
OBL = Obligate wetland, greater than 99% occurrence in wetlands.
All data collected by ERM on 18 August 2006.

Table 4
Summary of Wildlife Observations On and Adjacent to Site
Former Raytheon Facility
Wayland, Massachusetts

SCIENTIFIC NAME	COMMON NAME
Amphibians and Reptiles	
Rana clamitans	Green frog
Birds	
Agelaius phoeninceus	Red-winged blackbird
Anas platyrhynchos	Mallard
Anas rubripes	Black duck
Ardea herodias	Great blue heron
Buteo jamaicensis	Red-tailed hawk
Cardinalis cardinalis	Northern cardinal
Charadrius vociferous	Killdeer
Colaptes autetus	Northern flicker
Cyanocitta cristata	Blue jay
Dendroica petechia	Yellow warbler
Dumetella carolinensis	Gray catbird
Egretta thula	Snowy egret
Melospiza Georgiana	Swamp sparrow
Melospiza melodia	Song sparrow
Molothrus ater	Brown-headed cowbird
Quiscalus quiscala	Common grackle
Tachycineat bicolor	Tree swallow
Zenadia marcoura	Mourning dove
Mammals	
Odocoileus virginianus	White-tailed deer
Procyon lotor	Raccoon
Sciurus carolinensis	Gray squirrel
Sylvilagus floridanus	Eastern cottontail
Insects	
Enallagma signatum	Orange blue damselfly
Melanoplus sp.	Grasshopper
Sympetrum internum	Ruby meadowhawk
Vanessa cardui	Painted lady butterfly
Fish	
Ameiurus catus (or similar species)	White catfish

Notes:
All data collected by ERM on 18 August 2006.

Figures



Scale 1:25,000

0.5 km 0 500 m

0.5 mi 0 1,000 ft

Legend

Subject Property Line

Figure 1 - Site Locus Map
Former Raytheon Facility - Wayland, MA

ERM

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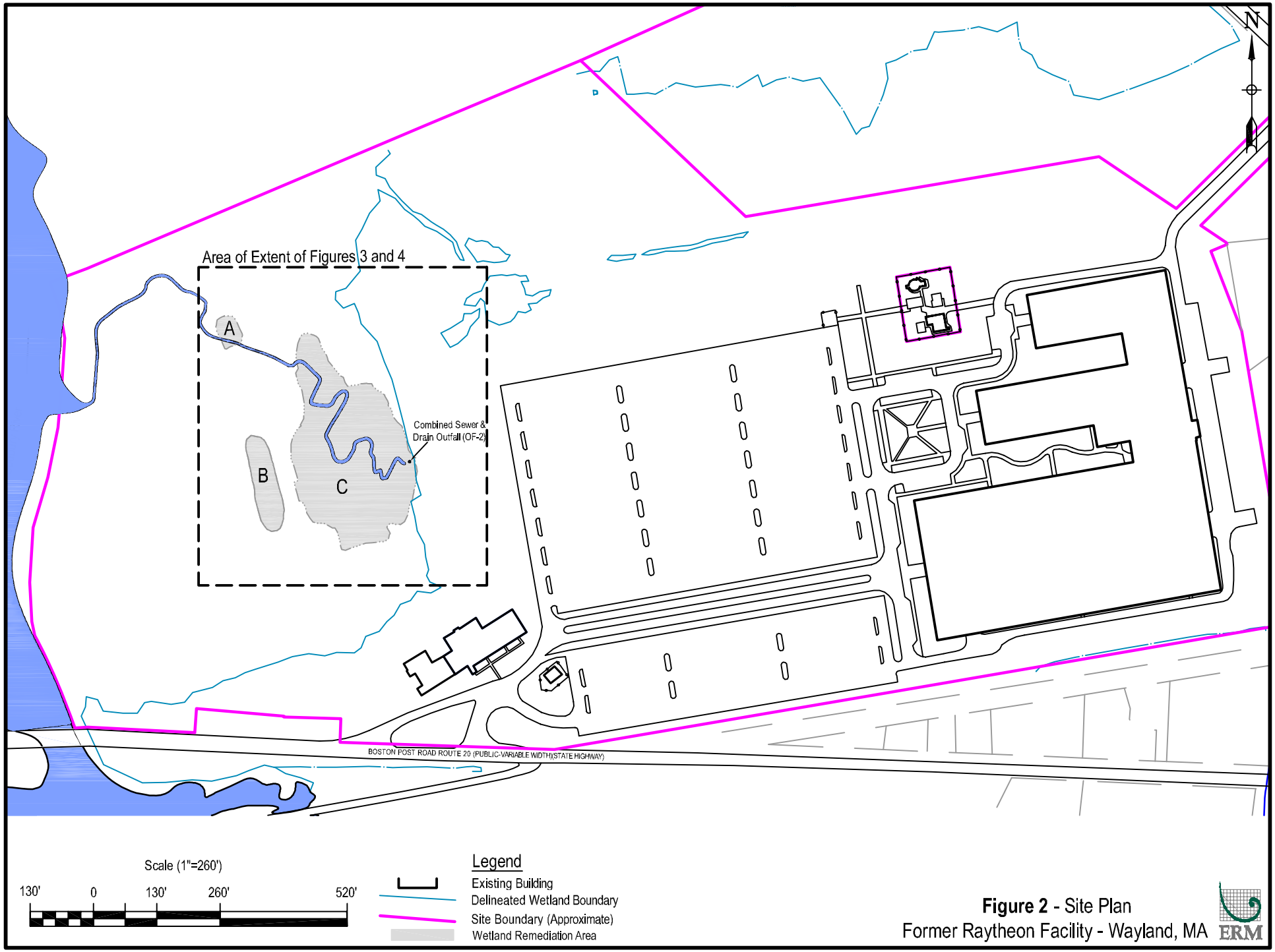

Figure 2 - Site Plan
Former Raytheon Facility - Wayland, MA

ERM

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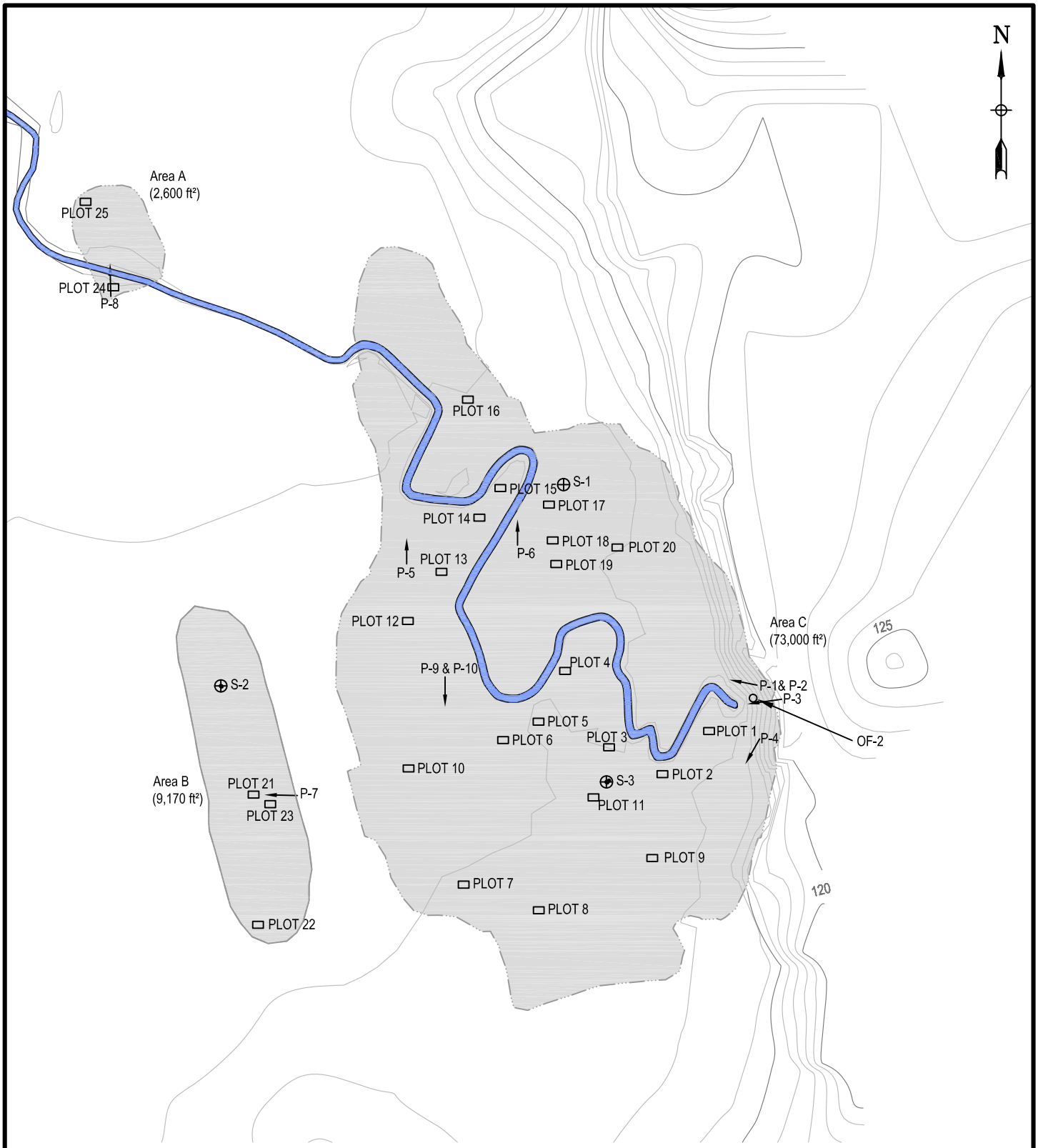

Figure 3 - Wetland Assessment Locations
Former Raytheon Facility - Wayland, MA

ERM

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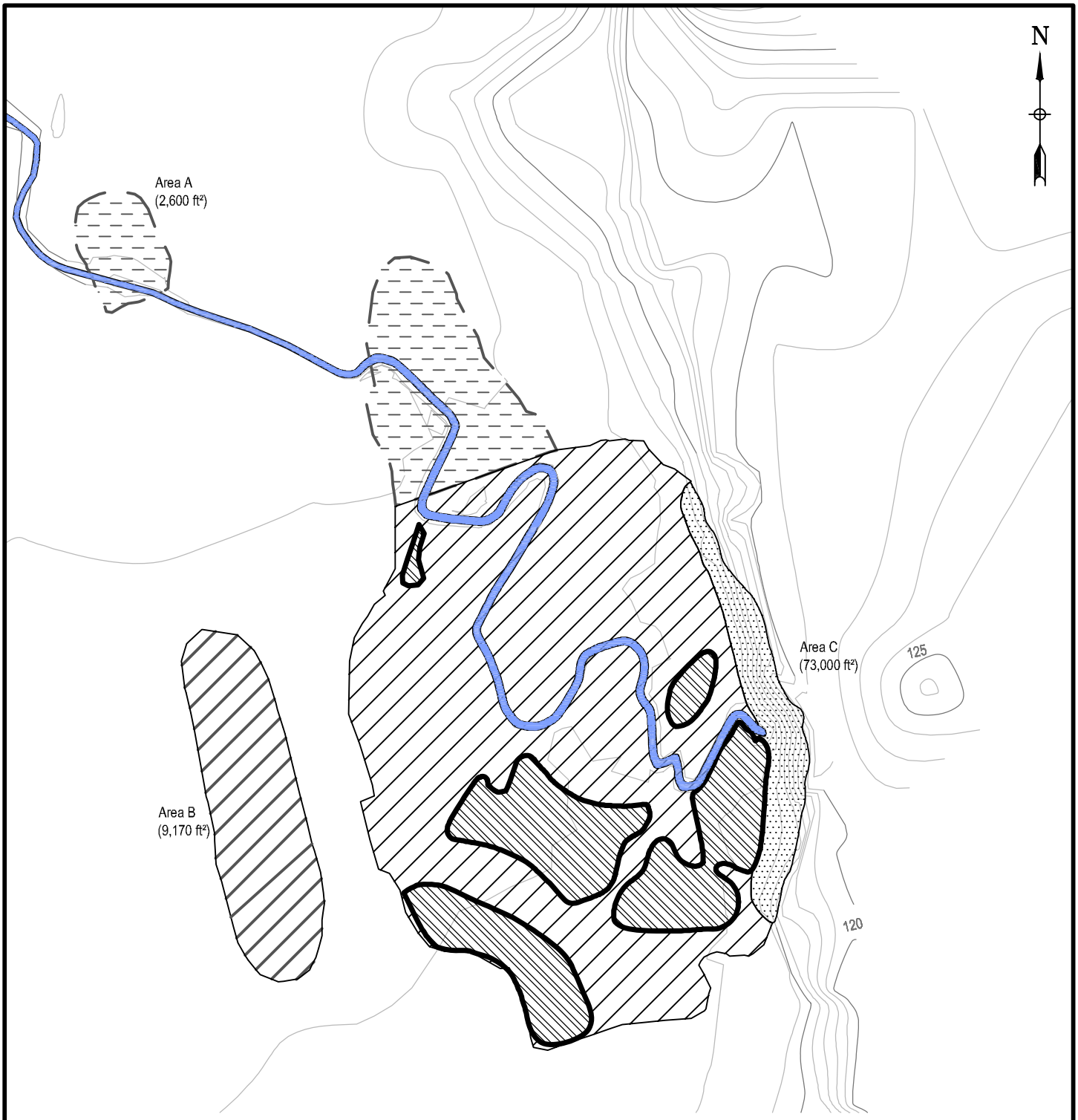

Legend

- Stream Habitat (Includes Non -Invasive Vegetative Communities in Stream Channel) - 2,935 SQ.FT.
- Wetland Communities: Less Than 25% Aeral Coverage of Invasive Species (Barnyard Grass/Cattail) - 14,425 SQ.FT
- Wetland Communities: 25%-75% Aeral Coverage of Invasive Species (Barnyard Grass) - 11,550 SQ.FT
- Wetland Communities: Over 75% Aeral Coverage of Invasive Species (Barnyard Grass) - 51,210 SQ.FT
- Upland Communities: Less Than 25% Aeral Coverage of Invasive Species - 4,650 SQ.FT.
- 5' Topographic Contour
- 1' Topographic Contour

Notes:

1. Vegetative Communities were Field Estimated by ERM on 10-06-06.
2. Stream Segment in Area A is Vegetated.
3. ft² = square feet

Scale (1"=80')

40' 0 40' 80' 160'

Figure 4 - Invasive Species Mapping
Former Raytheon Facility - Wayland, MA

ERM

R:\Raytheon\Wayland - 1922\raytheon wetlands\Fig 2 Site Map.dwg (12/05/2006 - 11:08am Boston)

Appendix A
Photographs

Photograph 1 – Area C looking northwest from culvert (5/16/06).

Photograph 2 – Area C looking northwest from culvert (8/18/06).

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Photograph 3 – Area C looking west from culvert (8/18/06).

Photograph 4 – Area C looking southwest from culvert (8/18/06).

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Photograph 5 – Northern extent of Area C and stream channel (8/18/06).

Photograph 6 – Central portion of Area C looking southwest along stream channel (8/18/06).

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Photograph 7 – Vegetation Plot 21 in Area B (8/18/06).

Photograph 8 – View of Area A looking north across stream channel (8/18/06).

Photograph 9 – View of south-central portion of Area C, where barnyard grass is dominating vegetative cover (8/18/06).

Photograph 10 – Similar view as Photograph 9 taken on 10/6/06.

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