Inventory and Analysis of Tidal Wetlands

Prepared for
New Hampshire Coastal Program

Prepared by
Normandeau Associates, Inc.

October 2007

INVENTORY AND ANALYSIS OF TIDAL WETLANDS

Prepared for
NEW HAMPSHIRE COASTAL PROGRAM
Office of State Planning and Energy Programs
152 Court Street, Suite 1
Portsmouth, NH 03801

Prepared by
NORMANDEAU ASSOCIATES, INC.
25 Nashua Road
Bedford, NH 03110

R-19853.000

October 2007

TABLE OF CONTENTS

PAGE

INTRODUCTION **1**

METHODS **1**

DELINEATION 1
2004 POSITIONAL ACCURACY 2
MAP COMPARISONS 2

RESULTS AND DISCUSSION **6**

DELINEATION NOTES AND OBSERVATIONS 6
2004 POSITIONAL ACCURACY 7
MAP COMPARISONS 7

List of Figures

Page

Figure 1. Examples of GPS continuous stream data (yellow lines) overlain on 2004 cover type map. We used the Phragmites patch (in red) and the bridge point at bottom of page for positional analysis. The lines in the center indicate areas of salt marsh dieback. 3

Figure 2. An example of differences in ground (yellow) and aerial (blue) cover type definitions. The patch shown is a Phragmites stand (not used in the positional accuracy analysis). 4

Figure 3. An example of the point selection process at Site D on the Squamscott River. The middle 3 points were used in the positional accuracy analysis. 5

List of Tables

Page

Table 1. National Standard for Spatial Data Accuracy test to assess horizontal positional accuracy of the 2004 NHCP coastal wetland map. Units are in feet. 8

Table 2. Results (in acres) of cover type discrepancies >5.0 acres between JEL/NWI and 2004 maps. 10

INTRODUCTION

Normandeau Associates Inc was contracted by NH Coastal Program (NHCP) to prepare a set of digital maps of tidally-influenced wetlands in New Hampshire. The maps delineated emergent tidal wetlands within the coastal zone of NH, including the Atlantic coastline from the Massachusetts to the Maine border, the NH side of the Piscataqua River, Great Bay and its tributaries up to the head of tide, and the NH Isles of Shoals. The GIS metadata for the maps describe the specifics of the cover type categories employed, but in general they are based on the US Fish and Wildlife's wetland classification system developed by Cowardin et al. in 1979. The purpose of the project was to map all emergent tidal wetlands, with an emphasis on the invasive Phragmites (*Phragmites australis*) and purple loosestrife (*Lythrum salicaria*). Cattail (*Typha angustifolia* and occasionally *T. latifolia*) were delineated in large stands. Because of the brackish nature of these species and the salinity gradients in the study area, no attempt was made to determine whether they were Palustrine or Estuarine; they were simply recorded by species.

A second phase of the study was to evaluate discrepancies between three sets of coastal wetland maps: National Wetland Inventory (NWI; photos dated 1985-86), Great Bay wetlands mapped by UNH's Jackson Estuarine Laboratory (JEL; photos dated 1990-92), and Normandeau Coastal Mapping (photos dated 2004). The overarching interest was to determine the extent of change in salt marsh acreage over the 19-year period. A preliminary assessment performed by P. Trowbridge at NH Estuaries Program (NHEP) identified a 14% decline in salt marsh acreage between the merged early maps and the 2004 Normandeau maps, however the details indicated that mapping protocols may account for a portion of the discrepancies. New Hampshire Coastal Program (NHCP) requested that Normandeau perform two tasks: 1) assess the accuracy of the 2004 map (positional accuracy), and 2) to assess and refine discrepancies between the three map sets. This report provides a summary of the methods used in the mapping process, and analyses of the positional accuracy of the data and potential sources of error among the current map and two of its predecessors.

METHODS

DELINEATION

The current mapping effort used aerial photographs flown between August 4 and 9, 2004 by Sewall Co, Old Town, ME. The aerials are true-color positive transparencies, have a scale of 1:9600, and were flown during the lower half of the tide cycle. The transparencies are generally very high quality, although in some cases, the photos were taken early or late enough in the day that shadows prohibit detection of vegetation near the tree line. The delineations were made on acetate overlays, which were then scanned, rubber-sheeted to fit 2003 orthophotos of the area, digitized, and analyzed using ArcView 9.1. Quality control was implemented at all stages of the process, including almost 100% QC of the photointerpretation, groundtruthing to verify representative cover types, and 100% of the digitizing and edit reviews for all changes in GIS. The QC was documented in hard copy whenever possible. The minimum map unit was typically 0.25 acres, although when smaller features were clearly visible, polygons less than 0.25 acres were created.

2004 POSITIONAL ACCURACY

Normandeau followed a positional accuracy protocol to assess how accurately the 2004 delineated features compare to their actual location. This protocol was developed by the Minnesota Planning Department's Land Management Information Center using the National Standard for Spatial Data Accuracy[1] (NSSDA) to determine positional accuracy within a geographic data set. Normandeau selected 30 polygons from the 2004 map for evaluation. The polygons were selected based on geographic location (Great Bay, major tributaries, and Atlantic coast), and clear field characteristics such as well defined edges, manageable size (0.5-2 acres), and uniform vegetation of *Spartina* sp. or Phragmites. The selected polygons were ground delineated in 2005 by NHCP using sub-meter accuracy GPS. The GPS data for each polygon were mostly provided as a continuous stream of coordinates. In some cases the entire stand was delineated, in others just a portion of the stand was delineated.

Normandeau overlaid the 2005 GPS delineations onto the 2004 photointerpreted boundaries. After review of the maps and NHCP's notes, twelve locations were selected for analysis based on how well defined the field boundary was. Some of the 30 polygons were clearly unsuitable because the GPS boundary delimited a different location or shape, due either to changing ground conditions or different interpretations of vegetation boundaries (Figure 1). Locations that were best suited to comparison were those adjacent to manmade structures such as riprap or a road; had a sharp vegetation change such as some Phragmites stands; or were adjacent to a stable edge of water (some pools). Locations that showed poor overlap were those with changing conditions, such as potential *Spartina* dieback areas or expanding Phragmites stands (Figure 2), or poorly defined boundaries such as shallow pools and accreting shorelines.

The GPS lines for the 12 locations were divided into quarters using GIS. The 3 points marking the quarter breaks on the interior portion of the line were selected as arbitrary points to enter into the positional accuracy analysis (see example in Figure 3). These were considered the most accurate ground assessment and became the "independent" data set against which the 2004 data were compared. The points from the 2004 data set which most closely corresponded to the GPS points were selected for the "test" points in the analysis. In total 36 points were compared which is well above the 20 points required for statistical significance in the NSSDA.

MAP COMPARISONS

Normandeau recreated the NHEP analysis that compared the wetland maps from NWI and JEL and the 2004 study. All parcels >5.0 acre in size that showed discrepancies in cover type or polygon shape between the NWI/JEL data set and the Normandeau maps were selected for further study. All of the 7 parcels in which the NHEP showed Normandeau adding coastal wetland acreage relative to the JEL/NWI maps were evaluated; these ranged in size from 2.1 to 4.5 acres. Using the Normandeau layer, 47 parcels that were dominated by salt marsh, Phragmites, Typha and open water showed discrepancies. For each of 47 polygons, the 2004 condition was verified through reviewing the aerial photographs, and in some cases, ground verification by NHCP. The JEL Color Infrared

---

[1] Minnesota Planning Land Management Information Center. Positional Accuracy Handbook: Using the National Standard for Spatial Data Accuracy to measure and report geographic data quality. October 1999. St. Paul, MN.

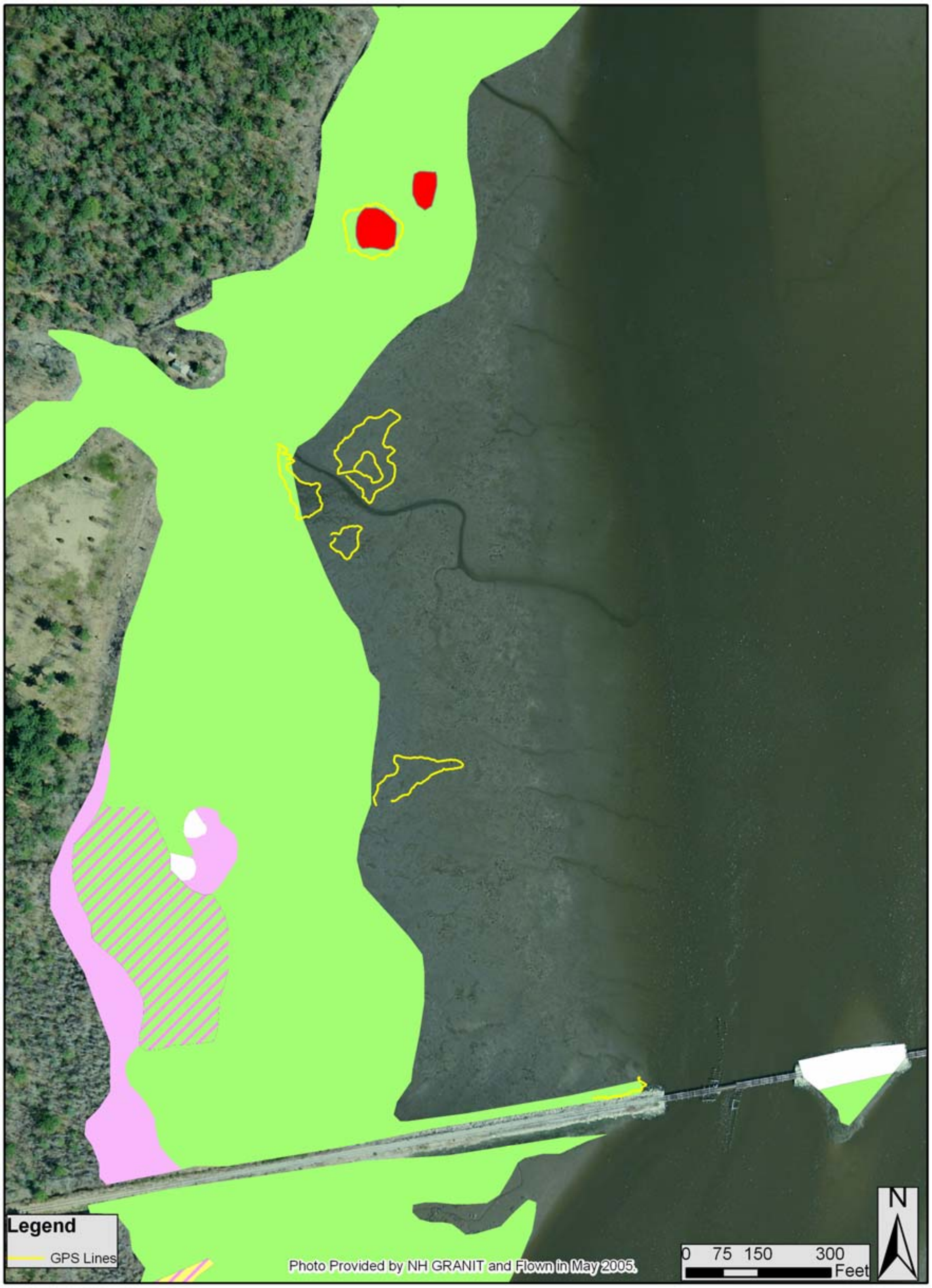

Figure 1. Examples of GPS continuous stream data (yellow lines) overlain on 2004 cover type map. We used the Phragmites patch (in red) and the bridge point at bottom of page for positional analysis. The lines in the center indicate areas of salt marsh dieback.

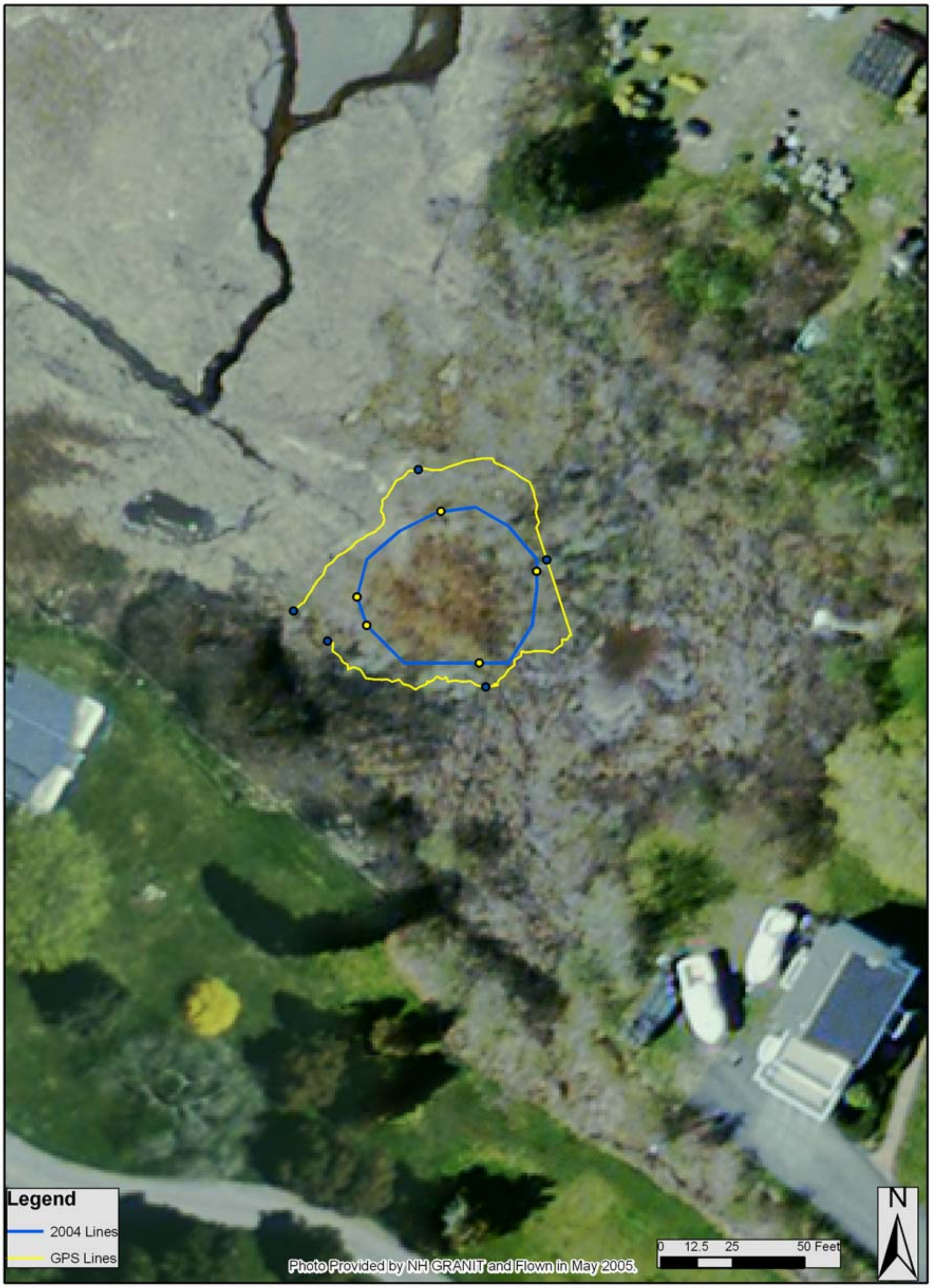

Figure 2. An example of differences in ground (yellow) and aerial (blue) cover type definitions. The patch shown is a Phragmites stand (not used in the positional accuracy analysis).

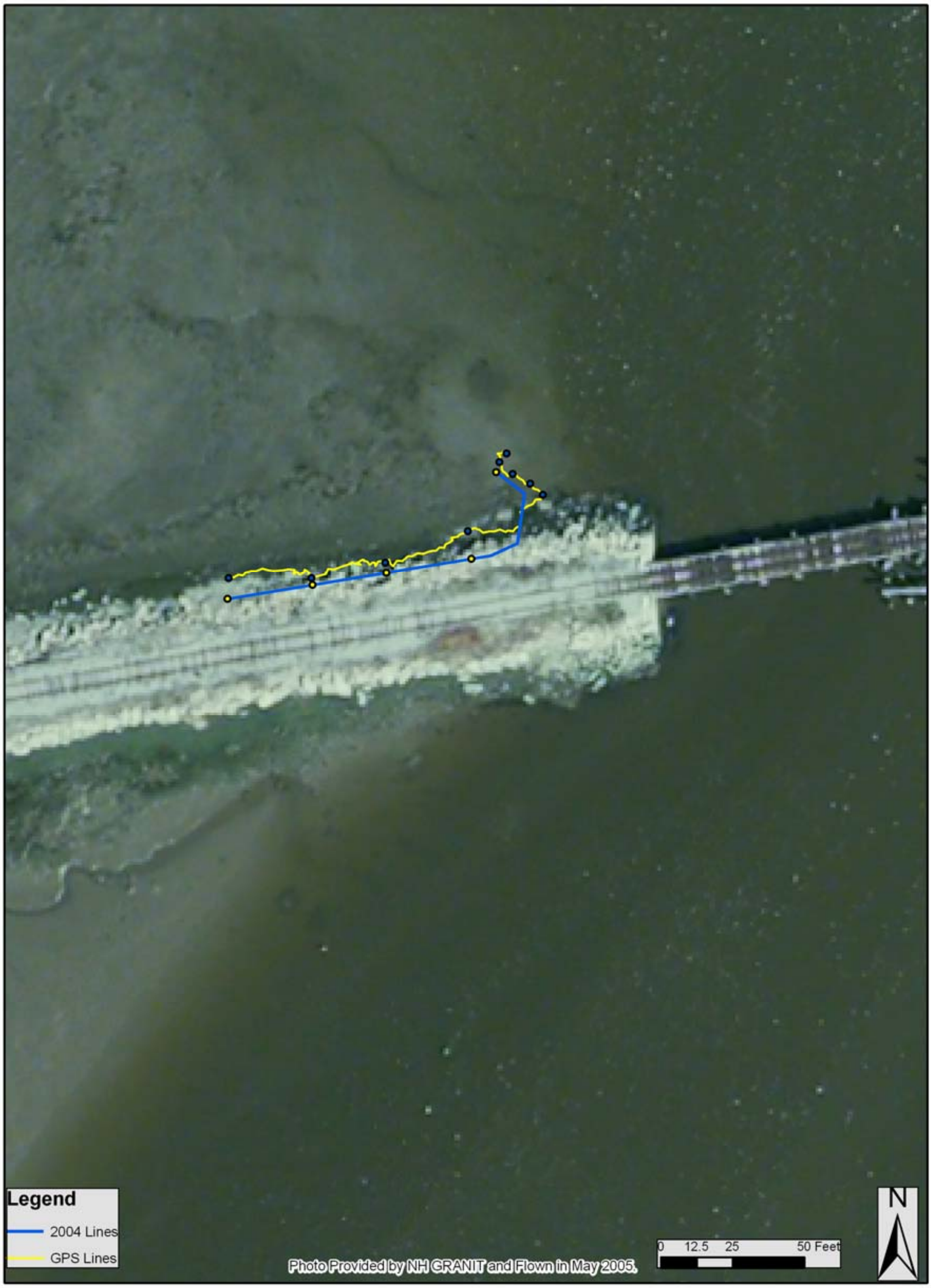

Figure 3. An example of the point selection process at Site D on the Squamscott River. The middle 3 points were used in the positional accuracy analysis.

photos (provided by NHCP) were reviewed for cover type accuracy, and mapping protocol and definitions that could produce discrepancies between the two data sets identified. The NWI maps were similarly reviewed for cover type definitions. A set of mylar orthophotos used in a 1987 mapping effort by Normandeau provided a third photographic reference.

The causes of the cover type differences were categorized according to the source of discrepancy for each polygon as salt marsh gain or loss, transitional, definitional differences, and mapping errors. Salt marsh gain was defined as a change from Brackish in the JEL/NWI maps to salt marsh in 2004. Salt marsh loss was the reverse. Definitional differences included matters of scale, typically including smaller creeks and pools in a larger cover type by NWI. Errors included areas mapped as upland or open water by that were clearly salt marsh after further review. The transitional category describes areas that are currently transitional between salt marsh and brackish/fresh marsh, and may have been that way in the JEL/NWI maps but mapped as salt marsh. If we were unable to determine if a polygon was dominated by transitional vegetation in the older aerial photos and maps, it was labeled "Transition?". In one case, NHEP was missing a piece of an NWI quadrangle; once corrected the discrepancy disappeared (labeled Analytical). For polygons containing 2 or more categories of discrepancies, the acreage of the polygon was split evenly among the categories.

RESULTS AND DISCUSSION

DELINEATION NOTES AND OBSERVATIONS

- Short Phragmites was difficult to distinguish from cattail, especially in small or sparse non-flowering stands. Along Rt 1A, the questionable areas were mostly typed as Phragmites, as supported by groundtruthing. Along the Piscataqua and its tributaries, cattail predominated. Continued groundtruthing will be required to verify those stands.
- Purple loosestrife was not prevalent in intertidal areas, but was more common on drainages leading to the marshes and along roadsides.
- Salt marsh pools and channels were delineated when large and well-defined, as an aid in rubber-sheeting, and generally characterization of the marshes. These delineations are not intended to completely capture all pools and channels.
- Variations in the extent of salt marsh vegetation expanding onto mudflats were evident between 2004 and 2005. For example, *Spartina alterniflora* colonies were plentiful on the deeper tidal flats at the mouth of the Lamprey River in 2004, but groundtruthing in 2005 found few.
- Restoration areas were typed as they occurred in 2004, even though groundtruthing in 2005 indicated more vegetation.
- The emergent areas of Great Bog were delineated to the extent possible. Flightlines 8 and 10 covered the west and east sides, respectively, but a photo gap on Flightline 9 precluded complete coverage. As explanation, Sewall was asked to photograph intertidal areas in the coastal zone and selectively skipped shooting inland areas along some flight lines.

2004 POSITIONAL ACCURACY

The results of the positional accuracy analysis are presented in Table 1. Using the NSSDA, the 2004 coastal wetlands map tested 22.76 feet horizontal accuracy at 95% confidence level. This means that the horizontal position of a well defined feature on this map will be within 22.8 feet of its "true" location, based on the GPS delineation, 95% of the time. For comparison, the horizontal positional accuracy for a typical 1:24,000 US Geological Survey quadrangle is 40 feet.

Several features of the maps are worth discussion, mostly based on some of the 18 polygons not selected. In several Phragmites stands (T, U, and V), the GPS and 2004 lines disagreed by a considerable amount (Figure 3). It is possible that the Phragmites has expanded, or more simply, the on-ground interpretation is different than the aerial. In other Phragmites sites (Sites B, Y and AA), the agreement between the 2 lines was strong. Areas identified as "die-off" (Sites A & C) or accreting (Sites O & P) consistently had poor agreement between the 2 lines (Figure 2), potentially due to a definitional difference between cover types of salt marsh, salt marsh/open water mix, and open water. Another difficult cover type was a set of pools in Hampton Marsh (Site CC). We used this location in the positional analysis but it had one of the highest differences between the independent and test coordinates, in part because the borders of the pool/pannes were not well defined in the aerials, and were probably that way on the ground.

MAP COMPARISONS

The total acreage of the 47 polygons showing discrepancies between the various mapping sources was 356.3, averaging 7.6 acres per polygon with a range of 25.7 to 2.1. When the polygons that had two types of discrepancies were divided into their respective major categories, the primary sources of discrepancy were Transitional (38.2% with both transitional categories combined), Loss (22.6%), Map Error (22.2%) and Definitional (15.4%). Lumping these categories further into a general assessment, more than one-third (38.3%) of the discrepancies can be considered map-related (Analytical, Definitional or map Error). Another 60.8% are either a recent Loss due to erosion, dieback and encroachment by brackish species, or in some cases, brackish Transition zones in both time periods. Only 0.8% could be considered a Gain, and that comes from the Awcommin Marsh restoration.

Table 1. National Standard for Spatial Data Accuracy test to assess horizontal positional accuracy of the 2004 NHCP coastal wetland map. Units are in feet.

		Independent Data		Test Data						
Pt	**Location**	**X (GPS)**	**Y (GPS)**	**X((NAI)**	**Y (NAI)**	**Diff in X**	**Diff in X^2**	**Diff in Y**	**Diff in Y^2**	**Diff in X^2 +Diff in Y^2**
AA1	Hampton aa	1203663.62913	157355.96714	1203663.25038	157355.27277	0.3787	0.1435	0.6944	0.4821	0.6256
AA2		1203688.73453	157357.68547	1203689.34576	157349.44401	-0.6112	0.3736	8.2415	67.9217	68.2953
AA3		1203713.71749	157349.41594	1203713.95381	157350.65499	-0.2363	0.0558	-1.2391	1.5352	1.5911
B1	Squamscott b	1185180.12722	204106.99059	1185168.96259	204106.75736	11.1646	124.6490	0.2332	0.0544	124.7034
B2		1185116.32828	204163.74465	1185116.23617	204158.96008	0.0921	0.0085	4.7846	22.8921	22.9006
B3		1185062.04226	204111.47345	1185082.25462	204112.27723	-20.2124	408.5395	-0.8038	0.6461	409.1856
BB1	Hampton bb	1203500.23642	157338.01552	1203500.37129	157340.11128	-0.1349	0.0182	-2.0958	4.3922	4.4104
BB2		1203483.22653	157340.24654	1203483.32879	157338.62919	-0.1023	0.0105	1.6173	2.6158	2.6263
BB3		1203440.38425	157307.15404	1203440.58643	157306.65208	-0.2022	0.0409	0.5020	0.2520	0.2928
CC1	Hampton cc.1	1202928.14393	156225.54878	1202935.29300	156235.59322	-7.1491	51.1092	-10.0444	100.8908	152.0000
CC2		1202880.43246	156295.04403	1202890.15186	156308.67527	-9.7194	94.4667	-13.6312	185.8107	280.2774
CC3		1202850.33235	156305.33760	1202851.56947	156294.60511	-1.2371	1.5305	10.7325	115.1863	116.7168
D1	Squamscott d	1185663.75081	202311.42119	1185665.02672	202301.77461	-1.2759	1.6279	9.6466	93.0565	94.6845
D2		1185635.09441	202300.33564	1185635.43488	202296.88777	-0.3405	0.1159	3.4479	11.8878	12.0037
D3		1185609.23243	202295.03520	1185609.61299	202292.62351	-0.3806	0.1448	2.4117	5.8162	5.9611
I1	Bellamy i2	1203337.30079	231688.85975	1203329.09663	231702.35329	8.2042	67.3082	-13.4935	182.0756	249.3839
I2		1203312.80667	231682.52972	1203311.20666	231685.93185	1.6000	2.5600	-3.4021	11.5745	14.1345
I3		1203298.67365	231634.93356	1203279.96498	231647.02631	18.7087	350.0143	-12.0927	146.2346	496.2489
K1	Bellamy k2	1203492.78854	236402.58567	1203474.98811	236405.35541	17.8004	316.8553	-2.7697	7.6715	324.5268
K2		1203525.70517	236483.88350	1203518.06984	236489.60378	7.6353	58.2983	-5.7203	32.7216	91.0199
K3		1203557.73608	236524.08222	1203548.08277	236533.21453	9.6533	93.1864	-9.1323	83.3991	176.5855
O1	Winicut o	1204193.96754	202498.48911	1204192.84119	202483.09701	1.1264	1.2687	15.3921	236.9167	238.1854
O2		1204214.69722	202446.92951	1204223.07945	202455.43081	-8.3822	70.2618	-8.5013	72.2721	142.5339
O3		1204256.66976	202394.92351	1204262.30028	202397.96250	-5.6305	31.7028	-3.0390	9.2355	40.9382
Q1	Winicut q	1206405.48353	201944.03090	1206385.43253	201943.42323	20.0510	402.0426	0.6077	0.3693	402.4119
Q2		1206439.00237	201898.93365	1206432.13122	201890.13601	6.8711	47.2127	8.7976	77.3985	124.6112
Q3		1206489.85481	201850.39171	1206480.86784	201839.87094	8.9870	80.7656	10.5208	110.6866	191.4522
R1	Winicut r	1207598.86499	201418.41221	1207598.98509	201390.30827	-0.1201	0.0144	28.1039	789.8314	789.8459
R2		1207545.25278	201407.81087	1207545.54250	201404.92453	-0.2897	0.0839	2.8863	8.3310	8.4149
R3		1207466.37488	201392.40138	1207466.11263	201397.16389	0.2622	0.0688	-4.7625	22.6815	22.7503

(continued)

Table 1. (Continued)

		Independent Data		Test Data						
Pt	**Location**	**X (GPS)**	**Y (GPS)**	**X((NAI)**	**Y (NAI)**	**Diff in X**	**Diff in X^2**	**Diff in Y**	**Diff in Y^2**	**Diff in X^2 +Diff in Y^2**
S1	Hampton s	1223690.99743	171119.43060	1223690.37570	171135.38546	0.6217	0.3865	-15.9549	254.5576	254.9441
S2		1223664.18985	171116.48477	1223663.52184	171132.02830	0.6680	0.4462	-15.5435	241.6013	242.0476
S3		1223637.21225	171115.27812	1223637.10179	171131.34405	0.1105	0.0122	-16.0659	258.1141	258.1263
Y1	Hampton y	1204926.64548	157550.54071	1204928.15206	157556.13757	-1.5066	2.2698	-5.5969	31.3248	33.5946
Y2		1204859.00884	157518.96719	1204857.20559	157542.91078	1.8033	3.2517	-23.9436	573.2955	576.5472
Y3		1204796.83825	157490.84413	1204796.87448	157506.71839	-0.0362	0.0013	-15.8743	251.9921	251.9934

Table 2. Results (in acres) of cover type discrepancies >5.0 acres between JEL/NWI and 2004 maps.

			Breakdown by major category		
Category	**Total (ac)**	**Number of Parcels**	**Acres**	**%**	**General Assessment**
Analytical	2.5	1	2.5	0.7%	38.3%
Defin	20.1	5	54.8	15.4%	
Defin/ Tran?	11.4	2			
Defin/Error	52.6	7			
Error	29.6	4	79.2	22.2%	
Error/ Tran?	46.7	4			
Gain	3.0	1	3.0	0.8%	0.8%
Loss	77.8	9	80.6	22.6%	60.8%
Loss/Defin	5.6	1			
Tran	16.7	3	16.7	4.7%	
Tran?	90.3	10	119.4	33.5%	
Total	356.3	47	356.3	100.0%	100.0%