

**LIBBY RIVER RESTORATION PROJECT  
SCARBOROUGH, MAINE  
THIRD YEAR POST-CONSTRUCTION MONITORING REPORT**



**MAY 2010**

**LIBBY RIVER RESTORATION PROJECT  
SCARBOROUGH, MAINE  
THIRD YEAR POST-CONSTRUCTION MONITORING REPORT**

**Prepared for  
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## **1.0 INTRODUCTION**

The Friends of Scarborough Marsh (FSM) collaborated with several partners including the Maine Department of Transportation (MDOT), Maine Department of Inland Fisheries and Wildlife (MDIFW), Natural Resources Conservation Service (NRCS), Ducks Unlimited, and others, with the goal of enhancing tidal flows to the Libby River portion of the 3,100-acre Scarborough Marsh (Figure 1). A single 5-foot diameter culvert under Black Point Road restricted tidal flow to the upper marsh causing an alteration of the natural hydrology and vegetation of the marsh on the northeast side of the road. The conversion of several areas of high salt marsh habitat to a community type dominated by Phragmites (*Phragmites australis*), a nuisance invasive plant species, was evidence of the adverse ecological effects caused by the tidal flow restriction.

To address the conditions of inadequate tidal flow, a restoration design was developed by the partners to supplement flow through the existing 60-inch diameter culvert under Black Point Road with two 72-inch culverts. MDOT implemented the restoration plan in 2006, opening the new culverts on November 16, 2006.

As part of a pre-construction monitoring effort, Normandeau Associates, Inc. (Normandeau) measured tides and salinities in 2001 in the Libby River above and below Black Point Road (Normandeau 2001). NRCS provided elevations of the hydrologic gauges and some ground survey data. These data provided the initial physical baseline information used by MDOT in the planning process for the new culverts. In 2004, Normandeau collected additional baseline data on hydrology, salinity and vegetation in the marsh (Normandeau 2005). After construction in 2006, FSM implemented a 5-year monitoring program in which data collection occurs in Year 1, Year 3 and Year 5. In 2007, Normandeau collected the first post-construction data (Year 1), sampling hydrology and vegetation (Normandeau 2008). Year 3 studies were conducted in 2009 as the second post-construction monitoring effort, in which only vegetation data was collected. This report covers the findings of the 2009 data collection effort.

## **2.0 STUDY AREA**

The monitoring area extends northeast from Black Point Road approximately two-thirds of a mile upstream to the first major fork in the River (Figure 2). This upper limit was assumed to be the extent of the potential influence of tidal flows under post-construction conditions. However, field studies have indicated that tidal flow and elevated salinities extend beyond this point. The Study Area also extends approximately 300 feet downstream of Black Point Road where no tidal restriction is known to occur. This area serves as a control site, and provides a reference in assessing the effectiveness of the restoration of tidal hydrology, and for vegetative recovery.

## **3.0 METHODS**

### **3.1 FIELD MEASUREMENTS**

#### **3.1.1 Transects**

To facilitate long-term monitoring of vegetation along tidal gradients throughout the marsh, six permanent transect locations were established during the baseline study period in 2004. One meter

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Figure 1. Location of Libby River and Scarborough Marsh.



Figure 2. Study area and transect locations for Libby River long-term monitoring.

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square vegetation plots were located to sample the baseline zonation of the marsh, including low marsh, several types of high marsh, brackish marsh, and *Phragmites* stands. Five transects were located upstream of Black Point Road, and one in the reference area, downstream of the road (Figure 2). Each of these transects begins at the edge of the main channel edge extending perpendicularly across the marsh surface to the upland edge (Transects 2, 3, 5, and 6) or into the *Phragmites* (Transects 1 and 4). The end of each transect was marked with 0.5 inch (127mm) diameter PVC pipe and was located with hand-held GPS. In addition, three short transects (Transects 7, 8, and 9) were established in representative stands of *Phragmites* to track the response of this species to the increase in tidal exchange and salinity (Figure 2).

Data were collected during late August or early September in 2004, 2007, and 2009. One meter square plots were located along each transect during the initial sampling year, marked with PVC pipe and located with hand-held GPS. Five or more plots were established on each long transect in areas representative of the various plant communities at baseline. On the shorter transects, three 1-m<sup>2</sup> plots were located: one at the edge of the (2004) *Phragmites* stand, one 5 m into the stand and the third 5 m into the adjacent marsh vegetation. Within each plot, percent cover of the herbaceous species and of bare ground was estimated using a modification of the Braun-Blanquet cover classes as follows: <1%, 1-5%, 6-25%, 26-50%, 51-75%, and >75%. The height of the ten tallest plants of the dominant (>25%) species were measured, as was *Phragmites* if it occurred. Photographs of each plot were taken, as well as panoramic views of the marsh at each transect.

In total, 40 vegetation plots were sampled. Thirty-one were collected on the six long transects and nine on the shorter *Phragmites* transects. One plot was not located in 2009. Vegetative cover at the upland end of Transect 1 was dominated by *Phragmites* and *Agrostis*, with a smaller percent of *Typha* and other species, however, Plot 1 was not located and no data were recorded.

### **3.2 WILDLIFE**

Observations of wildlife were made during data collection of the vegetation plots and were recorded as incidental information.

## **4.0 RESULTS**

### **4.1 VEGETATION**

During the preconstruction (baseline) vegetation sampling effort (2004), a total of 39 species were identified; a total of 26 species were identified during the first post-construction monitoring season (2007), and 30 species were recorded in 2009 (Table 1). Many of the species absent in 2007 and 2009 were freshwater species that comprised low percentages (<1% or, 1 -5% cover) in 2004; most were along the upper marsh transects where salinities were generally higher compared with the baseline period (Normandeau 2005). All plants observed over all three monitoring years were wetland species, with a range of salinity tolerances from fully saline (such as the true salt marsh species, *Spartina* and *Suaeda*) to those typically associated with fresh water, such as sensitive fern (*Onoclea sensibilis*) and cinnamon fern (*Osmunda cinnamomea*) (Table 2).

In 2004, the low marsh vegetation occurred along the edges of the main channel, some of the side channels and on several relatively small sections of the marsh plain. In all three sampling periods, the low marsh was dominated almost exclusively by salt cordgrass (*Spartina alterniflora*) with very few



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**Table 1. Plant species identified during vegetation sampling at Libby River Marsh 2004-2009.**

Scientific Name	Common Name	2004	2007	2009
<i>Agrostis stolonifera</i>	Creeping bent	X	X	X
<i>Aster puniceus</i>	Purple-stemmed aster	X	X	X
<i>Aster</i> sp.	Aster sp.	X	X	X
<i>Aster subulatus</i>	Salt marsh aster		X	
<i>Atriplex patula</i>	Halberd-leaved orach	X	X	X
Bryophyta	Moss		X	
<i>Calamagrostis canadensis</i>	Bluejoint grass	X		
<i>Calystegia sepium</i>	Hedge bindweed	X	X	X
<i>Carex crinita</i>	Fringed sedge	X	X	
<i>Cladium mariscoides</i>	Twig rush			X
<i>Cuscuta</i> sp.	Dodder	X	X	
<i>Cyperus filiculmis</i>	Upland umbrella sedge	X	X	X
<i>Distichlis spicata</i>	Spike grass	X	X	X
<i>Eleocharis parvula</i>	Dwarf spikerush			X
<i>Galium</i> sp.	Bedstraw	X		X
<i>Gratiola aurea</i>	Golden hedge-hyssop.	X		X
<i>Impatiens capensis</i>	Jewelweed	X		
<i>Juncus balticus</i>	Baltic rush	X	X	X
<i>Juncus gerardi</i>	Black rush	X	X	X
<i>Juncus</i> sp.	Rush sp.	X		X
<i>Lonicera morrowii</i>	Morrow's honeysuckle	X		
<i>Myrica pensylvanica</i>	Bayberry	X		
<i>Onoclea sensibilis</i>	Sensitive fern	X	X	
<i>Osmunda cinnamomea</i>	Cinnamon fern	X		
<i>Phragmites australis</i>	Common reed	X	X	X
Poaceae	Grass sp.	X		X
<i>Polygonum ramosissimum</i>	Bushy knotweed			X
<i>Potentilla anserina</i>	Silverweed	X		X
<i>Salicornia europaea</i>	Slender glasswort	X	X	X
<i>Scirpus americanus</i>	Three-square	X	X	X
<i>Scirpus maritimus</i>	Saltmarsh bulrush	X	X	X
<i>Scirpus robustus</i>	Stout bulrush	X	X	X
<i>Scirpus</i> sp.	Bulrush	X		
<i>Solidago sempervirens</i>	Seaside goldenrod	X		X
<i>Solidago</i> sp.	Goldenrod	X		
<i>Spartina alterniflora</i>	Salt water cord grass	X	X	X
<i>Spartina patens</i>	Salt meadow grass	X	X	X
<i>Spartina pectinata</i>	Fresh-water cord grass			X
<i>Spiraea latifolia</i>	Meadowsweet	X		
<i>Suaeda maritima</i>	Seaside blite	X	X	X
<i>Thelypteris palustris</i>	Marsh fern	X	X	X
<i>Triadenum virginicum</i>	Marsh St. Johnswort	X		
<i>Triglochin maritima</i>	Seaside arrowgrass	X	X	X
<i>Typha angustifolia</i>	Narrowleaf cattail	X	X	X
<i>Typha latifolia</i>	Broadleaf cattail	X	X	

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**Table 2. Dominant species by year and number of plots.**

<b>Scientific Name</b>	<b>Common Name</b>	<b>2004</b>	<b>2007</b>	<b>2009</b>
<i>Phragmites australis</i>	Common reed	6	9	9
<i>Carex crinita</i>	Fringed sedge	1	1	0
<i>Spartina patens</i>	Salt hay	17	13	15
<i>Spartina alterniflora</i>	Salt water cordgrass	9	10	12
<i>Typha latifolia</i>	Broadleaved cattail	1	1	2
<i>Agrostis stolonifera</i>	Creeping bent	0	2	1
<i>Juncus balticus</i>	Baltic rush	0	1	1
<i>Scirpus robustus</i>	Stout bulrush	2	2	2
<i>Scirpus americanus</i>	Three-square	0	1	1
<i>Distichlis spicata</i>	Spike grass	1	3	5
<i>Juncus gerardii</i>	Black rush	4	4	1
<i>Suaeda maritima</i>	Sea-side blight	0	1	1
<i>Atriplex patula</i>	Halberd-leaved orach	0	2	0

additional species, mostly the occasional orach (*Atriplex patula*) (Appendix A). The salt cordgrass was tallest adjacent to the channel, with the tallest plants in 2009 occurring on Transect 1 where mean height recorded was 65.8 inches, compared to 36.6 inches in 2007 and 43.3 inches in 2004. During previous years, tallest salt cordgrass plants were found on Transect 6 in the reference marsh, where the mean height recorded in 2009 was 55.5 inches compared to 73.3 inches in 2007 and 70.7 inches in 2004

During both the baseline period and the post-construction monitoring, high salt marsh was the most abundant community type, both in the study area and the reference marsh (Table 2). In all three sampling years, salt hay (*Spartina patens*) was dominant in 13 plots in the restricted marsh (Transects 1-5), and 2 plots on the reference marsh (Transect 6) (Appendix A). Spike grass (*Distichlis spicata*) was also prevalent on the high marsh, dominating in 5 plots in 2009. Spike grass and short form cord grass (*S. alterniflora*) also occurred frequently as a minor component with salt hay on the high marsh during all years.

Other plant species dominated on sections of the high marsh, forming zones distinct from the salt hay and spike grass communities. With only one exception, Black rush (*Juncus gerardii*) was dominant in plots near or adjacent to the main channel on Transects 3, 4, 5, and 6. This is atypical of the classic profile of the New England salt marsh, which places black rush closer to the upland edge (Nixon 1982). At Libby River, a slightly elevated broad levee occurs adjacent to some sections of the channel, and probably provides the microsite conditions of drainage, salinity and hydroperiod preferred by black rush. This species occurred in six plots in 2004, when it was dominant in 5 plots (Table 3). In 2007, black rush was present in and dominated only three plots. In 2009, black rush was present in four plots but only dominated in one. Average height decreased from 22.0 inches in 2004 to 17.7 inches in 2007; average height in 2009 was 19.5 inches (Table 3). Creeping bent grass (*Agrostis stolonifera*) was also common on the site and its abundance varied only slightly among years. It dominated 3 plots on the upper transects (1, 2 and 3) during the baseline period and both post-construction monitoring periods (Appendix A).

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During the baseline period, brackish species were more prevalent on the upper transects, with dominants including cattail (*Typha angustifolia* and *T. latifolia*), a sedge (*Carex cf crinita*), and salt marsh bulrush (*Scirpus robustus*). Species diversity was highest in these areas, and included the true salt marsh species as well as many that are typically associated with fresh to brackish conditions. While species diversity remained high in the upper transects in 2009, cattail was dominant in only one plot (on Transect 2) and no *C. crinita* was noted. Salt marsh bulrush was observed at the channel edge at Transect 2 and in the upland end of Transect 3. These shifts in vegetation distribution could be caused by increasing salinities and tidal range in the northern end of the marsh as a result of the culvert enhancement.

The vegetation zonation suggests that salinities remain highest close to the channel and decline with distance from the channel. Both Transects 1 and 2, and to a lesser extent, Transect 3, had notably higher species diversity at the “upland” ends, when compared to the channel ends or the other transects during the baseline period (Table 4). Less disparity was noted during 2007 and 2009, when, in general, fewer species were noted along six of the nine transects in 2009 compared with 2004. Exceptions include: Transect 4 had 17 species in 2004 and 2009; Transects 6 and 8 each had more species in 2009 compared with both 2004 and 2007.

**Table 3. Occurrence and %Cover of Black rush by Location and Year**

<b>Transect and Plot</b>	<b>2004</b>	<b>2007</b>	<b>2009</b>
T1-2	1-5%	0	0
T3-3	6-25%	0	0
T3-5	6-25%	0	6-25%
T4-5	>75%	51-75%	6-25%
T5-4	51-75%	51-75%	51-75%
T6-4	>75%	26-50%	1-5%

The *Phragmites* on the Libby River marsh occurs in bands along sections of the upland edges of the marsh. Two of the long transects (Transects 1 and 4) extend into *Phragmites* stands, as do the three short transects (Transects 7, 8 and 9) placed for the purpose of measuring the long-term response of *Phragmites* to increases in salinity and flooding (Normandeau 2008). Nine plots had *Phragmites* as a dominant species in 2007 and in 2009, compared with 6 in 2004 (Table 5). During 2007 and 2009, *Phragmites* density increased to 25% cover at two more plots (T7-2 and T8-2) compared to 2004. Plots dominated by *Phragmites* included the upland end plots 1 and 2 on Transects 1, 7, 8, and 9, and one plot on Transect 4. The average *Phragmites* height in the stands ranged from just under 2.0 feet at Transect 8 to over 13 feet at T9. The tallest plants observed were found at T7 in 2004 and in 2007. Although *Phragmites* was observed as a dominant species in more plots compared with 2004, average height was less (Table 6). Five areas of *Phragmites* were treated with herbicide by NRCS in 2005 (L. Crosby, NRCS, personal communication, Oct. 30, 2007). Treated areas remained visibly reduced in densities and plant height in 2009 and bare ground was still visible in the treated area between Transect 2 and Transect 8, and also north of Transect 4.

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**Table 4. Number of species by Plot by Year**

Plot	2004	2007	2009	Plot	2004	2007	2009
T1-1	7	6	5* n/l	T5-1	4	2	2
T1-2	9	7	4	T5-2	1	1	1
T1-3	4	4	5	T5-3	2	1	1
T1-4	5	4	4	T5-4	4	3	4
T1-5	5	7	3	T5-5	4	3	2
T2-1	6	4	3	T6-1	1	2	2
T2-2	6	4	6	T6-2	2	1	1
T2-3	3	2	2	T6-3	2	3	3
T2-4	3	3	2	T6-4	3	3	3
T2-5	4	3	3	T6-5	1	1	2
T3-1	7	6	5	T7-1	1	1	1
T3-2	1	1	1	T7-2	6	5	3
T3-3	4	2	2	T7-3	3	3	2
T3-4	2	2	2	T8-1	7	3	10
T3-5	4	4	3	T8-2	8	6	8
T4-1	5	3	3	T8-3	2	2	2
T4-2	3	3	2	T9-1	8	3	1
T4-3	1	2	1	T9-2	6	3	2
T4-4	2	1	2	T9-3	3	2	2
T4-5	3	3	5				
T4-6	3	2	4				

**Table 5 Number of plots and combined height (inches) data from plots where Phragmites was dominant**

Phragmites	2004	2007	2009
No. of Plots	6	9	9
Average height (in.)	112.4	83.6	98.4
Range of heights (in.)	55.9 – 141.8	24.2 – 140.7	23.5-158.3

**Table 6. Occurrence and % Cover of Phragmites by Location and Year**

Transect and Plot	2004	2007	2009
T1-1	51-75%	51-75%	51-75%
T1-2	0	51-75%	51-75%
T4-1	51-75%	>75%	>75%
T7-1	>75%	>75%	>75%
T7-2	6-25%	51-75%	51-75%
T7-3	<1%	0	0
T8-1	>75%	6-25%	26-50%
T8-2	6-25%	6-25%	26-50%
T9-1	>75%	>75%	>75%
T9-2	6-25%	6-25%	>75%

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**Table 7. Wildlife species observed during field work on Libby River Marsh 2007-2009.**

Species	Common Name	Approximate Location	Activity	2004	2007	2009
<b>Birds</b>						
<i>Phalacrocorax aurita</i>	Double-crested cormorant	In channel	Feeding	X	X	X
<i>Branta canadensis</i>	Canada geese	General	Feeding	X	X	X
<i>Anas rubripes</i>	Black duck	General	Feeding, 5 young	X	X	X
<i>Larus argentatus</i>	Herring gull	General	soaring	X	X	X
<i>Larus delawarensis</i>	Ring-billed gull	General	Soaring	X	X	
<i>Plegadis falcinellus</i>	Glossy ibis	Pools, T4	Feeding		X	
<i>Ardea alba</i>	Great egret	T4, T6	Feeding		X	X
<i>Egretta thula</i>	Snowy egret	General T4-T6	Feeding, roosting		X	X
<i>Rallus limicola</i>	Virginia rail	T1, T7, T8, T9	Feeding on Phragmites/Cordgrass edge	X		X
<i>Botaurus lentiginosus</i>	American bittern	T-2	Flushed from cattail	X		
<i>Charadrius vociferous</i>	Killdeer	T4	Feeding		X	X
<i>Tringa melanoleuca</i>	Greater yellowlegs	T4, T6	Feeding		X	X
<i>Ceryl alcyon</i>	Belted kingfisher	General	Feeding, roosting		X	X
<i>Accipiter striatus</i>	Sharp-shinned hawk	General	Soaring	X	X	X
<i>Buteo jamaicensis</i>	Red-tailed hawk	General	Soaring		X	
<i>Circus cyaneus</i>	Northern harrier	General	Aerial feeding, hunting		X	X
<i>Haliaeetus leuccephalus</i>	Bald eagle	General	Soaring		X	
<i>Hirundo rustica</i>	Barn swallow	General	Aerial feeding	X	X	X
<i>Tachycineta bicolor</i>	Tree swallow	General	Aerial feeding		X	
<i>Corvus brachyrhynchos</i>	American crow	General	Overhead, on marsh	X	X	X
<i>Parus atricapillus</i>	Black-capped chickadee	General	Roosting, feeding	X	X	X
<i>Colaptes auratus</i>	Northern flicker	T1	Roosting, feeding		X	
<i>Cistothorus palustris</i>	Marsh wren	Widespread	Nests, adults in tall vegetation	X	X	X
<i>Dendroica petchia</i>	Yellow warbler	General	On Phrag/woodland edge	X	X	X
<i>Amospiza sp.</i>	A salt marsh sparrow	T1-2	On creekbank	X	X	X
<i>Carduelis tristis</i>	American goldfinch	General	Overhead	X	X	
<i>Columba livia</i>	Rock dove	General	Flyby		X	X
<i>Zenaida macroura</i>	Mourning dove	General	Flyby, feeding		X	X
<i>Molothrus ater</i>	Brown-headed cowbird	General	Feeding		X	X

(continued)

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**Table 7. (Continued)**

<b>Species</b>	<b>Common Name</b>	<b>Approximate Location</b>	<b>Activity</b>	<b>2004</b>	<b>2007</b>	<b>2009</b>
<b>Reptiles</b>						
<i>Chelydra serpentine</i>	Snapping turtle	T-2	In deep pool near T2, small carcass in 2009.	X	X	X
<b>Mammals</b>						
<i>Cf Microtus pennsylvanicus</i>	Meadow vole	General	Trails, feeding		X	X
<i>Procyon lotor</i>	Raccoon	General	tracks		X	X
<i>Ondatra zebithicus</i>	Muskrat	T1, T3,	Dens, trails, feeding, carcass		X	X
<i>Odocoileus virginicus</i>	White-tailed deer	General	Trails, browsing		X	X
<i>Lontra canadensis</i>	River otter	T1	Scat			X

### **4.2 WILDLIFE**

Incidental observations of wildlife were noted during field work on the Libby River marsh. Table 6 provides a list of species observed and approximate locations. Noteworthy observations include: a bald eagle, great egrets, and glossy ibis all observed throughout the marsh, and a large snapping turtle using an extensive pool complex near Transect 2. Marsh wren nests were abundant in the taller vegetation, including Phragmites, cattail, and bulrush. A salt marsh sparrow species was observed in the cordgrass along the main channel. This species may utilize the high marsh on Libby River for breeding because of its relatively low frequency of flooding. Higher numbers of species noted in 2007 may, in part, be attributable to more time spent on the marsh during hydrologic monitoring compared to 2004 and 2009.

### **5.0 SUMMARY**

In 2009, third-year post-construction data were collected on the 9 permanent vegetation transects at the Libby River Marsh. Five transects were located upstream of Black Point Road, and one reference transect was located downstream. Three short transects were located on the edges of Phragmites stands to track this species. During the pre-construction monitoring, hydrologic data indicated that the tide range above the culvert was reduced to approximately two-thirds that of the reference marsh (Normandeau 2005). The first-year post-construction data (2007) showed the tidal range in the restricted marsh was reduced to 81% of downstream conditions immediately above Black Point Road and to 77% at mid-marsh. This represents an approximately 20% improvement over pre-construction conditions. This increase of tidal water through the culverts has also increased salinity and hydroperiod on the marsh surface, which may, over time, result in restoration of salt marsh habitat and improved wildlife habitat.

The distribution of vegetation communities reflected the hydrologic patterns; near the culverts, typical salt marsh vegetation was the predominant cover type, and brackish communities were restricted to the upland edge. With distance from the culvert, the salt marsh community became narrowed along the channel and the brackish communities broadened across the marsh plain. The vegetation community zonation appears relatively unchanged in post-construction monitoring to date. Some shift in species richness was noted in 2009, with generally fewer brackish and freshwater species

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being observed in a number of plots, although this condition was not consistently observed (Appendix A). Phragmites was dominant in two more plots in 2009, compared with 2004, but average height of the plants was less.

The final post-construction sampling effort is planned for 2011. Normandeau will monitor the hydrology (surface water and ground water) and vegetation at the permanent stations similar to 2007. The results of all years of monitoring will be summarized to provide an ecological assessment of the culvert replacement.

### **6.0 LITERATURE CITED**

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## **APPENDIX A**

### **Vegetation Summary by Transect and Plot**



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Transect	Quad-rat	Scientific Name	Common Name	Percent Cover %			Mean Height (inches)		
				2004	2007	2009	2004	2007	2009
1	1	<i>Agrostis stolonifera</i>	Creeping bent	51-75%	1-5%	Plot not located			Plot not located
1	1	<i>Aster puniceus</i>	New England Aster		1-5%				
1	1	<i>Aster</i> sp.	<i>Aster</i> sp.	<1%					
1	1	<i>Distichlis spicata</i>	Spike grass		6-25%				
1	1	<i>Galium</i> sp.	Bedstraw	<1%					
1	1	<i>Phragmites australis</i>	Common reed	51-75%	51-75%		97.4	72.3	
1	1	<i>Solidago</i> sp.	Goldenrod	1-5%					
1	1	<i>Spartina patens</i>	Salt meadow cordgrass	<1%					
1	1	<i>Typha angustifolia</i>	Narrowleaf cattail	26-50%	1-5%				
1	2	<i>Agrostis stolonifera</i>	Creeping bent	51-75%	6-25%	>75%			
1	2	<i>Aster novae-angliae</i>	New England aster	6-25%	6-25%				
1	2	<i>Calystegia sepium</i>	Hedge bindweed	<1%					
1	2	<i>Cuscuta</i> sp.	Dodder	<1%	<1%				
1	2	<i>Distichlis spicata</i>	Spike grass		6-25%				
1	2	<i>Juncus gerardi</i>	Black rush	1-5%					
1	2	<i>Phragmites australis</i>	Common reed		51-75%	51-75%		84.5	99.0
1	2	<i>Solidago sempervirens</i>	Seaside goldenrod	1-5%		1-5%			
1	2	<i>Spartina patens</i>	Salt meadow cordgrass	1-5%					
1	2	<i>Triglochin maritima</i>	Seaside arrowgrass	1-5%	1-5%				
1	2	<i>Typha angustifolia</i>	Narrowleaf cattail	6-25%	26-50%	1-5%		53.3	
1	3	<i>Aster novae-angliae</i>	New England aster	<1%	<1%				
1	3	<i>Calystegia sepium</i>	Hedge bindweed	<1%					
1	3	Bare	Bare		>75%	51-75%			
1	3	<i>Carex crinita</i>	Fringed sedge	>75%	51-75%		42.4	41.94	
1	3	<i>Juncus balticus</i>	Baltic rush			1-5%			
1	3	<i>Spartina patens</i>	Salt meadow cordgrass	1-5%		1-5%			
1	3	<i>Spartina pectinata</i>	Fresh-water cord grass			<1%			
1	3	<i>Typha angustifolia</i>	Narrow leaf cattail		1-5%	26-50%			61.74
1	4	<i>Agrostis stolonifera</i>	Creeping bent	6-25%	6-25%	26-50%			
1	4	<i>Carex crinita</i>	Fringed sedge	1-5%					
1	4	<i>Scirpus robustus</i>	Stout bulrush		6-25%	6-25%			
1	4	<i>Spartina alterniflora</i>	Salt water cordgrass	1-5%		6-25%			
1	4	<i>Spartina patens</i>	Salt meadow cordgrass	>75%	>75%	51-75%	23.3	21.9	23.8
1	4	<i>Triglochin maritima</i>	Seaside arrowgrass	6-25%	<1%				
1	5	<i>Agrostis stolonifera</i>	Creeping bent	51-75%	6-25%	51-75%			
1	5	<i>Atriplex patula</i>	Halberd-leaved orach	1-5%					
1	5	Bare	Bare	1-5%	6-25%				
1	5	<i>Carex crinita</i>	Fringed sedge		1-5%				
1	5	<i>Distichlis spicata</i>	Spike grass		6-25%				
1	5	<i>Spartina alterniflora</i>	Salt water cordgrass	51-75%	26-50%	26-50%	43.3	36.6	65.8
1	5	<i>Spartina patens</i>	Salt meadow cordgrass	1-5%	6-25%				

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Transect	Quad-rat	Scientific Name	Common Name	Percent Cover %			Mean Height (inches)		
				2004	2007	2009	2004	2007	2009
1	5	<i>Typha angustifolia</i>	Narrow leaf cattail		1-5%	6-25%			
2	1	<i>Aster subulatus</i>	Salt marsh aster		<1%				
2	1	Bare	Bare		6-25%				
2	1	<i>Calamagrostis canadensis</i>	Bluejoint grass	<1%					
2	1	Poacea	Grass sp.			<1%			
2	1	<i>Galium</i> sp.	Bedstraw	1-5%					
2	1	<i>Onoclea sensibilis</i>	Sensitive fern	1-5%					
2	1	<i>Thelypteris palustris</i>	Marsh fern	6-25%	1-5%	1-5%			
2	1	<i>Triadenum virginicum</i>	Marsh St. Johnswort	6-25%					
2	1	<i>Typha latifolia</i>	Broadleaf cattail	>75%	51-75%	>75%	82.9	54.2	80.4
2	2	<i>Agrostis stolonifera</i>	Creeping bent	51-75%	26-50%	>75%		23.9	
2	2	<i>Aster</i> sp.	<i>Aster</i> sp.		<1%				
2	2	<i>Calystegia sepium</i>	Hedge bindweed	6-25%	<1%				
2	2	<i>Juncus balticus</i>	Baltic rush	6-25%	51-75%			24.9	
2	2	<i>Scirpus americanus</i>	Three-square	1-5%		26-50%			
2	2	<i>Solidago sempervirens</i>	Seaside goldenrod	<1%		1-5%			
2	2	<i>Triglochin maritima</i>	Seaside arrowgrass	<1%					
2	3	Bare	Bare	6-25%	1-5%	1-5%			
2	3	<i>Spartina alterniflora</i>	Salt water cordgrass	51-75%	>75%	>75%	22.2	20.8	18.0
2	3	<i>Spartina patens</i>	Salt meadow cordgrass	<1%					
2	4	<i>Agrostis stolonifera</i>	Creeping bent	<1%	1-5%				
2	4	<i>Spartina alterniflora</i>	Salt water cordgrass	1-5%	6-25%	6-25%			
2	4	<i>Spartina patens</i>	Salt meadow cordgrass	>75%	>75%	>75%	22.1	23.1	26.5
2	5	<i>Agrostis stolonifera</i>	Creeping bent	6-25%		1-5%			
2	5	Bare	Bare		1-5%				
2	5	<i>Calystegia sepium</i>	Hedge bindweed	<1%					
2	5	<i>Scirpus robustus</i>	Stout bulrush	>75%	51-75%	>75%	69.2	54.6	61.8
2	5	<i>Spartina alterniflora</i>	Salt water cordgrass		26-50%	6-25%		51.6	
2	5	<i>Typha angustifolia</i>	Narrowleaf cattail	1-5%		1-5%			
3	1	<i>Agrostis stolonifera</i>	Creeping bent	26-50%		26-50%			28.2
3	1	<i>Aster</i> sp.	<i>Aster</i> sp.	1-5%		<1%			
3	1	<i>Aster subulatus</i>	Salt marsh aster		1-5%				
3	1	Bare	Bare	6-25%					
3	1	<i>Calystegia sepium</i>	Hedge bindweed	1-5%					
3	1	<i>Distichlis spicata</i>	Spikegrass		6-25%				
3	1	<i>Juncus balticus</i>	Baltic rush	6-25%	26-50%	26-50%	26.5	31.1	
3	1	<i>Scirpus americanus</i>	Three-square	6-25%	26-50%	51-75%	34.7	42.6	
3	1	<i>Typha latifolia</i>	Broadleaf cattail		<1%				
3	1	<i>Triglochin maritima</i>	Seaside arrowgrass	26-50%	6-25%	<1%			
3	2	<i>Scirpus robustus</i>	Stout bulrush	>75%	>75%	>75%	76.8	65.8	71.2
3	3	<i>Juncus gerardi</i>	Black rush	6-25%					
3	3	<i>Potentilla anserina</i>	Silverweed	<1%					
3	3	<i>Spartina alterniflora</i>	Salt water cordgrass	6-25%	6-25%	6-25%			
3	3	<i>Spartina patens</i>	Salt meadow	>75%	>75%	>75%	25.0	26.9	29.4

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Transect	Quad-rat	Scientific Name	Common Name	Percent Cover %			Mean Height (inches)		
				2004	2007	2009	2004	2007	2009
			cordgrass						
3	4	Bare	Bare		6-25%	6-25%			
3	4	<i>Spartina alterniflora</i>	Salt water cordgrass	>75%	>75%	>75%	19.8	18.6	24.5
3	4	<i>Spartina patens</i>	Salt meadow cordgrass	1-5%					
3	4	<i>Salicornia europaea</i>	Slender glasswort			<1%			
3	5	<i>Atriplex patula</i>	Halberd-leaved orach	1-5%	1-5%	<1%			
3	5	Bare	Bare		>75%				
3	5	<i>Juncus gerardi</i>	Black rush	6-25%		6-25%			
3	5	<i>Potentilla anserina</i>	Silverweed	6-25%		6-25%			
3	5	<i>Scirpus robustus</i>	Stout bulrush		<1%	<1%			
3	5	<i>Spartina patens</i>	Salt meadow cordgrass	>75%	6-25%	>75%	30.0		28.9
4	1	<i>Aster puniceus</i>	Purple-stemmed Aster			1-5%			
4	1	<i>Aster</i> sp.	Aster		1-5%				
4	1	<i>Calystegia sepium</i>	Hedge bindweed	6-25%	<1%	<1%			
4	1	<i>Cuscuta</i> sp.	Dodder	<1%					
4	1	<i>Phragmites australis</i>	Common reed	51-75%	>75%	>75%	112.4	102.6	100.5
4	1	<i>Scirpus</i> sp.	Bulrush	6-25%					
4	1	<i>Solidago</i> sp.	Goldenrod	1-5%					
4	2	<i>Agrostis stolonifera</i>	Creeping bent	6-25%	1-5%				
4	2	<i>Spartina alterniflora</i>	Salt water cordgrass	1-5%	6-25%	26-50%			29.4
4	2	<i>Spartina patens</i>	Salt meadow cordgrass	>75%	>75%	>75%	19.1	20.0	18.8
4	3	Bare	Bare		6-25%				
4	3	<i>Spartina alterniflora</i>	Salt water cordgrass	>75%	>75%	>75%	19.6	19.7	26.0
4	4	<i>Agrostis stolonifera</i>	Creeping bent	<1%					
4	4	<i>Spartina alterniflora</i>	Salt water cordgrass			1-5%			
4	4	<i>Spartina patens</i>	Salt meadow cordgrass	>75%	>75%	>75%	18.5	18.8	16.9
4	5	Bare	Bare			6-25%			
4	5	<i>Salicornia europaea</i>	Slender glasswort			1-5%			
4	5	<i>Distichlis spicata</i>	Spike grass	6-25%	26-50%	51-75%		16.3	19.7
4	5	Forb sp.	Forb sp.	1-5%		1-5%			
4	5	<i>Juncus gerardi</i>	Black rush	>75%	51-75%	6-25%	26.3	19.5	
4	5	<i>Suaeda maritima</i>	Seaside blite		6-25%				
4	6	<i>Atriplex patula</i>	Halberd-leaved orach			1-5%			
4	6	<i>Polygonum ramosissimum</i>	Bushy knotweed			1-5%			
4	6	<i>Distichlis spicata</i>	Spike grass	>75%	26-50%	26-50%	19.8	19.1	23.8
4	6	<i>Juncus gerardi</i>	Black rush	6-25%					
4	6	<i>Spartina patens</i>	Salt meadow cordgrass	6-25%	26-50%	51-75%		25.3	28.1
5	1	<i>Solidago sempervirens</i>	Seaside goldenrod	<1%					
5	1	<i>Spartina alterniflora</i>	Salt water cordgrass	1-5%	>75%	6-25%		33.3	
5	1	<i>Spartina patens</i>	Salt meadow cordgrass	>75%	26-50%	>75%	21.6	20.1	33.3
5	2	<i>Spartina patens</i>	Salt meadow cordgrass	>75%	>75%	6-25%	15.4	18.8	8.4

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Transect	Quad-rat	Scientific Name	Common Name	Percent Cover %			Mean Height (inches)		
				2004	2007	2009	2004	2007	2009
5	2	Bare	Bare			>75%			
5	3	<i>Spartina alterniflora</i>	Salt water cordgrass	<1%					
5	3	<i>Spartina patens</i>	Salt meadow cordgrass	>75%	>75%	>75%	18.7	15.1	20.9
5	4	<i>Distichlis spicata</i>	Spike grass	1-5%	1-5%	6-25%			17.8
5	4	Forb sp.	Forb sp.	26-50%					
5	4	<i>Juncus gerardi</i>	Black rush	51-75%	51-75%	51-75%	22.0	17.7	19.5
5	4	<i>Juncus</i> sp.	Rush sp.			1-5%			
5	4	<i>Suaeda maritima</i>	Seaside blight		26-50%	26-50%		10.5	13.3
5	4	<i>Triglochin maritima</i>	Seaside arrowgrass	<1%					
5	4	<i>Solidago sempervirens</i>	Seaside goldenrod			1-5%			
5	5	<i>Atriplex patula</i>	Halberd-leaved orach		26-50%			26.1	
5	5	Bare	Bare			6-25%			
5	5	<i>Distichlis spicata</i>	Spike grass	6-25%	1-5%				
5	5	<i>Spartina alterniflora</i>	Salt water cordgrass	<1%					
5	5	<i>Spartina patens</i>	Salt meadow cordgrass	>75%	>75%	51-75%	26.1	22.1	28.1
5	5	<i>Suaeda maritima</i>	Seaside blite	<1%					
6	1	<i>Atriplex patula</i>	Halberd-leaved orach		<1%				
6	1	<i>Polygonum ramissimum</i>	Bushy knotweed			<1%			
6	1	<i>Distichlis spicata</i>	Spike grass	>75%	>75%	>75%	20.2	26.6	29.2
6	2	<i>Salicornia europaea</i>	Slender glasswort	1-5%					
6	2	<i>Spartina alterniflora</i>	Salt water cordgrass	>75%	>75%	>75%	21.0	18.0	19.5
6	3	Bare	Bare			<1%			
6	3	<i>Salicornia europaea</i>	Slender glasswort	<1%	<1%	<1%			
6	3	<i>Spartina alterniflora</i>	Salt water cordgrass			51-75%			11.2
6	3	<i>Spartina patens</i>	Salt meadow cordgrass	>75%	>75%	26-50%	15.8	16.7	17.3
6	3	<i>Triglochin maritima</i>	Seaside arrowgrass		<1%				
6	4	<i>Atriplex patula</i>	Halberd-leaved orach	1-5%	6-25%	<1%		13.7	
6	4	<i>Distichlis spicata</i>	Spike grass	6-25%	26-50%	>75%		19.7	21.1
6	4	<i>Juncus gerardi</i>	Black rush	>75%	26-50%	1-5%	25.9	20.6	
6	5	<i>Spartina alterniflora</i>	Salt water cordgrass	>75%	>75%	26-50%	70.7	73.3	55.5
6	5	<i>Spartina patens</i>	Salt meadow cordgrass			>75%			26.9
7	1	<i>Phragmites australis</i>	Common reed	>75%	>75%	>75%	159.2	140.7	130.3
7	2	<i>Agrostis stolonifera</i>	Creeping bent	6-25%	26-50%	1-5%		23.3	
7	2	Bare	Bare	6-25%					
7	2	<i>Phragmites australis</i>	Common reed	6-25%	51-75%	51-75%		96.1	94.8
7	2	<i>Scirpus maritimus</i>	Saltmarsh bulrush	6-25%	1-5%				
7	2	<i>Spartina alterniflora</i>	Salt water cordgrass	26-50%		>75%	31.2		40.74
7	2	<i>Spartina patens</i>	Salt meadow cordgrass	1-5%	26-50%			29.0	
7	2	<i>Triglochin maritima</i>	Seaside arrowgrass	6-25%	1-5%				
7	3	Bare	Bare		1-5%				
7	3	<i>Phragmites australis</i>	Common reed	<1%					
7	3	<i>Spartina alterniflora</i>	Salt water cordgrass	51-75%	>75%	>75%	28.7	27.0	33.4
7	3	<i>Spartina patens</i>	Salt meadow	26-50%	26-50%	6-25%	32.8	19.6	

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Transect	Quad-rat	Scientific Name	Common Name	Percent Cover %			Mean Height (inches)		
				2004	2007	2009	2004	2007	2009
			cordgrass						
7	3	<i>Triglochin maritima</i>	Seaside arrowgrass		<1%				
8	1	<i>Agrostis stolonifera</i>	Creeping bent	6-25%	6-25%	6-25%			
8	1	<i>Atriplex patula</i>	Halberb-leaf orach			<1%			
8	1	<i>Aster puniceus</i>	Purple-stemmed aster	1-5%	6-25%	1-5%			
8	1	<i>Solidago sempervirens</i>	Seaside goldenrod			<1%			
8	1	<i>Salicornia europaea</i>	Slender glasswort			1-5%			
8	1	<i>Potenilla anserina</i>	Silverweed			<1%			
8	1	Bare	Bare		51-75%	26-50%			
8	1	<i>Calystegia sepium</i>	Hedge bindweed	1-5%					
8	1	<i>Eleocharis acicularis</i>	Needle shape spike rush			6-25%			
8	1	<i>Myrica pensylvanica</i>	Bayberry	1-5%					
8	1	<i>Phragmites australis</i>	Common reed	>75%	6-25%	26-50%	107.7	46.3	60.9
8	1	<i>Spartina patens</i>	Salt meadow cordgrass	1-5%					
8	1	<i>Triglochin maritima</i>	Seaside arrowgrass	1-5%					
8	1	<i>Scirpus americanus</i>	Three-square			1-5%			
8	1	<i>Scirpus maritimus</i>	Saltmarsh bulrush			1-5%			
8	2	<i>Aster puniceus</i>	Purple-stemmed aster	1-5%	>1%	<1%			
8	2	<i>Agrostis stolonifera</i>	Creeping bent		6-25%	6-25%			
8	2	Bare	Bare	26-50%	51-75%	26-50%			
8	2	<i>Calystegia sepium</i>	Hedge bindweed	<1%					
8	2	<i>Cyperus filiculmis</i>	Upland umbrella sedge	1-5%	<1%	1-5%			
8	2	<i>Juncus</i> sp.	Rush sp.	<1%					
8	2	<i>Eleocharis parvula</i>	Dwarf spike rush			6-25%			
8	2	<i>Phragmites australis</i>	Common reed	6-25%	6-25%	26-50%		24.2	28.2
8	2	<i>Scirpus americanus</i>	Three square		1-5%	1-5%			
8	2	<i>Scirpus maritima</i>	Saltmarsh bulrush			1-5%			
8	2	<i>Spartina alterniflora</i>	Salt water cordgrass	<1%					
8	2	<i>Spartina patens</i>	Salt meadow cordgrass	1-5%					
8	2	<i>Triglochin maritima</i>	Seaside arrowgrass	6-25%	1-5%	6-25%			
8	3	Bare	Bare	6-25%	1-5%				
8	3	<i>Spartina alterniflora</i>	Salt water cordgrass	1-5%	6-25%	26-50%			22.5
8	3	<i>Spartina patens</i>	Salt meadow cordgrass	51-75%	>75%	51-75%	17.0	16.3	15.2
9	1	Bare	Bare	<1%		<1%			
9	1	Aster sp.	Aster sp.	<1%					
9	1	Bryophyta	Moss		1-5%				
9	1	<i>Impatiens capensis</i>	Jewelweed	1-5%					
9	1	<i>Lonicera morrowii</i>	Morrow's honeysuckle	6-25%					
9	1	<i>Onoclea sensibilis</i>	Sensitive fern		<1%				
9	1	<i>Osmunda cinnamomea</i>	Cinnamon fern	26-50%					
9	1	<i>Phragmites australis</i>	Common reed	>75%	>75%	>75%	141.8	132.8	149.9
9	1	Poaceae	Grass sp.	1-5%					

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Transect	Quad-rat	Scientific Name	Common Name	Percent Cover %			Mean Height (inches)		
				2004	2007	2009	2004	2007	2009
9	1	<i>Spiraea latifolia</i>	Meadowsweet	26-50%					
9	1	<i>Typha</i> sp.	Cattail	6-25%					
9	2	<i>Agrostis stolonifera</i>	Creeping bent	26-50%					
9	2	Aster sp.	Aster sp.	1-5%					
9	2	Poacea	Grass			<1%			
9	2	<i>Phragmites australis</i>	Common reed	6-25%	6-25%	>75%	55.9	52.6	128.2
9	2	<i>Solidago sempervirens</i>	Seaside goldenrod	<1%					
9	2	<i>Spartina alterniflora</i>	Salt water cordgrass	6-25%	>75%			35.7	
9	2	<i>Spartina patens</i>	Salt meadow cordgrass	26-50%	6-25%		30.3		
9	3	<i>Atriplex patula</i>	Halberd-leaved orach	6-25%					
9	3	Bare	Bare		<1%				
9	3	<i>Spartina alterniflora</i>	Salt water cordgrass	26-50%	26-50%	>75%	31.6	24.8	31.9
9	3	<i>Spartina patens</i>	Salt meadow cordgrass	51-75%	>75%	>75%	31.6	24.8	25.0

**APPENDIX B**

**2009 Photo Documentation**

***Libby River Third Year Monitoring Report***

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Transect 6, Plot 5, tall form salt cordgrass and high marsh at channel edge.



Transect 5, Plot 5 – wrack trapped on high marsh.



Transect 1, Plot 5 at channel edge



***Libby River Third Year Monitoring Report***

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Transect 1, Plot 1 – in Phragmites facing channel



Transect 4, from edge of Phragmites facing channel.



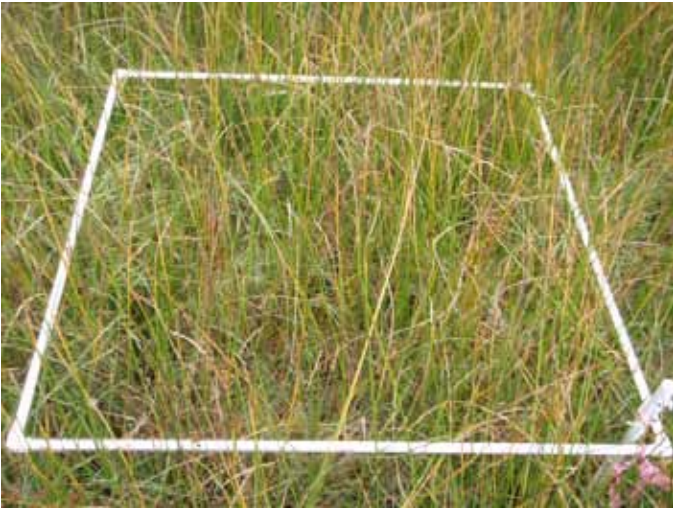
Transect 2, view from cattail edge facing channel.

***Libby River Third Year Monitoring Report***

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Transect 4, Plot 3 – short form cordgrass.



Transect 3, Plot 1 – dominated by Baltic rush.



Transect 6 in reference marsh, Plot 1 – spike grass.

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Transect 2, Plot 4 – salt hay with cordgrass.



Transect 4, Plot 6 – Spike grass with salt hay near main channel.



Transect 1, Plot 2 – from Phragmites/high marsh edge facing channel.

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Transect 8, Plot 2 – edge of Phragmites and high marsh.



View of large pannes formed along Black Point Road at T5.



Egrets in panne near Transect 7.