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Cold Regions Research and Engineering Laboratory

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Engineer Research and Development Center

Remediating and Monitoring White Phosphorus Contamination at Eagle River Flats (Operable Unit C), Fort Richardson, Alaska

FY07 Data Report

Susan R. Bigl and Charles M. Collins, Report Editors

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I. EXECUTIVE SUMMARY

INTRODUCTION

This is the eighteenth annual contract report prepared by researchers from CRREL and other Federal agencies for the U.S. Army Garrison Alaska, Public Works, describing results of research, remediation, and monitoring efforts addressing white phosphorus (WP) contamination in Eagle River Flats, an 865-ha estuarine salt marsh on Fort Richardson, Alaska. Fort Richardson is on the National Priority List, and Eagle River Flats (ERF) is designated Operable Unit C under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA).

Over the five-year period from 1999–2003, full-scale remediation was performed at Eagle River Flats using six remote-controlled pumps to temporarily drain contaminated ponds, allowing the sediments to dry and the WP to oxidize. This effort successfully remediated about 90% of the ponds. More recently, limited remediation using one or two pumps has been conducted to address the remaining few white-phosphorus-contaminated areas.

During 2004, the first year of the monitoring phase, little remediation was performed since monthly flooding tides were predicted. A single pump in Pond 146 was used to lower water levels in Area C, primarily to facilitate sampling and monitoring and to reduce its attractiveness to waterfowl. In fall 2004, several white phosphorus UXOs were detonated in the C-Marsh treatment area. After considering this event and analyzing the 2004 season mortality data, Remedial Action managers decided to expand treatment of the C-Marsh section of Area C during 2005 to better address the last known hot spots on the Flats. A second pump system was utilized in the existing ditch and sump complex in C-Marsh that season. During the 2006 season, along with the Pond 146 pump, two additional pumps were utilized in previously prepared sumps in Northern C Marsh. The monitoring study identified that WP remained in this area and contributed to a majority of the waterfowl mortality observed during the fall migration. Limited pumping during the final 2007 season provided additional remediation in this area, but the damp summer weather reduced the potential for significant drying of sediments.

A test of the procedure for capping a contaminated area was conducted on a pre-designated hot spot in February. The area to be capped was accessed over the frozen surface of the flats, trucking gravel from a local borrow pit. Gravel was spread approximately 40 cm thick over an open-weave natural-fiber geotextile. Coverage of the intended area was complete and the cap integrity held through the Spring and Fall.

II-1. WATERBIRD USE OF EAGLE RIVER FLATS FROM AERIAL SURVEYS, APRIL–OCTOBER 2007

Dennis Marks and William D. Eldridge

U.S. Fish and Wildlife Service conducted 35 aerial surveys to monitor waterfowl use within Eagle River Flats during the spring, summer, and fall of 2007. Observers counted or estimated waterfowl numbers and recorded the numbers categorized by species or species group and by location on ERF using standardized study areas. Tundra and trumpeter swans used ERF only in small numbers during the spring of 2007 and increased in fall to a peak of 224 birds, almost double the 2006 peak of 113. Fall goose migration and duck species use of ERF in 2007 were similar to other years. The mean number of ducks observed in the fall (981) was higher than the mean of 836 during the 1988–1997 period, prior to the start of major pond pumping remediation. Duck use of the ponds in Areas A and D continued to show an increase over the past few years, and the importance of ponds in Area B and Coastal West continued to decline.

II-2. 2007 GROUND-BASED WATERFOWL MORTALITY SURVEYS

Charles M. Collins, Marianne E. Walsh, Ann Staples, and Jon E. Zufelt

Ground-based surveys to determine waterfowl mortality were again conducted in 2007. A core group of transects, in areas with known remaining white phosphorus contamination and other areas most frequented by waterfowl, was surveyed at least three times a week over the fall migration period (mid-August to mid-October). These transects covered the marshes of northern Area C and eastern BT Area and the major waterfowl feeding ponds in Area C. Other transects in remediated areas with waterfowl use and in areas with no known contamination were surveyed less frequently. The surveys located 35 waterfowl mortalities, as identified by carcasses, feather piles, and partial skeletal remains. Thirteen mortalities, or 37% of the total, were along the Ditch Transect in Northern C Marsh, an area with known remaining white phosphorus contamination. Seven mortalities were found in Area A, an increase from 2006, although additional sampling in the area of the mortalities has found no contamination. The minimum mortality rate of the fall dabbling duck population was 0.7%, similar to last year’s 0.6%. This compares to a minimum mortality rate of 2.3% in 2005 and 3.0% in 2004.

III-1. EAGLE RIVER FLATS REMEDIATION PROJECT

Michael R. Walsh, JoAnn Walls, Jon E. Zufelt, Charles M. Collins, and Susan Rego

The 2007 field season was the fourth year of the monitoring phase of the Eagle River Flats project as set out in the Record of Decision signed October 1998. In 2007, tidal predictions indicated an excellent opportunity for drying over the core treatment period, with no flooding tides from mid-May through the end of August. This was the final year of planned limited remediation.

In February, a capping test was conducted on a pre-designated hot spot on the Flats. We utilized the frozen surface of the flats to access the area to be capped, trucking gravel from a local borrow pit. The gravel was spread to a thickness of approximately 40 cm on top of an open-weave natural-fiber geotextile. The capped area was checked for integrity in both the Spring and Fall. Coverage was complete and the cap integrity held.

Three pump units were again deployed this year. System 3, the large, 189-L/s (3,000-gpm) shore-based unit was reinstalled in the sump in Pond 146. This system required no helicopter support for installation and most of the discharge line remained in place over the winter so installation was relatively straight-forward. The system was activated at 189 L/s on 22 May. Intermittent problems and a serious electrical short in the generator resulted in a shutdown of the system after initial drawdown of the C-pond complex on 30 May. The system was repaired and put back into service on 1 August and run until the cessation of operations on 25 August. Two systems were placed in C-Marsh to address the last large area of concern: System 4 in the Bomb Crater sump, activated 22 May, and System 5 in the southern-most C-Marsh ditch complex sump, activated 23 May. Both units have 126-L/s pumps and were cycling the same day they were started. These systems ran throughout the season with few problems. They were shut down on 22 and 23 August.

The CRREL–FRA office once again handled normal equipment operation and maintenance. Age-related problems with the equipment, specifically System 3, resulted in much down time but did not adversely affect the remediation because of the lack of flooding tides and heavy or sustained rains. Medium-lift helicopter support was provided by the Army National Guard in a timely and efficient manner. ERA once again provided us with excellent service. Project personnel were shared, with resources allocated to areas of need, especially in the fall. Travel costs were thus minimized through the bulk of the season. Logistics duties were assumed this year by CRREL, resulting in smoother operations and significant cost savings to the project. UXO support was very good with coordination and communications between the various elements on Post and the UXO technician working well. Support from the Corps District Office was essential to completing the mission.

Overall this was a fairly good season. The capping test was a hard-won success, and the cap held up well through the thaw and flooding tide cycles. We had a good, as well as safe, final remediation season.

III-2. LONG-TERM MONITORING AND SAMPLING OF SEDIMENTS OF PONDS TREATED TO REMOVE WHITE PHOSPORUS

Marianne E. Walsh, Ronald N. Bailey, and Charles M. Collins

The summer of 2007 was the fourth field season of long-term-monitoring after five years of full-scale active remediation by pond pumping of white phosphorus-contaminated ponds at Eagle River Flats. Monitoring of sublimation/ oxidation conditions was concentrated in Area C and the eastern side of Area BT (Duck Ponds). Area BT showed clear evidence of favorable drying and decontamination of the surface sediment; conditions in Area C varied from poor to somewhat favorable.

Confirmatory sampling was conducted in ponds previously treated by pond pumping. Only Pond 155 has detectable concentrations of white phosphorus, but the concentrations are too low to present a risk to waterfowl. No new areas with white phosphorus were found.

In preparation for capping during the winter of 2008 and beyond, we resampled and photographed all hotspots (localized areas with white phosphorus concentrations greater than 1 µg/g) found since 2002 in Areas C and BT. Based on the results of sediment sampling and analysis for WP, 23 discrete locations that are generally less than 2 m in their longest dimension were marked for capping. In addition to the discrete hotspots, six areas were marked. These included three areas within the drainage ditches, two areas that corresponded to trenches containing 57-mm projectiles, and one area that corresponded to the cluster of blow-in-place craters (BIPS). These areas range in size from 14 to 48 m^2.

III-3. 2007 WEATHER DATA FOR EAGLE RIVER FLATS

Charles M. Collins

Temperatures in Eagle River Flats were normal to slightly above normal throughout the summer remediation season from mid May through August. Total cumulative precipitation for the season was below normal (118 mm), with May and June being below normal, July above normal, and August well below normal. Over half of the cumulative precipitation for the season was spread over a one-month period from late June to late July. The normal temperatures and below normal precipitation provided good drying and remediation conditions through the early and late part of the season.

II-1. WATERBIRD USE OF EAGLE RIVER FLATS FROM AERIAL SURVEYS, APRIL–OCTOBER, 2007

Dennis Marks and William D. Eldridge
U.S. Fish and Wildlife Service, Anchorage, AK

INTRODUCTION

Aerial surveys to monitor waterbird use of Eagle River Flats (ERF) during the spring, summer, and fall of 2007 were conducted by the U.S. Fish and Wildlife Service as part of the ongoing waterbird mortality and monitoring studies of ERF sponsored by the U.S. Army at Fort Richardson, Anchorage, Alaska. The purpose and history of these investigations have been presented elsewhere (Racine and Cate, Eds. 1996).

STUDY AREA

Eagle River Flats is a salt marsh complex comprising 870 hectares (ha) on the south side of Knik Arm, approximately 10 kilometers (km) east of Anchorage (Fig. II-1-1). A detailed description of this area is presented in Racine and Cate, Eds. (1996).

METHODS

Aerial surveys of ERF were flown from April through October, 2007. Surveys were conducted more frequently during fall than in spring and summer and were flown with a fixed-wing aircraft at an airspeed of 130 to 170 km/hr and an altitude of 30 to 45 m. Total coverage of ERF was obtained by overlapping transects. Numbers of waterbirds were counted or estimated and recorded by species or species group with digital sound recorder. Waterfowl numbers were classified by locations on ERF, using standardized study areas (Fig. II-1-1). When possible, bird numberss were also recorded by individual ponds within each study area, using a standardized pond-numbering system developed for the ERF database by the Cold Regions Research and Engineering Laboratory (CRREL). Areas (ha) of permanent and intermittent study ponds were obtained from digitized maps provided by CRREL and used to convert bird numbers to densities within the study areas.

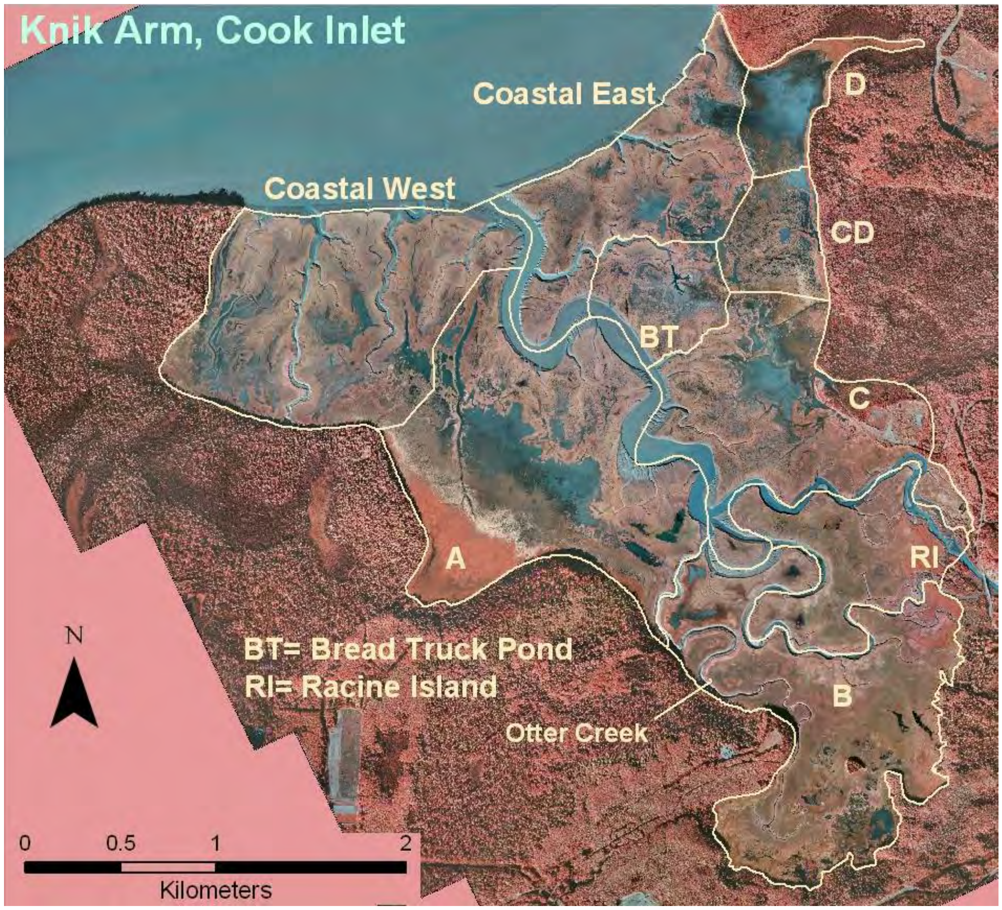

Figure II-1-1. ERF study area with standardized survey areas, ponds, sloughs and Eagle River.

RESULTS AND DISCUSSION

Moisture conditions

ERF experienced a slightly earlier spring breakup in 2007 than 2006. ERF was not completely open until early May. Although, by the end of April pond surfaces were mostly clear of ice; on 20 April 2007 70% of the flats were frozen except for Areas A (70% open), Coastal West (50% open), and Area B (80% open). By 30 April, only sunken ice remained and waterfowl were first observed in significant numbers. Summer moisture conditions are explained in detail elsewhere in this report (Walsh, M.E. et al., Section III-2; Collins, Section III-3). Precipitation in 2007 was below 2006 levels for most months, similar to 2005. Fall high tides flooded most of the ponds in mid-August and pond boundaries expanded; several of the northern ponds (Coastal East, Bread Truck, C, CD, and D) became a single lake after inundation. In October, ponds began freezing. By 8 October, 85% of ponds were frozen and were almost 100% frozen three days later. Although periodic thawing occurred in the following weeks, few waterfowl were observed after 17 October.

Abundance and distribution of waterbirds on ERF

The number of fall surveys used to evaluate mortality was slightly greater in 2007 (n=19) than in past years. A total of 35 aerial surveys were conducted throughout the 2007 season (Appendix II-1-A), with 20 of these in the fall. The first two spring surveys and the last fall survey were not included in mortality estimates because ponds were frozen and the few birds present were restricted to tidal sloughs and the river. Although ponds were 85 to 95% frozen during the two surveys prior to the last of the season, these surveys were used in the mortality estimates because ducks were present in open water.

Species composition and abundance for all birds and wildlife surveyed in 2007 was similar to past years (Fig. II-1-2; Appendix II-1-B).

Similar to past years, numbers of ducks and geese on ERF in 2007 showed a small peak in late April and early May; whereas the major influx of waterfowl began in early to mid August and peaked mid August to the end of September (Fig. II-1-3, Appendix II-1-A). Of all ducks counted 97.7% were identified to species. Use of the nine study areas in ERF by ducks, geese and swans was similar to past years with ducks again concentrated in Areas D, CD and A.

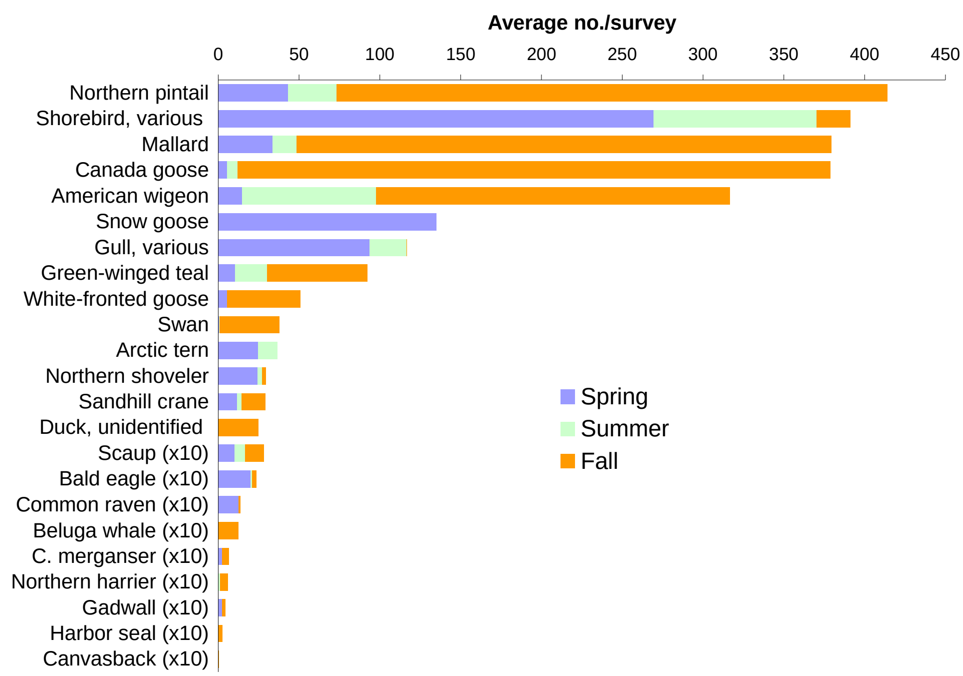

Figure II-1-2. Relative abundance of all species or species groups counted during ERF aerial surveys in 2007. Listed in order of yearly abundance. Bars of less common species represent numbers of individuals multiplied by 10.

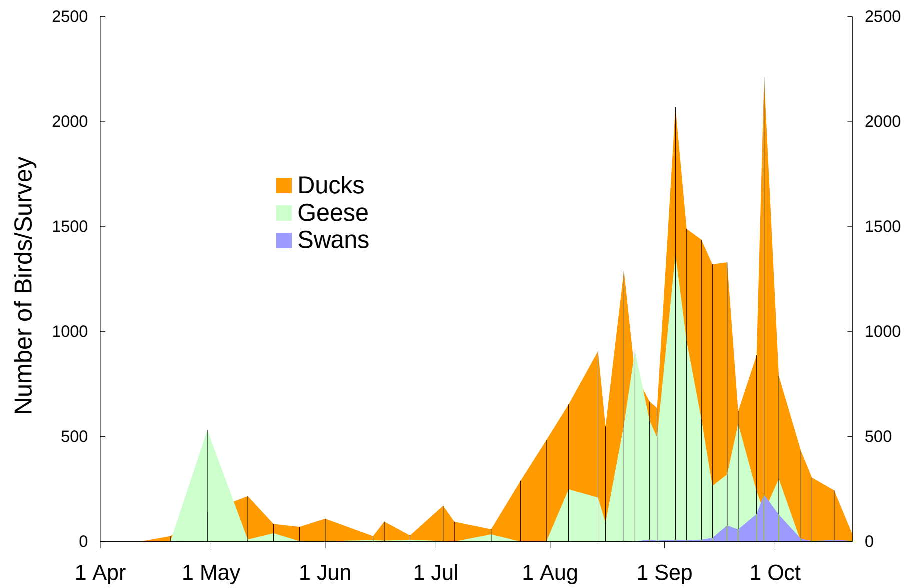

Figure II-1-3. Numbers of swans, geese, and ducks counted on ERF during aerial surveys in 2007. Vertical lines mark survey dates.

Ducks

Total number of ducks counted in 2007 was similar to 2006 (641 and 582 ducks per survey, respectively), but lower than previous years. Compared to previous years, total duck numbers for spring and summer 2007 more closely approximated the "long-term low" average for years 1991-2005 (Fig. II-1-4). Species composition in 2007 was similar to previous years, and dabbling ducks

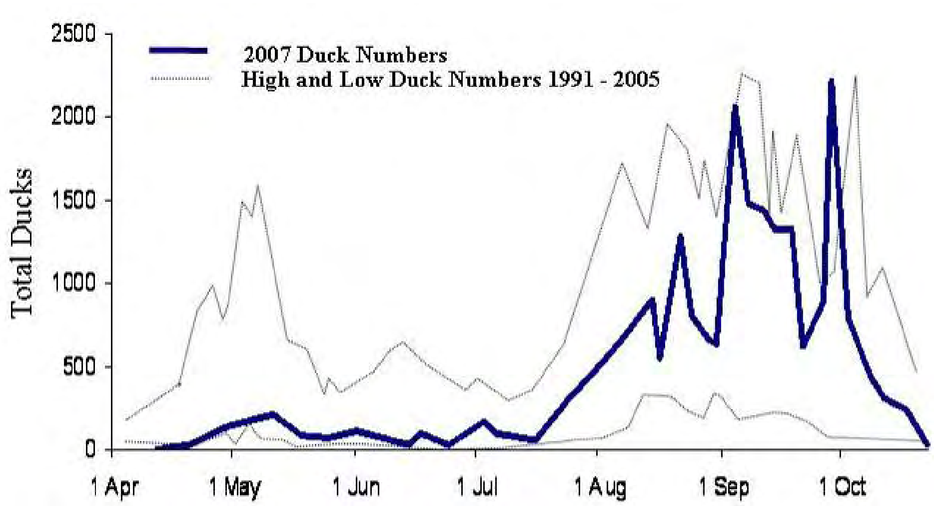

Figure II-1-4. Numbers of ducks observed during aerial surveys of ERF in 2007, compared to the low and high numbers of ducks observed from 1991 through 2005.

Were a 99.8% fraction of the ducks counted throughout the season. Mallards (*Anas platyrhynchos*), northern pintail (*A. acuta*), and American wigeon (*A. americana*) accounted for 92% of all ducks recorded on ERF in 2007; these, together with green-winged teal (*A. crecca*) and northern shoveler (*A. clypeata*) made up 99.8% of all identified ducks in 2007.

In spring, the number of ducks peaked on 11 May (8 May, in 2006) and duck use of ERF was generally light. Areas A, B and C had the highest densities and numbers of ducks in spring (Fig. II-1-5, Appendix II-1-C). Unlike 2006, rainfall was low in the Anchorage area and Upper Cook Inlet area in 2007, possibly resulting in poor habitat conditions for ducks relative to 2006. As a result, fewer ducks were observed in spring and summer.

Migration phenology for ducks during fall 2007 was similar to 2006, but earlier than other recent years, with peak numbers occurring in late August. Like 2006, a second large influx of ducks into ERF occurred in late September (Fig. II-1-2, Appendix II-1-A). The mean number of ducks observed in fall 2007 (981), was similar to the 2006 mean (912), and higher than both the 2005 and 1988-97 means. Note that these counts represent fall visitations prior to disturbances on the flats related to remedial investigations.

Similar to previous years, distribution of ducks in fall showed highest numbers and densities in Areas A, C, CD and D (Fig. II-1-5). In fall, 96% of all duck observations in ponds were identified to specific ponds. The large permanent ponds of Areas A, C, CD and D were especially important to ducks (Fig. II-1-6). Ponds in Bread Truck and Coastal East were also important after flooding connected these to ponds in areas D, CD and C.

Changes in Fall Pond Use by Ducks

Duck use between study areas has changed from 1997 due to ongoing treatability studies, a rotation of pond remediation and other efforts to reduce exposure of ducks to white phosphorus (Fig. II-1-7, Appendix II-1-D, E). Of the four major habitat types used to classify duck locations (ponds, river, slough and shoreline), ponds, as expected, were by far the most important in 2007. Use of ponds over other habitat types by ducks has become even more apparent in recent years. Most significantly, use of Areas A and D in 2007 continued to show an increase in relative fall abundance of ducks over the past few years and the use of ponds in areas B and Coastal West continued to decline from earlier years.

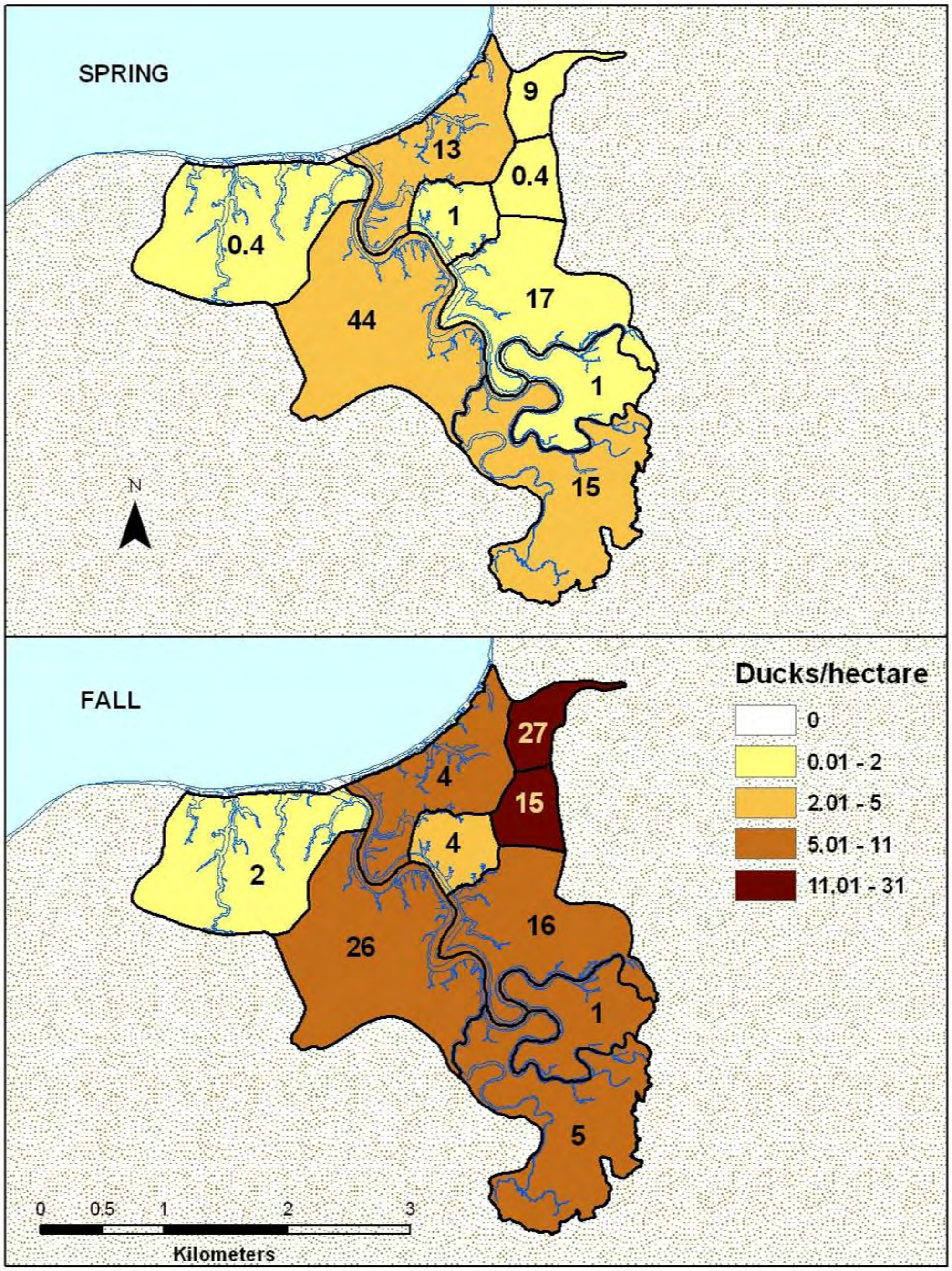

Figure II-1-5. Mean densities of ducks on ERF study areas in spring and fall 2007. Numbers within areas are the percent total ducks observed in each area. The area (ha) of permanent and intermittent ponds in each area was used to calculate densities.

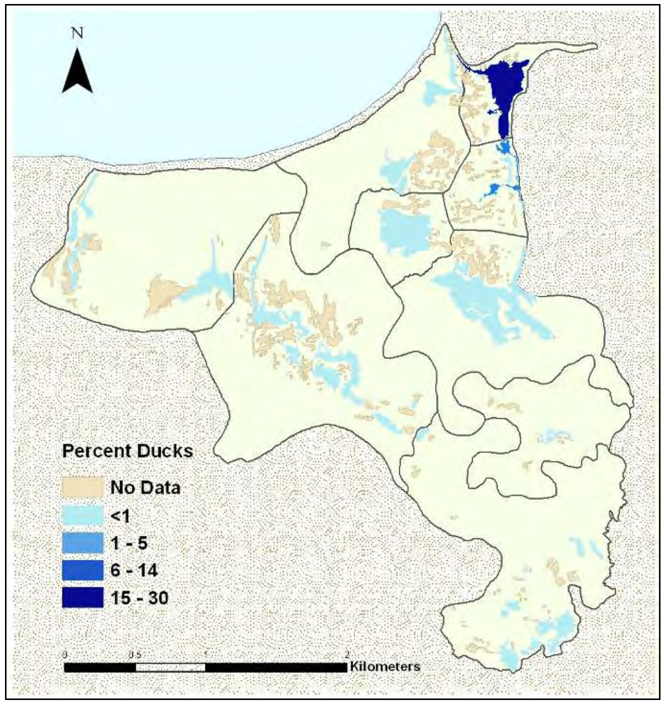

Figure II-1-6. Percent use of ponds by ducks in fall 2007. Data are for duck observations classified to pond numbers. A majority (96 %) of duck observations in ponds were in ponds identified by pond number.

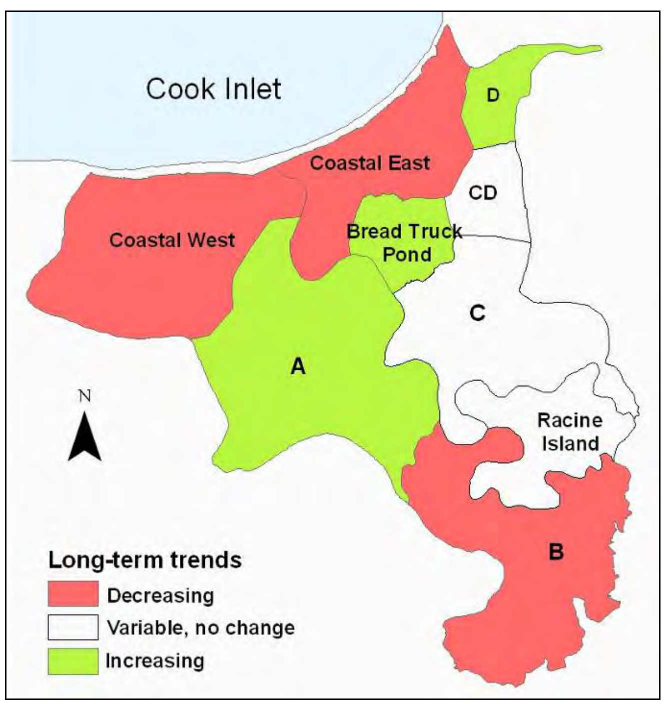

Figure II-I-7. Standardized areas of ERF showing trends of duck use for fall 1997-2007 aerial surveys.

Geese

At 92% of the total geese counted, snow geese (*Chen caerulescens caerulescens*) were the most abundant waterfowl species to visit ERF in the spring; goose numbers and timing were similar to those in 2005 and 2006. Spring peak counts of all three geese species occurred on 30 April, with 4% “tule" greater white-fronted geese (*Anser albifrons frontalis*) and 2% Canada geese (*Branta canadensis*). Apart from a large flock of snow geese in Area B, geese mostly used Coastal East, Bread Truck and Area C in spring (Fig. II-1-8). A small number of Canada geese usually use ERF during summer for nesting or brood-rearing.

Fall goose migration was similar to other years; though the influx of geese was earlier, with a count of 910 on 24 August. Peak use (count of 1369) occurred in early September, with 82% Canada geese and the remainder greater white-fronted geese. Tule white-fronted geese were more consistently present and in greater numbers in ERF than in fall 2006. Snow geese generally do not migrate through Cook Inlet in fall and were not observed in ERF in fall 2007. As in the past, the heaviest use by geese occurred in Area A, Coastal West and Coastal East, but also in several other locales (Fig. II-1-8, Appendix II-1-A).

Swans

Tundra (*Cygnus columbianus*) and trumpeter swans (*C. buccinator*) cannot be distinguished from the air. As is typical, these species only used ERF in small numbers during spring 2007. Swans were much more abundant in fall and numbers peaked in late September at 224 individuals, almost double the 2006 peak of 113 (Appendix II-1-A). They primarily visited the large, often flooded and contiguous lakes of Area D and Coastal East. These ponds contained 75% of the total swans in ERF during fall (Fig. II-1-9, Appendix II-1-A), and together with ponds in Areas C and B contained 93% of the fall total. No dead swans were observed during surveys.

Bald Eagles, Other Raptors and Ravens

Numbers of bald eagles (*Haliaeetus leucocephalus*) were low in 2007, at 19 (Appendix II-1-A), and similar to recent years. While specific shoreline surveys for eagles were not conducted, concentrations similar to earlier years of 50 or more eagles would have been noticed if present. Lower eagle numbers in recent years may be due to decreased mortality of waterbirds on ERF. Individual northern harriers (*Circus cyaneus*) were observed ten times, although in recent years CRREL personnel observed them on a daily basis. Common ravens (*Corvus corax*) were seen less frequently (7 total).

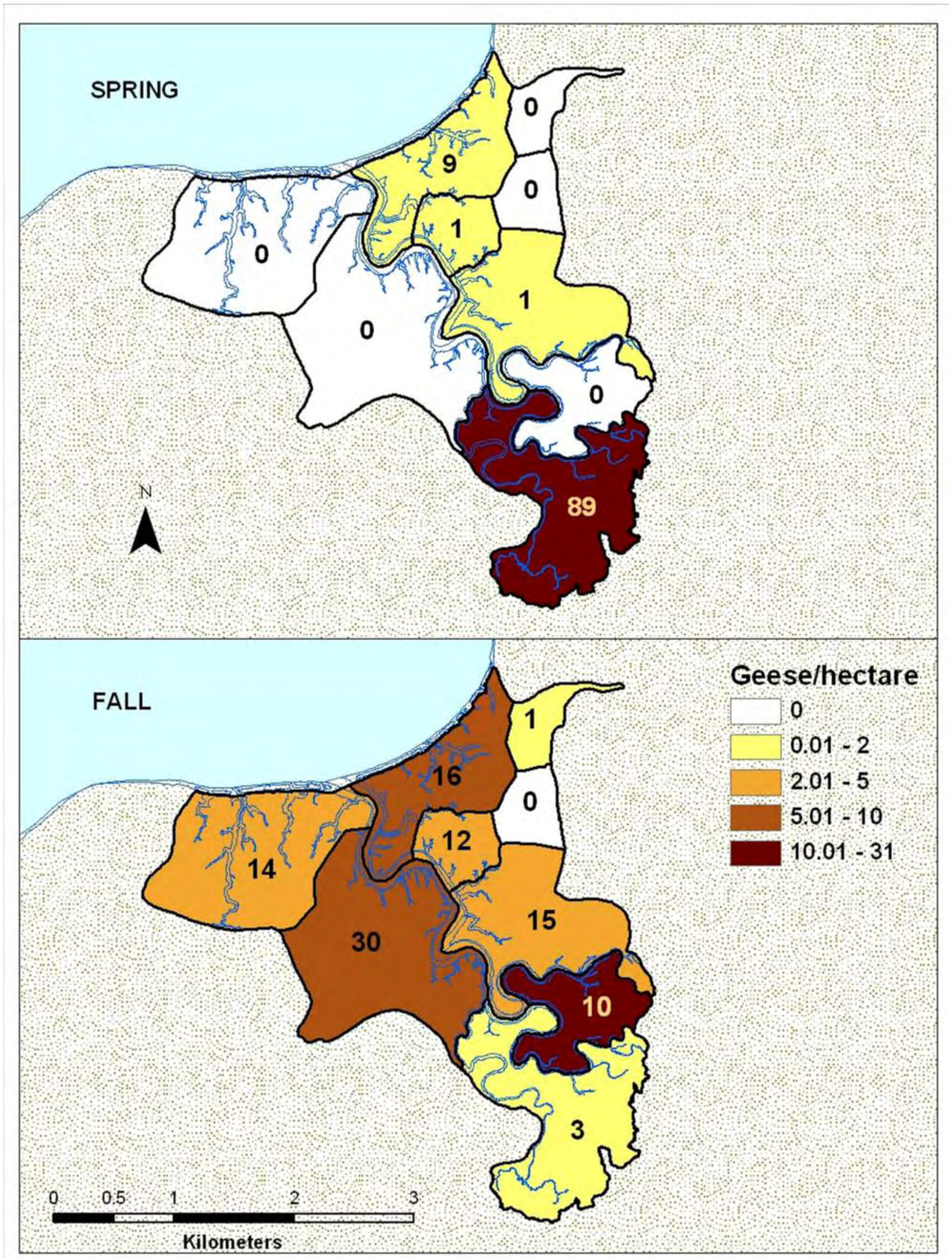

Figure II-1-8. Mean densities of geese on ERF study areas in spring and fall 2007. Numbers within areas are the percent of total geese observed in each area. A large flock of snow geese accounted for 96% of spring Area B birds. The area (ha) of permanent and intermittent ponds in each area was used to calculate densities.

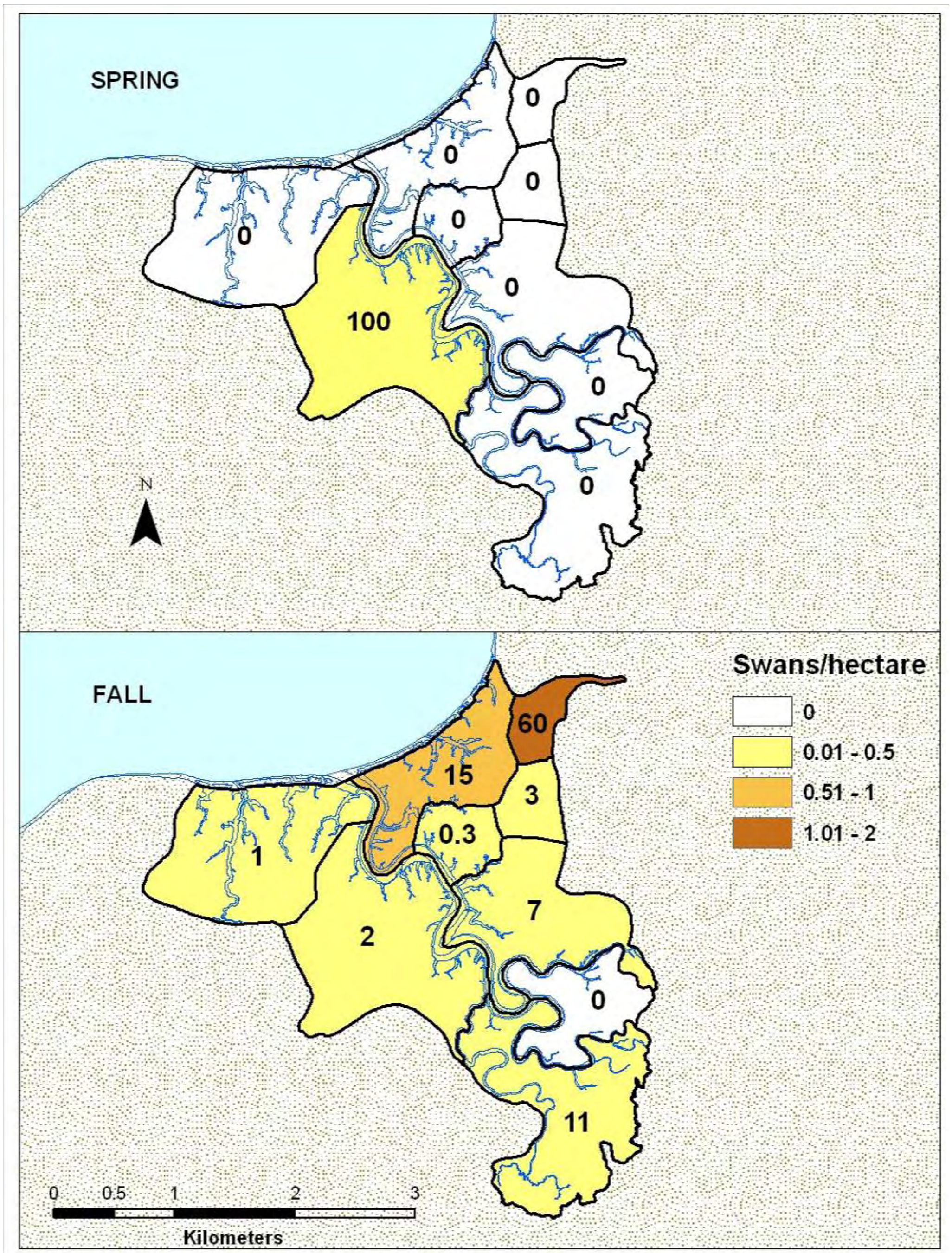

Figure II-1-9. Mean densities of swans on ERF study areas in spring and fall 2007. Numbers within areas are the percent of total swans observed in each area. The area (ha) of permanent and intermittent ponds in each area was used to calculate densities.

Shorebirds

Shorebirds were most abundant on ERF in spring. Although yellowlegs were sometimes recorded (Appendix II-1-A), total numbers of shorebirds were combined for all species since individuals were usually not identified to species. Numbers of shorebirds in 2007 were only slightly higher than in 2006 (2380 and 2022, respectively) which were lower than other recent years. Common species on ERF include least sandpipers (*Calidris minutilla*), semi-palmated sandpipers *(C. pusilla*), western sandpiper (*C. mauri*), dowitchers (*Limnodromus* spp.), and greater and lesser yellowlegs (*Tringa* spp.). Many pectoral sandpipers (*Calidris melanotos*) have been observed by CRREL personnel in previous years.

Gulls and Terns

Gull species were combined for aerial surveys (Appendix II-1-A). They are primarily mew gulls (*Larus canus*) and herring gulls (*L. argentatus*) but also include glaucous-winged (*L. glaucescens*) and Boneparte's gulls (*Larus philadelphia*). Arctic terns (*Sterna paradisaea*) were common into July. As of 2006, the mew gull colony formerly in Area D only consisted of a few pairs.

Sandhill Cranes

Sandhill cranes (*Grus canadensis*) were observed on ERF sporadically from spring through mid September 2007 (Appendix II-1-A) and totaled 353 for all surveys; as many as 70 cranes were counted on individual surveys. One pair of cranes nested in Area C in 2006.

REFERENCES

Racine, C.H., and D.W. Cate (Eds.) (1996) Interagency expanded site investigation: Evaluation of white phosphorus contamination and potential treatability at Eagle River Flats, Alaska. FY 95 Final Report. CRREL Contract Report to U.S. Army, Alaska Directorate of Public Works, Ft. Richardson, Alaska.

Appendix II-1-A. Number of birds, by species or species group, observed for each aerial surveys of ERF in 2007 (page 1 of 3).

	4/12	4/20	4/30	5/11	5/18	5/25	6/1	6/14	6/17	6/24	7/3	7/6
Ducks												
Mallard	0	26	44	57	23	11	20	2	36	13	3	34
Northern pintail	0	0	68	77	17	11	12	2	8	10	30	10
American wigeon	0	0	6	35	7	12	42	10	29	6	118	26
Green-winged teal	0	0	0	26	16		25	12	13	0	14	25
Northern shoveler	0	0	25	21	20	32	10	0	10	0	0	0
Scaup	0	0	0	0	0	4	0	0	0	0	6	0
Gadwall	0	0	0	0	1	0	0	0	0	0	0	0
Canvasback	0	0	0	0	0	0	0	0	0	0	0	0
C. merganser	1	0	0	0	0	0	0	0	0	0	0	0
Unidentified Duck	0	0	0	0	0	0	0	0	0	0	0	0
Subtotal Ducks	**2**	**26**	**137**	**216**	**84**	**70**	**109**	**26**	**96**	**29**	**171**	**95**
Geese												
White-fronted goose	0	0	22	0	0	0	0	0	0	0	0	0
Snow goose	0	0	500	0	40	0	0	0	0	0	0	0
Canada goose	0	0	10	10	0	2	2	7	5	9	2	0
Subtotal Geese	**0**	**0**	**532**	**10**	**40**	**2**	**2**	**7**	**5**	**9**	**2**	**0**
Swans	0	2	0	0	0	2	0	0	0	1	0	1
Other birds												
Bald eagle	2	1	6	1	0	1	0	0	0	0	0	0
Northern harrier	0	0	0	0	0	0	0	0	0	0	0	1
Common raven	0	0	5	0	0	0	0	0	0	0	0	0
Sandhill crane	0	2	2	28	14	2	3	1	3	5	2	0
Artic tern	0	0	12	47	12	28	9	41	7	22	12	5
Mew gull	0	0	0	287	17	0	0	0	0	1	7	2
Herring/glaucous-winged gull	0	0	15	0	0	0	0	0	0	0	0	0
Misc Gull	0	0	16	0	0	39	51	70	42	32	0	0
Yellowlegs	0	0	0	0	15	1	0	0	0	24	20	0
Shorebirds	0	0	0	1060	2	0	29	35	0	165	186	185

Appendix II-1-A (cont.). Number of birds, by species or species group, observed for each aerial surveys of ERF in 2007 (page 2 of 3).

	7/16	7/24	7/31	8/6	8/14	8/16	8/21	8/24	8/28	8/30	9/4	9/7
Ducks												
Mallard	17	5	4	23	73	21	87	211	105	151	638	426
Northern pintail	0	86	113	396	421	299	697	354	303	174	857	370
American wigeon	17	161	335	232	405	229	495	218	253	299	548	465
Green-winged teal	25	36	29	2	8	0	10	16	0	4	4	173
Northern shoveler	0	2	2	0	0	0	2	0	6	7	22	0
Scaup	0	0	0	0	0	0	0	0	0	2	0	0
Gadwall	0	0	0	0	0	0	0	0	0	0	0	0
Canvasback	0	0	0	0	0	0	0	0	0	0	0	0
C. merganser	0	0	0	0	0	0	0	0	0	0	0	0
Unidentified Duck	0	0	0	0	0	0	0	0	0	0	0	55
Subtotal Ducks	**59**	**290**	**483**	**653**	**907**	**549**	**1291**	**799**	**667**	**637**	**2069**	**1489**
Geese												
White-fronted goose	0	0	0	0	0	30	5	130	87	110	249	113
Snow goose	0	0	0	0	0	0	0	0	0	0	0	0
Canada goose	35	0	0	250	210	60	552	780	488	387	1120	843
Subtotal Geese	**35**	**0**	**0**	**250**	**210**	**90**	**557**	**910**	**575**	**497**	**1369**	**956**
Swans	0	0	0	0	0	0	2		10	5	9	7
Other birds												
Bald eagle	1	0	0	2	1	0	0	0	0	0	0	0
Northern harrier	0	0	0	1	0	0	1	1	2	1	1	0
Common raven	0	0	0	0	0	0	0	0	1	0	0	0
Sandhill crane	6	2	6	2	14	8	2	10	27	9	40	45
Artic tern	7	3	0	0	0	0	0	0	0	0	0	0
Mew gull	0	0	1	5		1	0	0	0	0	0	0
Herring/glaucous-winged gull	0	0	0	0	0	0	0	0	0	0	0	0
Misc Gull	2	0	0	0	0	0	0	0	0	0	0	0
Yellowlegs	6	140	17	190	20	3	3	0	0	1	0	0
Shorebirds	70	30	0	0	0	0	0	0	0	0	102	0

Appendix II-1-A (cont.). Number of birds, by species or species group, observed for each aerial surveys of ERF in 2007 (page 3 of 3).

	9/11	9/14	9/18	9/21	9/26	9/28	10/2	10/8	10/11	10/17	10/22
Ducks											
Mallard	565	549	473	96	468	1232	349	318	299	204	23
Northern pintail	285	222	115	447	287	711	406	115	3	14	4
American wigeon	168	250	200	64	70	230	30	0	0	0	0
Green-winged teal	250	275	297	10	62	35	5	0	3	25	0
Northern shoveler	0	0	0	4	0	0	0	0	0	0	0
Scaup	0	0	20	0	0	0	0	0	0	0	0
Gadwall	0	0	0	0	0	4	0	0	0	0	0
Canvasback	0	0	0	0	0	0	0	0	0	1	0
C. merganser	0	0	0	0	0	0	0	0	0	0	8
Unidentified Duck	170	25	225	0	0	0	0	0	0	0	0
Subtotal Ducks	**1438**	**1321**	**1330**	**621**	**887**	**2212**	**790**	**433**	**305**	**244**	**43**
Geese											
White-fronted goose	69	15	0	50	0	2	0	0	0	0	0
Snow goose	0	0	0	0	0	0	0	0	0	0	0
Canada goose	515	250	320	512	240	140	300	0	0	0	0
Subtotal Geese	**584**	**265**	**320**	**562**	**240**	**142**	**300**	**0**	**0**	**0**	**0**
Swans	9	18	77	58	131	224	128	14	3	8	3
Other birds											
Bald eagle	0	0	1	0	0	0	1	0	0	0	2
Northern harrier	0	0	0	1	0	0	1	0	0	0	0
Common raven	0	0	0	0	0	1	0	0	0	0	0
Sandhill crane	43	2	70	5	0	0	0	0	0	0	0
Artic tern	0	0	0	0	0	0	0	0	0	0	0
Mew gull	0	0	0	0	0	0	0	0	0	0	0
Herring/glaucous-winged gull	0	0	0	0	0	0	0	0	0	0	0
Misc Gull	0	0	0	0	0	0	0	0	0	0	0
Yellowlegs	0	0	0	0	0	0	0	0	0	0	0
Shorebirds	0	0	0	56	0	0	0	20	0	0	0

Appendix II-1-B. Waterfowl and habitats observed in Eagle River Flats 1991-2003 (from web site: http://www.crrel.usace.army.mil/erf/ecology/ecology-birds.html).

Species	Status	Habitat
Red-Throated Loon	r	Permanent Pond
Common Loon	r	Permanent Pond
Horned Grebe	u	Permanent Pond
Great Blue Heron	+	
Trumpeter Swan	c	Permanent Pond
Tundra Swan	u	Permanent Pond
Canada Goose	c	Vegetated Mudflat
Cackling Goose	u	Vegetated Mudflat
Brant	u	Vegetated Mudflat
Greater White-Fronted Goose	c	Vegetated Mudflat
Snow Goose	c	Vegetated Mudflat
Mallard	c, B	Bulrush Marsh Permanent Pond
Northern Pintail	c	Permanent Pond Temporary Pond
American Wigeon	c, B	Permanent Pond Temporary Pond
Eurasian Wigeon	r	Permanent Pond Temporary Pond
Northern Shoveler	c	Permanent Pond Temporary Pond
Cinnamon Teal	+	
Blue-Winged Teal	r	Permanent Pond Temporary Pond
Green-Winged Teal	c, B	Permanent Pond Temporary Pond
Ring-Necked Duck	r	Permanent Pond
Greater Scaup	r	Permanent Pond
Lesser Scaup	r	Permanent Pond
Long-Tailed Duck (Oldsquaw)	r	Permanent Pond
Common Goldeneye	r	Permanent Pond
Bufflehead	r	Permanent Pond
Common Merganser	r	Permanent Pond

c = common, u = uncommon, r = rare, + =casual or accidental, B = confirmed breeder in ERF, b = probable breeder in ERF

Appendix II-1-C. Number, mean, percent of total, and density for each standardized area for waterfowl groups determined by aerial surveys in 2007. Data are presented by season and standardized area (Fig. II-1-1). The number of surveys used to classify observations by area for spring, summer and fall were 4, 9 and 19, respectively.

Area	Number			Mean (no./survey)			Percent of Total			Density (no./hectare)		
	DUCKS	GEESE	SWANS	DUCKS	GEESE	SWANS	DUCKS	GEESE	SWANS	DUCKS	GEESE	SWANS
Spring												
A	224		2	56.0	0.0	0.5	43.7	0.0	100.0	2.305	0.000	0.021
B	75	520		18.8	130.0	0.0	14.6	89.0	0.0	2.045	14.177	0.000
BREAD TRUCK	4	6		1.0	1.5	0.0	0.8	1.0	0.0	0.092	0.137	0.000
C	88	6		22.0	1.5	0.0	17.2	1.0	0.0	1.465	0.100	0.000
CD	2			0.5	0.0	0.0	0.4	0.0	0.0	0.107	0.000	0.000
COASTAL EAST	67	52		16.8	13.0	0.0	13.1	8.9	0.0	2.207	1.713	0.000
COASTAL WEST	2			0.5	0.0	0.0	0.4	0.0	0.0	0.032	0.000	0.000
D	44			11.0	0.0	0.0	8.6	0.0	0.0	0.939	0.000	0.000
RACINE ISLAND	7			1.8	0.0	0.0	1.4	0.0	0.0	1.232	0.000	0.000
Summer												
A	512	37		56.9	4.1	0.0	37.7	61.7	0.0	2.341	0.169	0.000
B	128	2		14.2	0.2	0.0	9.4	3.3	0.0	1.551	0.024	0.000
BREAD TRUCK	17	1		1.9	0.1	0.0	1.3	1.7	0.0	0.173	0.010	0.000
C	34	5		3.8	0.6	0.0	2.5	8.3	0.0	0.252	0.037	0.000
CD	286		1	31.8	0.0	0.1	21.1	0.0	50.0	6.790	0.000	0.024
COASTAL EAST	107	4		11.9	0.4	0.0	7.9	6.7	0.0	1.566	0.059	0.000
COASTAL WEST	16	11		1.8	1.2	0.0	1.2	18.3	0.0	0.112	0.077	0.000
D	242		1	26.9	0.0	0.1	17.8	0.0	50.0	2.294	0.000	0.009
RACINE ISLAND	16			1.8	0.0	0.0	1.2	0.0	0.0	1.252	0.000	0.000
Fall												
A	4838	2321	13	254.6	122.2	0.7	26.0	29.7	1.8	10.479	5.027	0.028
B	996	265	78	52.4	13.9	4.1	5.3	3.4	11.1	5.717	1.521	0.448
BREAD TRUCK	817	923	2	43.0	48.6	0.1	4.4	11.8	0.3	3.938	4.449	0.010
C	3024	1169	50	159.2	61.5	2.6	16.2	14.9	7.1	10.596	4.096	0.175
CD	2749		24	144.7	0.0	1.3	14.7	0.0	3.4	30.915	0.000	0.270
COASTAL EAST	724	1232	104	38.1	64.8	5.5	3.9	15.7	14.8	5.020	8.543	0.721
COASTAL WEST	319	1067	7	16.8	56.2	0.4	1.7	13.6	1.0	1.061	3.550	0.023
D	5021	40	425	264.3	2.1	22.4	26.9	0.5	60.5	22.548	0.180	1.909
RACINE ISLAND	154	810		8.1	42.6	0.0	0.8	10.3	0.0	5.708	30.022	0.000

Appendix II-1-D. Percent use, by ducks, of major habitat types on ERF in 2007.

	no. Ducks	Ponds	Eagle River	Tidal Sloughs	Knik Shore
Spring	513	100.0	0.0	0.0	0.0
Summer	1,358	96.7	3.3	0.0	0.0
Fall	18,642	96.8	2.8	0.3	<1

Appendix II-1-E. Percent use of ERF study areas and major habitat types by ducks in fall 1997-2007. Habitat types within study areas used by <u><</u>1% of ducks are not listed.

Area/Habitat	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Coastal West	9.9	17.6	18.8	7.9	6.0	3.4	7.2	4.7	5.6	2.5	1.6
Ponds	5.6	9.1	10.9	5.8	5.4	1.9	1.1	1.7	1.4	1.7	1.6
Knik Shoreline	4.3	7.6	6.6	1.8	0.2	<0.1	0.7	0.0	0.1	<0.1	0.0
Area A	14.6	5.6	14.9	23.5	18.7	16.9	10.3	18.2	24.6	23.7	27.1
Ponds	14.5	5.0	11.5	16.7	9.8	7.6	5.0	7.8	11.9	14.8	26.1
Eagle River	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	0.1	1.6
Area B	25.0	19.2	20.1	19.0	10.5	21.4	33.0	19.3	9.8	14.3	6.0
Ponds	19.2	18.2	16.1	17.8	9.7	17.6	25.3	10.2	7.0	9.1	5.6
Eagle River	5.8	1.0	1.4	1.2	0.2	1.3	0.4	0.0	0.1	0.1	0.0
Otter Creek											0.2
Racine Island	0.6	1.1	1.5	0.7	0.2	0.1	0.6	1.0	0.4	<0.1	0.9
Area C	17.9	4.8	4.8	10.0	25.4	21.1	15.1	13.0	17.2	10.1	15.4
Ponds	2.4	4.7	1.0	4.6	23.3	15.5	13.6	4.1	10.2	7.9	14.3
Eagle River	15.5	0.1	1.0	4.8	0.3	0.1	0.0	0.1	1.9	0.2	1.4
Area CD	11.4	15.3	8.5	9.0	12.5	17.5	17.4	14.0	13.0	15.9	14.8
Ponds	11.4	15.3	3.7	5.7	8.1	12.8	10.6	6.3	8.8	11.5	14.8
Bread Truck	1.3	1.9	2.3	3.7	0.0	0.1	0.3	3.5	2.0	2.0	4.1
Ponds	1.3	1.9	1.1	1.5	0.0	0.0	0.0	0.9	0.2	0.5	4.0
Coastal East	9.1	21.1	9.1	6.6	3.6	0.7	4.4	7.2	11.6	7.2	4.4
Ponds	2.8	9.3	5.0	4.5	5.4	0.4	0.0	3.3	5.8	6.3	3.9
Knik Shoreline	6.3	11.7	0.9	1.4	0.2	0.0	0.0	0.2	0.2	0.0	0.1
Area D	10.7	13.4	20.0	19.7	23.1	19.0	11.8	19.0	15.7	24.3	25.8
Ponds	10.7	13.4	13.3	19.6	23.1	18.9	10.3	16.7	15.7	24.0	25.8

II-2. 2007 GROUND-BASED WATERFOWL MORTALITY SURVEYS

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INTRODUCTION

This marks the fourth year of using ground-based waterfowl mortality surveys to determine waterfowl mortality rates due to white phosphorus poisoning in Eagle River Flats. Ground-based mortality surveys have been a very successful, cost effective, and repeatable process for determining waterfowl mortality. This contrasts with the original method of capturing and equipping a small subsample of wild ducks in Eagle River Flats with radio collars. The extremely high costs of the helicopter support to capture the ducks and the great variability in the mortality data produced made that method problematic.

During 2004, ground-based mortality transects were established in the marshes of northern Area C and eastern BT Area and near the major waterfowl feeding ponds in Area C that have been remediated. We designed and located these transects based on our knowledge of known remaining areas with white phosphorus contamination and long-term observations of waterfowl usage in Eagle River Flats. In surveys conducted to determine waterfowl mortality during 2004, 2005, and 2006, we counted 111, 49, and 25 waterfowl mortalities, respectively (Collins et al. 2005, 2006, 2007).

Mortality rate of dabbling ducks in Eagle River Flats was chosen as the short- and long-term method of determining the effectiveness of remediation in white-phosphorus-contaminated sediments in Eagle River Flats. The Remedial Action Objectives (RAOs) specified in the Record of Decision (ROD) (CH2M Hill 1998) signed in October 1998 are:

> "Within 5 years of the ROD being signed, reduce the dabbling duck mortality rate attributable to white phosphorus to 50 percent of the 1996 mortality rate attributable to white phosphorus. Radio tracking and aerial surveys suggest that about 1,000 birds died from white phosphorus at ERF in 1996. Therefore, the allowable number of duck deaths from white phosphorus would be approximately 500.
>
> Within 20 years of the ROD being signed, reduce the mortality attributable to white phosphorus to no more than 1 percent of the total annual fall population of dabbling ERF ducks. Currently, that population is about 5,000. Therefore, the allowable number of duck deaths from white phosphorus would be approximately 50. This long-term goal could be adjusted based on future population studies conducted during the monitoring program."

METHODS

The 2007 mortality surveys used three types of ground-based transects. The first, and most important, type were transects covering areas with known remaining white phosphorus contamination (the marshes of northern Area C and eastern BT Area) and the major feeding ponds in Area C with the highest waterfowl use. Also included were transects in a portion of Area C that had been remediated but were in proximity to areas of known contamination. This core group of transects was surveyed four to five times a week during the fall 2007 migration period from mid August to near the end of October (except during periods of flooding tides). This survey rate was an increase over the rate of three times a week used in 2006, which in turn was an increase from the twice a week surveys conducted during the two previous years. This survey frequency increase was an attempt to locate as many dead waterfowl as possible prior to predators consuming the carcasses, leaving only featherpiles.

The second transect type covered areas used by waterfowl that have been remediated or have no known contamination. Included were transects in Area A covering ponds that have undergone remediation, a canoe transect of Pond 40 in the C/D area, and a grid transect covering much of the remaining area of C/D. These transects were covered less frequently than the core transects, generally on a weekly or bi-weekly basis.

The third transect type were transects along the forest edge to the east of Eagle River Flats. These were checked for feather piles from carcasses carried into the woods by predators and scavengers, mainly eagles. Because no feather piles had been found in recent years along these transects, they were checked only once during the fall.

Transect Survey Procedure

Ground-based transect lines for all the surveys were the same as in 2006 (Fig. II-2-1; Collins et al. 2007). The first of the known contaminated areas core group, the Ditch transect, covers small pools in the Northern C marsh where two large interconnected drainage ditches were excavated for pumping remediation. The second, Duck Ponds transect, covers the small ponds in the eastern BT area that were drained with a small ditch system excavated in July 2004. Transects were also positioned around the perimeter of the large waterfowl feeding ponds previously treated by pumping – Pond 183 in Area C and Pond 730 in western C/D Area. Transects in this core survey group include:

Northern C Marsh Ditch Transect .... 1,040 m total transect length
Pond 183 Transect .... 900 m
Pond 730 and Duck Ponds Transects .... 2,360 m combined length

Total lane length of the four transects covers approximately 4,300 m; this allows a pair of observers to walk the entire distance in about four hours.

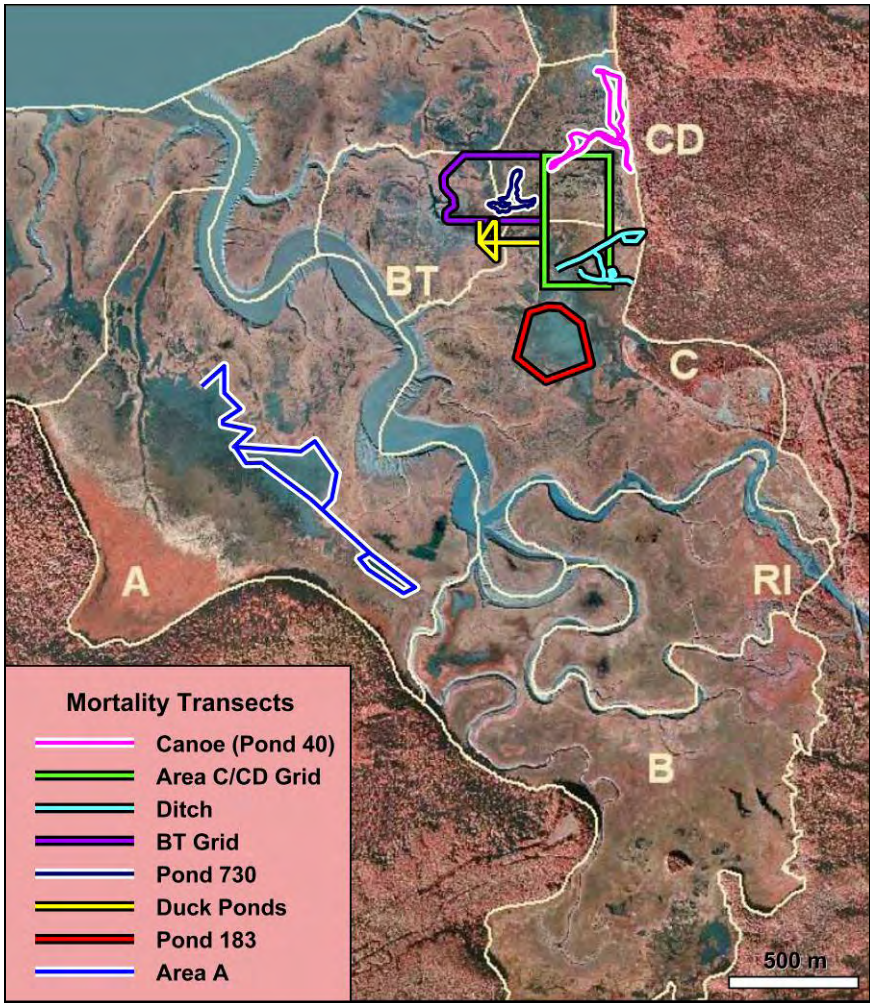

Figure II-2-1. Mortality transects monitored at Eagle River Flats during 2007.

The second (remediated areas) transect type includes:

Area A..2,600 m plus 4,250 m round-trip walking access
Canoe Transect of Pond 40........1,440 m plus 2,400-m round-trip walking access
C/D Grid Transect......................1,500 m
BT Grid Transect ....1,500 m

Area A transect takes approximately five hours to survey, including the walking time to access the area from Lower Cole Point. It is approached with an access trail from Lower Cole Point, the nearest point where a vehicle can be driven, that follows Otter Creek and the western edge of Eagle River Flats. The transect starts at the south end of Pond 290, follows the east side of Pond 290, then heads along the east side of the Northern A pond complex and back, and returns along the west side of Pond 290.

The Canoe Transect starts along the east shore of C/D and follows the entire edge of Pond 40. The C/D grid transect covers a 250- x 500-m grid laid out through the C/D marsh, and the BT transect runs west from the C-C/D transect to the BT gully, south along the east side of the gully, then east along the north side of the Duck Ponds.

Forest-edge transects consist of four 400-m long transects heading into the forest perpendicularly from the salt marsh boundary on the eastern side of Eagle River Flats and one 50- by 200-m quadrat located along the forest edge east of Northern C Marsh.

Transect locations were originally surveyed with a Trimble Pathfinder Pro XR Global Positioning System. The centerline of the 10-m wide lanes was marked with 1.5-m orange fiberglass markers with the tops painted fluorescent lime-green. Past experience with these fiberglass markers in Eagle River Flats shows that they are highly visible from great distance. They also survive winter ice conditions well and can be expected to last for a number of years, thus facilitating re-establishment of the transect lanes each year. All the fiberglass markers were still in place when the transects were relocated this year. Lane widths were delineated with pairs of 1.2-m wood lath with lime-green painted tops, spaced 10-m apart and placed every 50 or 100 m along the survey lanes. The wooden laths were replaced or repainted as needed. During the installation and marking of the 10-m wide lanes, the UXO technician swept the lane width between pairs of lath for avoidance UXO. This allowed the survey team to subsequently walk the lane periodically to conduct the mortality surveys without the UXO technician escort.

All transects were observed similarly during the mortality surveys. A two-person observation team walked (or canoed in case of the Canoe Transect) each of the transect lanes in turn, visually scanning for waterfowl carcasses or feather-pile remains of carcasses. The observers especially checked the nooks and crannies within standing bulrush along the water edges of ponds. When a carcass or feather pile was found, the team recorded the date, location (UTM coordinate using a GPS system or estimated from UTM-gridded photo maps of the areas), species, and an estimate of the carcass freshness. A unique sequential sample identification number was assigned (e.g. MORT 001, MORT 002, etc.) to all carcasses and feather piles. The location was marked with a PVC pin flag annotated with the identification number and date. If the carcass was in good shape, it was collected and brought back to the lab in Building 992. There the gizzard was removed for later white phosphorus analysis. The carcass was then preserved in the freezer for later screening for H5N1 avian influenza. Further discussion of the carcass-handling procedure follows below.

If the mortality indication was a feather pile rather than a carcass, similar information was recorded, including date, location, identification number, and species (if it could be determined from the feathers). The feather pile location was marked with a PVC pin flag with an identification number and date. This prevented recounting on future surveys.

Waterfowl Carcass Handling Procedure

Personal protective equipment worn by personnel in the field whenever handling waterfowl consisted of rubber gloves; when in the laboratory, Level D protection (gloves, eye protection, and a dust mask) were worn whenever dissecting waterfowl and gizzards. The survey team collected all found carcasses that were not too decayed to handle. After moving the carcass to the laboratory in Building 992, the gizzard was removed. A razor blade was used to cut a 5-cm slit in the carcass just below the breastbone. Reaching into the slit and up behind the breastbone, the gizzard was pulled out and removed. The gizzard was placed in a sample bag, and the date, carcass number, and location information was recorded on the bag and in the field book. The bagged gizzard was then placed in the refrigerator. Every few days the gizzards were dissected, the gizzard contents removed and placed in glass vials. Approximately once a week the gizzard content samples were shipped to the CRREL-Hanover chemistry laboratory, where the contents were analyzed for white phosphorus on a gas chromatograph using EPA Method 7580 (U.S. EPA 1995).

Throughout the field season, the status of testing for highly pathogenic avian influenza (HPAI) was followed closely using the system posted on a website entitled HEDDS (**H**ighly Pathogenic Avian Influenza **E**arly **D**etection **D**ata **S**ystem) http://wildlifedisease.nbii.gov/ai/. During 2007, over 12,000 waterfowl samples collected in Alaska and over 80,000 collected in the United States were analyzed for HPAI. If any positive samples had been reported, additional safety measures would have been implemented during the mortality surveys as outlined in the safety and health plan. These could have included additional personal protection equipment or the suspension of mortality surveys if deemed necessary.

Period of Observations

The mortality surveys were conducted during the fall migration period from 14 August to 11 October 2007, when Eagle River Flats froze up. Over 130 individual transect surveys were conducted over the 10-week period. The core mortality transects were surveyed four to five times a week (generally Monday through Friday) except during periods of flooding tides. This frequency was an increase from the three times a week during 2006 and twice weekly in prior years. The increase was an attempt to collect dead waterfowl prior to predation by eagles and other scavengers. In previous years, the number of predated feather piles often outnumbered carcasses. This complicated the intent to confirm that all mortalities were due to white phosphorus poisoning; if carcasses were removed from ERF by predators, the mortality count would be underestimated. The secondary transects were surveyed approximately weekly. The forest edge transects were surveyed once during the fall.

RESULTS

Mortality Data

During the survey period from mid-August to 11 October, the surveys identified 35 waterfowl mortalities in Eagle River Flats, consisting of carcasses, feather piles and partial skeletal remains. Waterfowl mortalities have been decreasing since the ground-based mortality surveys began three years ago, with 111, 49, and 25 mortalities identified in 2004, 2005, and 2006, respectively. Table II-2-1 summarizes by transect the 2007 seasonal waterfowl mortality totals attributed to white phosphorus poisoning. Figure II-2-2 gives an overview of all 2007 duck mortality locations in Eagle River Flats. An expanded view of the mortalities in Areas C and C/D, including the Ditch transect area in Northern C Marsh, are shown in Figure II-2-3.

Thirteen mortalities, or over one third of the total, were found along the Ditch Transect in Northern C Marsh, an area of known remaining white phosphorus contamination. This indicates that the remaining small areas of contamination in Northern C marsh, including short sections of the large drainage ditches, the ten BIP locations, and the dozen or so small contaminated pools and puddles remain the largest source of waterfowl poisoning in Eagle River Flats.

Pond 730 transect had nine mortalities in 2007 (26% of the total), one less than in 2006. Pond 730 was previously remediated by pond pumping and, based on sediment sampling, was felt to be clean. Because several mortalities were observed in this area during the initial 2004 observations, additional sediment

Table II-2-1. Summary of 2007 mortality results by transect.

Transect	Number
Ditch Transect	13
Pond 730 Transect	8
Pond 183 Transect	1
Duck Pond Transect	1
BT Transect	0
C/D Transect	3
Canoe (Pond 40) Transect	0
Other Area C	2
Forest Transects	0
Area A Transect	7
Total	**35**

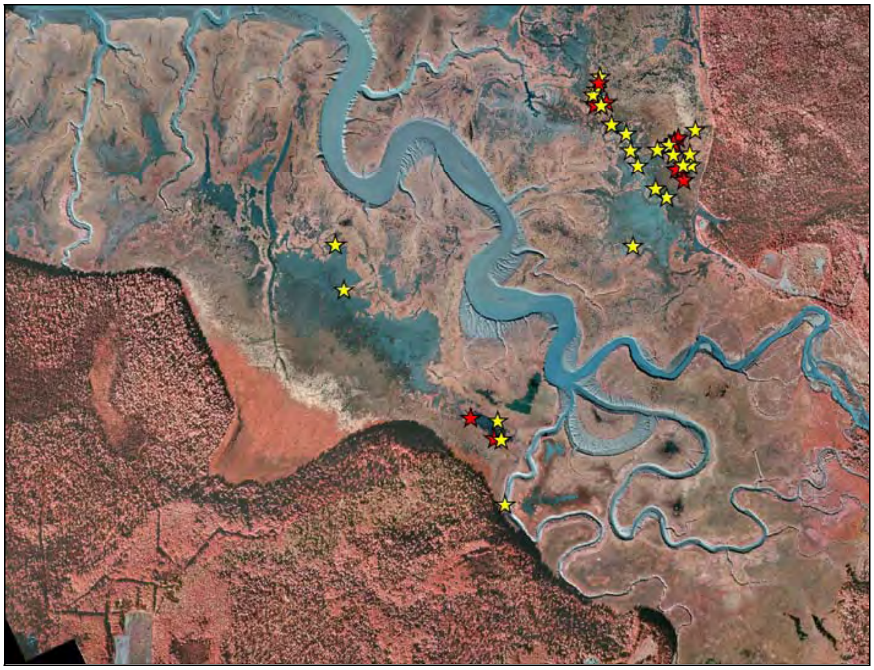

Figure II-2-2. Locations of 2007 duck mortalities in Eagle River Flats. Carcasses shown as red stars and feather piles by yellow stars.

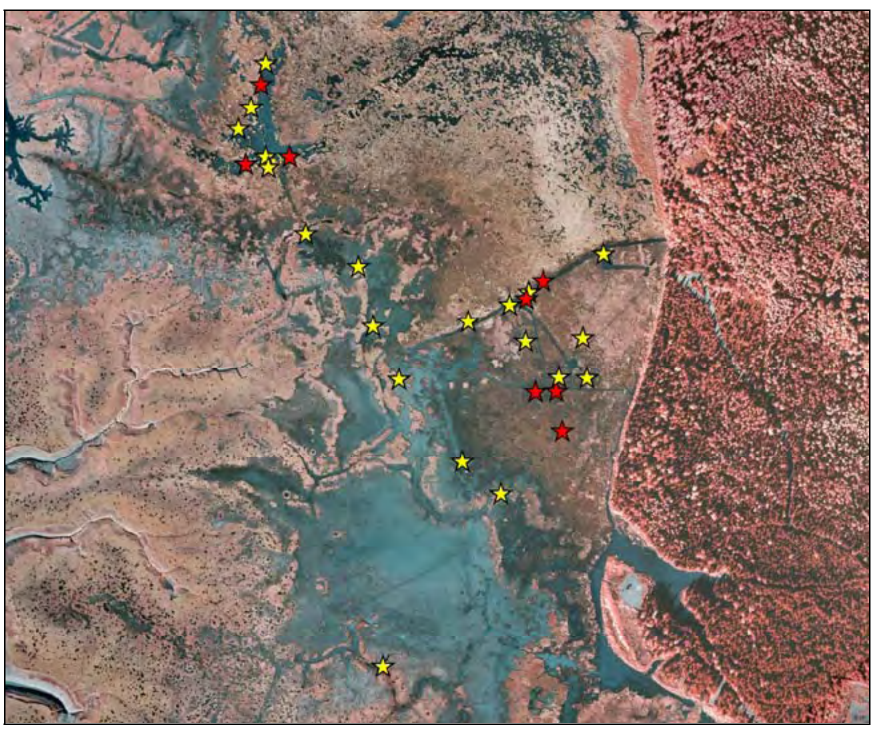

Figure II-2-3. Locations of 2007 duck mortalities in Areas C and C/D. Carcasses shown as red stars and feather piles by yellow stars.

sampling was conducted (Walsh et al. 2005) and several previously unidentified small ponds contaminated with low levels of white phosphorus were found adjacent to Pond 730 just to the west and the south. Additional extensive sampling in Pond 730 this year (Walsh, M.E. et al. this report) failed to find any contaminated areas. Pond 730 is not very far from known areas of contamination in Northern C Marsh and a duck could be poisoned in a contaminated area of a ditch prior to moving to Pond 730.

One mortality, a feather pile, was found on the Pond 183 transect. One carcass and two feather piles were found northeast of the Pond 183 transect, between Pond 183 and the Ditch transect. All were found next to convenient perches such as driftwood logs or the old observation tower. We assume the feather piles are the remains of carcasses picked up by predators elsewhere, most probably the nearby Ditch transect area, and carried to the Pond 183 area and consumed. Pond 183 was remediated by pond pumping several years ago and repeated sampling continues to show that the surface sediments are clean.

The three mortalities along the C/D transect were all near the southern end of the transect lines near the Ditch Transect. It is likely that the same area of contamination caused the mortalities. No mortalities were found on the BT Transect, which is further north and west.

This year, no evidence of dabbling duck mortality was found on the Canoe Transect around the perimeter of Pond 40, compared with one in 2006, four in 2005, and six in 2004. This large, deep pond is a major resting and loafing area for ducks and numerous ducks are always observed in this area during the surveys. The lack of mortality here this year and the decrease over the last several years are very encouraging. Pond 40 is too deep to allow effective feeding by ducks over much of its area and past sampling has shown no contamination. Ducks often feed in other adjacent areas and return to this large pond to rest and loaf in its relatively safe waters. The lack of mortality indicates that fewer waterfowl are being poisoned while feeding in the contaminated areas of the Ditch Transect and the small ponds adjacent to Pond 730 before returning to the Pond 40 area for the evening.

A single mortality was observed along the Duck Pond Transect near the eastern end adjacent to the Ditch Transect area and the mortality is probably related to feed in the ditch area. The drainage ditches installed in July 2004 were successful in draining the majority of the small contaminated ponds in this area and removing them as waterfowl feeding habits where waterfowl could potentially pick up particles of white phosphorus and be poisoned.

Seven mortalities (two carcass and five feather piles) were found in Area A this fall, an increase from previous years. The two carcasses and two of the feather piles were found adjacent to Pond 290, the southernmost pond in Area A. Two of the other feather piles were located adjacent to Pond 226 in Northern A. The last feather pile found in this area was along the trail leading into Area A along the bank of Otter Creek. Known contaminated ponds in Area A were pumped and treated over several years from 1998 to 2002. Repeated sediment sampling for white phosphorus since then has been negative. It is possible that isolated hot spots of white phosphorus contamination remain somewhere in the Area A pond complex or that waterfowl may have fed in a contaminated area east of the river then flew into Area A. The feather piles, especially the ones in Northern A and the one along the bank of Otter Creek may be the remains of naturally predated waterfowl. Without testing the carcass for white phosphorus it is impossible to know for sure the cause of waterfowl deaths represented by the feather piles. In future years, to try to negate this problem, the sampling teams will attempt to collect bits of skin from feather pile locations. In theory, there should be enough subcutaneous fat attached to a small skin sample to determine if the waterfowl died from white phosphorus.

No feather piles were found in the woodland transects.

During the mortality surveys, 36 carcasses and feather piles were found. However, one gizzard did not test positive for white phosphorus, indicating this particular duck may have died from some other cause. This is the first duck gizzard collected from dead waterfowl in Eagle River Flats over the last four years that tested negative for white phosphorus. Because of this result, we attribute only 35 mortalities to white phosphorus poisoning—10 carcasses and the 25 feather piles. We still assume all the feather piles are attributable to white phosphorus poisoning, which gives a conservative estimation (an over estimation) of mortality rate due to white phosphorus poisoning. The ratio of carcasses to feather piles decreased this year compared to last, even with the increased survey frequency on the core transects. Despite the best efforts of the survey teams, predators are getting to the dead ducks faster than the survey teams, leaving feather piles to count instead of carcasses. However, the lack of feather piles along the forest edge transects indicates that the predator numbers are not enough that they are picking up and moving carcasses off ERF and into the woods before consuming them to escape other predators. This was the case in the early and middle 1990s when large numbers of ducks were dying and large numbers of predators, mainly eagles, preyed on them. Detailed data about each mortality, including date, species, collector, and location (UTM coordinates) are given in Appendix Table II-2-A1.

Again, we must address this concern of the higher percentage of feather piles versus carcasses that can be easily tested for white phosphorus, and the one negative test of a gizzard this year. Therefore, when possible, next year we will attempt to use a method to confirm the cause of death resulting in a feather pile. We feel that for a good percentage of feather piles by closely inspecting and collecting any available scraps of skin attached to the wing feathers or scraps of tissue and fat attached to skeletal parts, we could be able to confirm whether or not white phosphorus caused the death. There is enough subcutaneous fat attached to skin that a small skin sample should, in theory, be able to be tested to attached to skin that a small skin sample should, in theory, be able to be tested to determine if the waterfowl died from white phosphorus.

Estimates of Waterfowl Population and Mortality Rate

To calculate the estimated fall dabbling duck mortality rate for Eagle River Flats requires an estimate of both the total duck population using Eagle River Flats and the total number of ducks that die from white phosphorus. The fall duck population estimate was made using the aerial census population data collected over the summer and fall by the U.S. Fish and Wildlife Service (Marks and Eldridge, this report). Estimating a total duck population from periodic aerial census data is complicated by lack of information on how many ducks seen on one census flight were the same ones present during the previous census. However, the radio-collar tracking data collected between 1996 and 2002 by the National Wildlife Research Center (NWRC 2004) enables us to estimate the turnover rate, which is the number of ducks that leave Eagle River Flats between censuses. This tries to account for ducks that may fly into Eagle River Flats, feed and potentially be exposed to white phosphorus poisoning, then fly out prior to the next aerial census flight. In previous years, NWRC calculated the turnover rate for each census period based on the turnover of the radio-collared mallards used in the telemetry study. Turnover is defined as the proportion of ducks that remained on ERF between two aerial censuses (or 1 – [the proportion that left]). Since we do not have a measured turnover rate, we estimated it by using the average turnover rate of 0.83 that was based on the long-term average turnover rate for the entire length of the telemetry studies (NWRC 2004).

Using the NWRC population estimate model, the aerial census data, and the average turnover rate, a population estimate was determined for each census period (Table II-2-2). The NWRC model uses the total dabbling duck population, i.e. the sum of each of the duck species plus the unknown or unidentified ducks, then adjusts total for the average turnover to determine estimated total duck population for that census period. The total increase in duck population for each census period was then estimated by subtracting the previous period's adjusted population from the current period's adjusted population. If the current period's population was higher than the previous period then the difference was the total increase in duck population for that period. If the current period's population was lower than the previous period, then there was no net increase in the duck population for that period. At the end of the season, the total increases for each census period were summed to give the total estimated dabbling duck population for the season.

Table II-2-2. NWRC population model using the aerial count by species of ducks plus unidentified ducks. Total is adjusted for average turnover ratio. Positive changes in population from one period to the next are then summed to obtain total population estimate.

Observation Date	Aerial Count	Unknown Dabblers	Total Dabblers	Adjusted for Turnover	Population Change*
7/16/07	59	0	59	71	71
7/24/07	290	0	290	349	278
7/31/07	483	0	483	582	301
8/6/07	653	0	653	787	205
8/14/07	907	0	907	1093	306
8/21/07	1291	0	1291	1555	463
8/24/07	799	0	799	963	0
8/28/07	667	0	667	804	0
8/30/07	637	0	637	767	0
9/4/07	2069	0	2069	2493	1725
9/7/07	1434	55	1489	1794	0
9/11/07	1268	170	1438	1733	0
9/14/07	1296	25	1321	1592	0
9/18/07	1105	225	1330	1602	11
9/21/07	621	0	621	748	0
9/26/07	887	0	887	1069	320
9/28/07	2212	0	2212	2665	1596
10/2/07	790	0	790	952	0
10/8/07	433	0	433	522	0
10/11/07	305	0	305	367	0
10/17/07	244	0	244	294	0
10/22/07	43	0	43	52	0
		Total Fall Dabbling Duck Population			**5,279**

* Change in population from previous period.

Using this method, the total Fall 2007 dabbling duck population was calculated to be 5,279 birds. The observed mortality was 35, giving a minimum mortality rate of the Fall 2007 dabbling duck population in Eagle River Flats of 0.7%. This compares to a minimum mortality rate of 0.6% in 2006, 2.3% in 2005, and 3.0% in 2004 (Table II-2-3.)

Table II-2-3. Total dabbling duck populations, duck mortalities, and minimum mortality rates for 2004 through 2007 in Eagle River Flats.

Item	2004	2005	2006	2007
Duck Population	3,659	2,130	4,479	5,279
Mortality Number	111	49	25	35
Mortality Percentage	3.0 %	2.3 %	0.6 %	0.7%

Estimates of Errors in Waterfowl Population and Mortality Rate

A number of uncertainties are included when determining a mortality rate:

- Errors in counting waterfowl numbers during the aerial census flights.
- Periodicity of aerial flights, which might miss peaks of waterfowl population.
- Errors in applying an average turnover rate.
- Errors in counting actual carcasses on the ground:
  - Missing carcasses along a transect
  - A small contaminated area not covered by a transect.
  - Waterfowl that feed in a known contaminated area (with transects) but fly to another area without transects or are carried to a non-transect area by a scavenger or predator.

Although it is difficult to quantify the cumulative error bars for these uncertainties, we estimate that the actual total fall population of dabbling ducks may be plus or minus 20% of the total dabbling ducks determined using the NWRC Population Model with aerial census data and an average turnover rate. Previously we evaluated the accuracy of the method for calculating total population of ducks using an average turnover value (Collins et al. 2005). During years when actual turnover rates from telemetry data were available, we determined the fall population amount calculated with both an average turnover rate and actual turnover rates from telemetry data. Population estimates using both methods were similar.

Based on field observations, and our experience and knowledge of Eagle River Flats, we estimate that the duck mortality may be as much as 50% higher than the 35 duck mortalities actually counted on our surveyed transects, but not likely to be higher than that. Following the extensive remediation over the last eight years, the number of places where waterfowl can feed during the early part of the fall migration are greatly restricted. In addition, other open water areas where waterfowl concentrate, such as Areas B and D, have never been found to be contaminated with white phosphorous (CRREL 1992). Also, we are conservatively counting all feather piles as ducks dying from white phosphorus, even without confirmatory laboratory analysis.

Combining our estimated error for carcass counts and population estimates produces a range in mortality rate between 0.6% and 1.3% of the estimated fall

2007 dabbling duck population, with the median estimate being 0.9% (Table II-2-4). This mortality rate is just below the long-term goal of 1% mortality rate of the fall dabbling duck population. Because of the natural population variability and the considerable uncertainties in estimating both population and mortality, it will take several additional years of data collection to confirm that, indeed, we are meeting the long-term goal. Applying these same error bars to the data from 2004 through 2006 gives us median mortality estimates of 4.1, 3.1 and 0.8% (Table II-2-5.)

Figure II-2-4 plots the estimated fall dabbling duck population each year from 1996 through 2007 along with the estimated number of duck mortalities each year. Duck mortalities from 1996-2002 were determined from the NWRC telemetry studies. Mortality data are missing for 2000 and 2003 when telemetry studies were not conducted because no helicopters were available to support the project. Mortalities from 2004 through 2007 were determined from the ground-based transect surveys. Error bars for the population estimates and for the mortalities from 1996-2002 are based on the same assumptions used for the transect mortality analysis above. However, more uncertainties are involved with the telemetry methods of determining waterfowl mortality (NWRC 2004) and actual error bars for the 1996-2002 mortalities may be larger.

Table II-2-4. 2007 Mortality rate estimate with estimated error bars.

Parameter	Amount
Fall Population Estimate	5,279
Range in Population Estimate (± 20%)	4, 223 — 6,335
Range in Mortalities (+ 50% of those counted)	35 — 53
Range in Estimated Mortality Rate	0.55% —1.26%
Median Estimated Mortality Rate	0.9%

Table II-2-5. Mortality rate estimates for 2004 – 2007 with estimated error bars.

Year	Fall Population Estimates (±20%)	Mortality (+50%)	Mortality Rate	Median Mortality Rate
2004	2,927 – 4,391	111 – 167	2.5 –5.7%	4.1%
2005	1,704 – 2,556	49 – 74	1.9 –4.3%	3.1%
2006	3,583 – 5,375	25 – 38	0.5 –1.1%	0.8%
2007	4,223 – 6,335	35 – 53	0.6 –1.3%	0.9%

Figure II-2-5 plots mortality rate as a percentage of the total fall dabbling duck population from 1996 through 2007. Again, error bars for the 1996-2007 data may be larger than shown. Also shown are the five-year short-term and 20-year long-term remediation goals. The downward trend in mortality rates is pronounced with the long-term remedial action goal of less than 1% mortality of the fall dabbling duck population being met in each of the last two years. This reflects the tremendous amount of remediation that has occurred over the last ten years. In order to truly determine if the 20-year remedial action goal of 1% mortality rate has been met, annual monitoring of mortality should continue for the next several years. The exact amount of mortality monitoring that will take place will be determined as the Long-Term Monitoring Plan is developed over the next few months.

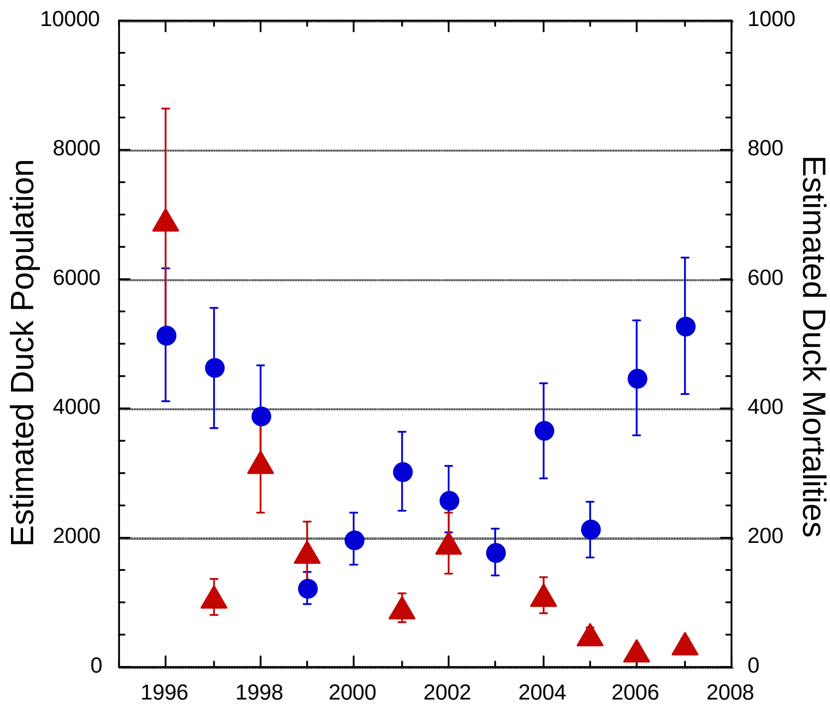

Figure II-2-4. Estimated fall dabbling duck population (dots) plus estimated number of duck mortalities (triangles). Duck mortalities from 1996—2002 were determined from NWRC telemetry studies. Mortality data are missing for 2000 and 2003 when telemetry studies were not conducted. Mortalities from 2004 through 2007 are from the ground-based transect surveys.

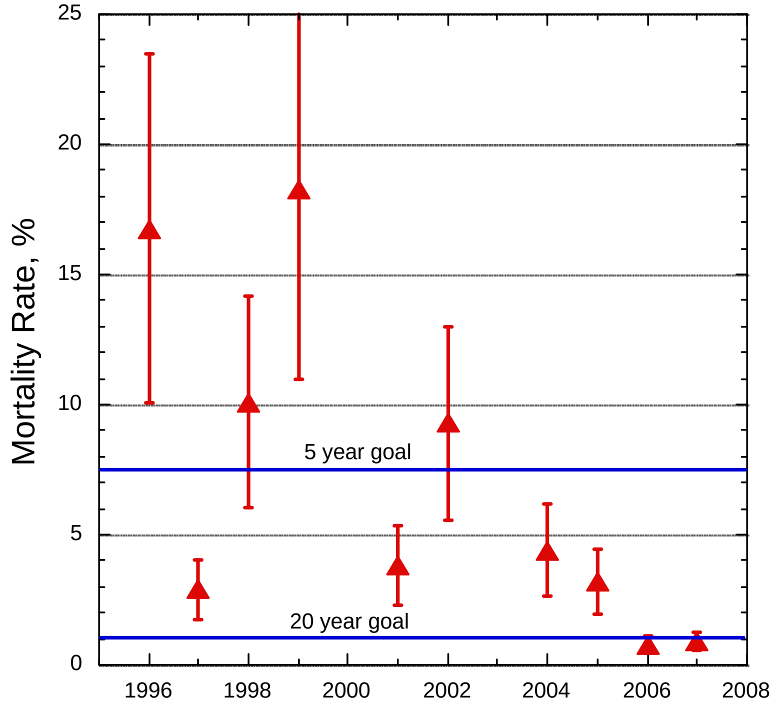

Figure II-2-5. Plot of estimated duck mortality rate as a percentage of fall Eagle River Flats dabbling duck population from 1996 – 2007. Included are the estimated mortality rates from 1996 – 2002 determined with NWRC waterfowl telemetry studies and the 2004 – 2007 mortality rates determined from the ground-based mortality surveys. Missing are data for 2000 and 2003 when waterfowl telemetry data were not collected.

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Table II-2-A1. Detailed data on the 36 duck mortalities in Eagle River Flats in 2007 (Page 1 of 2).

ID [1]	Date	Type [2]	Species	Found By [3]	Gizzard Collected?	Nearest Landmark
1	8/14	FP	GWT	CMC, JJ	No	North Ditch. Just E of X ditch
2	8/14	Partial Carcass	Mallard	CMC, JJ	No	Pond 730, S side adjacent to sump
3	8/14	FP	Mallard	CMC, JJ	No	Pond 730, south side.
4	8/22	Carcass	Mallard	CMC, JZ	Yes	Pond 720, east of sump
5	8/22	Carcass	GWT	CMC, JZ	Yes	North Ditch
6	8/24	Carcass	GWT	CMC, JZ	Yes	North Ditch
7	8/25	FP	Mallard (?)	CMC	No	E side of Pond 290
8	8/25	Carcass	Mallard	CMC	Yes	W side of Pond 290
9	8/25	Carcass, old	Mallard	CMC	No	W side of Pond 290
10	8/25	FP	Mallard	CMC	No	W side of Pond 290
11	9/4	FP	Mallard	AS, JZ	Yes	NW side of Pond 730
12	9/4	Carcass	Mallard	AS, JZ	Yes	South Ditch, cross ditch, S side.
13	9/4	FP	GWT	AS, JZ	No	North Ditch at T, SW edge of T
14	9/4	Carcass	Mallard	AS, JZ	Yes	On way from ditches to Clunie Point
15	9/7	FP	Mallard	CMC, AS	No	Main trail to ditches
16	9/7	FP	Mallard	CMC, AS	No	Corner of North Ditch and N Sump.
17	9/10	FP	GWT	JZ, AS	No	Top of Tower
18	9/10	Carcass	Mallard	JZ, AS	Yes	Pond 730, S Center side.
19	9/10	FP	?	JZ, AS	No	SW corner of Pond 730
20	9/10	FP	GWT	JZ, AS	No	Just next to Cap Hotdog Pond
21	9/10	Carcass	Mallard	JZ, AS	Yes[4]	By T on S side of S ditch
22	9/10	FP	Mallard	JZ, AS	No	NE corner of South Sump
23	9/10	FP	GWT	JZ, AS	No	NE side of South Ditch
24	9/12	FP	GWT	JZ, AS	No	SW of T Ditch in Center
25	9/19	FP	Mallard	CC, AS	No	On island, N end of tip of Pond 730
26	9/19	Carcass	Mallard	CC, AS	Yes	Near NW end of Pond 730
27	9/20	FP	Mallard (?)	CC, AS	No	Pond 226, north of tower.
28	9/24	FP	Mallard	CC, AS	No	On stump, E of C pond, main trail.
29	9/24	FP	Mallard	CC, AS	No	North ditch, SW end
30	9/24	FP	Mallard (?)	CC, AS	No	North ditch, north side
31	9/24	FP	GWT	CC, AS	No	West wing, on island. Pond 730
32	9/26	FP	Mallard	CC, AS	No	Just South of Hotdog ponds
33	9/26	FP	Mallard	CC, AS	No	Path from pond 730 to north ditch
34	9/26	FP	GWT	CC, AS	No	North ditch, north side
35	10/11	FP	Pintail?	CC, AS	No	Pond 226, NE corner
36	10/11	FP	Mallard	CC, AS	No	On trail by ice ridges, area A

[1] Mort ID Number; [2] FP–Feather Pile;

[3] CMC – Charles Collins, CC – Coleman Chalup, JJ – Jim Jepson, AS – Ann Staples, JZ – Jon Zufelt.

[4] Gizzard tested negative for WP.

Table II-2-A1 (cont.). Detailed data on the 36 duck mortalities in ERF in 2007 (Page 2 of 2).

ID [1]	Date	Easting	Northing	Vicinity	Nearest Landmark
1	8/14	355205	6801636	Ditch T	North Ditch. Just E of X ditch
2	8/14	354891	6801798	730	Pond 730, S side adjacent to sump
3	8/14	354881	6801804	730	Pond 730, south side.
4	8/22	354910	6801804	730	Pond 720, east of sump
5	8/22	355223	6801650	Ditch T	North Ditch
6	8/24	355202	6801628	Ditch T	North Ditch
7	8/25	354431	6800402	Area A	E side of Pond 290
8	8/25	354312	6800414	Area A	W side of Pond 290
9	8/25	354416	6800324	Area A	W side of Pond 290
10	8/25	354448	6800319	Area A	W side of Pond 290
11	9/4	354863	6801864	730	NW side of Pond 730
12	9/4	355239	6801515	Ditch T	South Ditch, cross ditch, S side.
13	9/4	355181	6801621	Ditch T	North Ditch at T, SW edge of T
14	9/4	355247	6801465	Other C	On way from ditches to Clunie Point
15	9/7	355171	6801388	Other C	Main trail to ditches
16	9/7	355297	6801684	Ditch T	Corner of North Ditch and N Sump.
17	9/10	355025	6801175	183	Top of Tower
18	9/10	354856	6801795	730	Pond 730, S Center side.
19	9/10	354847	6801838	730	SW corner of Pond 730
20	9/10	354930	6801708	Duck	Just next to Cap Hotdog Pond
21	9/10	355213	6801514	Ditch T	By T on S side of S ditch
22	9/10	355277	6801531	Ditch T	NE corner of South Sump
23	9/10	355272	6801580	Ditch T	NE side of South Ditch
24	9/12	355201	6801576	Ditch T	SW of T Ditch in Center
25	9/19	354881	6801919	730	On island, N end of tip of Pond 730
26	9/19	354875	6801893	730	Near NW end of Pond 730
27	9/20	353756	6800978	Area A	Pond 226, north of tower.
28	9/24	355123	6801427	Other C	On stump, E of C pond, main trail.
29	9/24	355045	6801529	Ditch T	North ditch, SW end
30	9/24	355131	6801600	Ditch T	North ditch, north side
31	9/24	354884	6801791	730	West wing, on island. Pond 730
32	9/26	355243	6801532	C/D	Just South of Hotdog ponds
33	9/26	354995	6801668	C/D	Path from pond 730 to north ditch
34	9/26	355013	6801595	Ditch T	North ditch, north side
35	10/11	353717	6801180	Area A	Pond 226, NE corner
36	10/11	354463	6800034	Area A	On trail by ice ridges, area A

III-1. EAGLE RIVER FLATS REMEDIATION PROJECT: REMEDIATION OPERATIONS

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INTRODUCTION

The 2007 field season was the fourth year of the monitoring phase for the Eagle River Flats remediation project as set out in the Record of Decision (RoD) signed in October of 1998 (CH2M Hill 1998). Since the 2003 season, limited active (pumping) and passive (controlled draining) remediation operations have been conducted to address the remaining known locations of white-phosphorus contamination. Residues from the detonation of several white-phosphorus (WP or P4) rounds and the number of mortalities in the Northern C-Marsh are indicators that active remediation efforts should be directed at this area. Additional contaminated areas, including the Duck Ponds, Pond 23, and the newly-discovered contaminated ponds in southern Area C, are also being addressed by non-active means (Figure III-1-1).

C-Marsh area requires remediation to fulfill the mortality endpoint obligation of the RoD, which specifies the use of pumping to remove overlying water in contaminated areas. This allows contaminated sediments to desaturate and the WP to sublimate. Pumping was carried out during the 2007 season within the drainage system developed in C-Marsh during previous seasons.

New this year was a capping test of Pond 23. Using locally sourced materials, CRREL conducted the test in early March. Gravel was placed over a mat on the previously demarcated pond. Following the spring melt and at the end of the summer season, the capped area was inspected for integrity.

Improvements to the site and our procedures continue to be implemented. We coordinated security of the area with Range Control to prevent fuel theft. Helicopter time has been reduced to a minimum. The diameter of the discharge line carrying the combined flow of the two pumps in C-Marsh was increased from 20 cm to 25 cm. We continue to assume a greater range of tasks related to operations, reducing both costs and time required to fulfill the mission.

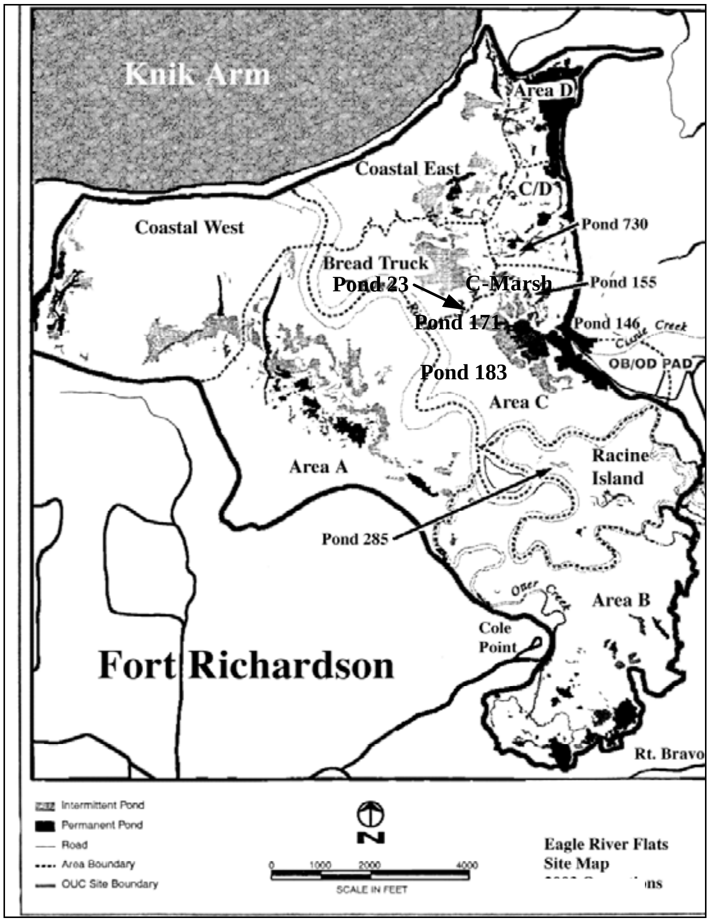

Figure III-1-1. Map of Eagle River Flats showing areas and pond identification numbers.

DEPLOYMENTS AND IMPLEMENTATION

Capping

The first deployment of the year in February and March was a test of the procedure for capping a pond in a marshy area east of the duck ponds. This entailed the rental of heavy equipment to dig and transport capping material. The winter timing of the work allowed access to the pre-marked site over an ice road.

The Record of Decision for Eagle River Flats states that the selected alternatives for remediation are pond pumping treatment followed by cap and fill application to address remaining areas not treatable by pond pumping. Previous attempts at capping with a bentonite / ballast mixture (AquaBlok®) transported by helicopter and applied aerially proved only partially successful and the deployment method expensive and problematic. Flushing action of the tides separated the bentonite from the mixture over time and slowly dissipated. Another method of capping was needed.

Previous success with construction of the flow control structure in the Bread Truck ditch indicated that winter application of capping material could be a cost-effective way to accomplish the work. To test this theory, a preliminary capping operation had been scheduled for winter 2007.

During the 2006 fall deployment, Pond 23 located in a marshy area between the Duck Ponds and Pond 730 was marked with large orange survey markers for future identification during treatment (Figure III-1-2). In March, after UXO clearance was completed, a 2-yard front-end loader was used to clear the roads, access to a gravel pile on the EOD pad, and the test site. A plow truck followed

a. Aerial view of Pond 23. Pond 730 is to the northwest.

b. Ground view of Pond 23 with marker stakes in place.

Figure III-1-2. Pond 23 prior to capping test.

the loader to clean up the areas and keep them clear of blowing snow. Then, the loader and a 5-yard dump truck were used to transport material from the gravel pile to the test site.

Retrieving gravel from the pile on the EOD Pad proved nearly impossible due to the presence of fines that froze the pile into one solid block. Access to the Otter Creek pit was granted and we used this source for almost all the capping test material. The material, unsorted gravel ranging from granulated fines up to 30-cm cobbles, was laid on an open-weave jute mat to a depth of about 20 to 40 cm (Figure III-1-3). It was difficult to apply an even layer because of the uneven size of the material constituents. However, the designated area was completely covered with additional material extending beyond the edge of the mat along the perimeter to ensure the mat stayed in place during spring thaw. All work was completed within the planned one-week timeframe.

In May, the site was inspected for cap coverage and integrity. The markers remained through the winter season, giving us physical reference points. As shown in Figure III-1-4, the cap remained in place over the winter and is contiguous over the area of the test cell. The water-filled low points correspond to the deeper areas of the original pond.

Pumping

Although we tentatively met our long-term mortality goal in 2006, the remediation project managers (RPMs) felt it was necessary to execute one more year of comprehensive treatment in the C-Marsh area to ensure we had truly met our goal. In addition, mortalities continued to be clustered around the Bangalore ditch areas; it was felt an additional season of draining and drying would reduce the presence of WP available for ingestion by the dabbling ducks. Draining the area also facilitates sampling and creates a safer operating environment for the different projects conducted in the area. Therefore, a partial pump deployment was tasked for the 2007 season.

Initial deployment for the pumping project occurred in May, when three pump systems were once again fielded at the Flats. System 3, which was reinstalled in Pond 146, has a theoretical capacity of up to 189 L/s (3000 gpm). Through a complex of interconnecting ditches, this system addresses most areas known to remain contaminated: C-Marsh, Ponds 155 and 171, and the less-contaminated Pond 183 (Figure III-1-1). Draining these areas allows in-situ remediation to occur.

a. Laying out geotextile mat at test site. Note survey markers.

b. Spreading last load of gravel. Wind and drifting snow are evident.

Figure III-1-3. Winter capping operations on Pond 23.

To address the Bangalore ditches and locally-contaminated areas in C-Marsh, two pumps (Systems 4 and 5) were installed in sumps located within the ditch system. These are 126 L/s (2000 gpm) pump systems with shore-based trailer-mounted generators located at the Bomb Crater Pad east of C-Marsh. The pumps were located in the Bomb Crater sump (#4) and the South sump (#5). The 20-cm discharge lines were tied together in a “Y” north of the north Bangalore ditch, connecting with a 25-cm line that led to a gully draining into the Eagle River.

a. Aerial view in Fall looking west.

b. View from ground level looking northwest (Spring).

Figure III-1-4. Capped pond following the first winter.

The 2007 season tidal pattern favored deployment of the systems in late May. System 3 was installed in the sump at the end of the old dredge channel in Pond 146. The pump was installed by floating it into position from Clunie Pad. On 18 May, the genset and 1900-L single-walled mobile fuel tank were put in place on a fuel-spill containment structure at the EOD gravel pad on shore nearby (Figure

III-1-5a). Two other 1900-L stationary double-walled fuel tanks were also co-located with the genset. On 21 May, System 3 was hooked up, test-fired, and placed in operation later in the day.

Preparations for deployment of Systems 4 and 5 started on 18 May. The two gensets were set up on spill containment structures at the Bomb Crater Pad (Figure III-1-5b). Double-walled fuel tanks were emplaced on 19 May and all materiel for the remediation project was on site by the end of the day. Maintenance was performed on the fuel tanks and pumps and the discharge line was readied for airlift to the field. On the 22nd, the pumps were flown out to their respective sumps by the Alaska Army Air National Guard using a UH-60L Black Hawk helicopter. On the 23rd, the pipe was flown out and assembled to the pumps in C-Marsh. Both systems were operational that afternoon.

While Systems 4 and 5 were operating well, problems with System 3 started almost immediately. A serviceman from Cummins Northwest worked on the system five times over the course of nine days before the generator shorted out, rendering the system inoperable. Fortunately, the pumps operated long enough to drain the area down and cycle a few times. On 18 June, Genset 3 was pulled and taken to the Cummins Northwest shop for a rebuild.

Other service and maintenance functions were performed during the spring deployment. The oil and filters were changed on Systems 3 and 5 since the maintenance had not been done on these units the previous fall. Switch control cords for Systems 4 and 5 were rebuilt because the connectors had corroded. Hose sections on System 3 were repaired or replaced due to age or porcupine attack. In addition, discharge line connector clamps on System 3 had to be replaced due to corrosion. Most of these clamps no longer function and will need to be replaced before the start of the next season.

The systems were fueled on 25 May (7,230 L). Implementation of additional security measures at the genset sites negated the need for a mid-season refueling deployment.

On 1 August, repairs to System 3 were completed and the system was reinstalled. It was placed in operation 2 August and left running through the end of the season.

In late August, the final field deployment was conducted to pull the equipment from the field. System 5 was shut down on 22 August and System 4 shut down the following day. System 3 was shut down on 25 August, concluding the (maybe) last season of active remediation for the Eagle River Flats project. The discharge line for Systems 4 and 5 was flown out on 24 August and the pumps on 28 August. Oil and filters were changed on each genset as they were taken out of service. Operations concluded on 29 August.

a. System 3, off the EOD Pad.

b. Systems 4 and 5 on the BC Pad.

Figure III-1-5. Generator and fuel tank setups for the 2007 season.

IMPLEMENTATION

The 2007 season was predicted to be very good for remediation based on the lack of flooding tides over the majority of the season (Table III-1-1). Weather conditions during this period have normally been favorable, with summer rains holding off until early July and sometimes into August. Moderately high flooding tides at the end of August would terminate the contiguous dry spell, and very high flooding tides in mid-September were predicted to finish off the season. We therefore set the installation date to mid-May and the pull-out date to the end of August, prior to the flooding tides.

Primary early season pump-down of the C-Marsh / Pond 146 area was relegated to System 3. Water level in the area was drawn down within three days, but the pump system operated only sporadically over the period and suffered a fatal malfunction shortly after cycling began. After the initial pump-down, Systems 4 and 5 were engaged. Less pumping time was logged this season than last, especially for System 3, which was down over 60 days. No flooding tides occurred during the treatment season. Although no problems occurred this season with the Bread Truck structure, rapid downstream erosion on the west side will eventually compromise its ability to function.

This season we monitored water levels in several locations within the Bangalore ditch system. An area along the northern Bangalore ditch is one of the most heavily contaminated at the Flats and is where many mortalities were found during the 2005 and 2006 field seasons. Although pumps operated in two sumps within the ditch system, some water remained in the major ditches over the summer (Fig. III-1-6). Several high points along the Bangalore ditches were deepened by digging to facilitate drainage, and a few small hot spots connected and drained to the ditch system. The diversion ditch parallel to and north of the northern Bangalore ditch created in 2006 was further developed to drain water away from the north side of the Bangalore ditch. The drainage in Area C created to facilitate drying the sides of the ditches and to port off water from leaky discharge lines was cleaned up to enable better flow. No additional work was conducted in southern Area C. The Duck Ponds continued to slowly dry out as

Table III-1-1. Predicted 2007 flooding tides (May–September).

Day		Time	Height (m)	Time	Height (m)
May	15	0658	9.54	1950	9.08
	16	0740	**9.78**	2041	9.17
	17	0823	**9.91**	2129	9.17
	18	0906	**9.81**	2216	9.08
	19	0951	9.54	2303	8.93
June		–	–	–	–
July		–	–	–	–
August	29	0859	9.63	2132	9.51
	30	0942	9.66	2206	**9.75**
	31	1026	9.54	2241	**9.91**
September	1	1111	9.24	2319	**9.85**
	2	1159	8.81	2400	9.54

Notes: Pre-season tidal predictions.
> 9.48 m tides are normally flooding tides.
Actual flooding tides in **Bold RED**.

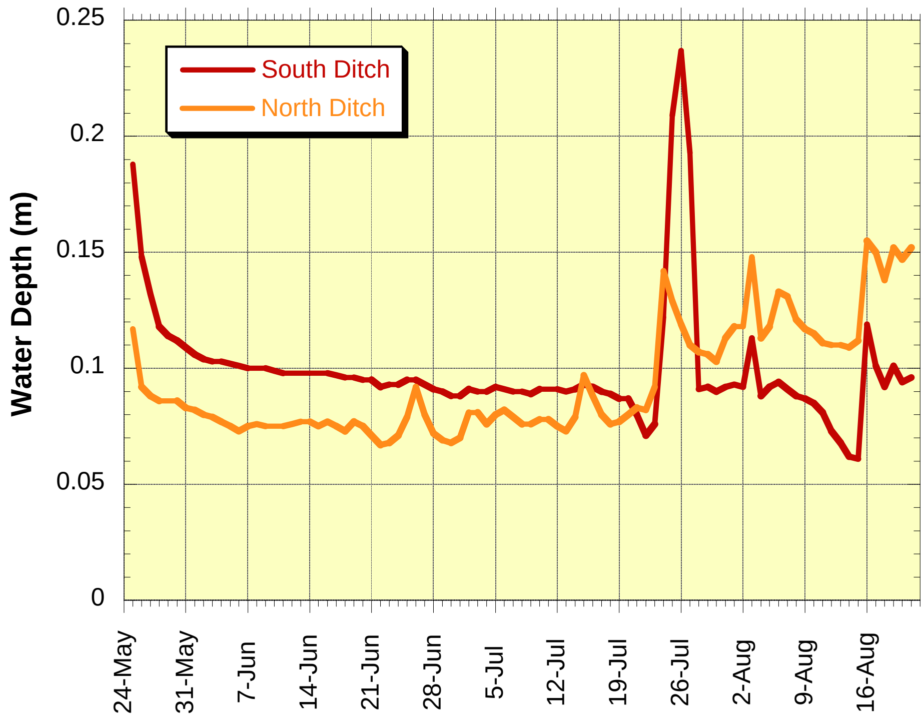

Figure III-1-6. Water levels in the Bangalore ditch system.

well, and the tide gate on the drainage ditch was re-seated to help control inflow. As previously stated, no flooding tides occurred over the course of the season and no additional fuel was brought on site.

Although rainfall amounts were low, frequent showers seemed to hamper remediation in the areas drained. However, this was a good season. There were no flooding events between startup (21 May) and shutdown (28 August), giving us an effective contiguous "dry" period of 98 days. All the ponds and hot spots drained over the course of this span of 15 May to 10 August (Fig. III-1-7).

PERFORMANCE EVALUATION

Sediments in Ponds 146, 155, and 171 continued to dry this season. The lack of flooding tides throughout the season was offset somewhat by frequent rains, as reflected in the higher than normal water levels in Pond 146. Discrete sampling as well as UXO clearance indicate that C-Marsh remains contaminated, and once again a significant proportion of mortalities were recorded in this area, specifically near the major ditches. The statistics related to run times for the 2007 season are given in Table III-1-2. The large number of cycles for System 4 is indicative of the constant flow of water into the northern Bangalore ditch from the northern reaches of the Flats.

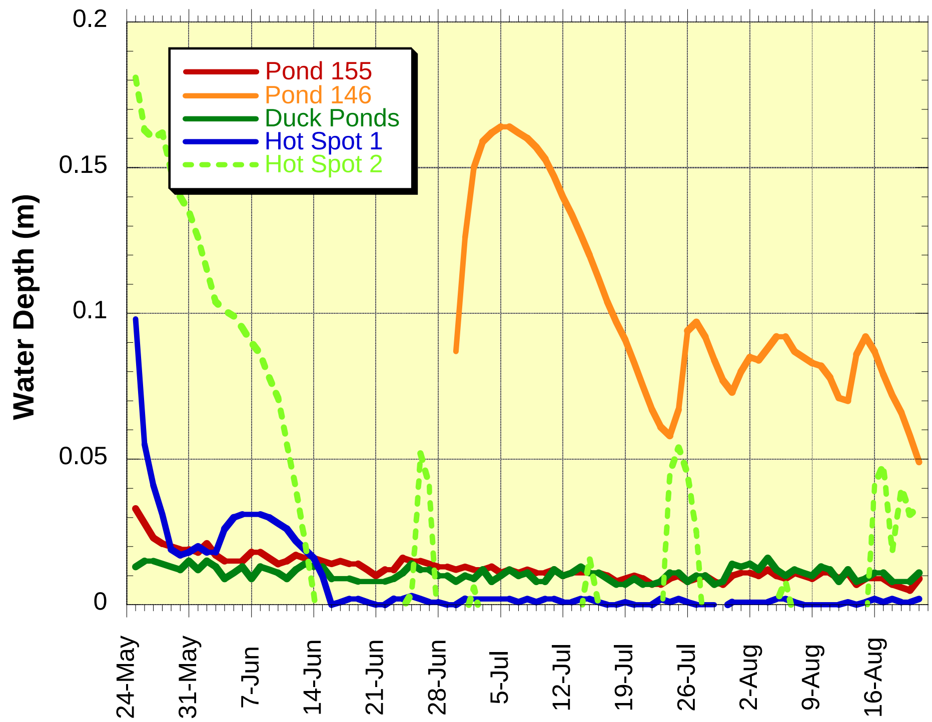

Figure III-1-7. Water levels in treated ponds.

Table III-1-2. Pump operation statistics for the 2007 season.

System	Start date	Stop date	Span (days)	Genset hours	Pump hours*	Pump cycles
3	21 May	25 Aug	96	62.3	38 (1)	51 (1)
					30 (2)	16 (2)
4	24 May	23 Aug	91	289	149	916
5	24 May	22 Aug	90	20	11	76

* System 3 has two pumps, 126-L/s (1) and 63-L/s (2).

Parameters of the pumping system operation are graphed in Figure III-1-8. Although the Flats were flooded when we arrived in the Spring, not a lot of water was present. Therefore, the initial pump-down only took a short time. The steady climb in System 4 pump cycles resulted from flow through a beaver channel near the east edge of the flats into the north Bangalore ditch. System 5 ran very little, due partly to a lack of maintenance over the summer that resulted in the battery going dead (See spike in water elevation in South Ditch, Figure III-1-6).

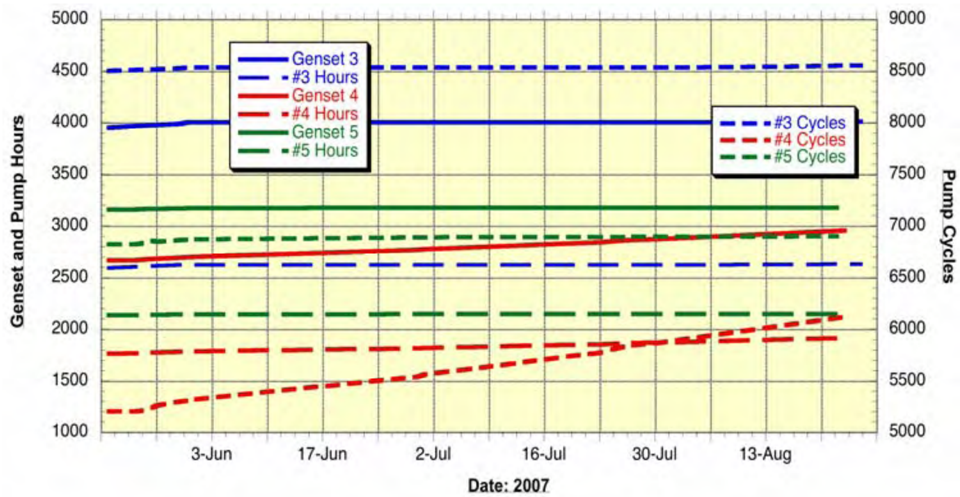

Figure III-1-8. Pump and genset operation over the course of the 2007 season. Cumulative genset hours are shown with solid lines, pump hours in long dashed lines, and pump cycles in short dashed lines.

The two-pump arrangement in C-Marsh worked well. The larger discharge line downstream from the Y decreased the load on the pumps and no erratic behavior during pumping was observed. The constant flux of water towards and along the north rim of the north Bangalore ditch kept most of that side of the ditch from drying. The det cord ditch installed in 2006 was not sufficient to effectively drain the water from the side of the ditch.

The cap placed on Pond 23 held up well through the spring thaw and flooding tides. Vegetation is encroaching along the edges of the gravel and we anticipate a slow accumulation of fines and vegetation over the years. The site will continue to be monitored in the out years.

A summary of the events in the 2007 season is given in Appendix III-1-A. Appendix III-1-B has information related to all the 2007 operation and maintenance activities. And finally, Appendix III-1-C gives an abbreviated historical chronology of all pumping operations since 1997.

BEYOND THE 2007 SEASON

The final active remediation season at Eagle River Flats (OU-C) that had been planned in the 1998 Record of Decision occurred during the 2003 season (CH2M Hill 1998). The plan also called for the remaining WP contamination to be either covered with a cap-and-fill material or remediated in a limited, area-specific manner using pumps or ditching as we have done the last few seasons. Determination whether the remediation goals of a 50% reduction in the 1996 mortality rate and a 1% overall mortality rate after 20 years have been achieved will need to be made with the minimum of activity on the Flats. The initial goal of a 50% reduction in the 1996 overall mortality was achieved during the 5-year intensive remediation phase of the project (1999–2003), based on data from the mortality studies conducted by the National Wildlife Research Center (Cummings et al. 2003). Data from the mortality transects over the last two treatment seasons indicate that the 1% overall goal has been met.

Since the 2003 season, limited remediation activities, concentrated in the C-Marsh area, have been conducted. This has resulted in the slow, steady decrease in duck mortalities. With two successful seasons behind us, the RPMs have decided to halt active remediation operations (pumping) with the 2007 season. It is anticipated that System 3 will be redeployed to Pond 146 in 2008 but only to drain the C-Marsh area temporarily during the spring and fall deployments to facilitate sampling and enhance operational safety.

The successful capping test in 2007 indicates that winter capping of hotspots is a feasible and cost-effective method of remediation of recalcitrant areas. The RPMs tasked CRREL at the year-end meeting to address as many hot spots over the winter of 2008 as possible in a single mission. A deployment is scheduled for early February, and planning is under way. It is anticipated that at least one additional capping mission will be required to address all the major hot spots.

Monitoring of the capped areas is also a task outlined in the RoD. The 2007 and 2008 caps will be monitored on a yearly basis in the out years. Revegetation experiments will also be conducted on some of the capped areas.

Contingency planning is currently underway to address a possible future spike in mortalities. Action levels and options are being considered. The pumping equipment is to be put in maintained storage until a sufficient number of seasons pass with the mortality rate below the goal specified in the RoD. Remobilization for an additional capping mission will be possible on short notice.

REFERENCES

CH2M Hill (1998) Record of decision for Operable Unit C, Fort Richardson, Alaska. Contract document no. DAC85-95-D-0015, Delivery Order 0012.

Cummings, J.L., P.A. Pipas, C.H. Racine, R.E. Johnson, J.B. Bourassa, J.C. Carlson, K.H. Sheffer, K.L. Tope, and J.E. Davis (2003) Movement, distribution, and relative risk of mallards using Eagle River Flats. In *Remediating and Monitoring White Phosphorus Contamination at Eagle River Flats (Operable Unit C), Fort Richardson, Alaska* (C.M. Collins and D.W. Cate, ed.). CRREL Contract Report to U.S Army, Alaska, Directorate of Public Works. FY 2002 Final Report, p.23–43.

APPENDIX III-1-A. CHRONOLOGY OF EVENTS FOR THE 2007 SEASON

The following is a chronology of the pond pumping project for the 2007 season from January through December.

Date	Event
January	Develop pumping, capping, monitoring, and sampling master schedules
February	27 Feb: Mobilize for capping ops. Briefings, organizing, and clearing areas. 28 Feb: Start of capping operation. 1 March: Finish capping operation. 2 March: Demobilization day.
May	15 May: BSE and CRREL start clearing operations. 17 May: Start mobilization of equipment. 18 May: Set up System 3. 19 May: Finish transfer of equipment to EOD Pad. Prep equipment for airlift. 21 May: System 3 operational. Remediation begins. 22 May: National Guard flies out remaining two pumps. System 3 down. 23 May: Fly out and assemble discharge line. Fuel all systems. Test run System 4. System 3 operational. 24 May: All systems on line. Treatment areas drained. System 3 goes down again. 25 May: Fueling run (1910 gals.). Start demobilization. 29 May: System 3 back up and running. 30 May: System 3 down. 31 May: Fifth service visit. System 3 down until major repairs can be conducted.
June	1 June: Equipment turned over to CRREL-FRA for O&M. 18 June: Genset 3 transported to Cummins Northwest for repair.
August	1 August: Genset 3 repairs completed. Unit retrieved. 2 August: Genset 3 operational. 21 August: Mobilization day – Fall deployment. 22 August: Shut down System 5. Change oil and filters. Start equipment transfer to Post. 23 August: Shut down System 4. Change oil and filter. Equipment transfer to Post. 24 August: Transfer discharge line to EOD Pad and transport to ENV yard. 25 August: Shut down System 3. Change oil. Clean up containment units and EOD Pad. 26 August: Hot spot and capping work. Pack containment units. 28 August: Pumps flown back to EOD Pad. Finish retrograde of equipment to Environmental yard. 29 August: Demobilization day.
October	Data analysis. Start rough draft of report. Presentation preparation for end of year meeting.
December	11 – 12 December: Year end review: Seattle. Start developing pumping, capping, monitoring, and sampling master schedules. Start organizing capping mission for February.

APPENDIX III-1-B. O&M LOG FOR THE 2007 SEASON

The following table (Table III-1-B) constitutes the operation and maintenance (O&M) log for units fielded at Eagle River Flats during the 2007 season. The shorting of the generator coil on System 3 was the major problem that occurred during the 2007 season. This occurred during the initial deployment of the season and rendered the unit inoperable after the initial pump-down and cycling of Pond 146. The unit was towed to the repair shop and put back on line on 2 August. Over 60 days of the core season were missed. Several problems were addressed during deployment prior to turning the equipment over to the summer O&M crew. Over the summer, only dead batteries caused any problems with Systems 4 and 5. As all systems were shore-based this year, O&M required only one person and no helicopter-assisted refueling operations were conducted. Increased security measures aimed at preventing fuel theft and a shortened remediation season allowed us to operate the whole season on the original fuel allotment. These factors saved the project a significant amount of money.

In addition to servicing the fielded equipment, CRREL also maintained the stored equipment. Five generators were started once a month in the Environmental (ENV) storage yard. We are still experiencing some starting difficulties, even with the shut-off switches to the batteries. We have worked around this problem for the time being.

At the end of the season, CRREL did an oil and filter change on the active units. All systems are now in the ENV storage yard.

Table III-1-B. O&M Log for 2007.

	System 3					System 4			System 5			
	Genset	Pump 1		Pump 2		Genset	Pump		Genset	Pump		
Date	(Hrs)	Hours	Cycles	Hours	Cycles	(Hrs)	Hours	Cycles	(Hrs)	Hours	Cycles	Notes
20-May	3949	2591.0	8501	1239.0	922	2664.5	1763.0	5200	3156.8	2134.8	6822	Start #3. Test 4&5. Sys 4 Running
23-May						2665.1	1763.5	5202	3156.8	2134.8	6822	Sys 3 Down. Sys 4 & 5 Running.
24-May						2669.1	1767.3	5203	3158.6	2134.9	6823	Sys. #3 intermittent.
25-May						2675.5	1771.0	5220	3163.4	2137.9	6860	
26-May						2679.7	1773.3	5255	3165.4	2139.0	6848	
29-May	3987.7	2621.8	8527	1269.0	938							System 3 running again.
30-May	4000.4	2622.5	8532	1269.0	938							Sys. 3 dead.
1-Jun						2699.8	1783.0	5321	3170.1	2141.6	6869	O&M turned over to CRREL - FRA
29-Jun						2764.7	1814.2	5536	3174.1	2143.6	6887	
1-Jul						2772.8	1818.2	5562	3174.4	2143.7	6888	
6-Jul						2786.9	1825.3	5607	3174.8	2144.0	6890	
12-Jul						2805.0	1834.3	5665	3174.8	2144.0	6890	
19-Jul						2827.3	1845.7	5735	3175.3	2144.2	6892	
23-Jul						2838.9	1851.7	5770	3175.3	2144.2	6892	
26-Jul						2858.7	1862.4	5828	3175.3	2144.2	6892	
27-Jul						2861.8	1864.0	5838	3175.9	2144.5	6894	
30-Jul						2869.5	1867.9	5863	3175.9	2144.5	6894	
1-Aug	4000.4	2622.5	8532	1269.0	938							Sys 3 reinstalled. #5 down-switched w/#4
2-Aug												Sys 3 back on line. 4&5 switched back.
8-Aug												#5 down again-Battery.
22-Aug									3177.0	2145.3	6898	#5 shut down. Oil/filter changed.
23-Aug						2953.2	1911.6	6116				#4 shut down. Oil/filter changed.
25-Aug	4011.3	2628.9	8552	1269.1	938							#3 shut down for season. Oil changed only
Totals	62.3	37.9	51	30.1	16	288.7	148.6	916	20.2	10.5	76	

APPENDIX III-1-C. SYSTEM DEPLOYMENT DATA FOR PUMPING PROJECT

Appendix III-1-C contains a brief history of pumping activity since the start of large-scale pump tests during the remediation investigation phase of the project. The period of full-scale remediation occurred from 1999 through the 2003 season.

Table III-1-C1. Pond pumping activity at ERF.

Year	Start Date	Stop Date	Pond	Pond Area(Ha)	Duration (Days)	Description	Predicted Flood Tides	Flooded (Days)	O&M Support
1997									
	16-May	13-Sep	183	2.87	121	System 1: 126 L/s	20 - 24 Jul	7	CH2M Hill
							18 - 23 Aug	10	
1998									
	1-Jun	27-Aug	183	2.87	88	System 1: 126 L/s	23 -25 Jun	0	CH2M Hill
	25-Jun	27-Aug	258	1.72	64	System 2: 126 L/s	1-12 Aug	5	
	27-May	28-Aug	146	5.54	94	Sys. 3: 63/126/189		(No flood	
	23-Jun	27-Aug	256	0.39	66	System 4: 126 L/s		in Area	
	28-May	27-Aug	290	0.91	92	System 5: 126 L/s		A)	
	1-Jun	27-Aug	155	0.35	88	System 6: 63 L/s.			
1999									
	26-May	21-Sep	183	2.87	129	System 1: 126 L/s	12 - 17 Jun	7	Weldin
	27-May	21-Sep	730	0.78	128	System 2: 126 L/s	12 - 15 Jul	0	
	21-May	23-Sep	146	5.54	136	Sys. 3: 63/126/189	11 - 13 Aug	0	
	26-May	21-Sep	258	1.72	129	System 4: 126 L/s			
	27-May	21-Sep	256	0.39	128	System 5: 126 L/s			
	26-May	21-Sep	155	0.35	129	System 6: 63 L/s.			
2000									
	11-May	15-Aug	183	2.87	97	System 1: 126 L/s	2 - 5 Jun	0	Weldin
	11-May	16-Aug	258	0.39	98	System 2: 126 L/s	1 - 5 Jul	5	
	8-May	17-Aug	146	5.54	102	Sys. 3: 63/126/189	30 Jul - 3 Aug	10	
	11-May	16-Aug	256	1.72	98	System 4: 126 L/s			
	12-May	16-Aug	730	0.78	97	System 5: 126 L/s			
	11-May	17-Aug	155	0.35	99	System 6: 63 L/s.			
2001									
	10-May	8-Sep	183	2.87	122	System 1: 126 L/s	21 - 24 Jul	7	Weldin
	10-May	8-Sep	75	0.1	122	System 2: 126 L/s	19 - 23 Aug	9	
	3-May	13-Sep	146	5.54	134	Sys. 3: 63/126/189			
	10-May	8-Sep	730	1.72	122	System 4: 126 L/s			
	10-May	8-Sep	246	1.32	122	System 5: 126 L/s			
	10-May	8-Sep	155	0.35	122	System 6: 63 L/s.			

Table III-1-C1 (cont.). Pond pumping activity at ERF.

Year	Start Date	Stop Date	Pond	Pond Area(Ha)	Duration (Days)	Description	Predicted Flood Tides	Flooded (Days)	O&M Support
2002									
	30-May	22-Aug	BC	–	86	System 1: 126 L/s	25 - 28 May	2	Weldin
	18-May	22-Aug	75	0.1	97	System 2: 126 L/s	10 - 12 Aug	2	
	15-May	27-Aug	146	5.54	105	Sys. 3: 63/126/189			
	18-May	22-Aug	246	1.32	97	System 4: 126 L/s			
	20-May	22-Aug	730	1.72	95	System 5: 126 L/s			
	20-May	22-Aug	155	0.35	95	System 6: 63 L/s.			
2003									
	24-May	10-Sep	C-So	–	110	System 1: 126 L/s	14 - 15 Jun	2	Weldin
	24-May	10-Sep	C-No	–	110	System 2: 126 L/s	30 - 31 Jul	1 (?)	
	19-May	10-Sep	146	5.54	116	Sys. 3: 63/126/189			
	24-May	10-Sep	730	1.72	110	System 4: 126 L/s			
	24-May	10-Sep	BC	–	110	System 5: 126 L/s			
	24-May	10-Sep	155	0.35	110	System 6: 63 L/s.			
2004									
	13-May	28-Aug	146	5.54	106	Sys. 3: 63/126/189	3-4 June	12	CRREL
							3-4 July	7	
							1-2 Aug	4	
2005									
	21-May	14-Sep	146	5.54	117	System 3: 126 L/s*	22 - 25 July	10	CRREL
	26-May	13-Sep	BC	–	111	System 5: 126 L/s	19 - 23 Aug	10	
2006									
	15-May	29-Aug	146	5.54	107	Sys. 3: 63/126/189	10 - 14 Aug	12	CRREL
	19-May	28-Aug	C-So		102	System 4: 126 L/s			
	19-May	28-Aug	BC	–	102	System 5: 126 L/s			
2007									
	21 May	25 Aug	146	5.54	34**	Sys. 3: 63/126/189	None	0	CRREL
	24 May	23 Aug	BC		91	System 4: 126 L/s			
	24 May	22 Aug	C-So	–	90	System 5: 126 L/s			

*63 L/s Pump down for the season shortly after start-up.
System 3 down for most of the middle of the core season

III-2. LONG-TERM MONITORING AND SAMPLING OF SEDIMENTS OF PONDS TREATED TO REMOVE WHITE PHOSPORUS

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INTRODUCTION

Summer 2007 was the fourth field season of long-term-monitoring after five years of full-scale active remediation by pond pumping of white phosphorus-contaminated ponds at Eagle River Flats (ERF). The major objectives of the 2007 season were to

- identify which small pools and ditch segments will require capping,
- assess continued clean status of ponds previously remediated using pond pumping and determine if a rebound in contamination due to exposure of buried white phosphorus (WP) residue has occurred,
- monitor sediment moisture and sediment temperature conditions in pools and ponds to determine the effectiveness of pumping in producing favorable remediation conditions, and
- locate remaining small areas of white phosphorus contamination not previously identified.

Monitoring methods include

- collecting multi-increment samples of pond surface sediments to determine how much WP is present,
- collecting discrete samples from locations that previously had high concentrations of WP to monitor temporal concentration changes,
- measuring sediment moisture and temperature to assess sublimation/ oxidation conditions at selected locations within contaminated and remediated ponds, and
- measuring residual WP from planted white phosphorus particles of known initial mass.

Monitoring also includes a ground-based waterfowl mortality survey and a meteorological station that are described elsewhere in this report (Collins et al. Section II-2, Collins Section III-3).

METHODS

Discrete Samples

In 2003 we found that high concentrations of white phosphorus were generally co-located with metallic remnants of detonated WP ordnance items such as mortar tail assemblies. In 2004 we performed a systematic magnetometer survey of the Area C Marsh (Fig. III-2-1) and the southeast section of Area BT to locate potential hotspots (localized areas of very high white phosphorus concentration). Between 2003 and 2004 we found 81 locations with WP and ordnance scrap. Additional surveys in 2005 and 2006 revealed three more hotspots. In May 2007 we resampled 77 previously identified hotspots (Fig. III-2-2), plus six new locations where metallic scrap was found. To locate the sample positions in the field, we navigated with a Trimble GPS Pathfinder Pro XR system to the selected UTM coordinates and used the site markers that remained from previous sampling. At each location, at least 20 increments of surface sediment were collected to fill a 250-mL container. All discrete sample

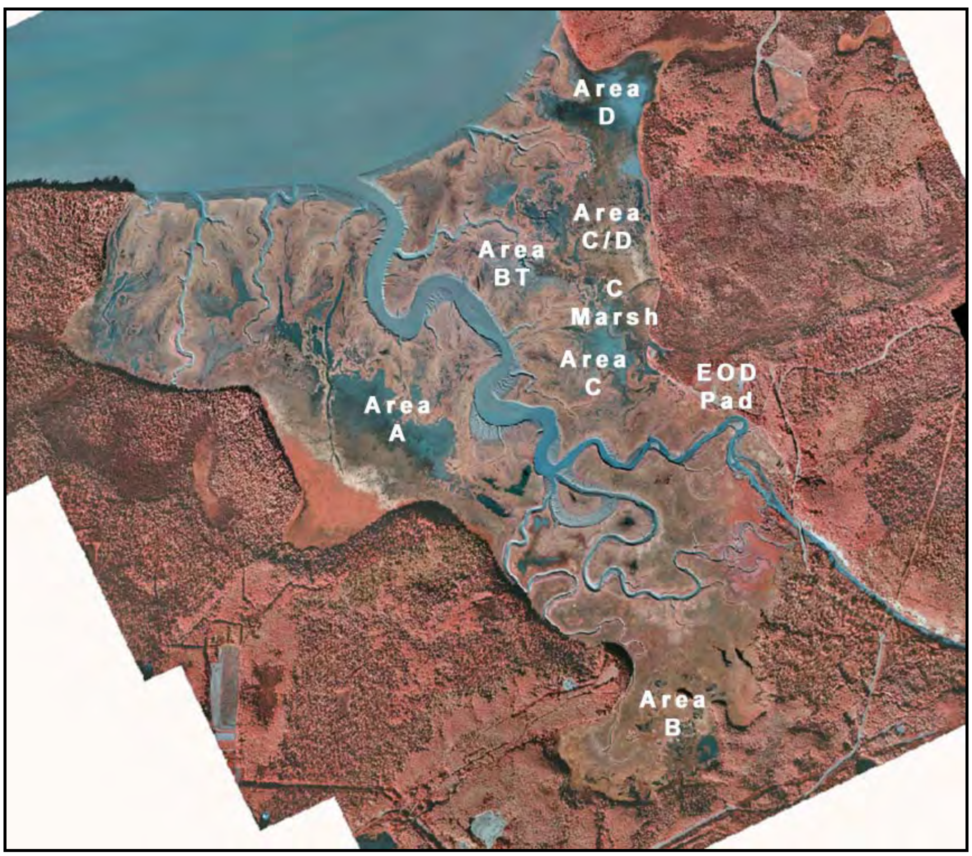


Figure III-2-1. Aerial photo of ERF (Aero-Metric September 2006) annotated with the standard area designations. Most residual white phosphorus resides in Area C Marsh.

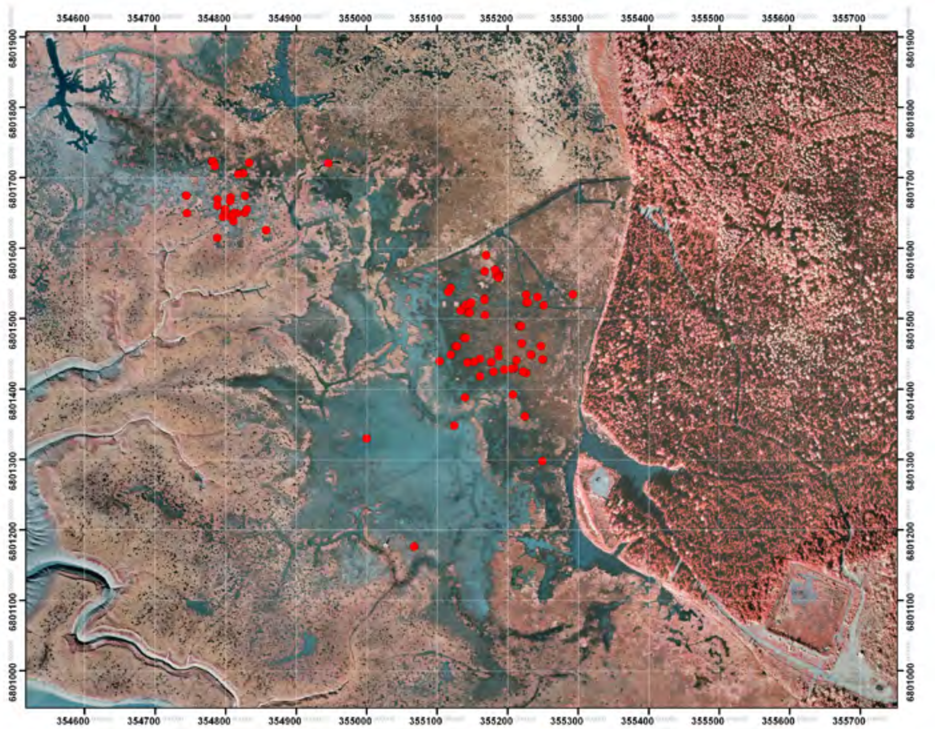


Figure III-2-2. Map of discrete locations in Area C and Area BT that were resampled in 2007 to determine if capping is required.

locations were photographed in May 2007 (Appendix III-2-A); in August 2007, we marked all locations where WP concentrations were still greater than 1 µg/g with an orange survey stake for subsequent capping.

Multi-increment Samples

Multi-increment sampling mimics the way that dabbling ducks feed in shallow ponds. Samples are collected from an area much larger than that for discrete samples. This sampling method is more likely to reveal the presence of hotspots than discrete sampling because each multi-increment sample is composed of many subsamples over the area we wish to represent. We collect multi-increment sediments using three methods (Fig. III-2-3).

The first method (grid multi-increment sampling) was developed in 1996 (Walsh et al. 1997) as an alternative to using penned sentinel ducks to determine if sufficient WP mass was present in a defined area to poison waterfowl. In this method, samples are formed by combining sediment subsamples collected using an Oakfield corer (2-cm diameter) to a depth of 10 cm at the nodes of a 1.82-m-square grid. Spacing of the subsamples is designed to detect 2-m diameter hotspots (Gilbert 1987). Use of a quadrat helps to maintain relatively precise subsample spacing (Fig. III-2-3a). Decision unit grid size is generally around

a. 1.82-m square grid (sediment)

b. linear (sediment)

c. sieved (≥0.59-mm size fraction)

Figure III-2-3. Three methods used to form multi-increment samples.

5.46 x 20 m, yielding 48 subsamples per multi-increment sample. Each multi-increment sample, which weighs about 2 kg, is mixed by stirring; a 200-g sub-sample made up of at least 30 increments is analyzed for white phosphorus. Based on the method detection limit for the analytical method (0.0002 µg/g), a single sediment increment with a white phosphorus concentration of 0.01 µg/g will yield a detectable white phosphorus concentration in the multi-increment sample. Lethal white phosphorus particles are generally associated with much higher concentrations (1 µg/g). Placement of the decision unit grids is tailored to the area to be sampled. To sample small ponds, decision unit grids are placed to maximize coverage of open water (i.e. ponds in Area C/D); to sample marsh areas such as C Marsh that contain many small pools, decision unit grids are placed at intervals (e.g., 30-m). When WP was detected within the marsh, then individual pools within and near the positive grids were individually sampled.

The second sampling method is tailored for linear features such as the drainage ditches in C Marsh that are narrow for a quadrat (Fig. III-2-3b). Multi-increment samples are built with sediment subsamples taken every one to two meters from the walls and bottoms of the ditches. A 20- to 60-m-long segment of a ditch may be sampled to form one multi-increment sample.

The third method (sieved multi-increment) is for water-covered areas and is used to sample a large area (entire pond) or to intensively sample smaller areas by taking increments at least every half meter and placing them in a sieve bucket (0.59 mm mesh) (Fig. III-2-3c). The sediment is stirred underwater to remove the fine-grained sediment. The mesh is sufficiently fine to also retain the ecologically relevant white phosphorus particles that, if present, would pose significant hazard to waterfowl. This method was used in 2007 in the South Ponds of Area C, Pond 730 in Area C/D and Pond 290 in Area A (Fig. III-2-4).

Treated Ponds

We resampled Ponds 146, 171, and 155 (Fig. III-2-4) using the grid multi-increment sampling method. Within these ponds, sediment samples were collected from previously sampled 5.46-m x 20-m decision units. All three ponds were last sampled in 2006. At that time WP was not detectable above the method detection limit (0.0002 µg/g) in Ponds 146 and 171; in Pond 155, WP was still detectable. White phosphorus has remained detectable in Pond 155 for a much longer time than other treated ponds. In May 2007, we temporarily removed the metal tripods used to support datalogger stations, and our UXO technician performed a thorough survey for metallic scrap using a Schonstedt (Fig. III-2-5). At each point where metallic scrap was found, a co-located sample of sediment was collected for analysis of WP.

Surveys for metallic scrap were also conducted in Pond 730, in Area C/D (Fig. III-2-4), and in Pond 290 in Area A. These ponds historically have not had detectable WP concentrations, but multiple waterfowl carcasses have been found around each of these ponds. Because of the waterfowl mortality, Pond 290 was pumped during the summer of 1998 and Pond 730 was pumped each summer between 1991 and 2003. Carcasses and feather piles continue to be found around these ponds (Collins et al. Section II-2). In 2007, duplicate sieved multi-increment samples were collected concurrent with the metallic ordnance surveys.

In conjunction with studies for the Environmental Impact Statement for year-round training at Eagle River Flats, multi-increment samples were collected from Ponds 109 and 99 in Area BT (Fig. III-2-4), which had been drained in 1996 by ditching. Details of the studies in support of the Environmental Impact Statement will be presented elsewhere; results for WP analysis are summarized in this report. Briefly, triplicate 100-increment samples were collected from a 200-m x 200-m target area before and after the firing of fourteen 120-mm mortar projectiles into Eagle River Flats on 6 June 2007. The increments were collected using a 3-cm diameter corer to a depth of 2.5 cm. Only three projectiles actually detonated in the targeted area; the others detonated on the mudflat south and southeast of the targeted area. All 14 impact craters were also sampled. One

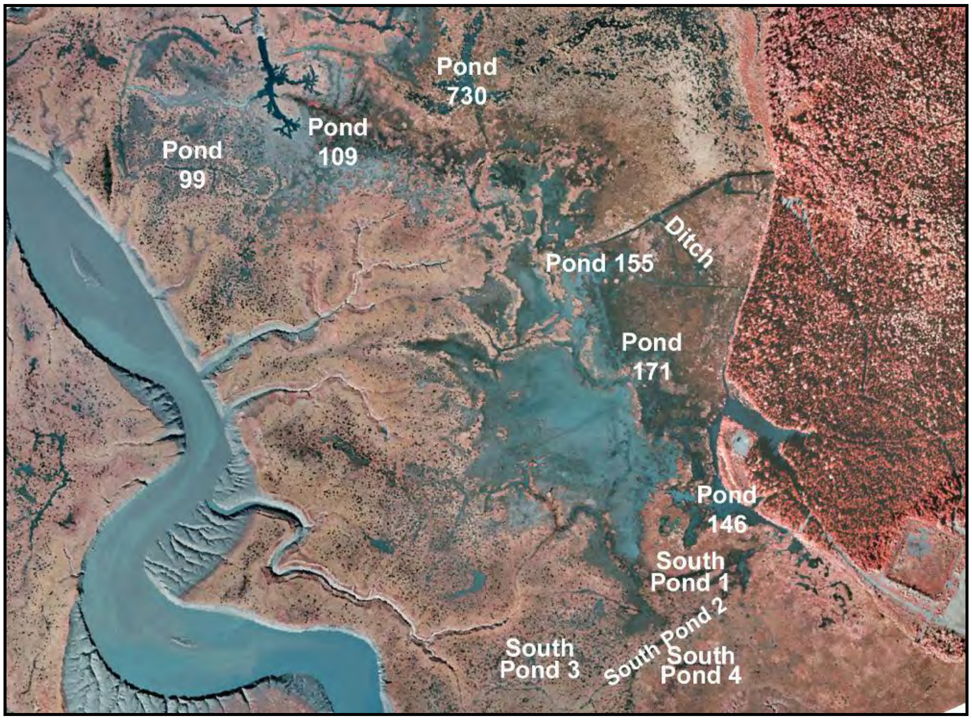


Figure III-2-4. Aerial photograph taken (Aero-Metrics, 2006) showing the identification numbers of ponds where multi-increment samples were collected.

sample was formed from at least 30 increments of mud from the walls and bottom of each crater; a second sample was formed from at least 30 increments of the mud ejected from each crater. The mud was collected using a gloved hand. Similarly, mud was sampled from within other craters formed on 20 June 2007 as a result of acoustic testing.

Area C South Ponds

The Area C South ponds are shallow, narrow ponds that appear to be remnant distributary channels (Fig. III-2-4). They are located in a densely cratered area and we have observed waterfowl feeding in these ponds. Sieved multi-increment samples were collected from three ponds in southern Area C in 2006 and a very small mass (maximum of 0.0007 mg) of WP was detected. In May 2007, sieved multi-increment samples were collected from the three previously sampled ponds and a fourth shallow pond (labeled South Pond 4 in Figures III-2-4 and III-2-6).

a. Survey for metallic debris.

b. Ordnance scrap removed from the sediment.

Figure III-2-5. Survey of Pond 155 for metallic scrap in May 2007.

a. South Pond 2 (with feeding Northern Shovelers).

b. South Pond 4.

Figure III-2-6. Images (May 2007) of shallow ponds in southern Area C.

Drainage Ditches

The drainage ditches that had been explosively excavated in the Area C Marsh to enhance the remediation of the WP-contaminated sediments had the unintended consequence of attracting waterfowl. In 2006, we intensively sampled the sediments of the ditches by collecting sieved multi-increment samples and were able to identify four 5-m sections that had milligram quantities of WP in the >0.59-mm size fraction (Fig. III-2-7).

A shallow connector ditch excavated in July 2006 appears fairly large on the aerial photograph (Fig. III-2-7); so in 2007, we collected duplicate sieved multi-increment samples from the entire length (70 m) of the ditch. The actual ditch was smaller than anticipated from the aerial image (Fig. III-2-7).

Laboratory Analysis of Sediments for White Phosphorus Residues

Samples were analyzed for white phosphorus by EPA SW-846 Method 7580 (USEPA 1995). First, all samples were screened for WP presence using headspace Solid Phase Micro-extraction. Then, estimates of WP concentration were obtained using solvent extraction and gas chromatography. For multi-increment sediment samples, a 200-g subsample was formed from at least 30 increments of the field sample and extracted with 100 mL of isooctane. For sieved multi-increment samples, the entire sample was extracted with isooctane. Discrete samples were subsampled by taking a 40-g portion and extracting the white phosphorus with 20 mL of isooctane. White phosphorus was determined using a nitrogen-phosphorus detector. The method detection limit is estimated to be 0.0002 µg/g.

Sublimation/Oxidation Conditions

We installed sensors and dataloggers at eight locations (Fig. III-2-8, Table III-2-1) to monitor sediment temperature and moisture conditions using the same configuration we have used since 1997 (Walsh et al. 2003). The sensors were Campbell Scientific (Logan, UT) Model 107B soil/water thermistor probes for temperature, Campbell Scientific Model 257 (Watermark 200) soil moisture sensors, SoilMoisture® (SoilMoisture Equipment Corp., Santa Barbara, CA) Series 2725 tensiometers for sediment moisture, and Druck (New Fairfield, CT) pressure transducers (PDCR 1830) for water level. At one location (Pond 155 Piezo), the Druck was placed within a piezometer well at 1 m below the ground surface to measure groundwater elevation. At the remaining stations, the Drucks were at the sediment surface to measure water depth in each pond during tidal flood events and to confirm subsequent draining.

Sublimation/ oxidation conditions are favorable if the sediments dry below water saturation and warm to at least 15°C. The sediments are deemed fully unsaturated when tensiometers read at least 10 cbars. The maximum tensiometer reading is about 70 cbars.

a. Ditch sections (red rectangles, 5-m-long) where particulate WP was detected in 2006.

b. Ground view of new ditch blasted in 2006.

Figure III-2-7. Drainage ditches in C Marsh

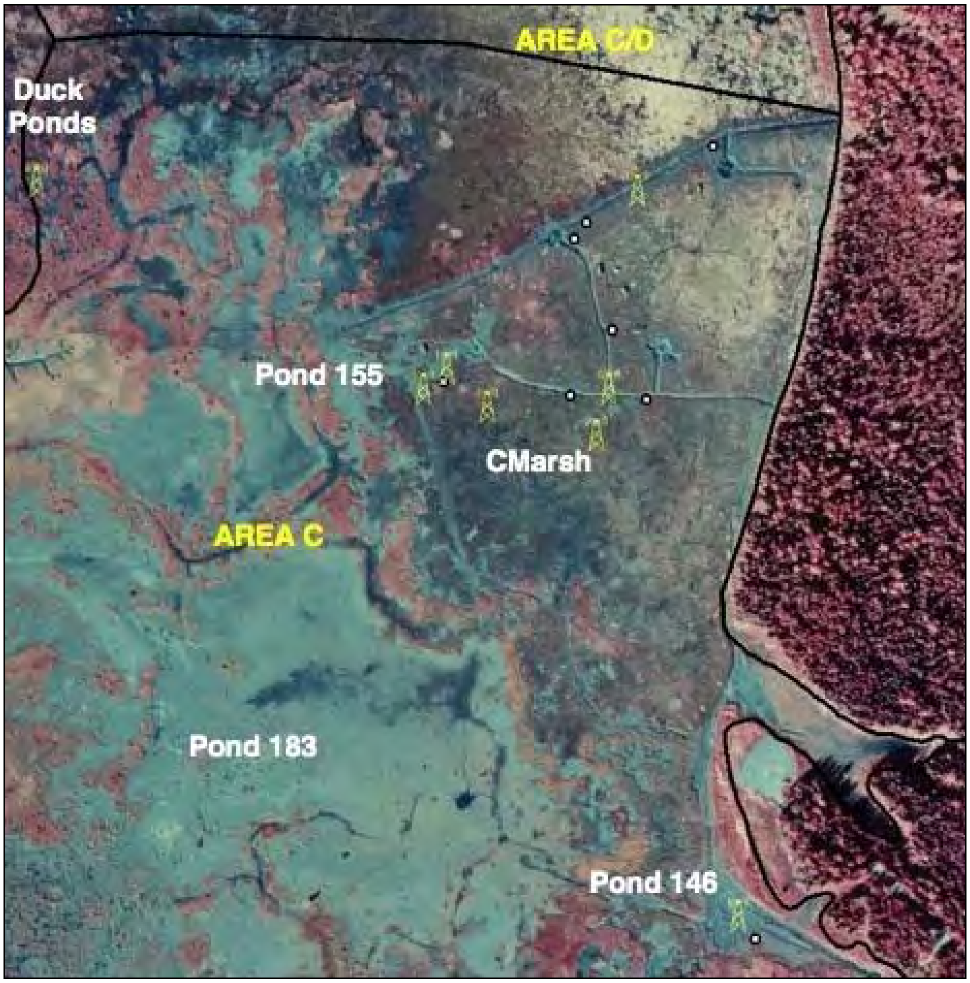


Figure III-2-8. Datalogger locations used to monitor 2007 sublimation and oxidation conditions in Area C of Eagle River Flats (shown with yellow towers). Also shown (white circles) are sites of web cameras or water level sensors. Background aerial photo was taken in 2003 (Aeromap).

Table III-2-1. UTM coordinates (NAD 27 Zone 6N) of dataloggers.

Area	Datalogger Site	East (m)	North (m)
Area C	C Marsh North (Ditch)	355,244	6,801,658
	C Marsh South (Ditch)	355,237	6,801,515
	Pond 146	355,311	6,801,171
	Pond 155	355,116	6,801,537
	Pond 155 Piezometer	355,101	6,801,524
	C Marsh Hotspot #1 (03DIS38)	355,216	6,801,492
	C Marsh Hotspot #2 (03DIS42)	355,143	6,801,511
Area BT	Duck Pond	354,841	6,801,662

At seven of the datalogger stations, five white phosphorus particles of known mass (5.6±0.5 mg) were planted in the sediment in May and removed in August to determine if the WP mass decreased. Each WP particle was placed in a plug of clean sediment and then the sediment placed in a nylon fine-mesh bag. The five replicate sediment plugs were buried at 5 cm depth at each datalogger station. To determine if the WP particles had decreased in mass, the sediment plugs containing particles were recovered on 22 August 2007 and placed into isooctane to extract WP residue prior to analysis by gas chromatography.

RESULTS AND DISCUSSION

Two conditions are needed to remove white phosphorus from the surface sediments *in situ*. The sediments must desaturate and the sediment temperatures must warm sufficiently to vaporize the white phosphorus particles. At ERF, pumps are used to remove the surface water. This year surface water was removed from Area C in late May by three pumps (Walsh, M.R. et al. this volume, Section III-1). However, the generator for the large pump in Pond 146 failed, and was not operational for general de-watering until early August.

Groundwater levels were monitored at one Area C location (Pond 155 Piezo). The groundwater level at this location was falling in May when we installed the datalogger, and eventually dropped enough to desaturate the surface sediments for four multi-day intervals in June and July and one week in August (indicated by a rise in tension in Figure III-2-9). However, the tension exceeded

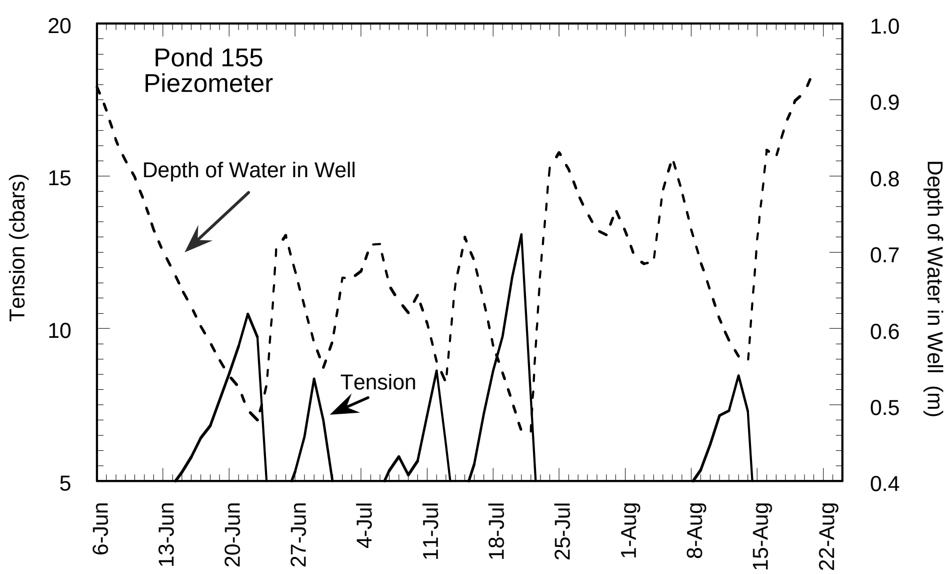


Figure III-2-9. Output from the SoilMoisture tensiometer and Druck pressure transducer in Area C Pond 155. Tension increases as the groundwater level drops and the sediment dries.

10 cbars for only a few days, indicating that drying was minimal. Last summer, the 24-hour average tension at this location reached 73 cbars and was over 10 cbars for 59 days.

Sublimation/oxidation conditions were monitored in the surface sediment of previously monitored locations in Pond 146, Pond155, the Duck Ponds, the drainage ditches and within two small pools located south of the C Marsh drainage ditches where WP ordnance scrap and high concentrations of WP were found (Fig. III-2-8).

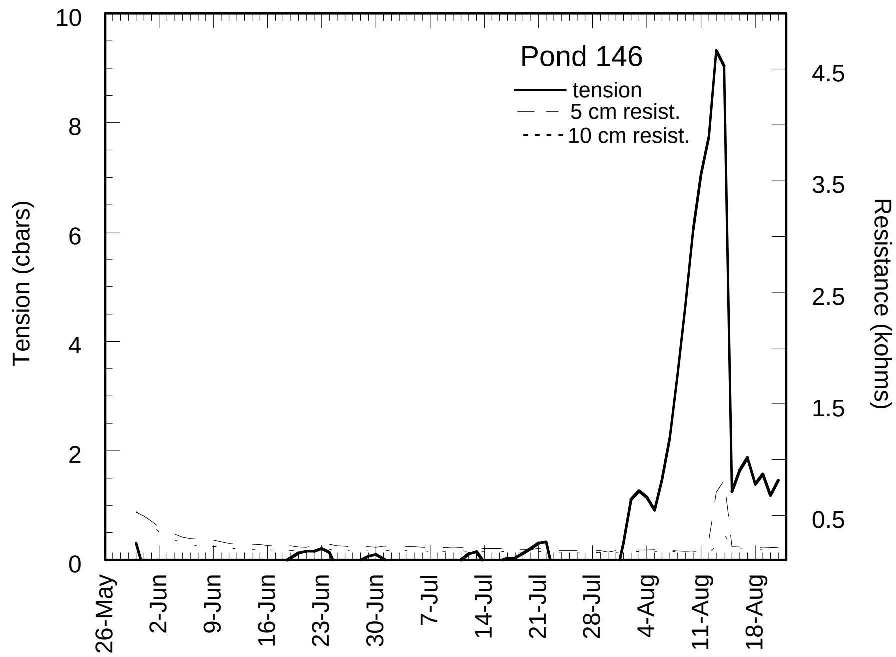
Pond 146

Pond 146 is a permanent pond located adjacent to the EOD pad and Clunie Inlet (Fig. III-2-4). This pond was heavily contaminated prior to treatment by dredging and pumping, but the surface sediments dried significantly during the summers that the pond was pumped. In 2007, the pond was flooded most of the summer. The pond sediments started to desaturate in August (Fig. III-2-10a), but the time was too short for removal of WP from the particles we had planted in May 2007. Only 0.6% of the mass was lost (Table III-2-2). Nonetheless, WP was not detectable in the duplicate multi-increment samples collected and analyzed as part of the periodic resampling of the remediated ponds (Table III-2-3). The surface sediments of Pond 146 should be considered remediated.

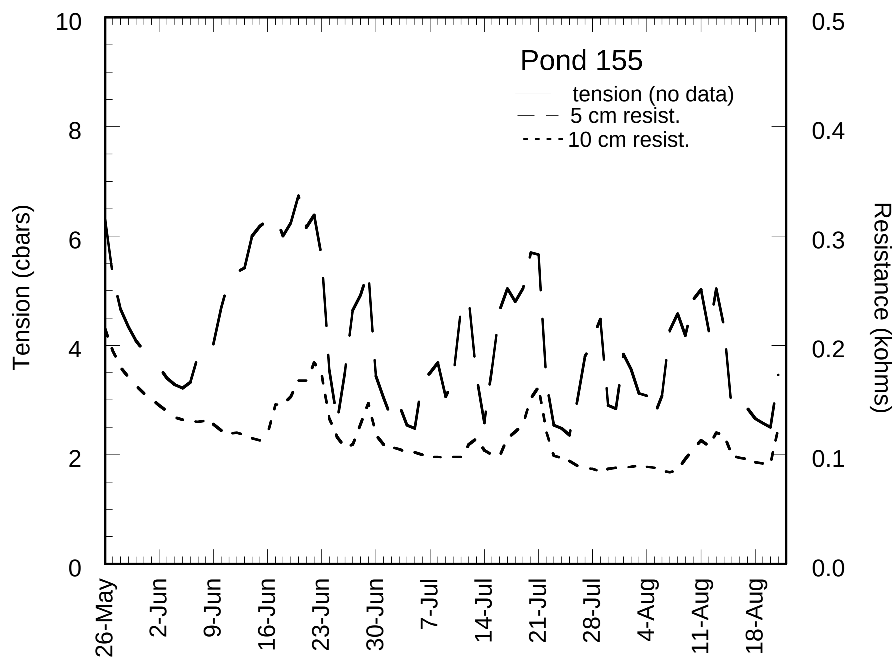
Table II-2-2. Loss of white phosphorus from particles planted in the top 5 cm of sediment. Locations correspond to data stations in Table III-2-1.

Area	Datalogger Site	Loss (%)*
Area C	C Marsh North (Ditch)	23
	C Marsh South (Ditch)	60
	Pond 146	0.6
	Pond 155	42
	C Marsh Hotspot #1 (03DIS38)	55
	C Marsh Hotspot #2 (03DIS42)	28
Area BT	Duck Pond	79

* Nominal initial mass was 5.6±0.5 mg for each of five particles yielding an initial total mass of 28 mg. Loss (%) was computed as follows: 100 X [1-(sum of mass remaining)/(total initial mass)]

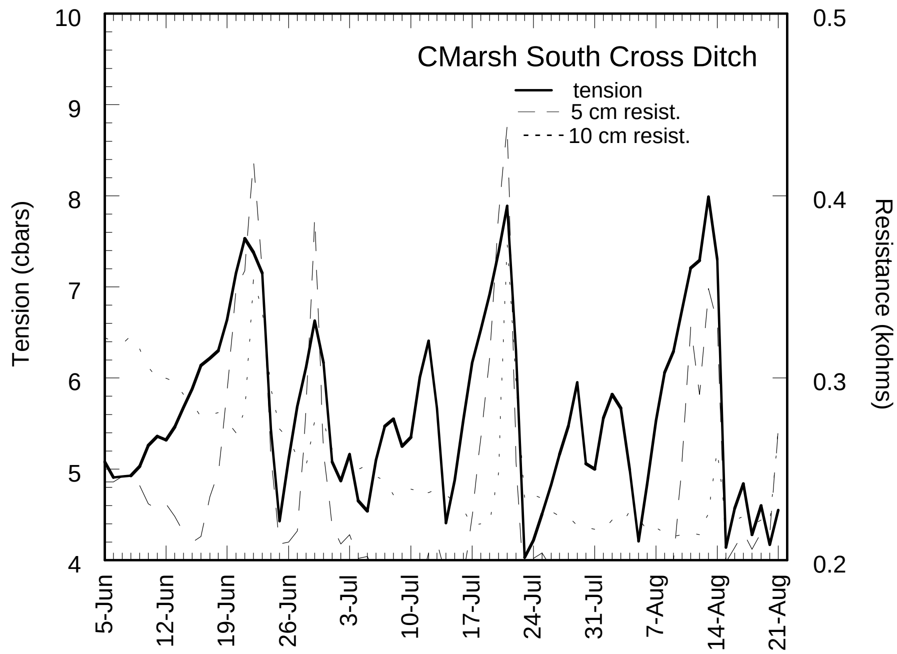


a. Pond 146.

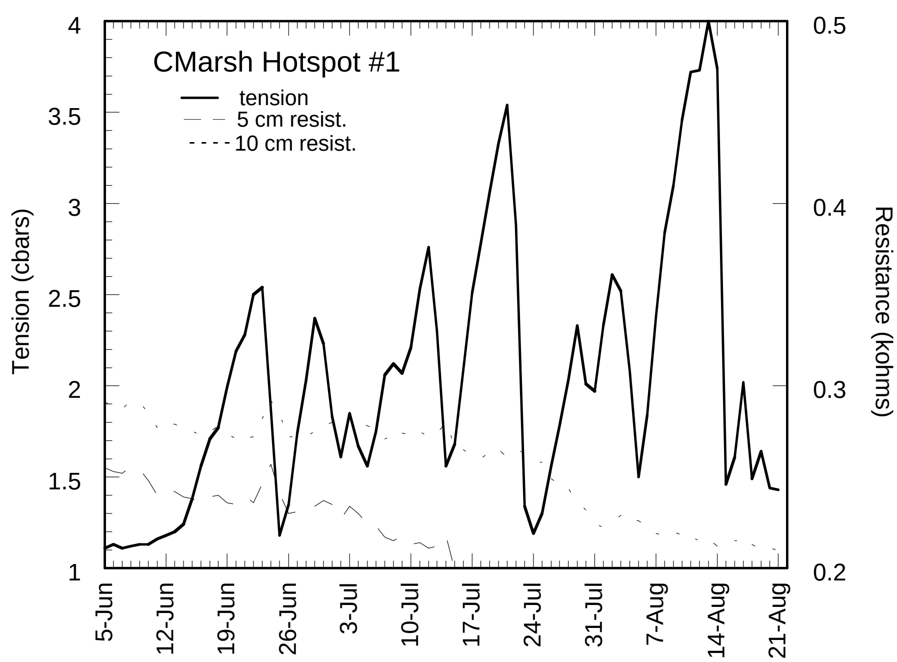


b. Pond 155.

Figure III-2-10. Output from moisture sensors during the summer of 2007. Increases in tension and resistance indicate the sediment was drying.

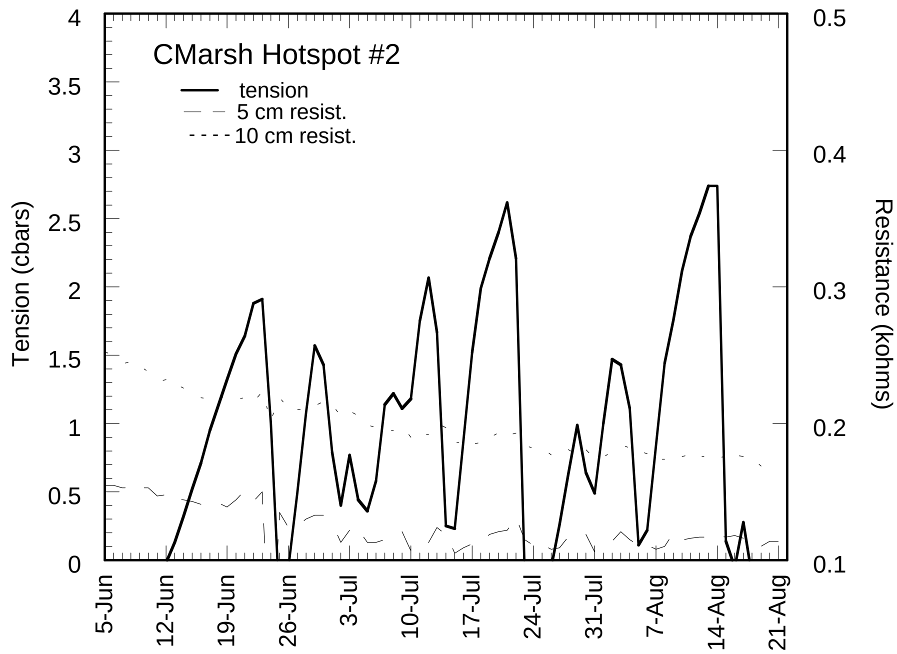


c. C Marsh South (Ditch).

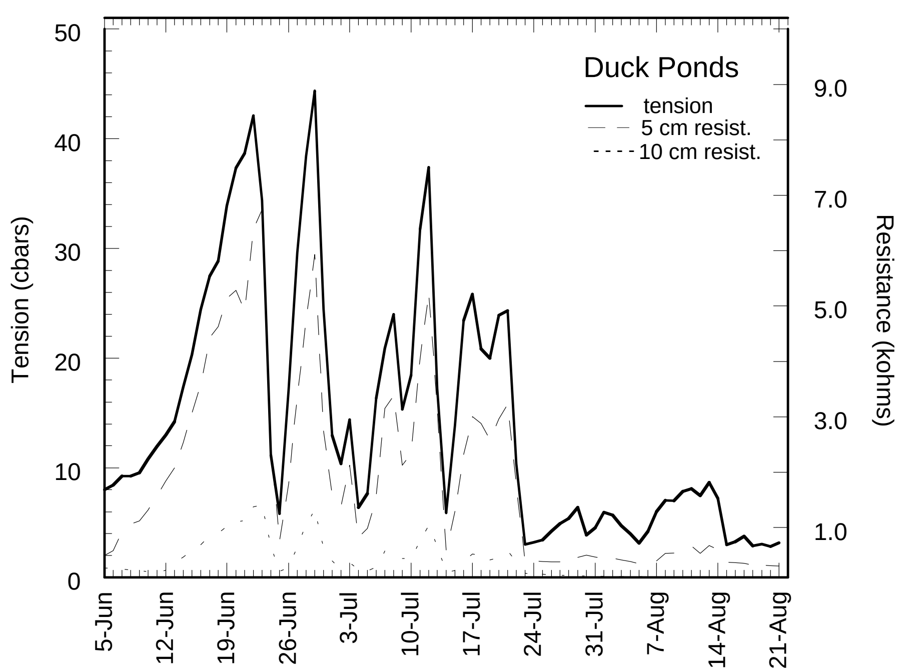


d. C Marsh Hotspot #1 (03DIS38).

Figure III-2-10 (cont.). Output from moisture sensors during the summer of 2007. Increases in tension and resistance indicate the sediment was drying.



e. C Marsh Hotspot #2 (03DIS42).



f. Duck Ponds.

Figure10 (cont.). Output from moisture sensors during the summer of 2007. Increases in tension and resistance indicate the sediment was drying.

Table III-2-3. White phosphorus concentrations found in multi-increment samples collected from grids in Pond 146 of Area C.

Date	White Phosphorus Concentration (µg/g)	
	146-1	146-2
8-Jun-99	0.027	7.31
14-Sep-99	0.005	2.68
16-Aug-00	0.0001*	0.0014
10-Sep-01	0.0001*	0.0005
24-Aug-02	not detected	0.0001*
29-Aug-06	not detected	not sampled
23-Aug-07	not detected	not detected

*Detected but below method detection limit.

Pond 171

Pond 171 is located on the southwestern edge of the C Marsh (Fig. III-2-4). This pond is deemed remediated so we did not monitor sublimation/oxidation conditions. However, in compliance with the long term monitoring plan, we collected duplicate multi-increment samples from the same part of this pond where we previously found WP (0.03 µg/g in 2000, 0.01 µg/g in 2002, <0.0002 µg/g in 2003 and 2006). WP was not detectable in the 2007 samples (Appendix III-2-B, Table II-2-B1).

Pond 155

During summer 2007, the surface sediments at the monitoring station in Pond 155 were just barely unsaturated for a total of 26 non-sequential days and the mean sediment temperature was 18°C (Fig. III-2-10b). Sediments shown in the web camera images from this site (Fig. III-2-11) appear to be unsaturated. The amount of residue remaining from the planted WP particles was 42%, similar to 2005 and 2006 (Table III-2-2). For the first time since we have been sampling this pond, WP was not detectable in one multi-increment sample and was at the detection limit (0.0002 µg/g) in the other sample (Table III-2-4).

In 2001, we collected 65 discrete samples from Pond 155, of which 75% had detectable WP. Most detected concentrations were low, less than 0.001 µg/g. WP remained detectable in most of the discrete samples in 2002. In 2003, drying of this pond was enhanced by the new sumps and pumps installed in the adjacent C Marsh; by the end of that summer, only two discrete samples had detectable WP. However, one of them had a fairly high concentration (8.1 µg/g) (Fig. III-2-12). In 2007, we collected sediment from the two locations that had had detectable WP in 2003. Concentrations were 0.005 µg/g and 0.002 µg/g (Fig. III-2-12, Appendix Table III-2-B2). These concentrations would not have sufficient WP mass to threaten waterfowl and appear to be less than in 2003, but given the sampling uncertainty associated with white phosphorus, follow-up sampling was warranted.

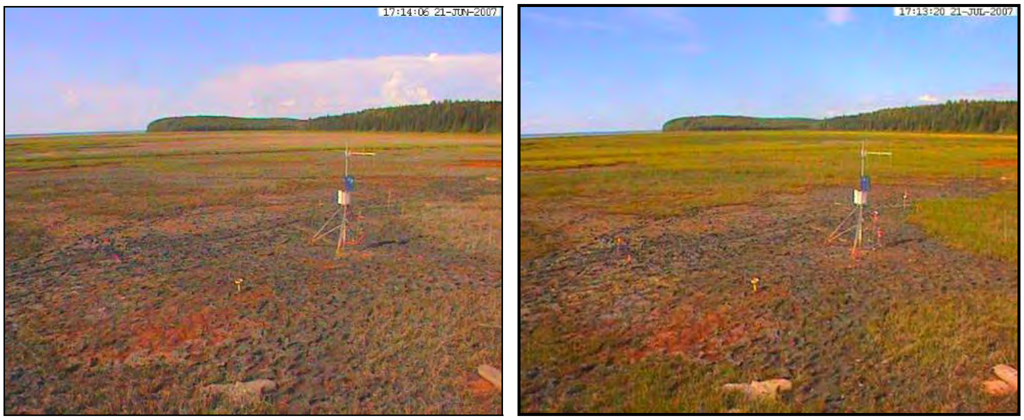


Figure III-2-11. Web-camera images showing visual evidence of some drying of Pond 155 surface sediments.

In 2007, we temporarily moved the datalogger tripods away from the pond and performed a thorough magnetometer survey of this pond to see if we could locate WP ordnance scrap. (The steel tripods interfered with the magnetometer surveys performed here previously). Our UXO technician found two clusters of ordnance scrap (Fig. III-2-5), none of which could be identified as metal from a WP projectile. WP was not detectable in the sediment at one of the scrap locations and was 0.0004 µg/g at the other.

Pond 155 has been slowly decontaminating over the years. The small amount of residual WP is probably not sufficient to present a risk to waterfowl, so capping of this pond is not recommended. Continued monitoring by sediment sampling should continue to be sure that any remaining subsurface WP does not recontaminate the surface sediments.

Table III-2-4. White phosphorus concentrations found in multi-increment samples from the SW grid in Pond 155.

Date Collected	Concentration (µg/g)
August 1998	0.023
June 1999	0.45
September 1999	0.018, 0.015
August 2000	0.034, 0.044
September 2001	0.005, 0.004
August 2002	0.003, 0.008
September 2003	0.001, 2.25
May 2005	0.006, 0.32
September 2005	0.0006, 0.002
August 2006	0.0056, 0.0013
August 2007	<0.0002, 0.0002

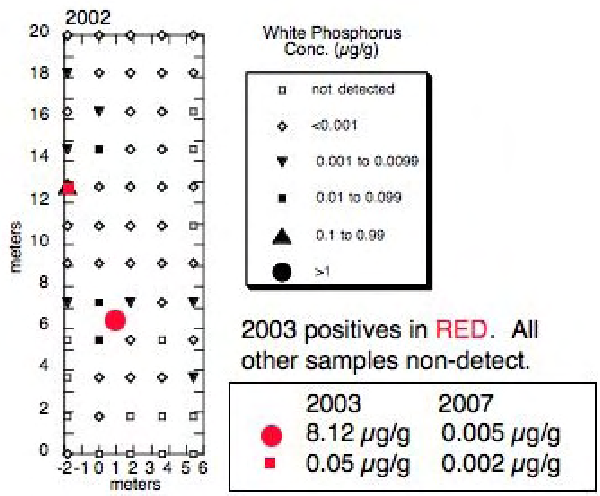


Figure III-2-12. Spatial representation of WP concentrations (µg/g) in discrete samples collected from Pond 155 in 2002, 2003 and 2007.

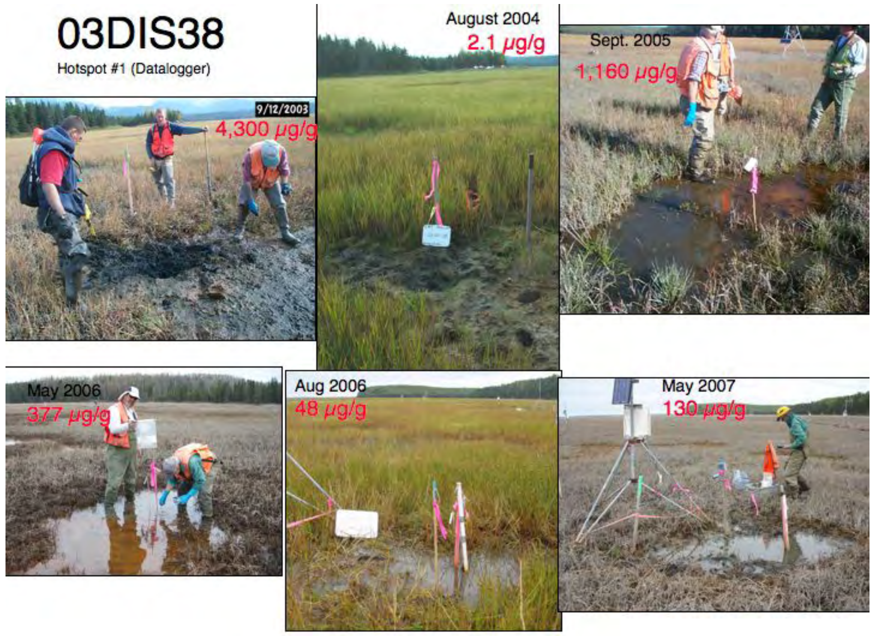
Drainage Ditches

Two monitoring stations were located within the C Marsh drainage ditches. The sensors in the sediment in the C Marsh north drainage ditch showed little drying, and loss from the planted particles was 23%. The sediments at the southern end of the cross ditch did periodically dry (Fig. III-2-10c), but drying was minimal and WP loss in planted particles was 28% (Table III-2-2).

The duplicate sieved multi-increment samples from the shallow connector ditch (Fig. III-2-7) blasted in 2006 did not have detectable concentrations of WP.

Hotspots

Monitoring stations were placed in two C Marsh pools where WP ordnance scrap was found in 2003(Fig. III-2-13a). Both locations [03DIS38 (Hotspot#1) and 03DIS42 (Hotspot#2)] had high concentrations of WP in 2003 (4300 and 204 µg/g, respectively). Both locations have consistently had concentrations of greater than 1 µg/g in the surface sediments at each sampling event (Fig. III-2-13 and Appendix Table III-2-B3). The May 2007 concentrations were 130 and 44 µg/g, respectively. Despite the general downward trend in WP concentrations between May and August samples, which indicates that surface sediments are drying somewhat during the summer, there is still ample WP to poison waterfowl in these two shallow pools. The moisture sensors in 2007 show that surface sediments of both pools dried only a slight amount (Fig. III-2-10d and III-2-10e). Losses of WP from the planted particles were 55% and 28%, respectively. If these pools were pumped for many, many more years, the surface sediment would eventually decontaminate. Given their small size, capping would be the preferred approach.



a. 03DIS38.

b. 03DIS42.

Figure III-2-13. Views of pools where samples 03DIS38 and 03DIS42 were collected. Both originally contained WP-filled mortar tail assemblies. The numbers in red are WP concentrations in the surface sediment.

In preparation for capping during the winter of 2008, we resampled and photographed all hotspots we have found since 2002 in Areas C and BT, plus Miller's Hole, which is the location of a blow-in-place detonation of an 81-mm WP mortar projectile in 1992. Our general criterion for a hotspot was where a surface sediment sample resulted in a WP concentration greater than 1 µg/g the last time the location was sampled. For locations with multiple year data, sites were resampled even if concentrations had dropped below 1 µg/g. The complete data set with the 2007 and historical data is given in Appendix Table III-2-B3. All locations that had WP concentrations greater than 1 µg/g were marked in August 2007 with a black-tipped orange survey stake (Fig. III-2-14). In addition to the discrete hotspots that are generally less than 2 m in their longest dimensions (Appendix A), six areas were marked. These included three areas within the drainage ditches, two areas that corresponded to trenches containing 57 mm projectiles, and one area that corresponded to the cluster of blow-in-place craters (BIPS) (Fig. III-2-15). The sizes (m^2) of these areas were estimated by walking the boundaries with the GPS unit (Table III-2-5).

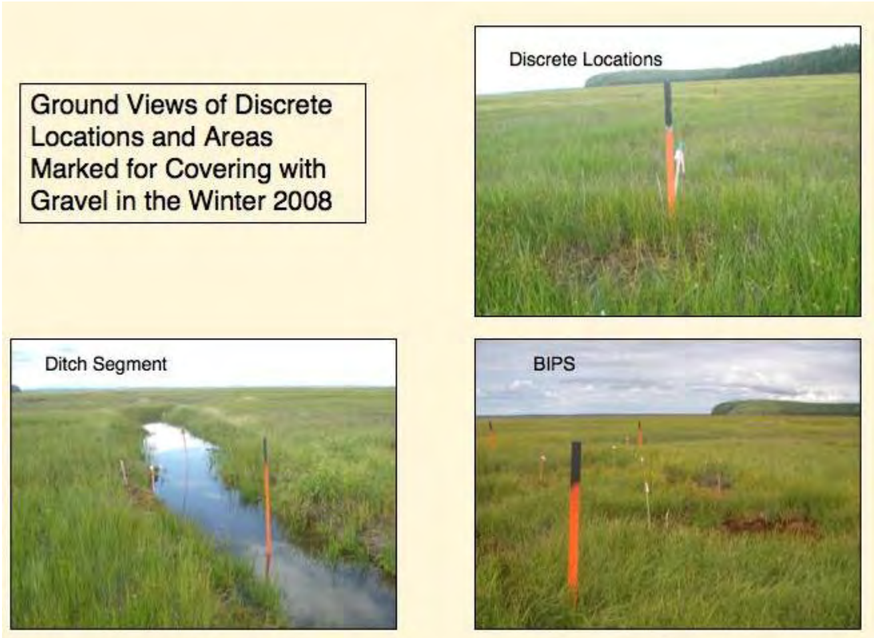
Table III-2-5. Sizes (m^2) of areas marked for capping.

Location	GPS Area (m^2)
Drainage Ditch Sections	
North Ditch	71
South Ditch (West, 04DIS126)	16
Cross Ditch	44
South Ditch (East)	21*
WP Munitions Burial Trenches	
04DIS84	14
04DIS21	14.5
BIPS	
BIPS 5 to 9 Cluster	48

*Location was not walked with the GPS. Area estimated from ground measurements.

Area BT Duck Ponds

The last monitoring station was located within the pond complex in the southeast corner of Area BT, known as the Duck Ponds (Fig. III-2-4). These ponds were sampled in 2003 after three Green-winged Teal carcasses were found. Subsequent sampling of the ponds and surrounding marsh in 2003 and 2004 detected several white phosphorus hotspots. Drainage channels and a tide gate were installed in July 2004 to remove as much surface water as possible and remove the ponds as waterfowl habitat between flooding tides.



a. Close-up views in August 2007.

b. View across the C Marsh from Clunie Pad.

Figure III-2-14. Orange markers designating points or boundaries of areas to be capped.

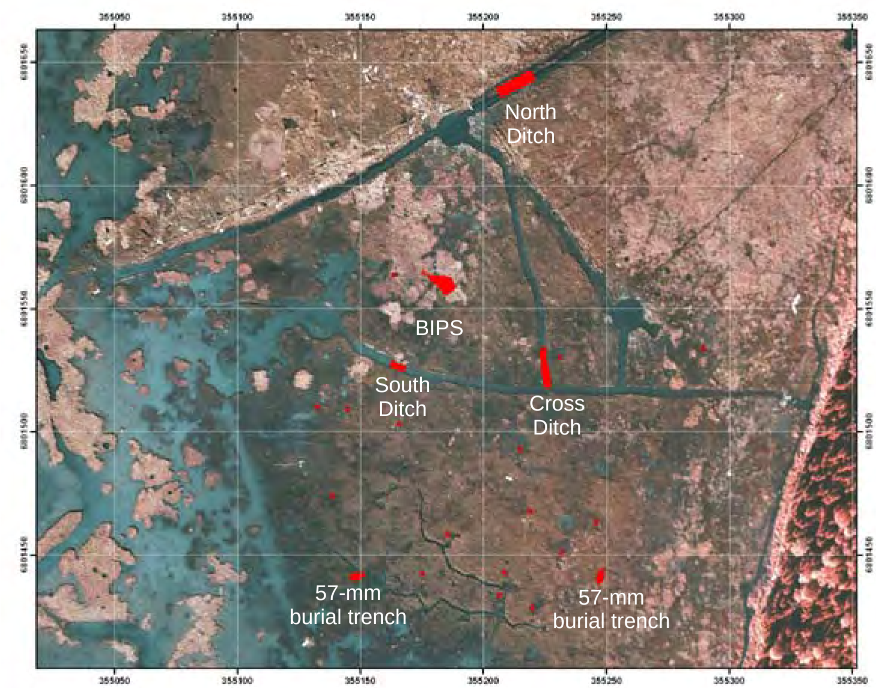


Figure III-2-15. Aerial image showing locations of areas that have been marked for capping. Discrete locations are shown by small red circles.

In 2007, sediments at the Duck Ponds monitoring station were desaturated for 39 days (Fig. III-2-10f); the mean temperature during the time the sediments were unsaturated was 18°C. The loss of mass from the planted white phosphorus particles was 79% (Table III-2-2).

We resampled 24 discrete locations within this area and marked six for potential covering (Appendix Table III-2-B3). Since this area does not normally hold ponded water, the risk to waterfowl is low, except perhaps when the flats are inundated by a flooding tide. Hotspot locations in C Marsh should have priority for capping over the hotspots in this area.

EIS Background and Crater Samples

White phosphorus was not detectable in any of the samples collected for the Environmental Impact Statement. These results are consistent with the hypothesis that WP is not persistent in the mudflats that intermittently desaturate.

Area C South Ponds

WP was not detectable in the four shallow ponds that we sampled in the southern part of Area C (South Ponds 1, 2, 3, and 4 in Figure III-2-4). Ditching with detonation cord occurred in July 2006 to improve the drainage. These ponds appear to have intermittently dried and probably present little risk to waterfowl at the present time, so no further action is needed.

Area A

Two locations in Area A were sampled in August 2007. The first was Pond 290 (Fig. III-2-16). This oval shaped 0.91-ha pond is heavily used by ducks for resting and feeding. Although WP has not been detected in the pond sediments, waterfowl carcasses have been found in the past and continue to be found around the pond. The pond was pumped in 1998 due to waterfowl mortality and as part of the feasibility study. Confirmatory sampling in 2004 did not detect any WP. In August 2007, our UXO technician performed a magnetometer survey of the pond. The only metal detected was from rebar from duck traps set out by DWRC for telemetry studies several years ago. In conjunction with the magnetometer survey, duplicate sieved multi-increment samples were collected and no WP was detected. This pond should continue to be monitored for waterfowl mortality.

The second location sampled in Area A was the excavation hole and adjacent intermittent pond where our UXO technician found an almost empty 155-mm WP howitzer projectile buried almost 1 m deep at the mudflat/ intermittent pond boundary in September 2006. No samples were taken 2006 because the projectile was smoking (Fig. III-2-17) and we moved away for safety reasons. In August 2007, a discrete surface sediment sample from the excavation hole had 0.0003 µg/g WP (just above the detection limit). Within the adjacent intermittent pond (Pond number 243) we collected duplicate 100-increment sediment samples from a 20-m x 20-m decision unit (Fig. III-2-17). White phosphorus was not detectable in either sample. The pond was very shallow when we sampled the pond bottom sediments. The pond bottom sediments have very likely dried out many times over the years since this 155-mm WP projectile was fired, removing any residual WP.

Area C/D

Pond 730 in Area C/D (Fig. III-2-4), like Pond 290 in Area A, is heavily used by ducks for feeding and resting. We have flushed hundreds of ducks from this pond on several occasions. Waterfowl carcasses have been found in the past and continue to be found around the pond. White phosphorus has never been detected within the main body of the pond. The pond was pumped due to waterfowl mortality from 1999 to 2003. Some WP (0.0003 µg/g) was detected in 2004 to the southwest of the main body of the pond. Repeat and more intensive sampling in 2006 did not detect any WP.

Our UXO technician conducted a magnetometer survey of Pond 730 in August 2007 and detected one piece of metal (Fig. III-2-18), which may or may not have been ordnance related. Mud co-located with metal had no detectable WP. Multi-increment (sieved) samples from the pond did not have detectable WP (as in the past). We plan to continue to monitor this pond to see if mortality continues. Given the proximity of the C Marsh hotspots, capping should reduce the number of waterfowl carcasses around this pond if the source of the poisoning is not within the pond.

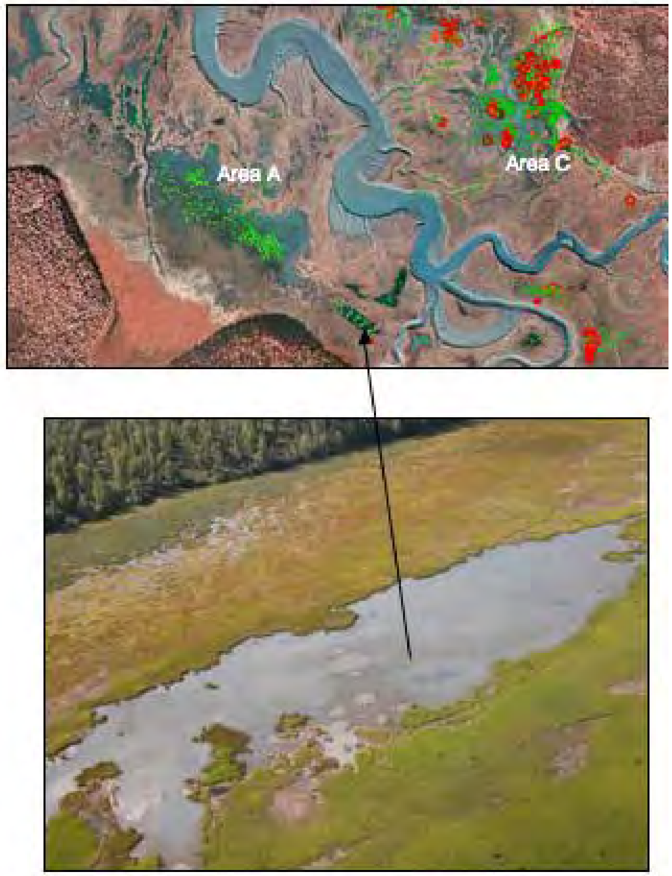


Figure III-2-16. Orthophotograph (Aerometric 2006) and image from a helicopter (24 August 2004) showing Pond 290 in Area A.

Figure III-2-17. Images showing (left) a smoking 155-mm WP projectile after it was brought to the surface by our UXO technician in September 2006 and sampling the adjacent intermittent pond in August 2007.

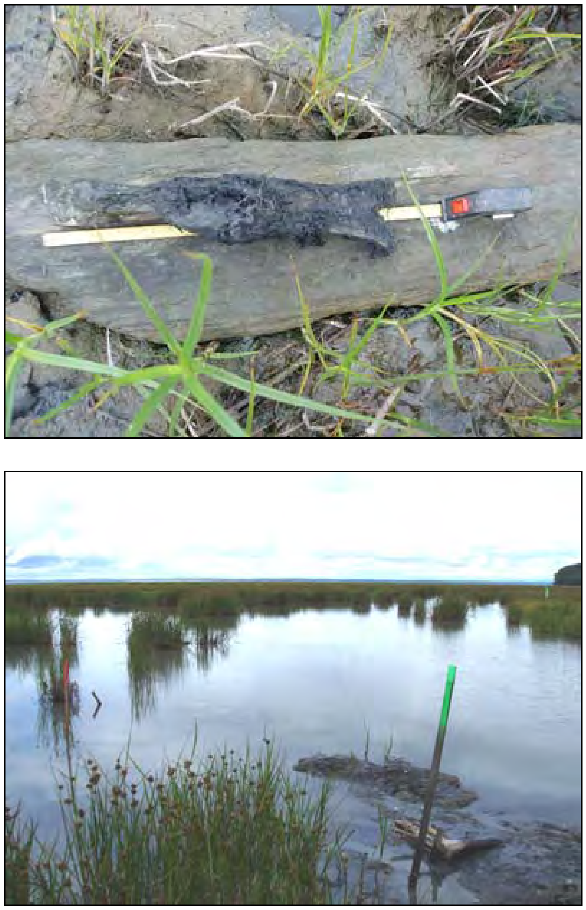


Figure III-2-18. The one piece of metallic scrap found in Pond 730 in August 2007 (upper image). The location of the scrap is indicated by the lath in the bottom image.

CONCLUSIONS

During summer 2007, sublimation/oxidation conditions were marginal for all locations in Area C. Sublimation/oxidation conditions were more favorable at the eastern side of Area BT (Duck Ponds), where some decontamination was evident.

Based on the results of sediment sampling and analysis for WP, 23 discrete locations and six small areas were marked for capping during the winter of 2008.

Confirmatory sampling in previously decontaminated ponds showed that the surface sediments of the treated ponds do not have detectable WP residues.

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Walsh, M.E., R.N. Bailey, and C.M. Collins (2007) Long-term monitoring and sampling of sediments of ponds treated to remove white phosphorus. In Remediating and monitoring white phosphorus contamination at Eagle River Flats (Operable Unit C), Fort Richardson, Alaska. FY06 Data Report. S.R. Bigl and C.M. Collins, Eds. CRREL Contract Report to US Army, Alaska, Directorate of Public Works and the U.S. Army Engineer District, Alaska. FY06 Final Report. pp. 61-112.

APPENDIX III-2-A. PHOTOS OF LOCATIONS TO BE CAPPED.

Photographs of sample locations as they appeared on May 2007.

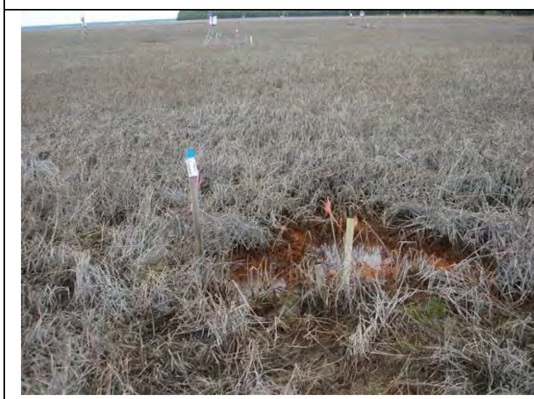
Area C

03DIS03

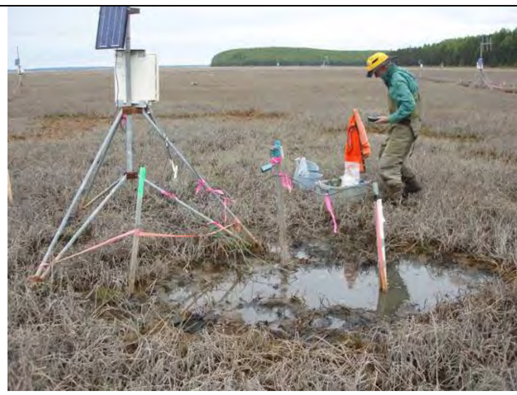
03DIS11

03DIS18

03DIS36



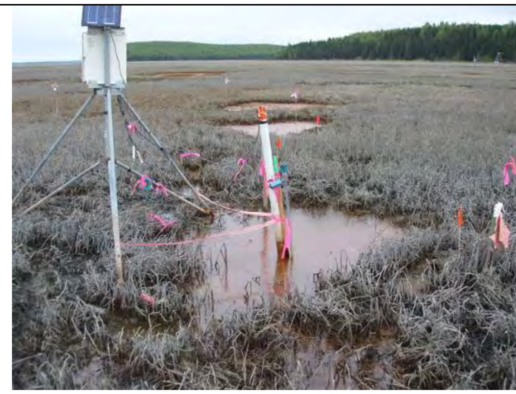
03DIS37



03DIS38

Appendix III-2-A (cont.). Photos of locations to be capped (taken 30 August 2007).

03DIS40



03DIS42

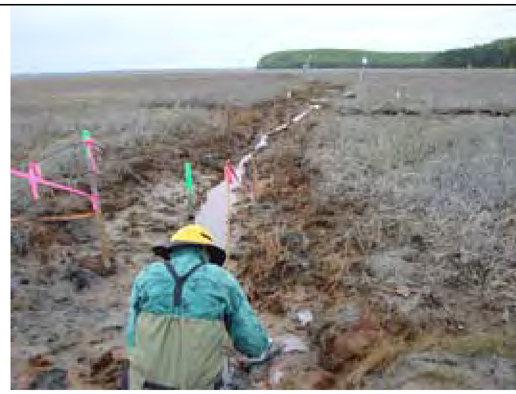
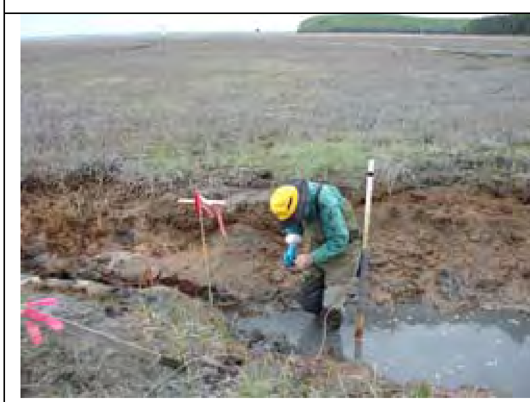
03DIS43

04DIS68

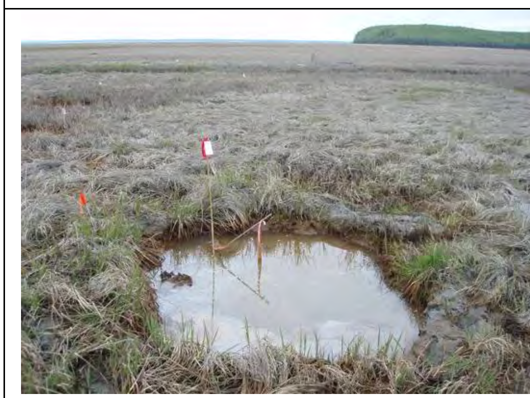
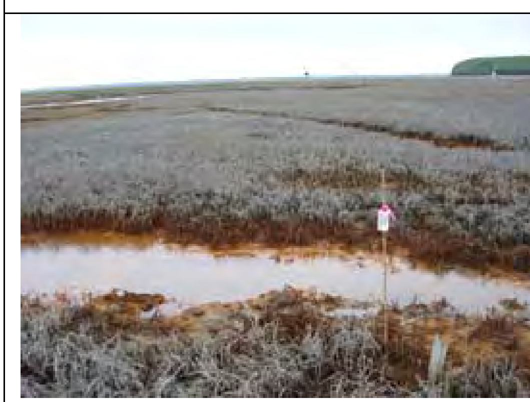
04DIS76

04DIS82

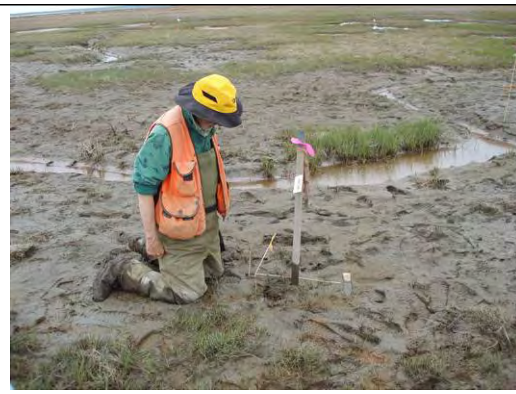
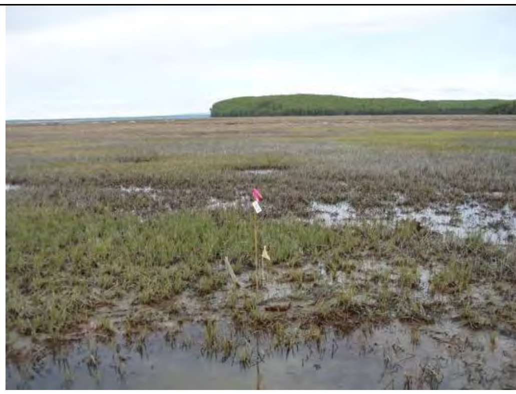
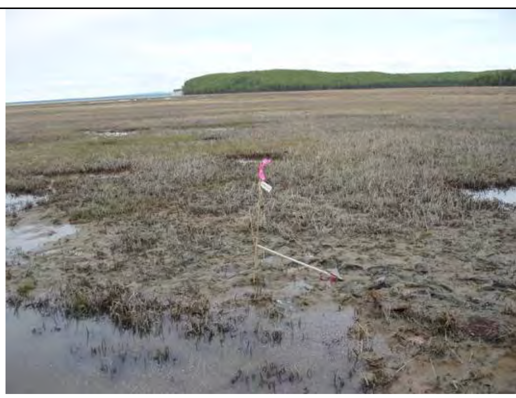
Appendix III-2-A (cont.). Photos of locations to be capped (taken 30 August 2007).

<table>
<tr><td>
04DIS85</td><td>
04DIS125 (In Ditch Segment 5: Cross Ditch)</td></tr>
<tr><td>
04DIS126 (In Ditch Segment 1:
South Ditch West Section)</td><td>
C Marsh Pond 23</td></tr>
<tr><td>
06DIS02 (In Ditch Segment 3:
South Ditch East Section)</td><td></td></tr>
</table>

Appendix III-2-A (cont.). Photos of locations to be capped (taken 30 August 2007).

 BIP 2	 BIP 10
 BIP 11	 BIPS 5 to 9
 03DIS21 (57mm trench)	 04DIS84 (57mm trench)

Appendix III-2-A (cont.). Photos of locations to be capped (taken 30 August 2007).

Area BT	
	
04DIS86	04DIS90
	
04DIS93	04DIS96
	
04DIS97	04DIS106

APPENDIX B. 2007 SAMPLE LOG.

Table B1. Multi-increment sediment samples. Location coordinates are UTM (m) Zone 6N, in NAD 27.

Area	Location	Position	Easting	Northing	Collection Date	Field Rep	Sample Mass (kg)	WP Conc. (µg/g)
BT	EIS Grid 200 m x 200 m	Before 120-mm firing	354,515	6,801,652	4-June-07	1 (N8, W13)	1.5*	not detected
						2 (N18, W6)	1.5*	not detected
						3 (N17,W4)	1.5*	not detected
		After 120-mm firing	354,515	6,801,652	6-June-07	1 (N7, W19)	1.9*	not detected
						2 (N11, W9)	1.7*	not detected
						3 (N16, W12)	1.7*	not detected
C	Pond 146	146-1	355,322	6,801,172	23-Aug-07	1	1.7	not detected
						2	1.7	not detected
		146-2	355,302	6,801,169	23-Aug-07	1	1.8	not detected
						2	1.5	not detected
	Pond 171		355,160	6,801,419	23-Aug-07	1	1.0	not detected
						2	1.0	not detected
	Pond 155	SW Grid	355,115	6,801,543	23-Aug-07	1	1.4	0.0002
						2	1.5	not detected
	03DIS72 to 03DIS73	Grid	355,113	6,801,445	23-Aug-07	1	1.3	not detected
						2	1.4	not detected
	C Marsh	Connector Ditch	355,235	6,801,579	22-Aug-07	1	2.3	not detected
						2	1.6	not detected
A	Pond 243	20-m x 20-m near 155-mm	354,107	6,800,878	25-Aug-07	1	4.2	not detected
						2	4.6	not detected

*EIS samples were also analyzed for high explosives. Sample mass is the air-dried sample mass after a 200-g subsample was removed for WP analysis

Table III-2-B2. Multi-increment sieved sediment samples (>0.59 mm).

Area	Location	Section	Center of Sampled Area* Easting	Center of Sampled Area* Northing	Collection Date	Field Rep	Sample Mass (g)	WP Conc. (µg/g)
C	South Pond 1	West	355,246	6,801,052	21-May-07		129	not detected
		East	355,261	6,801,056	21-May-07		257	not detected
	South Pond	West	355,178	6,800,920	21-May-07		208	not detected
		East	355,199	6,800,939	21-May-07		126	not detected
	South Pond 3	A	355,011	6,800,913	21-May-07		93	not detected
		B	355,018	6,800,935	21-May-07		96	not detected
		C	355,038	6,800,937	21-May-07		123	not detected
		D	355,058	6,800,937	21-May-07		97	not detected
	South Pond 4	West	355,246	6,800,911	21-May-07		305	not detected
		East	355,270	6,800,915	21-May-07		152	not detected
C/D	Pond 730		354,880	6,801,858	21-Aug-07	1	1647	not detected
						2	1012	not detected
A	Pond 290		354,382	6,800,381	28-Aug-07	1	363	not detected
						2	352	not detected

*Location coordinates are UTM (m) Zone 6N, in NAD 27.

Table III-2-B3. Discrete sediment samples. Location coordinates are UTM (m) Zone 6N, in NAD 27.

Marked for Capping?	Sample ID	Easting	Northing	Collection Date	Area	Depth	WP Conc. (µg/g)	Field Notes
n	03DIS01	355,161	6,801,443	05/23/03	C	0 to 5 cm	80.6	3.7 m x 3.2 m. WP mortar fin.
				05/29/07		0 to 5cm	0.0002	Surface sediment from 1.3-m x 0.7-m depression.
y	03DIS03	355,187	6,801,456	05/23/03	C	0 to 5 cm	1.3	4.9 m x 2.5 m. WP mortar fin.
				05/29/07		0 to 5cm	**4.04**	Sampled east of drainage ditch and north of metal stake. Log across area. Water depth 15 cm.
y	03DIS11	355,212	6,801,441	05/28/03	C	0 to 5 cm	5.7	WP mortar fin.
						0 to 5cm	**68**	Sampled 1.2-m X 0.8-m area east of drainage ditch. Metal stake present.
n	03DIS16	355,226	6,801,423	05/28/03	C	0 to 5 cm	459	WP mortar fin.
				08/27/04		0 to 5 cm	1.7	
				09/08/05		0 to 5 cm	90	
				08/30/06		0 to 5 cm	34	Surface sediment from drainage channel.
				05/29/07		0 to 5cm	0.0097	Surface sediment from crater adjacent to drainage ditch. Water (1.5-m X 0.7-m) covered area 20 cm deep.
				08/23/07		0 to 5cm	0.0052	
y	03DIS18	355,210	6,801,429	05/28/03	C	0 to 5 cm	400	WP mortar fin. Two pools: east and west.
	03DIS18 East	355,209	6,801,430	07/09/03		0 to 5 cm	240	
				08/27/04		0 to 5 cm	0.002	
				09/08/05		0 to 5 cm	0.08	

Table III-2-B3 (cont.). Discrete sediment samples.

Marked for Capping?	Sample ID	Easting	Northing	Collection Date	Area	Depth	WP Conc. (µg/g)	Field Notes
y	03DIS18 East (cont.)			08/30/06	C	0 to 5 cm	0.007	Surface sediment from drainage channel.
				05/29/07		0 to 5cm	**0.69**	Surface sediment from water-filled drainage channel.
				08/23/07		0 to 5cm	0.0055	
n	03DIS19	355,195	6,801,428	05/28/03	C	0 to 5 cm	32.6	WP mortar fin.
				08/27/04		0 to 5 cm	0.0001	
				09/08/05		0 to 5 cm	<0.0002	
				08/30/06		0 to 5 cm	<0.0002	Surface sediment (marked with metal stake)
				05/29/07		0 5cm	<0.0002	Surface sediment from 1-m diameter area. No standing water.
Area Marked	03DIS21	355,153	6,801,439	05/28/03	C	0 to 5 cm	7.0	Rectangular pool. 57mm projectiles.
				05/29/07		0 to 5cm	0.072	Surface sediment. 2-m East-West and 1.8-m North-South
n	03DIS22	355,126	6,801,461	05/28/03	C	0 to 5 cm	47.1	Two shallow pools. WP mortar fin. Another fin in bare area to the east.
				08/27/04		0 to 5 cm	95	
				09/08/05		0 to 5 cm	3.8	
				05/16/06		0 to 5 cm	0.57	
				08/30/06		0 to 5 cm	0.002	0.7-m X 0.7-m area of 18-cm deep depression at end of drainage channel.
				05/29/07		0 to 5cm	0.0016	Depression at edge of drainage channel. Mortar fin still present.

Table III-2-B3 (cont.). Discrete sediment samples.

Marked for Capping?	Sample ID	Easting	Northing	Collection Date	Area	Depth	WP Conc. (µg/g)	Field Notes
	03DIS22 (2-m radius)	355,127	6,801,461	05/16/06	C	0 to 5 cm	0.00167	2 m from center point
	03DIS22 (3-m radius)	355,128	6,801,461	05/16/06	C	0 to 5 cm	0.00039	3 m from center point
n	03DIS29	355,187	6,801,447	07/11/03	C	0 to 5 cm	3.58	About 9m south of 03DIS03. CMC saw some smoke and some metal fragments.
				05/29/07	C	0 to 5cm	0.014	Bisected by drainage ditch.
n	03DIS31	355,180	6,801,425	07/11/03	C	0 to 5 cm	1.17	About 12 m east of tower in Pond 171. Smoke. Fin.
				05/29/07	C	0 to 5cm	0.0006	Sediment south of and within drainage ditch. Fin still present.
y	03DIS36	355,233	6,801,449	09/12/03	C	0 to 5 cm	450	26 m northeast of 03DIS16. Pieces of WP mortar. Odor of WP.
				08/27/04	C	0 to 5 cm	6.5	
				09/08/05	C	0 to 5 cm	24	
				08/30/06	C	0 to 5 cm	28	Puddle in bulrush with WP ordnance scrap.
				05/29/07	C	0 to 5cm	**17**	Puddle in bulrush. WP ordnance scrap still present.
y	03DIS37	355,220	6,801,465	09/12/03	C	at UXO scrap	66	37 m north of 03DIS18. Mortar fin with WP.
				08/27/04	C	0 to 5 cm	19	
				09/08/05	C	0 to 5cm	0.04	
				08/30/06	C	0 to 5 cm	19	Surface 0.8-m X 1.5-m
				05/29/07	C	0 to 5cm	**1.91**	Sampled surface sediment around excavation.
	03DIS37 Subsurface	355,220	6,801,465	09/08/05	C	excavation hole	16	

Table III-2-B3 (cont.). Discrete sediment samples.

Marked for Capping?	Sample ID	Easting	Northing	Collection Date	Area	Depth	WP Conc. (µg/g)	Field Notes
	03DIS37	355,220	6,801,465	08/30/06	C	24.5 cm	2.6	Hole 0.5-m x 0.5 m Subsurface 24.5 cm deep
y	03DIS37 (cont.)	355,220	6,801,465	05/29/07	C	25 cm	**29**	Sediment from 25 cm deep excavation.
y	03DIS38	355,217	6,801,490	09/12/03	C	0 to 5 cm	4300	Pieces of mortar found. Smoke from metal.
				08/27/04		0 to 5 cm	2.1	
				09/08/05		0 to 5 cm	1161	
				05/16/06		0 to 5 cm	377	
				08/30/06		0 to 5 cm	48	Datalogger Hotspot #1. Surface sediment 1.1-m X 1.4-m
				05/29/07		0 to 5cm	**130**	Surface sediment of bare area (Datalogger Hotspot #1)
	03DIS38 (2-m radius)	355,218	6,801,490	05/16/06		0 to 5 cm	0.0035	2 m from center point
	03DIS38 (3-m radius)	355,219	6,801,490	05/16/06		0 to 5 cm	<0.0002	3 m from center point
y	03DIS40	355,168	6,801,505	09/12/03	C	0 to 5 cm	38	15 m north of 03DIS05. Metal piece of WP shell.
				08/27/04		0 to 5 cm	355	
				09/08/05		0 to 5 cm	75	
				08/30/06		0 to 5 cm	6.7	Surface 2-m X 1.7-m.
				05/29/07		0 to 5cm	**37**	Surface of bare area.
n	03DIS41	355,137	6,801,515	09/12/03	C	0 to 5 cm	1300	30 m south of Pond 155 sump. Metal casing of WP mortar. Also fuze.
				08/27/04		0 to 5 cm	11	
				09/08/05		0 to 5 cm	1.9	
				08/30/06		0 to 5 cm	0.25	Surface 1.5-m diameter
				05/29/07		0 to 5cm	0.0093	Surface sediment of 1.5-m

Table III-2-B3 (cont.). Discrete sediment samples.

Marked for Capping?	Sample ID	Easting	Northing	Collection Date	Area	Depth	WP Conc. (µg/g)	Field Notes
								diameter area.
	03DIS41 Subsurface	355,137	6,801,515	08/30/06	C	15 cm	0.07	30-cm diameter depression. Water depth 15 cm.
y	03DIS42	355,144	6,801,509	09/12/03	C	0 to 5 cm	204	40 m south of Pond 155 sump. Signal on Schonstadt.
				08/27/04		0 to 5 cm	11	
				09/08/05		0 to 5 cm	98.6	
				05/16/06		0 to 5 cm	264	
				08/30/06		0 to 5 cm	72	Datalogger Hotspot #2. Surface sediment 1.7-m diameter.
				05/29/07		0 to 5cm	**44**	Surface sediment at Datalogger Hotspot#2. Collected sediment away from sensors. Mortar fin still present.
	03DIS42 (2-m radius)	355,145	6,801,509	05/16/06		0 to 5 cm	<0.0002	2 m from center point
	03DIS42 (3-m radius)	355,146	6,801,509	05/16/06		0 to 5 cm	0.0007	3 m from center point
y	03DIS43	355,138	6,801,473	09/12/03	C	0 to 5 cm	150	17 m northeast of 03DIS22. Smoke. Mortar fragments. Mortar fin.
				08/27/04		0 to 5 cm	112	
				09/08/05		0 to 5 cm	15	
				05/16/06		0 to 5 cm	13	
				08/30/06		0 to 5 cm	7.1	Surface area 1.3-m X 1.5-m. Water depth 20 cm. Mortar fin still present.
				05/29/07		0 to 5cm	**9.1**	Sampled 2-m X 2-m area. Fin still present.
	03DIS43 (2-m radius)	355,139	6,801,473	05/16/06		0 to 5 cm	0.001	2 m from center point
	03DIS43 (3-m radius)	355,140	6,801,473	05/16/06		0 to 5 cm	0.001	3 m from center point

Table III-2-B3 (cont.). Discrete sediment samples.

Marked for Capping?	Sample ID	Easting	Northing	Collection Date	Area	Depth	WP Conc. (µg/g)	Field Notes
n	03DIS44	355,143	6,801,438	09/15/03	C	0 to 5 cm	1750	9 m west of 03DIS21
				08/27/04		0 to 5 cm	0.37	
				09/08/05		0 to 5 cm	0.068	
				08/30/06		0 to 5 cm	0.0003	Hole 0.7-m X 0.5-m located 10-m west of 57-mm trench (03DIS21)
				05/29/07		0 5cm	0.0011	Surface sediment from 0.7-m X 0.5-m depression. Hunk of metal next to hole.
n	04DIS057	355,139	6,801,388	05/20/04	C	at UXO scrap	93	57mm projectiles buried along a line
				05/30/07		0 15cm	0.0002	Hole 15 cm deep and 15 cm wide. Sediment from walls and bottom
n	04DIS058	355,224	6,801,362	05/20/04	C	at UXO scrap	15	57mms
				05/30/07		0 5cm	<0.0002	Hole 40 cm long, 20 cm wide and 15 cm deep.
n	04DIS060	355,207	6,801,393	05/21/04	C	at UXO scrap	3204	Large frag. Fin and mortar body. (Sediment "smoking" when weighed in lab).
				05/30/07		0 5cm	0.054	Sediment from walls and bottom of 30-cm X 20-cm hole, 25 cm deep. No frag visible.
n	04DIS066	355,161	6,801,418	05/21/04	C	at UXO scrap	60	Mortar casing in Pond 171 5 m SW of logger
				05/29/07		0 5cm	<0.0002	Surface sediment from 30-cm diameter hole. Splayed mortar body still present. Water depth 10 cm.

Table III-2-B3 (cont.). Discrete sediment samples.

Marked for Capping?	Sample ID	Easting	Northing	Collection Date	Area	Depth	WP Conc. (µg/g)	Field Notes
n	04DIS068	355,177	6,801,438	05/22/04	C	10 15cm	29.1	Approximately 1 m from 03DIS30 (toward pond 171 logger). Mortar Body 20 cm deep with smoke. Two samples: Surface 0 to 10 cm and Subsurface 10 to 15 cm deep.
				05/22/04		0 to 10cm	0.14	
				05/29/07		0 5cm	<0.0002	1.7-m X 1-m isolated crater. Metal detected 1 m southwest of crater. Subsurface was still frozen in May. Excavated in August and WP frag found. Discrete sample listed below.
n	04DIS072	355,103	6,801,440	05/22/04	C	at UXO scrap	3.2	87 m S of Pond 155 camera. Thin metal fragments with WP odor. Eastern edge of Pond 183.
				05/29/07		0 to 15cm	<0.0002	Small depression east edge of Pond 183. Hole 20-cm X 20-cm. 15-cm deep.
n	04DIS073	355,119	6,801,449	05/22/04	C	at UXO scrap	5600	77 m S of Pond 155 camera. Metal on surface of sediment.
				08/27/04		0 to 2cm	32	
				09/08/05		0 to 5cm	0.752	
				08/30/06		0 to 5cm	<0.0002	Surface 1-m X 1-m. Surface sediment water covered but shows desiccation cracks.
				05/29/07		0 5cm	0.0002	Sampled 1-m X 1-m around stake.
	04DIS73 Subsurface			08/27/04		2 to4cm	73	

Table III-2-B3 (cont.). Discrete sediment samples.

Marked for Capping?	Sample ID	Easting	Northing	Collection Date	Area	Depth	WP Conc. (µg/g)	Field Notes
	04DIS73 Subsurface			09/08/05		5 to 10cm	0.00075	
y	04DIS076	355,133	6,801,512	05/22/04	C	at UXO scrap	39.8	Approx. 2 m SE of 03DIS41. Pieces of mortar body. Smoke.
				05/29/07		0 to 5cm	**0.95**	Puddle with large metal scrap. 20 cm deep water. Sampled ~1-m diameter area.
n	04DIS077	355,141	6,801,520	05/24/04	C	at UXO scrap	1.2	Approx. 27 m E of Pond 155 camera. Very thin metal casing with hunk of crusty material.
				05/29/07		0 to 5cm	<0.0002	Small (15 cm diameter) depression in bulrush. Uncertain location.
n	04DIS078	355,147	6,801,520	05/24/04	C	at UXO scrap	933	Approximately 6 m E of 04DIS77. Thin cased metal with smoking crusty material.
				05/29/07		0 to 5 m	0.011	Pool 3-m North-South and 2-m East-West. Excavation point not obvious.
n	04DIS079	355,148	6,801,523	05/24/04	C	at UXO scrap	152	Approximately 2 m N of 04DIS78. Thin cased metal. Looks like split open mortar projectile.
				05/29/07		0 to 5cm	0.17	Surface sediment from 3-m diameter bare area.
y	04DIS082	355,247	6,801,461	05/24/04	C	at UXO scrap	1605	WP fin. Small bare patch.
				09/08/05		0 to 5cm	31.7	
				08/30/06		0 to 5cm	33	Surface 1-m X 0.5-m. Mortar fin with scrap present.
				05/29/07		0 to 5cm	**160**	Sample from puddle and second sample from hole where Jim excavated large (35 cm long) scrap. Placed scrap

Table III-2-B3 (cont.). Discrete sediment samples.

Marked for Capping?	Sample ID	Easting	Northing	Collection Date	Area	Depth	WP Conc. (µg/g)	Field Notes
								with existing fin.
Area marked	04DIS084	355,249	6,801,443	05/24/04	C	at UXO scrap	3678	Appears to be a trench filled with 57-mm projectiles
				09/08/05		0 to 5 cm	209	
				08/30/06		0 to 5 cm	4.6	Trench. 4.3-m X 0.7-m. Still contains 57-mm projectiles.
				05/29/07		0 5cm	**120**	57-mm trench surface sediment.
y	04DIS085	355,222	6,801,425	05/24/04	C	0 to 5 cm	91	WP fin. 6 m W of 03DIS16 and E of 03DIS18. Collected surface sediment.
				09/08/05		0 to 5 cm	7.66	
				08/30/06		0 to 5 cm	32	Surface sediment.
				05/29/07		0 5cm	**65**	Surface sediment for 0.8-m X 0.6-m area. One increment from hole.
	04DIS085 Subsurface			08/30/06		0 to 16 cm	0.05	Sediment from 20-cm diameter hole 16 cm deep.
y	04DIS086	354,857	6,801,626	05/25/04	BT	0 to 5 cm	12	Duck Ponds. Split open mortar projectile with smoke. Collected surface sediment.
				09/09/05		0 to 5 cm	2.17	
				08/30/06		10 to 17 cm	0.43	Oblong hole 50-cm X 20-cm. Sediment from 10 to 17 cm depth. Mortar scrap still present.
				05/25/07		0 5cm	0.0003	Surface sediment of depression. Water covered area
				05/25/07		10cm	**13**	Subsurface.

Table III-2-B3 (cont.). Discrete sediment samples.

Marked for Capping?	Sample ID	Easting	Northing	Collection Date	Area	Depth	WP Conc. (µg/g)	Field Notes
n	04DIS089	354,816	6,801,650	05/25/04	BT	at UXO scrap	109	Large rectangular fragment. No WP odor, but burning on 26 May 04.
				05/25/07		0 5cm	0.0017	Surface sediment. Scrap present
y	04DIS090	354,827	6,801,651	05/25/04	BT	at UXO scrap	5284	Split mortar. Smoke on 16 May 04.
				09/09/05		0 to 5 cm	0.66	
				08/30/06		0 to 9 cm	0.002	Within former Duck Pond 2 (drained by ditching). Hole 20-cm diameter. Depth 9 cm.
				05/25/07		0 9cm	**2.2**	Walls of hole.
n	04DIS091	354,830	6,801,655	05/25/04	BT	0 to 5 cm	2.1	Mortar body with WP odor. Surface sediment only (0 to 5 cm).
				05/25/07		0 5cm	<0.0002	No evidence of excavation point. Mortar scrap still present. Surface sediment collected around GPS point. Adjacent to drainage channel.
n	04DIS092	354,827	6,801,675	05/25/04	BT	at UXO scrap	3.1	Bell shape. Smoking in 26 May 2004.
				05/25/07		0 5cm	<0.0002	Surface sediment. Bell still present.
y	04DIS093	354,823	6,801,706	05/25/04	BT	at UXO scrap	3444	Metal frag. Smoke.
				09/09/05		0 to 5 cm	311	
				05/15/06		0 to 5 cm	12.2	
				08/30/06		0 to 5 cm	3.3	Surface 1-m diameter around stake. Scrap present.
				05/25/07		0 5cm	**6.9**	Surface sediment.

Table III-2-B3 (cont.). Discrete sediment samples.

Marked for Capping?	Sample ID	Easting	Northing	Collection Date	Area	Depth	WP Conc. (µg/g)	Field Notes
	04DIS93 (2-m radius)	354,824	6,801,706	05/15/06	BT	0 to 5 cm	<0.0002	2 m from center point
	04DIS93 (3-m radius)	354,825	6,801,706	05/15/06		0 to 5 cm	<0.0002	3 m from center point
n	04DIS094	354,818	6,801,705	05/25/04	BT	at UXO scrap	68	Split mortar rounds.
				05/25/07		0 5cm	<0.0002	Surface sediment.
y	04DIS096	354,833	6,801,722	05/26/04	BT	at UXO scrap	165	Thin metal frag buried deep.
				05/25/07		0 5cm	**7.6**	Surface sediment. Old 155 scrap nearby.
y	04DIS097	354,780	6,801,724	05/26/04	BT	at UXO scrap	2767	Rectangular metal 30 cm X 17 cm. WP odor. Burning on 27 May 2004.
				09/09/05		0 to 5 cm	2.51	
				05/15/06		0 to 5 cm	59.6	
				08/30/06		0 to 5 cm	0.12	Surface 1-m diameter around stake.
				05/25/07		0 5cm	**6.7**	Surface sediment at stake.
	04DIS97 (2-m radius)	354,781	6,801,724	05/15/06		5 cm	<0.0002	2 m from center point
	04DIS97 (3-m radius)	354,782	6,801,724	05/15/06		5 cm	<0.0002	3 m from center point
n	04DIS099	354,784	6,801,717	05/26/04	BT	at UXO scrap	17.4	Split mortar round. Buried 66 cm deep.
				05/25/07		0 16cm	0.0073	Sediment from walls and bottom of 16 cm deep hole.
n	04DIS100	354,788	6,801,670	05/26/04	BT	at UXO scrap	21.5	Split mortar round. On 27 May 2004, evidence of burning. WP odor.
n	04DIS101	354,807	6,801,673	05/26/04	BT	at UXO scrap	324	Split mortar round.
				05/25/07		0 5cm	0.0003	Surface sediment of shallow hole.

Table III-2-B3 (cont.). Discrete sediment samples.

Marked for Capping?	Sample ID	Easting	Northing	Collection Date	Area	Depth	WP Conc. (µg/g)	Field Notes
n	04DIS102	354,806	6,801,667	05/26/04	BT	at UXO scrap	117	Metal hunk. 30 cm long. WP odor. Burning on 27 May 2004.
				05/25/07		0 15cm	0.094	Surface sediment from 40-cm x 30-cm depression 15 cm deep.
n	04DIS103	354,788	6,801,661	05/26/04	BT	0 5 cm	8.8	Split mortar round. Smoke. Collected surface sediment.
				05/26/04		0 5 cm	<0.0002	70-cm diameter surface area. 17-cm deep hole.
				05/25/07		0 5cm	<0.0002	Surface sediment from 40 cm diameter depression.
n	04DIS105	354,812	6,801,651	05/27/04	BT	at UXO scrap	5.6	Rectangular metal 32 x 18 cm.
				05/25/07		0 5cm	<0.0002	Surface sediment at stake. Uncertain as to location of excavation. Scrap still present.
y	04DIS106	354,798	6,801,649	05/27/04	BT	0 5 cm	0.0211	Rectangular metal 30 cm x17 cm. Collected surface sediment sample.
				05/25/07		0 5cm	**0.82**	Surface sediment within 0.5 m of stake. No evidence of excavation. Split mortar still present.
n	04DIS107	354,799	6,801,656	05/27/04	BT	at UXO scrap	9.7	Rectangular metal 30 x 15 cm.
				05/25/07		0 5cm	0.016	Surface sediment around stake. No evidence of excavation. Rectangular metal still present.
n	04DIS108	354,796	6,801,645	05/27/04	BT	0 5 cm	0.4	Split mortar round buried 40 cm deep. WP odor. Collected surface sediment.
				05/25/07		0 5cm	0.0008	In drainage channel. Fragment present.

Table III-2-B3 (cont.). Discrete sediment samples.

Marked for Capping?	Sample ID	Easting	Northing	Collection Date	Area	Depth	WP Conc. (µg/g)	Field Notes
n	04DIS109	354,802	6,801,646	05/27/04	BT	at UXO scrap	69.3	Rectangular metal piece 15 cm x13 cm.
				05/25/07		0 5cm	0.11	Shallow depression.
n	04DIS110	354,809	6,801,646	05/27/04	BT	at UXO scrap	0.43	Two rectangular metal pieces 30 cm long and 1 m apart.
				05/25/07		0 5cm	<0.0002	Surface sediment from 40-cm diameter depression. Two metal plates still present.
n	04DIS111	354,811	6,801,639	05/27/04	BT	0 5 cm	0.39	Split mortar round buried 40 cm deep. Collected surface sample.
				05/25/07		0 5cm	<0.0002	Surface sediment around stake. Mortar body present, but excavation point not obvious.
n	04DIS114	354,788	6,801,615	05/27/04	BT	0 5 cm	0.5	Split mortar round. Collected surface sediment.
				05/27/04		0 5 cm	<0.0002	30-cm diameter hole. 25 cm deep. Sediment from bottom and sides of hole.
				05/25/07		0 5cm	<0.0002	Sediment from walls and bottom of hole. Not duck habitat.
n	04DIS117	355,124	6,801,348	05/27/04	C	0 5 cm	0.0005	Split round. 36 cm X 10 cm. Base plate is 80 mm. Smoking. Collected 0 to 5 cm surface sample.
				05/30/07		0 5cm	<0.0002	Surface sediment from bottom of hole. In patch of sedge at east edge of Pond 183. Frag still present.

Table III-2-B3 (cont.). Discrete sediment samples.

Marked for Capping?	Sample ID	Easting	Northing	Collection Date	Area	Depth	WP Conc. (µg/g)	Field Notes
n	04DIS119	354,745	6,801,650	08/18/04	BT	at UXO scrap	10	Thin metal buried 30 cm deep. Round not removed. Subsurface sediment smoking. Surface sediment (0-5 cm) taken for analysis.
				05/25/07		0 30cm	<0.0002	Surface sediment from walls and bottom of 30-cm diameter, 30-cm deep hole. Not duck habitat
n	04DIS120	354,744	6,801,675	08/18/04	BT	at UXO scrap	>10	Subsurface sediment (30 to 50 cm) smoking when removed from hole. Sample not collected for analysis.
				08/18/04		0 5 cm	0.0002	
				05/25/07		0 25cm	<0.0002	Surface sediment from 60-cm x 40-cm hole, 25 cm deep. Split mortar and fin still present.
Covered	04DIS123	354,945	6,801,721	08/24/04	C	at UXO scrap	162	Split mortar round in small pond south of Pond 730.
				09/05/06		5 cm	1.32	DP23 (South of Pond 730)
				05/26/07		0 5cm	<0.0002	Under gravel cover. Sampled edge of covering.
Area marked	04DIS125	355,228	6,801,523	08/25/04	C	at UXO scrap	950	Location of WP fin found in May.
				09/12/05		5 cm	1.71	
				05/23/06		5 cm	84	
				08/30/06		5 cm	<0.0002	Intersection of cross-ditch and south ditch. Location was blasted to deepen ditch on 11 July 2006.

Table III-2-B3 (cont.). Discrete sediment samples.

Marked for Capping?	Sample ID	Easting	Northing	Collection Date	Area	Depth	WP Conc. (µg/g)	Field Notes
Area marked	04DIS125 (cont.)	355,228	6,801,523	05/29/07	C	0 5cm	0.0058	In south cross-ditch. Surface sediment from walls and bottom of ditch east of data logger sensors.
Area marked	04DIS126	355,167	6,801,527	08/25/04	C	at UXO scrap	2033	Thick metal fragment. WP odor in peat layer.
	04DIS126 (Ditch Bottom)	355,167	6,801,527	05/19/06		5 cm	40	
	04DIS126 (High Wall)	355,167	6,801,529	05/19/06		5 cm	0.001	
	04DIS126 (Mid Wall)	355,167	6,801,528	05/19/06		5 cm	0.07	
	04DIS126 (South Wall)	355,167	6,801,527	08/30/06		5 cm	14.4	
	04DIS126	355,167	6,801,527	05/29/07		0 5cm	**48**	Surface sediment from south wall of south ditch.
Area marked	06DIS02	355,251	6,801,519	08/28/06	C	5 cm	23	Ditch Segment 3 @20 m. Location where WP ordnance frag was uncovered during ditch blasting 2006.
	06DIS02			05/29/07		0 5cm	<0.0002	From south ditch segment 3 at plunge pool.
Area marked	06DIS03	355,226	6,801,535	08/28/06	C	5 cm	1000	Ditch Segment 5 @10 m. WP mortar tail assembly (with WP) found by magnetometer survey.
	06DIS03			05/29/07		0 5cm	0.16	Surface sediment from cross ditch (segment 5).
y	BIP 2	355,242	6,801,531	05/23/06	C	5 cm	24.8	
				08/31/06		5 cm	0.004	Drained by ditching 11 July 2006
				05/29/07		0 5cm	0.023	Surface sediment from walls and bottom of crater.
Area	BIP 5	355,188	6,801,563	06/01/05	C	5 cm	8.24	

Table III-2-B3 (cont.). Discrete sediment samples.

Marked for Capping?	Sample ID	Easting	Northing	Collection Date	Area	Depth	WP Conc. (µg/g)	Field Notes
marked								
				09/12/05		5 cm	1.31	
				08/31/06		5 cm	185	
				05/29/07		0 5cm	**1.2**	Surface sediment from walls and bottom of crater.
Area marked	BIP 6	355,184	6,801,562	06/01/05	C	5 cm	72	
				09/12/05		5 cm	0.012	
				08/31/06		5 cm	62	
				05/29/07		0 5cm	**97**	Surface sediment from walls and bottom of crater.
Area marked	BIP 7	355,185	6,801,565	06/01/05	C	5 cm	53	
				09/12/05		5 cm	0.83	
				08/31/06		5 cm	1.4	
				05/29/07		0 5cm	**66**	Surface sediment from walls and bottom of crater.
Area marked	BIP 8	355,184	6,801,567	06/01/05	C	5 cm	29	
				09/12/05		5 cm	2.89	
				08/31/06		5 cm	3.5	
				05/29/07		0 5cm	**29**	Surface sediment from walls and bottom of crater.
Area marked	BIP 9	355,182	6,801,570	06/01/05	C	5 cm	1329	
				09/12/05		5 cm	0.677	

Area	BIP 9 (cont.)	355,182	6,801,570	08/31/06	C	5 cm	51	UXO tech found another 105-

Table III-2-B3 (cont.). Discrete sediment samples.

Marked for Capping?	Sample ID	Easting	Northing	Collection Date	Area	Depth	WP Conc. (µg/g)	Field Notes
marked								mm WP round on west rim of BIP 9 (25 May 2006).
				05/29/07		0 5cm	**3000**	Surface sediment from walls and bottom of crater.
y	BIP 10	355,167	6,801,567	06/01/05	C	5 cm	1164	
				09/12/05		5 cm	0.624	
				08/31/06		5 cm	750	
				05/29/07		0 5cm	0.004	Surface sediment inside rim.
y	BIP 11	355,169	6,801,590	06/01/05	C	5 cm	511	
				08/31/06		5 cm	31	Crater 1.6-m to 2-m across. Depth in center is 67 cm.
				05/29/07		0 5cm	0.019	Surface sediment inside rim.
Area marked	CMarchPond15	355,187	6,801,558	06/01/05	C	5 cm	8.30	
				09/12/05		5 cm	1.98	
				08/31/06		5 cm	12	UXO tech found two more 105-mm WP rounds less than 1 m west of pond (25 May 2006).
				05/29/07	C	0 5cm	0.068	Surface sediment from walls and bottom of pool.
y	Edge of CMarsh Pond 23 (E of Line 2.5 120m S)	355,292	6,801,535	08/24/02	C	5 cm	0.161	
				05/30/07		0 5cm	**1.3**	Surface sediment from walls and bottom of pool. UXO tech found 105-mm UXO. EOD removed projectile, which they identified as a practice round.
n	Miller's Hole	355,067	6,801,177	09/15/03	C	20 cm	104	

Table III-2-B3 (cont.). Discrete sediment samples.

Marked for Capping?	Sample ID	Easting	Northing	Collection Date	Area	Depth	WP Conc. (µg/g)	Field Notes
				09/15/03		25 cm	0.0857	
				09/15/03		20 cm	0.0012	
				09/15/03		15 cm	0.0005	
				09/15/03		10 cm	0.0005	
				09/15/03		5 cm	0.0002	
				05/30/07		0 5cm	<0.0002	Surface sediment from walls and bottom of crater.
				05/30/07		30cm	<0.0002	Sediment from 30 cm depth.
n	Near 240 (under geotextile)	355,000	6,801,330	08/26/02	C	25 cm	1.6	
				08/26/02		20 cm	0.42	
				08/26/02		20 cm	0.003	
				08/26/02		15 cm	0.002	
				08/26/02		10 cm	0.0006	
				08/26/02		5 cm	0.0005	
				05/30/07		0 5cm	<0.0002	Surface sediment around GPS point and inside wood markers.
n	Pond 146 near P4 Round	355,249	6,801,298	08/23/02	C	5 cm	0.298	
				05/30/07		0 5cm	0.0003	Surface sediment near WP fragment.
n	Pond 155 (Row 4.5 – Column 1.5)	355,119	6,801,544	09/10/03	C	5 cm	8.12	
				08/27/04		5 cm	0.0005	
				05/29/07		0 5cm	0.005	Sampled within 1 m of GPS coordinate
n	Pond 155 (Row 8 – Column 0)	355,116	6,801,538	08/22/02	C	5 cm	0.832	
				09/10/03		5 cm	0.050	

Table III-2-B3 (cont.). Discrete sediment samples.

Marked for Capping?	Sample ID	Easting	Northing	Collection Date	Area	Depth	WP Conc. (µg/g)	Field Notes
				08/27/04		5 cm	0.0009	
				05/29/07		0 5cm	0.002	Sampled within 1 m of GPS coordinate
n	Near ordnance in ditch	355,208	6,800,458	05/29/03	RI	5 cm	284	
New Samples in 2007								
n	Pond 155 FRAGS 1 m south of 4.5 – 1.5	355,119	6,801,543	05/29/07	C	0 5cm	0.0004	Mud from frag excavation
n	Pond 155 FRAG ROW 12	355,107	6,801,536	05/29/07	C	0 5cm	<0.0002	Mud from frag excavation
Area marked	0.5 m S of 04DIS82	355,247	6,801,461	05/29/07	C	0 5cm	**1.7**	Jim excavated a large frag (35 cm long) from a 105 or 155-mm projectile.
y	1 m SW of 04DIS68	355,176	6,801,437	05/29/07	C	0 5cm	**41**	Possible WP projectile.
n	Pond 730 close to sump	354,888	6,801,806	08/21/07	C/D	0 10cm	<0.0002	Mud co-located with metal scrap. Jim Jepson collected sample.
n	155-mm WP excavation	354,092	6,800,886	08/25/07	A	0 10cm	0.0003	Mud from 2006 excavation of 155-mm WP projectile that was mostly empty.
n	EIS Crater 1	354,845	6,801,288	06/07/07	C	0 5cm	<0.0002	
n	EIS Crater 2	354,881	6,801,199	06/07/07	C	0 5cm	<0.0002	
n	EIS Crater 3	354,856	6,801,162	06/07/07	C	0 5cm	<0.0002	
n	EIS Crater 4	354,911	6,801,139	06/07/07	C	0 5cm	<0.0002	
n	EIS Crater 5	354,814	6,801,251	06/07/07	C	0 5cm	<0.0002	
n	EIS Crater 6	354,771	6,801,325	06/07/07	C	0 5cm	<0.0002	
n	EIS Crater 7	354,776	6,801,435	06/07/07	C	0 5cm	<0.0002	
n	EIS Crater 8	354,549	6,801,539	06/07/07	BT	0 5cm	<0.0002	
n	EIS Crater 9	354,514	6,801,525	06/07/07	BT	0 5cm	<0.0002	

Table III-2-B3 (cont.). Discrete sediment samples.

Marked for Capping?	Sample ID	Easting	Northing	Collection Date	Area	Depth	WP Conc. (µg/g)	Field Notes
n	EIS Crater 10	354,503	6,801,528	06/07/07	BT	0 5cm	<0.0002	
n	EIS Crater 11	354,511	6,801,538	06/07/07	BT	0 5cm	<0.0002	
n	EIS Crater 12	354,504	6,801,611	06/07/07	BT	0 5cm	<0.0002	
n	EIS Crater 13	354,536	6,801,617	06/07/07	BT	0 5cm	<0.0002	
n	EIS Crater 14	354,533	6,801,637	06/07/07	BT	0 5cm	<0.0002	
n	Ejecta EIS Crater 1			06/07/07	C	0 5cm	<0.0002	
n	Ejecta EIS Crater 2			06/07/07	C	0 5cm	<0.0002	
n	Ejecta EIS Crater 3			06/07/07	C	0 5cm	<0.0002	
n	Ejecta EIS Crater 4			06/07/07	C	0 5cm	<0.0002	
n	Ejecta EIS Crater 5			06/07/07	C	0 5cm	<0.0002	
n	Ejecta EIS Crater 6			06/07/07	C	0 5cm	<0.0002	
n	Ejecta EIS Crater 7			06/07/07	C	0 5cm	<0.0002	
n	Ejecta EIS Crater 8			06/07/07	BT	0 5cm	<0.0002	
n	Ejecta EIS Crater 9			06/07/07	BT	0 5cm	<0.0002	
n	Ejecta EIS Crater 10			06/07/07	BT	0 5cm	<0.0002	
n	Ejecta EIS Crater 11			06/07/07	BT	0 5cm	<0.0002	
n	Ejecta EIS Crater 12			06/07/07	BT	0 5cm	<0.0002	
n	Ejecta EIS Crater 13			06/07/07	BT	0 5cm	<0.0002	
n	Ejecta EIS Crater 14			06/07/07	BT	0 5cm	<0.0002	
n	EIS Acoustic C4 Crater 1	354,478	6,801,942	06/21/07	BT	0 5cm	<0.0002	
n	EIS Acoustic C4 Crater 2	354,458	6,801,964	06/21/07	BT	0 5cm	<0.0002	
n	EIS Acoustic C4 Crater 3	354,438	6,801,986	06/21/07	BT	0 5cm	<0.0002	
n	EIS Acoustic C4 Crater 4	354,418	6,802,009	06/21/07	BT	0 5cm	<0.0002	

III-3. 2007 WEATHER DATA FOR EAGLE RIVER FLATS

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INTRODUCTION

The remediation process in Eagle River Flats is greatly dependent on the weather conditions during the summer remediation season. The shallow ponds and marsh areas contaminated with white phosphorus are remediated by temporarily draining the water from the treatment area with large pumps and allowing the contaminated sediment to dry. This in turn allows the white phosphorus to sublime and oxidize into non-toxic phosphate compounds. Because of the importance of weather in the success of the remediation effort, we have monitored meteorological conditions every summer since a meteorological data station was first installed at the edge of the EOD pad in May 1994 (Haugen 1995). Each summer a standard suite of meteorological data including air temperature, wind speed and direction, radiation, precipitation, and evaporation are collected. Meteorological data are posted daily on the Eagle River Flats web page linked to the CRREL public web site, allowing interested personnel to check on-site conditions on a regular basis from off site (www.crrel.usace.army.mil/erf).

METEOROLOGICAL STATION

The Eagle River Flats meteorological station (Fig. III-3-1) is located off the edge of the EOD pad on a small gravel pad extending into the salt marsh of Area C. Atop the 4-m guyed tower is a wind anemometer that records wind direction and speed. This location is high enough to be above any effects caused by the edge of the nearby EOD pad. Air temperature and relative humidity sensors within standard shields are located at 2-m and 0.5-m heights on the tower. At the 2-m height, a side arm holds two Epply radiation sensors that measure incoming and reflected short wave radiation (0.3 to 3 µm). A white fiberglass enclosure mounted on the tower contains the Campbell Scientific CR10 datalogger system and data storage module. All meteorological data collected for the season are stored on the storage module. Also mounted in the enclosure is a radio modem that communicates between the met station and the Ethernet RF modem base station at Building 724. The antenna for the radio is attached to the top of the tower. A wind-shielded precipitation gage is located 5 m to the east of the tower. A second backup unshielded precipitation gage is located nearby. A standard 1.22-m (48-in) diameter evaporation pan is located 2 m west of the tower. A

Druck pressure transducer at the bottom of the evaporation pan measures water depth. The station is powered with a 12-V battery, charged by a solar panel mounted on the tower. Table III-3-1 summarizes the instruments and parameters measured at the ERF meteorological station.

RESULTS

The full suite of measurements including precipitation and evaporation pan measurements was restarted for the 2007 summer season on 1 May. The meteorological station ran throughout the previous winter, collecting temperature, relative humidity, and radiation measurements. At the end of August the precipitation and evaporation pan measurements were again discontinued while temperature, relative humidity, and radiation measurements were continued. Reliability of the station was good throughout the summer season except when the precipitation gage became partially clogged with spider webs in August.

Table III-3-2 summarizes the Eagle River Flats 2007 weather data from May through August. It presents monthly average temperatures for Eagle River Flats and for the National Weather Service (NWS) station in Anchorage, along with the normal monthly temperatures for Anchorage. The Anchorage NWS data are

Figure III-3-1. Eagle River Flats meteorological station located along the edge of the OB/OD pad in Area C. The 4-m tower is located in the right center, the 1.22-m-diameter evaporation pan is located to the right, and the shielded rain gage is located to the left.

Table III-3-1. Summary of meteorological station instruments and the parameters measured.

Instrument	Parameter Measured
R.M. Young wind anemometer, 4-m height	Average wind speed (m/s) Average wind direction (m/s) Peak wind speed (m/s) Time of peak wind speed
(2) Air temperature sensors, 2-m and 0.5 -m heights	Average 2-m temperature (°C) Maximum 2-m temperature (°C) Minimum 2-m temperature (°C) Average 0.5-m temperature (°C) Maximum 0.5-m temperature (°C) Minimum 0.5-m temperature (°C)
(2) Relative Humidity sensors, 2 m-and 0.5-m heights	Average 2-m relative humidity (%) Maximum 2-m relative humidity (%) Minimum 2-m relative humidity (%) Average 0.5-m relative humidity (%) Maximum 0.5-m relative humidity (%) Minimum 0.5-m relative humidity (%)
(2) Epply radiation (0.3–3 µm) sensors, incident and reflected	Average shortwave incident radiation (W/m^2) Average shortwave reflected radiation (W/m^2)
Tipping bucket rain gage	Tipping bucket 15-min precipitation (mm) Tipping bucket total daily precipitation (mm)
Druck 357/D pressure transducer	Evaporation pan water level 15-min sample

Table III-3-2. Monthly summary of temperatures and precipitation for ERF and Anchorage (ANC), showing the 2007 monthly (or partial monthly) average temperatures for both sites, normal monthly average temperatures for Anchorage, monthly total measured precipitation for ERF, and monthly total and normal average precipitation for Anchorage.

	Average Temperature (°C)			Rainfall (mm)		
Month	ANC normal	ANC 2007	ERF 2007	ANC normal	ANC 2007	ERF 2007
May	8.3	8.8	–	17.8	16.8	–
20-31 May	9.9	10.3	10.0	8.1	5.3	4.6
June	12.6	12.9	13.0	26.9	27.9	17.3
July	14.7	14.7	14.7	43.2	46.0	53.8
August	13.5	14.7	13.6	74.4	53.1	40.6
1-24 Sept	9.7	10.9	10.0			*
Sept	8.5	9.2	–	72.9	109.2	*

*Rain gage clogged and inoperable.

included because we have no long-term average data for the Eagle River Flats site. Table III-3-2 also presents the monthly total rainfall for Eagle River Flats and for Anchorage, along with the Anchorage normal monthly rainfall. Temperatures in Eagle River Flats were normal to slightly above normal throughout the summer remediation season from May through September.

Figure III-3-2 plots the maximum, minimum, and average air temperatures for the summer. We had just slightly above normal (+0.2°C) average temperatures for the four months. The highest temperature of the 2007 summer, 28.1°C, occurred on 20 June. There were 42 prime remediation days when maximum temperatures reached 20°C or more: zero days in May, 12 in June, 11 in July, and 18 in August. The 42-day total is more than the 37 days in 2006, but less than the previous two very warm years. There were 58 such days in 2005 and 67 days in 2004. This

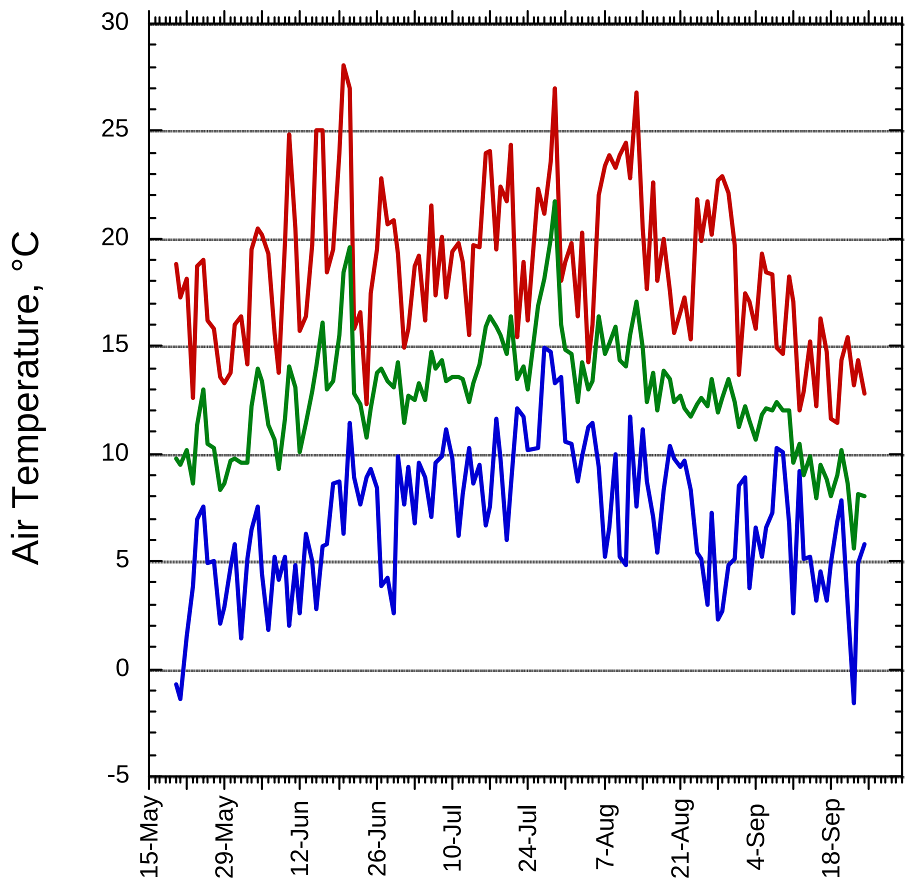

Figure III-3-2. Maximum, minimum, and average air temperatures for the Eagle River Flats meteorological station from May through August 2007 shown in red, blue, and green, respectively. The season had just slightly above normal temperatures with 42 days with maximum temperatures of 20°C or more. The warmest day was 20 June, when the maximum temperature was 28.1°C.

year's total is comparable to the 48 days in 2003, 42 in 2002, 39 in 2001, and 38 in 2000, all of which were also good drying years. This contrasts with only 18 days during the summer of 1998 and 30 days during the summer of 1999, the first two years of pumping remediation (Collins 2001–2007).

Precipitation was below normal in May and June, slightly above normal in July, and well below normal in August. Over half of the cumulative precipitation of 118 mm from May through August was spread over a one-month period from late June to late July. Much of the rest occurred over a weeklong period in mid August (Fig. III-3-3). The largest single rainfall event of the summer was on 19 July, with 16.8 mm of rain.

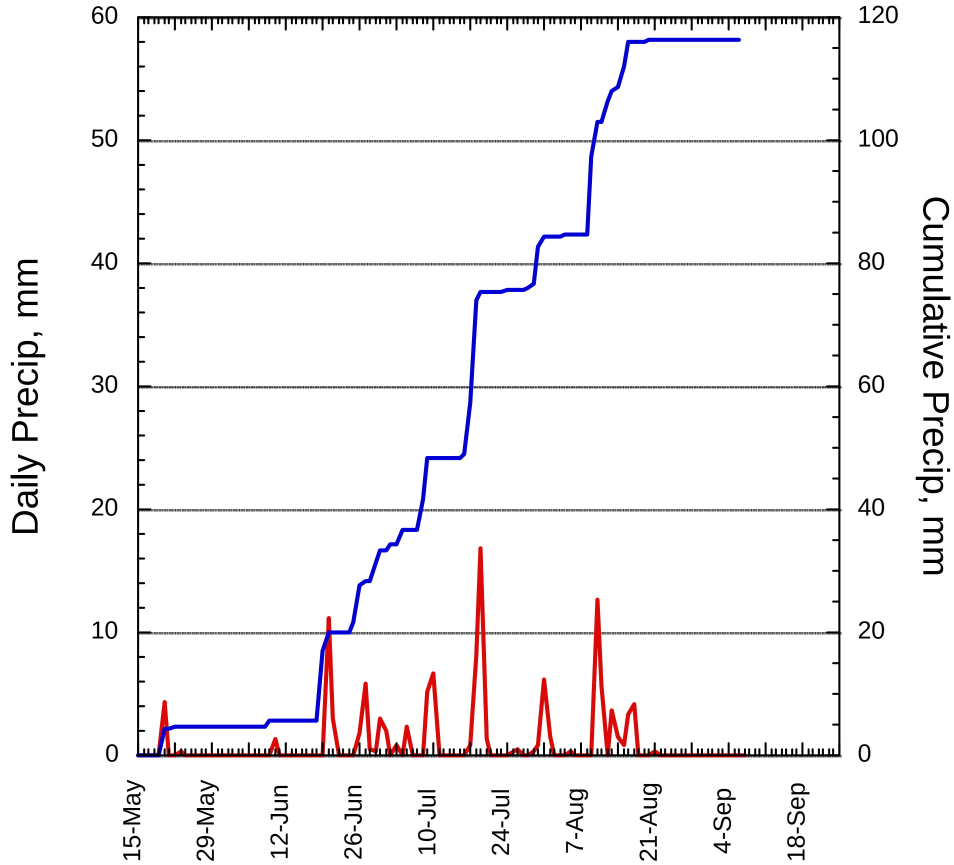

Figure III-3-3. Daily (red) and cumulative (blue) precipitation at the ERF meteorological station for the season from May through August 2007. Cumulative precipitation was below normal (118 mm), and over half the precipitation occurred over a one-month period from late June to late July.

Finally, the drying conditions throughout the season can be interpreted from the slope of the plot of the cumulative evaporation data from the 1.22-m evaporation pan (Fig. II-3-4). High evaporation rates occurred early in the summer until late June. More moderate evaporation took place after that until mid August when warmer than normal temperatures occurred.

Daily meteorological data for the summer season are summarized in Table II-3-3. If needed, more detailed data, including all the 15-minute observations and additional measured parameters, are available from CRREL in spreadsheet format.

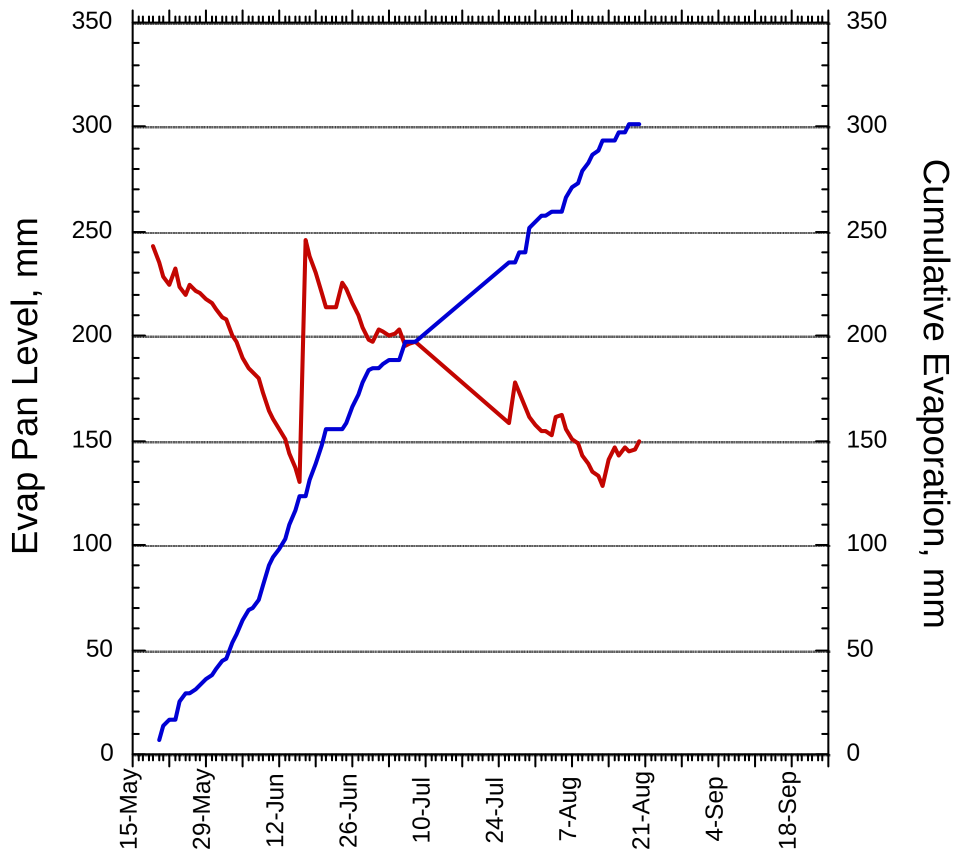

Figure II-3-4. Evaporation pan data showing evaporation pan water level data (red) and net cumulative evaporation for the season (blue). Evaporation rate is consistent over the season, reflecting the normal to slightly above normal temperatures. Pan water levels show decreases due to evaporation, and increases due to addition of make-up water on 17 June.

Table II-3-3. Daily climatic data for Eagle River Flats meteorological station from May through August 2007.

Date	Air temperature (°C)			Precip. (mm)	Wind speed (m/s)		Ave Radiation (W/m^2)	
	Max	Ave	Min		Ave	Max	Incident	Reflected
20 May	18.8	9.8	-0.7	0.0	1.8	3.9	328	34
21 May	17.3	9.5	-1.4	0.0	1.5	3.4	321	36
22 May	18.1	10.2	1.5	0.0	1.2	3.5	187	19
23 May	12.6	8.6	3.9	4.3	1.1	2.7	49	4
24 May	18.7	11.3	7.0	0.0	1.4	4.0	219	23
25 May	19.0	13.0	7.5	0.0	1.1	3.0	209	22
26 May	16.2	10.5	4.9	0.0	0.9	2.6	109	11
27 May	15.8	10.3	5.0	0.3	0.7	2.4	166	16
28 May	13.6	8.3	2.1	0	1.0	3.5	152	16
29 May	13.3	8.6	2.9	0	0.9	3.4	126	13
30 May	13.8	9.7	4.7	0	0.9	2.8	112	11
31 May	16.0	9.8	5.8	0	1.4	3.6	149	16
01 Jun	16.4	9.6	1.4	0	1.0	3.3	190	21
02 Jun	14.2	9.6	5.1	0	1.0	2.6	141	15
03 Jun	19.5	12.2	6.5	0	1.4	3.2	270	30
04 Jun	20.5	14.0	7.5	0	1.5	5.0	189	21
05 Jun	20.2	13.4	4.4	0	1.9	5.6	292	34
06 Jun	19.3	11.3	1.8	0	1.2	3.2	254	29
07 Jun	15.6	10.7	5.2	0	1.9	5.0	195	23
08 Jun	13.8	9.3	4.1	0	1.5	3.7	193	22
09 Jun	19.8	11.6	5.2	0	1.2	3.2	264	31
10 Jun	24.9	14.1	2.0	0	1.2	3.2	344	40
11 Jun	20.5	13.1	4.8	0	1.5	4.2	273	33
12 Jun	15.7	10.1	2.6	0	1.7	3.6	223	28
13 Jun	16.4	11.4	6.3	0	1.3	2.9	239	30
14 Jun	19.7	12.9	5.0	1.3	1.2	3.0	347	42
15 Jun	25.0	14.1	2.8	0	1.2	3.4	344	42
16 Jun	25.0	16.1	5.7	0	1.5	3.9	355	44
17 Jun	18.4	13.0	5.8	0	1.7	4.0	200	25
18 Jun	19.5	13.4	8.6	0	1.2	3.0	290	38
19 Jun	24.0	15.5	8.7	0	1.5	2.9	330	42
20 Jun	28.1	18.4	6.3	0	1.3	3.3	347	44
21 Jun	27.0	19.6	11.4	0	1.4	3.2	332	43
22 Jun	15.8	12.8	8.9	0	1.4	3.4	150	21
23 Jun	16.6	12.3	7.6	0	1.1	4.5	122	15
24 Jun	12.3	10.8	8.9	11.2	0.6	2.0	68	8
25 Jun	17.5	12.1	9.3	3.0	0.6	2.5	192	25
26 Jun	19.5	13.8	8.4	0.0	1.4	2.8	301	40
27 Jun	22.8	14.0	3.9	0.0	1.3	2.8	335	44

Table II-5-3. Daily climatic data for Eagle River Flats meteorological station from May through August 2007.

Date	Air temperature (°C)			Precip. (mm)	Wind speed (m/s)		Ave Radiation (W/m²)	
	Max	Ave	Min		Ave	Max	Incident	Reflected
28 Jun	20.7	13.4	4.2	0.0	1.3	3.0	347	46
29 Jun	20.9	13.1	2.6	0.0	1.5	4.5	320	43
30 Jun	19.3	14.3	9.9	1.8	0.9	2.2	178	23
01 Jul	14.9	11.4	7.6	5.8	0.4	1.7	97	12
02 Jul	15.8	12.7	9.4	0.5	1.0	2.5	139	18
03 Jul	18.7	12.5	6.8	0.3	0.8	2.6	129	17
04 Jul	19.2	13.3	9.6	3.0	0.7	2.0	127	16
05 Jul	16.2	12.5	8.9	2.0	1.0	2.4	119	15
06 Jul	21.5	14.7	7.1	0.0	1.0	3.3	285	37
07 Jul	17.4	14.0	9.6	0.8	0.5	2.1	126	15
08 Jul	20.1	14.4	9.9	0.0	1.0	2.8	245	32
09 Jul	17.3	13.4	11.1	2.3	0.7	2.5	156	21
10 Jul	19.4	13.6	9.8	0.0	0.8	2.9	164	22
11 Jul	19.8	13.6	6.2	0.0	1.1	3.3	236	31
12 Jul	18.9	13.5	8.1	0.0	1.2	3.1	231	32
13 Jul	15.5	12.4	10.3	5.1	0.5	1.6	100	13
14 Jul	19.7	13.3	8.6	6.6	0.5	2.3	192	26
15 Jul	19.6	14.2	9.5	0.0	1.1	2.6	262	37
16 Jul	24.0	15.9	6.7	0.0	1.1	2.7	328	44
17 Jul	24.1	16.4	7.5	0.0	1.5	3.8	325	45
18 Jul	19.5	15.9	11.6	0.0	0.8	2.9	157	21
19 Jul	22.4	15.5	9.8	0.0	1.1	2.9	233	33
20 Jul	21.7	14.6	6.0	0.0	1.2	3.1	287	41
21 Jul	24.4	16.4	8.5	0.8	0.9	2.3	288	39
22 Jul	15.4	13.5	12.1	8.1	0.4	2.0	46	6
23 Jul	18.9	14.1	11.7	16.8	0.5	2.6	149	20
24 Jul	16.2	13.0	10.2	1.3	0.3	1.2	84	11
06 Jul	20.9	15.5	10.3	0.0	0.8	2.5	215	28
26 Jul	22.3	16.9	10.3	0.0	1.1	2.9	392	54
27 Jul	21.2	18.1	14.9	0.0	1.4	2.4	413	57
28 Jul	23.6	20.0	14.7	0.0	1.2	2.1	493	67
29 Jul	27.0	21.7	13.3	0.0	1.4	2.4	124	15
30 Jul	18.0	16.0	13.6	0.5	0.8	2.4	159	21
31 Jul	18.9	14.8	10.6	0.0	1.0	2.7	209	29
01 Aug	19.8	14.6	10.5	0.0	1.2	3.2	107	14
02 Aug	16.4	12.4	8.7	0.3	0.8	2.6	125	16
03 Aug	20.3	14.3	9.9	0.8	0.6	2.9	56	6
04 Aug	14.3	13.0	11.2	6.1	0.3	1.0	39	5
05 Aug	16.0	13.4	11.4	1.5	0.6	3.4	255	34
06 Aug	22.0	16.4	9.4	0.0	2.2	3.8	84	11

Table II-5-3. Daily climatic data for Eagle River Flats meteorological station from May through August 2007.

Date	Air temperature (°C)			Precip. (mm)	Wind speed (m/s)		Ave Radiation (W/m^2)	
	Max	Ave	Min		Ave	Max	Incident	Reflected
07 Aug	23.4	14.6	5.2	0.0	1.1	3.2	271	38
08 Aug	23.9	15.1	6.6	0.0	1.0	3.0	274	38
09 Aug	23.3	15.9	10.0	0.3	1.0	3.3	257	37
10 Aug	23.9	14.4	5.2	0.0	0.9	2.7	270	38
11 Aug	24.5	14.1	4.8	0.0	0.8	2.9	258	36
12 Aug	22.8	15.5	11.7	0.0	0.6	2.2	136	18
13 Aug	26.8	17.1	7.5	0.0	1.0	2.8	255	35
14 Aug	20.5	14.9	11.1	12.7	0.9	3.1	114	15
15 Aug	17.7	12.4	8.7	5.6	0.2	1.0	86	10
16 Aug	22.6	13.8	7.1	0.0	0.5	1.7	177	24
17 Aug	18.0	12.0	5.4	3.6	0.8	3.6	98	13
18 Aug	20.0	13.9	8.3	1.5	0.7	2.3	177	24
19 Aug	17.6	13.5	10.4	0.8	0.5	1.8	89	11
20 Aug	15.6	12.4	9.8	3.3	0.2	1.3	53	6
21 Aug	16.6	12.7	9.4	4.1	0.4	2.3	88	11
22 Aug	17.3	12.1	9.7	0.0	0.4	1.6	76	9
23 Aug	15.3	11.7	8.3	0.0	0.4	1.2	92	11
24 Aug	21.8	12.3	5.4	0.0	0.8	2.6	231	33
25 Aug	19.9	12.6	5.1	0.3	1.0	2.5	233	33
26 Aug	21.7	12.2	3.0	0.0	0.6	1.9	204	29
27 Aug	20.2	13.5	7.3	0.0	0.7	2.4	167	23
28 Aug	22.7	11.9	2.3	0.0	0.8	2.5	214	31
29 Aug	22.9	12.6	2.7	0.0	0.7	2.2	214	31
30 Aug	22.1	13.5	4.8	0.0	0.9	2.4	192	28
31 Aug	19.7	12.4	5.1	0.0	0.7	2.2	164	22
01 Sep	13.7	11.2	8.5	0.0	0.4	1.5	39	5
02 Sep	17.5	12.2	8.9	0.0	0.6	1.7	129	17
03 Sep	17.1	11.5	3.8	0.0	0.8	3.0	152	21
04 Sep	15.8	10.7	6.6	0.0	0.5	2.5	97	12
05 Sep	19.3	11.8	5.2	0.0	1.0	3.1	196	28
06 Sep	18.4	12.1	6.6	0.0	0.7	3.0	168	24
07 Sep	18.3	12.0	7.3	0.0	0.8	4.4	100	13
08 Sep	14.9	12.4	10.3	0.0	1.3	4.9	22	3
09 Sep	14.6	12.0	10.1	0.0	0.2	0.9	37	4
10 Sep	18.2	12.0	6.8	0.0	0.6	2.3	133	18
11 Sep	17.1	9.6	2.6	0.0	0.6	2.5	100	13

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