WHATCOM CREEK RESTORATION PROJECT REPORT: 2009

Associated with the Whatcom Creek Restoration Plan Developed for the June 10, 1999 Olympic Pipe Line Gasoline Spill

September 2010

Brenna Forester
City of Bellingham
Department of Public Works
Environmental Resources Section
Bellingham, WA

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1 OVERVIEW

On June 10, 1999 an underground pipeline ruptured in Bellingham, Washington, releasing approximately 277,200 gallons of unleaded gasoline into Hannah and Whatcom Creeks. The gasoline was subsequently ignited, resulting in a fire which burned approximately 25 acres of riparian vegetation along the Whatcom Creek corridor. During this event, the fishery and aquatic resources of Whatcom Creek were severely impacted. A Long-term Restoration Plan was designed to determine the impacts of the spill on natural resources and identify measures that would be implemented to restore those injured resources. The goals for rehabilitation and enhancement center on addressing injuries by creating and improving salmonid habitat associated with Whatcom Creek. Monitoring and restoration activities associated with the Long-term Restoration Plan are outlined in the following report:

- *Monitoring and Maintenance Plan: Associated with the Whatcom Creek Restoration Plan* (City of Bellingham 2006). This report specifies monitoring protocols and restoration actions for the burn zone and associated restoration sites.

Monitoring and restoration has occurred in two areas: the burn zone and associated restoration projects (Cemetery Creek and Salmon Park). Evaluation of recovery in the burn zone was completed in 2009; results and analysis are presented in two companion reports:

- *Whatcom Creek Post-Fire Evaluation: Ten Years After* (Madsen and Nightengale 2009). This final report details scientific monitoring results and restoration effectiveness in the burn zone along Whatcom and Hannah Creeks from 1999-2009.
- *Whatcom Creek – Ten Years After: Summary Report* (Madsen 2009). This final report summarizes monitoring results and restoration effectiveness in the burn zone and associated restoration sites in the ten years since the incident.

The Cemetery Creek and Salmon Park restoration projects (Figure 1-1) were completed in 2006; monitoring of these sites was started in 2007. Results and analysis of the first two years of monitoring at the restoration sites is presented in the following report:

- *Whatcom Creek Restoration Project Report: 2007-2008* (Forester 2009). This report details monitoring results from 2007-2008 in the restoration sites associated with burn zone recovery (Cemetery Creek and Salmon Park). Monitoring at these sites will continue periodically until 2016 (see below).

This report presents the results of monitoring surveys conducted at the Cemetery Creek and Salmon Park restoration sites in 2009. This report is an update of results presented in the companion report *Whatcom Creek Restoration Project Report: 2007-2008* (Forester 2009). The 2007-2008 report is available through the City of Bellingham Public Works Department and online at: http://www.cob.org/documents/pw/environment/restoration/whatcom-creek-restoration-project-report.pdf. That report includes background information on the pipeline rupture, subsequent fire, and mitigation and restoration actions. In this update, introduction and methods sections have been shortened. Detailed introduction and methods can be referenced in the *Whatcom Creek Restoration Project Report: 2007-2008* (Forester 2009).

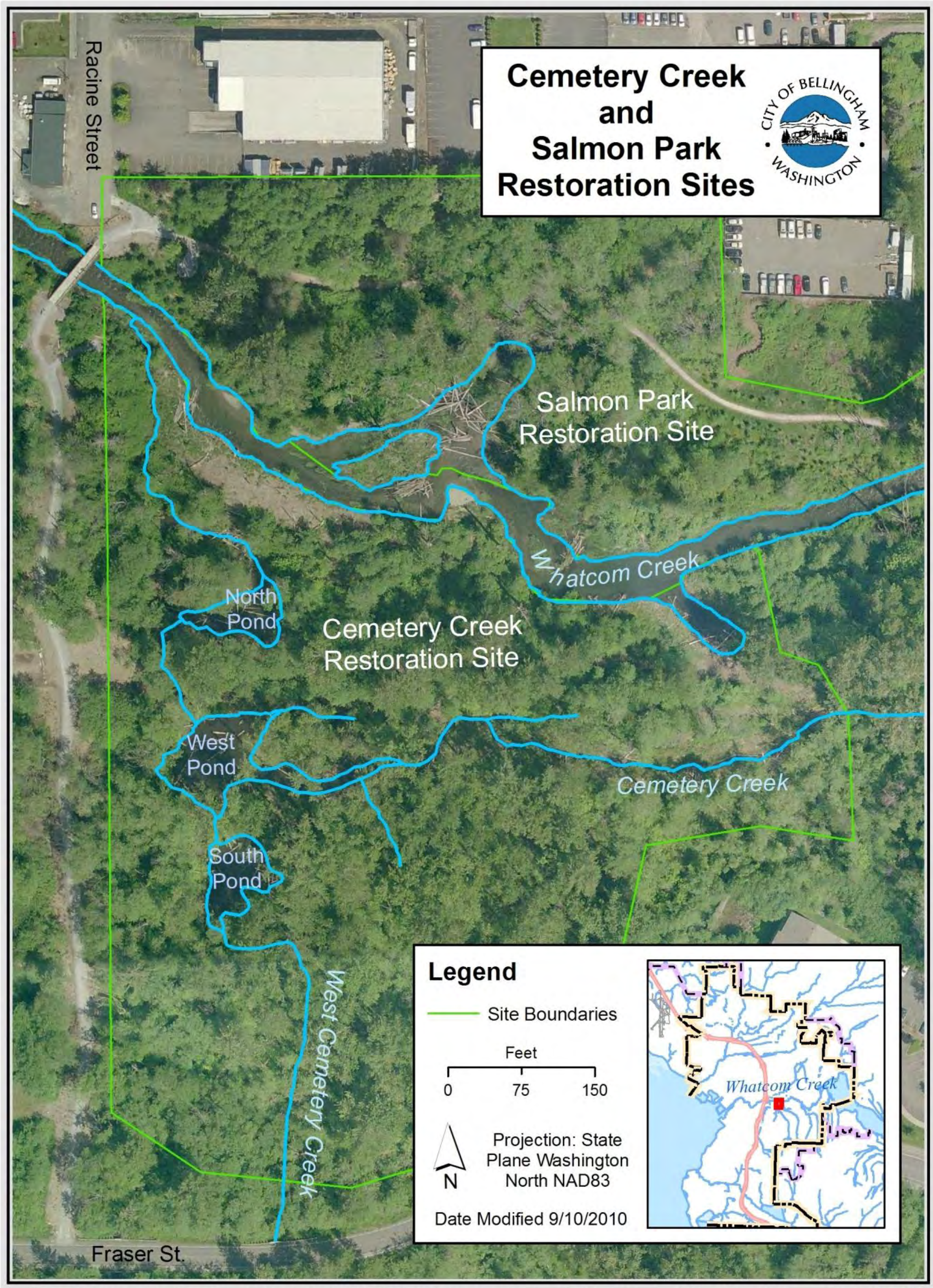
Monitoring of the Cemetery Creek and Salmon Park restoration sites focuses on eight areas, subdivided into three groups:

1) Biological Monitoring
   - Vegetation
   - Fish community
   - Aquatic macroinvertebrates
   - Riparian and terrestrial wildlife community
2) Physical Monitoring
   - Hydrology
   - Instream habitat
   - Water quality
3) Photodocumentation

The *Monitoring and Maintenance Plan* (COB 2006) specifies that monitoring of the restoration sites shall occur in post-construction years 1, 2, 3, 5, 7, and 10, corresponding to years 2007, 2008, 2009, 2011, 2013, and 2016, respectively.[1] This report details monitoring results from post-construction year 3 (2009).

[1] Monitoring of juvenile salmonids using a smolt trap follows a different schedule. Monitoring will occur in post-construction years 1, 3, 6, and 10, corresponding to years 2007, 2009, 2012, and 2016, respectively.

Figure 1-1. Map of the Cemetery Creek and Salmon Park Restoration Sites.



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2 BIOLOGICAL MONITORING

2.1 VEGETATION

2.1.1 Introduction

The objective of vegetation surveys is to document establishment and success of native riparian species while ensuring that invasive species are not interfering with native plant growth and survival. A detailed introduction and site background are available in the *Whatcom Creek Restoration Project Report: 2007-2008* (Forester 2009).

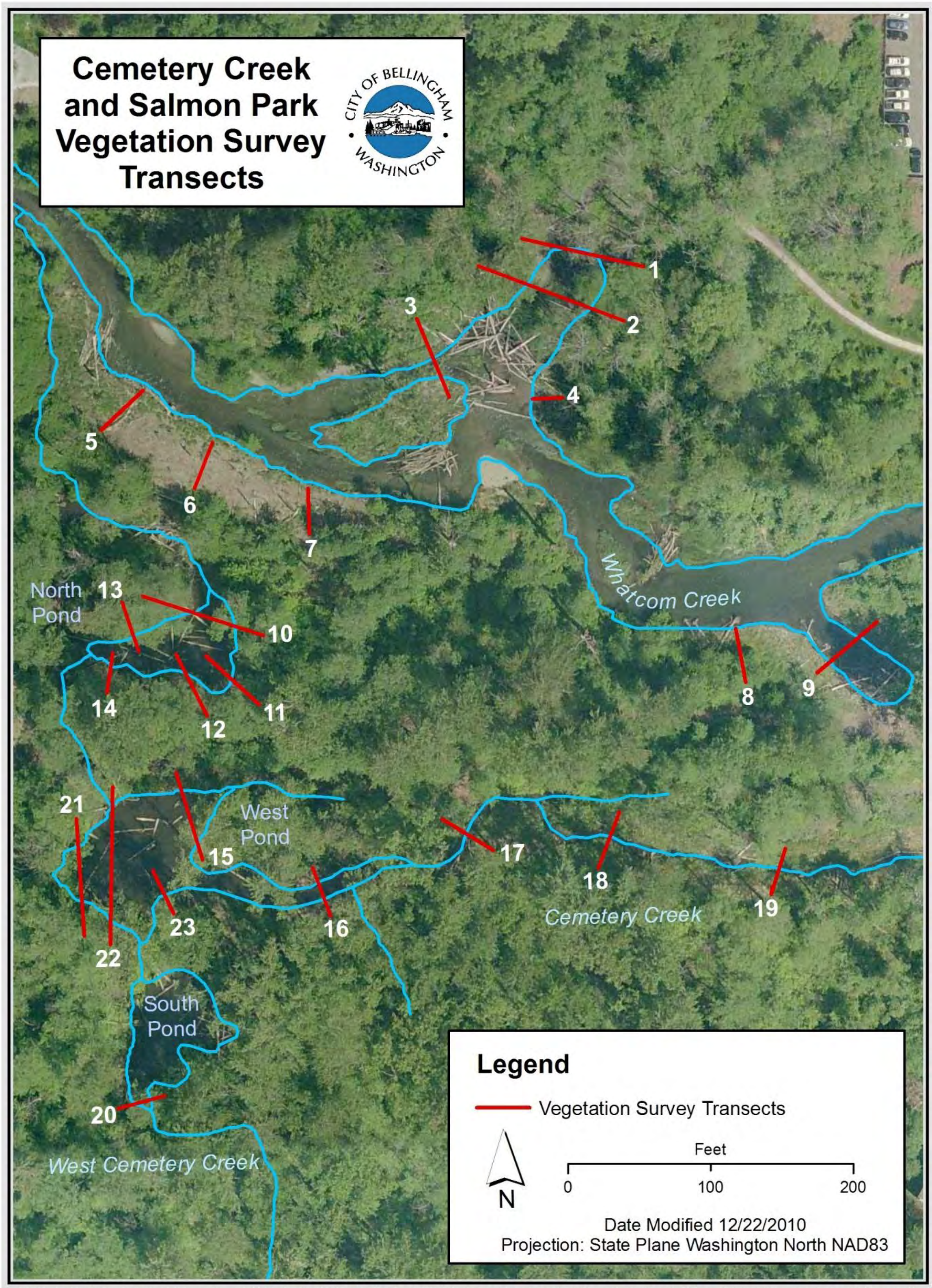
2.1.2 Methods

Detailed methods for vegetation monitoring can be found in the *Whatcom Creek Restoration Project Report: 2007-2008* (Forester 2009). There were no changes to the monitoring methods for the 2009 season.

2.1.3 Results

A map of vegetation survey transects is presented in Figure 2-1. Transect 3 was not surveyed in 2009 due to the presence of wasp and yellow jacket nests in the transect; this transect should be included in subsequent surveys. The results of vegetation surveys are compared against the following criteria for success, as specified in the *Monitoring and Maintenance Plan* (COB 2006): (1) survival of plantings should be at least 75% at the end of three years and through the lifetime of the monitoring plan; and (2) non-native/invasive plant species should represent less than 10% of the plant community at the end of 10 years. Changes in tree height and canopy cover will also be considered in documenting survival and growth of plants within the sites.

Figure 2-1. Map of vegetation survey transects.



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Plant survival: Results indicate that all transect plots surpassed the 75% survivability criteria during 2007, 2008 and 2009 surveys (Table 2-1). The survival of plantings, determined by the percentage of plants characterized as having good or fair condition, was high in all transects. Plant numbers continue to increase in most transects due to natural recruitment. Infill planting in 2009 was limited to two locations at the restoration sites which are not represented in vegetation surveys.

Tree height: Trees are defined as single-stemmed, woody plants greater than 30 feet in height when mature (Pojar and Mackinnon 2004). At the restoration sites the following tree species have been documented: western hemlock, Douglas-fir, grand fir, Sitka spruce, western red cedar, red alder, bigleaf maple, black cottonwood, paper birch, black oak, and Oregon ash. The majority of trees remain in the 1- to 5-foot size class following the 2009 survey (Table 2-2). The 2009 survey shows a shift in the percentage of live trees in the 5- to 15-foot size class, however; trees in this size class have increased from 13% in 2007 to 30% in 2009 (Table 2-2). This is consistent with the successful establishment and growth of young trees at the site.

Many transects show an increase in the number of trees in the 1- to 5-foot size class, though some show a decline, with a concurrent increase in the 5- to 15- foot size class (Table 2-3). The latter pattern is likely to increase as trees become established and available habitat for seedling colonization decreases.

Transect 5 shows a loss of 50 trees in the 1- to 5-foot category. This is partly due to the washout of 14 feet of bank during a January 2009 flood event; this transect length was 41 feet in 2007-2008 while in 2009 the length was 27 feet. Transects 5 and 6 are also exposed and dry during summer months, which may lead to higher seedling mortality.

Table 2-1. Results of vegetation surveys conducted during from 2007-2009 at the Cemetery Creek and Salmon Park restoration sites. All transects surpassed the 75% survivability criteria.

Transect	Total # (G/F/P/D)[1]			# Live (G/F/P)[1]			# Good/Fair			% of Total that are G/F		
	2007	2008	2009	2007	2008	2009	2007	2008	2009	2007	2008	2009
1	70	275	338	69	270	335	65	269	332	93%	98%	98%
2	138	241	330	138	239	328	136	235	328	99%	98%	99%
3	106	244	--[2]	88	242	--[2]	85	238	--[2]	80%	98%	--[2]
4	42	46	68	42	45	67	40	45	67	95%	98%	99%
5	14	143	113	12	142	111	11	140	110	79%	98%	97%
6	42	160	188	42	158	188	38	156	188	90%	98%	100%
7	48	100	154	48	100	154	45	98	154	94%	98%	100%
8	49	128	178	49	128	178	49	128	178	100%	100%	100%
9	90	211	372	90	211	370	87	210	370	97%	100%	99%
10	119	168	297	111	161	295	111	159	294	93%	95%	99%
11	75	126	192	70	126	191	70	125	189	93%	99%	98%
12	47	70	83	45	68	81	45	65	81	96%	93%	98%
13	53	75	108	49	71	108	49	68	107	92%	91%	99%
14	57	72	119	47	70	118	47	67	118	82%	93%	99%
15	94	156	200	92	155	200	91	153	200	97%	98%	100%
16	113	111	168	113	106	167	112	104	165	99%	94%	98%
17	90	123	192	85	118	191	81	117	191	90%	95%	99%
18	156	150	246	151	147	246	147	147	246	94%	98%	100%
19	127	159	251	124	159	250	123	159	250	97%	100%	100%
20	85	99	291	80	98	291	80	98	291	94%	99%	100%
21	164	209	240	159	207	239	159	207	234	97%	99%	97%
22	48	47	91	45	47	91	44	47	91	92%	100%	100%
23	31	32	61	30	31	61	29	31	61	94%	97%	100%
Average	81	137	195	77	135	194	76	133	193	93%	97%	99%

[1] G=Good, F=Fair, P=Poor, D=Dead

[2] Transect 3 was not surveyed in 2009.

Table 2-2. Percent size classes of live trees in all vegetation transects in 2007, 2008 and 2009.

	2007	2008	2009[1]
Total # Live	340	1030	1360
1-5 feet	82%	87%	68%
5-15 feet	13%	11%	30%
15+ feet	5%	2%	2%

[1] Transect 3 was not surveyed in 2009.

Table 2-3. Size classes of individual live trees in 2007, 2008 and 2009, and the change in each size class between 2009 and 2007.

Transect	1-5 feet				5-15 feet				15+ feet			
	2007	2008	2009	Change 2007-2009	2007	2008	2009	Change 2007-2009	2007	2008	2009	Change 2007-2009
1	10	157	149	139	5	9	33	28	2	2	2	0
2	23	44	76	53	3	4	29	26	2	2	2	0
3	2	17	--[1]	--[1]	9	6	--[1]	--[1]	0	0	--[1]	--[1]
4	4	14	28	24	5	5	5	0	0	0	1	1
5	2	82	32	30	0	16	29	29	0	0	1	1
6	11	75	35	24	3	4	28	25	0	0	1	1
7	15	7	11	-4	2	17	13	11	0	2	5	5
8	18	85	73	55	1	1	51	50	0	0	0	0
9	9	113	126	117	1	6	70	69	0	0	0	0
10	9	21	26	17	0	4	13	13	1	1	1	0
11	12	23	36	24	2	4	6	4	1	1	1	0
12	4	13	13	9	0	0	8	8	2	2	2	0
13	7	5	8	1	1	3	4	3	0	0	0	0
14	6	11	15	9	3	3	11	8	0	0	1	1
15	36	47	75	39	0	9	10	10	2	2	1	-1
16	5	6	29	24	0	0	0	0	1	1	1	0
17	29	44	74	45	0	2	23	23	2	2	2	0
18	40	43	38	-2	4	7	29	25	0	0	4	4
19	24	76	51	27	3	5	42	39	1	1	1	0
20	1	6	15	14	0	3	4	4	1	1	1	0
21	11	9	8	-3	0	1	2	2	2	2	2	0
22	1	0	0	-1	1	2	1	0	0	0	0	0
23	1	2	2	1	0	0	0	0	0	0	0	0

[1] Transect 3 was not surveyed in 2009.

Ground cover, invasive plants and canopy cover: The protocols for monitoring ground and canopy cover were changed in 2008 to provide a more repeatable and quantitative assessment of these parameters (see the *Whatcom Creek Restoration Project Report: 2007-2008*, Forester 2009). Data collected in 2007 used different methodologies and so will be excluded from further analysis.

Ground cover increased or stayed the same at all transects between 2008 and 2009; on average, ground cover increased from 69% to 82% (Table 2-4). Native ground cover consists of sedges, grasses, forbs, and ferns. Average ground cover of invasive species has remained constant, with small decreases and increases at most transect (Table 2-4). Invasive species ground cover mainly consists of creeping buttercup, reed canary grass, and seedling blackberry.

Invasives are regularly removed from the restoration site. These plants include Himalayan and evergreen blackberry with a small number of English holly. Larger invasive plants are uncommon at the sites; in 2008 they represented 3% of live plants in the transects, while in 2009 they accounted for 5% of live plants. In 2009, maintenance work, including removal of invasives, occurred after vegetation surveys were completed, accounting for the slightly higher percentage in 2009. Invasives continue to be monitored and removed as necessary; invasive ground cover, especially reed canary grass, should decrease as native trees and shrubs grow and shade the site.

Beginning in 2008, a spherical concave densiometer was used to quantify canopy cover. Results from 2008 and 2009 surveys are presented in Table 2-4; 100% canopy cover would read 17.0 while 0% canopy cover would read 0.0. From 2008 to 2009, canopy cover has increased at 24 of 34 surveyed transects; 4 transects showed no change, while 6 transects had a loss of canopy cover. Average canopy cover has increased from 7.7 to 9.8, a 27% increase. At some transects (for example transects 7, 18, and 19) canopy cover has increased dramatically, with rapid growth of trees and shrubs from 2008 to 2009. Photos of two of these transects are presented in Figure 2-2 and 2-5.

Table 2-4. Percentage estimates of ground cover and invasive species at vegetation transects. Invasive estimates in red are above the 10% cover criteria. Canopy cover measurements are taken with a spherical concave densiometer; 100% canopy cover is 17.0; 0% canopy cover is 0.0.

Transect	Ground cover		Invasives		Canopy Cover	
	2008	2009	2008	2009	2008	2009
1 - L	80%	80%	15%	10%	3.5	7.0
1 - R	40%	55%	20%	15%	9.0	10.0
2 - L	95%	95%	5%	5%	9.3	8.0
2 - R	95%	95%	0%	5%	12.3	13.0
3 - L	25%	--[1]	20%	--[1]	8.5	--[1]
3 - R	35%	--[1]	30%	--[1]	6.8	--[1]
4 - R	50%	50%	35%	35%	1.0	1.3
5	10%	40%	8%	20%	0.8	0.8
6	20%	35%	5%	10%	0.3	1.3
7	75%	90%	15%	15%	0.3	10.8
8	90%	95%	70%	40%	0.0	0.8
9 - L	100%	100%	45%	40%	0.3	0.3
9 - R	100%	95%	40%	45%	0.3	0.3
10 - L	95%	100%	30%	50%	12.3	11.5
10 - R	40%	65%	10%	5%	11.8	11.3
11 - R	30%	45%	10%	20%	10.5	12.8
12 - R	50%	85%	15%	5%	8.5	13.3
13 - L	95%	100%	35%	35%	10.0	13.0
14 - R	40%	85%	10%	25%	9.8	14.0
15 - L	40%	55%	5%	5%	9.3	10.0
15 - R	45%	65%	35%	35%	5.8	3.8
16 - L	45%	60%	15%	10%	10.5	11.3
16 - R	75%	85%	5%	15%	10.5	11.3
17 - L	85%	85%	20%	50%	10.3	9.8
17 - R	90%	90%	20%	15%	10.5	14.0
18 - L	100%	100%	65%	75%	7.0	15.3
18 - R	90%	90%	60%	40%	6.8	13.8
19 - L	100%	100%	80%	50%	5.3	15.3
19 - R	95%	95%	75%	45%	7.3	12.8
20 - L	100%	100%	10%	45%	9.3	10.0
20 - R	95%	95%	15%	15%	13.0	13.5
21 - L	40%	95%	5%	5%	11.5	10.8
21 - R	40%	75%	15%	15%	14.5	14.8
22 - L	90%	100%	10%	1%	11.8	16.5
22 - R	40%	95%	10%	5%	10.5	10.5
23 - L	80%	99%	50%	55%	7.8	8.8
Averages	69%	82%	25%	25%	7.7	9.8

[1] Transect 3 was not surveyed in 2009.

Aquatic plants: Monitoring of aquatic plants in wetted transects (excluding Whatcom Creek) was added in 2008 to document the recolonization of constructed stream channels and ponds by aquatic plants. Aquatic plants provide important habitat for fish, amphibians, insects, and macroinvertebrates; data on the establishment and spread of aquatic plants can be used as an indicator of habitat quality for these species. There are no performance specifications for this new monitoring component; recolonization will be documented over time and may be used to establish performance specifications for future restoration projects.

Plant identification is taken to the lowest practical level; identification of some aquatic plants to species is not practical without expert guidance. Overall, average percentage cover has increased slightly from 2008 to 2009. The Whatcom Creek swale continues to have high coverage of American waterweed (*Elodea canadensis*). Starwort (*Callitriche* sp.) is the most common aquatic plant in the transects. Other documented aquatic plants include tapegrass (*Vallisneria americana*), duckweed (family Lemnaceae), and an unidentified plant (likely either *Ruppia* sp. or *Potamogeton* sp.).

Another benefit of monitoring aquatic plants is to ensure a prompt response if aquatic invasive and noxious species are found at the restoration sites. Two highly problematic invasive aquatic plants, Brazilian elodea (*Egeria densa*) and hydrilla (*Hydrilla verticillata*), have not been found at the restoration sites. Confirmed presence of either of these aquatic invasives will be immediately reported to the Washington Department of Ecology so that removal action can be funded and initiated (more information at the Washington Department of Ecology website, http://www.ecy.wa.gov/programs/eap/lakes/aquaticplants/index.html).

Table 2-5. Percent cover of aquatic plants at surveyed transects, 2008-2009. Average percent cover increased from 9% in 2008 to 16% in 2009.

Transect	Percent Cover		Transect	Percent Cover	
	2008	2009		2008	2009
2	5%	0%*	16	5%	5%
9	50%	70%	17	5%	0%*
10	5%	20%	18	1%	1%
11	5%	6%	19	1%	0%
12	1%	2%	20	0%	0%
13	2%	3%	21	2%	11%
14	1%	1%	22	1%	2%
15	2%	8%	23	5%	3%

* Dewatered in 2009

Photographs: Photographs of vegetation transects were started in 2008. Selected photograph comparisons from 2008 to 2009 are presented below (Figures 2-2 through 2-5).

Figure 2-2. Vegetation transect 7, along Whatcom Creek, August 23, 2008 (left) and August 27, 2009 (right).

Figure 2-3. Vegetation transect 10, North Pond, August 23, 2008 (left) and August 25, 2009 (right).

Figure 2-4. Vegetation transect 16, near West Pond on Cemetery Creek, August 22, 2008 (left) and August 27, 2008 (right).

Figure 2-5. Vegetation transect 19, mainstem Cemetery Creek, September 5, 2008 (left) and September 1, 2009 (right).

2.1.4 Discussion

Plant survival rates continue to be high at the restoration sites. Survival rates over subsequent years will provide better information on the long-term effectiveness of the vegetation plan, its implementation, and ongoing maintenance. Natural recruitment of tree and shrub seedlings continues to result in an increase in plant numbers at most transects. It is expected that plant numbers will decrease over the ten-year monitoring period as available habitat for additional seedlings declines. Likewise, the number of trees and shrubs in the taller height classes (5-15 and 15+ feet) should increase over this same period; this pattern is already becoming apparent at some transects (Figure 2-6).

Washington Conservation Corps (WCC) crews continue control measures to remove invasive plants. High coverage of invasive grass and forb species will remain in some transects as native vegetation continues to grow. Reed canary grass, established throughout the restoration sites, is intolerant of shade and will likely be shaded out as native plants grow. Willow stakes installed in 2006-2007 are provided substantial shade along water margins. Other non-native plants, such as creeping buttercup, may be more difficult to eliminate.

Aquatic plants are slowly recolonizing the disturbed Cemetery Creek channels and ponds. Continued growth of aquatic plants will provide improved habitat conditions for aquatic insects, macroinvertebrates, fish, and amphibians.

Figure 2-6. WCC crew member Melissa Thompson assists with vegetation surveys at the Cemetery Creek restoration site.

Source: City of Bellingham

2.1.5 Recommendations

- ✓ No changes are recommended at this time.

2.2 FISH COMMUNITY

2.2.1 Spawner Surveys

There are no new results to report for the 2009 season; spawning data collected during 2008-2009 were presented in the previous report. These results are available in the *Whatcom Creek Restoration Project Report: 2007-2008* (Forester 2009). A fourth season of spawner surveys will be conducted starting in the fall of 2010. Results will be presented in the 2011 monitoring report.

2.2.2 Juvenile Rearing in Ponds and Streams

2.2.2.1 Introduction

The objective of monitoring the outmigration of juvenile salmonids from the Cemetery Creek restoration site is to document use of the site for rearing. This monitoring component was initiated in 2007 and repeated in 2009; the next monitoring year will be 2012.

2.2.2.2 Methods

A smolt trap is generally in place from mid-March to early June, or when low flows create insufficient water depth in the live box. In 2007, the trap was installed on March 28 and maintained until June 7 (72 days total). In 2009, the trap was installed on March 18 and maintained until May 26 (70 days total). Detailed methods are outlined in the *Whatcom Creek Restoration Project Report: 2007-2008* (Forester 2009). Recommended modifications to the trap and live box were instituted for the 2009 season.

Figure 2-7. WCC crew members checking the smolt trap for fish, May 5, 2009.

Source: City of Bellingham

2.2.2.3 Results

A total of 932 fish were intercepted in the live trap in 2009, compared to 1,978 fish in 2007 (Table 2-6). Coho salmon and cutthroat trout dominated out-migration during both seasons. Other species caught in the trap in 2009 included rainbow/steelhead trout, stickleback, lamprey, sculpin, and redside shiner. A high-flow release panel was incorporated into the 2009 smolt trap design. This panel was used once during the 2009 season (May 14) during a high-flow event due to fish mortality. It is probable that fish passed (uncounted) downstream through the panel during this time.

Table 2-6. Total catch for the Cemetery Creek smolt trap, 2007 and 2009.

Common Name	Latin Name	Number of Individuals	
		2007	2009
Coho	*Onchorynchus kisutch*	871	528
Salmonids	*Onchorynchus* sp.	771	27
Cutthroat trout	*Onchorynchus clarki*	294	178
Rainbow trout/steelhead	*Onchorynchus mykiss*	9	63
Trout	*Onchorynchus* sp.	0	87
Three-spine stickleback	*Gasterosteus aculeatus*	8	6
Sculpin	*Cottus* sp.	6	22
Lamprey	*Lampetra* sp.	9	12
Redside shiner	*Richarsonius balteatus*	1	1
Smallmouth bass	*Micropterus dolomieu*	1	0
Goldfish	*Carassius auratus*	8	0
Unknown	---	0	8
TOTALS		1978	932

In this study, length measurements are used to estimate salmonid age. Age class information provides insight into habitat and foraging use of Cemetery Creek by fish during certain times of the year. The majority of fish intercepted in the smolt trap during 2007 and 2009 were in the 100- to 150-mm size class (Figures 2-8 and 2-9), indicating these fish were age 1+ years. Most of these fish were coho, and many of them exhibited evidence of smoltification. No young of the year coho were observed during 2007; no adult fish or carcasses were observed in the surveyed sections of Cemetery Creek in 2006-2007. Eight young of the year coho were intercepted during 2009; two redds, likely coho, were seen during spawner surveys in 2008-2009.

Cutthroat trout intercepted in the trap exhibited considerable size variation during 2007 and 2009. A number of adult fish in excess of 200 mm were intercepted moving downstream during both survey seasons. Adult (>200 mm) and age 1+ (100-200 mm) cutthroat trout were caught throughout both survey periods.

Figure 2-8. Size class distribution of salmonids caught in the 2007 Cemetery Creek smolt trap.

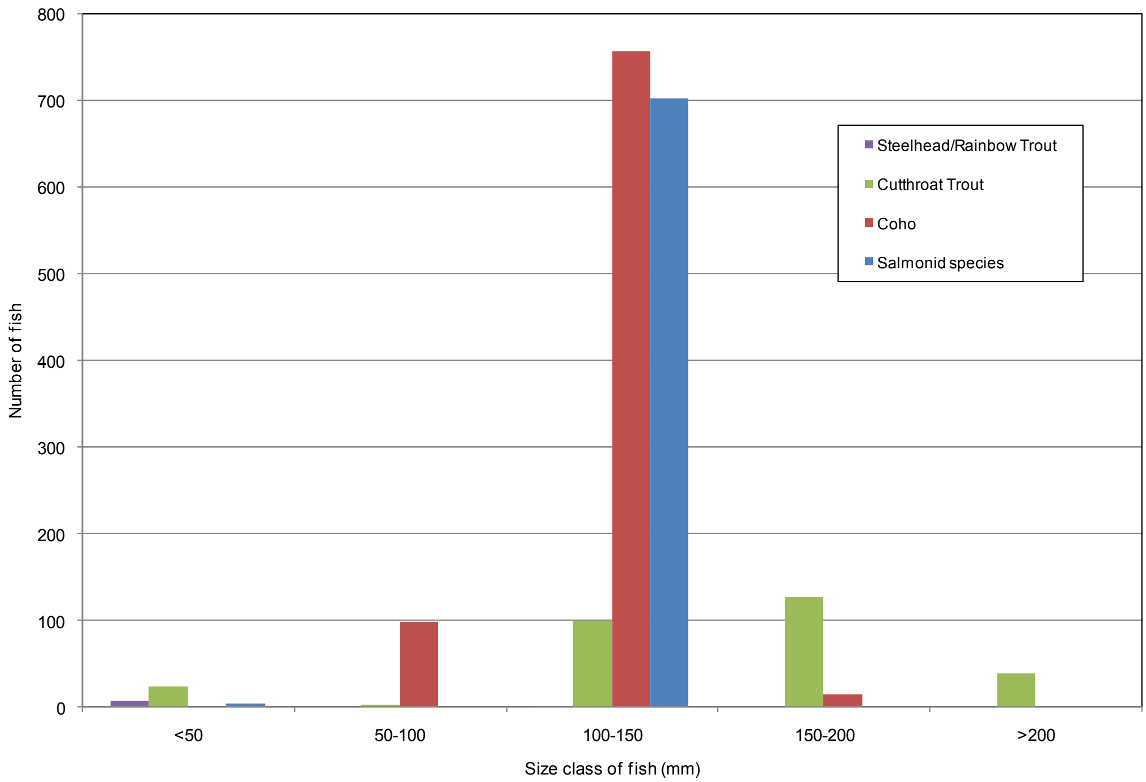
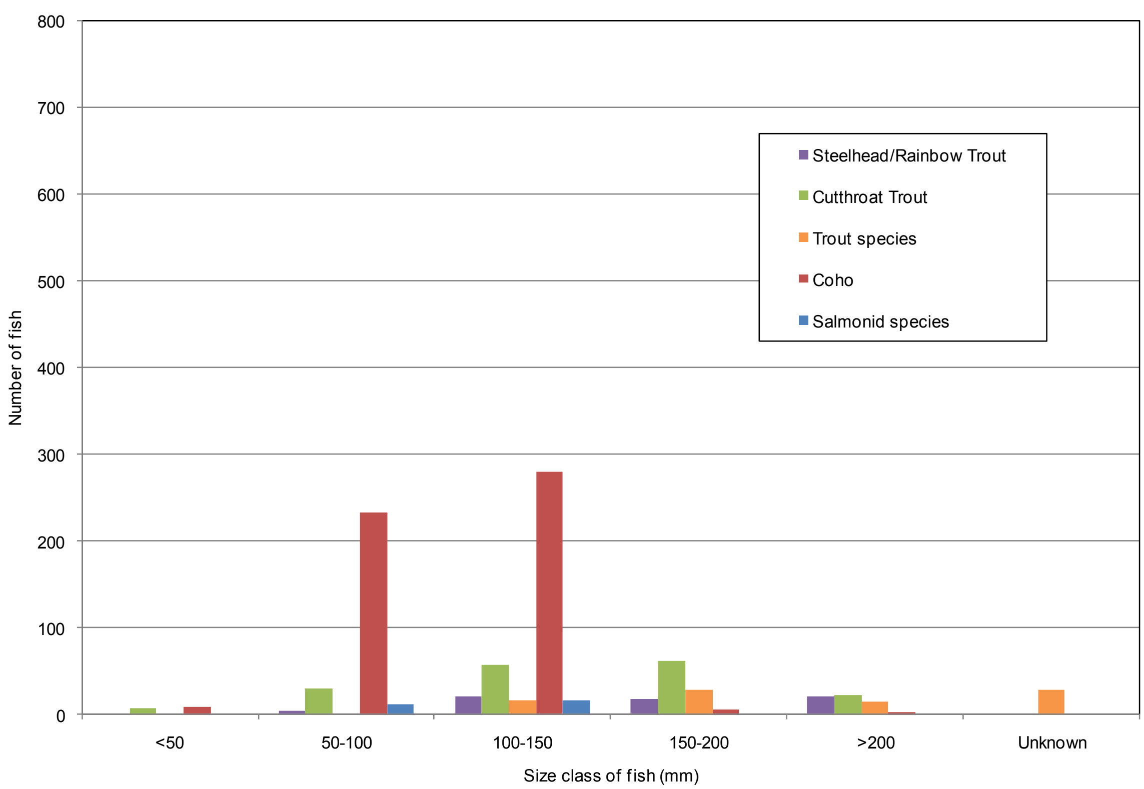


Figure 2-9. Size class distribution of salmonids caught in the 2009 Cemetery Creek smolt trap.

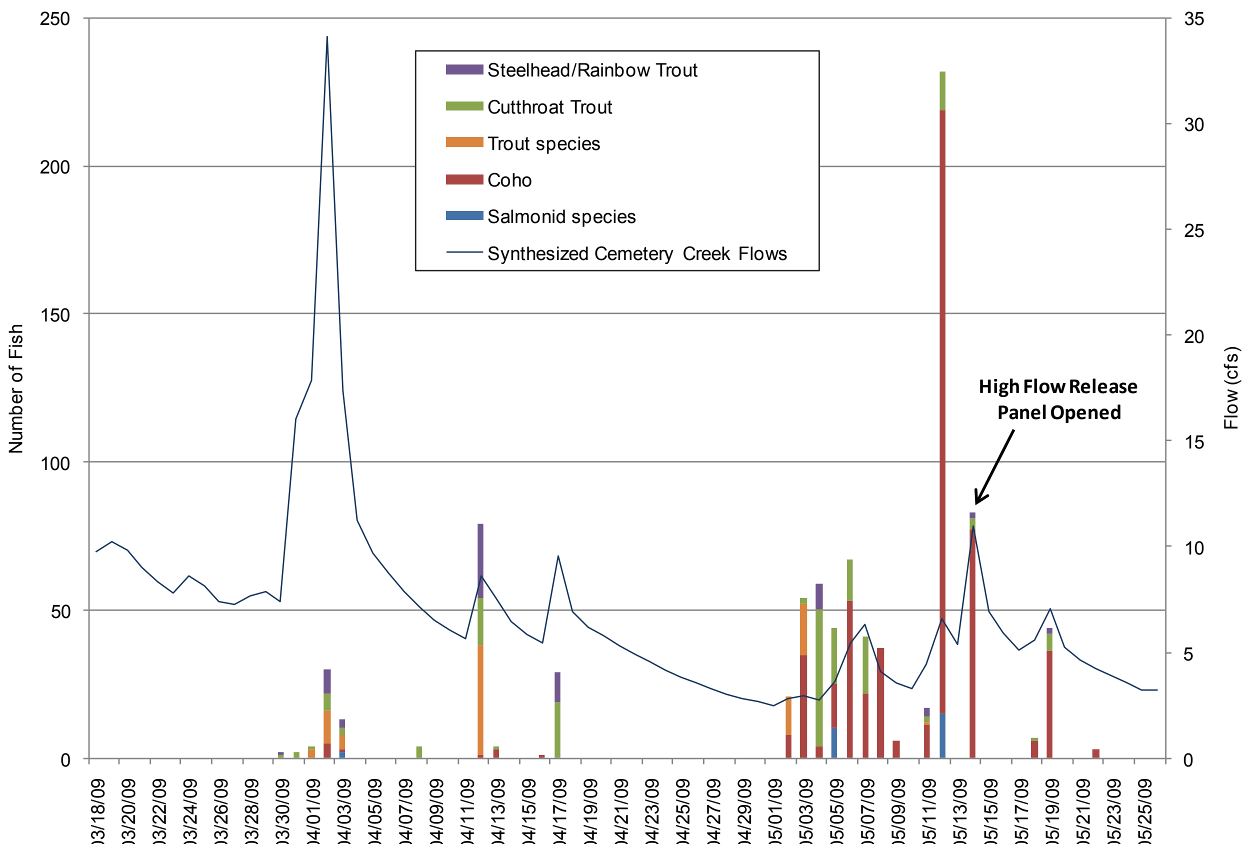


2.2.2.4 Discussion

Out-migration patterns: During the 2009 smolt trapping season Cemetery Creek flows were higher than in 2007. Reconstructed flows[2] peaked at 34 cfs, compared with 7 cfs in 2007. Peak outmigration coincided with peak flow events in 2009 (Figure 2-10). The first coho smolts were captured on April 2 during a high-flow storm event. Large numbers of coho smolts were captured while outmigrating during high-flow events on May 12 (204 total) and May 14 (77 total, not including fish missed due to release of the high-flow panel). The first trout species were captured on March 30.

2007 to 2009 comparison: The main difference in fish abundance between 2007 and 2009 was in the number of coho/salmon species intercepted. In 2009, 1,087 fewer coho/salmon species were captured than in 2007. Use of the high-flow release panel is likely part of the explanation, though that one event is unlikely to account for the entire difference. It is probable, even accounting for use of the high-flow panel, that there were fewer outmigrating coho/salmon species in 2009 compared with 2007. In contrast, there were 25 more trout intercepted in 2009 compared with 2007, even with use of the high-flow panel. This indicates that outmigrating trout numbers are remaining consistent over this time frame.

Figure 2-10. Outmigration pattern of juvenile salmonids from Cemetery Creek, 3/18/09 – 5/26/09.



[2] Methods for calculating synthesized flows are included in the *Whatcom Creek Restoration Project Report: 2007-2008* (Forester 2009).

Fish mortality during smolt trap operation: Fish mortality was higher than in 2007, representing about 6% of fish handled. Two high-flow events represented the bulk of fish losses: 7 mortalities during the May 7-8 event, and 27 mortalities during the May 14 event. Total numbers are provided in Table 2-7. Of these 53 mortalities, 44 occurred from fish being impinged on the weir screening upstream of the live box. The frequency of trap checks was increased during high-flow events, and screens were modified to deflect high-velocity flows in order to reduce mortality. Modification of the trap design is suggested to alleviate this problem in the future (see Recommendations).

Table 2-7. Species and numbers of mortalities at smolt trap, 2009 season.

Species	Number
Coho	37*
Cutthroat Trout	6
Rainbow trout/steelhead	1
Salmonid species	1
Sculpin	1
Lamprey species	1
Three-spine stickleback	4
Unknown	2
Total	53

* 22 of 37 during one high flow event, 5/14/2010.

2.2.2.5 Recommendations

- ✓ Fish mortality due to impingement on the weir screening was problematic in the 2009 smolt trap survey. Comparison with the 2007 design would be useful to determine why impingement occurred more frequently in 2009. Increasing the angle of the upstream weir screens may help funnel fish into the live box more effectively during high flows.

2.3 AQUATIC MACROINVERTEBRATES

Macroinvertebrates were collected by COB and WCC staff in September of 2007, 2008, and 2009. Samples were sorted and processed by R2 Resource Consultants. Two reports have been prepared: the 2009 report is presented in Appendix A; the 2007-2008 report is presented in Appendix B.

2.4 RIPARIAN AND TERRESTRIAL WILDLIFE COMMUNITY

2.4.1 Amphibians

2.4.1.1 Introduction

The objective of amphibian surveys is to document amphibian use of the restoration areas and to determine species composition and, if possible, abundance. A detailed introduction can be found in the *Whatcom Creek Restoration Project Report: 2007-2008* (Forester 2009).

2.4.1.2 Methods

Detailed methods for amphibian surveys are available in the *Whatcom Creek Restoration Project Report: 2007-2008* (Forester 2009). There were no changes to the monitoring methods for the 2009 season.

2.4.1.3 Results

Four amphibian surveys were completed during 2007; six surveys were completed during both 2008 and 2009. These surveys have confirmed the presence of two native frog species, one native salamander species, and one non-native, invasive frog species at the restoration sites. A map of the survey transects is presented in Figure 2-11.

Summary tables of 2007-2009 survey data are presented below. Numbers of positively identified amphibians in each survey year are compared in Table 2-8. These data include all individuals seen during surveys and incidental sightings. Invasive American bullfrog sightings have increased since 2007, while native amphibian sightings have stayed relatively constant. Table 2-9 provides relative abundance based on survey sightings only. Detections for all survey years are low relative to the number of transects/perimeters surveyed. Results of amphibian surveys and incidental sightings in 2009 are summarized in Table 2-10. Photographs of some of the amphibians found during 2009 are presented in Figures 2-12 through 2-15.

Table 2-8. Numbers of positively identified individuals by year; surveys and incidental sightings.

Species	2007	2008	2009
Pacific tree frog	2	1	1
Red-legged frog	1	3	1
American bullfrog	1	6	9
Long-toed salamander	0	1	2

Table 2-9. Amphibian abundance for 2007-2009; includes survey sightings only.

Year	Number of detections	Number of transects and perimeters searched
2007	7	89
2008	3	161
2009	12	162

Figure 2-11. Map of amphibian survey transects. Surveyors randomly selected the right or left bank of each transect for sampling.

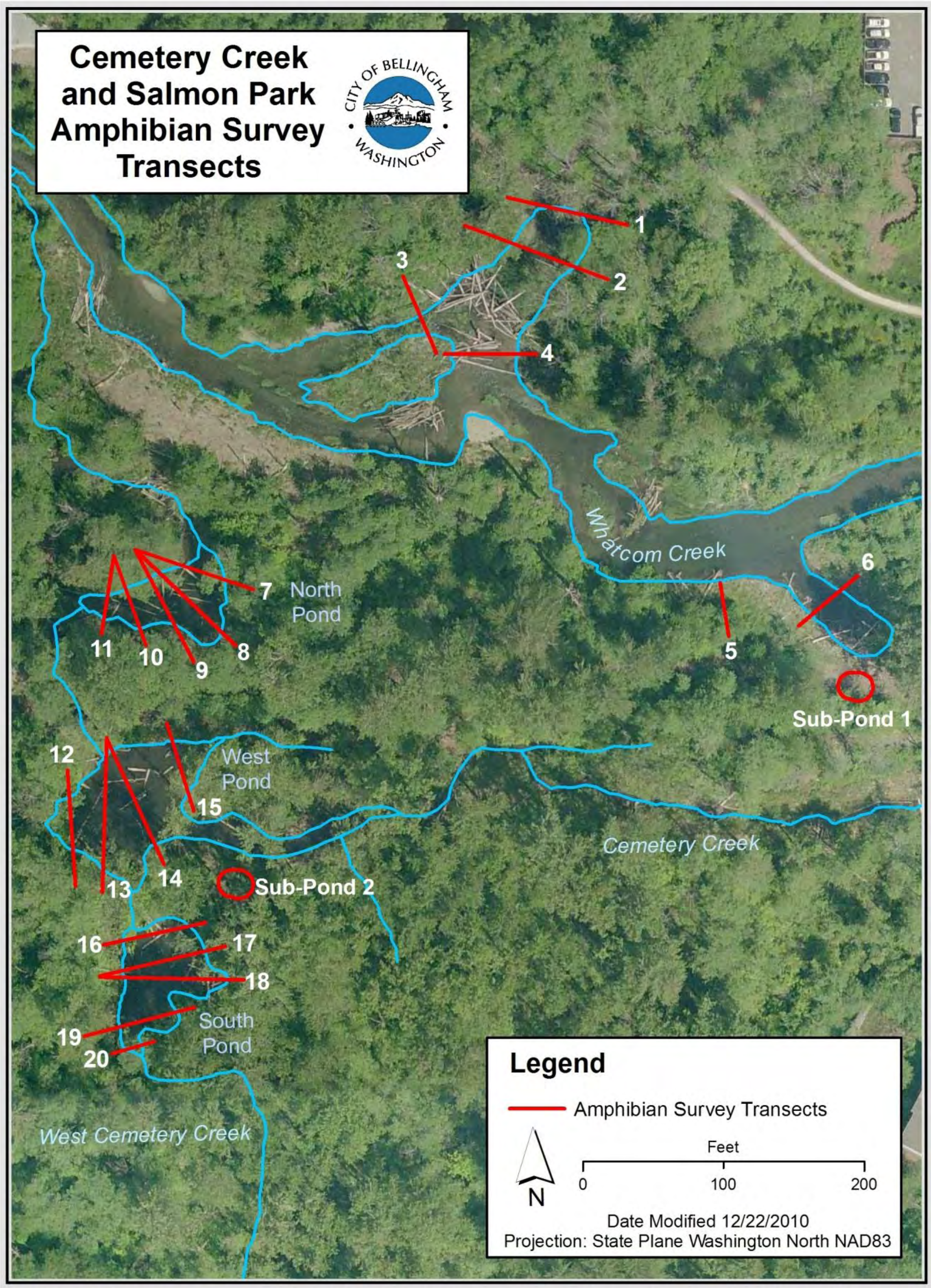


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Table 2-10. Results of all amphibian surveys and incidental sightings for 2009.

Date	*Sighting Type*	*Common Name*	*Scientific Name*	*Life Stage*	*Location*	*Description/Notes*
03/04/09	Survey	Long-toed salamander	*Ambystoma macrodactylum*	Adult	Sub-Pond 1	Under log; no standing water but area wet.
03/26/09	Survey	Long-toed salamander	*Ambystoma macrodactylum*	Adult	Sub-Pond 1	Under log; no standing water but area wet.
05/05/09	Survey	Frog sp. (2)	-	Adult	Salmon Park Perimeter	At water's edge; jumped into water.
05/05/09	Survey	American bullfrog	*Rana catesbeiana*	Adult	Whatcom Creek Swale Perimeter	At water's edge; jumped into water.
05/20/09	Survey	Pacific tree frog	*Pseudacris regilla*	Adult	1 - Right	Under well-rotted log.
05/20/09	Survey	American bullfrog	*Rana catesbeiana*	Adult	Whatcom Creek Swale Perimeter	At water's edge; jumped into water.
05/20/09	Survey	Frog sp. (2)	-	Adult	Whatcom Creek Swale Perimeter	At water's edge; jumped into water; likely bullfrogs but couldn't confirm.
06/09/09	Survey	American bullfrog	*Rana catesbeiana*	Adult	15 - Right	At water's edge; jumped into water.
06/09/09	Survey	American bullfrog (2)	*Rana catesbeiana*	Adult	Whatcom Creek Swale Perimeter	At water's edge; jumped into water.
03/05/09	Incidental	American bullfrog	*Rana catesbeiana*	Adult	Mouth of Cemetery Creek	Sitting on bottom of creek; very sluggish due to cold water temperatures.
05/20/09	Incidental	Red-legged frog	*Rana aurora*	Adult	East of 20 - Right	In moist, shaded area with thick vegetation by South Pond.
06/04/09	Incidental	American bullfrog (2)	*Rana catesbeiana*	Adult	West Pond Perimeter	Sunning by pond's edge; one small, on very large (>10 inches).
06/08/09	Incidental	American bullfrog	*Rana catesbeiana*	Adult	West Pond Perimeter	Sunning by pond's edge.

Amphibian abundance for 2009 Survey sightings: 12 amphibian detections in 162 transects/perimeters searched.

Figure 2-12. Long-toed salamander at Sub-Pond 1 on March 4, 2009.

Source: City of Bellingham

Figure 2-13. Red-legged frog near the South Pond on May 20, 2009.

Source: City of Bellingham

Figure 2-14. Pacific tree frog at Salmon Park on May 20, 2009.

Source: City of Bellingham

Figure 2-15. Invasive American bullfrog captured during a spawner survey at the mouth of Cemetery Creek on March 5, 2009.

Source: City of Bellingham

2.4.1.4 Discussion

Amphibian abundance has been very low during all survey years (Table 2-9), likely due to a lack of habitat complexity and the presence of American bullfrogs at the restoration sites. Habitat quality is slowly improving as plants grow and become established; emergent vegetation remains minimal but is increasing due to natural colonization. Overall cover and habitat complexity at the restoration sites, however, remains poor. Native amphibians are generally found in those areas that have established habitat complexity, such as decaying wood, emergent vegetation, and abundant leaf litter.

American bullfrogs remain common throughout the restoration sites. It is probable that this non-native species is predating and outcompeting native amphibian populations. Because complete removal is not feasible, long-term efforts to lower stream temperatures, improve habitat complexity and preserve wetland habitats are the best options for increasing native amphibian populations.

2.4.1.5 Recommendations

- ✓ Remove American bullfrog egg masses if found. Upon confirmed identification, these egg masses should be removed and destroyed.
- ✓ Continue detailed recording of incidental sightings to supplement surveys.
- ✓ Time permitting, increase the number of transects to include stream habitat areas.
- ✓ With the dependence of many amphibian species on downed wood, particularly decaying logs, it is recommended that these materials be incorporated into future restoration projects to improve amphibian habitat conditions.

2.4.2 Avians

2.4.2.1 Introduction

The objective of avian surveys is to identify species composition and abundance as well as changes in composition and abundance of bird species at the restoration sites over time.

2.4.2.2 Methods

Survey methods for the 2009 season were identical to those outlined in the *Whatcom Creek Restoration Project Report: 2007-2008* (Forester 2009). Six surveys were completed during the season; the first survey was March 4, 2009, and the final survey was June 9, 2009.

A new point was added halfway through the survey season (starting with the May 1, 2009 survey) and was surveyed three times. This point (Point 4) is located in the newly restored Red Tail Reach area, about 500 feet downstream of the outlet of Cemetery Creek. This point was added because it has different habitat characteristics compared with the Cemetery Creek and Salmon Park restoration sites. With a minimal investment of time, this site can be surveyed during point count monitoring, providing valuable comparative data for an adjacent, but different habitat type.

Plants were installed at Red Tail Reach in February 2009 after the site had been regraded during construction; consequently, the site lacks large vegetation or trees in most areas. It has abundant swale and backwater habitat and plentiful large woody debris, including many large vertical snags. In this report, presentation and analysis of data collected from point 4 will remain separate from data collected at points 1-3.

2.4.2.3 Results

A map of point count locations is presented in Figure 2-16. Identification of birds during other activities at the restoration site ("incidental sightings") resulted in the detection of some species not identified during point counts. The species composition for the restoration site (all species detected during point counts and incidental sightings) is presented in Table 2-11. Incidental sightings are listed separately in Table 2-12.

Figure 2-16. Map of point count locations.

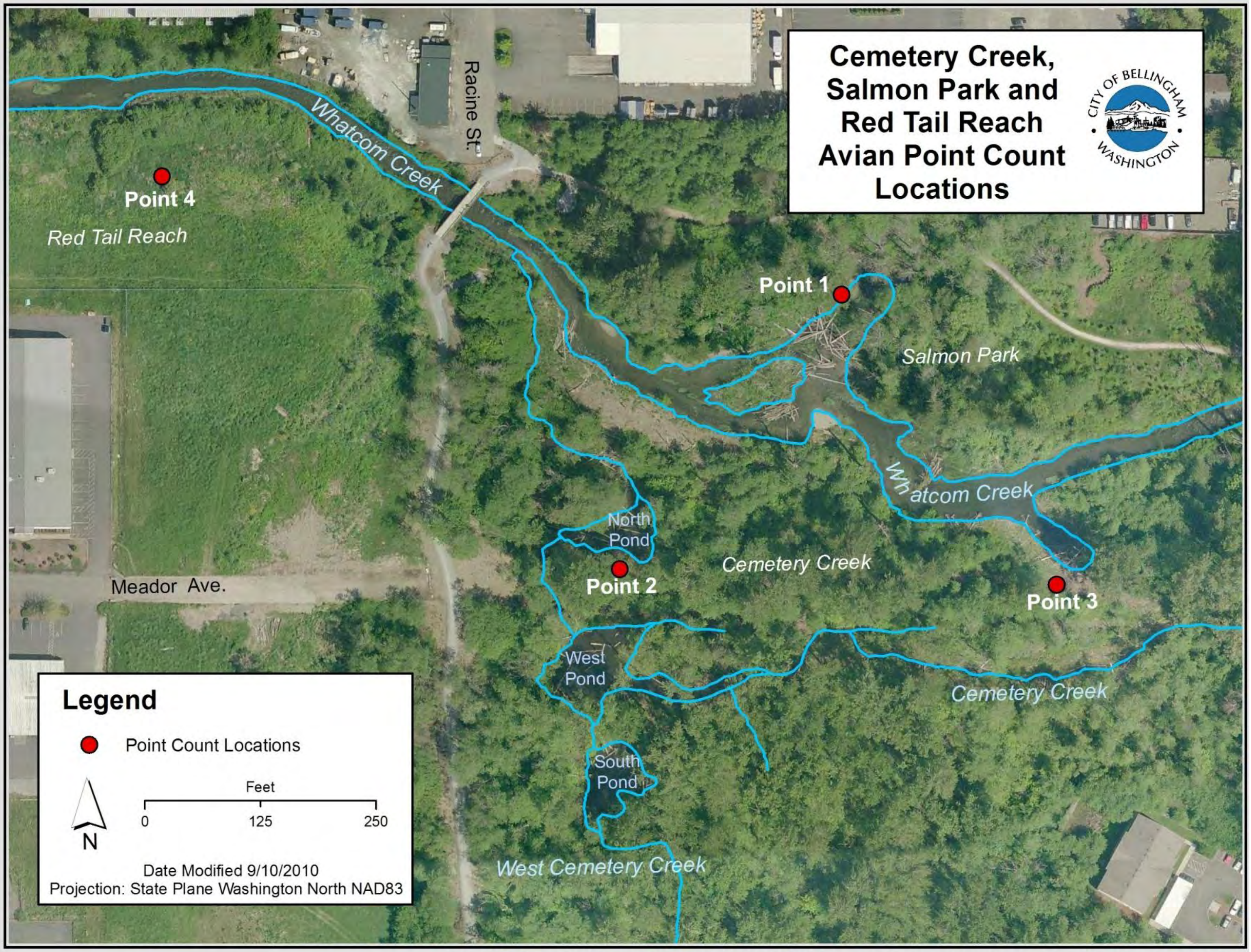

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Table 2-11. Bird species composition (point counts and incidental sightings) for the Cemetery Creek and Salmon Park restoration sites, 2007-2009. Total number of species is 69.

Common Name	Scientific Name	Common Name	Scientific Name
American Crow	*Corvus brachyrhynchos*	Mallard	*Anas platyrhynchos*
American Goldfinch	*Carduelis tristis*	Marsh Wren	*Cistothorus palustris*
American Robin	*Turdus migratorius*	Merlin	*Falco columbarius*
Bald Eagle	*Haliaeetus leucocephalus*	Northern Flicker	*Colaptes auratus*
Barn Swallow	*Hirundo rustica*	Northern Harrier	*Circus cyaneus*
Belted Kingfisher	*Megaceryle alcyon*	Orange-crowned Warbler	*Vermivora celata*
Bewick's Wren	*Thryomanes bewickii*	Pacific-slope Flycatcher	*Empidonax difficilis*
Black-capped Chickadee	*Poecile atricapillus*	Pileated Woodpecker*	*Dryocopus pileatus*
Black-headed Grosbeak	*Pheucticus melanocephalus*	Pine Siskin	*Carduelis pinus*
Brown Creeper	*Certhia americana*	Purple Finch	*Carpodacus purpureus*
Brown-Headed Cowbird	*Molothrus ater*	Red-breasted Sapsucker	*Sphyrapicus ruber*
Bufflehead	*Bucephala albeola*	Red-tailed Hawk	*Buteo jamaicensis*
Bullock's Oriole	*Icterus bullockii*	Red-winged Blackbird	*Agelaius phoeniceus*
Bushtit	*Psaltriparus minimus*	Ruby-crowned Kinglet	*Regulus calendula*
Canada Goose	*Branta canadensis*	Rufous Hummingbird	*Selasphorus rufus*
Caspian Tern	*Sterna caspia*	Sharp-shinned Hawk	*Accipiter striatus*
Cedar Waxwing	*Bombycilla cedrorum*	Song Sparrow	*Melospiza melodia*
Chestnut-backed Chickadee	*Poecile rufescens*	Spotted Towhee	*Pipilo maculatus*
Common Merganser	*Mergus merganser*	Stellar's Jay	*Cyanocitta stelleri*
Common Nighthawk	*Chordeiles minor*	Swainson's Thrush	*Catharus ustulatus*
Common Yellowthroat	*Geothlypis trichas*	Turkey Vulture	*Cathartes aura*
Dark-eyed Junco	*Junco hyemalis*	Varied Thrush	*Ixoreus naevius*
Downy Woodpecker	*Picoides pubescens*	Vaux's Swift	*Chaetura vauxi*
European Starling†	*Sturnus vulgaris*	Violet-green Swallow	*Tachycineta thalassina*
Fox Sparrow	*Passerella iliaca*	Western Tanager	*Piranga ludoviciana*
Golden-crowned Kinglet	*Regulus satrapa*	Western Wood-Pewee	*Contopus sordidulus*
Golden-crowned Sparrow	*Zonotrichia atricapilla*	White-crowned Sparrow	*Zonotrichia leucophrys*
Great Blue Heron	*Ardea herodias*	Willow Flycatcher	*Empidonax traillii*
Gull species	*Laridae* family	Wilson's Snipe	*Gallinago delicata*
Hairy Woodpecker	*Picoides villosus*	Wilson's Warbler	*Wilsonia pusilla*
Hammond's Flycatcher	*Empidonax hammondii*	Winter Wren	*Troglodytes troglodytes*
Hooded Merganser*	*Lophodytes cucullatus*	Wood Duck*	*Aix sponsa*
House Sparrow†	*Passer domesticus*	Yellow Warbler	*Dendroica petechia*
Killdeer	*Charadrius vociferus*	Yellow-rumped Warbler	*Dendroica coronata*
Macgillivray's Warbler	*Oporornis tolmiei*		

* WDFW Priority Species; Meets criteria for Priority Area: Breeding Areas.
† Non-native species.

Table 2-12. Bird species documented during incidental sightings only at the restoration sites in 2007-2009.

Incidental Sightings		
2007	**2008**	**2009**
Great Blue Heron	Bald Eagle	Barn Swallow
Merlin	Belted Kingfisher	Bufflehead
Red-breasted Sapsucker	Chestnut-backed Chickadee	Bullock's Oriole
Red-tailed Hawk	Common Merganser	Common Yellowthroat
Tern species	Common Nighthawk	Golden-crowned Sparrow
Yellow Warbler	Fox Sparrow	Hairy Woodpecker
	Golden-crowned Sparrow	Hooded Merganser
	Great Blue Heron	House Sparrow (non-native)
	Hooded Merganser	Orange-crowned Warbler
	Northern Harrier	Pileated Woodpecker
	Red-tailed Hawk	Sharp-shinned Hawk
	Steller's Jay	Turkey Vulture
	Varied Thrush	Vaux's Swift
	Vaux's Swift	Wood Duck
	Wood Duck (pair with 3 fledglings)	

All species seen/heard at the sites but not recorded during point counts.

Surveys have documented the presence of three Washington Department of Fish and Wildlife priority species: Wood Ducks, Pileated Woodpeckers, and Hooded Mergansers (WDFW 2008). In 2009, Hooded Mergansers were found using one of the nest boxes at the Cemetery Creek restoration site (Figure 2-17). This species now qualifies as a WDFW priority species since it has been documented as breeding at the restoration site.

New species identified at the restoration sites in 2009 are: Barn Swallow, Bufflehead, Bullock's Oriole, Sharp-shinned Hawk, and Turkey Vulture. Non-native House Sparrows were another new addition in 2009. They are common in developed and disturbed areas. Like the non-native European Starling, they are aggressive cavity nesters that often outcompete native species for limited cavity space. Brown-Headed Cowbirds continue to be present in large numbers, especially in the early spring.

Species positively identified as nesting at the restoration sites in 2009 include: American Robin (Figure 2-18), Black-capped Chickadee, Brown Creeper, Bushtit, European Starling, Hooded Merganser, and Song Sparrow.

A summary of point count data from the restoration sites is presented in Table 2-13. Summary statistics are presented in Table 2-14.

Figure 2-17. Hooded Merganser eggs in one of the Cemetery Creek pond nest boxes, May 11, 2009.

Source: City of Bellingham

Figure 2-18. Fledgling American Robins in the nest, constructed in a Pileated Woodpecker cavity; Cemetery Creek, May 12, 2009.

Source: City of Bellingham

Table 2-13. Number of individual birds and species richness (total number of species detected) for each point count survey conducted in 2007, 2008 and 2009.

		2007		2008		2009	
Point Count Station	Survey number	Number of Individuals	Species Richness	Number of Individuals	Species Richness	Number of Individuals	Species Richness
1	1	20	9	14	8	11	7
1	2	15	7	13	6	25	11
1	3	11	5	16	9	15	9
1	4	21	11	15	11	13	8
1	5	27	14	10	6	14	9
1	6	22	11	15	8	23	15
2	1	17	9	18	8	26	11
2	2	19	9	23	15	22	11
2	3	12	5	20	9	16	9
2	4	30	16	17	10	17	9
2	5	18	8	13	7	14	11
2	6	19	13	15	8	19	11
3	1	14	8	12	7	27	12
3	2	18	10	13	7	29	12
3	3	14	8	13	8	13	11
3	4	31	17	18	10	18	10
3	5	20	13	15	12	19	13
3	6	19	13	17	10	16	9

Table 2-14. Summary statistics for point counts at each station for 2007, 2008 and 2009.

	2007		2008		2009	
Point Count Station	Average Number of Individuals	Cumulative Species Richness	Average Number of Individuals	Cumulative Species Richness	Average Number of Individuals	Cumulative Species Richness
1	19	24	14	20	17	28
2	19	23	18	28	19	24
3	19	26	15	25	20	30
Average	19	24	15	24	19	27
Cumulative	58	34	46	40	56	37

Average number of species seen that year during counts

Total number of species seen that year during counts

Staff continue to enter all point count results into the Bird Point Count Database, operated by the USGS Patuxent Wildlife Research Center. This database is a repository for storing and sharing avian point count data collected in North America. The database is located online at http://www.pwrc.usgs.gov/point/. Complete point count results for the Cemetery Creek and Salmon Park restoration sites are publicly available on this website.

Results for Point 4 at Red Tail Reach: Point 4 has a bird community that reflects the open habitat type of Red Tail Reach. Swallows and Red-winged Blackbirds are particularly common at the site. A complete species list for point 4 is presented in Table 2-15. Two species were identified using the Red Tail Reach habitat that have not been identified at the Cemetery Creek or Salmon Park restoration sites: House Finches and Spotted Sandpipers. The average number of individuals seen at Point 4 during counts was 24; the cumulative species richness (total number of species seen during counts) was 23.

Table 2-15. Bird species composition (point counts and incidental sightings) for point 4 at Red Tail Reach, 2009. Three surveys were conducted from 5/1/09 to 6/9/09. Total number of species is 25.

Common Name	Scientific Name	Common Name	Scientific Name
American Crow	*Corvus brachyrhynchos*	Killdeer	*Charadrius vociferus*
American Goldfinch	*Carduelis tristis*	Pine Siskin	*Carduelis pinus*
American Robin	*Turdus migratorius*	Red-winged Blackbird	*Agelaius phoeniceus*
Barn Swallow	*Hirundo rustica*	Song Sparrow	*Melospiza melodia*
Bewick's Wren	*Thryomanes bewickii*	Spotted Sandpiper	*Actitis macularia*
Black-capped Chickadee	*Poecile atricapillus*	Spotted Towhee	*Pipilo maculatus*
Black-headed Grosbeak	*Pheucticus melanocephalus*	Violet-green Swallow	*Tachycineta thalassina*
Brown-Headed Cowbird	*Molothrus ater*	White-crowned Sparrow	*Zonotrichia leucophrys*
Common Yellowthroat	*Geothlypis trichas*	Willow Flycatcher	*Empidonax traillii*
European Starling†	*Sturnus vulgaris*	Wilson's Snipe	*Gallinago delicata*
Gull species	Laridae family	Wilson's Warbler	*Wilsonia pusilla*
House Finch	*Carpodacus mexicanus*	Yellow-rumped Warbler	*Dendroica coronata*
House Sparrow†	*Passer domesticus*		

† Non-native species.

2.4.2.4 Discussion

Overall, the restoration sites continue to show good species richness, with 69 species positively identified in 2009. The average number of species identified during point counts increased to 27 species from the 2007-2008 level of 24 species. The total number of species seen during 2009 point counts (37 species) was slightly lower than in 2008 (40 species), but higher than 2007 (34 species). This likely indicates a plateau in new species identification at the sites as surveyors have improved their ability to identify species by ear.

European Starling and Brown-headed Cowbird activity remains high at the sites. Use of the restoration site by these species, which prefer open habitats, is not likely to decrease due to the fragmented nature of the habitat surrounding the restoration sites. An unpublished study of cavity-nesting birds at the restoration sites (Dolan 2008) is available in the *Whatcom Creek Restoration Project Report: 2007-2008* (Forester 2009).

Use of the sites as foraging, resting and nesting habitat by resident and migrating passerines is ongoing. The restoration sites and recently planted Red Tail Reach site will continue to provide important stopover habitat for migratory species (Moore et al. 2005). The addition of Point 4 at Red Tail Reach will provide an interesting comparison to point count locations at the restoration sites.

Use of the restoration sites by nocturnal and crepuscular (active at dawn and dusk) species has not been assessed. These species may include Barn, Great Horned, Barred and Western Screech Owls. A crepuscular species, the Common Nighthawk, was identified during an incidental sighting in 2008. Evening surveys would be a meaningful addition to the avian monitoring protocol.

2.4.2.5 Recommendations

- ✓ Continue point count at Red Tail Reach.
- ✓ Add evening surveys for nocturnal and crepuscular species, if staff time allows.

2.4.3 Mammals

2.4.3.1 Introduction

The distribution and composition of mammalian communities in the Whatcom Creek watershed has been poorly documented. Small mammal communities are likely well represented; medium and large mammals are also potentially diverse and commonly include raccoon, opossum, beaver, muskrat, river otter and coyote (Eissinger 2003). The objective of mammal monitoring is to document use of the restoration area by mammals.

2.4.3.2 Methods

Monitoring of mammals at the restoration sites is qualitative and used primarily to document presence. Monitoring is integrated with other activities, and consists of compiling a list of species observed using the site. Observations that document mammal use include direct sightings, tracks, scat, or browse patterns. Observations include detailed descriptions of key sightings (e.g. priority species, evidence of denning or breeding).

2.4.3.3 Results

Thirteen mammal species have been identified at the restoration sites to date. Eastern Cottontails and Eastern Gray Squirrels are the only non-native mammals identified. Results are summarized in Table 2-16. Photographs of some of the mammals seen in 2009 are presented in Figures 2-19 through 2-21.

Table 2-16. Summary of all mammals identified at the Cemetery Creek and Salmon Park restoration sites, 2007-2009.

Species	Latin Name	Notes
Beaver	*Castor canadensis*	Adults seen and browse patterns noted
Black-tailed Deer	*Odocoileus virginianus*	Multiple sightings of adults and fawns
Common Opossum	*Didelphis virginiana*	One sighting (2009) at North Pond
Coyote	*Canis latrans*	Multiple sightings of scat and tracks
Eastern Cottontail	*Sylvilagus floridanus*	Non-native species
Eastern Gray Squirrel	*Sciurus carolinensis*	Non-native species
Mink	*Mustela vison*	Multiple sightings of adults, also two kits
Mole species	*Scapanus* sp.	Found dead by South Pond; either Townsend's or Pacific
Muskrat	*Ondatra zibethicus*	West Pond and smolt trap (2009)
Raccoon	*Procyon lotor*	Sleeping in cedar tree by North Pond
River Otter	*Lontra canadensis*	Swimming in West Pond (2009)
Rodent species	Arvicolinae subfamily	Likely Vole species; babies found in nest
Townsend's Chipmunk	*Tamias townsendii*	Multiple sightings

Figure 2-19. One of two mink in the South Pond of Cemetery Creek on August 6, 2009.

Source: City of Bellingham

Figure 2-20. Beaver at the Cemetery Creek restoration site, March 26, 2009.

Source: City of Bellingham

Figure 2-21. Muskrat found in the Cemetery Creek smolt trap, May 16, 2009; released unharmed.

Source: City of Bellingham

2.4.3.4 Discussion

Mammal species identified are consistent with common urban mammalian wildlife; Eissinger (2003) lists mink as "rare" in the City of Bellingham. An adult mink with two kits was seen multiple times in 2009 at the Cemetery Creek site. No state-listed priority species were identified. Sightings recorded from 2007 to 2009 indicate the presence and habitat utilization by native mammal species at the restoration sites, as well as the absence of major site damage from mammals. Beaver damage was minimal in 2009.

2.4.3.5 Recommendations

- ✓ No changes are recommended at this time.

2.4.4 Other Observations

2.4.4.1 Western Brook Lamprey

Native western brook lamprey (*Lampetra richardsoni*) were documented building redds and spawning in multiple areas of Cemetery Creek in 2009 (Figure 2-22). Three adult lamprey were first noted on June 3, 2009 in the area of fine gravel just upstream of the North Pond. On June 8, other spawning groups were located in the mainstem of Cemetery Creek, upstream of the West Pond. Western brook lamprey are a non-parasitic lamprey species that live their entire lives in freshwater. Mature adults do not feed, but only reproduce before dying. The larvae (ammocoetes) live as filter feeders in quiet backwater areas with silty bottoms. They have been documented to live up to 6 years in British Columbia (Wydoski and Whitney 2003). The Cemetery Creek system, with its many backwater areas and ponds with deep silty bottoms in combination with areas of fine spawning gravel, likely provides an ideal habitat for the maintenance and reproduction of western brook lamprey populations. It is hypothesized that western brook lamprey have distinct population groups since they are limited in their ability to make long-distance movements within river systems (www.biologicaldiversity.org).

Staff should continue to watch for western brook lamprey spawning activity between the months of April and July, especially in areas of fine gravel in the Cemetery Creek channel. Care should be taken that redds are not disturbed or stepped on by staff; lamprey redds resemble small salmon redds (between 1 and 3 feet in diameter).

Figure 2-22. **Western brook lamprey building a redd in the Cemetery Creek channel, June 3 and 5, 2009. Size of these adults is approximately 6 inches.**

2.4.4.2 Insects

An adult banded alder borer (*Rosalia funebra*) was found at the Salmon Park restoration site on August 3, 2009 (Figure 2-23). These native long-horned wood-boring beetles (family Cerambycidae) have larvae that bore the wood of dead alder, maple, ash, sycamore, oak, and willow trees. Larvae overwinter as pupae before emerging in spring as adults (Oregon State University Entomology Program; http://entomology.oregonstate.edu).

Figure 2-23. Adult banded alder borer at Salmon Park, August 3, 2009.

The pond system at Cemetery Creek is widely used by dragonflies and damselflies (order Odonata) for feeding and reproduction. Many of these insects are emerging from restoration site aquatic habitats, as larval casings are frequently found by staff on logs, emergent vegetation, and even large woody debris jam cabling (Figure 2-24). Documented species include northern bluet (*Enallagma annexum*, Figure 2-25), cardinal meadowhawk (*Sympetrum illota*, Figure 2-25), and California darner (*Rhionaeshna californica*).

If staff time allows, summer dragonfly surveys would enhance our understanding of the use of the restoration site by these insects. State and local survey protocols can be found online; local experts in Odonata identification can be found by contacting the Padilla Bay National Estuarine Research Reserve, as they offer a course yearly in local dragonfly and damselfly identification and appreciation.

With two-thirds of U.S. Odonata species characterized as "Species of Greatest Conservation Need," survey data on local Odonata populations can assist in the creation of state wildlife action plans (Bried and Mazzacano 2010).

Figure 2-24. Dragonfly nymph casing on large woody debris cabling, Cemetery Creek, September 3, 2009.

Figure 2-25. Northern bluet (left) and cardinal meadowhawk (right) in the West Pond, July 10, 2009.

3 PHYSICAL MONITORING

3.1 HYDROLOGY AND HABITAT

3.1.1 Ponds – Bathymetry

3.1.1.1 Introduction

Three ponds were created in the Cemetery Creek channel to provide rearing habitat for juvenile salmonids: North Pond, West Pond and South Pond. The objective of pond bathymetry studies is to observe changes in the depth and volume characteristics of the ponds over time, and determine if the ponds maintain their designed functional characteristics.

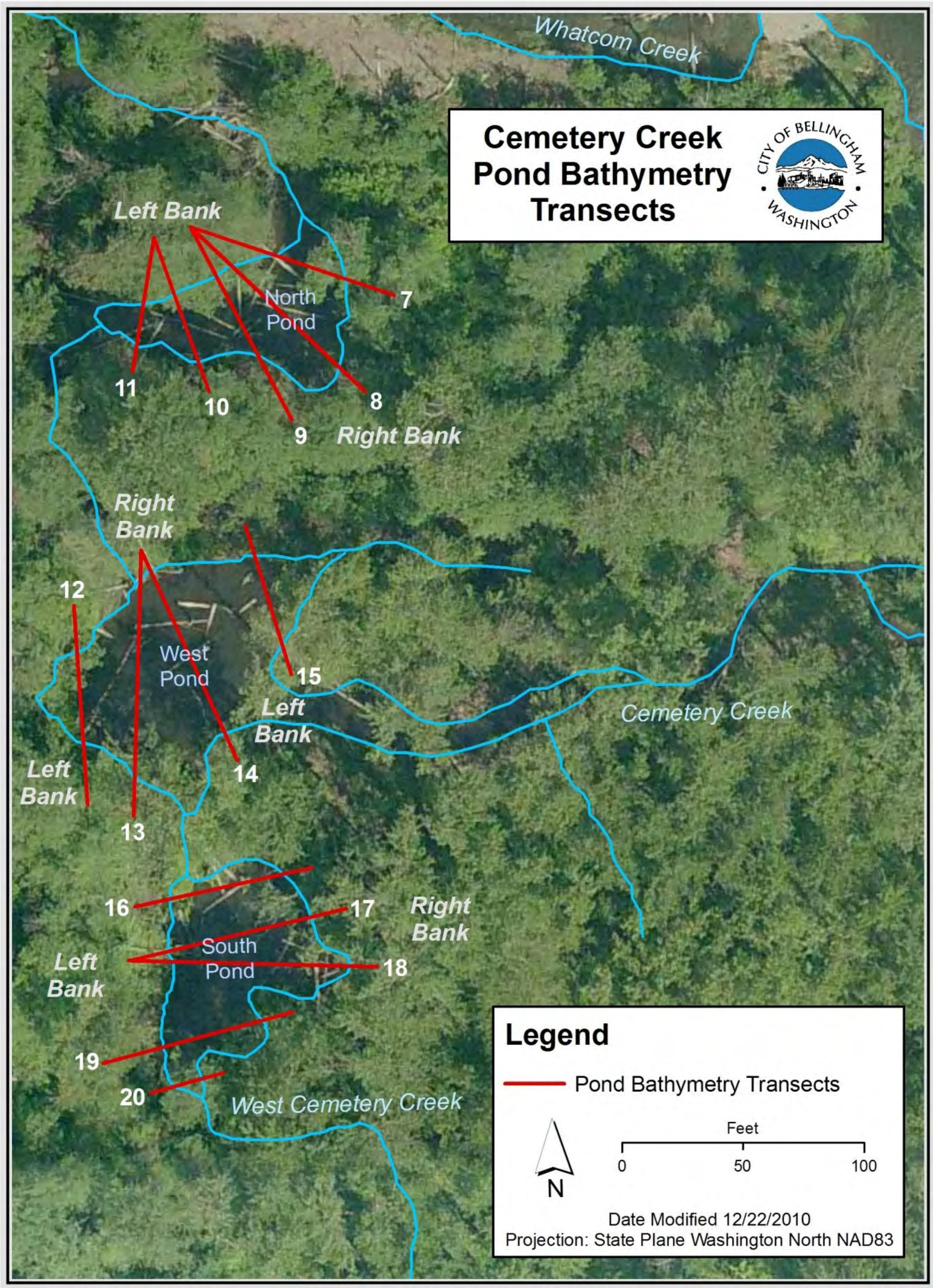
3.1.1.2 Methods

Per recommendations from the *Whatcom Creek Restoration Project Report: 2007-2008* (Forester 2009), pond bathymetry methods were altered for the 2009 monitoring season. Previous monitoring (2007-2008) was conducted using a stadia rod to measure pond depth across transects. A layer of soft substrate present at the bottom of the ponds made results difficult to reproduce using this method. To minimize changes due to methodological error, a weight and tape methodology was used in 2009.

A 4-ounce fishing weight was attached to a Kevlar measuring tape using a zip tie and lowered until it touched the bottom of the pond. At pond edges where the sediment was firm and the water was shallow (less than approximately 4 inches) the stadia rod was used to take the measurement. At these shallow pond edges, the weight and tape method is prone to error because the weight often stays vertical (does not lay on its side), biasing the measurement. Surveyor investigation noted that at greater depths the weight would fall to the bottom and lay on its side, making the measurement more accurate since the zero end of the tape would be flush with the substrate.

All transects were surveyed using the above methodology with the exception of transect 20, which was surveyed using the stadia rod only since the entire transect is very shallow and more closely resembles a stream transect. All other aspects of pond bathymetry survey methodology remained the same (see the *Whatcom Creek Restoration Project Report: 2007-2008*, Forester 2009).

Figure 3-1. Map of pond bathymetry transects.



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3.1.1.3 Results

Bathymetry surveys were conducted on June 3 and 4, 2009. Graphs of all bathymetry transects are provided in Appendix C.

Maximum depth and averaged volume (average width x average depth x length) for each pond for 2007-2009 are presented in Table 3-1. Average depth of each transect for each year is presented in Table 3-2. Annual changes were not calculated due to the modification of survey methodology. Selected transects in each pond were resurveyed using the 2007-2008 methodology to compare results between the two methods. The new tape/weight method resulted in decreases in almost all measurements (Table 3-2, Figure 3-2, Figure 3-3).

Table 3-1. Maximum depth and averaged volume of ponds, 2007-2009.

	Maximum Depth (ft)			Volume (ft^3)		
	2007	2008	2009*	2007	2008	2009*
North Pond	4.83	5.58	4.32	10,184	10,709	9,269
West Pond	7.84	8.67	7.43	19,178	19,824	16,539
South Pond†	7.45	7.70	6.89	19,597	21,112	16,314

*2009 methodology differs from 2007-2008. See text for details.

†Transect 20 excluded from volume calculation; transect crosses inflow and is not representative of pond conditions.

Table 3-2. Average depth of bathymetry transects, 2007-2009.

		Average Depth (ft)			
	Transect	2007	2008	2009*	2009-Old Method
North Pond	7	2.49	2.52	2.18	--
	8	2.50	2.65	2.49	--
	9	2.92	3.06	2.51	3.03
	10	2.06	2.30	1.90	--
	11	1.89	2.10	1.98	--
West Pond	12	3.77	3.85	3.31	--
	13	4.45	4.70	3.92	4.42
	14	4.82	4.96	4.15	--
	15	2.23	2.59	2.05	--
South Pond	16	1.85	2.10	1.60	--
	17	4.56	5.04	4.24	4.94
	18	3.81	3.96	3.18	--
	19	2.96	3.30	2.05	2.75
	20	0.25	0.24	0.28	--

*2009 methodology differs from 2007-2008. See text for details.

Figure 3-2. Plot of pond bathymetry data (2007-2009) for transect 9 in the North Pond. The water surface is represented by the top x-axis, with water surface elevation noted.

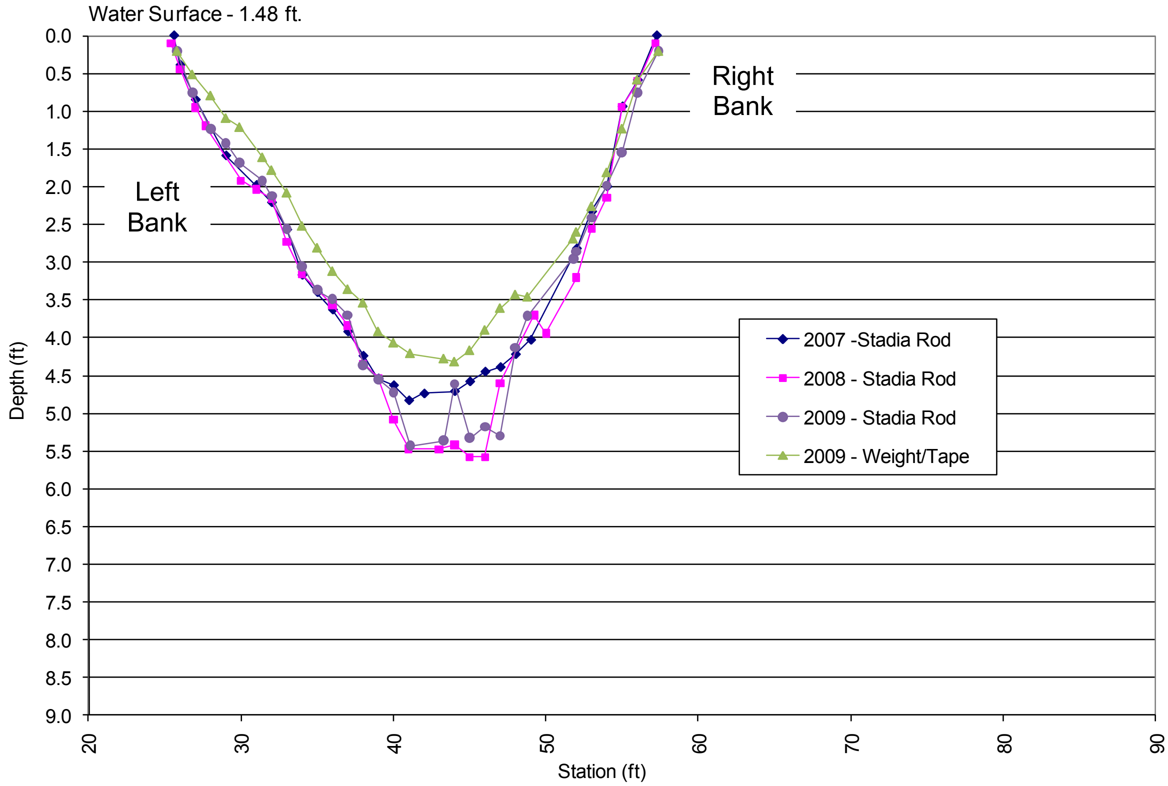
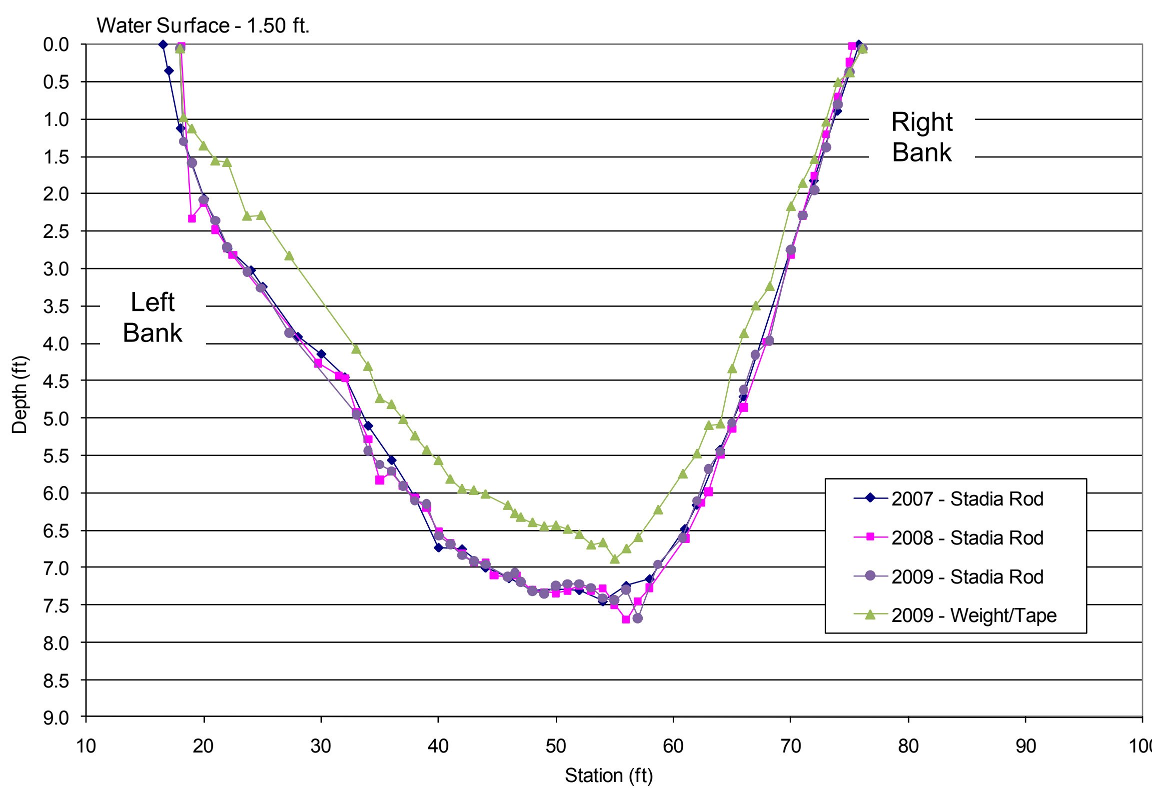


Figure 3-3. Plot of pond bathymetry data (2007-2009) for transect 17 in the South Pond. The water surface is represented by the top x-axis, with water surface elevation noted.



3.1.1.4 Discussion

Surveys conducted in 2009 using the new methodology indicate that the soft sediment layer present in the ponds affects measurements taken with the stadia rod by different surveyors. Figure 3-3 illustrates the location and depth of this soft sediment layer; it also indicates that use of the stadia rod can be repeatable at some transects. On the other hand, Figure 3-2 illustrates how use of the stadia rod is dependent on the surveyor. For a surveyor, it can be difficult to know how hard to push down on the rod, as there are sometimes multiple layers of sediment and gravel in the ponds. These figures indicate that a more repeatable methodology is called for. The 2009 Weight/Tape measurements in each figure illustrate how the new method is not dependent on the level of force used by the surveyor; instead, the weight sinks into the sediment under its own weight, yielding a more consistent measurement. It may be possible to apply a correction factor to the 2007 and 2008 measurements; it is recommended, however, that at least one additional survey period (2011) be analyzed to assess repeatability of the new method.

3.1.1.5 Recommendations

- ✓ No changes are recommended at this time.

3.1.2 Stream Channels – Cross-Sections

3.1.2.1 Introduction

The objective of channel cross-section surveys is to observe changes in the channels over time and determine if they maintain the functional intent of the design.

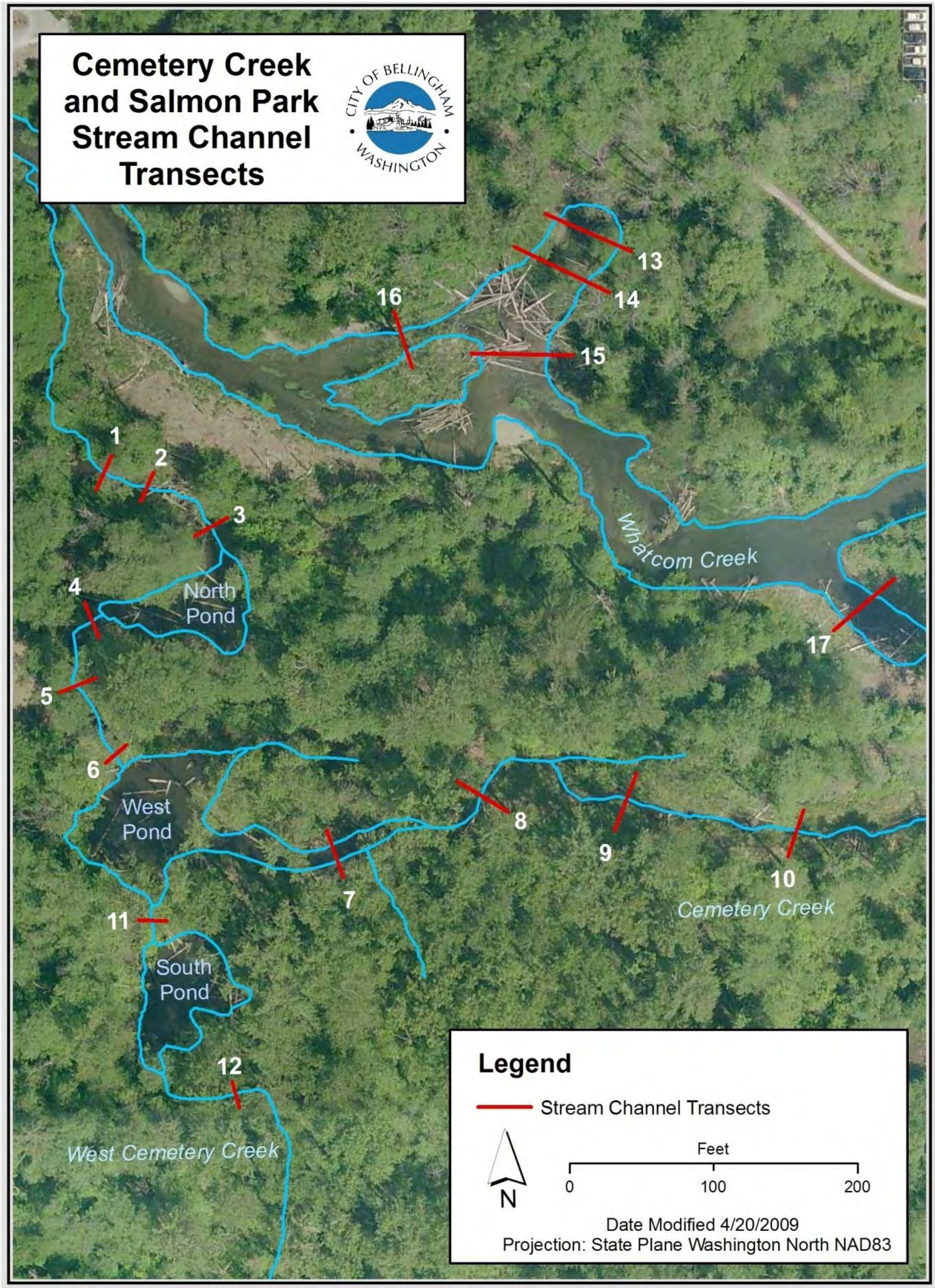
3.1.2.2 Methods

Detailed methods for channel cross-section surveys can be found in the *Whatcom Creek Restoration Project Report: 2007-2008* (Forester 2009). There were no changes to the monitoring methods for the 2009 season.

3.1.2.3 Results

A map of survey transects is presented in Figure 3-4. Surveys occurred in May and June of 2009; transect 8 was resurveyed on September 1, 2009 due to problems leveling the transect. Rebar and nails were installed during the 2009 surveys to facilitate future surveys using the sag tape method. Future surveys will be conducted by either stretching the tape across the top of the installed rebar or pinning the tape to the appropriate nail. Detailed descriptions of each transect have been provided for future surveyors. Graphs of all transects are provided in Appendix D.

Figure 3-4. Map of stream channel-cross section transects.



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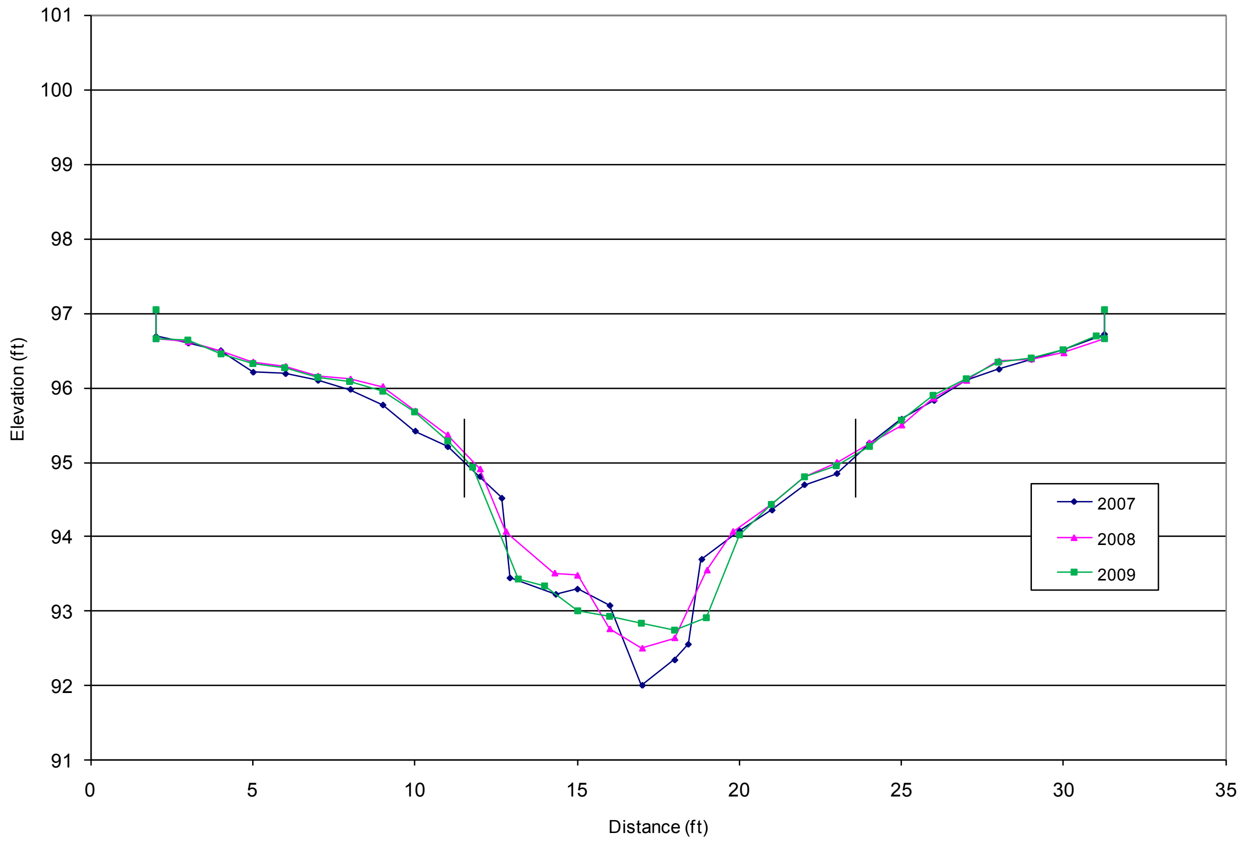
Mean bed elevations were calculated for each transect for each survey year. Changes in elevation are presented in Table 3-3. Overall there have been small changes in channel cross-sections over the monitoring period. Transect 4 (at the inlet to the North Pond) shows more variability than most other transects (Figure 3-5); surveyors have observed deposition of fine gravel in this area over the course of the monitoring period. This gravel is used as a spawning area by western brook lamprey (section 2.4.4.1).

Table 3-3. Mean bed elevations within the bankfull width for stream channel transects, 2007-2009, with change between years and over the entire monitoring period. A positive change in mean bed elevation indicates deposition, while a negative change indicates scouring.

Transect	Mean Bed Elevation (ft)			Change in Mean Bed Elevation (ft)		
	2007	2008	2009	2007 to 2008	2008 to 2009	2007 to 2009
1	95.75	95.81	95.95	0.06	0.14	0.20
2	95.28	95.38	95.35	0.11	-0.03	0.08
3	94.99	95.16	95.05	0.17	-0.11	0.06
4	93.64	93.81	93.70	0.17	-0.12	0.05
5	95.31	95.23	95.08	-0.08	-0.15	-0.23
6	95.24	95.34	94.96	0.10	-0.39	-0.28
7	94.83	94.94	95.03	0.11	0.09	0.20
8	96.64	96.67	96.67	0.04	0.00	0.03
9	96.22	96.22	96.28	0.01	0.05	0.06
10	98.45	98.36	98.53	-0.09	0.17	0.08
11	--	--	93.91	--	--	--
12	--	--	93.69	--	--	--
13	--	--	96.60	--	--	--
14	--	--	92.41	--	--	--
15	--	--	93.06	--	--	--
16	--	--	91.01	--	--	--
17	--	--	90.09	--	--	--

Figure 3-5. Plot of transect 4 cross-section data from 2007 - 2009. Vertical black lines indicate bankfull width.



Transect 5 (Figure 3-6) has continued to change slightly with some additional erosion of the bank to the right bank side of the placed log. A large rooted tree downstream of the erosion point is helping to minimize further erosion of the bank in this area.

Transect 6 (Figure 3-7) also shows yearly changes; this is likely due to two factors. The wetted edges of this transect are bounded by buried logs. A second log on the right bank is cabled into other large logs in the vicinity, but moves and shifts during high flows. These logs influence the measurements (and the ability to measure) on this right bank side. Also, transect 6 is located just downstream of the smolt trap installation site. In 2009, the transect was surveyed immediately upon removal of the smolt trap; it is expected that placement and removal of the smolt trap may disrupt the first few inches of stream bed material, since flashing is installed in the streambed to prevent erosion. Future surveys will be used to monitor this portion of the stream channel.

Figure 3-6. Plot of transect 5 cross-section data from 2007-2009. Vertical black lines indicate bankfull width. The brown oval represents the location of the log.

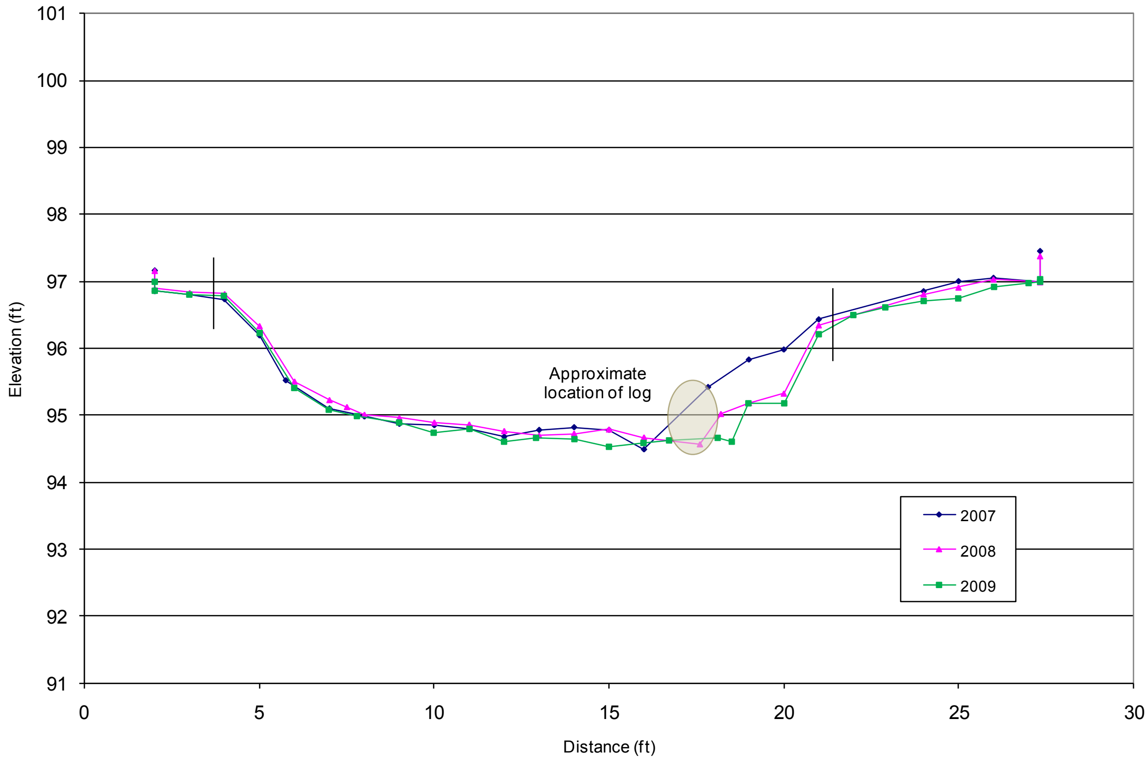
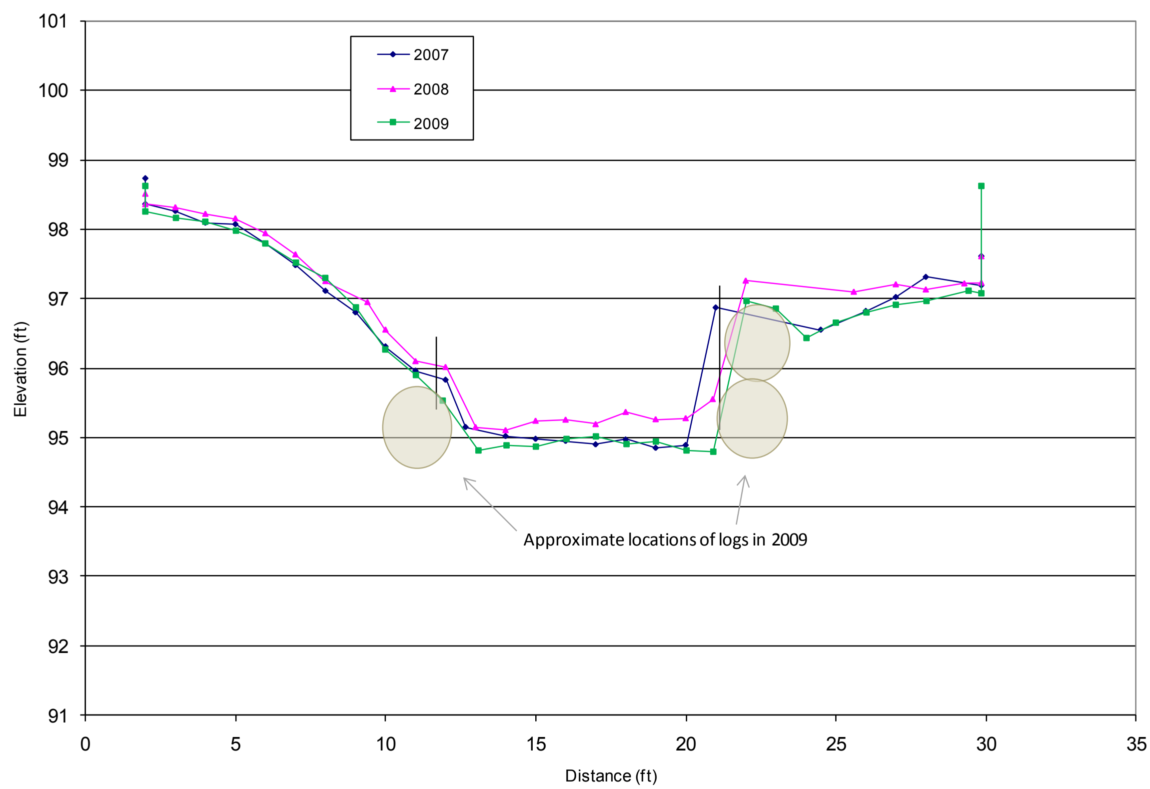


Figure 3-7. Plot of channel transect 6 cross-section data from 2007-2009. Vertical black lines indicate bankfull width. Brown ovals are the approximate location of logs in 2009.



3.1.2.4 Discussion

Overall, stream-channel transects appear to be maintaining the designed configuration. There have been a few transects with small changes, as noted above. None of these changes have been significant, however, and only one (transect 5) has documented channel bed erosion. Surveys conducted in 2011 will provide further data on transects 1-10 and a second set of data for comparison of transects 11-17.

3.1.2.5 Recommendations

- ✓ No changes are recommended at this time.

3.1.3 Stream Channels – Thalweg Profiles

Due to insufficient staff time and a lack of baseline data, this portion of the study plan has been discontinued. Changes in the channel thalweg profile have been tracked based on the thalweg elevations derived from cross-section data. To date, neither those data or visual observations suggest there has been any change in the thalweg profile.

3.1.4 Stream Channels – Habitat

3.1.4.1 Introduction

The objective of habitat surveys is to document that reconstructed stream channels are functioning as designed and provide suitable habitat for salmonids. More background information on the importance of pool and large woody debris (LWD) indices is available in the *Whatcom Creek Restoration Project Report: 2007-2008* (Forester 2009).

3.1.4.2 Methods

Detailed methods for habitat surveys can be found in the *Whatcom Creek Restoration Project Report: 2007-2008* (Forester 2009). Data collection occurred from September 8 to 10, 2009. Staff gages are monitored each survey day; there were small recorded changes in water surface elevation (WSE) between survey dates due to light rain on September 9. The largest change, 0.08, was at the West Pond gage; the smallest change, 0.02, was at the North Pond gage. Because these changes are relatively small, collected habitat data were deemed comparable between days. Between survey years (2008 and 2009) WSE changes were minor at pond gages (between 0.02 and 0.10).

The methods used in the identification of "key pieces" of LWD in jams was altered for 2009 surveys. The technique used in 2008 surveys was largely subjective; the protocol was changed in 2009 in order to standardize identification across survey years. The Timber Fish and

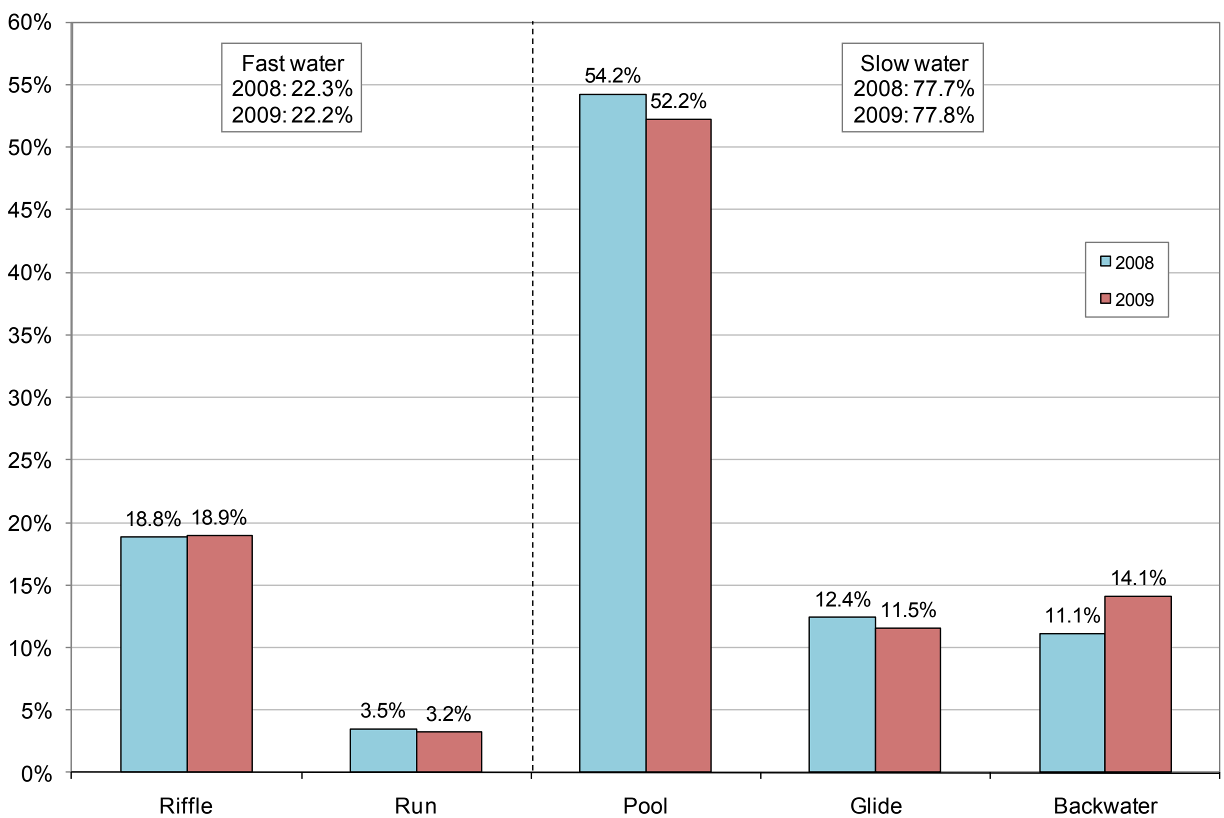
Wildlife “LWD Key Piece Volume Criteria” field sheet (Schuett-Hames et al. 1999a) was used to identify key pieces. The bankfull width of >0 m to <5 m was used to categorize LWD based on minimum diameter and length of each piece. This method should be used in all subsequent surveys. Key piece data collected in 2009 are not comparable to data collected in 2008.

As of this update report, LWD indices for pool-forming function and sediment storage will not be gathered. Despite guidelines provided in the TFW manual, designation of these characteristics is highly subjective. Furthermore, determining these indices is complicated because channels and pools are constructed and most of the LWD is placed and/or cabled. The usefulness of these indices for documenting habitat function is minimal.

3.1.4.3 Results

Habitat units: The reconstructed channels of Cemetery and West Cemetery Creeks have more slow water than fast water, as illustrated in Figure 3-8. Pools are the dominant habitat sub-unit. There have been only minor changes in habitat sub-unit types from 2008 to 2009, indicating that the reconstructed channels are maintaining the preferred proportion of habitat types.

Figure 3-8. Comparison of habitat sub-unit types from 2008-2009 at the Cemetery Creek restoration site. Riffles and runs are fast habitat; pools, glides and backwaters are slow habitat.



Pool assessment: Pool indices provide simple quantitative indicators of habitat quantity and quality. Pool indices for the Cemetery Creek restoration site from 2008 and 2009 are presented in Table 3-4. There have been minor changes in pool indices from 2008 to 2009, indicating that the reconstructed channel is maintaining the preferred pool characteristics.

Table 3-4. Pool indices at the Cemetery Creek restoration site, 2008 and 2009.

Pool Index	2008	2009
Pool Tally (#)	24	24
Pool Percentage (by length)	54%	52%
Pool Frequency (channel widths/pool)	3.7	3.7
Pool Spacing (pools/mile)	85.6	85.4
Holding Pools (residual depth > 3 ft)	3	3
Average Residual Pool Depth (ft)	2.3	2.2

Large woody debris assessment: Similar to pool indices, LWD indices provide quantitative indicators of habitat quantity and quality. They also allow for comparison over time, as LWD shifts, washes out, and is added to the stream through natural recruitment. Large woody debris indices for the Cemetery Creek restoration site from 2008 to 2009 are presented in Table 3-5. A table of LWD counted in the constructed ponds is presented in Table 3-6.

Overall, there was an increase in the total amount of LWD at the site due to natural recruitment. There was a small decrease in “large” pieces (those with a diameter ≥ 20 inches). This is likely due to the loss of bark and increased decay of LWD; in the 2008 survey there were three pieces of LWD with a diameter of exactly 20 inches. The location of LWD in the stream channel is determined by zones; there was an increase in the number of LWD pieces that extends into the wetted channel (zone 1), contributing to habitat complexity. Newly recruited pieces are stable in the channel, promoting habitat complexity. The amount of LWD in the ponds has remained stable.

Table 3-5. LWD indices at the Cemetery Creek restoration site, 2008-2009.

Large Woody Debris Index	2008	2009
Total number of LWD *(pieces and jams)*	249	274
Pieces per channel width (p/cw)	2.8	3.0
Large pieces* *(pieces and jams)*	32	28
Large pieces per channel width (p/cw)	0.4	0.3
Key pieces *(jams only)*	--	28
Key pieces per channel width (p/cw)	--	0.3
(all of the following indices are pieces only)		
Average diameter (inches)	13.8	12.5
Average piece length (Zones 1-3, feet)	13.2	12.9
Number of pieces in Zone 1	72	81
Number of pieces in Zone 2	19	27
Number of pieces in Zone 3	10	8
Percentage of pieces in Zone 1	71%	70%
Percentage of pieces in Zone 2	19%	23%
Percentage of pieces in Zone 3	10%	7%
Orientation in the channel:		
Perpendicular	45	45
Parallel	34	30
Upstream	14	24
Downstream	7	17
Stable pieces (#)	91	105
Unstable pieces (#)	10	11

*Piece diameter ≥ 20 inches

Table 3-6. Large woody debris in the constructed ponds of Cemetery Creek, 2008 and 2009.

	North Pond		West Pond		South Pond	
	2008	2009	2008	2009	2008	2009
Jams	1	1	1	1	2	2
Rootwads	0	0	0	0	0	0
Small Logs	0	1	0	3	1	4
Medium Logs	23	22	15	17	30	22
Large Logs	0	0	3	3	8	9
Total # Pieces	**23**	**23**	**18**	**23**	**39**	**35**

3.1.4.4 Discussion

The primary intent of habitat monitoring is to determine if constructed channels, designed to provide suitable salmonid habitat, remain functional over time. Habitat and LWD conditions in the restoration site can be rated using habitat condition diagnostics developed by the Washington Forest Practices Board (1997) and the National Marine Fisheries Service (1996). These diagnostics were developed based on conditions typically found in undisturbed forest streams. While they may not represent realistic target conditions for an urban stream system, they do provide a means of evaluating the effectiveness of restoration activities over time. Diagnostics and restoration site values and ratings are presented in Table 3-7.

Table 3-7. Indices of pool habitat and LWD conditions for interpretation of survey results and habitat analysis. Cemetery Creek restoration site values and ratings are listed at the right.

Parameter	Channel Morphology	Habitat Quality			Site Value		Site Rating	
		Good	Fair	Poor	2008	2009	2008	2009
Pool Percentage[1]	< 2% Gradient < 50 ft wide	>55%	40-55%	<40%	54%	52%	Fair	Fair
Pool Frequency[1]	< 2% Gradient < 50 ft wide	<2 cw/pool	2-4 cw/pool	>4 cw/pool	3.7	3.7	Fair	Fair
Pool Spacing[2]	15-20 ft wide	>70 pools/mile	56-70 pools/mile	<56 pools/mile	86	85.4	Good	Good
LWD pieces per channel width[1]	< 50 ft wide	>2	1-2	<1	2.8	3.0	Good	Good
Key pieces per channel width[1]	Bankfull width < 33 ft	>0.30	0.15-0.30	<0.15	--	0.3	--	Fair

[1]From WFPB 1997
[2]From NMFS 1996

Overall, habitat conditions range from fair to good at the Cemetery Creek restoration site and have not changed over the 2008-2009 monitoring period. Pool percentage was at the high end of the "fair" rating. Large woody debris indices easily met the "good" rating in both categories for both survey years.

3.1.4.5 Recommendations

- ✓ Resurvey the South Pond gage; this gage has shifted and should be moved to a stable location.
- ✓ Eliminate LWD indices for pool-forming function and sediment storage from subsequent surveys.
- ✓ Follow TFW protocols for the identification of key pieces of LWD in future surveys.

3.1.5 Stream Channels – Spawning Gravel Availability

3.1.5.1 Introduction

The objective of spawning gravel surveys is to assess the availability of potential spawning habitat at the Cemetery Creek restoration site and to document any changes in spawning habitat availability over time.

3.1.5.2 Methods

Spawning gravel surveys were not completed in 2007 or 2008 due to a lack of staff time. This monitoring component was initiated in 2009 and should be completed for the duration of the monitoring period. Spawning gravel surveys are conducted following a modified version of the Timber Fish and Wildlife methodology for assessing salmonid spawning habitat availability (Schuett-Hames et al. 1999b). Surveys are conducted by two surveyors working upstream; the entire channel within the restoration site is surveyed. Spawning gravel is categorized into two main groups, small spawning gravel (≥8 to 64 mm; minimum area 1 ft^2) and large spawning gravel (≥64 to 128 mm; minimum area 10.8 ft^2). Gravel must meet a minimum patch size to qualify as suitable spawning habitat. A "small patch" must be at least 1 ft^2 and can only be comprised of small gravel. A "large patch" must measure at least 10.8 ft^2 (1 m^2) and can be composed of either small or large gravel.

When a qualifying patch is identified, the dominant gravel size class is determined. The presence of boulders, bedrock or other substrates, such as LWD, in spawning gravel patches is noted. Sub-patches may be identified if there are qualifying patches of different gravel size within a larger patch. The habitat type (pool, backwater, riffle, run, or glide) containing the gravel patch is also identified. Length and width measurements are recorded to the nearest tenth of an inch.

To ease identification and measurement of spawning gravel patches as well as avoid disturbing fish during the spawning season, surveys are conducted during low flows before the start of spawning. Surveyors return during winter base flows (flows representative of spawning conditions) to confirm depth and water velocity criteria. Water depth criteria are: (1) at least 2 inches of water over small gravel patches, and (2) at least 4 inches of water over large gravel patches. For the water velocity criterion to be met, water flow over the spawning gravel patch must be greater than "slack".

For the 2009 survey, patch identification and measurement surveys were conducted on September 11 and 15, 2009. Water depth and velocity criteria were confirmed on December 17, 2009.

3.1.5.3 Results

Results of the first spawning gravel availability survey are presented in Table 3-8. There were 43 total spawning gravel patches identified at the restoration site, with a cumulative spawning area of 2,785.5 ft^2. Large patches of gravel (at least 10.8 ft^2) dominated at the restoration site. Small and large gravel were present in similar amounts in the channel. The majority of patches were present in riffle habitat types.

Table 3-8. Spawning habitat availability patch survey summary data, 2009.

	Small Gravel (≥8 to 64 mm)	Large Gravel (≥64 to 128 mm)
Total # of Spawning Gravel Patches	25	18
Total Surface Area (ft^2)	1330.9	1454.6
# Small Patches (at least 1 ft^2)	4	not applicable
Surface Area of Small Patches (ft^2)	25.9	not applicable
# Large Patches (at least 10.8 ft^2)	21	18
Surface Area of Large Patches (ft^2)	1305.0	1454.6

3.1.5.4 Discussion

Spawning habitat availability can be interpreted based on habitat preferences of local salmonid species within a stream or reach. Small spawning gravel (≥8 to 64 mm) is most often used by small-bodied salmonids, such as resident trout and anadromous cutthroat trout. Both small and large spawning gravel (≥8 to 128 mm) are used by large bodied salmonids, such as pink, chum, coho, steelhead, and Chinook (Schuett-Hames et al. 1999b).

Currently, the restoration site provides 1330.9 ft^2 of spawning habitat for small-bodied salmonids. This is also the spawning habitat used by western brook lamprey (section 2.4.4.1). Large-bodied salmonids, which will use both small and large gravel, have access to 2756.6 ft^2 of spawning habitat in the restoration site (all gravel patches except small gravel/small patches). This survey will serve as a baseline for future comparisons.

The number, type and size of spawning gravel patches is dynamic. For example, since construction in 2006, the upstream end of the restoration site in the mainstem of Cemetery Creek has consisted of deep, mucky sediment. Following the January 2009 flood event, this same part of the channel was found to contain a large, thick bed of small spawning gravel (Figure 3-9). With large pools on either side of this gravel patch, it is likely to provide excellent spawning habitat for small-bodied salmonids and brook lamprey in the future.

Figure 3-9. Newly deposited spawning gravel patch at the upstream end of the restoration site, mainstem Cemetery Creek, January 26, 2009.

3.1.5.5 Recommendations

- ✓ Reed canary grass should be pulled from the channel before the start of each spawning season. This invasive grass can bind spawning gravel in the channel, reducing habitat availability for spawning salmonids.

3.2 WATER QUALITY

3.2.1 Introduction

The Objectives of water quality surveys are: 1) to assess water quality within the Cemetery Creek restoration site; 2) to create temporal documentation of water quality conditions within the Cemetery Creek restoration site; 3) to determine if created ponds provide suitable year-round habitat conditions for native salmonids; and 4) to assess the influence of created ponds on stream water quality. A detailed explanation of water quality parameters sampled is included in the *Whatcom Creek Restoration Project Report: 2007-2008* (Forester 2009).

In order to best address these Objectives, the water quality section is divided into two components: 1) pond water quality and 2) stream water quality. Since the sampling methods for both the ponds and the stream are the same, the Methods are combined into one section (3.2.2). Following the combined Methods section are two Results and Discussion sections. Section 3.2.3 addresses the ponds and specifically addresses Objective 3 (see above). Section 3.2.4 provides Results and Discussion for the stream and specifically addresses Objective 4 (see above). This section also includes analysis of fecal coliform monitoring. Objectives 1 and 2 are addressed throughout both discussions.

3.2.2 Methods - Ponds and Streams

Detailed methods, including flow calculations and quality control procedures, are outlined in the *Whatcom Creek Restoration Project Report: 2007-2008* (Forester 2009). New water quality data discussed in this report includes sampling between December 3, 2008 and October 9, 2009. Sampling occurs monthly for most of the year, and biweekly from June to September (beginning in 2008). Biweekly summer sampling was initiated in 2007-2008 to provide more information on warm season temperature and dissolved oxygen levels. Fecal coliform sampling occurs monthly year-round. Water quality was not sampled during March 2009 due to maintenance being conducted on the Hydrolab. Sampling in April 2009 did not include pond stations accessed with the float tube (PWQ 4, 5, 6, and 9) due to equipment malfunction. A table of the 2008-2009 water quality sampling schedule is presented in Table 3-9.

All results are graphed with Washington State water quality standards for reference, with the exception of specific conductivity, which does not have a state standard. Synthesized flows are plotted for reference. The January 2009 synthesized flow peak represents a large flood event. Maps of sampling locations are presented in Figure 3-10 and Figure 3-11.

Table 3-9. Water quality sampling schedule for 2008-2009.

	Monthly sampling with Hydrolab	Biweekly sampling with Hydrolab	Hydrolab maintenance (no sampling)	Monthly fecal coliform sampling	Continuous temperature loggers
December 2008	x			x	
January 2009	x			x	
Februrary 2009	x			x	
March 2009			x	x	
April 2009	x			x	
May 2009	x			x	
June 2009	x			x	x
July 2009		x		x	x
August 2009		x		x	x
September 2009		x		x	x
October 2009	x			x	

Figure 3-10. Map of stream water quality testing stations (SWQ) and pond water quality testing stations (PWQ) at the Cemetery Creek restoration site.

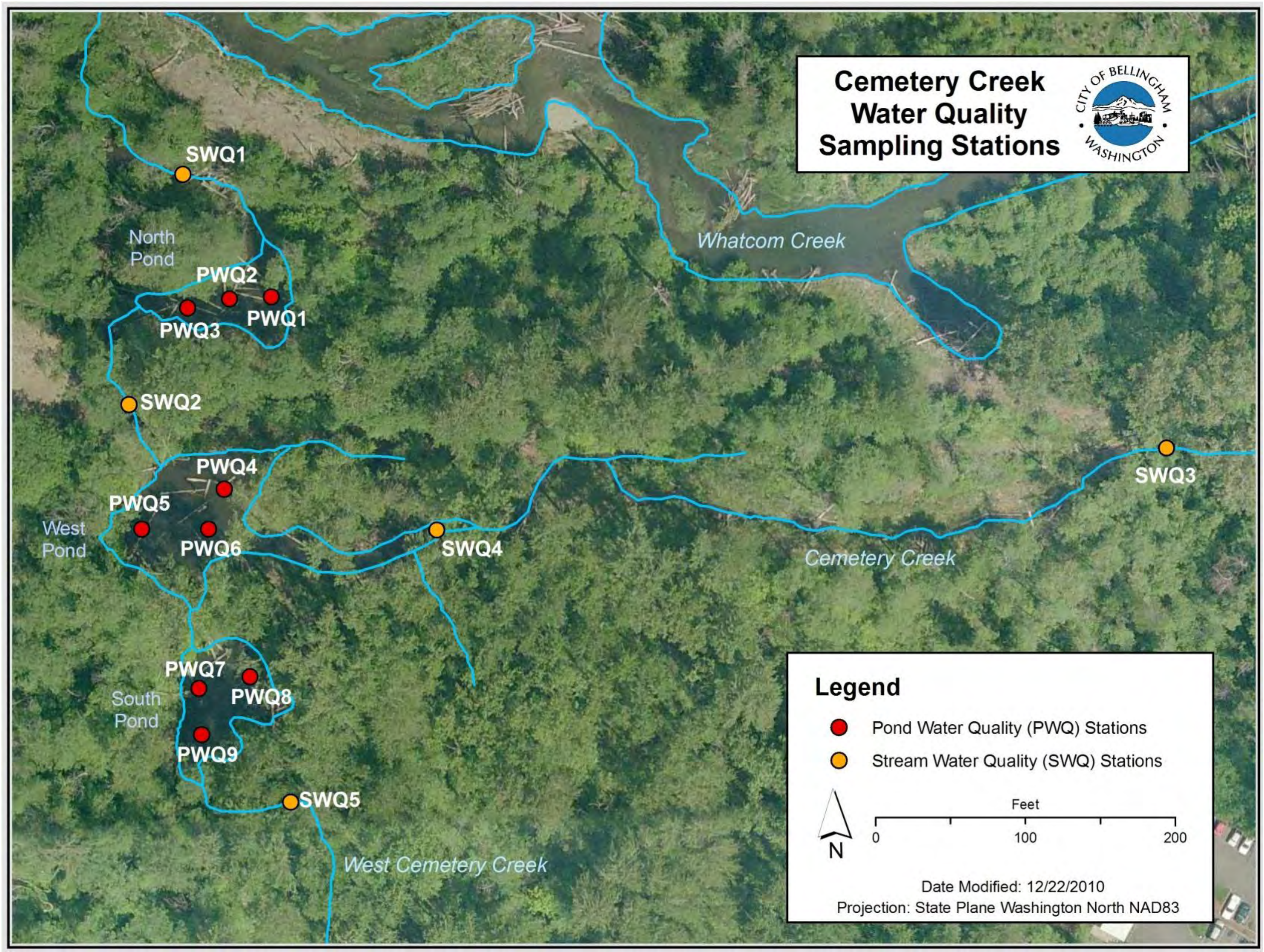


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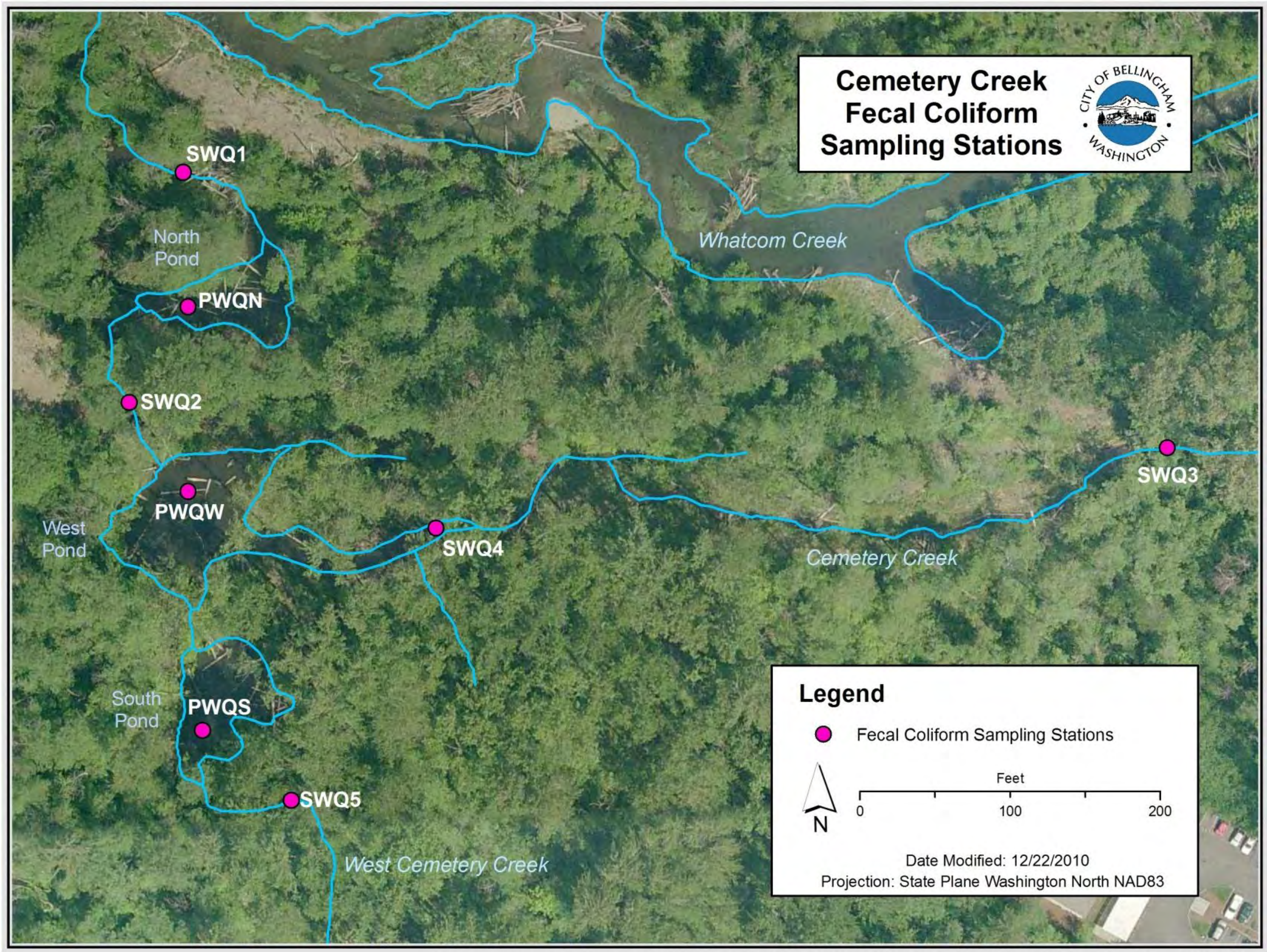
Figure 3-11. Map of fecal coliform testing stations at the Cemetery Creek restoration site.



M:\Data\E R\Restoration\Assessments\Monitoring\OP Monitoring&Maintenance\Restoration\Cemetery Creek Maps\Maps\Cemetery Creek Fecal Coliform

3.2.3 Results and Discussion – Ponds

Plots were constructed for each parameter and sample site to illustrate water quality fluctuations over time. At least one plot for each parameter (from sampling location PWQ8 in the South Pond) is presented below to illustrate general patterns. Depths (for example, 0.5 ft and 1.0 ft) represent depth of the sample from the water surface. A complete set of plots for each pond and each parameter is provided in Appendix E. Pond depths vary seasonally, with sampling depths measured from the surface; floating points in the graphed data are a result of these variations in pond depths.

Depth profiles were constructed for the deepest station in each pond: PWQ2 in the North Pond, PWQ4 in the West Pond, and PWQ8 in the South Pond. Depth profiles were constructed for each parameter on four sampling dates per year (one each in February, April, July, and October). A complete set of depth profiles is provided in Appendix F.

3.2.3.1 Pond temperature – Point-in-time measurements

The Ecology aquatic life temperature criterion is based on the 7-day average of the daily maximum temperatures (7-DADMax). The highest allowable 7-DADMax for Cemetery Creek is 16ºC (60.8ºF). Temperatures are not to exceed this standard of 16ºC more than once every ten years on average.

Temperature data collected with the Hydrolab are point-in-time measurements. These measurements cannot be used to calculate the 7-DADMax used as the state standard. In the following charts, the state standard of 16ºC (7-DADMax) is plotted as a reference point; temperatures that are higher than this criterion suggest that conditions may not meet the standard.

Temperature point-in-time data collected in 2009 followed similar patterns to 2007-2008 data. Pond water temperatures generally corresponded with seasonal air temperature variations: colder in the winter and warmer in the summer. During winter and spring months, temperatures met the state standard (below 16ºC). During the summer months, all pond stations had multiple temperature measurement that exceeded the state standard (Figure 3-12 and Figure 3-13). The highest point-in-time measurement, 19.18 ºC (20% exceedance), was recorded on July 23, 2009 in the West Pond at PWQ6. None of these recorded point-in-time temperatures would have been lethal to salmonids. Lethal temperatures vary by salmonid species, but usually range from 23ºC to 26ºC (Sullivan 2000).

Thermal stratification in lakes and ponds is the thermal layering of water due to differences in water density: warm water is less dense than cold water and so tends to float. Some thermal stratification was evident in the West Pond in 2009, especially during the summer months, when stream flows are low relative to pond volumes (Figure 3-13 and Figure 3-14). This summer stratification is weak, and to date, there is no evidence of a permanent thermocline. Weak reverse thermal stratification was noted in the South Pond (PWQ8) in February 2009 (Figure 3-12). The October 2008 West Pond reverse stratification event was likely a product of cold air temperatures and minimal inflow/mixing (Figure 3-13).

Figure 3-12. Temperature (°C) by date at 0.5 foot intervals in the South Pond at Station PWQ8.

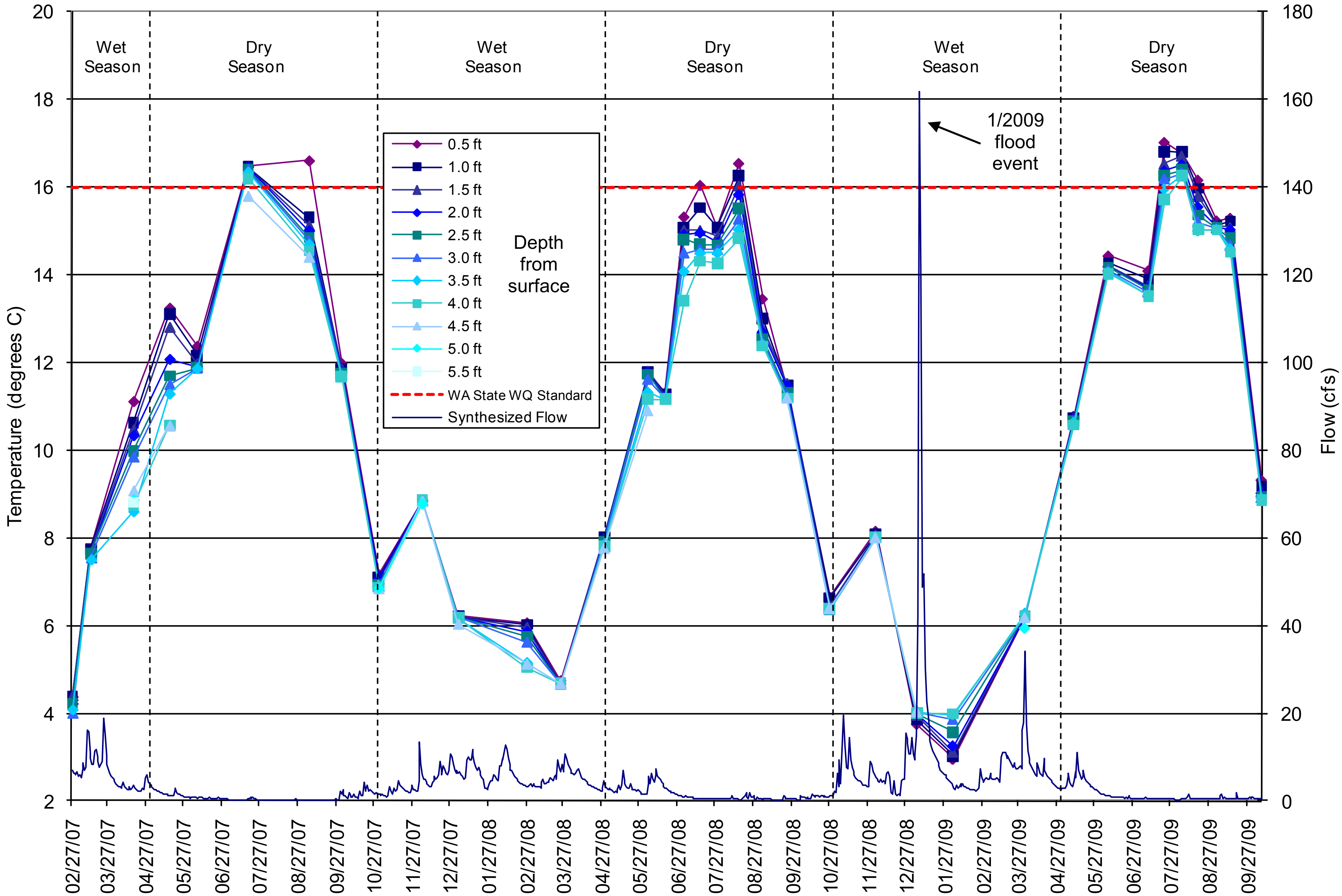


Figure 3-13. Temperature (°C) by date at 0.5 foot intervals in the West Pond at Station PWQ4.

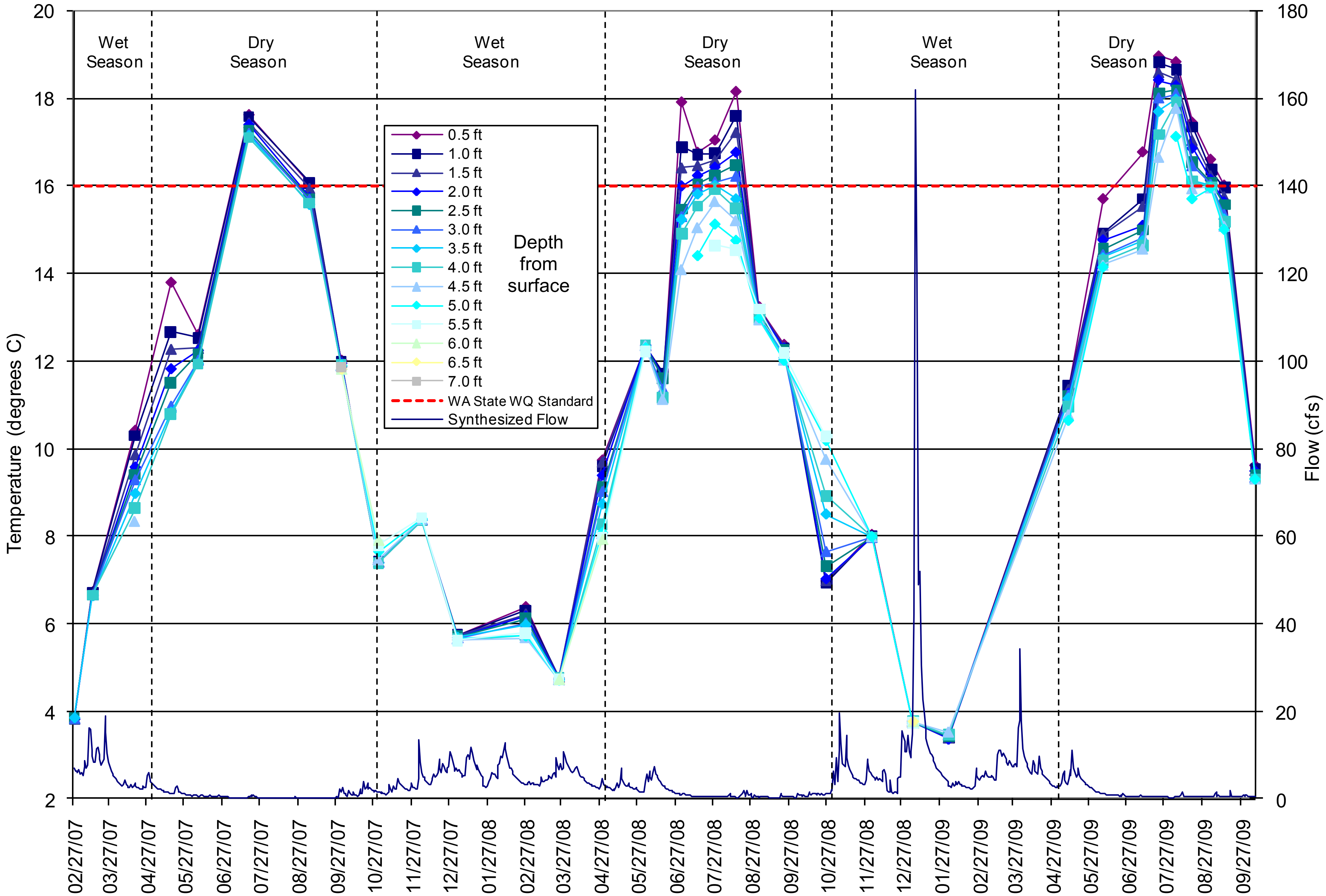
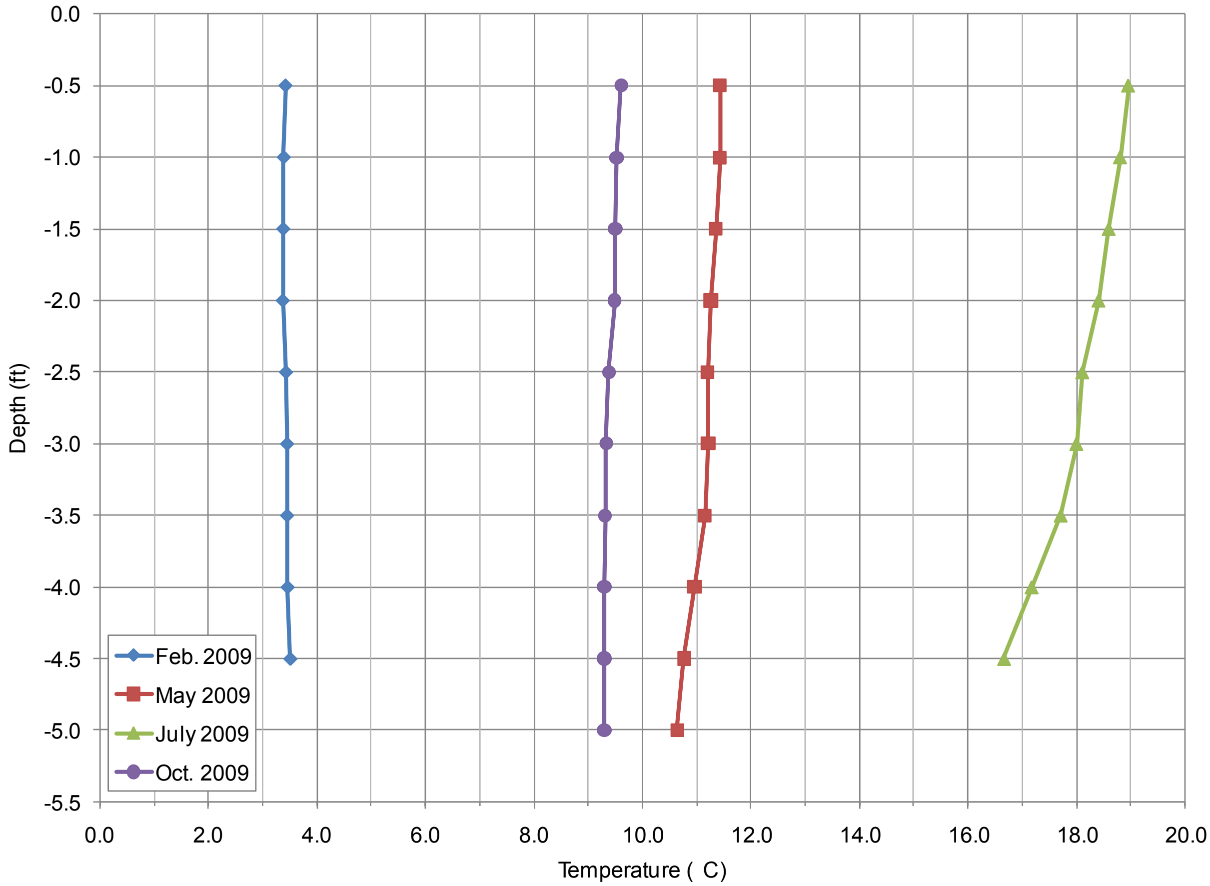


Figure 3-14. Temperature depth profile for four 2009 sampling dates at PWQ4 in the West Pond.



3.2.3.1 Pond temperature – Continuous temperature loggers

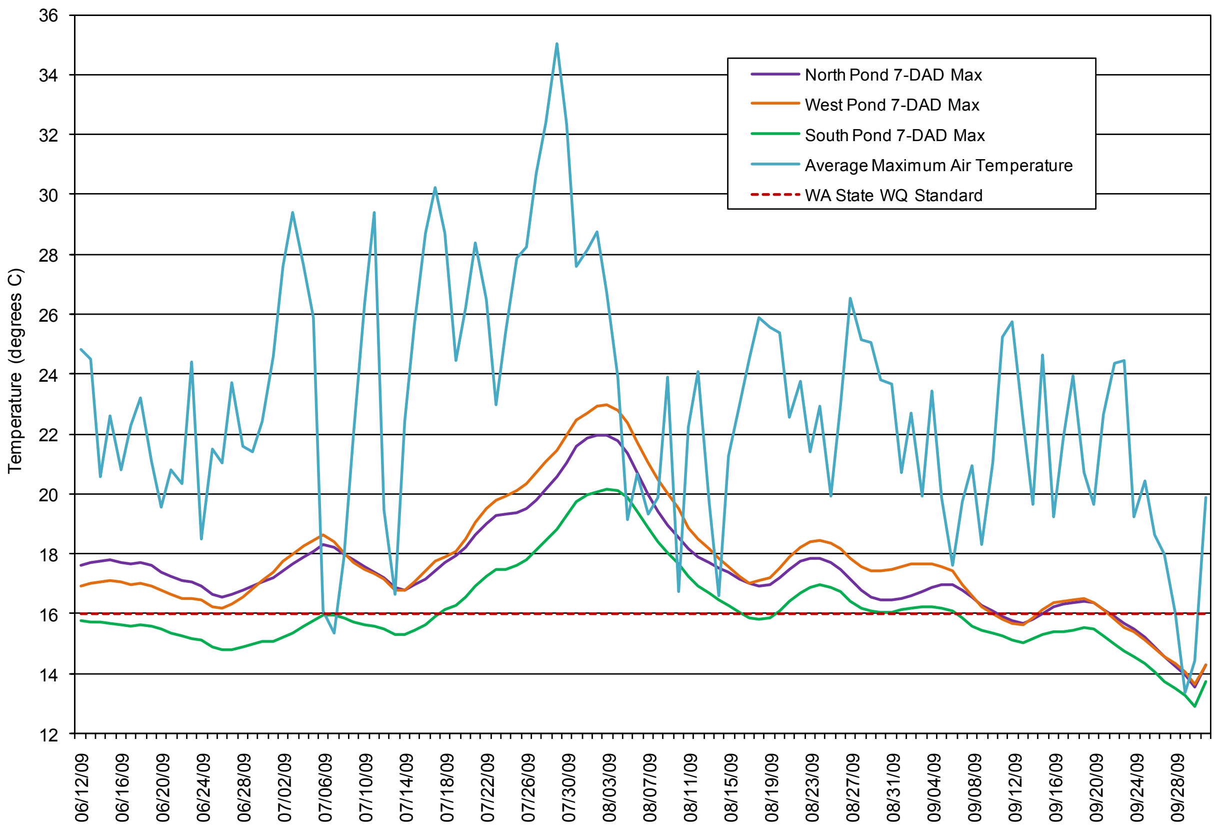
Continuous temperature loggers were installed between June 6 and October 1, 2009. A comparison of temperature logger data from 2008 and 2009 is presented in Table 3-9. The 2009 7-DADMax for the Cemetery Creek restoration site was 22.96°C, measured with the West Pond temperature logger. This is over 4 degrees warmer than the 2008 7-DADMax of 18.94°C, also in the West Pond. Both of these 7-DADMax temperatures exceed the state standard of 16°C. A plot of 2009 7-DADMax calculations for each pond is presented in Figure 3-15.

Continuous temperature loggers indicate that pond temperatures were generally higher in 2009 when compared to 2008. Future monitoring will help determine if this represents a warming trend in the Cemetery Creek ponds, or is part of interannual variability in summer temperatures.

Table 3-10. Continuous temperature logger data indices from 2008 and 2009 monitoring seasons.

	North Pond		West Pond		South Pond	
	2008	2009	2008	2009	2008	2009
Average water depth (ft)	2.66	2.27	2.32	2.17	2.39	2.06
Average tidbit depth (ft)	1.55	1.33	1.35	1.32	1.36	1.13
7-DADMax (°C)	--	--	18.94	22.96	--	--
Average diurnal temperature fluctuation (°C)	1.51	1.22	1.56	1.55	1.08	1.10
# of days where minimum daily temperature exceeds 16°C	37	55	37	49	8	25

Figure 3-15. Seven day rolling averages based on maximum temperatures (7-DADMax) calculated from pond temperature loggers, June 6 to October 1, 2009. Average maximum air temperature is calculated from values recorded by the air temperature loggers at each pond.



3.2.3.2 Pond dissolved oxygen

Dissolved oxygen (DO) levels show no major changes during the 2009 monitoring period. Levels continue to vary seasonally, with the highest DO recorded during the wet season and the lowest DO during the dry season (example plot from the South Pond presented in Figure 3-16). Dissolved oxygen levels are directly affected by water temperature, water flow rate, and turbulence, which aerates the water and increases DO; increased flows tend to be associated with higher DO levels, while slower flows are associated with lower DO levels. During the wet season there is increased inflow and lower ambient air temperatures. Dissolved oxygen levels met or were above the state standard (9.5 mg/L) during much of the wet season.

During the dry season, pond volumes are large relative to stream inflow, resulting in slow water movement through the ponds. Ambient air temperatures are also higher, warming surface waters. Dissolved oxygen levels have been below the state standard during dry seasons from 2007-2009. Additional point sampling at the inflow(s) and outflow of each pond (potential DO refuge areas where water movement is greater) during 2008 and 2009 showed minimally increased DO levels in those areas, the majority of which did not meet the state standard.

Potentially lethal DO levels (less than 3.3 mg/L, Spence et al. 1996) have been recorded in at least one location in every pond in every dry season to date (2007-2009). On the August 6, 2009 water quality sampling date, five coho fry and three adult resident trout species were found dead in the mainstem of Cemetery Creek, near SWQ4. On that same day, monitoring staff noted the presence of at least one hundred fish, from small sticklebacks to adult resident trout, gathered at the west fork inlet to the West Pond. This inflow from the South Pond maintains good flow levels throughout the season and likely represents an important DO refuge for fish in the West Pond. August 2009 was a particularly warm month, with very warm water temperatures recorded (section 3.2.3.1).

Depth profiles for DO (example from the South Pond in Figure 3-17) continue to show a variety of patterns, including moderate stratification (see February and July dates in Figure 3-17). These patterns do not appear to be distinguishable based on season. The effect of pond DO levels on the Cemetery Creek system is discussed in Section 3.2.4.2.

Figure 3-16. Dissolved oxygen (mg/L) by date at 0.5 foot intervals in the South Pond at Station PWQ8.

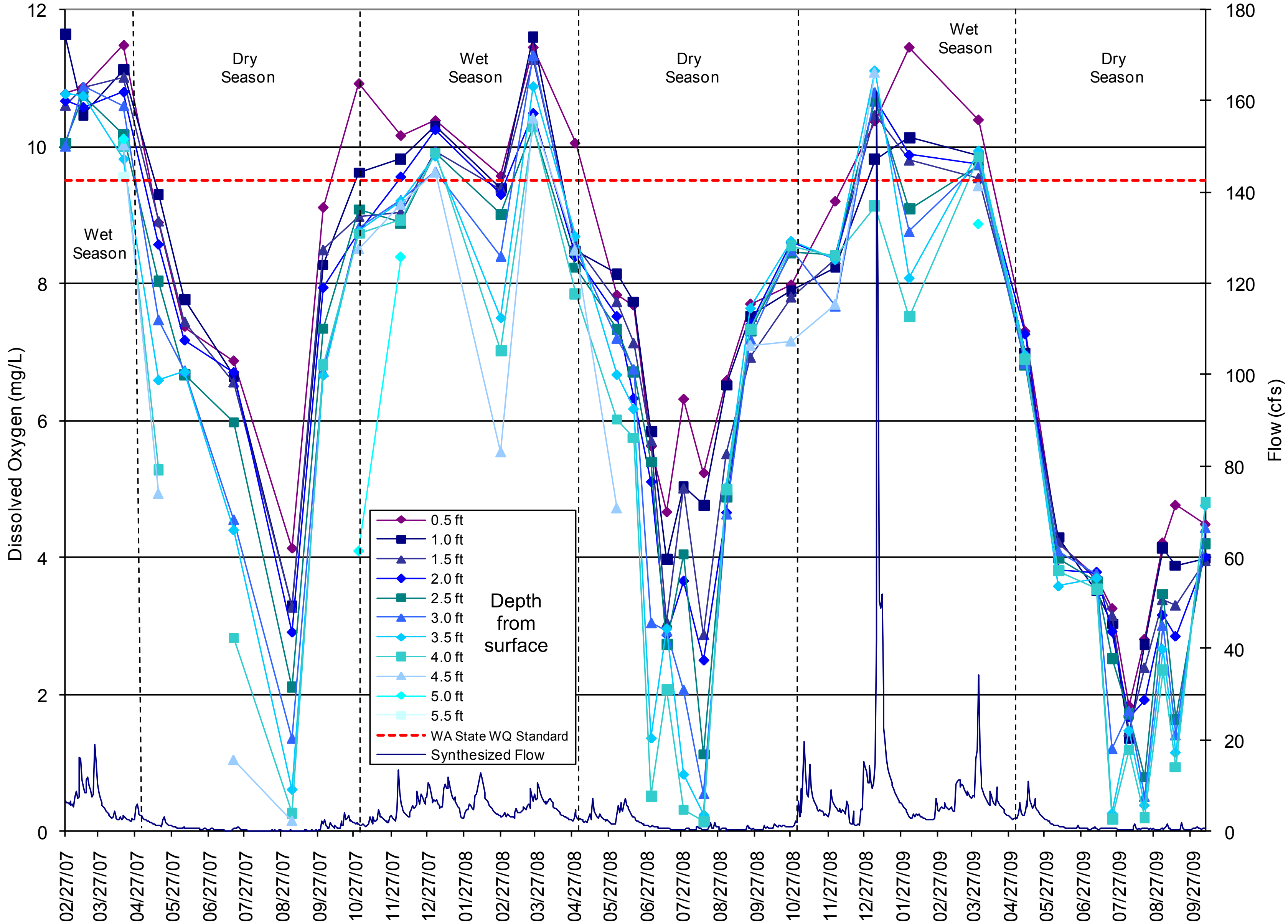
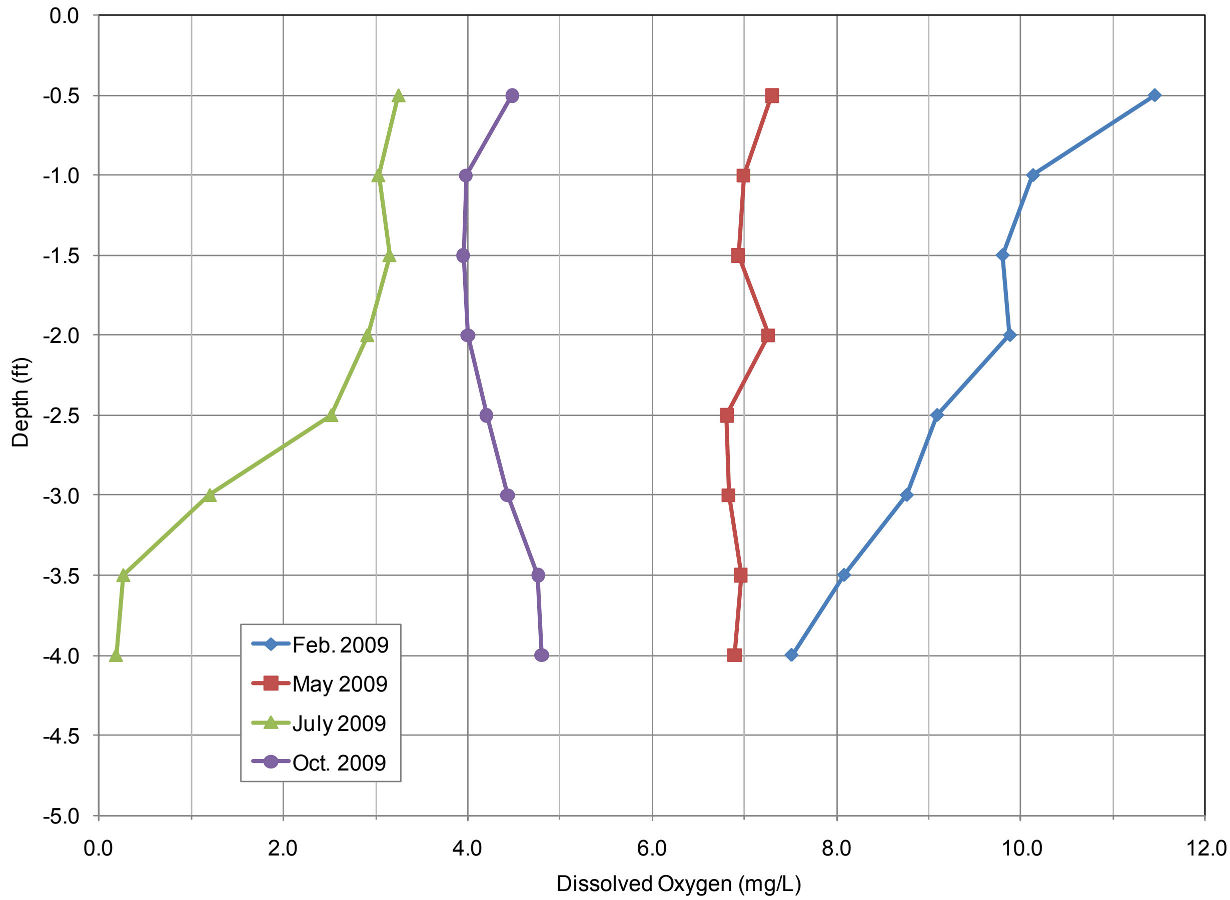


Figure 3-17. Dissolved oxygen depth profile for four 2009 sampling dates at PWQ8 in the South Pond.



3.2.3.3 Pond specific conductivity

Specific conductivity (SpC) levels in the ponds are generally at the low end of the range considered to support good mixed fisheries by the EPA (example plot presented in Figure 3-18). This range is between 0.150 and 0.500 mS/cm (U.S. EPA, 1997). Levels are consistent throughout the ponds, with some spread in the summer months. When spread, levels tend to be higher at the bottoms of the ponds, which is likely related to suspended materials in the water and the loose sediment present (Figure 3-19).

Figure 3-18. Specific conductivity (mS/cm) by date at 0.5 foot intervals in the South Pond at Station PWQ8.

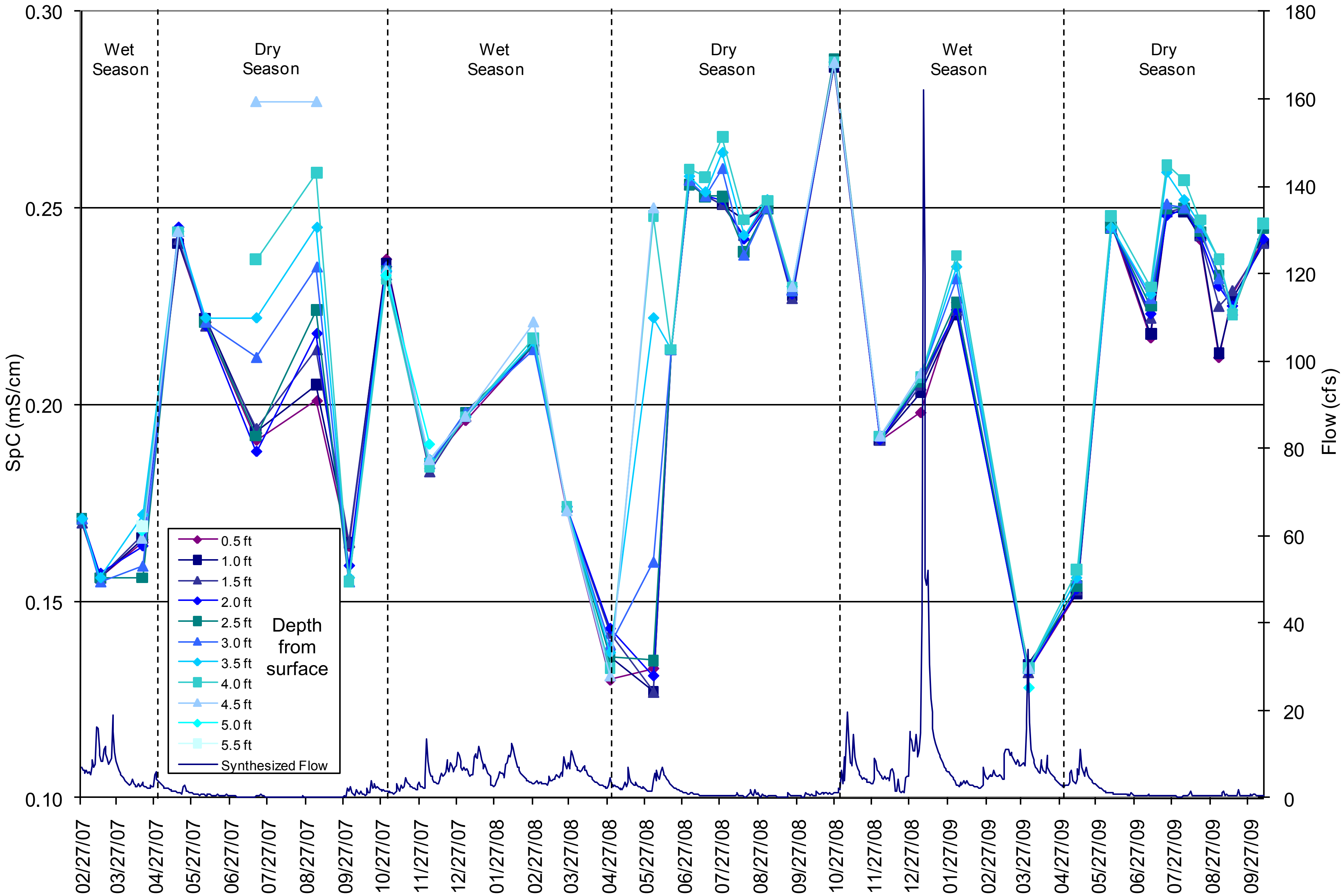
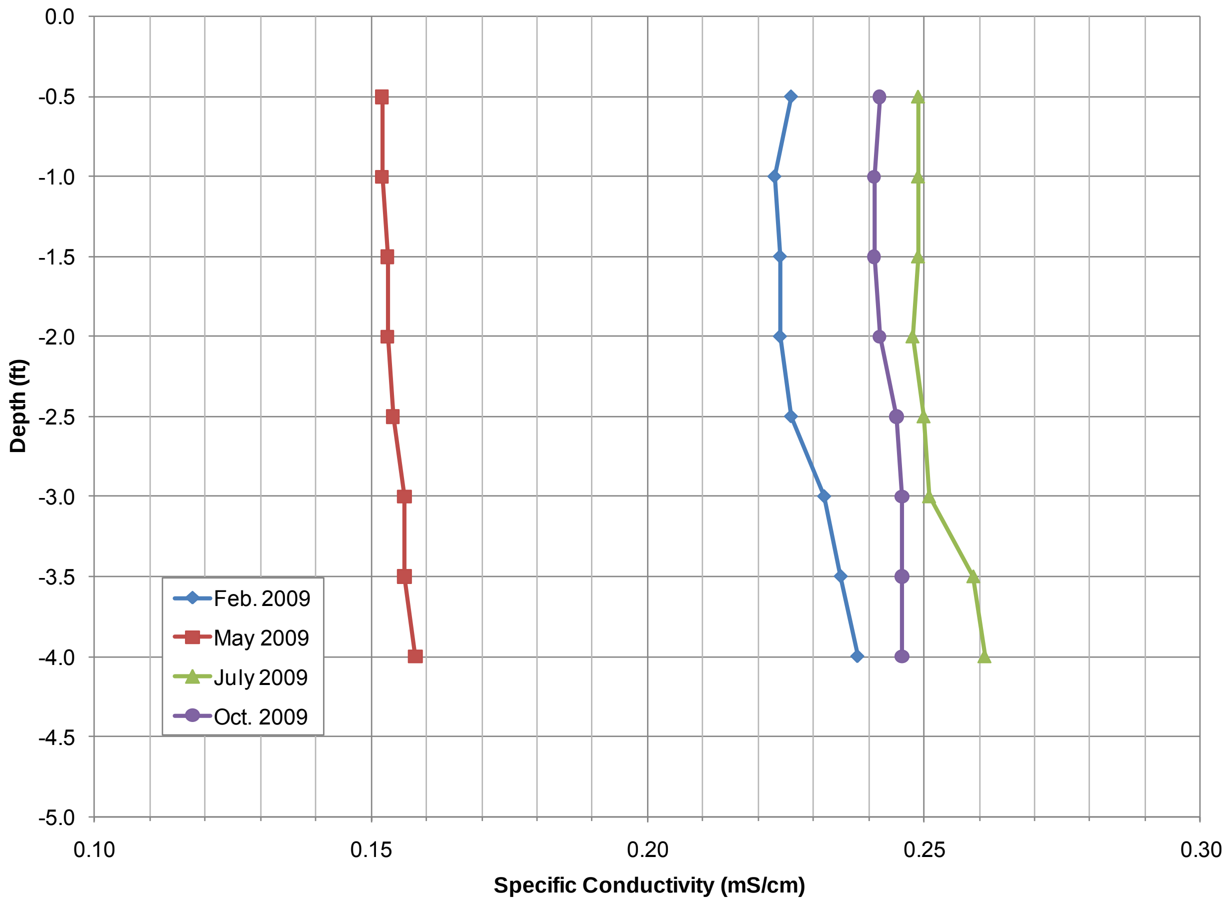


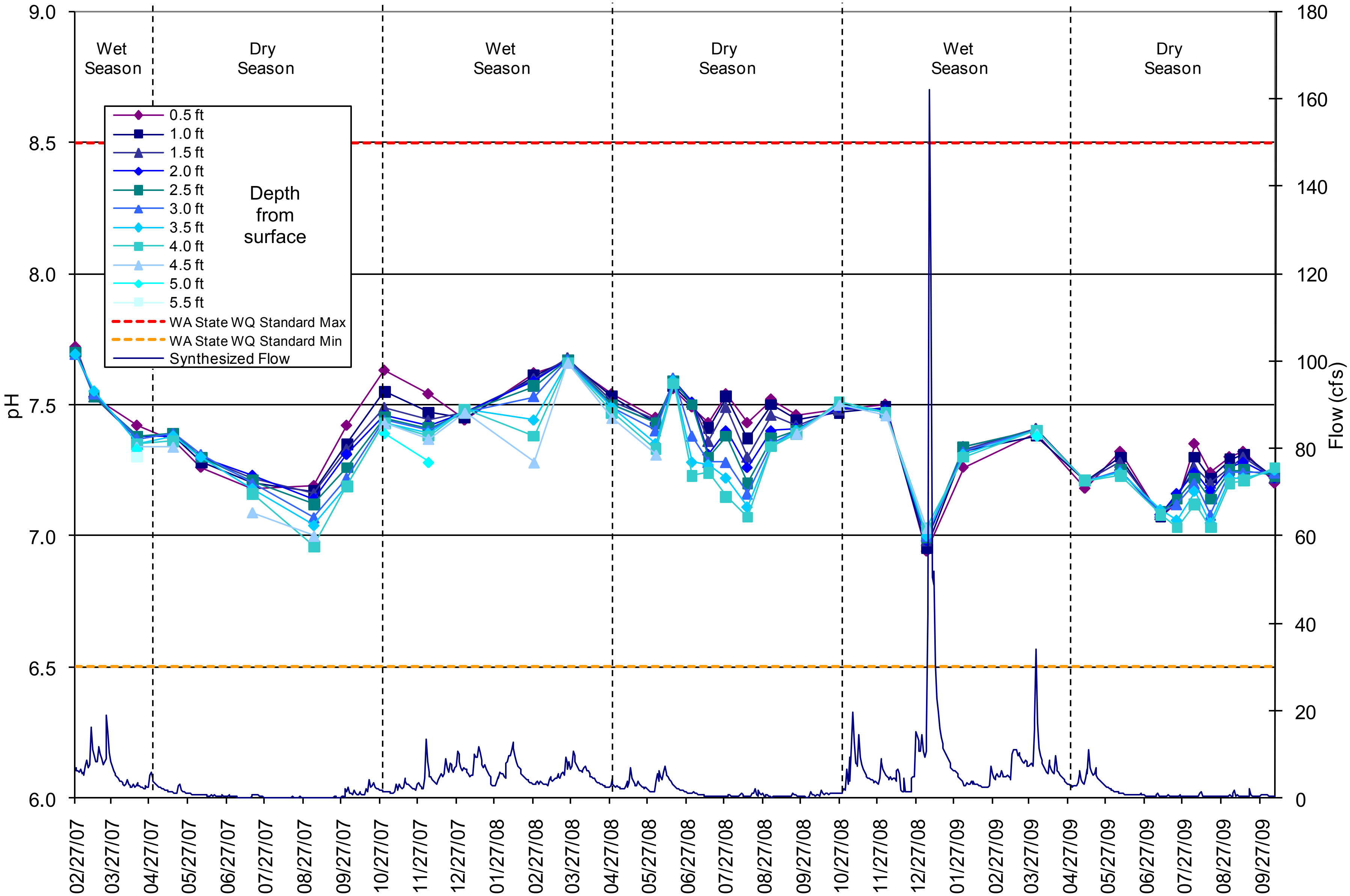
Figure 3-19. Specific conductivity depth profile for four 2009 sampling dates at PWQ8 in the South Pond.



3.2.3.1 Pond pH

All ponds met state standards for pH during the 2009 monitoring season. There continues to be some spread present in the values on some sampling dates (example plot presented in Figure 3-20). Spread of values by depth does not appear to be related to flow. At most pond sites, pH levels were very low during the January 2009 flood event. This may be due to the low pH of rainwater (usually between 5.5 and 6.0), as well as the probable introduction of large amounts of organic matter during the flood event, which can lower pH. Depth profiles for pH are available in Appendix F.

Figure 3-20. pH by date at 0.5 foot intervals in the South Pond at Station PWQ8.



3.2.4 Results and Discussion – Streams

The objective of monitoring Cemetery Creek stream water quality is to determine if the constructed ponds have an effect on water quality in the system. A map of stream water quality stations is presented in Figure 3-10.

In order to facilitate the examination of trends in the system, a single value for each parameter for each pond was calculated. This representative value is used to evaluate trends in water quality parameters throughout the system (i.e. changes in parameter value from inflow to outflow). Two types of graphs are presented in the following results: parameters over time (for example, Figure 3-21) and parameter schematics (for example, Figure 3-22). Different methods were used in the calculation of representative pond values for these two types of graphs.

Representative pond values for graphs of parameters over time: Parameter values from each sampling station were averaged at the 2.0-foot depth in each pond to create a representative pond value. The ponds vary in depth; 2.0 feet below the surface was chosen as it represents an approximate middle depth across all ponds. Also, according to depth profiles (presented in Appendix F), the 2.0 foot level has had no significant outlying measurements.

Representative pond values for graphs of parameter schematics: Parameter schematics are a map of measured parameters at a given date in the Cemetery Creek system. They are created for the warmest sampling day of each year. These days occur during the dry season, when flow levels are typically very low. Because of low water flow into and out of the ponds, mixing within the ponds is assumed to be low. Therefore, the most comparable pond depth to stream water conditions would be the surface depth (0.5 feet) in the ponds. Parameter values from each sampling station were averaged at the 0.5-foot depth in each pond to create a representative pond value. Parameter schematics are scaled based on distances between points.

3.2.4.1 Stream temperature

Water temperatures generally corresponded with seasonal air temperature variations: colder in the winter and warmer in the summer (Figure 3-21). During winter and spring months, stream water temperatures met the state standard (below 16ºC). During the summer months, stream water temperatures frequently exceeded the state standard.

In 2009, stream temperatures exceeded the standard on three consecutive testing dates (August 6 through September 3) at all stream sites except SWQ5. SWQ5 did not exceed the state standard during 2009 sampling. Instream water temperatures were as high as 18.57ºC in 2009 (at SWQ2 on July 23). In none of these cases would these temperatures have been lethal to salmonids.

Flow enters the project site from Cemetery Creek and West Cemetery Creek. In Cemetery Creek in 2009 temperatures increased by as much as 1.62ºC and decreased by as much as 1.72ºC as water flowed through the restoration site (from SWQ3 to SWQ4). Temperatures at the Cemetery Creek inflow (SWQ3) exceeded the water quality standard during the warmest periods of the dry season.

In contrast, inflow from West Cemetery Creek (SWQ5) was below the standard during all monitoring dates in 2009. This likely reflects higher ground water influence from the large forested wetland located upstream of the South Pond. SWQ5 exhibited the least amount of variability in temperature throughout the year, likely due to the mediating effects of ground water. Likewise, the South Pond is clearly influenced by the temperature regime of this inflow; this pond maintains the coolest temperatures of the three throughout the summer months.

A temperature schematic of the Cemetery Creek system is presented in Figure 3-22. . This schematic illustrates changes in temperature in the system on July 23, 2009, one of the warmest sampling dates of the year. Cemetery Creek inflow (SWQ3) was below the temperature standard but warmed by 1.62ºC as it flowed through the restoration site (SWQ4). West Cemetery Creek inflow was also below the state standard, with temperatures generally increasing as water flowed through the South and West Ponds toward SWQ2. Water generally cooled from SWQ2 through the North Pond to SWQ1. All pond inflows and outflows were cooler than the surface pond water, except the North Pond outflow. Overall there was a temperature increase of 2.54ºC from Cemetery Creek inflow to outflow and a temperature increase of 3.08ºC from West Cemetery Creek inflow to outflow.

Overall, no stream temperatures higher than 19°C have been recorded during monitoring at Cemetery Creek. While these temperatures alone would not be lethal to fish (Sullivan 2000), they likely contribute to depressed DO levels in the system. Pond effects on stream temperatures do not appear to be persistent. However, continued monitoring of pond temperatures, including inflows and outflows, is important to assess long-term trends.

Urban Stream Monitoring: Water quality near the mouth of Cemetery Creek has been monitored since 1990 as part of the City of Bellingham Urban Stream Monitoring (USM) program. The location of the USM station at Cemetery Creek is in the approximately location of SWQ2 (see Figure 3-10). Measurements are recorded using a Hydrolab Quanta. Only data in which sampling was conducted monthly for the calendar year is presented in this report. Data from 2006 was omitted since restoration site construction occurred mid-year. The temperature maximums from 2007-2009 are within the range measured prior to construction (Figure 3-23). The USM program is on-going and results will be updated in subsequent reports.

Figure 3-21. Temperature (ºC) by date at stream water quality stations and representative pond values (2.0 feet below the water surface).

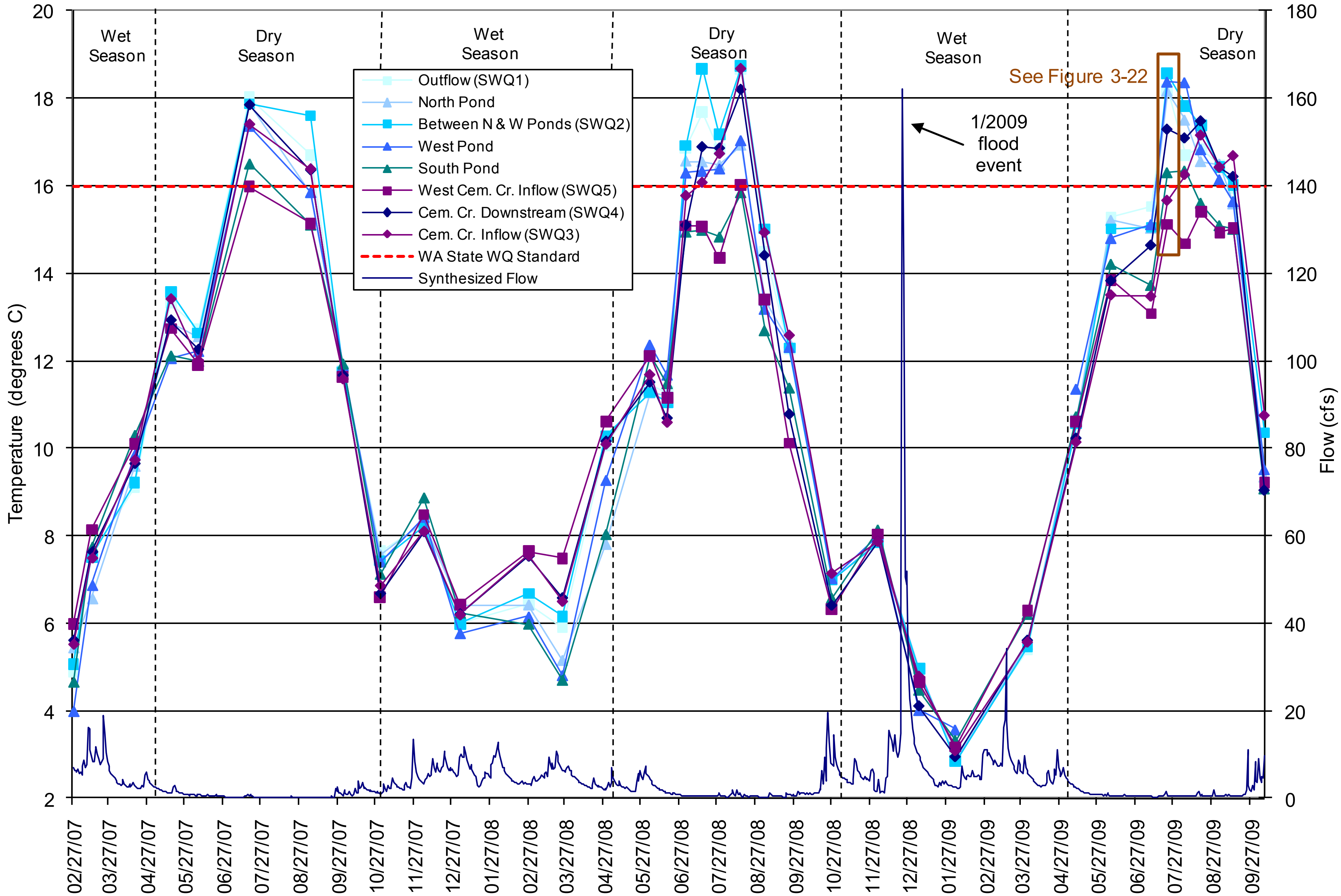


Figure 3-22. Temperature schematic of stream and representative pond values (0.5 feet below the water surface), July 23, 2009.

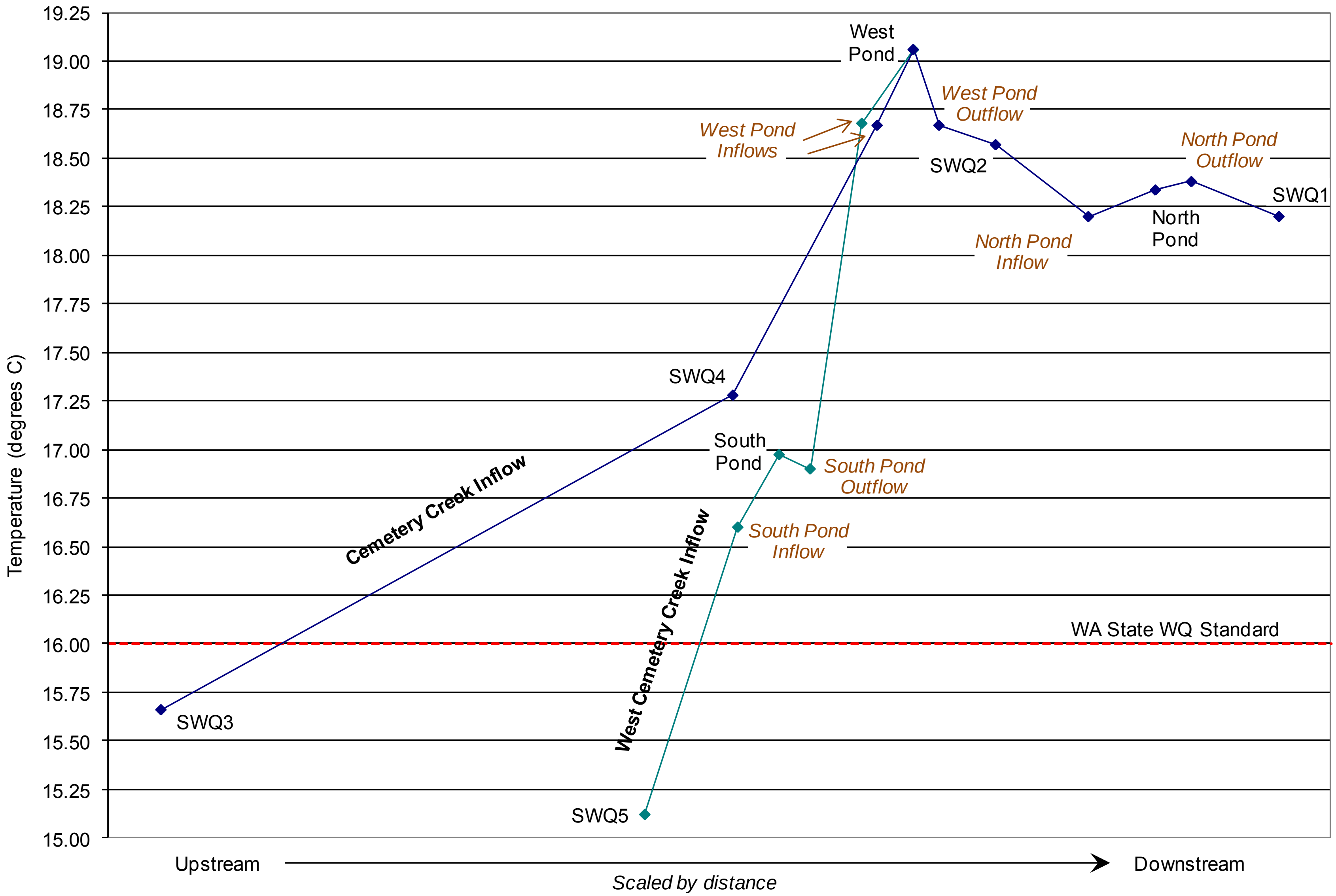
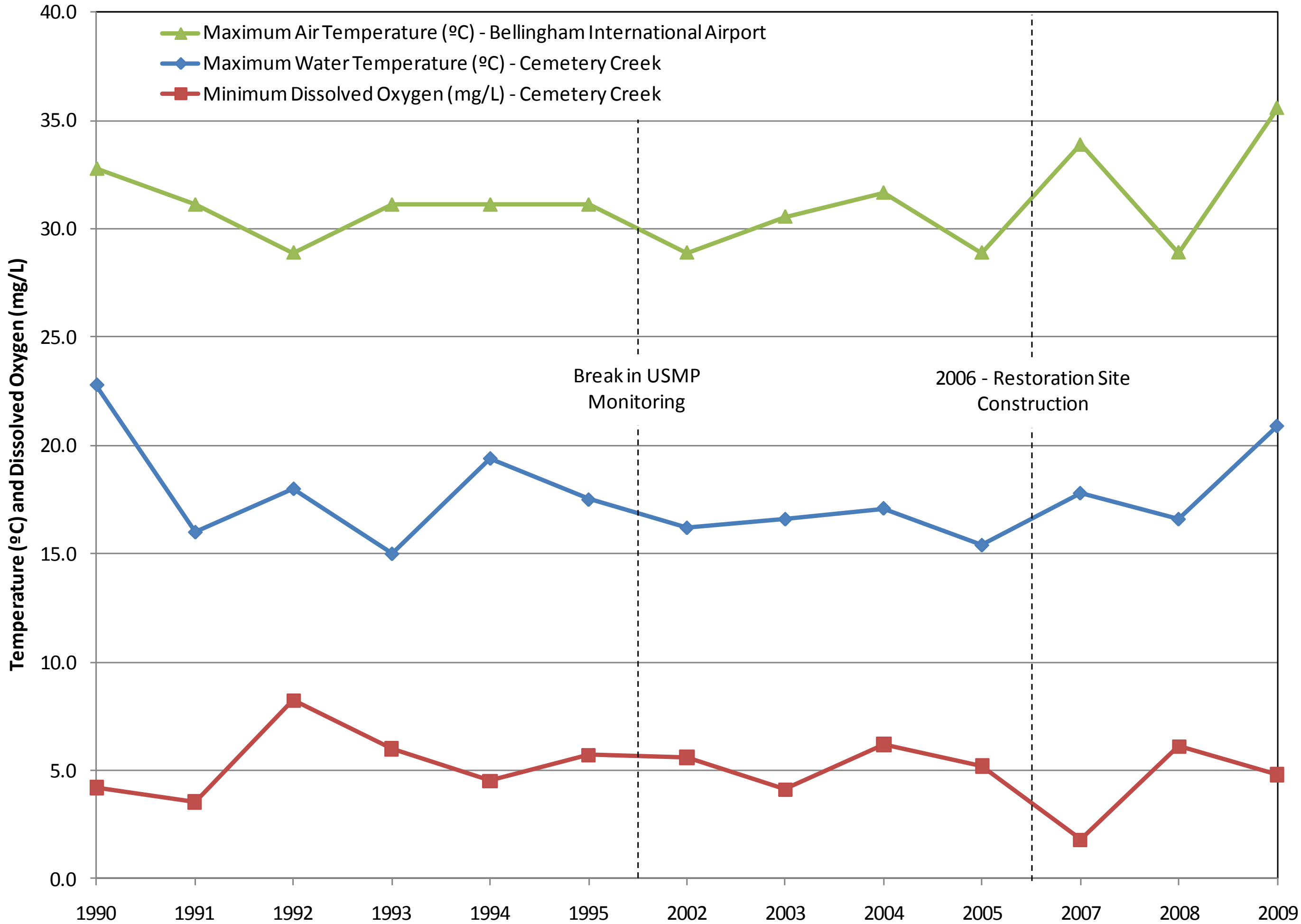


Figure 3-23. Maximum annual water temperature (ºC) and dissolved oxygen (mg/L) levels measured during Urban Stream Monitoring at the Cemetery Creek site. Maximum air temperatures are provided for reference.



3.2.4.2 Stream dissolved oxygen

Dissolved oxygen levels varied seasonally, being highest in the wet season, and lowest in the dry season (Figure 3-24). Dissolved oxygen levels met or were above the state standard (9.5 mg/L) at all stream sample sites during the wet seasons from 2007-2009. During the dry seasons, DO levels were frequently below the state standard.

In 2009, stream DO levels were below the standard on seven consecutive testing dates (June 8 through September 14) at all stream sites. Dissolved oxygen levels were as low as 1.47 mg/L in 2009. These DO levels, if widespread, are potentially lethal to fish (Spence et al. 1996). On that sampling date there were higher DO levels at other stations that could serve as DO refuge sites in the Cemetery Creek system.

Flow enters the project site from Cemetery Creek and West Cemetery Creek. During the dry season, the Cemetery Creek inflow is minimal compared to the West Cemetery Creek inflow. During the warmest periods of the dry season, Cemetery Creek inflow is inconsistent and sometimes subsurface. In Cemetery Creek in 2009, DO increased by as little as 1.88 mg/L and decreased by as much as 3.55 mg/L as water flowed through the restoration site (from SWQ3 to SWQ4). Dissolved oxygen at the Cemetery Creek inflow (SWQ3) did not meet the water quality standard during the warmest periods of the dry season.

In contrast, inflow from West Cemetery Creek (SWQ5) is much more consistent and has a higher volume during the dry season than that of Cemetery Creek. West Cemetery Creek inflow also has a much higher DO content relative to Cemetery Creek inflow. In 2009, the lowest DO value recorded at the West Cemetery Creek inflow (SWQ5) was 5.85 mg/L. This value is greater than the level (5.0 mg/L) recognize as reducing salmonid growth (Spence et al. 1996).

A dissolved oxygen schematic of the Cemetery Creek system is presented in Figure 3-25. This schematic illustrates changes in DO through the restoration site on August 19, 2009, one of the warmest sampling date of the year. Cemetery Creek (SWQ3) and West Cemetery Creek (SWQ5) inflows to the restoration site were below the state standard. DO levels increased slightly (by 0.49 mg/L) as water flowed through the reconfigured Cemetery Creek channel (SWQ3 to SWQ4). The West Cemetery Creek inflow maintained a higher DO value as it entered the South Pond (SP inflow) but dropped sharply in the South Pond. A similar pattern was observed in the West Pond; DO levels in the pond were low relative to inflows. Inflow and outflow points often provide areas of turbulence and mixing, increasing DO levels. Overall, for the August 19, 2009 sampling date there was a DO increase of 2.54 mg/L from Cemetery Creek inflow to outflow and a DO decrease of 3.08 mg/L from West Cemetery Creek inflow to outflow.

Overall, DO levels in the Cemetery Creek system continue to be adequate during the wet season and problematic during the dry season. The effect of the ponds on stream DO levels, while not significant in most cases, is still apparent. During both the wet and dry seasons, the ponds generally have the lowest DO content in the Cemetery Creek system. During the wet season, pond DO levels are generally (but not always) above the state standard (9.5 mg/L). During the dry season, the ponds have much lower DO levels, the majority of which are below the state standard. During these times, DO levels are frequently below the level that reduces salmonid growth (5.0 mg/L) and are sometimes below the lethal level (3.3 mg/L) (Spence et al. 1996). Despite this, at every sampling date, there have been sampling stations with DO levels above 5.0 mg/L (Figure 3-24). Furthermore, point samples at pond inflows and some outflows show DO refuges in the ponds, even during warm periods (Figure 3-25). These refugia are important. During low summer flows in Cemetery Creek, juvenile salmonids may not be able to escape pond environments by moving up or downstream; inflows and outflows may provide refuge from lower DO levels in the ponds.

Urban Stream Monitoring: Water quality near the mouth of Cemetery Creek has been monitored since 1990 as part of the City of Bellingham Urban Stream Monitoring (USM) program. Measurements are recorded using a Hydrolab Quanta. Only data in which sampling was conducted monthly for the calendar year is presented in this report. Data from 2006 was omitted since restoration site construction occurred mid-year. In 2007, the first season following construction of the restoration project, the minimum annual DO level at the mouth of Cemetery Creek was substantially lower than any that had been measured previously (Figure 3-23). However, the 2008 and 2009 values have been within the range of pre-project DO levels (Figure 3-23). The USM program is on-going and results will be updated in subsequent reports.

Figure 3-24. Dissolved oxygen (mg/L) by date at stream water quality stations and representative pond values (2.0 feet below the water surface).

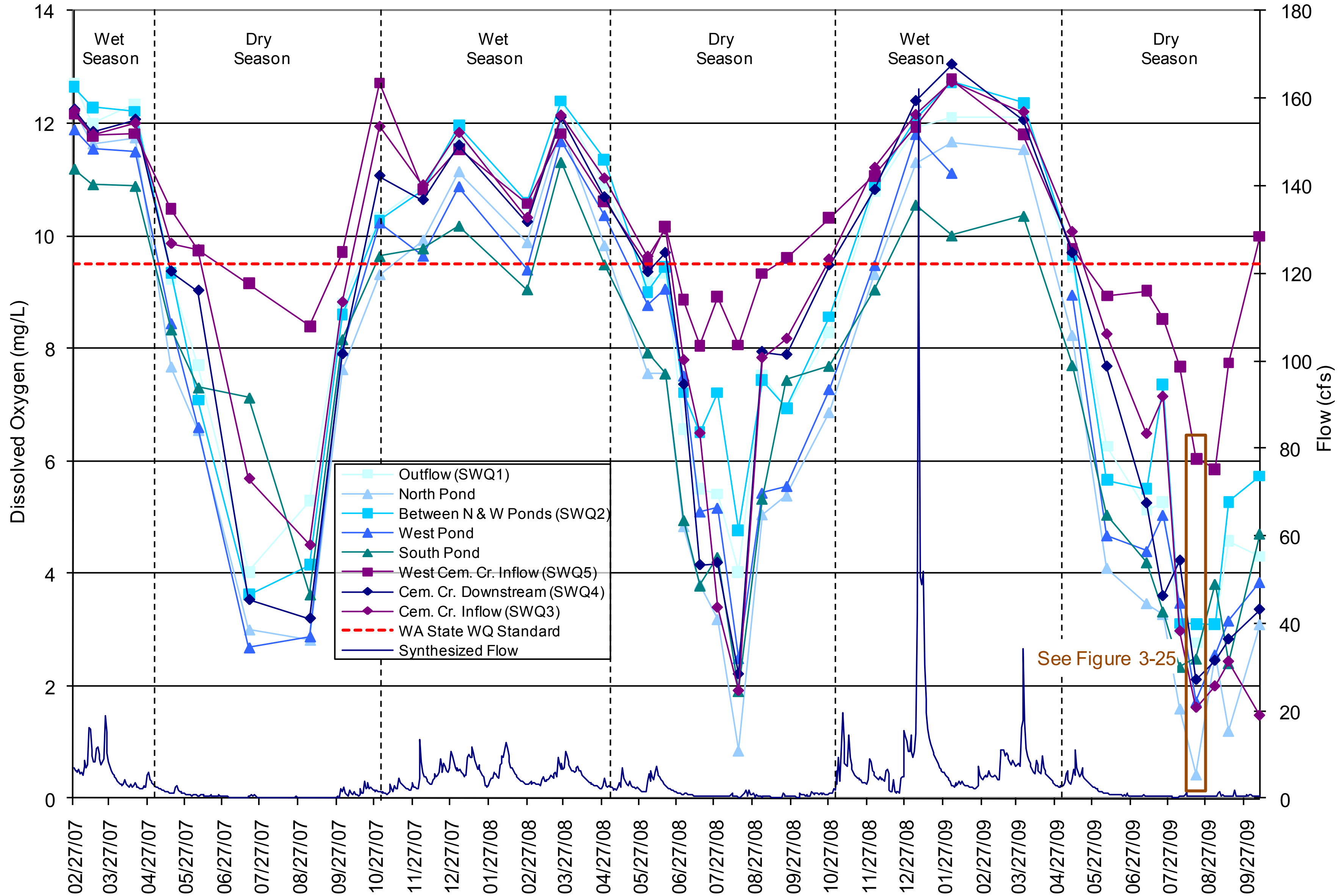
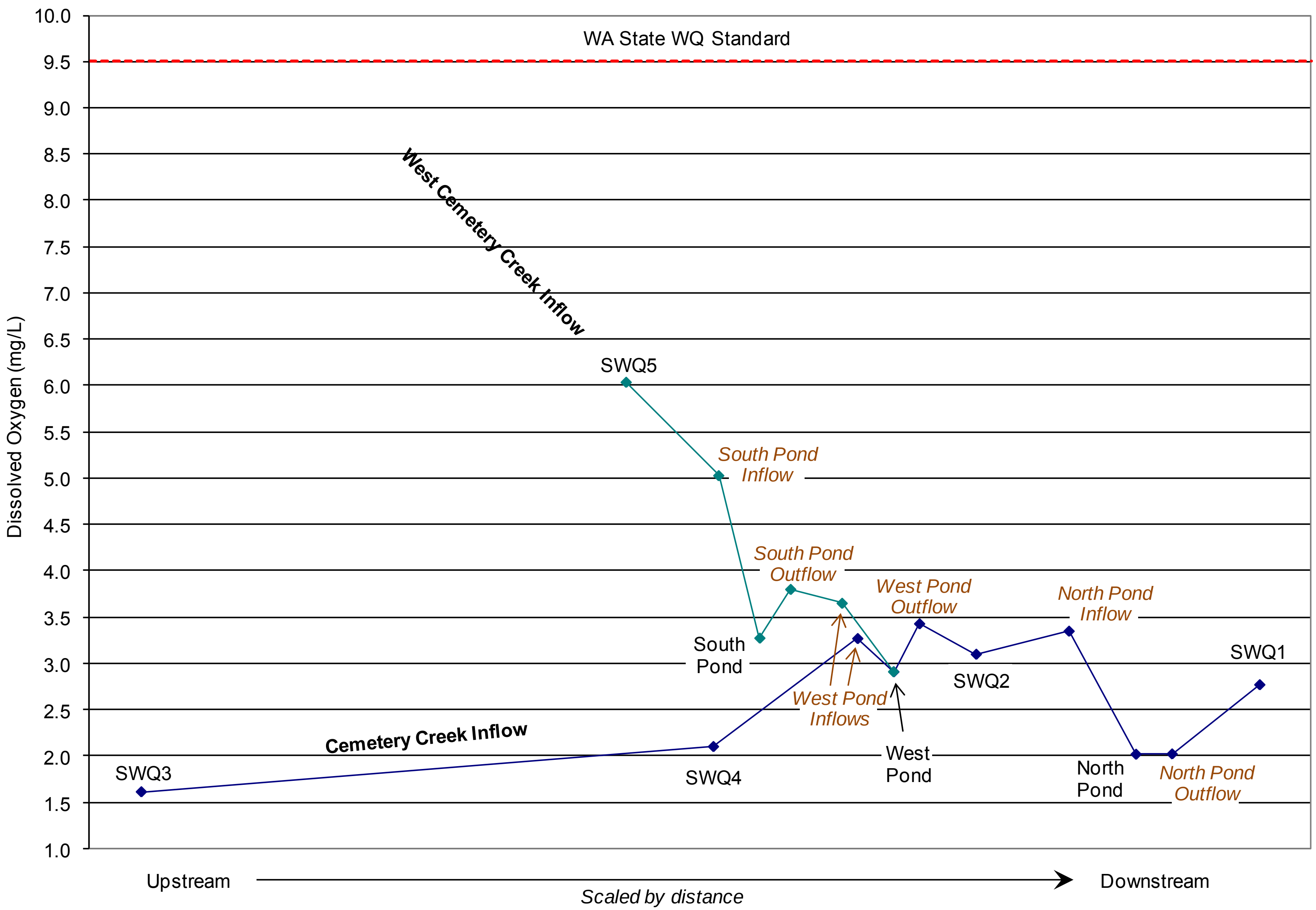


Figure 3-25. Dissolved oxygen schematic of stream and representative pond values (0.5 feet below the water surface), August 19, 2009.



3.2.4.3 Stream specific conductivity

Specific conductivity levels at the stream sites are generally at the low end of the range considered to support good mixed fisheries by the EPA (Figure 3-26). This range is between 0.150 and 0.500 mS/cm (U.S. EPA 1997). The general trend of lower SpC during wet months and higher SpC during dry months correlates with an increased dependence on ground water inputs during dry months. Evaporation can also concentrate ions in water during dry months.

High dry season values at the Cemetery Creek inflow site (SWQ3) in 2008 and 2009 are likely due to the low volume of inflow into Cemetery Creek during that time. During the warmest summer months, Cemetery Creek inflow is inconsistent and sometimes subsurface. These relatively high values are still within the range considered to support good mixed fisheries.

Another interesting trend is inflow bracketing of outflows during the wet season. Higher SpC in the West Cemetery Creek inflow (SWQ5) and South Pond and lower SpC in the Cemetery Creek inflow and outflow (SWQ3 and 4) bracket the downstream SpC values. The relatively higher SpC at the West Cemetery Creek inflow site and the South Pond are likely a result of the groundwater influence of the large wetland upstream.

3.2.4.4 Stream pH

Most 2009 pH levels at stream sites meet Ecology standards, with the exception of two sampling dates at SWQ1 (Figure 3-27). These samples were 0.10 and 0.17 below the Ecology minimum of 6.50. There appears to be an overall decreasing trend in stream site pH values over the monitoring period; continued monitoring will allow for further assessment of this trend. There is no distinguishable pattern between pH levels at inflow and outflow, although inflows (SWQ3 and SWQ5) sometimes bracket pH values at the site during the dry season (Figure 3-27).

3.2.4.5 Fecal coliform

Fecal coliform (FC) samples were collected from eight sites in the restoration area (Figure 3-28). Fecal coliform concentrations were lowest during the wet season. Fecal coliform was higher during the dry season, most likely due to concentration resulting from reduced flows. Sampling indicates that during periods of high FC concentrations, FC generally decreases from inflow points (SWQ3 and SWQ5) to the outflow point (SWQ1) within the restoration site, with some exceptions. There is a general trend of decreasing dry season FC concentrations from 2007-2009; future sampling will determine if this is a short- or long-term trend at the restoration site. For more information on fecal coliform levels in the Whatcom Creek watershed, please refer to the *Whatcom Creek Fecal Coliform Total Maximum Daily Load Study* (Shannahan et al. 2004).

3.2.5 Recommendations

- ✓ Install continuous temperature loggers in the Cemetery Creek ponds by early May to ensure sampling of the entire summer season.

Figure 3-26. Specific conductivity (mS/cm) by date at stream water quality stations and representative pond values (at 2.0 feet below the water surface).

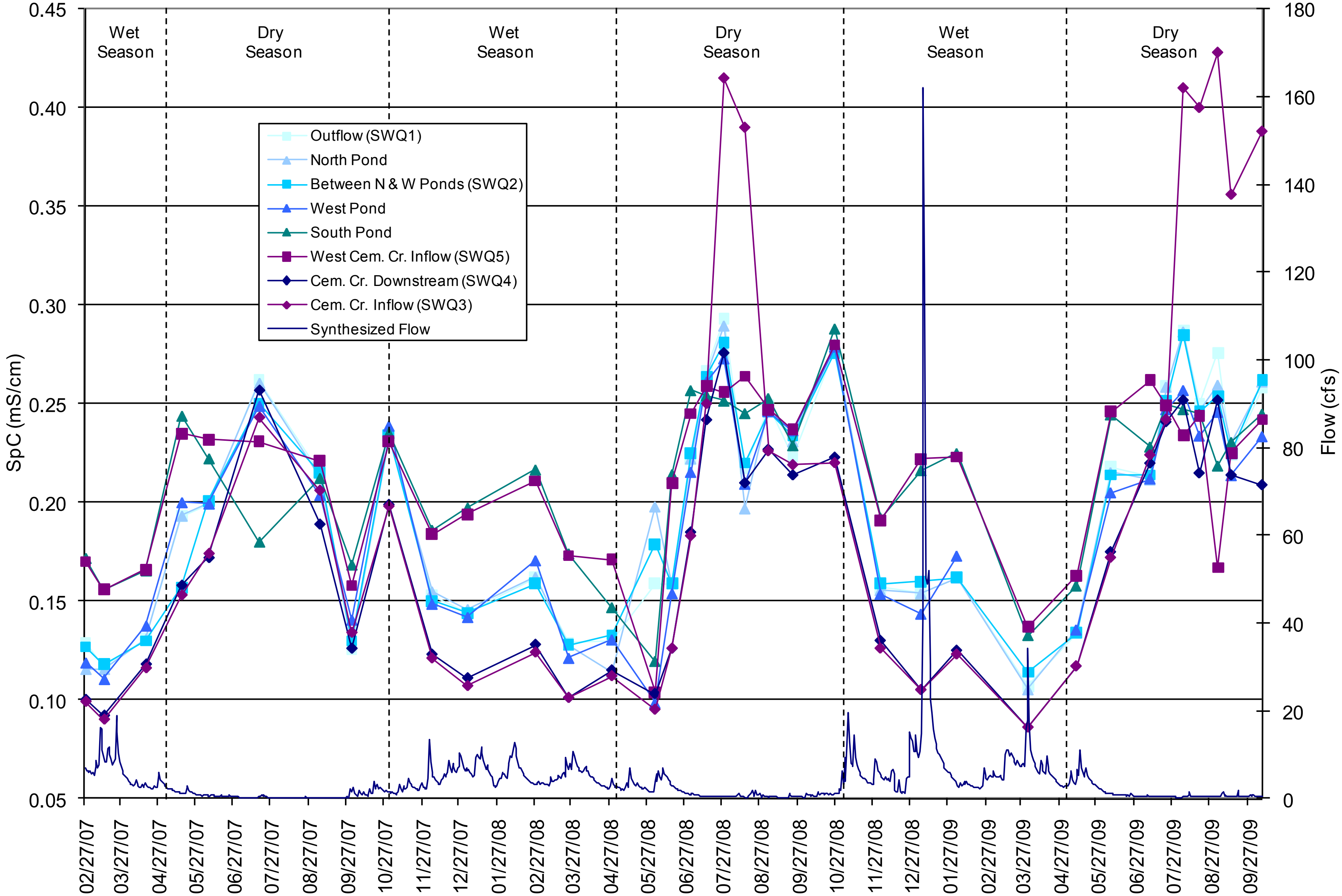


Figure 3-27. pH by date at stream water quality stations and representative pond values (at 2.0 feet below the water surface).

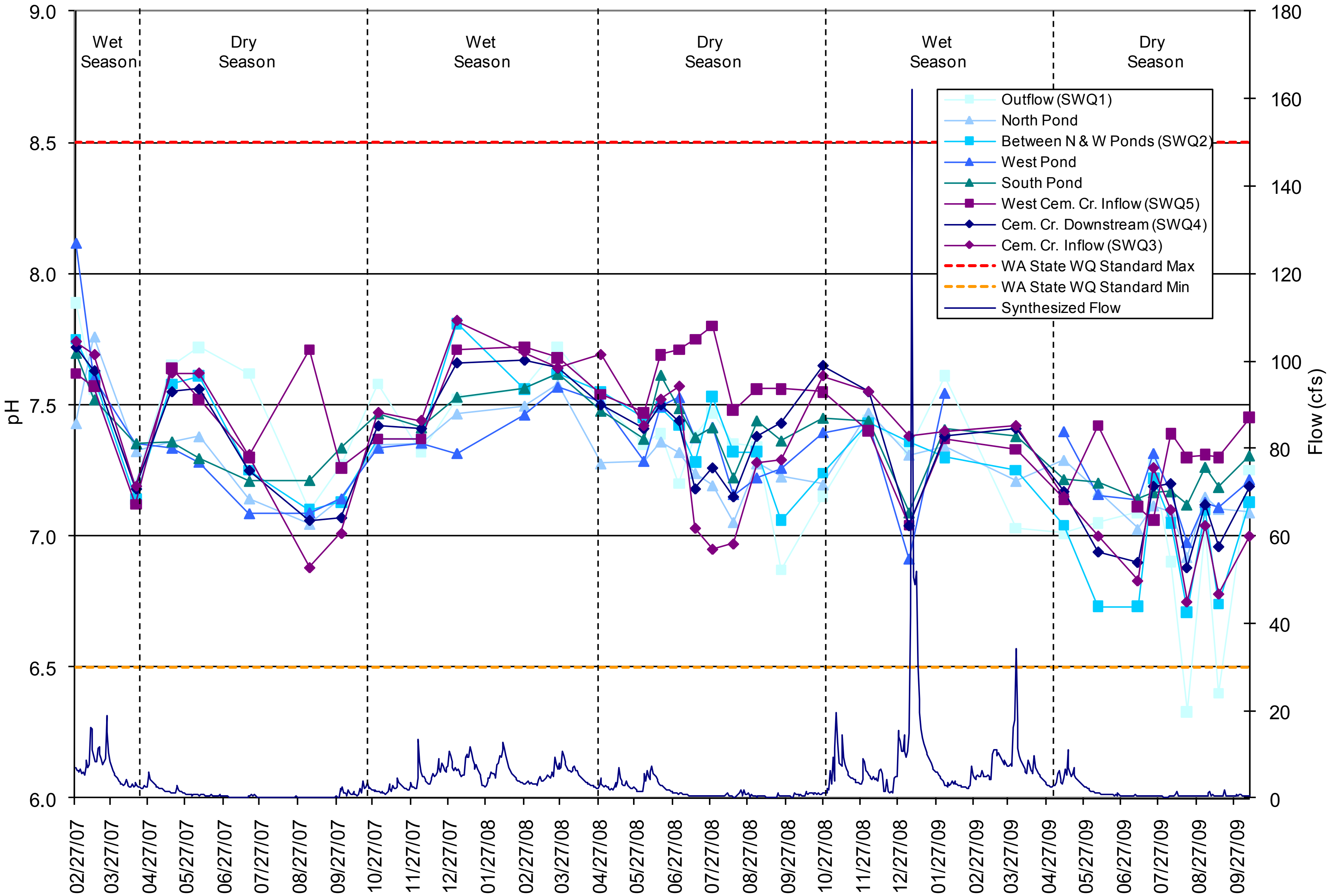
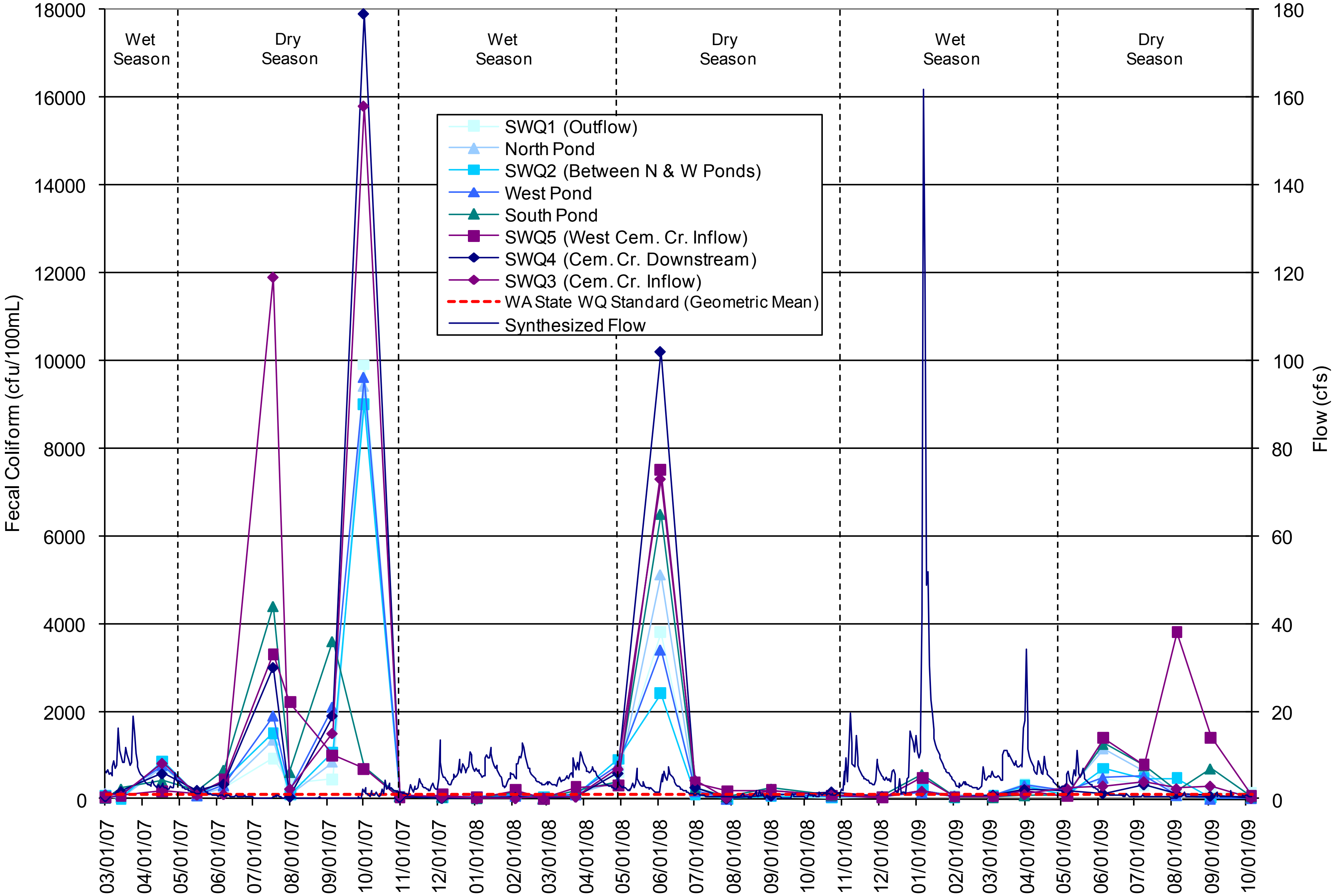


Figure 3-28. Fecal coliform concentrations (cfu/100ml) by date at stream and pond water quality stations.



4 PHOTODOCUMENTATION

4.1 INTRODUCTION

The objective of photodocumentation is to provide a visual record of habitat recovery within the restoration sites.

4.2 METHODS

Permanent photo points have been established at 16 locations throughout the restoration project area (Figure 4-1). Photopoint locations are selected to represent the range of habitat features within the project area. Each photopoint contains an easily recognizable feature that could reasonably be expected to remain in place throughout the 10-year monitoring period. Most photopoints have multiple angles, identified with letters (a, b, and c). Photopoint locations have been documented using metal tags on wooden stakes, trees or large woody debris. GPS coordinates have also been collected at each site to facilitate future relocation. Photopoints16a and 16b were added in February 2007 to track bank erosion mitigation efforts.

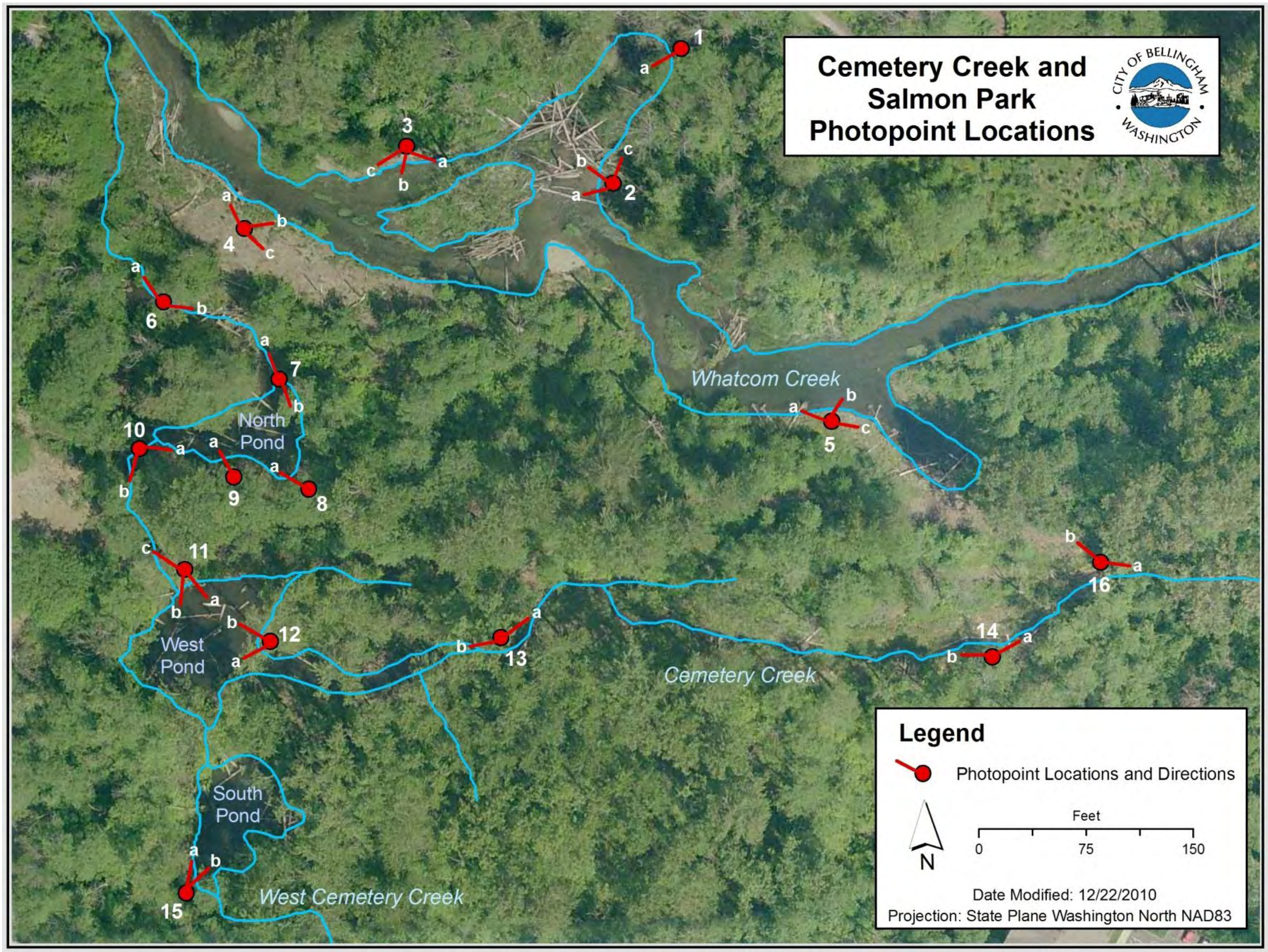
Photos are taken at each designated point using a digital camera. Photos are taken during July-September ("summer" or full canopy) and December-January ("winter" or after leaf fall).

4.3 RESULTS

Five photodocumentation periods have occurred during the report period. Find selected results below comparing winter photopoints from December 15, 2006 and December 26, 2009.

Following winter comparisons, find selected results of summer photopoints taken August 13, 2007 and July 31, 2009. All photopoints from the survey period can be viewed in Appendix G.

Figure 4-1. Map of photopoint locations. Red lines indicate direction of photographs from photopoint location.



M:\Data\E R\Restoration\Assessments\Monitoring\OP Monitoring&Maintenance\Restoration\Cemetery Creek Maps\Maps\Cemetery Creek Photopoints

Photopoints December 2006 and December 2009: 2a - Salmon Park log jam

5c - Whatcom Creek swale

8a - North Pond

10b - Between N. and W. Ponds

12b - West Pond

14b - Cemetery Creek Channel

15b - South Pond

Photopoints August 2007 and July 2009: 2a - Salmon Park log jam

5c - Whatcom Creek swale

8a - North Pond

10b - Between N. and W. Ponds

12b - West Pond

14b – Cemetery Creek Channel

15b - South Pond

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