WHATCOM CREEK RESTORATION PROJECT REPORT: 2007-2008

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

March 2009

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Acknowledgements:

This report would not have been possible without the initial monitoring set-up, data collection, and analysis by former City of Bellingham Americorps intern Kaci Radcliffe. City-sponsored Washington Conservation Corps (WCC) crew members have assisted with data collection for this report since 2006. The WCC crews are also responsible for planting, weeding and maintenance of the restoration sites. Many thanks to WCC members Emily Smith and Annie Honrath for assistance with data collection. Crew lead Andy Wargo and Corps member Melissa Thompson provided assistance with maps.

Special thanks to Renee LaCroix and Clare Fogelsong for input on drafts. And most of all, thanks to Susan Madsen, who is a patient teacher and indispensible in her assistance with field work, data analysis and draft review.

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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 (Figure 1-1). 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 mitigating damages by creating and improving salmonid habitat associated with Whatcom Creek.

The Long-term Restoration Plan includes three primary components: 1) monitoring to track recovery of injured resources within the burn zone; 2) restoration actions, including the purchase, replanting and instream habitat enhancement of several properties within the burn zone; and 3) monitoring and maintenance of sites where specific restoration actions were implemented (COB 2006a). Reports on monitoring and restoration in the burn zone (components 1 and 2) in the ten years since the incident are now available (Madsen 2009 and Madsen and Nightengale 2009).

Component 3 focuses on monitoring and maintenance of the Cemetery Creek and Salmon Park habitat restoration projects. These restoration sites are located near the confluence of Cemetery Creek and Whatcom Creek. The Salmon Park project covers over 300 feet of the Whatcom Creek stream bank to the north, while Cemetery Creek encompasses approximately 250 feet along the south bank of Whatcom Creek and over 1300 feet along Cemetery Creek and West Cemetery Creek.

Specific habitat objectives implemented in these projects include: increasing salmonid rearing habitat by creating off-channel pools in Cemetery Creek; increasing salmonid winter rearing habitat by creating backwater habitats along Whatcom Creek that fill during floods; improving habitat complexity for all life stages of salmonids in the lower portion of Cemetery Creek; reducing erosion in the lower portion of Cemetery Creek; removing human-placed gravel berms, where appropriate, to restore geomorphic function of stream processes within the confines of Salmon Park and the Whatcom Creek floodplain; and providing enhanced habitat conditions, while minimizing impacts to surrounding vegetation and ground surfaces.

Figure 1-1. Map of Whatcom and Hannah Creek Burn Zone and associated restoration sites. Monitoring presented in this report is conducted at the Salmon Park and Cemetery Creek Restoration Sites.

M:\Data\E R\Restoration\Monitoring\OP Monitoring&Maintenance\Restoration\Cemetery Creek Data and Maps\Maps\Cemetery Creek Vicinity

Aerial photos of the restoration site vicinity pre- and post-fire are presented in Figure 1-2 and Figure 1-3. Aerial photos of the vicinity pre- and post- restoration are presented in Figure 1-4 and Figure 1-5. The three pre-restoration aerials (Figure 1-2, Figure 1-3 and Figure 1-4) illustrate the channelized nature of Whatcom, Cemetery and West Cemetery Creeks as well as an overall lack of large woody debris and habitat complexity. The post-restoration aerial (Figure 1-5) illustrates some of the implemented habitat objectives including: removal of gravel berms and creation of backwater habitats in Salmon Park; creation of an additional backwater swale habitat upstream and opposite of Salmon Park; and creation of ponds and backwater habitats along Cemetery and West Cemetery Creeks. The Salmon Park "island", which divides the flow of Whatcom Creek, is also evident in the post-restoration aerial.

This report includes data collected as part of the monitoring and maintenance of the Cemetery Creek and Salmon Park restoration sites. Monitoring for these projects 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 2006a) specifies that monitoring of the restoration sites 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 analyzes the results of monitoring surveys conducted during post-construction years 1 and 2 (2007 and 2008)[2].

[1] Monitoring of juvenile salmonids using a smolt trap is the only monitoring component which 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.

[2] The monitoring of adult salmonids with spawner surveys begins in the fall and ends in the spring, spanning two calendar years. Therefore "2007" spawner survey data actually includes data collected during the fall of 2006; "2008" data includes data collected during the spring of 2009.

Figure 1-2. Aerial photo (1998) of Whatcom and Cemetery Creeks prior to the June 10, 1999 fire.

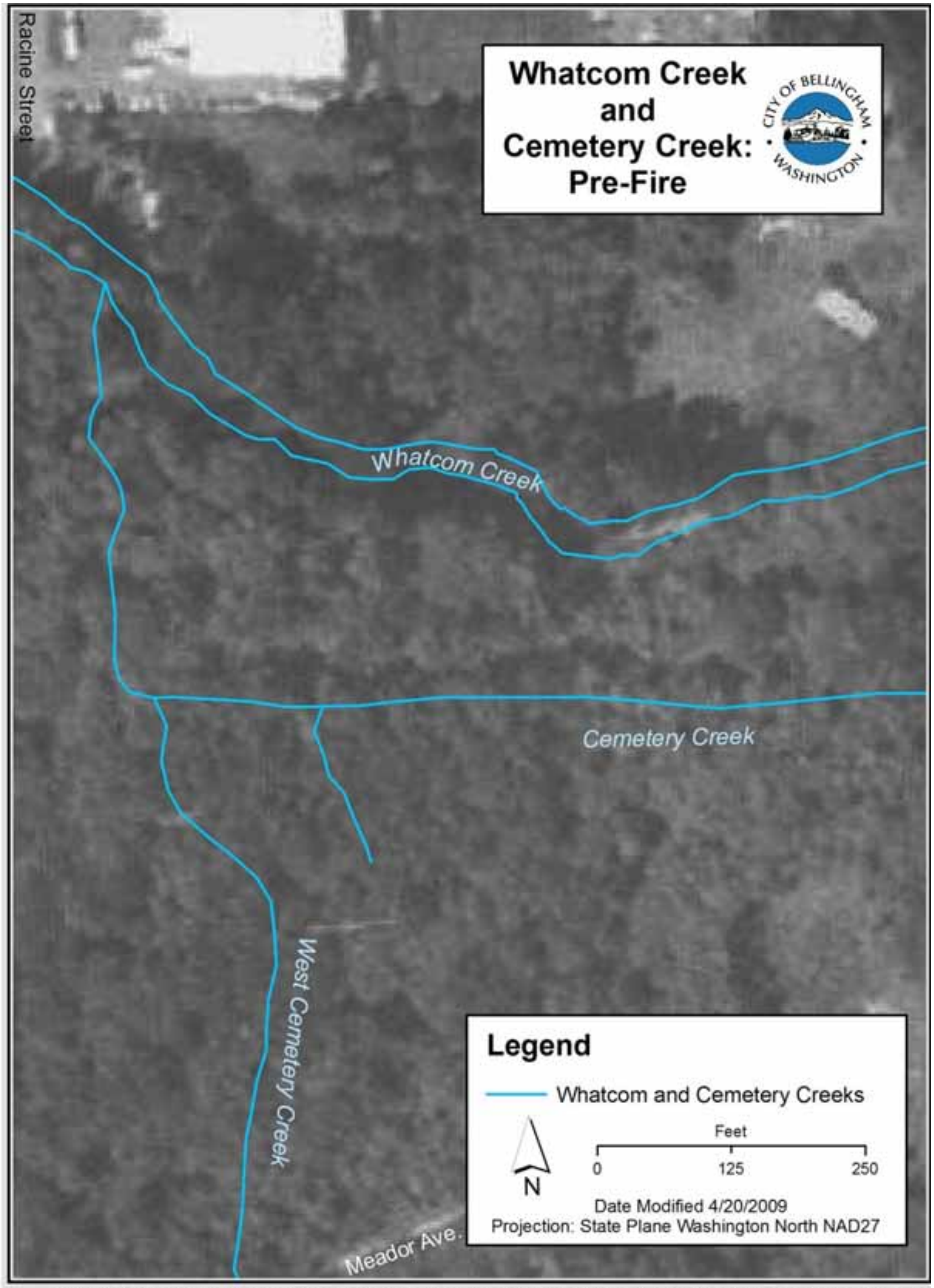

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Figure 1-3. Aerial photo (June 16, 1999) of Whatcom and Cemetery Creeks six days after the fire.

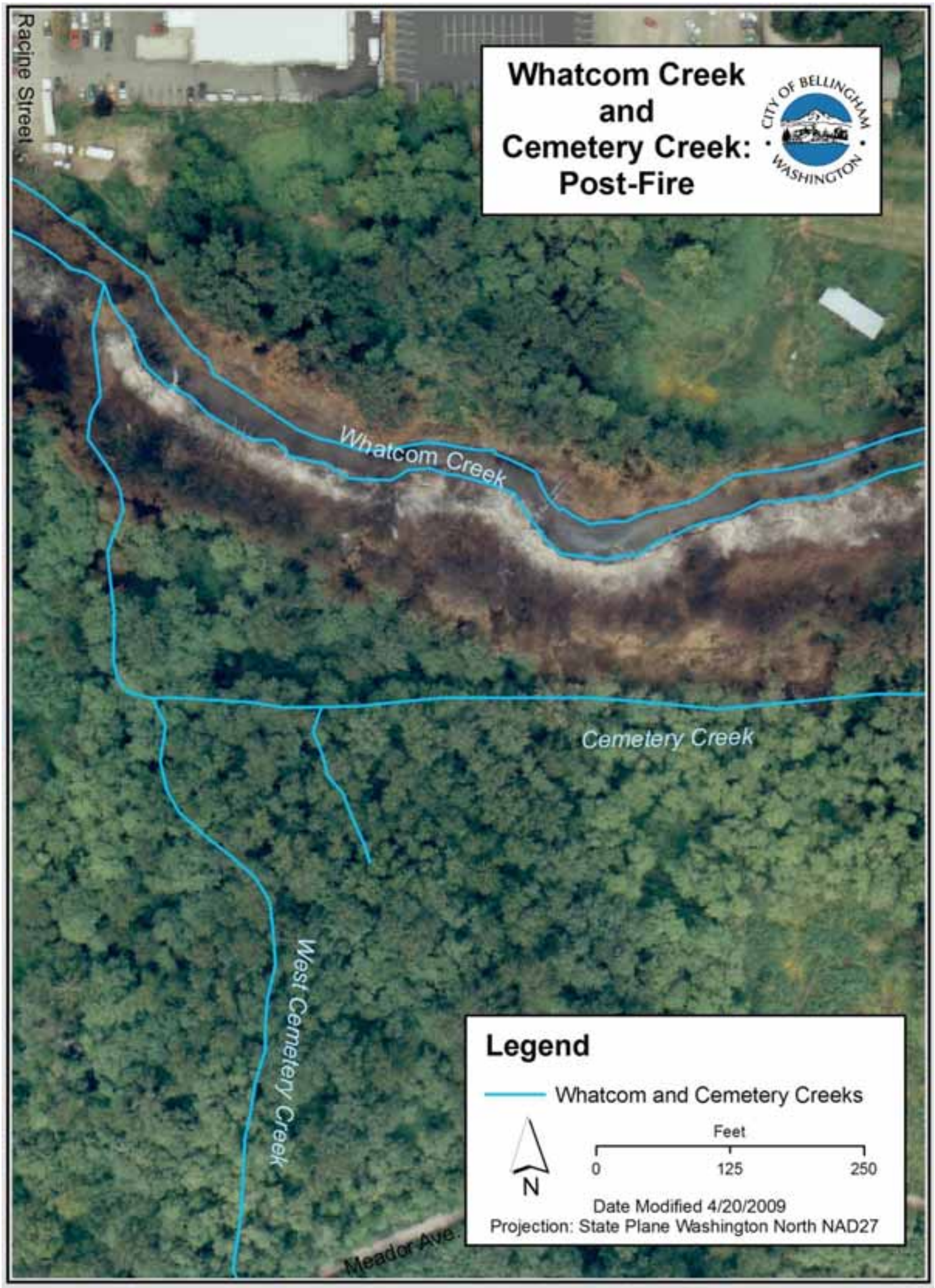

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Figure 1-4. Aerial photo (2006) of Cemetery Creek and Salmon Park restoration sites prior to restoration.

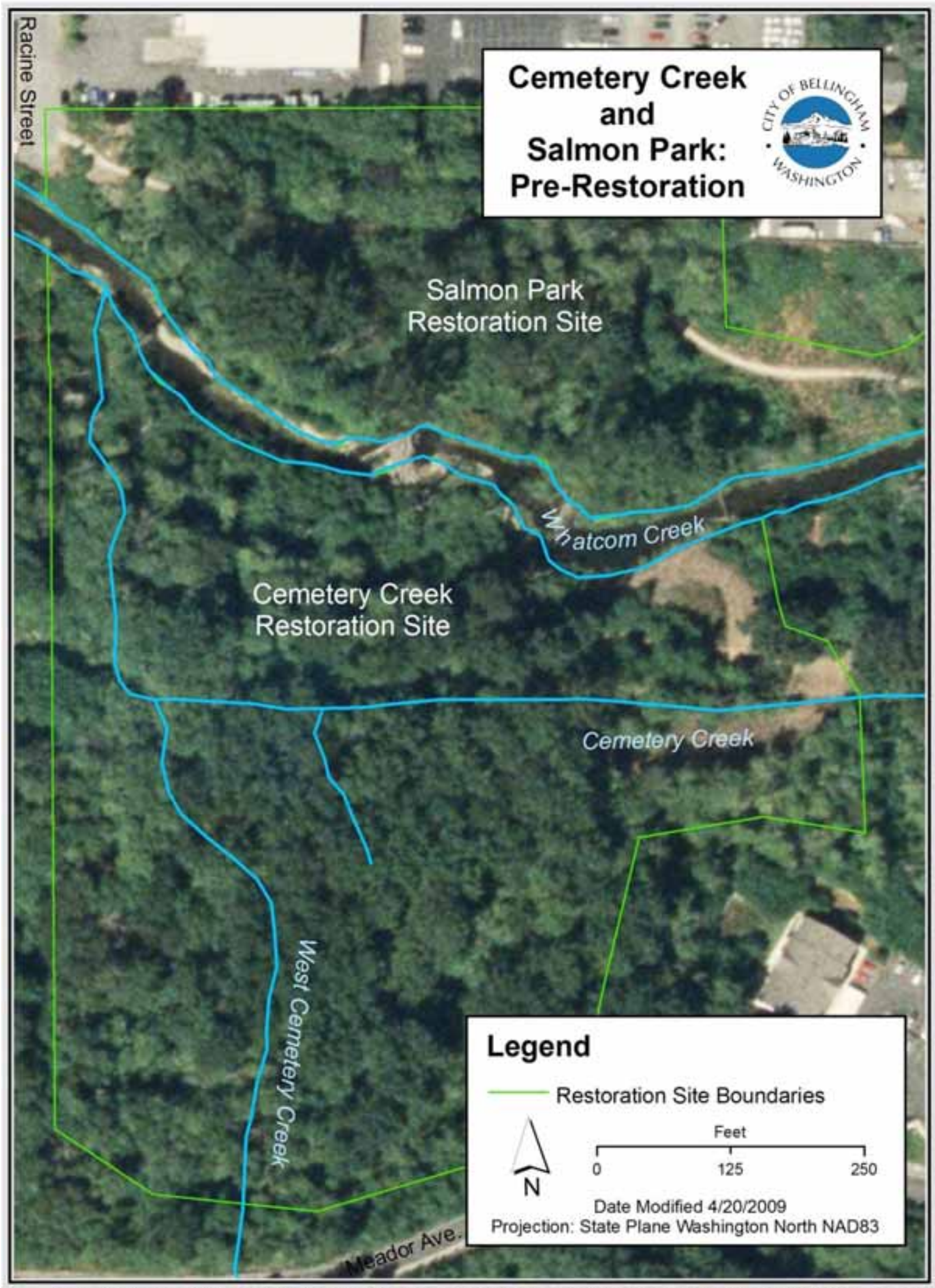

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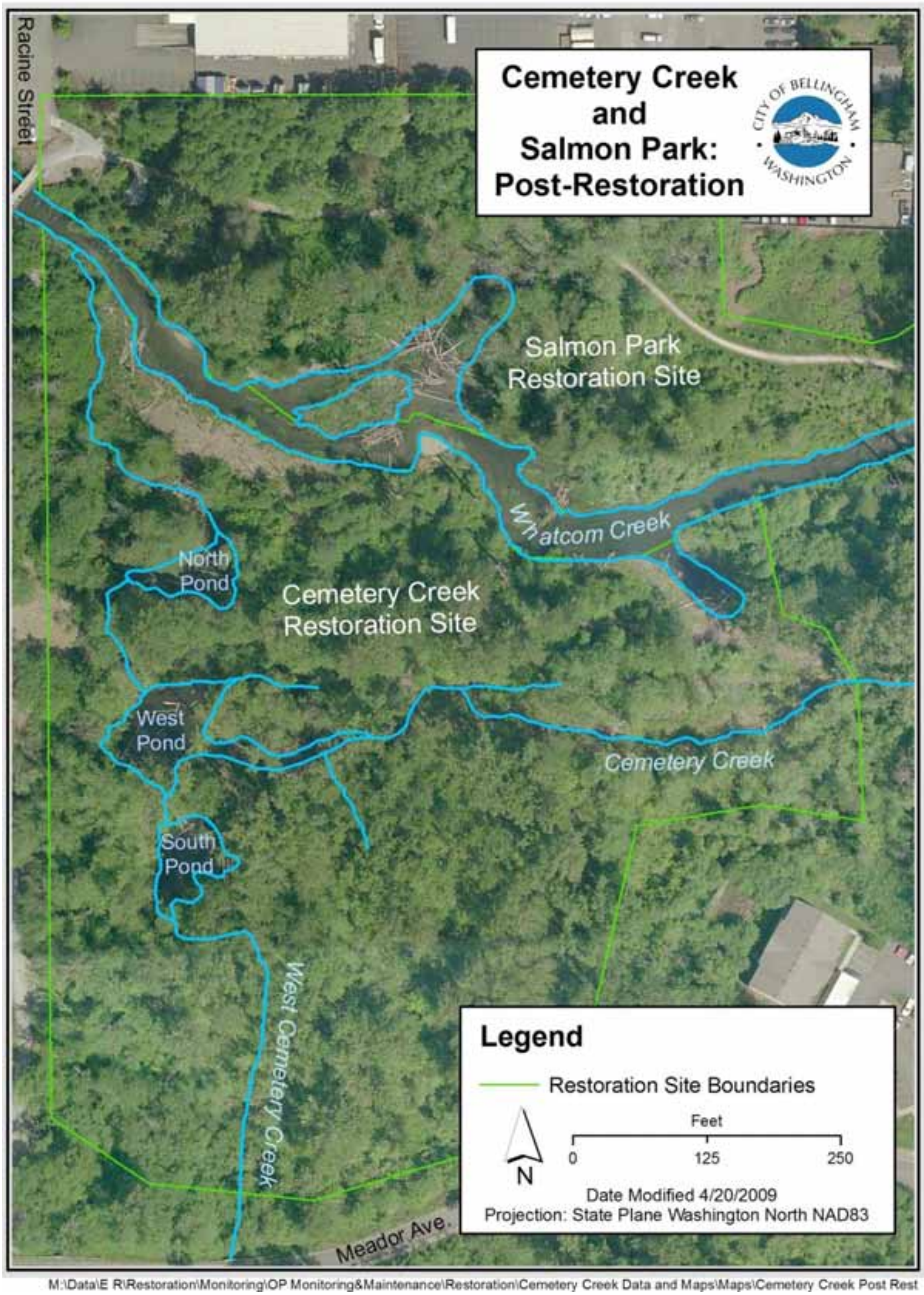
Figure 1-5. Aerial photo (2008) of Cemetery Creek and Salmon Park restoration sites after restoration.



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.

Construction at the restoration sites in July and August 2006 created ponds, reconfigured streambanks, and removed non-native vegetation. Surrounding habitat consisted of deciduous mid-successional forest and deciduous riparian vegetation. Care was taken to preserve as much of the pre-existing native riparian forest as possible. Cleared areas were planted with native shrubs and trees the following winter, between November 2006 and February 2007 (Figure 2-1). Sedges were planted in swales and along stream margins in April 2007.

Figure 2-1. Photo showing recently constructed stream channel in Cemetery Creek, with newly planted conifers, willow stakes and deciduous shrubs; March 6, 2007.

Source: City of Bellingham

Infill planting and the installation of additional willow cuttings occurred the following winter (2007). Supplementary infill planting, including additional sedges in swales and around pond margins occurred in April 2008.

Data collection for the 2007 season occurred between July 30, 2007 and September 13, 2007, approximately five months after the majority of plants had been installed at the restoration site. Data collection for the 2008 season occurred between August 25, 2008 and September 17, 2008.

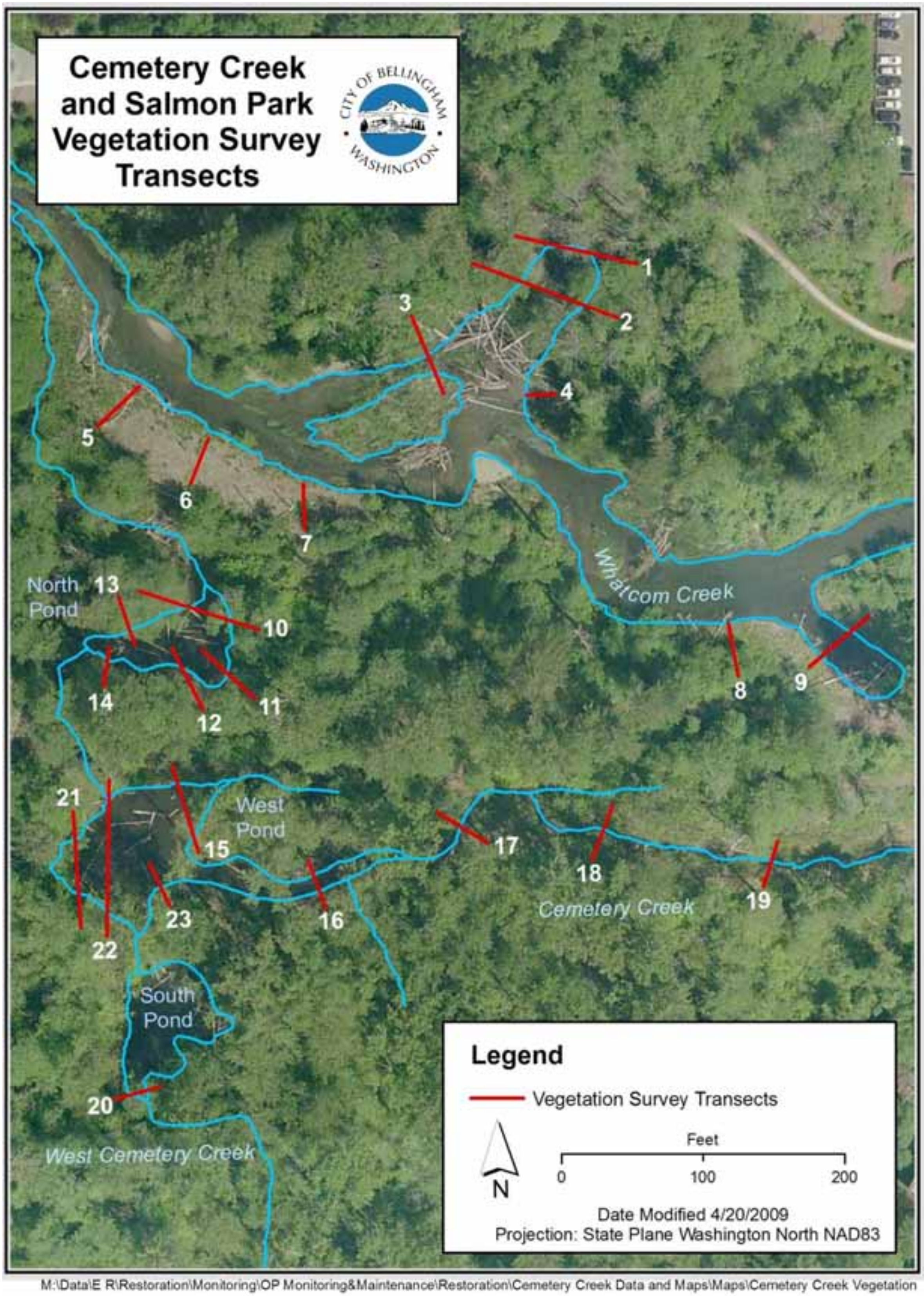
2.1.2 Methods

Riparian vegetation surveys are conducted within cleared and re-planted areas at the Cemetery Creek and Salmon Park restoration sites. Twenty-three transects have been established perpendicular to the stream throughout the restoration site (Figure 2-2). The ends of each transect are marked with wooden stakes or tags in established trees. Transects are 30 feet wide and extend from the stake/tag to the water's edge.

Each transect is characterized by vegetation community type (emergent wetland, shrub-scrub or riparian forest). Within the transect, all trees, woody shrubs and ferns greater than 1-foot tall are identified to species, counted, and characterized by condition (good/fair/poor/dead) and height class (1-5 feet/5-15 feet/15+ feet). The origin (planted/natural) of plants was determined during 2007 surveys; however this part of the protocol was eliminated in 2008. Determination of plant origin has become increasingly difficult in the field; as planted vegetation has become established, it is often impossible to determine planted vegetation from naturally recruited vegetation.

Ground cover (vegetation < 12 inches high) is estimated for each transect by vegetation type: sedges/native grasses, forb/fern, and invasive species. Canopy cover (vegetation > 6 feet high) is also estimated by canopy height (tree and shrub). During 2007 surveys, one estimate of ground cover and canopy cover was taken for each transect, including both banks of the transect, where applicable. Beginning with 2008 surveys, estimates of ground cover are separated by transect bank (left or right, where applicable) because there are often differences in cover between banks. Also beginning in 2008, qualitative estimates of canopy cover have been replaced with the use of a densiometer. Standardized use of the densiometer is less subjective than a percent estimate of canopy cover. Repeat measurements will therefore be more easily comparable between years, allowing for an accurate assessment of change over time. Four readings are taken while standing on the mid-line of the transect at the bank's edge: facing the bank, facing left, facing the stream, and facing right. Transects 5, 6, and 7 have only one densitometer station: standing on the mid-line of the transect at the center of the plot.

Figure 2-2. Map of vegetation survey transects.



Two additional monitoring components have been added to the protocol starting with 2008 surveys: transect photos and aquatic plant surveys. Photos are taken standing at each stake/tag facing toward the opposite stake/tag. Photos will allow for visual comparisons of vegetative growth and community change (if any) between monitoring years. Aquatic plant surveys have been added to monitor the recolonization of constructed stream channels and ponds by aquatic plants. Aquatic plants provide important habitat for fish, amphibians, insects and macroinvertebrates. Aquatic plant surveys are conducted within the transect area to a water depth of three feet. Plants are classified to the most practical level (family, genus and/or species) and percent cover is estimated.

2.1.3 Results

The results of vegetation surveys are compared against the following criteria for success, as specified in the Monitoring and Maintenance Plan: (1) survival of plantings should be at least 75 percent 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 percent 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.

Plant survival: Results indicate that all transect plots surpassed the 75 percent survivability criteria during 2007 and 2008 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. In many transects (for example, transects 1 and 3) there has been a dramatic increase in the total number, number of live, and number of good/fair plants. This is due to the recolonization of the restoration sites by naturally recruited seedlings, especially red alder, cottonwood, salmonberry, snowberry and Indian plum. It is expected that these numbers will decrease over time as the plants mature and thin due to competition for resources.

Tree height and canopy cover: 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 were documented: western hemlock, Douglas-fir, grand fir, Sitka spruce, western redcedar, red alder, bigleaf maple, black cottonwood and Oregon ash. At all transects in 2007 and 2008 the majority of live trees were categorized in the 1 to 5-foot height class, with a minority of plants in the 15 foot+ height class (Table 2-2). This is consistent with the recent installation of plants at the restoration sites.

There was an increase in the number of plants in the 1 to 5-foot size class in almost all transects (Table 2-3). This was due to natural recolonization by red alder and black cottonwood seedlings, as well as infill planting with willow stakes during the winter of 2007. In all but one transect[3] there was a positive or zero change in the number of trees in the 5 to 15-foot size class. Increased numbers of taller trees was due to rapid growth of willows, red alders and black cottonwoods. There was only one change (transect 7) in the 15 foot+ size class.

Due to changes in the protocol for measuring canopy cover (see methods section), canopy cover results from 2007 and 2008 will not be described in this report. Surveys conducted in 2009 will use the new quantitative methodology (densitometer) at which time comparisons will be possible between canopy cover in 2008 and 2009. Generally, canopy cover in 2008 is relatively high in many transects due to the presence of large red alders and black cottonwoods surrounding much of the restoration site. Some transects lack a nearby presence of these large trees and have a much lower or zero canopy cover (e.g. transects 6 and 9).

Ground cover and invasive plants: Because of changes in the protocol for monitoring ground cover (see methods section) weighted averages based on transect area have been calculated for 2008 transects (where applicable) in order to make comparison possible between survey years. Future surveys will estimate cover for each bank of the transect to allow for a more detailed assessment of ground cover and invasive species growth.

Generally, native ground cover increased at almost all transects due to growth of installed plants and natural recruitment (Table 2-4). Native ground cover consists of sedges, grasses, forbs and ferns. Invasive species ground cover also increased at most transects; a decrease was noted in three transects and no change was recorded at two (Table 2-4). In 2007, invasive cover exceeded the 10 percent cover criteria in seven transects; in 2008, invasive cover exceeded the criteria in 16 transects. Invasive species ground cover mainly consists of creeping buttercup, reed canary grass, and seedling blackberry.

Larger (> 1-foot high) invasives are regularly removed from the restoration site. These larger plants consist of Himalayan/evergreen blackberry with a small number of English holly. Larger invasive plants are uncommon at the sites, accounting for only 3% of all live plants in the transects. 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.

[3] The left bank transect stake for transect 3 was washed out prior to 2008 surveys; it was unclear where the 2007 stake was located. Location was estimated from notes, but does not appear to match the 2007 survey area based on species and height class results.

Table 2-1. Results of vegetation surveys conducted during 2007 and 2008 at the Cemetery Creek and Salmon Park restoration sites.

Transect	Total # (G/F/P/D)[1]		# Live (G/F/P)[1]		# Good/Fair		% of Total # that are G/F	
	2007	2008	2007	2008	2007	2008	2007	2008
1	70	275	69	270	65	269	93%	98%
2	138	241	138	239	136	235	99%	98%
3	106	244	88	242	85	238	80%	98%
4	42	46	42	45	40	45	95%	98%
5	14	143	12	142	11	140	79%	98%
6	42	160	42	158	38	156	90%	98%
7	48	100	48	100	45	98	94%	98%
8	49	128	49	128	49	128	100%	100%
9	90	211	90	211	87	210	97%	100%
10	119	168	111	161	111	159	93%	95%
11	75	126	70	126	70	125	93%	99%
12	47	70	45	68	45	65	96%	93%
13	53	75	49	71	49	68	92%	91%
14	57	72	47	70	47	67	82%	93%
15	94	156	92	155	91	153	97%	98%
16	113	111	113	106	112	104	99%	94%
17	90	123	85	118	81	117	90%	95%
18	156	150	151	147	147	147	94%	98%
19	127	159	124	159	123	159	97%	100%
20	85	99	80	98	80	98	94%	99%
21	164	209	159	207	159	207	97%	99%
22	48	47	45	47	44	47	92%	100%
23	31	32	30	31	29	31	94%	97%

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

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

	2007	2008
Total # Live	340	975
1-5 feet	82%	87%
5-15 feet	13%	11%
15+ feet	5%	2%

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

Transect	1-5 feet			5-15 feet			15+ feet		
	2007	2008	Change	2007	2008	Change	2007	2008	Change
1	10	102	92	5	9	4	2	2	0
2	23	44	21	3	4	1	2	2	0
3	2	17	15	9	6	-3	0	0	0
4	4	14	10	5	5	0	0	0	0
5	2	82	80	0	16	16	0	0	0
6	11	75	64	3	4	1	0	0	0
7	15	7	-8	2	17	15	0	2	2
8	18	85	67	1	1	0	0	0	0
9	9	113	104	1	6	5	0	0	0
10	9	21	12	0	4	4	1	1	0
11	12	23	11	2	4	2	1	1	0
12	4	13	9	0	0	0	2	2	0
13	7	5	-2	1	3	2	0	0	0
14	6	11	5	3	3	0	0	0	0
15	36	47	11	0	9	9	2	2	0
16	5	6	1	0	0	0	1	1	0
17	29	44	15	0	2	2	2	2	0
18	40	43	3	4	7	3	0	0	0
19	24	76	52	3	5	2	1	1	0
20	1	6	5	0	3	3	1	1	0
21	11	9	-2	0	1	1	2	2	0
22	1	0	-1	1	2	1	0	0	0
23	1	2	1	0	0	0	0	0	0

Table 2-4. Percentage estimates of ground cover at vegetation transects. Invasive estimates in red are above the 10% cover criteria.

Transect	2007		2008 (with *weighted averages*)[1]		2008	
	Native	Invasive	Native	Invasive	Native	Invasive
1 - L	45%	15%	*56%*	*18%*	80%	15%
1 - R					40%	20%
2 - L	45%	10%	*95%*	*2%*	95%	5%
2 - R					95%	0%
3 - L	10%	1%	*31%*	*26%*	25%	20%
3 - R					35%	30%
4 - R	20%[2]	5%[2]	50%	35%	50%	35%
5	25%	5%	10%	8%	10%	8%
6	5%	1%	20%	5%	20%	5%
7	30%	15%	75%	15%	75%	15%
8	75%	10%	90%	70%	90%	70%
9 - L	50%	20%	100%	45%	100%	45%
9 - R	75%	60%	100%	40%	100%	40%
10 - L	45%	15%	*78%*	*24%*	95%	30%
10 - R					40%	10%
11 - R	20%[2]	5%[2]	30%	10%	30%	10%
12 - R	20%[2]	5%[2]	50%	15%	50%	15%
13 - L	20%[2]	5%[2]	95%	35%	95%	35%
14 - R	30%[2]	5%[2]	40%	10%	40%	10%
15 - L	30%	5%	*44%*	*29%*	40%	5%
15 - R					45%	35%
16 - L	20%	5%	*60%*	*10%*	45%	15%
16 - R					75%	5%
17 - L	60%	5%	*87%*	*20%*	85%	20%
17 - R					90%	20%
18 - L	60%	20%	*95%*	*63%*	100%	65%
18 - R					90%	60%
19 - L	90%	15%	*98%*	*78%*	100%	80%
19 - R					95%	75%
20 - L	60%	1%	*97%*	*13%*	100%	10%
20 - R					95%	15%
21 - L	70%	10%	*40%*	*10%*	40%	5%
21 - R					40%	15%
22 - L	60%	1%	*65%*	*10%*	90%	10%
22 - R					40%	10%
23 - L	40%[2]	1%[2]	80%	50%	80%	50%

[1] Methodologies changed between 2007 and 2008; weighted averages (in *italics*) were calculated where applicable for 2008 in order to make possible comparison between 2007 and 2008. See text for details.

[2] Because of changes in the protocol, these 2007 cover estimates include both banks of the transect. 2008 data includes only the indicated bank. Comparison between 2007 and 2008 should be made with care.

Aquatic plants: Monitoring of aquatic plant recruitment was added to the vegetation protocol in 2008. Aquatic plants provide important habitat for fish, amphibians, insects and macroinvertebrates. Baseline data on the establishment and growth of aquatic plants will allow for monitoring of changing habitat quality for amphibians and macroinvertebrates and potential correlations with site recolonization by these species. This monitoring also allows for a prompt response if invasive aquatic plants are identified.

Identification was taken to the lowest practical level; identification to species can be difficult for many types of aquatic plants. Preliminary results indicate slow recolonization of the reconstructed channel and ponds. Cover in most transects was low (around 5%). Pond transects most commonly contained starwort (genus *Callitriche*) and duckweed (family *Lemnaceae*); some starwort and duckweed species are native while some are introduced. Positive identification to species requires the detailed examination of mature fruits; for this reason it is unknown whether the species at the restoration sites are invasive or not. Other documented aquatic plants in the ponds include native American waterweed (*Elodea canadensis*) and introduced tapegrass (*Vallisneria americana*). The West Cemetery Creek channel contained small but frequent patches of starwort (genus *Callitriche*). One exception to the low percent coverage was the Whatcom Creek swale transect (transect 9); this transect had high coverage (50%) of American waterweed (*Elodea canadensis*).

Fortunately there has been no indication of the presence of two highly problematic invasive aquatic plants: Brazilian elodea (*Egeria densa*) and hydrilla (*Hydrilla verticillata*). Confirmed presence of either of these aquatic invasives will be immediately reported to the Washington Department of Ecology.

Photos: Photos of vegetation transects were started in 2008. Since photos were not taken of transects in 2007, find below selected comparison photos from established photopoints taken August 13, 2007 and September 7, 2008 (Figure 2-3, Figure 2-4 and Figure 2-5). Note changes in plant growth between 2007 and 2008.

Figure 2-3. Photopoint 1a – Salmon Park restoration site.

(a) August 13, 2007.

(b) September 7, 2008.

Figure 2-4. Photopoint 10a – North Pond, Cemetery Creek restoration site.

(a) August 13, 2007.

(b) September 7, 2008.

Figure 2-5. Photopoint 14b – Cemetery Creek restoration site.

(a) August 13, 2007.

(b) September 7, 2008.

2.1.4 Discussion

The high rate of plant survival is an indicator of effective vegetation planning and planting in the short term. Survival rates over subsequent years will provide better information on the long-term effectiveness of the vegetation plan, its implementation and ongoing maintenance. The establishment of naturally recruited tree seedlings has dramatically increased the number of small trees (1-5 feet) in many transects. It is expected that these numbers will decrease over the ten year monitoring period as seedlings compete for resources; numbers of trees in the taller height classes (5-15 and 15+ feet) would be expected to increase over this same period.

Control measures have been taken since construction to physically remove invasive plants, specifically targeting Himalayan/evergreen blackberries and English holly. High coverage of invasive grass and forb species will remain in some transects as planted native vegetation continues to grow. Reed canary grass, becoming established throughout the restoration sites, is intolerant of shade, and will likely be shaded out as native plants grow. Willow stakes installed in 2006 and 2007 are already provided substantial shade along water margins.

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.

2.1.5 Recommendations

- ✓ When surveying for aquatic plants, add notation of water surface elevation (WSE) at the closest pond or stream gage. Surveys should be conducted at similar WSE in order to effectively track changes in aquatic plant coverage and composition.

2.2 FISH COMMUNITY

The fish community of Cemetery Creek is assessed using two types of surveys. Spawner surveys are conducted each fall and winter to evaluate use of the area by adult salmonids. From March through June, the outmigration of juvenile salmonids is monitored using a smolt trap. The following sections describe the results of these activities.

2.2.1 Spawner Surveys

2.2.1.1 Introduction

Whatcom Creek currently supports six species of anadromous salmon and trout: fall Chinook, coho, chum, and pink salmon, and winter steelhead and coastal sea-run cutthroat trout. Resident forms of rainbow and cutthroat trout are also present. For more information on historic and recent use of Whatcom Creek by salmonid and other fish species, see the *Whatcom Creek Post-Fire Evaluation* report (Madsen and Nightengale 2009). As a small tributary, Cemetery Creek is expected to provide suitable spawning habitat for smaller bodied salmonids such as coho, sea-run cutthroat and resident trout. However, larger salmonids such as steelhead, Chinook and chum have occasionally been observed in the stream. The objective of spawner surveys is to confirm that habitat within the restoration area is being used for salmonid spawning. Survey data from 2006-2009, representing three seasons of data collection, is presented in this report.

2.2.1.2 Methods

Spawner surveys are conducted to assess spawning habitat use by salmonid fishes. Monitoring reaches include the reconstructed stream channels of Cemetery Creek and West Cemetery Creek and one short undisturbed channel segment upstream of the South Pond. Surveys commence at the downstream end of the project area. Surveyors count the number of live fish, carcasses and redds, by species.

Spawner surveys are started in the fall of each year. An initial survey is conducted at low flows (usually between September and October). Subsequent surveys are conducted when flows became passable for adult fish. Survey frequency is dependent on flow conditions; ideal frequency is at seven to ten day intervals. Surveys continue through March and are completed by trained COB and WCC staff.

Live fish are identified to species (if possible) and observed to determine if the fish are building or guarding a redd. Redds are associated with a species (if possible) and marked with flagging denoting the survey date and location. Carcasses are identified to species (if possible) and assessed to determine whether eggs or milt has been released. If there is a large amount of either it is noted that the fish died before successfully spawning. The caudal fin is then cut off to indicate that the carcass has been counted.

Water and viewing conditions are assessed at each survey using codes provided by WDFW (Table 2-5). These codes describe water conditions, height and color, as well as viewing conditions that affect the ability of the surveyor to accurately count the number of spawning fish and redds within the survey reach. A qualitative estimate of visibility (percentage of the stream reach visible) is also assessed. Visibility of 80% or greater is considered good.

Table 2-5. Spawner survey codes used to describe water and viewing conditions.

Water Conditions	Viewing Conditions
20 Low – clear	30 Dark
21 Low – medium color	31 Dark in pools
22 Low – muddy	32 High glare
23 Medium – clear	33 Some glare
24 Medium – medium color	34 Raining
25 Medium – muddy	35 Snowing
26 High – clear	36 Frozen
27 High – medium color	37 Partly frozen
28 High – muddy	38 Water turbid
29 Flooding	39 Not surveyable

2.2.1.3 Results

A summary of survey conditions and results from all survey years is presented in Table 2-6. No fish or redds were seen during the 2006-2007 survey season. Results from the 2007-2008 season are presented in Table 2-7. Results from the 2008-2009 season are presented in Table 2-8.

Table 2-6. Spawner survey summary for 2006-2009 survey seasons.

Survey year	2006-2007	2007-2008	2008-2009
Number of surveys	8	18	20
Number of surveys with ≥ 80% visibility	7	14	14
Number of live fish	0	1	0
Number of dead fish	0	5	0
Number of redds	0	2	2

One live fish was identified during surveys in 2007-2008, a coho which was seen digging a redd in the Cemetery Creek channel. Five dead fish were found, two of which were positively identified: one male Chinook (Figure 2-6) and one coho. The male Chinook had not spawned; the coho was scavenged, preventing a determination of spawning status. Two redds were identified: the redd created by the coho and one additional redd also located in Cemetery Creek channel.

Figure 2-6. Male, unspawned Chinook, found at upper end of the restoration site in Cemetery Creek on November 1, 2007.

Source: City of Bellingham

Two redds were identified during the 2008-2009 survey season. No fish were observed on the redds. However, given the time of year and previous observations, they are likely coho redds. One live fish was seen during an incidental sighting on March 19, 2009 in West Cemetery Creek. The fish was a trout species and was not exhibiting spawning behavior.

Table 2-7. Summary of results from 2007-2008 spawner survey season.

Survey Date	Species	# Live	# Dead	# Redds	Visibility	Notes
10/04/07	-	0	0	0	100%	
10/18/07	-	0	0	0	95%	
10/25/07	-	0	0	0	100%	
11/01/07	Chinook	0	**1**	0	100%	Male Chinook, not spawned; found in upper part of Cemetery Creek.
11/13/07	Coho	**1**	0	0	95%	Digging in Cemetery Creek; redd not fully formed.
11/21/07	Coho	0	0	**1**	95%	Upmost pool in Cemetery Creek.; more developed.
11/28/07	Unknown	0	**1**	0	95%	Female, spawned; coho or Chinook.
12/04/07	-	0	0	0	10%	
12/06/07	Unknown	0	**1**	0	60%	Scavenged carcass.
12/10/07	-	0	0	0	90%	
12/18/07	-	0	0	0	95%	
12/26/07	Unknown	0	**1**	**1**	80%	Redd located midway up Cemetery Creek channel.
01/09/08	-	0	0	0	95%	
01/28/08	Coho	0	**1**	0	95%	Scavenged; still identifiable.
02/07/08	-	0	0	0	75%	
02/20/08	-	0	0	0	90%	
02/26/08	-	0	0	0	80%	
03/10/08	-	0	0	0	10%	

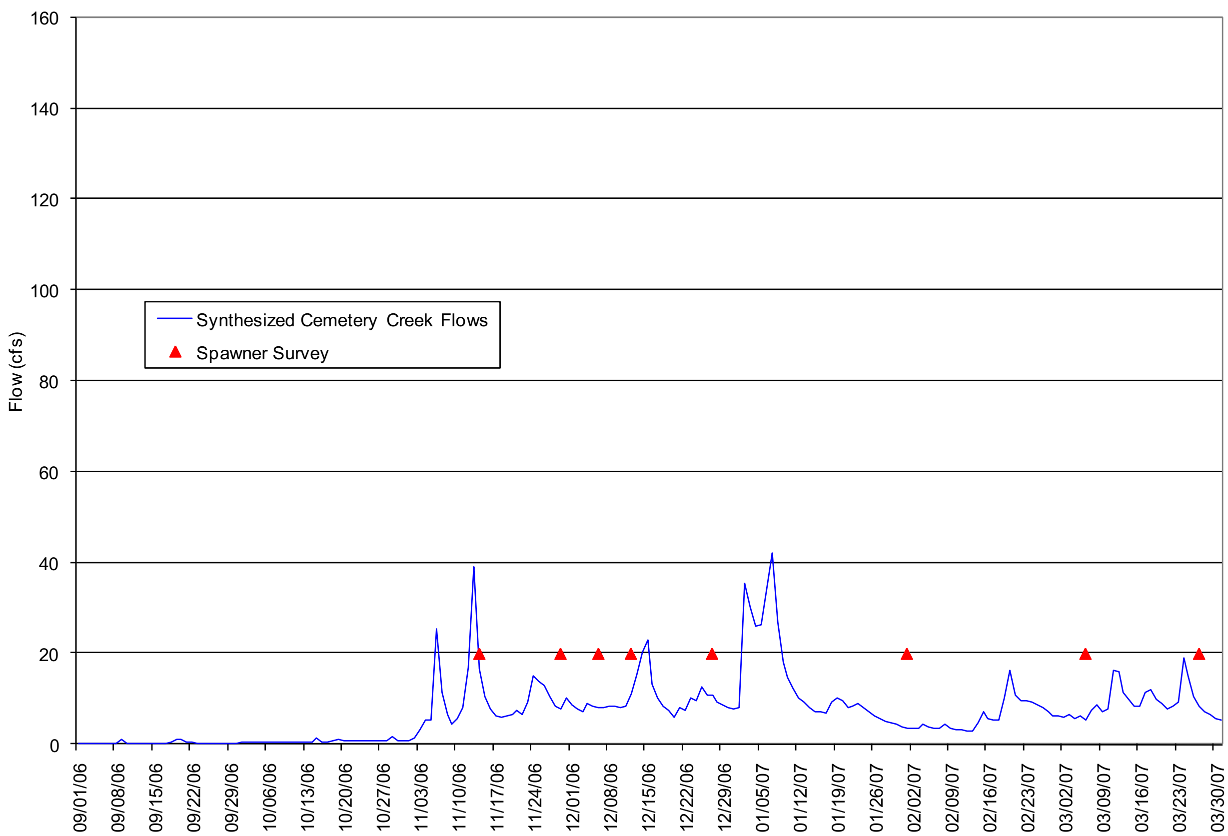
Table 2-8. Summary of results from 2008-2009 spawner survey season.

Survey Date	Species	# Live	# Dead	# Redds	Visibility	Notes
09/08/08	-	0	0	0	95%	
09/24/08	-	0	0	0	90%	
10/09/08	-	0	0	0	90%	
10/16/08	-	0	0	0	95%	
10/24/08	-	0	0	0	95%	
11/03/08	-	0	0	0	95%	
11/12/08	-	0	0	0	5%	
11/17/08	Unknown	0	0	**2**	95%	No fish seen, but likely coho redds. Both in Cemetery Creek channel.
11/26/08	-	0	0	0	100%	Test redd seen in Cemetery Creek.
12/04/08	-	0	0	0	95%	
12/15/08	-	0	0	0	75%	
01/02/09	-	0	0	0	60%	
01/08/09	-	0	0	0	0%	Area flooded; gages submerged.
01/16/09	-	0	0	0	75%	Flood event shifted gravel & LWD.
01/26/09	-	0	0	0	75%	
02/05/09	-	0	0	0	95%	
02/18/09	-	0	0	0	95%	
02/23/09		0	0	0	95%	
03/06/09		0	0	0	90%	
03/26/09	-	0	0	0	80%	

2.2.1.4 Discussion

The 2006-2007 survey season was characterized by low flows early in the season and high, flashy flows later in the season (Figure 2-7)[4]. Conditions were checked weekly; however, the start of formal surveys in Cemetery Creek was postponed until mid-November when flows increased sufficiently to provide access for adult salmonids. Subsequent flows were high (up to an estimated 42 cfs) and flashy, creating difficult survey conditions. No surveys were conducted from December 28, 2006 through January 31, 2007 due to flooded conditions at the restoration site. Although no fish or redds were observed during 2006-2007, this is not necessarily an indication that no adult salmonids or redds were present in Cemetery Creek during this period.

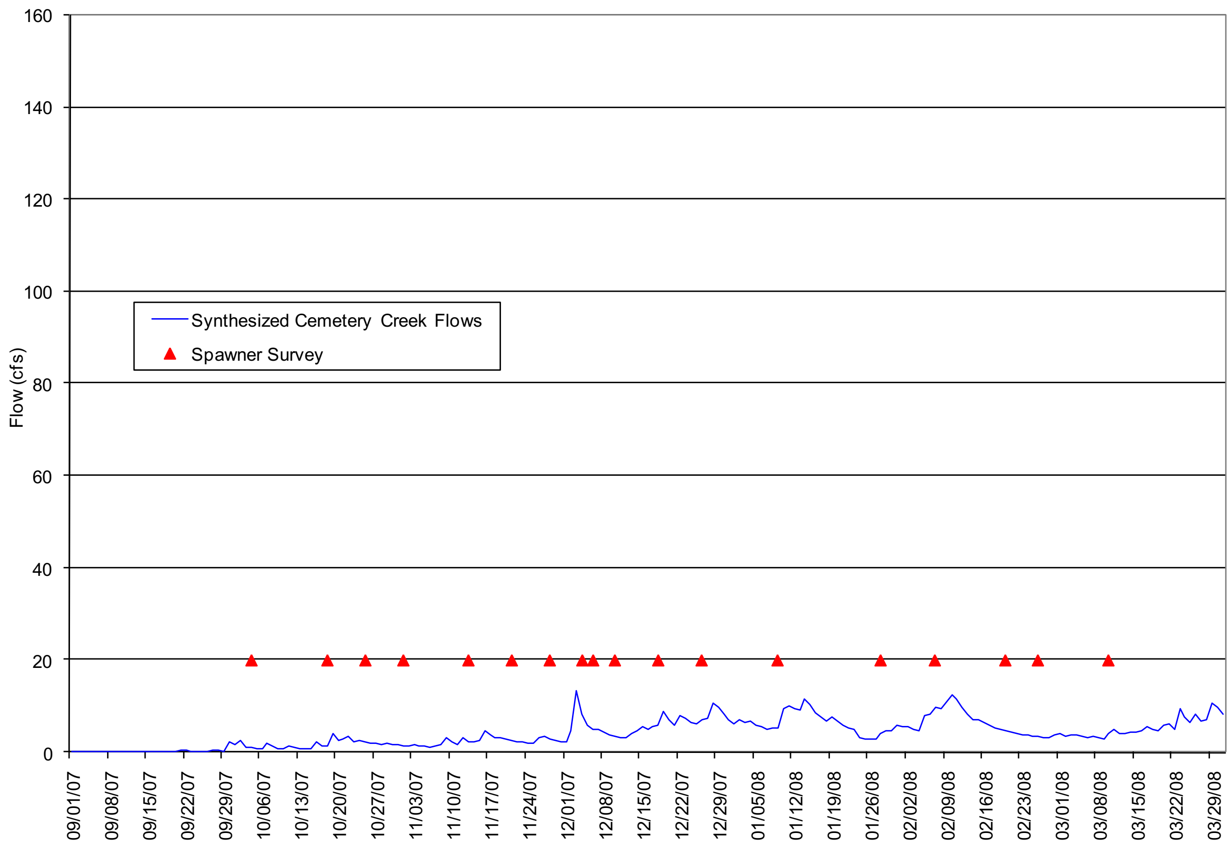
Figure 2-7. 2006-2007 spawner survey dates and Cemetery Creek flows.



[4] There is no continuous monitoring of flow on Cemetery Creek, so flows are synthesized from daily average values measured at the City of Bellingham's Padden and Chuckanut Creek gage sites. For more information on flow calculation for Cemetery Creek, see the Water Quality Methods sections, Section 3.2.2, "Cemetery Creek Flows".

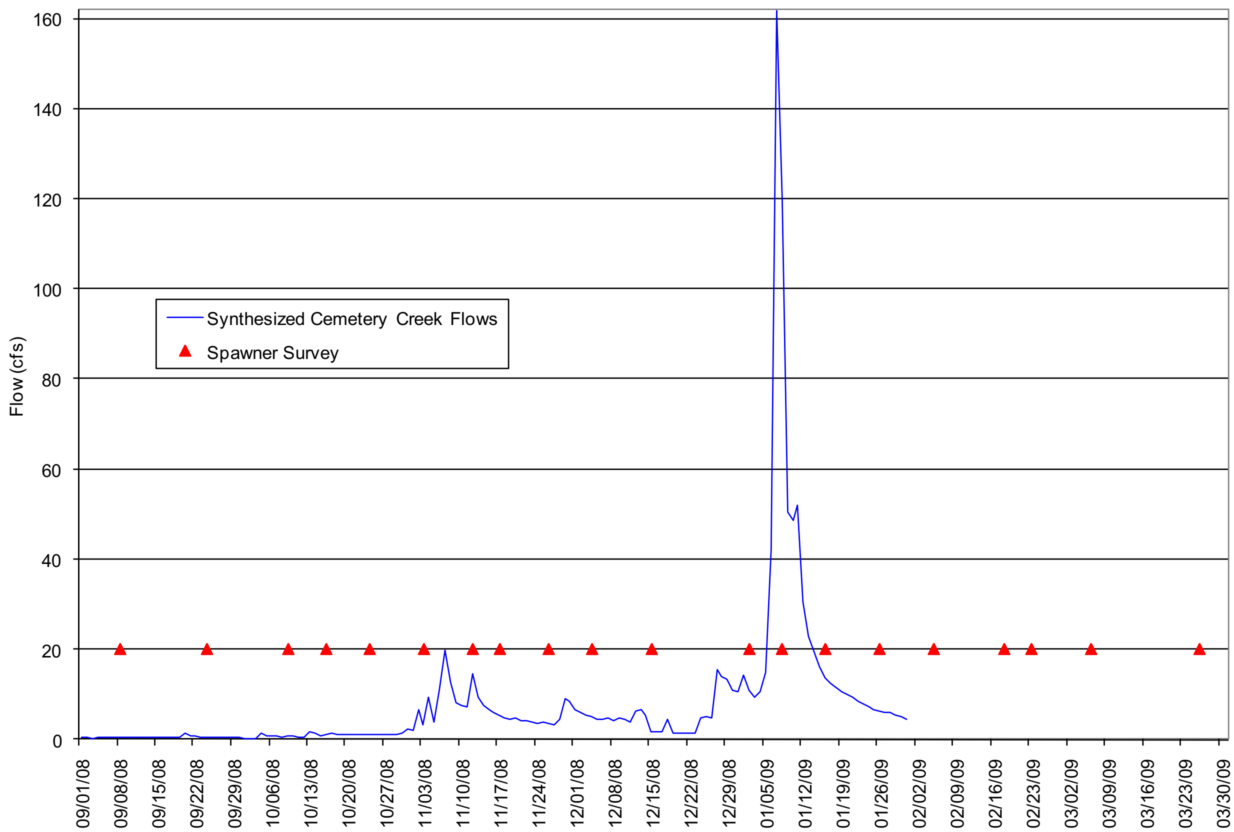
In contrast, the 2007-2008 survey season was characterized by moderate flows (estimated maximum of 13.5 cfs) and excellent survey conditions (Figure 2-8). Coho and Chinook were observed in the Cemetery Creek restoration area. Coho were confirmed to be spawning in the Cemetery Creek channel, with one additional unidentified redd that was likely coho also identified in Cemetery Creek. The location of redds indicate that salmonids are using spawning gravel patches placed during construction.

Figure 2-8. 2007-2008 spawner survey dates and Cemetery Creek flows.



The Red Tail Reach project was undergoing construction at the start of the 2008-2009 survey season. A fish exclusion fence was erected on September 4, 2008. A preliminary spawner survey was conducted to confirm the absence of spawning fish in Cemetery Creek. No adult salmonids were seen at the exclusion fence for the duration of the construction project. Surveys proceeded after removal of the fence on September 20 and continued through early March. Prolonged freezing temperatures in mid and late December froze much of Cemetery and West Cemetery Creeks, obscuring visibility and preventing effective surveys. Surveys resumed in early January, promptly followed by a large flood event (high flows up to an estimated 162 cfs in Cemetery Creek). This major flood event (Figure 2-9)[5] moved large woody debris and gravel throughout the restoration site. New gravel patches were noted, especially in Cemetery Creek. Despite generally good viewing conditions, only two redds were detected during the survey season (up to 2/18/09). One live resident trout was seen; no carcasses were found.

Figure 2-9. 2008-2009 spawner survey dates and Cemetery Creek flows.



2.2.1.5 Recommendations

No changes are recommended at this time.

[5] Synthesized flow data currently unavailable from February 1, 2009 through March 31, 2009. Data should be available beforefinal publication of the report.

2.2.2 Juvenile Rearing in Ponds and Streams

2.2.2.1 Introduction

Many fish species rely on the Cemetery Creek system to provide habitat for various life processes. Through the long-term monitoring program we will develop a better understanding of which species utilize Cemetery Creek during which life history stages. According to available data, Cemetery Creek currently provides habitat to support over-wintering multiple age classes of a diversity of salmonid species.

Ponds and backwater habitats constructed in the Cemetery and West Cemetery Creek channels in 2006 were designed primarily to improve salmonid rearing habitat. Juvenile salmonids anticipated in the Cemetery Creek system are coho, rainbow/steelhead trout and cutthroat trout due to their long rearing time in freshwater (up to 1½ years). Other possible juvenile salmonids include Chinook, chum and pink salmon. 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 will be repeated starting in March 2009. Survey data from the 2007 season are presented in this report.

2.2.2.2 Methods

Use of the pond and stream network for rearing habitat by juvenile salmonids is monitored using a smolt trap. Smolt traps are passive sampling devices that capture migratory fishes as they move upstream or downstream in river systems. Smolt trapping provides information on the species and number of juvenile salmon outmigrating from the Cemetery Creek system to Whatcom Creek. The smolt trap is installed in Cemetery Creek between the North and West Ponds. Installation at the original target location downstream of the restoration site was precluded by high water levels in Whatcom Creek, which produced a backwatered area over 5 feet-deep downstream of the North Pond during parts of the study period. Therefore, results will not include species utilizing the North Pond.

Smolt trapping is conducted following the methodology used in "Relation of salmonid survival, growth, and outmigration to environmental conditions in a disturbed, urban stream, Squalicum Creek, Washington" (Mark Downen 1999 pg. 27-30), with some adaptation. The V-shaped weir utilizes large screen panels to funnel fish into a live box while allowing water and small debris to pass through the mesh. The 3- x 6-foot panels are covered with ½- x ½-inch mesh screens, and are positioned to span the entire stream channel. To ensure no fish can pass under the weir, the bottom 16 inches of the weir is flashed with polyethylene plastic that extends far enough in front of the weir to be covered with gravel bags. All panels are latched together with wooden and metal supports and anchored in the stream with 7-foot steel fence posts. The combination of flow and weir design guides fish into the live box. The live box is made of wood and stands 2 feet tall by 4 feet long by 2 feet wide. The box is installed to keep water levels in the box at a minimum of 8 inches. The side of the live box is covered with ½- x ½-inch mesh screens. There are two wooden baffles inside the live box that create a refuge area from high velocities for captured fish. An adult migration tube is installed to allow spawning anadromous fish to navigate upstream into a temporary holding pool. The pool is checked twice daily to ensure that adult fish entering the pool are moved promptly upstream.

The trap is generally installed from mid-March into early June. In 2007, the trap was installed on March 28 and maintained until June 7, when low flows rendered it impossible to maintain sufficient water depth in the live box. The smolt trap is checked daily at approximately 7:30 am and 5:00 pm. The trap is checked more frequently during periods of heavy rain or high flows. At each check, fish intercepted by the trap are identified to species (when possible) and classified by size class, then released downstream in Cemetery Creek. Water temperature and water level are recorded on each visit. Debris that has accumulated on the screen is cleared, and the trap is assessed for damage.

2.2.2.3 Results

A total of 1,984 fish were intercepted in the live trap between March 28 and June 7, 2007 (Table 2-9). Coho salmon and cutthroat trout dominated out-migration, with numbers totaling 871 coho and 294 cutthroat. Over 750 additional salmonids were not identified to species. These fish were removed from the trap and passed downstream without identification, primarily during flood events. During floods, greater emphasis was placed on the safe transport of fish rather than on identification, particularly when the trap was checked during nighttime hours. Other fish species caught in the trap included rainbow/steelhead trout, stickleback, lamprey, sculpin, and red-sided shiner. Non-native species included small mouth bass and goldfish.

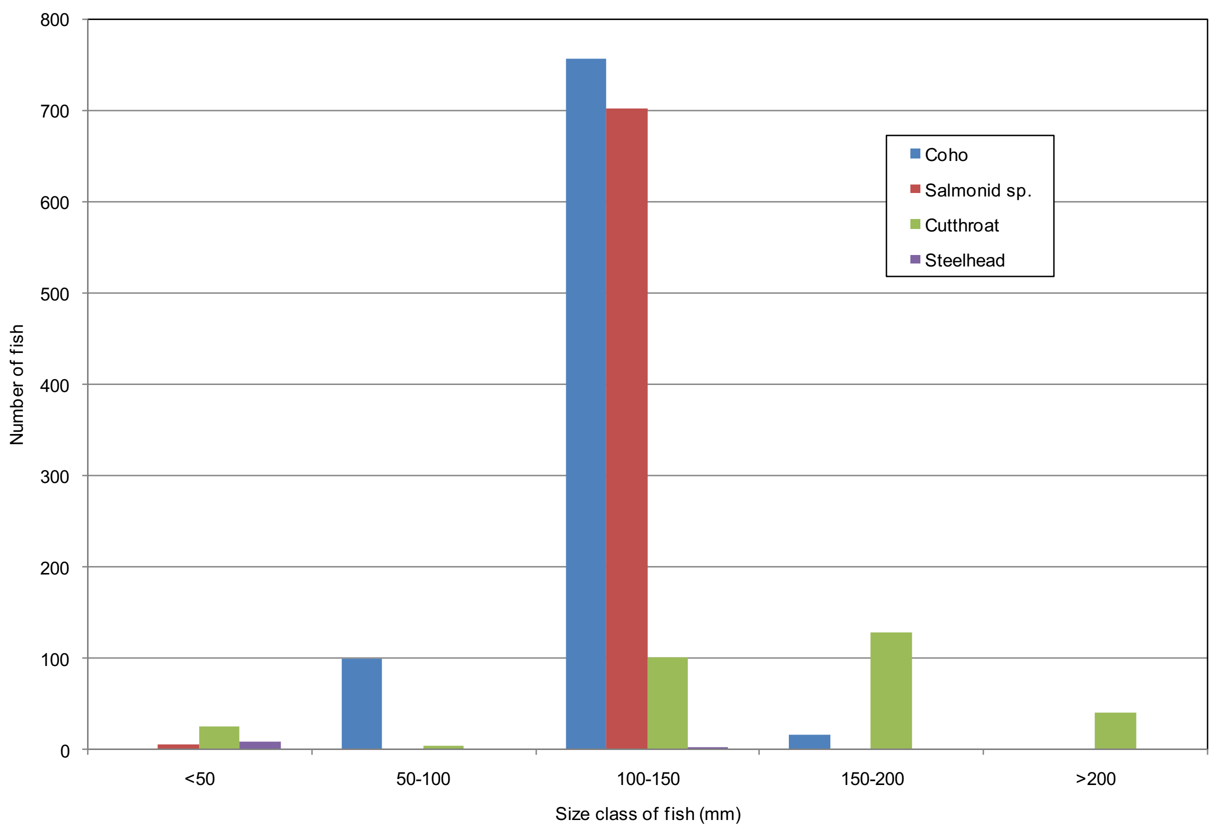
Table 2-9. Total catch for the Cemetery Creek smolt trap, March 28 - June 7, 2007.

Common Name	Latin Name	Number of Individuals
Coho salmon	*Onchorynchus kisutch*	871
Cutthroat trout	*Onchorynchus clarki*	294
Rainbow trout/steelhead	*Onchorynchus mykiss*	9
Salmonid sp.	*Onchorynchus sp*	771
Three-spine stickleback	*Gasterosteus aculeatus*	8
Sculpin	*Cottus sp*	6
Redside shiner	*Richarsonius balteatus*	1
Lamprey sp.	*Lampetra sp*	9
Crayfish sp.	*Pacifastacus sp.*	7
Smallmouth bass	*Micropterus dolomieu*	1
Goldfish	*Carassius auratus*	8

In this study, length measurements were 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 were in the 100-150 mm size class (Figure 2-10), indicating these fish were age 1+. Most of these fish were coho, and many of them exhibited evidence of smoltification. No young of the year coho were observed during operation of the trap; no adult fish or carcasses were observed in the surveyed sections of Cemetery Creek in 2006-2007 (Section 2.2.1).

Cutthroat trout intercepted in the trap exhibited much greater size variation (Figure 2-10). A number of adult fish in excess of 200mm were intercepted moving downstream. Adult (>200mm) and age 1+ (100-200mm) cutthroat trout were caught throughout the survey period. One likely cutthroat trout redd was observed upstream of the trap in March 2007, and young of the year cutthroat and rainbow/steelhead trout were intercepted starting in late May (Section 2.2.1).

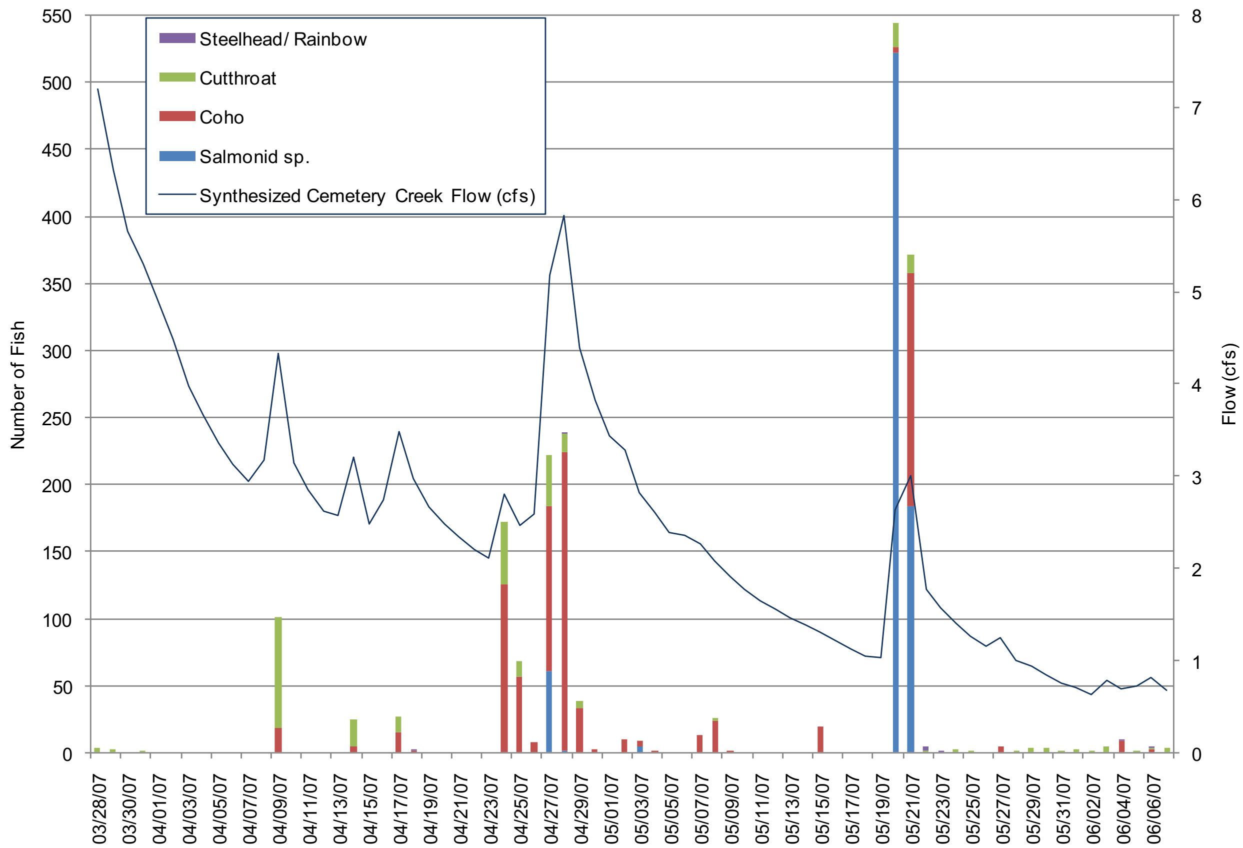
Figure 2-10. Size class distribution of salmonids caught in the Cemetery Creek smolt trap, March 28 - June 7, 2007.



2.2.2.4 Discussion

Out-Migration Patterns: Storm pulses created a very flashy flow regime for Cemetery Creek. Outmigration of juvenile salmonids often occurs in conjunction with flow pulses (Giorgi and Stevenson 1997). This relationship proved to be the case with Cemetery Creek as well (Figure 2-11). One or two cutthroat trout were intercepted every few days for the first week of trap operation. The first coho smolt was caught on April 9 during a small storm event. Large numbers of coho smolts were documented outmigrating during high flow events on April 28 and May 21. During those storms, as many as 100 outmigrating salmonids per hour were removed from the trap; many of those fish were not identified to species, particularly during the night. However, observations suggest that the majority of those fish were also coho. Outmigration during those two storm events represented more than 50 percent of the total number of fish caught.

Figure 2-11. Outmigration pattern of juvenile salmonids from Cemetery Creek, March 28 - June 7, 2007.



High-Flow Events: On several occasions, water levels in the creek rose over two feet within an hour. During storm events, the trap was checked at four-hour intervals, and staff stayed on site to remove fish as long as they were observed to be steadily entering the trap. During the storm event on May 20, fish were observed to be entering the trap at rates of more than 100 fish per hour for short periods of time. Ten mortalities were documented during this event. These ten fish represented less than one percent of all fish handled. Modifications to the trap design, including high flow release valves and a larger box with shorter baffles should help reduce future fish mortality associated with smolt trap operations.

2.2.2.5 Recommendations

- ✓ Modification of the trap and live box has been made for the 2009 season to reduce the risk of injuring or killing fish. Modifications include reconfiguring and shortening the baffles and incorporating a high flow release panel into the trap.

2.2.3 Juvenile Rearing in Backwater Habitats

The original study plan (COB 2006) called for monitoring of juvenile salmonid rearing in backwater habitats via beach seining. Backwater habitats constructed for the completed project contain abundant large woody debris. While this configuration provides excellent cover it makes collection of fish via beach seining impractical. This component of the monitoring plan was therefore discontinued. If time allows, monitoring by seining could be replaced with monitoring by snorkel surveys.

2.3 AQUATIC MACROINVERTEBRATES

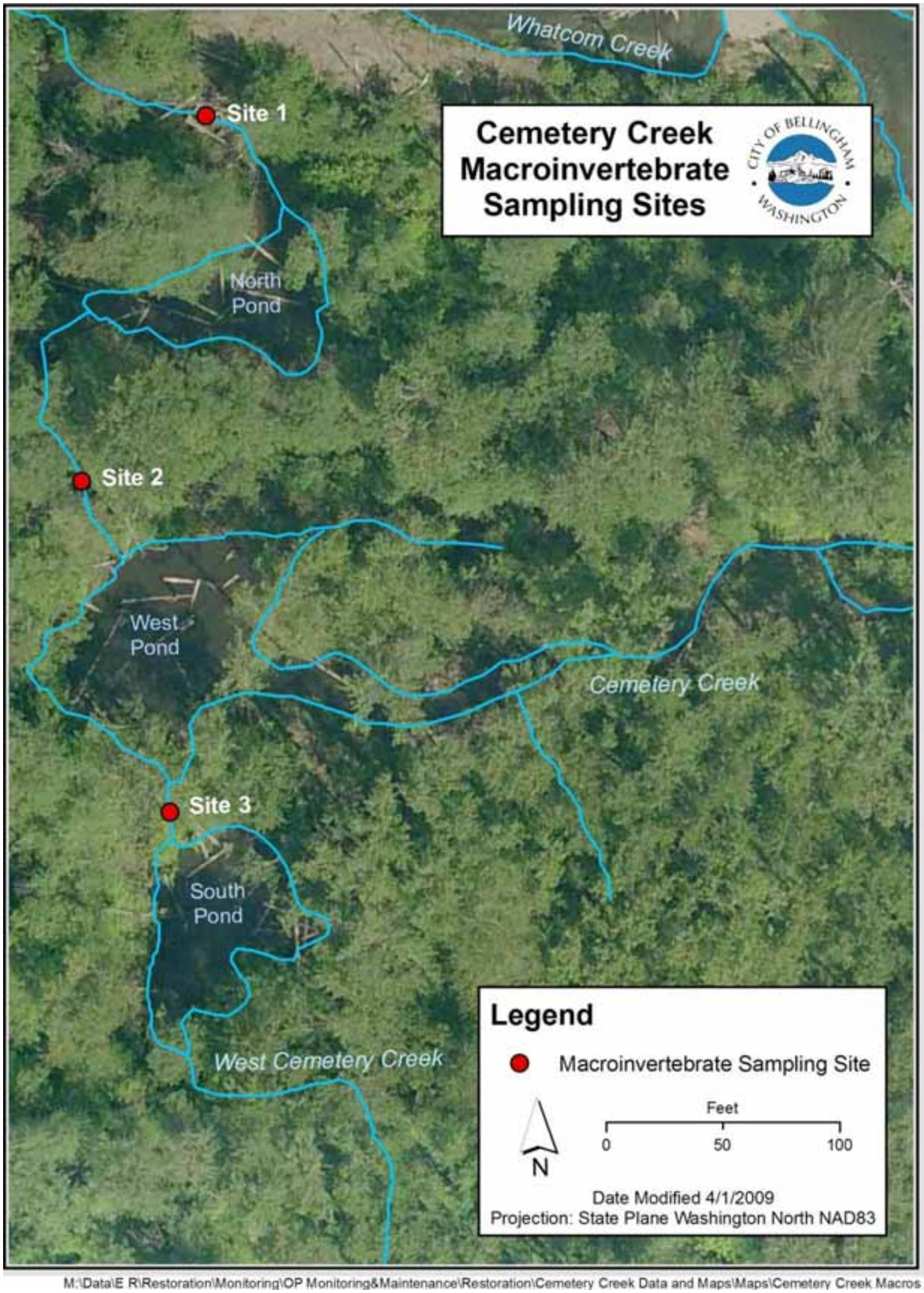
2.3.1 Introduction

Benthic macroinvertebrates are a diverse assemblage of organisms that inhabit the substrate of aquatic systems and are visible to the unaided eye. Because of their short life spans, abundance, and diversity, macroinvertebrates are a good indicator of community health and water quality. The objective of aquatic macroinvertebrate sampling is to document colonization and survivorship by the macroinvertebrate community in reconstructed channels in the restoration site. Parameters measured include community composition, functional feeding groups, taxa abundance, and species richness and abundance.

2.3.2 Methods

Sampling: Macroinvertebrate samples were collected from three sites within the reconstructed Cemetery Creek channel on September 25, 2007 and September 18 and 22, 2008 (Figure 2-12).

Figure 2-12. Map of macroinvertebrate sampling sites. Four riffles were sampled at each site.



Macroinvertebrate sampling follows the methodology found in "Benthic Macroinvertebrate Biological Monitoring Protocols for Rivers and Streams" (Plotnikoff and Wiseman, 2001), with some modifications. Four substrate samples are taken from riffles within each of the three sites. Samples are collected using a D-frame kick net with a 2.0 ft^2 delineation square (Figure 2-13). Rocks within the frame are brushed for collection and sediment is disturbed to release a larger number of macroinvertebrates. Samples are contained separately in half and one-liter polycarbonate containers and are preserved in 85 percent ethanol. Each sample includes a waterproof label with watershed and stream name, site number and riffle number, the date and collector's name.

Figure 2-13. WCC staff collecting a macroinvertebrate sample using the D-frame kick net.

Source: City of Bellingham

Qualitative observations are recorded for each site: water clarity, water odors, sediment odors and surface films. Water quality parameters (temperature, pH, conductivity, and dissolved oxygen) are recorded at each site using a Hydrolab, which reads each parameter simultaneously. The Hydrolab is calibrated before the survey session, and audited before and after sampling to ensure data accuracy. Before measurement at each point the Hydrolab is allowed to equilibrate by waiting for at least two minutes, or until dissolved oxygen has stabilized.

Associated habitat data is collected at each sampled riffle. Substrate measurements are collected using a metal grid with 50 equidistant points and a Plexiglas-bottomed viewing bucket (when needed). The substrate at each point is classified by size class and recorded. Canopy cover is recorded using a canopy densitometer, counting closed intersections. Six measurements are taken at each riffle: four at the center of the stream (facing upstream, downstream, right bank and left bank), and one on each stream bank, standing with the collector's back to the stream. Right and left bank are determined while standing facing downstream. Stream reach profile measurements are taken at each riffle and include: wetted width, bankfull width, maximum depth, and gradient. Sample collection is conducted by trained COB and WCC staff.

Sorting and Identification: Samples will be subsampled (300 count) and keyed to the lowest practical level as defined by Plotnikoff and White (1996). Processing is scheduled to be completed in 2009. Parameters measured will include community composition, functional feeding groups, taxa abundance, and species richness and abundance. Analysis will begin with the creation of a species diversity list and then consolidation into more general taxa. This will provide species richness and abundance, while also assessing taxa abundance. Unidentifiable specimens that are damaged or immature are assumed to be representatives of the next highest taxonomic level. Comparisons between the macroinvertebrate community and habitat and water quality data will be used to asses overall health of the community. Data may also be used in an annual population trend analysis.

2.3.3 Discussion

Samples collected in 2007 will be sorted and identified in 2009. Samples collected in 2008 will not be processed due to backwatering of the Cemetery Creek restoration area in the weeks prior to sampling. Backwatering from Whatcom Creek occurred frequently in September due to construction of the Red Tail Reach project. Samples collected after the backwater events may not be indicative of normal stream conditions at the Cemetery Creek site. Samples will be collected in 2009; once sorted and identified, these samples will be compared with those collected in 2007.

2.4 RIPARIAN AND TERRESTRIAL WILDLIFE COMMUNITY

2.4.1 Amphibians

2.4.1.1 Introduction

Amphibians are considered good indicators of general ecosystem health because of their close association with various aquatic habitats and sensitivity to different environmental stresses (USGS 2006). Ten species of amphibians (nine of them native) have been historically documented in the City of Bellingham (Table 2-10). There has been no previous study of the distribution and abundance of amphibians in the Whatcom Creek watershed (Eissinger 2003). Amphibians likely to occur at the Cemetery Creek and Salmon Park restoration sites include seven of the ten documented species: northwestern salamander, long-toed salamander, ensatina, rough-skinned newt, pacific treefrog, red-legged frog and American bullfrog. The objective of amphibian surveys is to document amphibian use of the restoration areas and to determine species composition and, if possible, abundance.

Table 2-10. Historically documented amphibians within the City of Bellingham. List and abundance determination from Eissinger 2003.

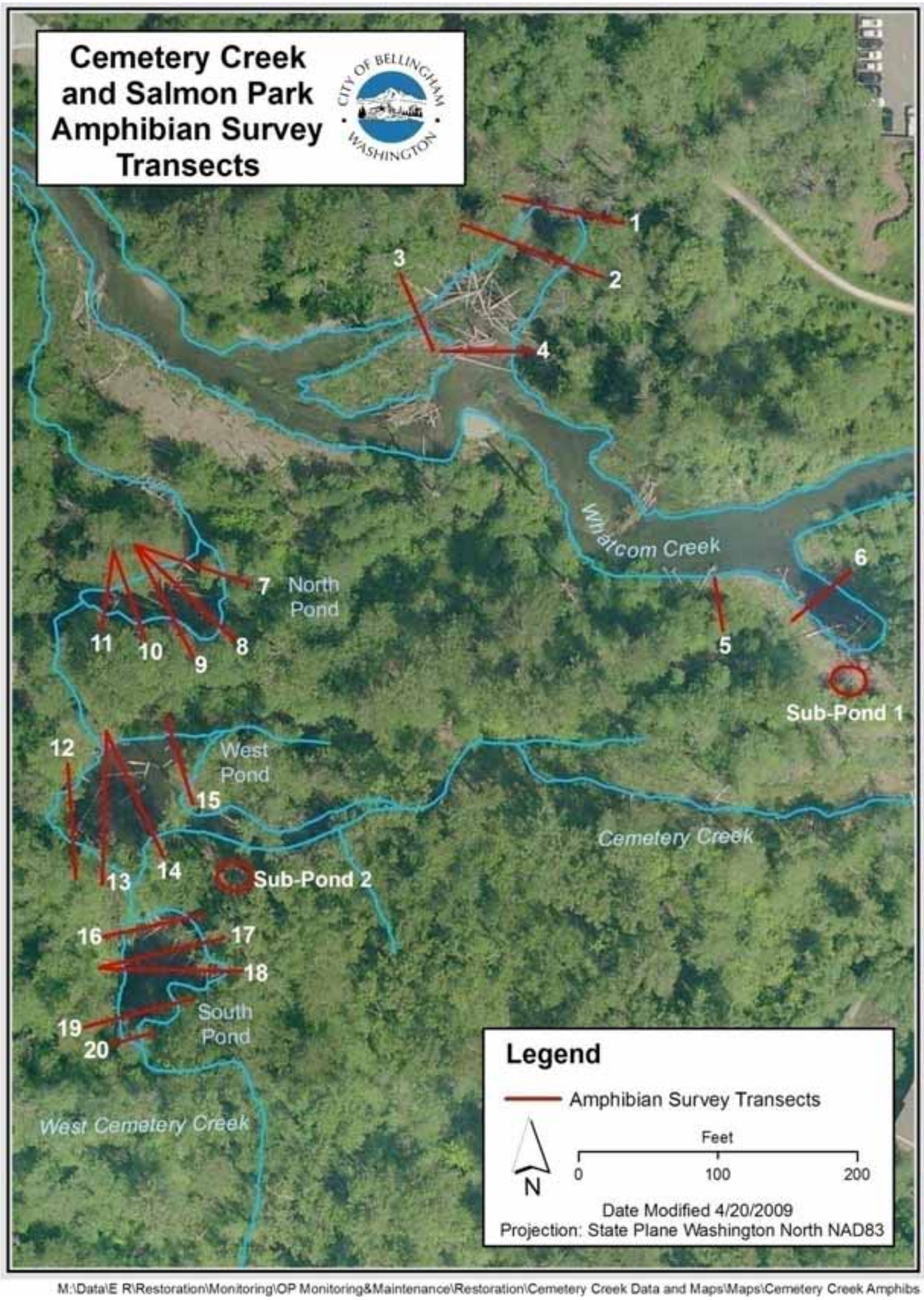
Common Name	Latin Name	Abundance
Northwestern salamander	*Ambystoma gracile*	Uncommon
Long-toed salamander	*Ambystoma macrodactylum*	Uncommon
Pacific giant salamander	*Dicamptodon tenebrosus*	Rare
Ensatina	*Ensatina eschscholtzii*	Uncommon
Western red-backed salamander	*Plethodon vehiculum*	Uncommon
Rough-skinned newt	*Taricha granulosa*	Uncommon
Western toad	*Bufo boreas*	Rare
Pacific treefrog	*Pseudacris regilla*	Common
Red-legged frog	*Rana aurora*	Common
American bullfrog*	*Rana catesbeiana*	Undetermined

*Introduced species

2.4.1.2 Methods

Transect and perimeter monitoring follow "Measuring and Monitoring Biological Diversity: Standard Methods for Amphibians" (Heyer et al. 1994) with some modifications. Terrestrial habitats are sampled along twenty transects and two sub-ponds (Figure 2-14).

Figure 2-14. Map of amphibian survey transects. Surveyors randomly selected the right or left bank of each transect for sampling.



Surveys begin in March and are completed approximately every 21 days until June. Sampling periods are separated by at least 21 days to allow for seasonal activity to be triggered. Incidental sightings are collected during amphibian surveys and while other work is being completed at the restoration sites. At the start of each survey, surveyors randomly select the right or left bank portion (determined while facing downstream) of each transect for sampling. Sample areas are 30 feet wide and extend from the transect end to the water's edge. Surveys are conducted by turning over objects and sifting through leaf litter within each of the designated transects (Figure 2-15). The search is constrained to a maximum of 20 minutes per transect. When an amphibian is found the species is identified (if possible) and the transect location is noted. In 2008, two seasonally-inundated wetland sub-ponds (a habitat type missing from the original monitoring scope) were added to the survey protocol. These areas are completely searched during each survey date using the same methodology and time constraints employed for transect surveys.

Perimeter searches are used to find and identify egg masses at the three constructed ponds, the Whatcom Creek swale, and Salmon Park swale. Surveys are completed by walking along the water line for each pond and swale within a 30 minute time constraint. When an egg mass is found, the species is identified (if possible) and the location described.

Figure 2-15. Surveyors lifting logs and debris while completing amphibian surveys in 2007. Note lack of vegetative cover.

Source: City of Bellingham

2.4.1.3 Results

Four amphibian surveys were completed during the 2007 season; six surveys were completed during 2008. Surveys confirmed the presence of two native frog species, one native salamander species, and one non-native frog species at the restoration sites.

In the spring of 2007, immediately following construction and planting, survey sites were characterized by a general lack of vegetative ground cover and no aquatic or emergent vegetation. Surveys were conducted prior to the first growing season. In 2008 the survey sites had much more vegetative growth and aquatic vegetation was becoming established in the ponds and stream channels. Results of amphibian surveys and incidental sightings are summarized in Table 2-11 and Table 2-12.

Figure 2-16. Pacific Tree Frog seen by WCC crew at Salmon Park on April 16, 2007.

Source: City of Bellingham

Table 2-11. Results of all amphibian surveys and incidental sightings for 2007.

Date	*Sighting Type*	*Common Name*	*Scientific Name*	*Life Stage*	*Location*	*Description/Notes*
03/26/07	Incidental	Pacific tree frog	*Pseudacris regilla*	Adult	Cemetery Creek	Inside large pile of mulch.
04/16/07	Incidental	Pacific tree frog	*Pseudacris regilla*	Adult	Salmon Park	At entrance to Salmon Park, inside understory.
05/15/07	Incidental	Salamander sp.	*Ambystoma* sp.	Hatchlings	Swale Sub-Pond (1)	10 hatchlings, likely long-toed or northwestern; water shallow and muddy.
06/26/07	Survey	Frog sp.	-	Tadpole	6 - Left	Edge of water under downed tree.
06/26/07	Survey	Frog sp.	-	Adult	14 - Right	Likely red-legged or pacific treefrog; underwater by end of log.
06/26/07	Survey	Not identified	-	Egg masses	16 - Left	Underside of logs.
06/26/07	Survey	Not identified	-	Egg masses	17 - Left	Underside of logs.
06/26/07	Survey	American bullfrog	*Rana catesbeiana*	Adult	Whatcom Creek Swale Perimeter	South end of swale, under log.
06/26/07	Survey	Frog sp.	-	Tadpole	Whatcom Creek Swale Perimeter	Edge of water under downed tree.
06/26/07	Survey	Not identified	-	Egg masses	Whatcom Creek Swale Perimeter	Underside and tops of logs.
08/16/07	Incidental	Red-legged frog	*Rana aurora*	Adult	Cemetery Creek	On north bank of mainstem channel.

Amphibian abundance for 2007 Survey sightings: 7 amphibian detections in 89 transects/perimeters searched.

Table 2-12. Results of all amphibian surveys and incidental sightings for 2008.

Date	*Sighting Type*	*Common Name*	*Scientific Name*	*Life Stage*	*Location*	*Description/Notes*
04/17/08	Survey	Long-toed salamander	*Ambystoma macrodactylum*	Adult	14 - Left	Under small log, moist and well-rotted.
05/27/08	Incidental	Pacific tree frogs	*Pseudacris regilla*	Adult	Salmon Park	Multiple individuals seen by WCC crew.
06/18/08	Survey	American bullfrog	*Rana catesbeiana*	Adult	Whatcom Creek Swale Perimeter	Moved from edge of swale into water and hid under LWD.
06/18/08	Survey	Frog sp.	-	Adult	Whatcom Creek Swale Perimeter	Likely bullfrog; seen with bullfrog at same location.
07/02/08	Incidental	American bullfrog	*Rana catesbeiana*	Adult	Cemetery Creek	Near Stream WQ station 1; two adult bullfrogs.
07/15/08	Incidental	American bullfrog	*Rana catesbeiana*	Adult	Cemetery Creek	Near Stream WQ station 1.
07/28/08	Incidental	Red-legged frog	*Rana aurora*	Adult	Cemetery Creek	Hopping along West Pond edge, on path moving toward South Pond.
07/28/08	Incidental	American bullfrog	*Rana catesbeiana*	Adult	Cemetery Creek	Near Stream WQ station 3; two adult bullfrogs.
07/29/08	Incidental	Red-legged frog	*Rana aurora*	Adult	Cemetery Creek	On edge of South Pond, near Pond WQ station 8.
09/08/08	Incidental	Red-legged frog	*Rana aurora*	Adult	Cemetery Creek	In LWD at bend in mainstem channel, just downstream of backwater.

Amphibian abundance for 2008 Survey sightings: 3 amphibian detections in 161 transects/perimeters searched.

2.4.1.4 Discussion

Amphibian abundance was very low during both 2007 and 2008 surveys. However, an increase in incidental sightings of adult native frogs (especially red-legged frogs) during 2008 is likely indicative of improving amphibian habitat conditions at the restoration sites (Figure 2-17).

Figure 2-17. Red-legged Frogs recorded as incidental sightings at Cemetery Creek restoration site, (a) July 29, 2008 and (b) September 8, 2008.

(a)

Source: City of Bellingham

(b)

Source: City of Bellingham

Low amphibian detection during 2007 and 2008 surveys could be the result of a number of factors. First, habitat quality was low during 2007 surveys, with surveys taking place directly after the large-scale disturbance of the area during construction. Because the area was replanted during the dormant season, most transects had an overall lack of vegetative cover near pond edges (Figure 2-13). Salmon Park sites (transects 1-4) were bare of most vegetative cover during all amphibian survey dates. Cemetery Creek sites (transects 5-20) had no aquatic vegetation and minimal vegetative cover within ten feet of the water's edge. There was also very little emergent vegetation. Emergent vegetation provides cover and food, as well as critical attachment points for the egg masses of some amphibians (Henning 2004).

Habitat quality was improved during the 2008 survey season, with the growth of plants, natural recruitment, and the additional planting of sedges and other plants along pond edges. Natural recruitment of aquatic vegetation had also begun. Nevertheless, cover and habitat complexity have still not reached optimal conditions. The one adult salamander that was found

(Figure 2-18) was located in an area of established habitat complexity, with decaying wood and leaf litter, uncharacteristic of many other transects.

Figure 2-18. Adult long-toed salamander found during 2008 surveys at transect 14 - Left.

Source: City of Bellingham

Secondly, incidental sightings have confirmed the use of habitat types outside of ponds and swales by amphibians. These include stream habitat types along Cemetery and West Cemetery Creeks. There is abundant decayed woody debris in many of these areas which would be attractive to amphibians. It is probable that the transects and perimeters as established are missing amphibian populations within these different habitat types in the restoration site.

Thirdly, native amphibian populations may be depressed due to the presence of American Bullfrogs at the restoration sites (Figure 2-19). American Bullfrogs had not been conclusively documented in the Whatcom Creek watershed prior to this survey (Eissinger, 2003). The presence of this non-native species would be expected, however, since it has been spreading throughout the Pacific Northwest since its introduction in the 1930s. Bullfrogs prey upon, outcompete and displace native amphibians in warm permanent ponds throughout the area. They also have few predators (Corkran 2006). Unfortunately, the complete removal of bullfrogs is difficult and time-intensive, and in some places, impossible (Link, 2004). A removal program at the restoration sites would be prohibitively time-consuming, requiring daily visits to remove eggs, tadpoles, and adults. Furthermore, re-colonization would be likely due to the proximity of the restoration sites to other bodies of water. Bullfrogs have not been documented using seasonal wetlands in Washington State due to its cool climate, although such cases have been documented in warmer areas of Oregon (Link 2004). Henning (2004) suggests that conservation efforts are better targeted to seasonal wetlands, "which will directly benefit natives and reduce non-native fish and bullfrog habitat". Seasonal wetlands identified at the restoration sites during 2007 could provide this important habitat type. Surveys of these two areas in 2008 did not yield amphibian sightings, likely due to a lack of standing water during the majority of the surveys.

Figure 2-19. American Bullfrog seen during amphibian survey during Whatcom swale perimeter search, June 18, 2008.

Source: City of Bellingham

2.4.1.5 Recommendations

- ✓ Train surveyors to identify American bullfrog egg masses. Upon confirmed identification, these egg masses will be removed and destroyed.
- ✓ Continue detailed recording of incidental sightings to supplement surveys.
- ✓ Increase 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

There have been few studies of bird populations in the Whatcom Creek watershed. Eissinger (2003) estimates that the Whatcom watershed may support up to 112 different bird species. The objective of avian surveys at Cemetery Creek and Salmon Park is to identify species composition and abundance as well as changes in composition and abundance at the restoration sites over time.

2.4.2.2 Methods

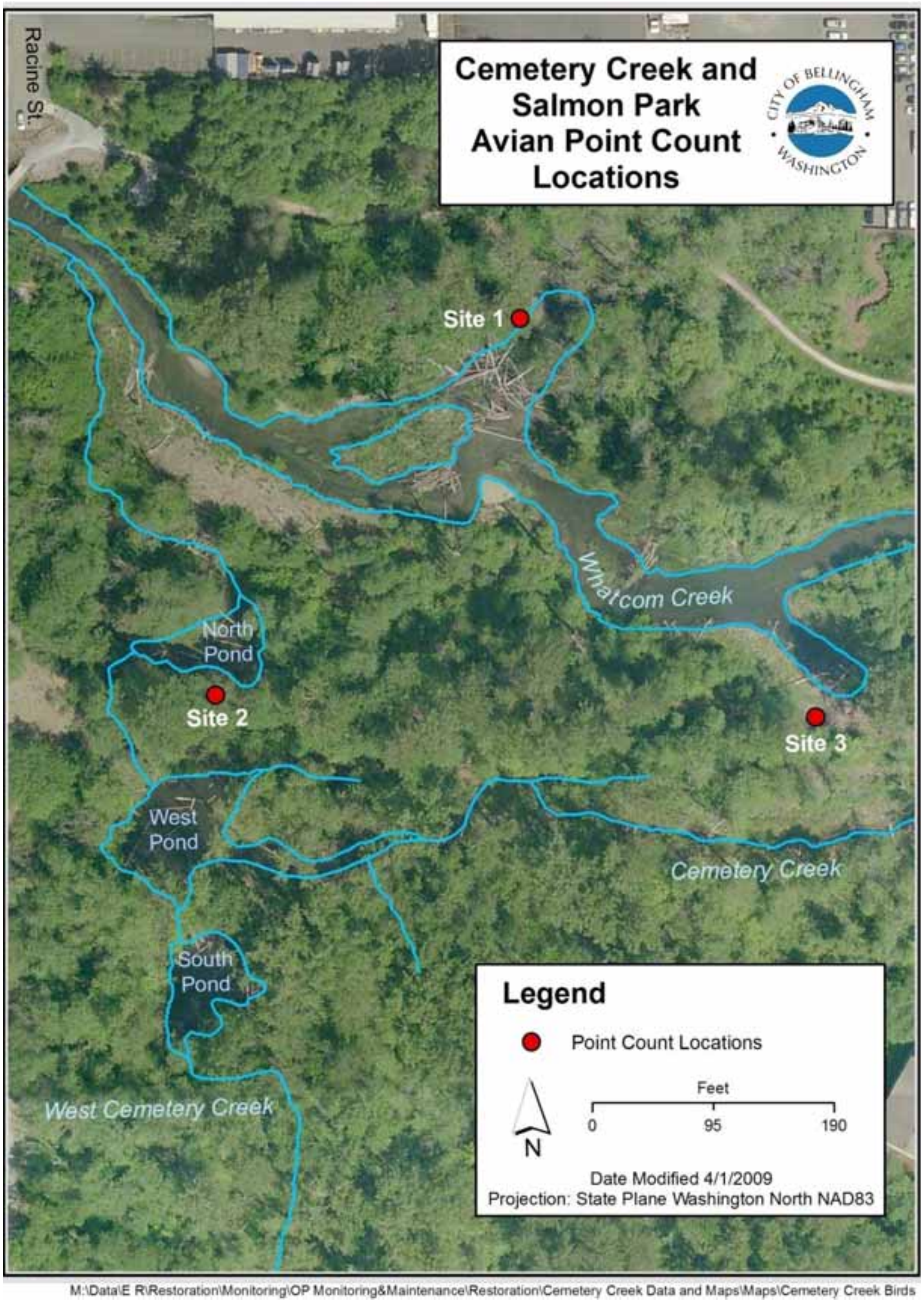
Monitoring protocols follow standard USDA methods and the "Handbook of field methods for monitoring landbirds" (Ralph 1993) with some modifications. Point counts are conducted at three locations within the restoration area that are distinguished by habitat type (Figure 2-20). Points 1 and 3 are characterized as wetland/swale, with Point 2 characterized as forested stream/pond network. While the points are not quite 820 feet (250 meters) away from one another as specified by the protocol, bird calls that are more than 500 feet away are not counted to reduce overlap. Ralph (1993) states that more than 99 percent of individual birds are detected within 410 feet (125 meters) of the observer, especially in forested habitats.

Point counts begin 30-45 minutes after sunrise and are completed within two hours. Surveyors approach the point count locations with as little disturbance as possible. Counts are conducted over three minutes. Birds are identified by primary song, calls, and sight and are placed in distance categories: 0-150 feet (approximately 0-50 meters), 150-500 feet (approximately 50-150 meters) and flyovers. Individuals are tallied into distance categories; no individual is to be counted twice. If a bird flees when surveyors arrive at the point, the bird is included according to its take-off location. Birds flushed within 150 feet of a point's center while entering or leaving the point are counted as being at the point if no other individuals are seen during the count period. Flocks or unknown individuals detected during counts can be followed at the end of the count to confirm flock composition, size and individual identity.

Surveys begin in March and are conducted every 20-30 days through June. Surveyors include COB and WCC staff, and experienced volunteers from Western Washington University. Incidental sightings are also noted while conducting unrelated activities within the restoration site.

Birds are not surveyed during poor weather conditions; rain, wind, fog and cold weather can all interfere with visibility, audibility and activity of birds. For subsequent survey years, the timing of the start of surveys should not differ by more than seven days from the date of the first count (March 6, 2007). The start of the count should also not differ by more than 30 minutes from that of the first year.

Figure 2-20. Map of point count locations.



2.4.2.3 Results

Point count surveys provide a quantitative estimate of the species and number of birds present during the breeding season. It should be noted that point counts do not provide reliable data on waterfowl and certain landbirds that are particularly quiet or nocturnal (Ralph 1993).

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 2-13. Incidental sightings are listed separately in Table 2-14.

Table 2-13. Bird species composition for the Cemetery Creek and Salmon Park restoration sites, 2007 and 2008. Total number of species is 63.

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

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

This list includes two Washington Department of Fish and Wildlife priority species, wood ducks and pileated woodpeckers (WDFW 2008). The presence of these priority species was reported to Washington Department of Fish and Wildlife. Additional species were seen at the sites that would qualify as priority species only under specific conditions that were not met at the restoration sites. For example, great blue herons and merlins are considered priority species only in areas used for breeding, which has not been documented at the sites.

Table 2-13 also indicates one non-native species seen at the restoration sites, the European starling. The European starling is an aggressive cavity-nesting species which often ejects other nesting birds from cavities. This species is associated with open field habitats and likely benefits from forest fragmentation. A 2008 survey of cavity-nesting birds at the restoration sites (Dolan 2008) is discussed below.

Also of note is the presence of brown-headed cowbirds. Although historically present in the short-grass prairies of Washington, cowbirds have extended their range into areas of human impact, and are currently present in most areas of Washington, outside of forest interiors. Cowbirds are nest parasites; common hosts include cedar waxwings, American robins and Stellar's jays, all of which can recognize cowbird eggs in the nest and will often eject them or rebuild their nest. Other common hosts cannot recognize cowbird eggs and often lose their broods to cowbird nestlings; these include the two most often parasitized species in the United States, yellow warblers and song sparrows (Seattle Audubon Society 2009), both of which are present at the restoration sites.

Table 2-14. Bird species documented during incidental sightings only in 2007 and 2008.

Incidental Sightings	
2007	**2008**
Great Blue Heron	Bald Eagle
Merlin	Belted Kingfisher
Red-breasted Sapsucker	Chestnut-backed Chickadee
Red-tailed Hawk	Common Merganser
Tern species	Common Nighthawk
Yellow Warbler	Fox Sparrow
	Golden-crowned Sparrow
	Great Blue Heron
	Hooded Merganser
	Northern Harrier
	Red-tailed Hawk
	Stellar's Jay
	Varied Thrush
	Vaux's Swift
	Wood Duck (pair with 3 fledglings)

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

A summary of point count data is presented in Table 2-15. Summary statistics are presented in Table 2-16.

Table 2-15. Number of individual birds and species richness (total number of species detected) for each point count survey conducted in 2007 and 2008.

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

Table 2-16. Summary statistics for point counts at each station, 2007 and 2008.

	2007		2008	
Point Count Station	Average Number of Individuals	Cumulative Species Richness	Average Number of Individuals	Cumulative Species Richness
1	19.33	24	13.83	20
2	19.17	23	17.67	28
3	19.33	26	14.67	25
Average	19.28	24	15.39	24
Cumulative	57.83	34	46.17	40

Average number of species seen that year during counts
Total number of species seen that year during counts

All point count results are being entered 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 the website.

2.4.2.4 Discussion

Overall, the restoration sites show high species richness, with 63 species positively identified. The species list does not include nocturnal birds that likely use the restoration site; these may include barn, great horned, barred and western screech owls. A crepuscular species, the common nighthawk, was identified during an incidental sighting in 2008. The average of cumulative species richness at each point count site stayed the same between 2007 and 2008: 24 species. The cumulative species richness of points increased between 2007 and 2008: from 34 to 40 species. This increase is likely due to an improvement in the skill level of surveyors, rather than a change in species richness.

A study of cavity-nesting birds at the restoration sites (Dolan 2008, attached in Appendix A) indicates that starling activity is detrimental to the breeding success of native cavity-nesters, such as red-shafted flickers, pileated woodpeckers and black-capped chickadees. The fragmented nature of the habitat surrounding the restoration sites indicates that the success of starlings in dominating cavities is not likely to decrease. However, numerous snags created from the 1999 fire also exist in the upland habitat inside Whatcom Falls Park, a more densely and extensively forested area. It is hypothesized that cavity use in these areas is less severely impacted by starling activity.

The restoration areas are used as foraging and nesting habitat by resident and migrating passerines. The fragmented nature of the surrounding habitat and the presence of starlings and cowbirds suggests that the restoration site may provide only marginal nesting habitat. Despite this, the site may supply important foraging and resting habitat for migrating birds, called stopover habitat (Moore et al. 2005). The sudden overnight arrival at Cemetery Creek of approximately thirty male Wilson's warblers on May 6, 2008 is suggestive of this. The following day, all but a handful of the warblers remained at the site, indicating that the rest of the birds had used the restoration site to forage and rest before continuing their migration. As native vegetation grows, habitat complexity will increase, providing improved stopover habitat for migrating songbirds.

2.4.2.5 Recommendations

- ✓ Continue to improve expertise of point count surveyors through additional training. Include additional biologists and identification experts as volunteers.
- ✓ Encourage an intern or student to conduct a companion survey on cavity-nesting birds in the burn zone located within Whatcom Falls Park.

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 this survey is to document use of the restoration area by mammals and assess damage of project components by wildlife, if applicable.

2.4.3.2 Methods

Monitoring of mammals at the restoration sites is qualitative and used primarily to document presence and to track damage of project components by wildlife. 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, damage).

Figure 2-21. Raccoon tracks seen along Cemetery Creek on January 16, 2009: hind foot on left, front foot on right.

Source: City of Bellingham

2.4.3.3 Results

Nine mammal species have been identified at the restoration sites. Eastern cottontails and eastern gray squirrels are the only non-native mammals identified to date. Results are summarized in Table 2-17.

Table 2-17. Summary of all mammals identified at the Cemetery Creek and Salmon Park restoration sites, 2007-2008.

Species	Latin Name	Type of Identification	Notes
Beaver	*Castor canadensis*	Visual, tracks, browse patterns	
Black-tailed Deer	*Odocoileus virginianus*	Visual, tracks, browse patterns	Adults and fawns
Coyote	*Canis latrans*	Scat, tracks	
Eastern Cottontail	*Sylvilagus floridanus*	Visual	Non-native species
Eastern Gray Squirrel	*Sciurus carolinensis*	Visual	Non-native species
Mink	*Mustela vison*	Visual	West Pond
Mustelid species	*Lontra canadensis* (likely)	Scat	Likely River Otter
Raccoon	*Procyon lotor*	Tracks	
Rodent species	*Arvicolinae* subfamily	Visual	Likely Vole species

Figure 2-22. Black-tailed Deer fawn seen with female and sibling at Cemetery Creek restoration site, August 23, 2008.

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. No state-listed priority species were identified. Sightings recorded in 2007 and 2008 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. Damage to trees by beaver in 2006 and 2007 has been ameliorated by the placement of fencing; beaver activity in 2008 was minimal. Beaver activity continues to be monitored and the deterrent program may be upgraded if damage resumes. At this time, there is no evidence that human use is detrimental to the mammalian wildlife community.

2.4.3.5 Recommendations

No changes are recommended at this time.

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 confirm that the three ponds maintain their functional intent and their designed depth and volume characteristics.

3.1.1.2 Methods

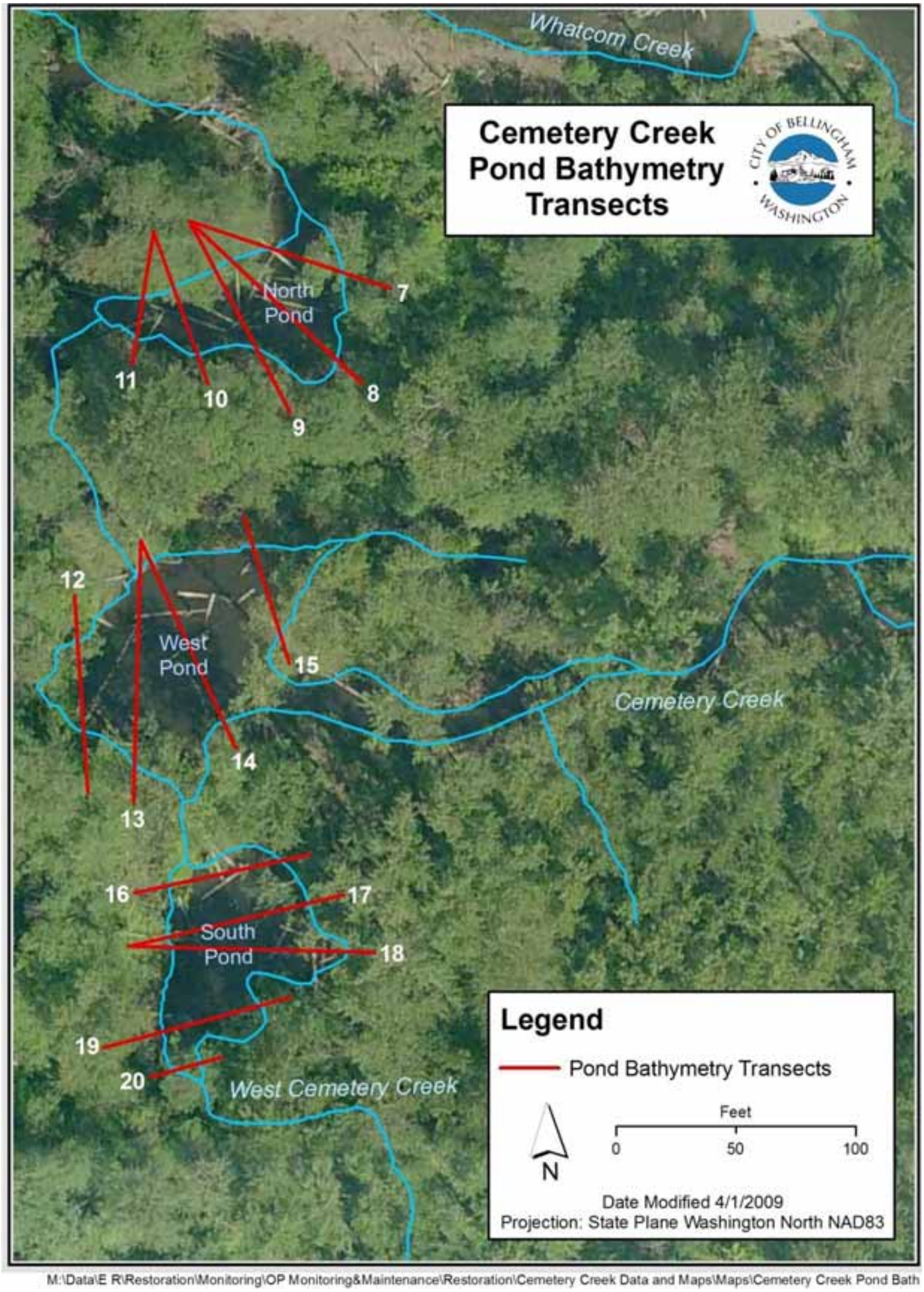
Fourteen bathymetry transects were surveyed: five in the North pond, four in the West Pond, and five in the South Pond (Figure 3-1).

A staff gage was installed in each of the three ponds to facilitate tracking of fluctuations in pond water surface elevation (WSE). Each staff gage is linked to a local benchmark. Pond water surface elevation is recorded monthly during water quality sampling, and each time the site is visited for other monitoring tasks including pond bathymetry surveys.

The depth of each pond is measured across a series of four to five transects. The WSE is recorded at the start and end of each survey. Pond depth from the WSE is measured at 1- or 2-foot intervals across each transect using a stadia rod. Survey data are corrected to a common reference to facilitate interannual comparisons.

Changes in pond depth will be tracked along each transect to determine whether the pond habitat is maintained, filling, or scouring. Transects coincide with those used for vegetation and amphibian surveys. As a result, transect endpoints are located well back from pond margins, and the measurement stations do not start at zero.

Figure 3-1. Map of pond bathymetry transects.



3.1.1.1 Results

Pond surveys were conducted on March 5 and April 18, 2007 and April 22-24 and May 27, 2008. Data are entered into spreadsheets and plotted on the same chart to facilitate identification of changes in pond depth over time. A separate chart is produced for each transect (see example in Figure 3-2). A full set of charts for each transect is provided in Appendix B.

Maximum depth and averaged volume (average width x average depth x length) increased for all ponds from 2007 to 2008 (Table 3-1). The average depth of each transect increased in all transects except for transect 20, which showed a small decrease (Table 3-2).

Figure 3-2. Plot of pond bathymetry data (2007 and 2008) for transect 17 in the South Pond. The water surface is represented by the top x-axis.

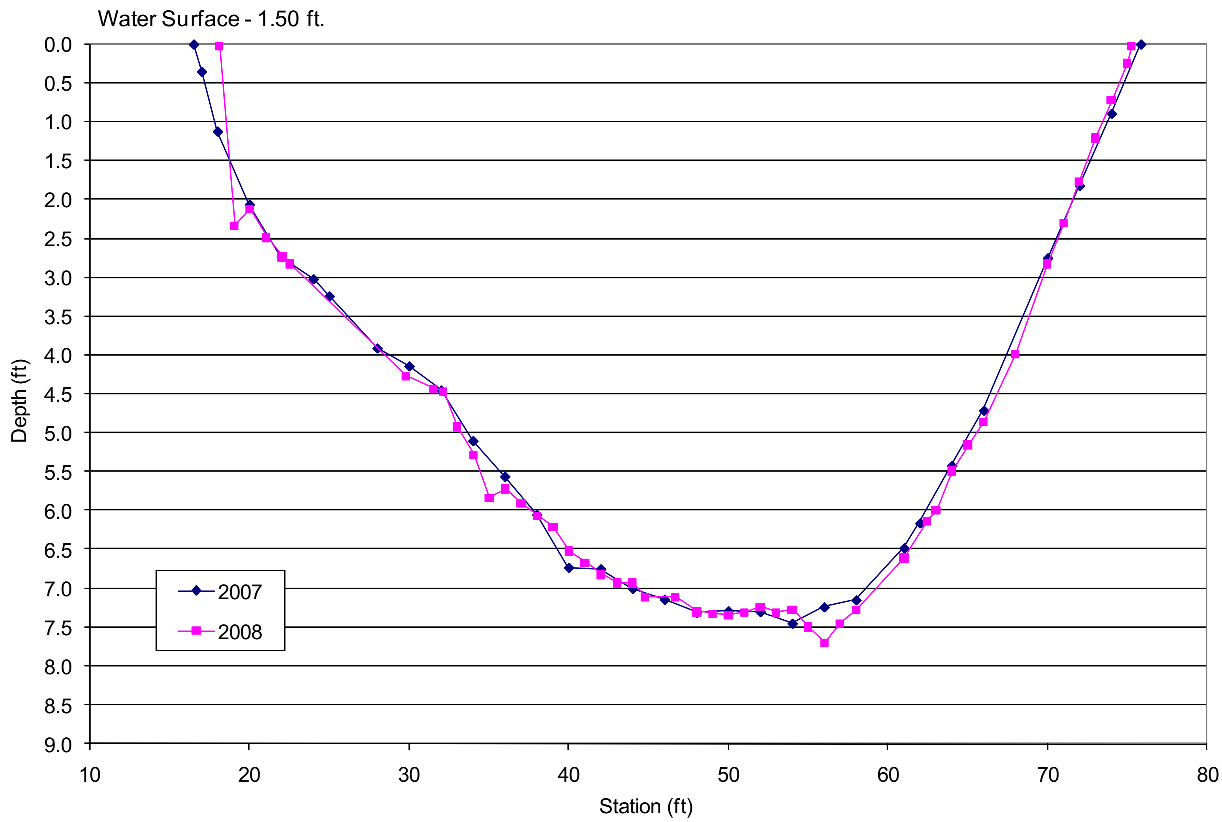


Table 3-1. Maximum depth, averaged volume and percent changes in ponds, 2007-2008.

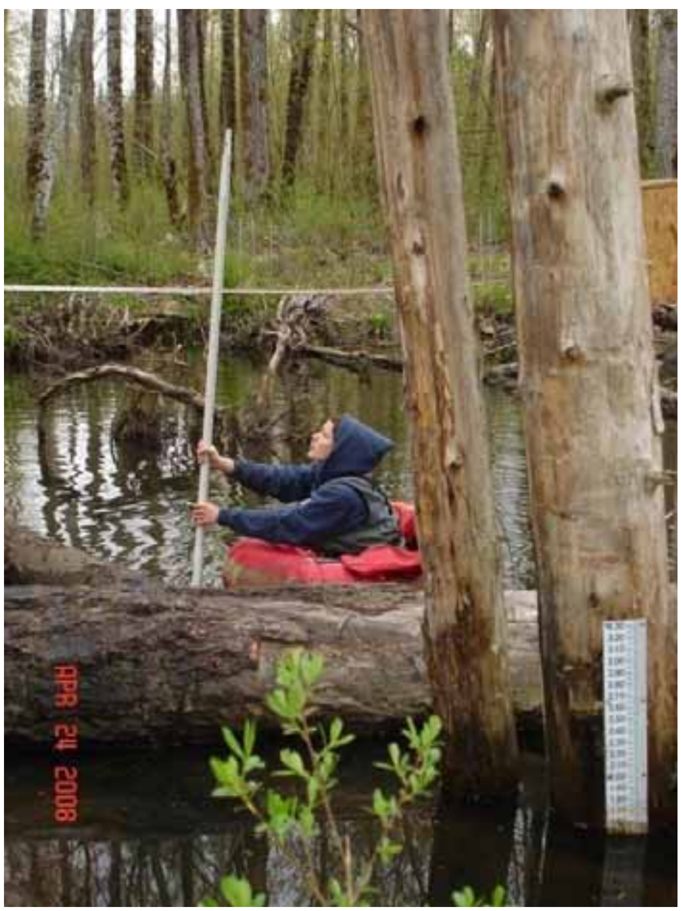
	Maximum Depth (ft)			Volume (ft^3)		
	2007	2008	% Change	2007	2008	% Change
North Pond	4.83	5.58	16%	10,184	10,709	5%
West Pond	7.84	8.67	11%	19,145	19,824	4%
South Pond*	7.45	7.70	3%	19,597	21,112	8%

*PTR20 data excluded from volume calculation; transect crosses inflow and is not representative of pond conditions.

Table 3-2. Average depth and percent changes in bathymetry transects, 2007-2008.

	Transect	Average Depth (ft) 2007	2008	% Change
North Pond	7	2.49	2.52	1%
	8	2.50	2.65	6%
	9	2.92	3.06	5%
	10	2.06	2.30	11%
	11	1.89	2.10	10%
West Pond	12	3.77	3.85	2%
	13	4.45	4.70	5%
	14	4.82	4.96	3%
	15	2.23	2.59	14%
South Pond	16	1.85	2.10	12%
	17	4.56	5.04	10%
	18	3.81	3.96	4%
	19	2.96	3.30	10%
	20	0.25	0.24	-2%

Figure 3-3. WCC surveyor using stadia rod to measure pond depth along transect marked by measuring tape, April 24, 2008. Staff gage in foreground.

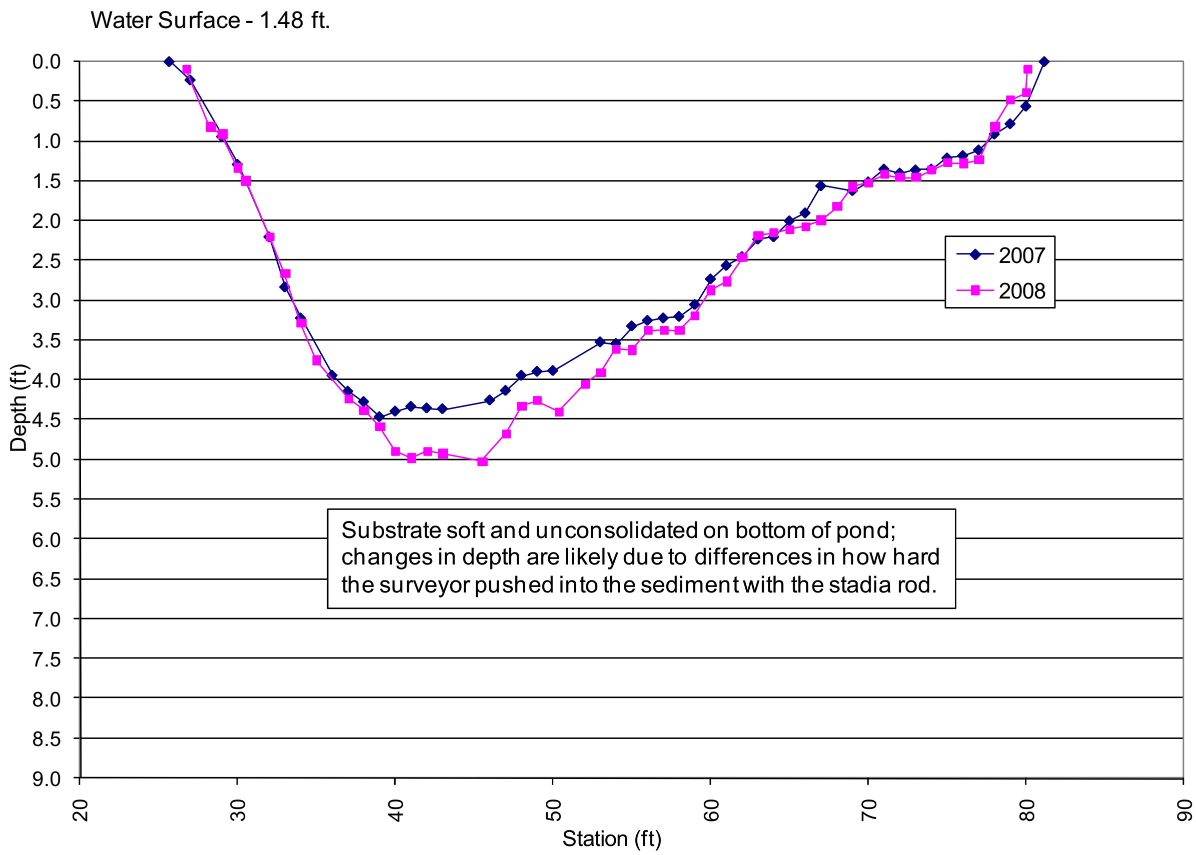


Source: City of Bellingham

3.1.1.2 Discussion

A layer of soft substrate was noted on the bottom of each pond during 2007 and 2008 bathymetry surveys. Depths during both years were measured by allowing the stadia rod to settle into this layer then pressing down until it hit a solid surface. Changes in depth between years are likely due to surveyor differences in holding the rod (Figure 3-4). Taking these changes into account, it appears that the ponds are maintaining their designed depth and volume characteristics.

Figure 3-4. Plot of pond bathymetry data (2007 and 2008) for transect 8 in the North Pond. The water surface is represented by the top x-axis.



3.1.1.3 Recommendations

- ✓ Due to the difficulty in reproducing survey techniques using the stadia rod, all future pond bathymetry surveys should use a weight and tape methodology. A 4 ounce fishing weight will be attached to a Kevlar measuring tape and lowered until it touches the bottom of the pond.

3.1.2 Ponds – Habitat

The original study plan called for the development of a schematic map of each pond. Large woody debris features were to be sketched into the schematic, and LWD length, diameter and condition were to be recorded. Due to insufficient staff time, the schematic portion of the monitoring plan was not completed during the 2007 or 2008 seasons. Data on LWD in the ponds is collected during habitat and LWD surveys. A table (Table 3-7) of LWD in the constructed ponds is presented in Section 3.1.5. Changes in the amount and condition of LWD in the ponds will be tracked through this survey and presented with other habitat and LWD results in the future.

3.1.3 Stream Channels – Cross-Sections

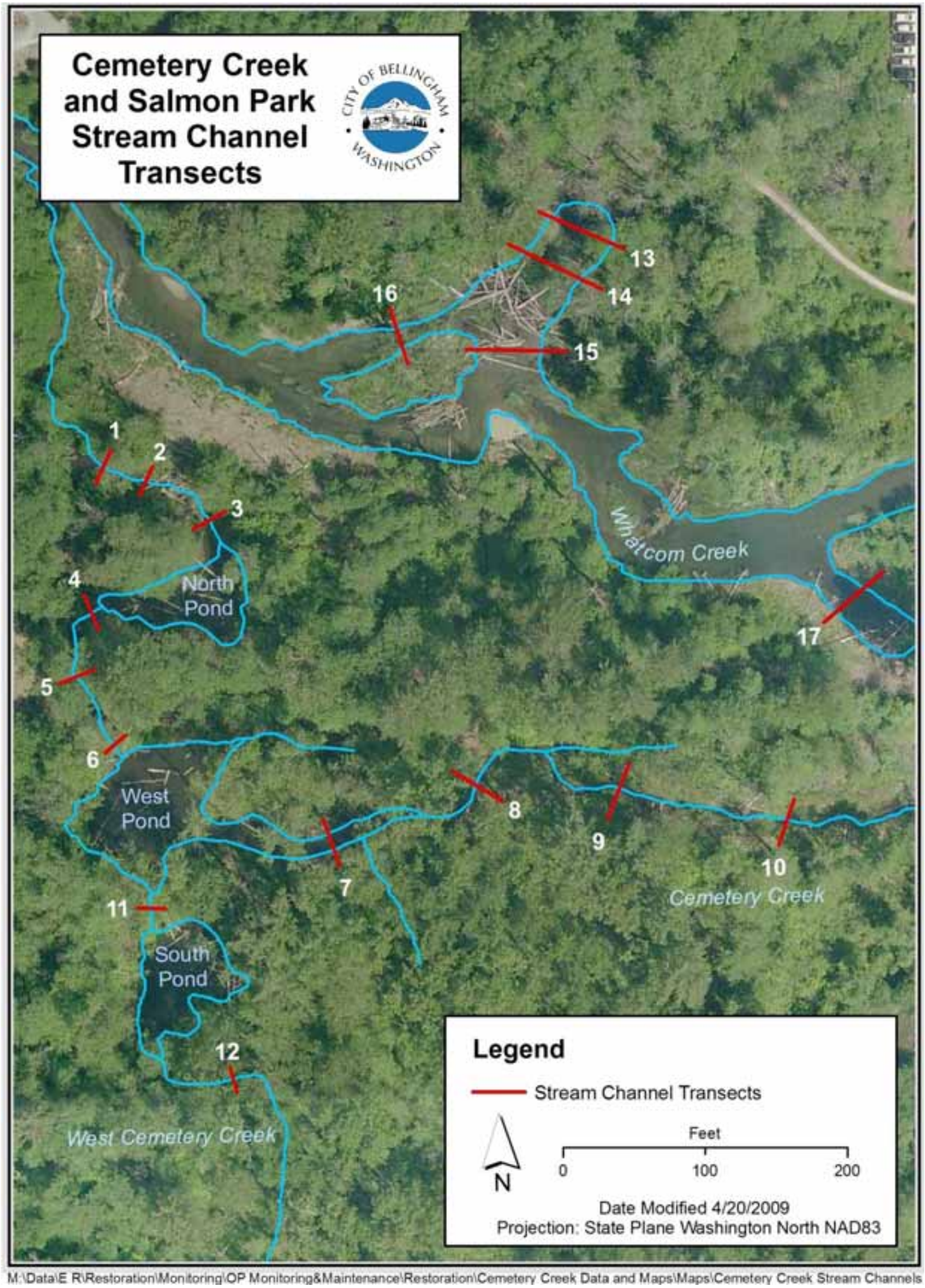
3.1.3.1 Introduction

Restoration actions involved constructing new portions of the Cemetery Creek and West Cemetery Creek channels to produce a meandering planform, reduce channel incision and increase habitat complexity. The newly created channels resulted in increased channel length, decreased channel slope and altered channel cross-sections in some places. A series of channel cross sections were surveyed to document the post-project channel configuration (Figure 3-5). The objective of channel cross section surveys is to confirm that the channels maintain the functional intent of the design.

3.1.3.2 Methods

In 2007, channel transects 1-10 were surveyed using an autolevel and stadia rod. Survey data were linked to local benchmarks. In 2008, an autolevel was not available, so transects 1-10 were surveyed using the sag tape method. Transects extend beyond the bankfull channel margins. Cross section end points are marked with wooden stakes or nails in trees, labeled with aluminum tags and located using GPS. Surveys are conducted during the winter or early spring when visibility is enhanced due to leaf fall. Due to insufficient staff time, transects 11 through 17 were not surveyed during the 2007 or 2008 seasons.

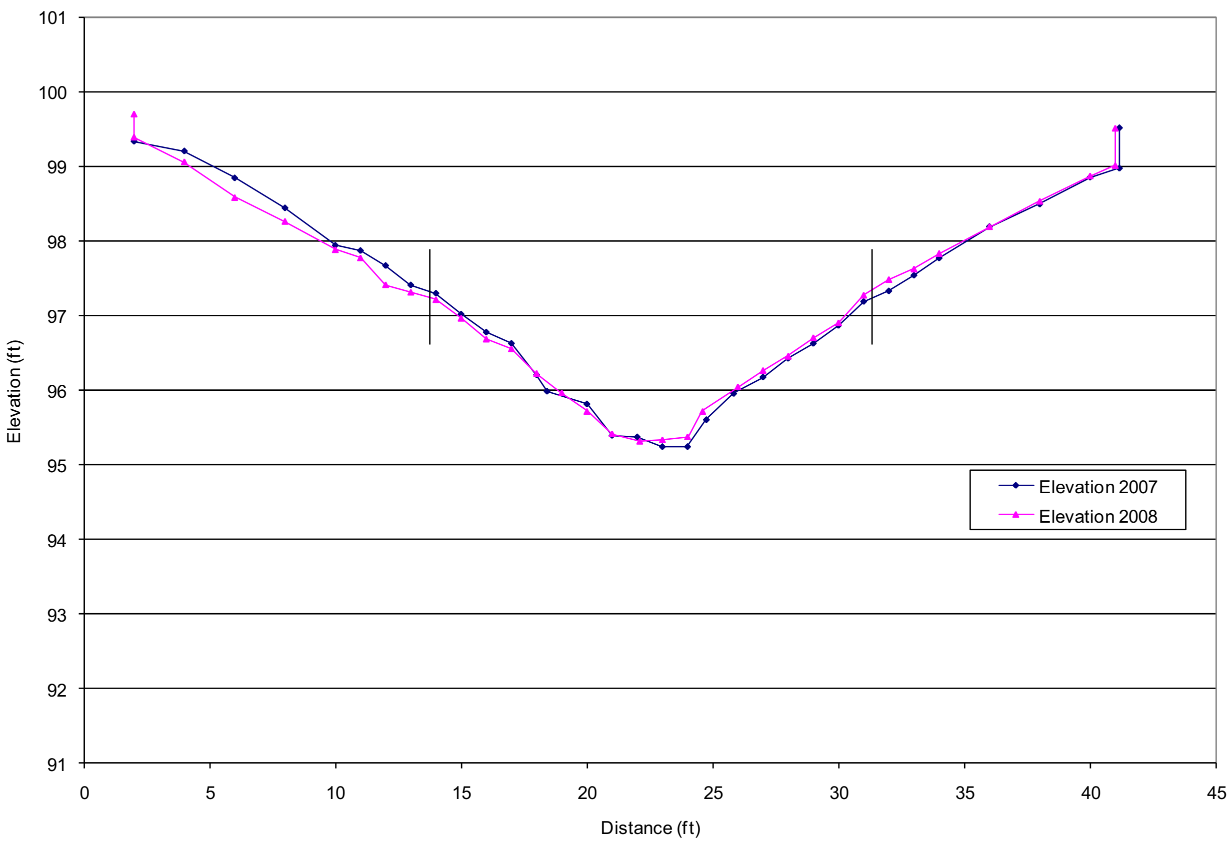
Figure 3-5. Map of stream channel cross section transects.



3.1.3.3 Results

A total of ten channel cross sections (transects 1-10) were surveyed on Cemetery and West Cemetery Creeks in 2007 and 2008. Data were entered into spreadsheets; data collected in 2007 and 2008 were plotted on the same chart to facilitate identification of changes in channel morphology. A chart was produced for each transect (see example in Figure 3-6). A full set of charts for each transect is provided in Appendix C.

Figure 3-6. Plot of channel cross section transect data from 2007 and 2008 for transect STR9. Vertical black lines indicate bankfull width.



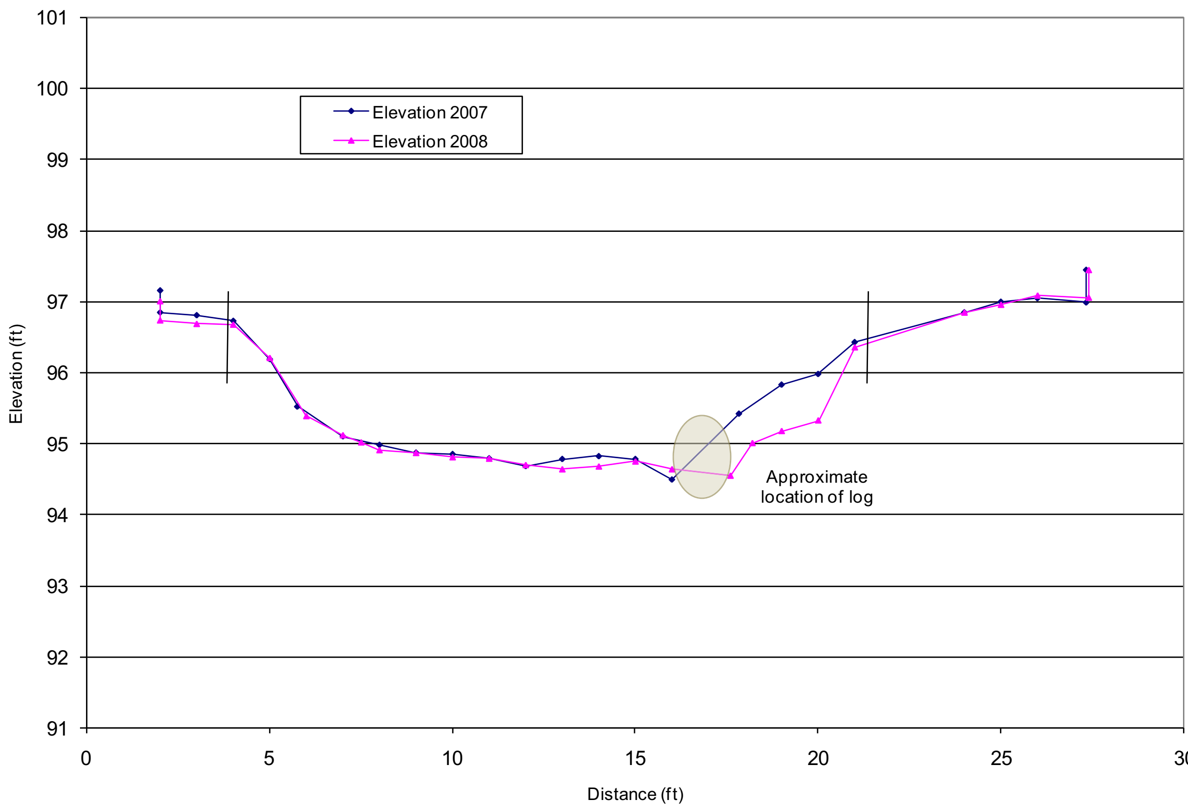
Mean bed elevations were calculated for each of the ten transects in 2007 and 2008, as well as the change in mean bed elevation from 2007 to 2008 (Table 3-3). Small positive changes in mean bed elevation are likely due to the differences in survey techniques used between years; the sag tape method often results in slightly increased measurements across the transect. In no case was the observed change more than 2.5 inches.

Table 3-3. Mean bed elevations within the bankfull width for stream channel transects, 2007 and 2008, with change from 2007 to 2008.

	Mean Bed Elevation (ft)		
Transect	2007	2008	Change
1	95.75	95.79	0.04
2	95.28	95.43	0.15
3	94.99	95.17	0.18
4	93.64	93.81	0.17
5	95.31	95.14	-0.17
6	95.24	95.26	0.02
7	94.83	94.97	0.14
8	96.14	96.13	-0.01
9	96.22	96.22	0.00
10	98.45	98.4	-0.05

One transect, transect 5, showed a change in channel configuration (Figure 3-7). There is a placed log near the right bank side of the transect, with a large rooted tree just downstream on the right bank. There has been some erosion of the bank, as indicated in Figure 3-7, to the right bank side of this log. The large rooted tree just downstream of the erosion point appears to be blocking any continued erosion of the bank. Future channel surveys will monitor any changes in this transect.

Figure 3-7. Plot of channel cross section transect data from 2007 and 2008 for transect 5. Vertical black lines indicate bankfull width. The brown oval represents the location of the log.



3.1.3.4 Discussion

Despite a change in surveying methodology, stream channel transects appear to be maintaining the designed configurations, with the exception noted at transect 5. Future surveys will be plotted on 2007 charts to illustrate changes in channel configuration, if any.

3.1.3.5 Recommendations

- ✓ Completely survey all transects (1-17) in 2009.

3.1.4 Stream Channels – Thalweg Profiles

The original study plan called for thalweg profiles in order to track changes in channel configuration. Due to insufficient staff time, this portion of the monitoring plan was not completed during the 2007 and 2008 seasons. Because of the resulting lack of baseline data, this portion of the study plan has been discontinued. Changes in the channel thalweg profile can be 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.

3.1.5 Stream Channels – Habitat

3.1.5.1 Introduction

The objective of habitat surveys is to document that reconstructed streams channels are functioning as designed and provide suitable habitat for salmonids. Channel complexity in streams has been demonstrated to support salmonid production. Specifically, pool habitats and the presence of large woody debris (LWD) are important for numerous salmonid life stages.

3.1.5.2 Methods

Habitat surveys are conducted following a modified version of the Timber Fish and Wildlife Methodology for Habitat Unit Survey (Pleus et al. 1999), and Level 2 Large Woody Debris Survey (Schuett-Hames et al 1999). Habitat is broken down into core types (fast water and slow water) and sub-unit types (riffle, run, glide, pool and backwater). Descriptions of sub-unit types can be found in Table 3-4. Constructed ponds are included in the habitat survey, and are counted as pools.

Habitat surveys are conducted by two surveyors working upstream. Lengths of units are measured using a fiberglass tape; wetted channel widths are measured with the tape or stadia rod. For pool units, maximum and outlet control depths are measured with the stadia rod. Residual pool depth, the difference between the maximum depth and the outlet control depth, are calculated from these measurements. Pool forming factors are also noted.

Level two large woody debris surveys are conducted concurrently with habitat unit surveys. Parameters measured include piece diameter, length in zones 1-3 (within the bankfull channel), stability, channel orientation, decay class, whether the piece was placed during construction, whether the piece contributes to sediment storage, and whether the piece has a pool forming function. Debris jams are identified as structures with a minimum of ten pieces of LWD, with at least one piece entering zones 1 or 2. Jams are tallied by size class, with key pieces noted.

Data collection occurred from September 8 to 12, 2008. Staff gages are monitored each survey day; there was no recorded change in water surface elevation between survey dates. Surveys are conducted by trained COB and WCC staff. Due to lack of staff time, habitat and LWD surveys were not initially conducted until January and February 2008. Because this initial survey was conducted at high flows, it is not comparable to the September 2008 survey. It is preferred that surveys are conducted at low flow levels; future surveys will be conducted during low flows in August or September and will be compared to the baseline September 2008 survey data.

Table 3-4. Sub-unit types used for Cemetery Creek habitat surveys.

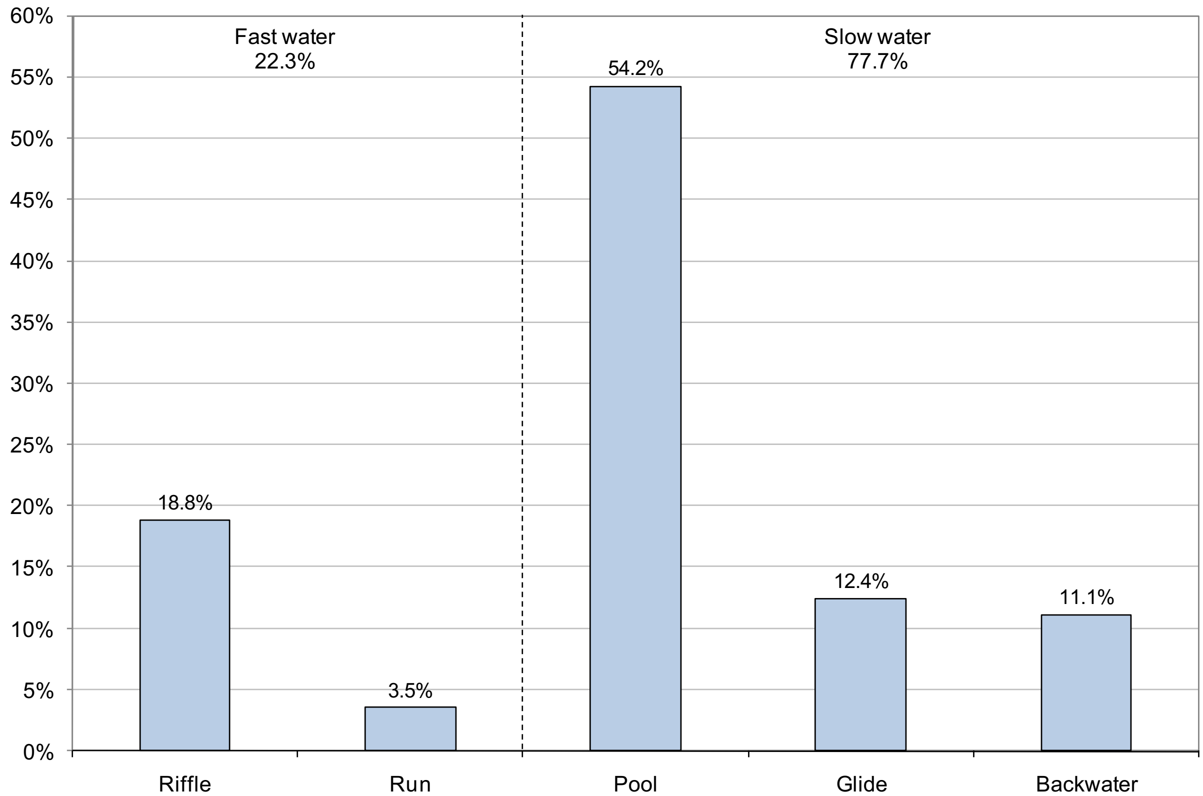
Riffle	A unit with predominantly fast water and notable surface turbulence.
Run	A unit with relatively deep, fast water and minimal surface turbulence.
Glide	A unit with relatively deep, slow water and minimal surface turbulence.
Pool	A unit with predominantly deep, slow water. In the survey area, an area qualifies as a pool if the residual pool depth* is at least 0.7 feet.
Backwater	A unit with slow water, deep or shallow; may be formed by a backup of water from a pond unit or by a secondary channel that dead-ends.

**Residual pool depth is the difference between the maximum depth of the pool unit and the depth of the crest that forms the pool's hydraulic control.*

3.1.5.3 Results

Habitat Units: The reconstructed channels of Cemetery and West Cemetery Creeks had more slow water than fast water, as illustrated in Figure 3-8. Pools were the dominant habitat sub-unit. Although there is no available pre-construction habitat data, Cemetery and West Cemetery Creeks were channelized and habitat complexity was likely low prior to restoration.

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



Pool Assessment*:* Pools are a sub-unit type of slow water that provide essential habitat for salmonids. Pool indices provide simple quantitative indicators of habitat quantity and quality. Pool indices for the Cemetery Creek restoration site are presented in Table 3-5.

The frequency that pools occur within a stream channel is a fundamental component of channel morphology (Montgomery et al. 1995). Pool frequency is expressed in terms of the channel length normalized by channel width, divided by the number of pools (channel widths/pool). Pool frequency is a primary channel attribute that is very sensitive to LWD loading in pool-riffle channel types, such as Cemetery Creek. Pools formed in association with LWD are often deep low velocity habitat with cover, an important habitat type for salmonids of varying life stages.

Deep pools are especially beneficial for rearing fish as they provide enhanced protection from predators and improved temperature and flow regulation. Residual pool depths greater than 3-feet ("holding pools") are also important for holding adult salmon prior to spawning. In the Cemetery Creek system the three pools that qualify as holding pools are the constructed North, West and South ponds.

Table 3-5. Pool indices at the Cemetery Creek restoration site.

Pool Indices	
Pool Tally (#)	24
Pool Percentage (by length)	54%
Pool Frequency (channel widths/pool)	3.7
Pool Spacing (pools/mile)	86
Holding Pools (residual depth > 3 ft)	3
Average Residual Pool Depth (ft)	2.3
Pools Formed by LWD (%)	67%

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 are presented below in Table 3-6.

Large woody debris was placed in the channel as part of the restoration project to provide cover, increase complexity, stabilize banks and maintain pools. Many of the pools currently present contain LWD. Wood placed as part of the construction project generally consisted of large conifers with attached rootwads. The location of LWD in the stream channel is determined by zones; most wood extended into the wetted channel (zone 1) and contributed to habitat complexity. The average diameter of individual pieces of LWD was 13.8 inches, and the average piece length (zones 1-3) was 13.2 feet. "Key pieces" aid in trapping additional in-channel wood and enhance woody debris and channel stability. Similarly, stability and orientation of individual pieces influence the long-term effectiveness of LWD in promoting habitat complexity. Changes in these indices over time will provide data on the effectiveness of LWD placement in improving habitat conditions. A table of LWD counted in the constructed ponds is presented below (Table 3-7).

Table 3-6. LWD indices at the Cemetery Creek restoration site.

Large Woody Debris Indices	
Total number of LWD *(pieces and jams)*	249
Pieces per channel width (p/cw)	2.8
Large Pieces *(pieces and jams)*	32
Large Pieces per channel width (p/cw)	0.4
Key Pieces *(jams only)*	132
Key Pieces per channel width (p/cw)	1.5
(all of the following indices are pieces only)	
Number of pieces in Zone 1	72
Number of pieces in Zone 2	19
Number of pieces in Zone 3	10
Percentage of pieces in Zone 1	71%
Percentage of pieces in Zone 2	19%
Percentage of pieces in Zone 3	10%
Pieces forming pools	39
Percentage of pieces forming pools	39%
Pieces trapping sediment	9
Percentage of pieces trapping sediment	9%
Orientation in the channel:	
Perpendicular	34
Parallel	45
Upstream	14
Downstream	7
Stable Pieces (#)	91
Unstable Pieces (#)	10

Table 3-7. Large woody debris in the constructed ponds of Cemetery Creek. Key pieces of each type are indicated in *italics*.

	North Pond	West Pond	South Pond
Jams	1	1	2
Rootwads	0	0	0
# Key	*0*	*0*	*0*
Small Logs	0	0	1
# Key	*0*	*0*	*1*
Medium Logs	23	15	30
# Key	*23*	*11*	*26*
Large Logs	0	3	8
# Key	*0*	*3*	*8*
Total # Pieces	**23**	**18**	**39**

3.1.5.4 Discussion

The primary intent of habitat mapping and monitoring is to document that constructed channels, designed to provide suitable salmonid habitat, are maintained 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 Figure 3-9.

Figure 3-9. Indices of pool habitat and LWD conditions for interpretation of survey results and habitat analysis (adapted from WFPB 1997 and NMFS 1996). Cemetery Creek restoration site values and ratings are listed at the right.

Parameter	Channel Morphology	Habitat Quality			Restoration Site Value	Restoration Site Rating
		Good	Fair	Poor		
Pool Percentage[1]	<2% Gradient <50ft wide	>55%	40-55%	<40%	54%	Fair
Pool Frequency[1]	<2% Gradient <50ft wide	<2 channel widths/pool	2-4 channel widths/pool	>4 channel widths/pool	3.7	Fair
Pool Spacing[2]	15-20ft wide	>70 pools/mile	56-70 pools/mile	<56 pools/mile	86	Good
LWD pieces per channel width[1]	<50ft wide	>2	1-2	<1	2.8	Good
Key pieces per channel width[1]	Bankfull width <33 ft	>0.30	0.15-0.30	<0.15	1.5	Good

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

Overall, the pool habitat conditions range from fair to good at the Cemetery Creek restoration site. Pool percentage was at the high end of the "fair" rating. Large woody debris indices easily met the "good" rating in both categories. Results from this initial survey provide a post-reconstruction baseline. Future monitoring will allow comparisons to determine whether constructed channels and LWD structures are remaining stable and functional.

3.1.5.5 Recommendations

No changes are recommended at this time.

3.1.6 Stream Channels – Spawning Gravel Availability

The original study plan called for surveys of spawning gravel availability along the entire length of the stream channel within the restoration area. Due to insufficient staff time, this portion of the monitoring plan has not yet been completed. A preliminary spawning gravel assessment will be conducted in the fall of 2009.

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 document that created ponds provide suitable year-round habitat conditions for native salmonids; and 4) to assess the influence of created ponds on stream water quality. There are four primary water quality parameters of concern for salmonid fishes: temperature, dissolved oxygen, specific conductivity, and pH. In addition, one parameter, fecal coliform, was measured to document conditions that may affect human health. Cemetery Creek is listed for bacteria exceedances, and is covered by the Whatcom Creek bacteria TMDL that is currently being developed by the City and the Washington State Department of Ecology (Ecology).

Temperature: Water temperature is an important measure of water quality because all aquatic organisms are dependent upon certain temperature ranges for optimal health. Water temperature also has a direct impact on dissolved oxygen levels. 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) (Ecology 2006). Temperatures are not to exceed this standard of 16ºC more than once every ten years on average. Cemetery Creek is listed as a Category 5 water body for temperature exceedances in the Washington State 2008 Water Quality Assessment (Ecology 2009). Category 5 represents the state's 303(d) list of impaired waters.

Dissolved oxygen: Aquatic organisms require oxygen to survive. Oxygen in water is measured in its dissolved form, dissolved oxygen (DO). Dissolved oxygen varies directly in response to atmospheric pressure and water temperature. Higher atmospheric pressure results in higher oxygen solubility in water and higher DO. Higher temperatures result in lower oxygen solubility and lower DO. Photosynthesis by aquatic plants and the turbulence of running water both increase DO. Dissolved oxygen levels vary seasonally. Dissolved oxygen is also affected by inputs of pollution. Feces from animals and failing septic systems, grass clippings, leaves and woody debris, and urban and agricultural runoff all contain organic matter that is decomposed by microorganisms, which consume oxygen in the decomposition process and can thus reduce DO.

Washington State aquatic life DO criteria are based on point-in-time measurements. The standard for Cemetery Creek is 9.5 mg/L (Ecology 2006). Dissolved oxygen that is lower than this criterion does not meet the Ecology standard. Cemetery Creek is listed as a Category 5 water body for DO levels in the Washington State 2008 Water Quality Assessment (Ecology 2009). Category 5 represents the state's 303(d) list of impaired waters.

Washington State standards for DO represent optimal conditions for salmonid growth in streams. In the restoration site ponds, where DO levels are important for rearing juvenile salmonids, lethal and sublethal DO levels can be instructive guidelines for habitat suitability. Spence et al. (1996) recognized 3.3 mg/l as a lethal DO level for salmonids, with DO levels of 5.0 mg/l reducing salmonid growth.

Specific conductivity: Specific conductivity (SpC) in stream water can be extremely variable. Natural variation is due mainly to the type of rocks weathered in the watershed, how much precipitation falls in the watershed, the chemical composition of the precipitation (which is largely dependent on distance from the ocean) and the relative contribution of ground water to total flow (Allan 1995). Groundwater typically contains higher concentrations of ions than surface water because of longer contact with rocks containing minerals (Allan 1995). Stream flow consists of a combination of both surface water and groundwater, with their relative influence changing seasonally. During drier periods SpC may increase as stream flow becomes more dependent on groundwater inputs. Evaporation can also contribute to increased conductivity levels by concentrating ions in water. In urban settings, pollution from point and non-point sources can contribute to the amount of dissolved ions in water, increasing SpC.

Conductivity is useful as a general water quality measurement. Each stream tends to have a relatively constant range of conductivity that, once established, can be used as a baseline for comparison with regular conductivity measurements. Significant changes in conductivity measurements can indicate contamination from point and non-point pollution sources.

Ecology has not specified standards for SpC. However, the U.S. Environmental Protection Agency (EPA) has designated a range that generally supports good mixed fisheries. This range is between .150 and .500 mS/cm (U.S. EPA 1997). Although the conductivity of rivers in the U.S. ranges from .050 to 1.500 mS/cm, conductivity outside the above range could indicate that water is not suitable for certain species of fish or macroinvertebrates (U.S. EPA 1997).

pH: The pH of a stream can affect both the physiology and behavior of organisms living in the water. The chemical conditions in acidified (low pH) waters are intolerable to some aquatic creatures or have sublethal physiological effects; some animals may actively avoid such waters. There are also indirect effects. The solubility and availability of nutrients can be affected by pH. Heavy metals can be more soluble at lower pH, and therefore more bioavailable and consequently more toxic.

A change in pH can indicate the presence of pollution. Organic matter introduced into streams during periods of low flow can cause low pH values. Lime used for industrial applications or applied to agricultural lands, lawns, and golf courses can be washed into streams during storm events, raising pH. Additionally, photosynthesis, respiration, and decomposition also affect pH levels.

The pH of uncontaminated rainwater in equilibrium with atmospheric carbon dioxide is 5.6. Normally the acids in rainwater are neutralized as the rainwater passes through soil (Allan 1995). In urbanized areas much of the precipitation falls onto impervious surfaces and flows directly into rivers and streams. Runoff from these surfaces may increase in acidity before entering streams (Mason 1989). Regardless of the extent of impervious surfaces in an urban area, the acid neutralizing mechanisms in the soil may not be able to keep pace during heavy continuous rain. During such events rainwater runs over the surface instead of filtering through the soil and enters streams with its chemical composition little changed (Mason 1989). The effects of high pH on fish include damage to outer surfaces like gills, eyes, and skin; an inability to dispose of metabolic wastes, and possible death. High pH may also increase the toxicity of other substances.

Ecology aquatic life pH criteria are represented as the negative logarithm of the hydrogen ion concentration. The pH standard for Cemetery Creek is within the range of 6.5 to 8.5 (Ecology 2006). pH measurements above or below these criteria do not meet the Ecology standard. Cemetery Creek is listed as a Category 2 water body in the Washington State 2008 Water Quality Assessment. Category 2 represents water bodies where there is some evidence of a water quality problem, but not enough to require production of a water quality improvement project (Ecology 2009).

Fecal coliform: Fecal coliform bacteria levels are used as an indicator of bacterial levels in surface waters because they are easily quantified. Sources of fecal contamination to surface waters include domestic and wild animal feces, human feces, on-site septic system leaks, and stormwater runoff. Although they are generally not harmful themselves, fecal coliform bacteria indicate the possible presence of pathogenic bacteria, viruses, and protozoans that also live in human and animal digestive systems. In addition to the possible human health risk associated with the presence of elevated levels of fecal bacteria, they can also cause cloudy water, unpleasant odors, and an increased oxygen demand (U.S. EPA 1997). Fecal coliform bacteria are generally not a health or habitat concern for salmonids or other fish.

Washington State bacteria criteria are based on the anticipated level of recreational use and are measured as a geometric mean value of all samples. Cemetery Creek is designated as Primary Contact Recreation, thus the standard for fecal coliform is a geometric mean value of 100 cfu/100 mL, with not more than 10 percent of all samples obtained for calculating the geometric mean value exceeding 200 cfu/100 mL (Ecology 2006). Cemetery Creek is listed as a Category 5 water body for fecal coliform in the Washington State 2008 Water Quality Assessment (Ecology 2009). Category 5 represents the state's 303(d) list of impaired waters. A water quality improvement project (TMDL) for bacteria in the Whatcom Creek basin is under development.

3.2.2 Methods - Ponds and Streams

Sampling dates: Water quality sampling began in February 2007. Data discussed in this report includes sampling through October 31, 2008, the end of the summer "dry season" (see definitions below). Sampling occurred monthly from February 2007 to June 2008. In 2007 it was noted that temperatures and DO did not meet state standards during summer months. The protocol was therefore modified to increase sampling to every two weeks from June to September, beginning in 2008. Sampling returned to a monthly schedule in early September. This modified sampling schedule will continue through the duration of the monitoring period.

Water quality was not sampled during August 2007 due to repairs being conducted on the Hydrolab. Fecal coliform grab samples were taken during August 2007. All results are graphed with Washington State water quality standards for reference.

Seasonal definitions: Typically, the wettest months of the year occur between November 1 and April 31 (the "wet season"), and the driest months occur between May 1 and October 31 (the "dry season"). During wet months, soil moisture content is generally high and surface water storage capacity decreases, resulting in increased water runoff. Consequently, during the wet season flows in Cemetery Creek tend to be flashy. During the dry season, flows respond more moderately to precipitation.

Cemetery Creek flows: There is no continuous monitoring of flow on Cemetery Creek, so flows were synthesized from daily average values measured at the City of Bellingham's Padden and Chuckanut Creek gage sites. Neither of these drainages are directly comparable to Cemetery Creek in terms of geomorphology and development: Padden contains a lake and Chuckanut is largely undeveloped. However, these creeks are comparable to Cemetery Creek in terms of climate, precipitation, size, and average level of development, and thus the average unit value of runoff for all these is considered to reasonably represent Cemetery Creek.

Flow per unit drainage area is calculated for each gaged basin in order to provide an estimate of Cemetery Creek flows. These synthesized flows are included on all water quality graphs to provide context for observed seasonal patterns.

Sampling methods and quality control – Temperature, DO, pH, SpC: Water temperature, DO, pH, and SpC are monitored monthly in each of the ponds and tributaries of Cemetery Creek within the restoration site using a Hydrolab Quanta. Three water quality monitoring stations are designated in each pond (Figure 3-10), for a total of nine sampling locations in ponds. Water quality parameters are measured at 0.5 foot vertical intervals to construct a depth profile at each station. Five stream sampling sites are also established (Figure 3-10). The measurement is taken in the middle of the stream so that the location is equally spaced top to bottom and side to side. Station SWQ4 was moved upstream beginning on February 4, 2008 since its previous location closer to the West Pond was frequently backwatered. The new sampling site is indicated on the map.

Additional sampling points were added beginning in 2008 during the warmest summer months, from June to September, to provide additional insight on DO variation within the ponds. A point measurement was taken at the inlet(s) and outlet of each pond. These additional summer sampling points will be continued through the duration of the monitoring period.

Water quality parameters are measured in-situ using a Hydrolab Quanta, which reads each parameter simultaneously. Before recording each measurement the Hydrolab is allowed to equilibrate by waiting for at least one minute, or until DO (which tends to exhibit the greatest fluctuations) has stabilized.

The Hydrolab is calibrated before each survey session, and audited before and after sampling to ensure data accuracy. Post-sampling audits that do not meet the parameter standard can indicate parameter drift in the Hydrolab; these audits are noted and the data flagged. Parameter drift was noted twice in 2007, both times in measurement of SpC. All other calibration audits in this report period have been within standards.

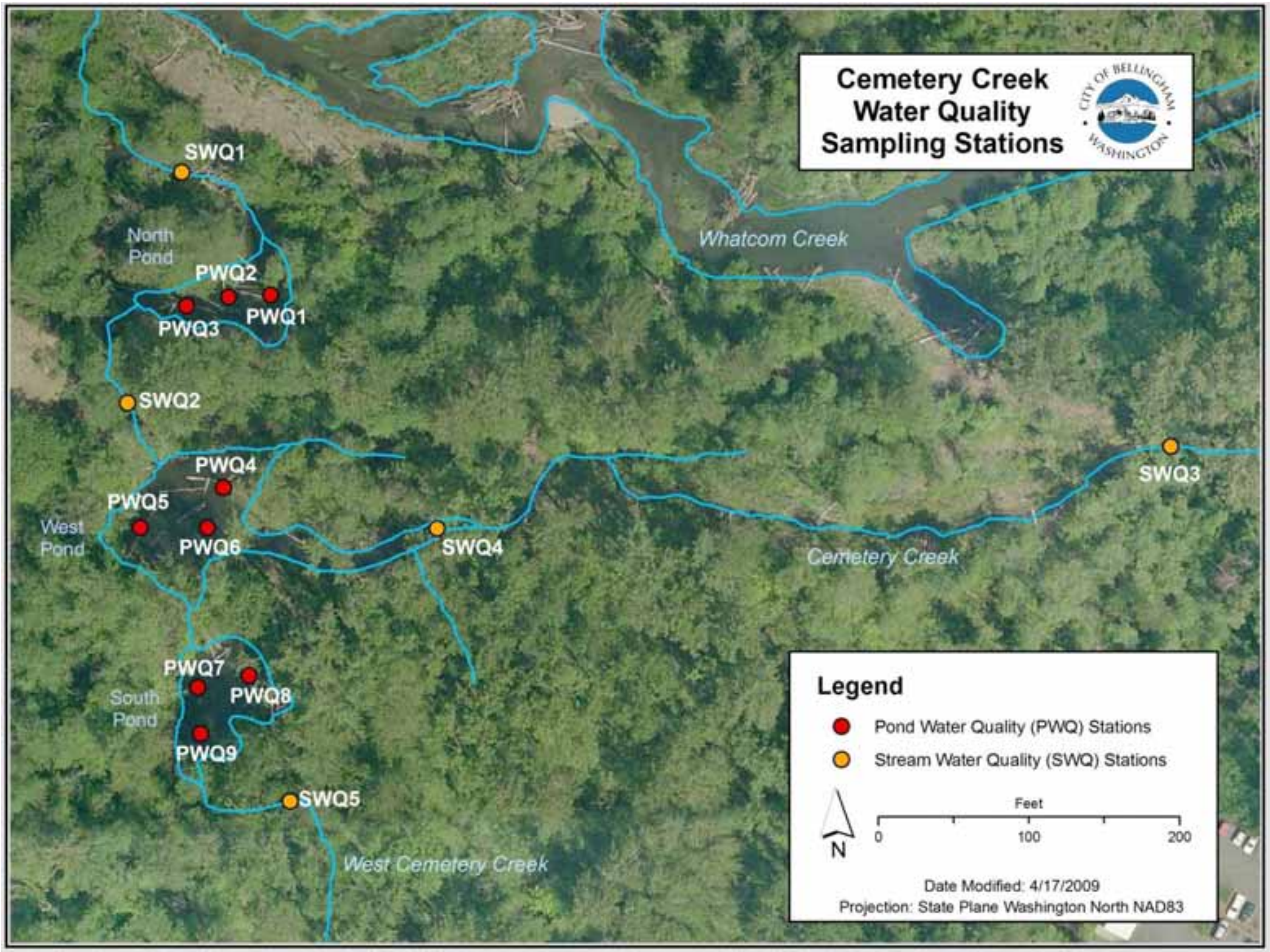
Sampling methods and quality control – Fecal coliform: A fecal coliform grab sample is obtained monthly from eight sampling stations in the Cemetery Creek restoration site (Figure 3-11). Fecal coliform sampling stations correlate with stream water quality stations and one sampling station in each of the constructed ponds. Only one sample is taken from each pond since fecal coliform levels are not expected to vary by depth. Pond samples are taken at an approximate depth of 1 foot from the water surface. Two replicate samples are taken on each sample date. Samples are immediately stored in a cooler on ice, and delivered to EDGE Analytical Lab for analysis within four hours of sample collection.

Sampling methods and quality control – Continuous temperature loggers: Beginning in 2008, continuous temperature loggers were installed in Cemetery Creek ponds between June and September in order to calculate 7-DADMax temperatures. The installation of temperature loggers between June and September will remain part of the water quality sampling procedure for the duration of the monitoring period. Loggers are programmed to collect temperature data hourly. One logger is installed near each pond outlet (average water depth 2.5 feet) in the middle of the water column and is paired with a nearby logger which monitored ambient air temperatures. Air temperature loggers are secured in shaded areas as close as possible to the location of water temperature loggers. Water temperature loggers are secured in the ponds by attaching the logger to the inside of a piece of 3-inch diameter PVC pipe secured to a piece of rebar pounded into the sediment. The rebar anchors the logger while the PVC shades the logger from direct sunlight. The PVC pipe is oriented so that water flow can move through it past the logger.

Loggers are checked and downloaded approximately every two weeks. During these checks, air and water temperature loggers are compared for accuracy against a calibrated field thermometer. These checks verify that the loggers are performing according to specifications and also provide a log of verified temperatures that may be used for troubleshooting purposes if post-season calibration of the loggers indicates problems.

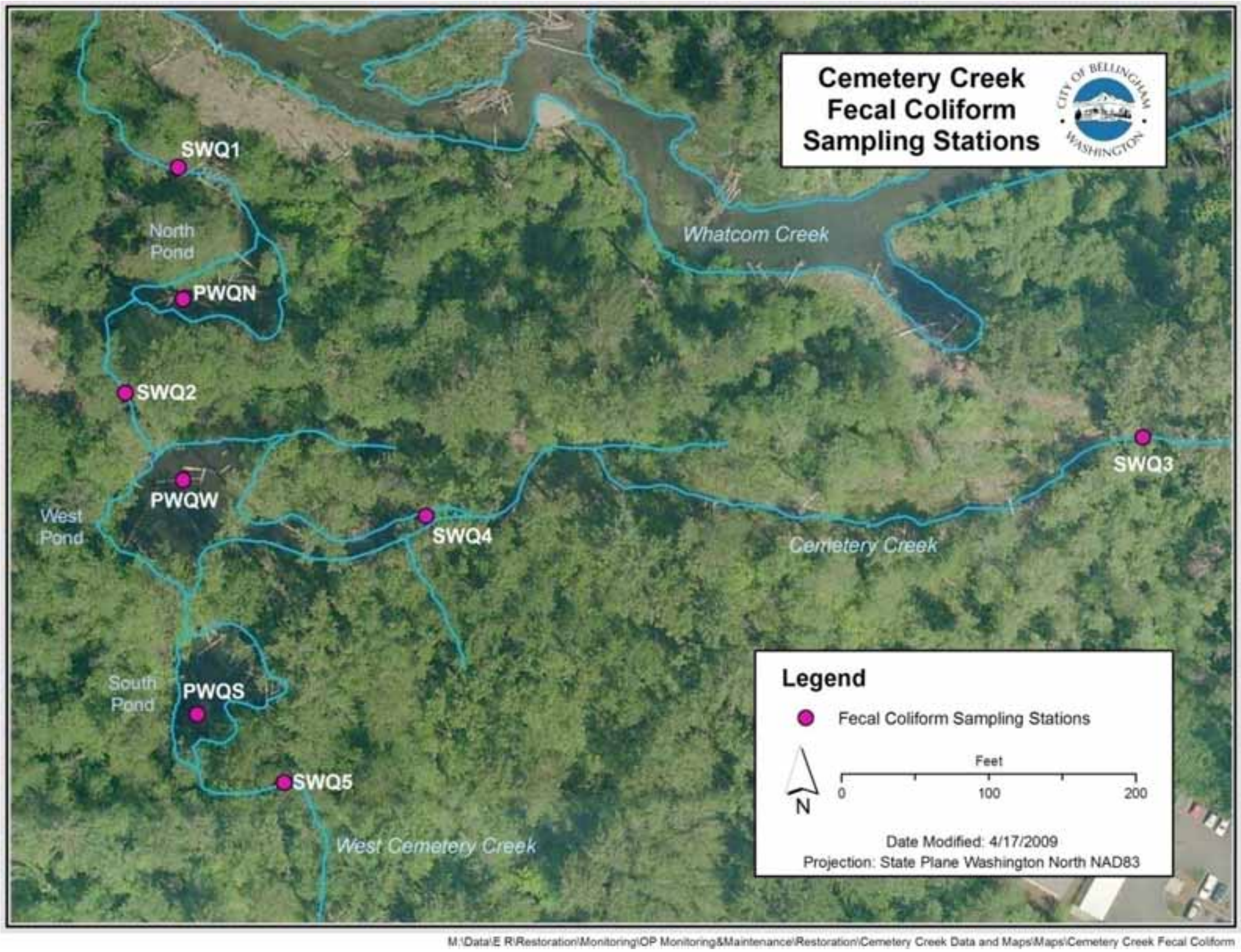
Continuous temperature loggers are calibrated prior to deployment and re-checked at the end of the season. A full methodology and standards for temperature logger calibration are provided in Appendix D.

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



M:\Data\E R\Restoration\Monitoring\OP Monitoring&Maintenance\Restoration\Cemetery Creek Data and Maps\Maps\Cemetery Creek Water Quality

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



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. 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 depth.

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/August and October). A complete set of these depth profiles is provided in Appendix F.

3.2.3.1 Temperature – Point-in-time measurements

Temperature data collected with the Hydrolab are point-in-time measurements, which cannot be used to calculate the 7-DADMax. In the following analyses and plots, these data are compared against the Ecology standard of 16ºC; temperatures that are higher than this criterion suggest that conditions may not meet the Ecology standard.

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 at least one (and often more) temperature measurement that exceeded the state standard (see Figure 3-13, Figure 3-14 and Figure 3-15).

The North Pond was the warmest, with sampling dates in which all temperature measurements in the pond were above the state standard of 16ºC (Figure 3-14). The highest point-in-time temperature measured in the North Pond was 18.68ºC (August 15, 2008). None of these recorded temperatures would have been lethal to fish. Lethal temperatures vary by salmonid species, but usually range from 23ºC to 26ºC (Sullivan 2000).

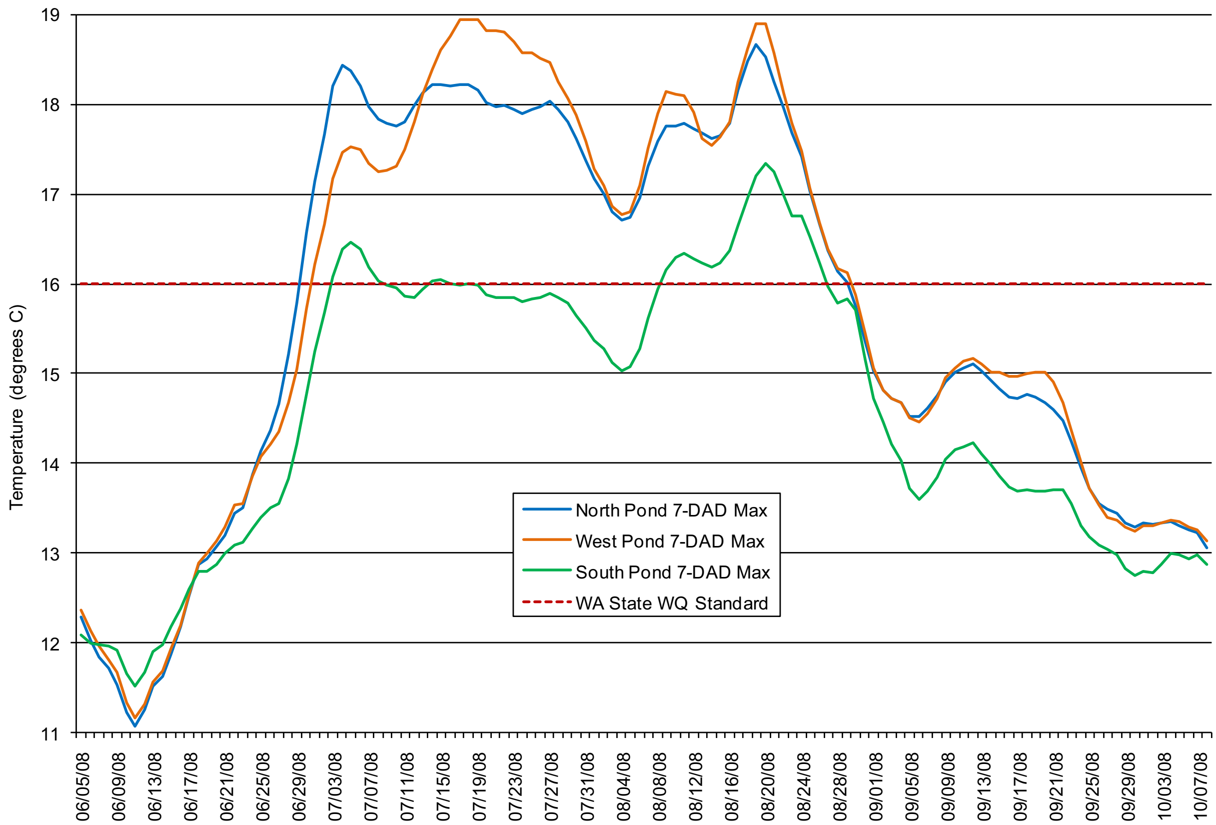
There is evidence of periodic thermal stratification beginning in late spring and continuing through the dry season. This stratification is common when stream flows are low relative to pond volumes, as they are during the dry season. The stratification is weak, and to date, there is no evidence of a permanent thermocline. The most developed stratification is present in the South Pond in April 2007. This stratification is not present the following year, however (compare depth profiles presented in Figure 3-16 and Figure 3-17).

In the West Pond, there is a reverse stratification seen at all three stations on the last sampling date of the report period, October 27, 2008 (plot of station PWQ4 provided in Figure 3-15). A similar, though much weaker pattern can be seen on October 31, 2007 (compare depth profiles presented in Figure 3-18 and Figure 3-19). In this reversed stratification pattern, bottom depths are warmer while shallow depths are cooler. This pattern develops as ambient air temperatures cool surface waters, while lower depths are insulated from these temperature changes. The reverse stratification is lost with increased precipitation during the wet season; higher volumes of inflow increase mixing in the pond. Strong reverse stratification is not present in the shallower North or South Ponds.

3.2.3.1 Temperature – Continuous temperature loggers

Continuous temperature loggers were installed between June and September of the 2008 season. The average water depth of the three stations was 2.5 feet, with an average logger depth of 1.4 feet. The 7-DADMax for Cemetery Creek was 18.94°C on July 18 and 19, 2008, measured with the West Pond temperature logger. This 7-DADMax temperature exceeds the state standard of 16°C. A plot of 7-DAD Max calculations for each pond is presented in Figure 3-12.

Figure 3-12. Seven day rolling averages based on maximum temperatures (7-DADMax) calculated from pond temperature loggers, June 15 to October 6, 2008.



Temperatures were highest in the ponds between June 28 and August 26, 2008. Average diurnal temperature fluctuations were 1.51°C in the North Pond, 1.56°C in the West Pond, and 1.08°C in the South Pond. The North and West Ponds both had 37 days in which the minimum daily temperature was above 16°C. The South Pond, by contrast, had only eight days in which the minimum daily temperature was above 16°C. This likely reflects higher ground water influence from the large forested wetland located upstream of the South Pond.

Figure 3-13. Temperature (°C) by date at 0.5 foot intervals in the South Pond at Station PWQ8.

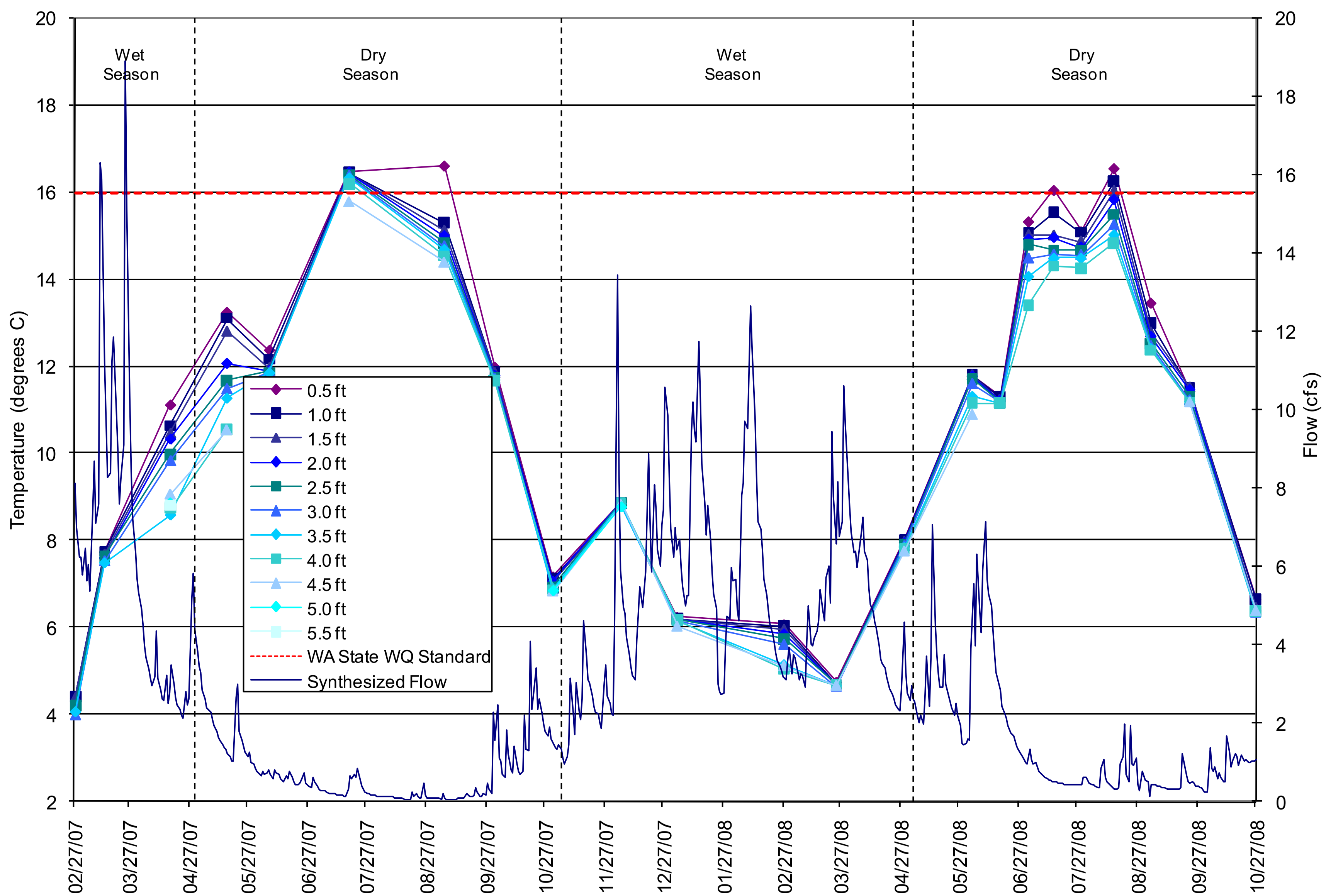


Figure 3-14. Temperature (°C) by date at 0.5 foot intervals in the North Pond at Station PWQ3.

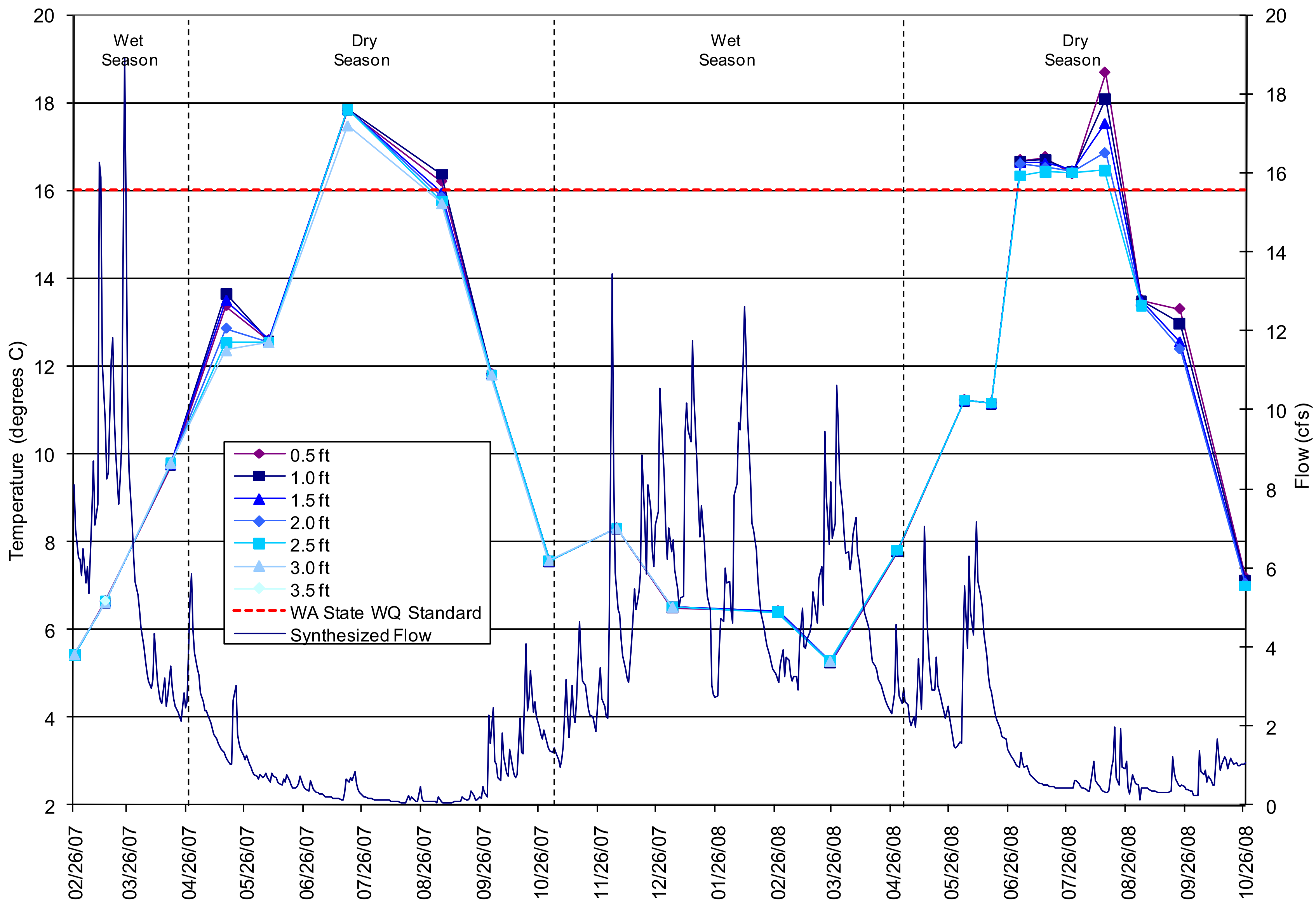


Figure 3-15. Temperature (°C) by date at 0.5 foot intervals in the West Pond at Station PWQ4. Note reverse stratification on final sampling date.

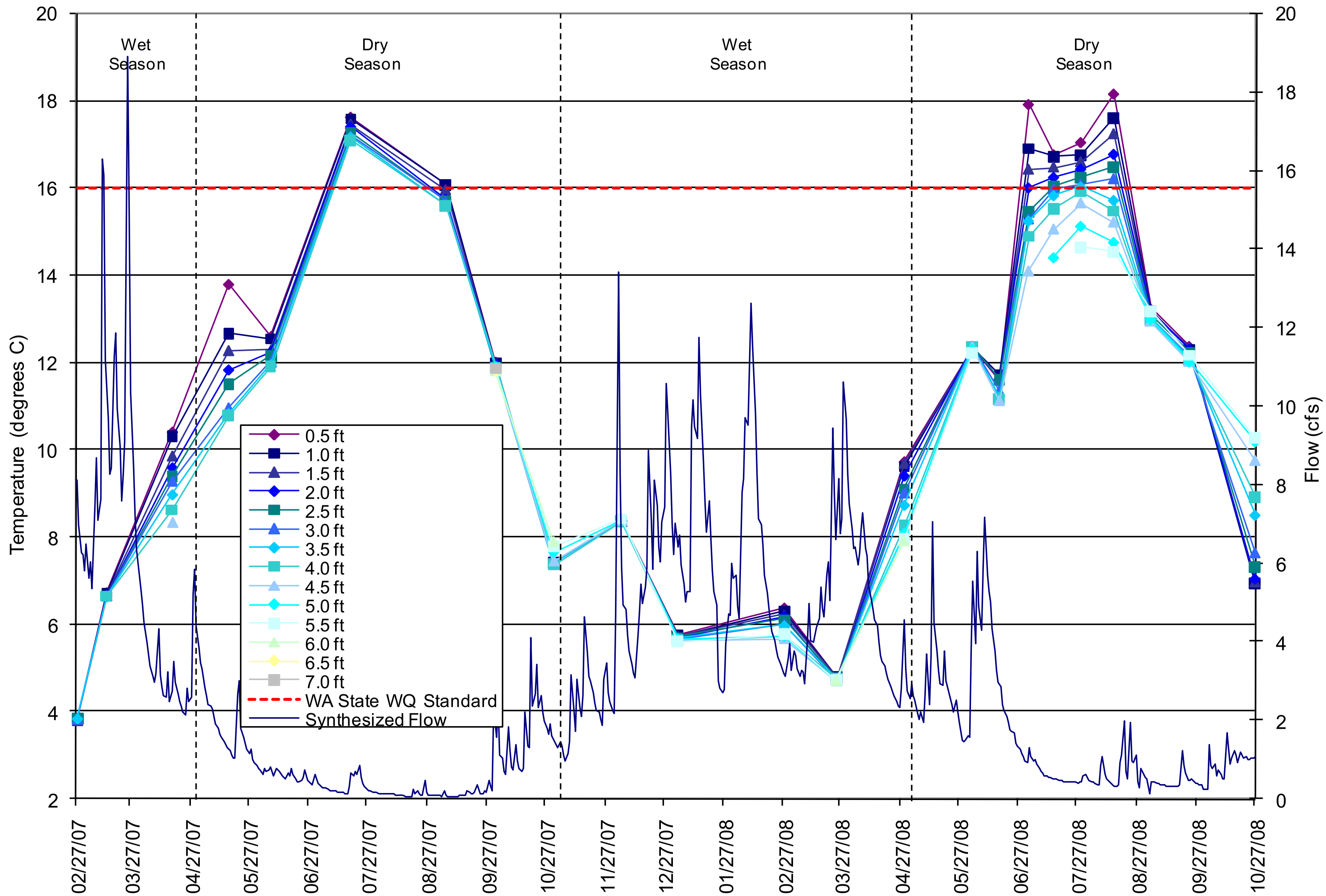


Figure 3-16. Temperature depth profile for four 2007 sampling dates at PWQ8 in the South Pond.

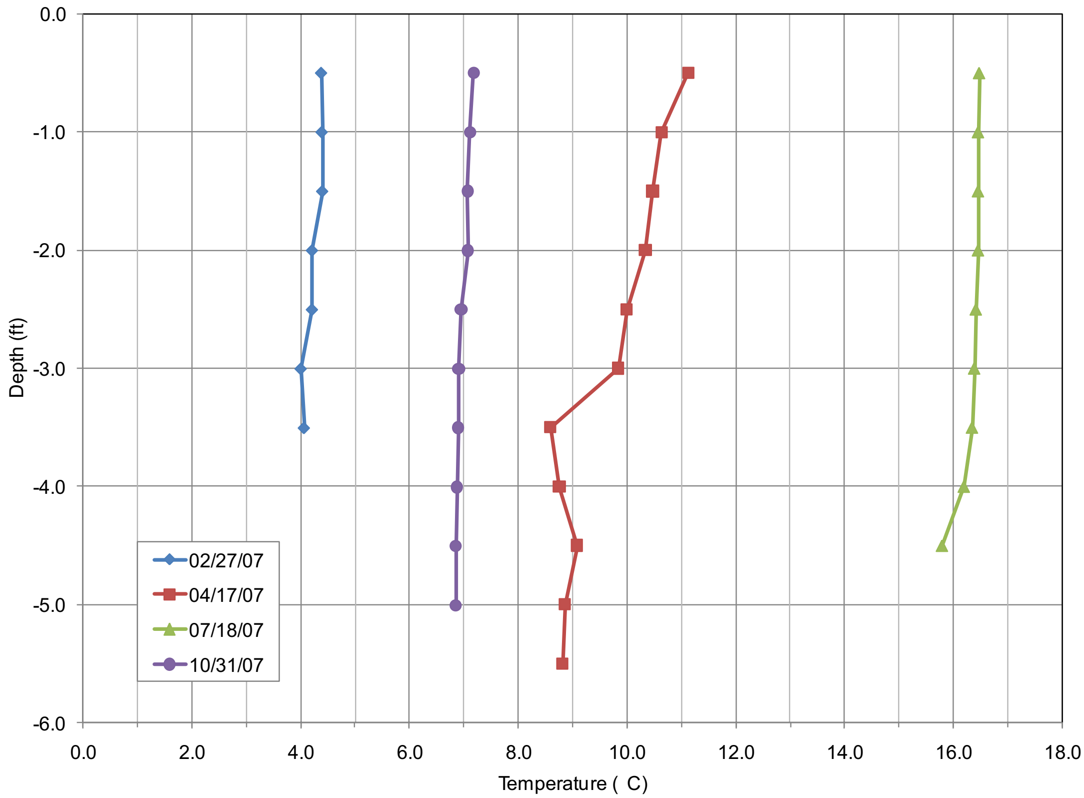


Figure 3-17. Temperature depth profile for four 2008 sampling dates at PWQ8 in the South Pond.

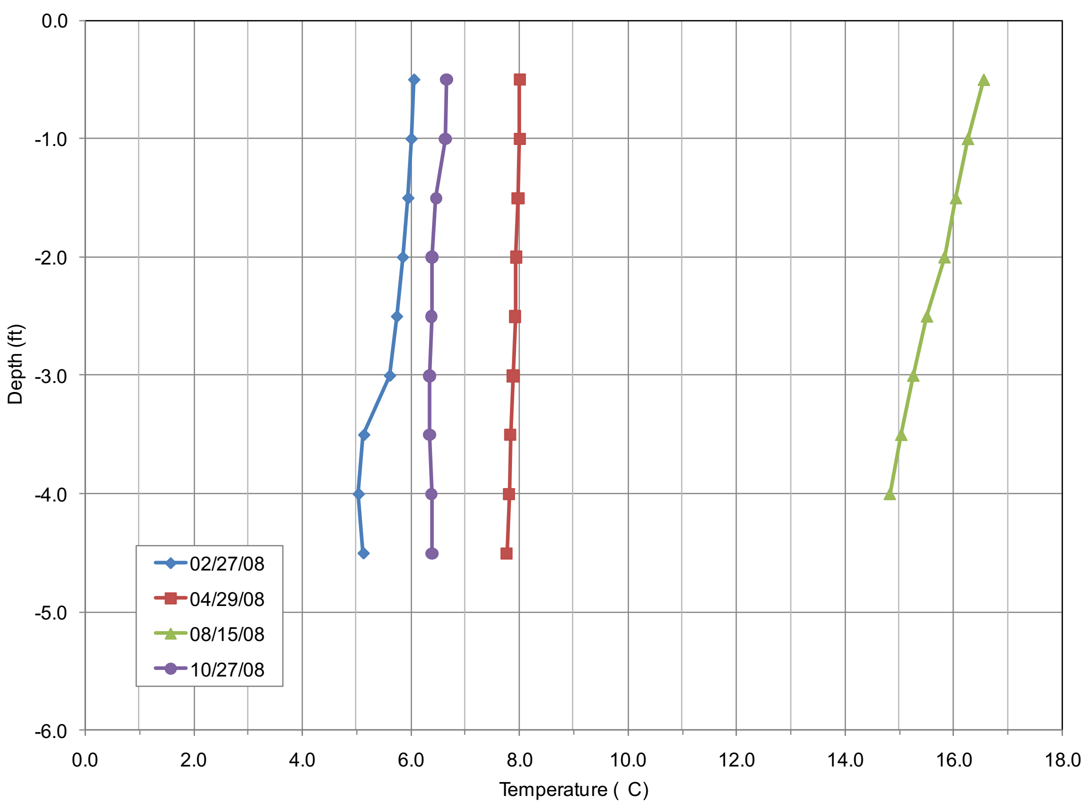


Figure 3-18. Temperature depth profile for four 2007 sampling dates at PWQ4 in the West Pond.

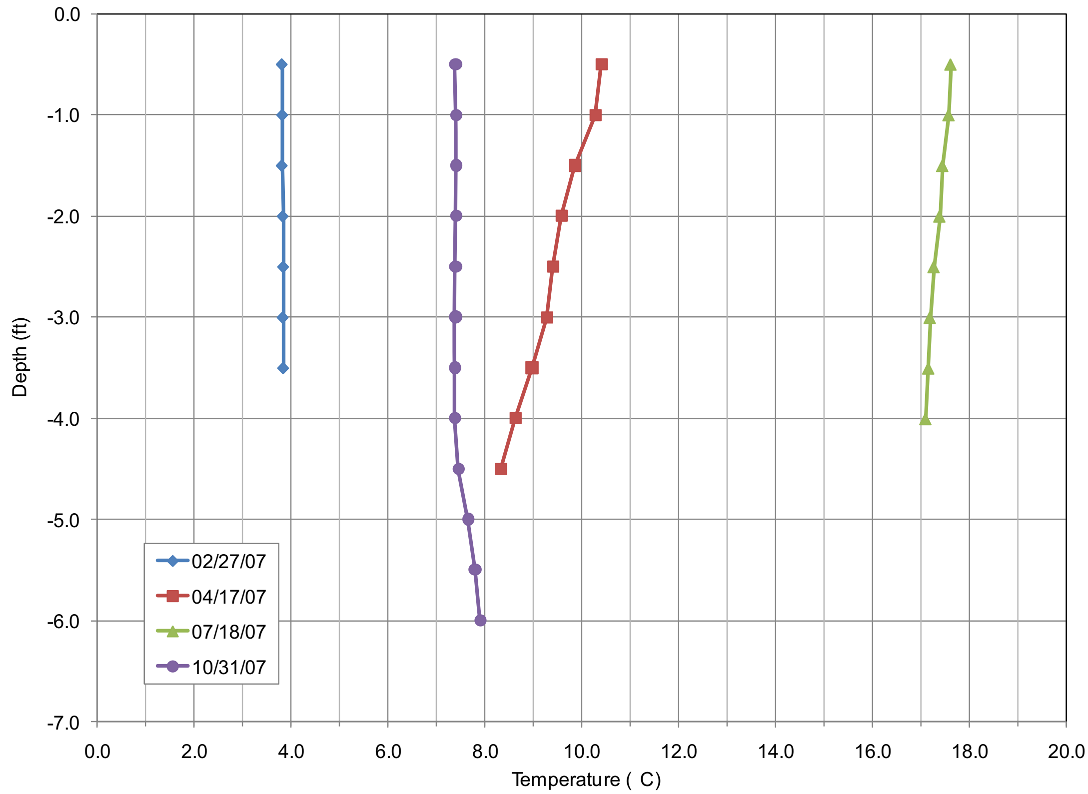
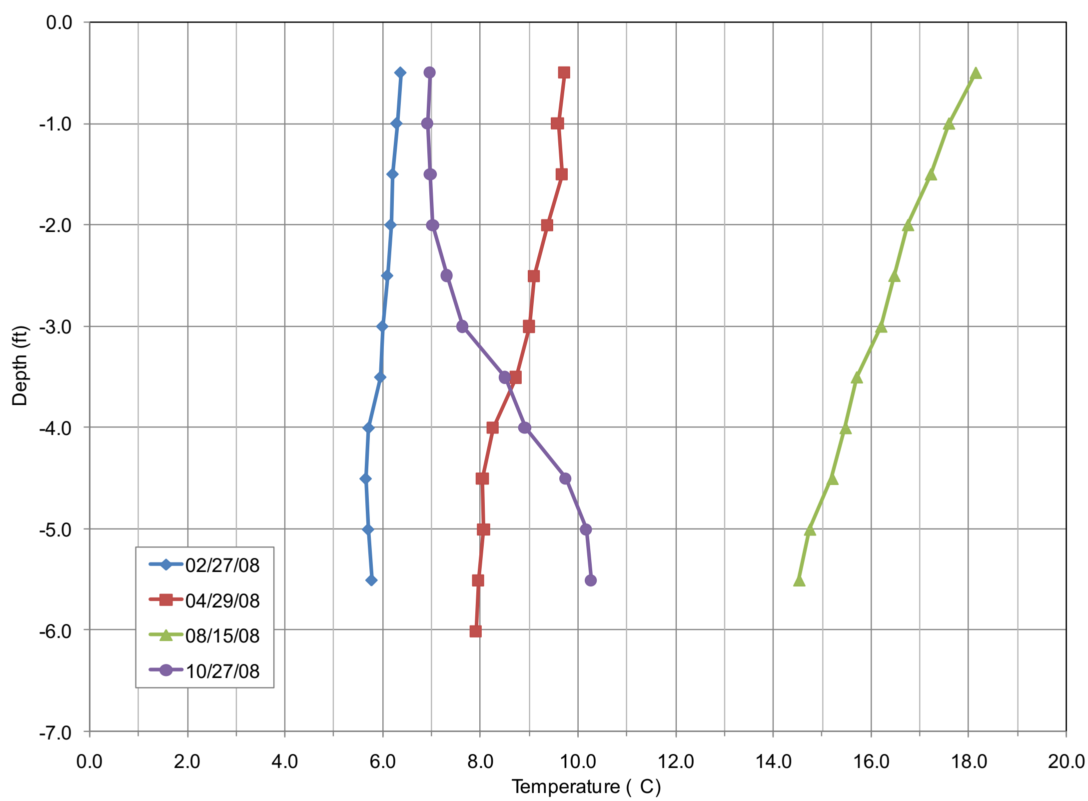


Figure 3-19. Temperature depth profile for four 2008 sampling dates at PWQ4 in the West Pond.



3.2.3.2 Dissolved Oxygen

Dissolved oxygen levels varied seasonally: highest during the wet season and lowest during the dry season (example plot presented in Figure 3-20). 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) at all pond stations at all depths during much of the wet season (testing dates in February, March and April of 2007 and March of 2008).

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. Dry season DO levels do not meet state standards in the ponds. Dissolve oxygen levels were almost all below[6] the state standard at all pond stations at all depths during the majority of the 2007 dry season (five of six sampling dates). Similarly, DO levels were almost all below[7] the state standard at all pond stations at all depths during the 2008 dry season (nine of nine sampling dates). In 2008, additional point sampling at the inflow(s) and outflow of each pond (potential DO refuge areas where water movement is greater) 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) were present in the West Pond at all depths on July 18, 2007. Sampling of inflows and outflow was not occurring in 2007, so there may have been potential DO refuges in those areas at that time. Potentially lethal DO levels were also present in the North Pond at all depths (with one exception of 3.34 mg/L at the surface) on August 15, 2008. However, sampling at the inflow and outflow confirmed the presence of DO refuges on that date: 4.49 mg/L at the inflow and 3.65 mg/L at the outflow.

Depth profiles in the ponds show a few different patterns. These include consistent DO content through the water column (see 4/17/08 and 2/26/08 in Figure 3-21), rapidly declining DO at lower depths (see 2/27/08 and 10/27/08 in Figure 3-22), and variable DO levels by depth (see 4/29/08 in Figure 3-22). There do not appear to be distinguishable patterns based on season.

The effect of pond DO levels on the Cemetery Creek system is discussed in Section 3.2.4.2.

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[6] The exceptions were both at 0.5 feet from the water surface: 5/16/07 at PWQ9 (9.80 mg/L) and 10/1/07 at PWQ3 (10.63 mg/L).

[7] All exceptions were in surface waters (0.5 and 1.0 feet from the water surface) on 6/17/08: 9.55mg/L and 9.50 mg/L at PWQ4; 9.71 mg/L at PWQ6; and 9.50mg/L and 9.52 mg/L at PWQ9.

Figure 3-20. Dissolved oxygen (mg/L) by date at 0.5 foot intervals in the South Pond at Station PWQ8.

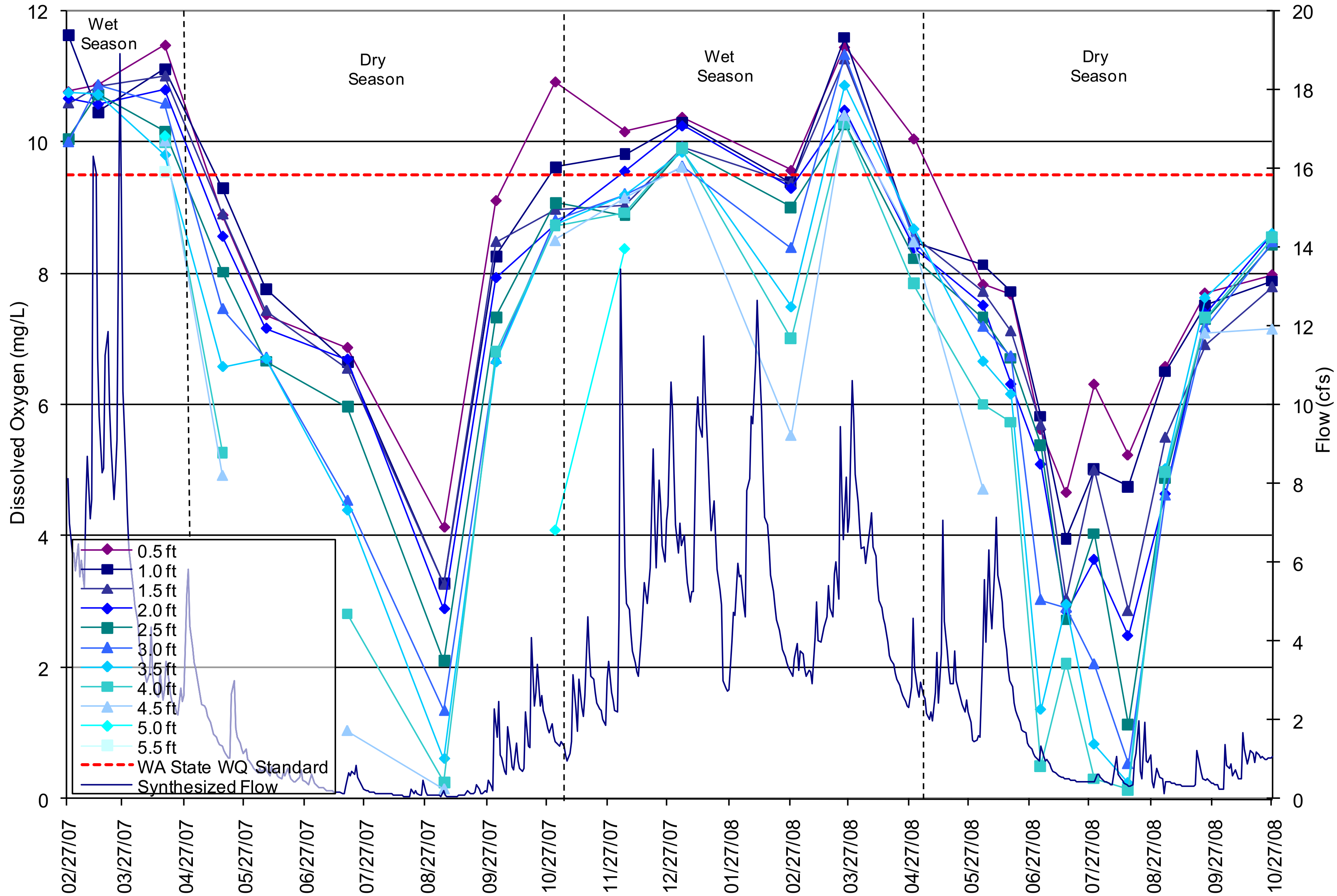


Figure 3-21. Dissolved oxygen depth profile for four 2007 sampling dates at PWQ2 in the North Pond.

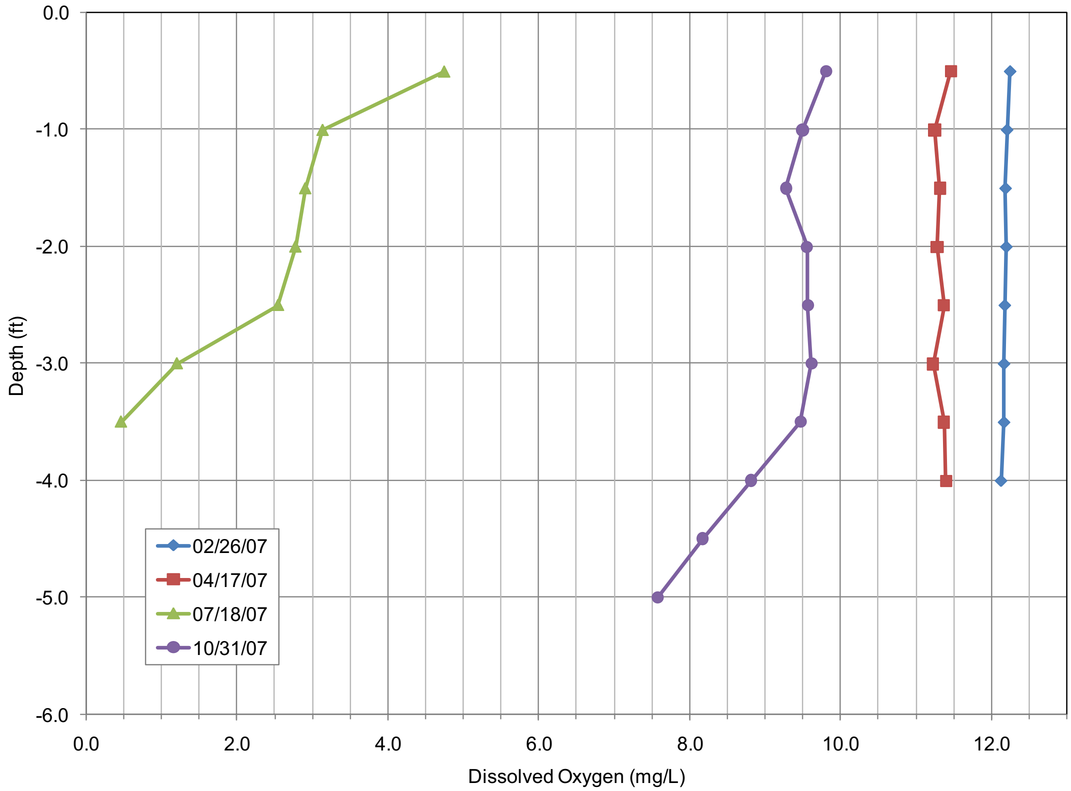
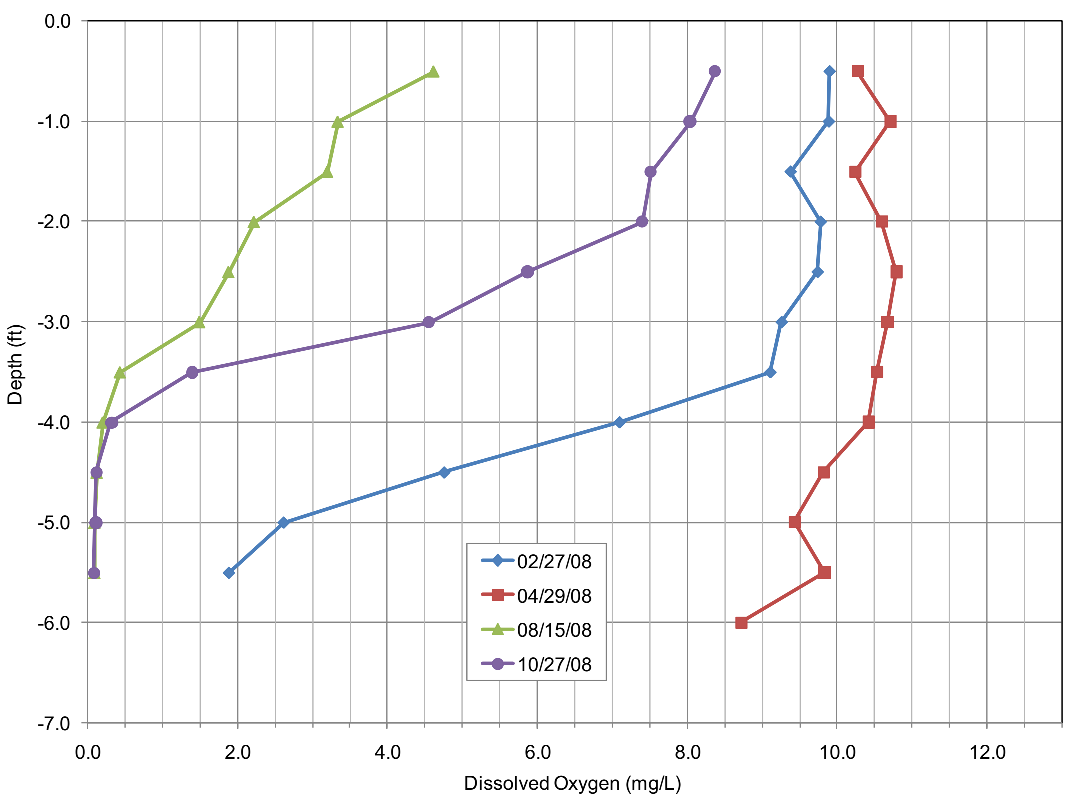


Figure 3-22. Dissolved oxygen depth profile for four 2008 sampling dates at PWQ4 in the West Pond.

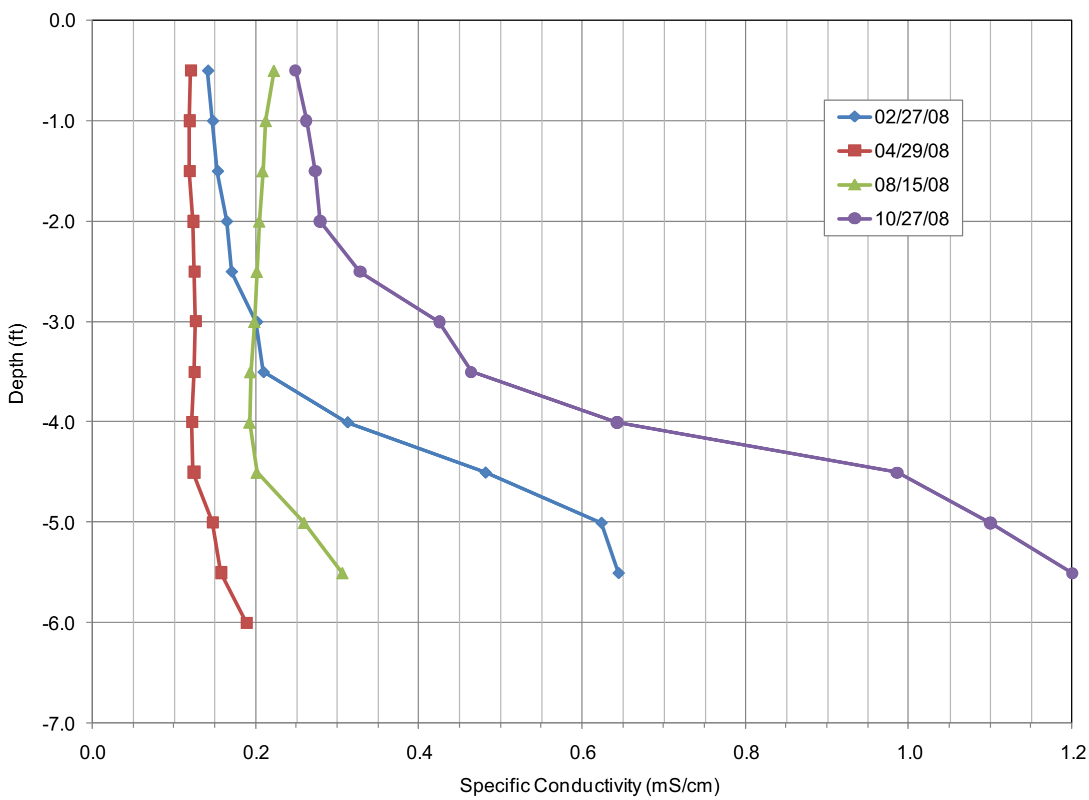


3.2.3.3 Specific Conductivity

Specific conductivity 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 3-24). This range is between .150 and .500 mS/cm (U.S. EPA, 1997). Levels are consistent throughout the ponds, with some spread in the summer months, especially in the West Pond (Figure 3-23). When spread, levels tend to be higher at the bottoms of the ponds. High values near the bottom of the West Pond could be related to suspended materials in the water and the very loose sediment present.

Hydrolab drift was noted in the post-sampling audit on two sampling dates: July 18, 2007 and October 1, 2007.

Figure 3-23. Specific conductivity depth profile for four 2008 sampling dates at PWQ4 in the West Pond.



3.2.3.1 pH

Almost all ponds met state standards; the one exception was PWQ5 on February 27, 2007, when 0.5 and 1.0 depths exceeded the pH maximum by 0.12 and 0.03, respectively. There is some spread present in the values on some sampling dates (example plot presented in Figure 3-25). Spread of values by depth does not appear to be related to flow. Depth profiles are available in Appendix F.

Figure 3-24. Specific conductivity (mS/cm) by date at 0.5 foot intervals in the South Pond at Station PWQ8.

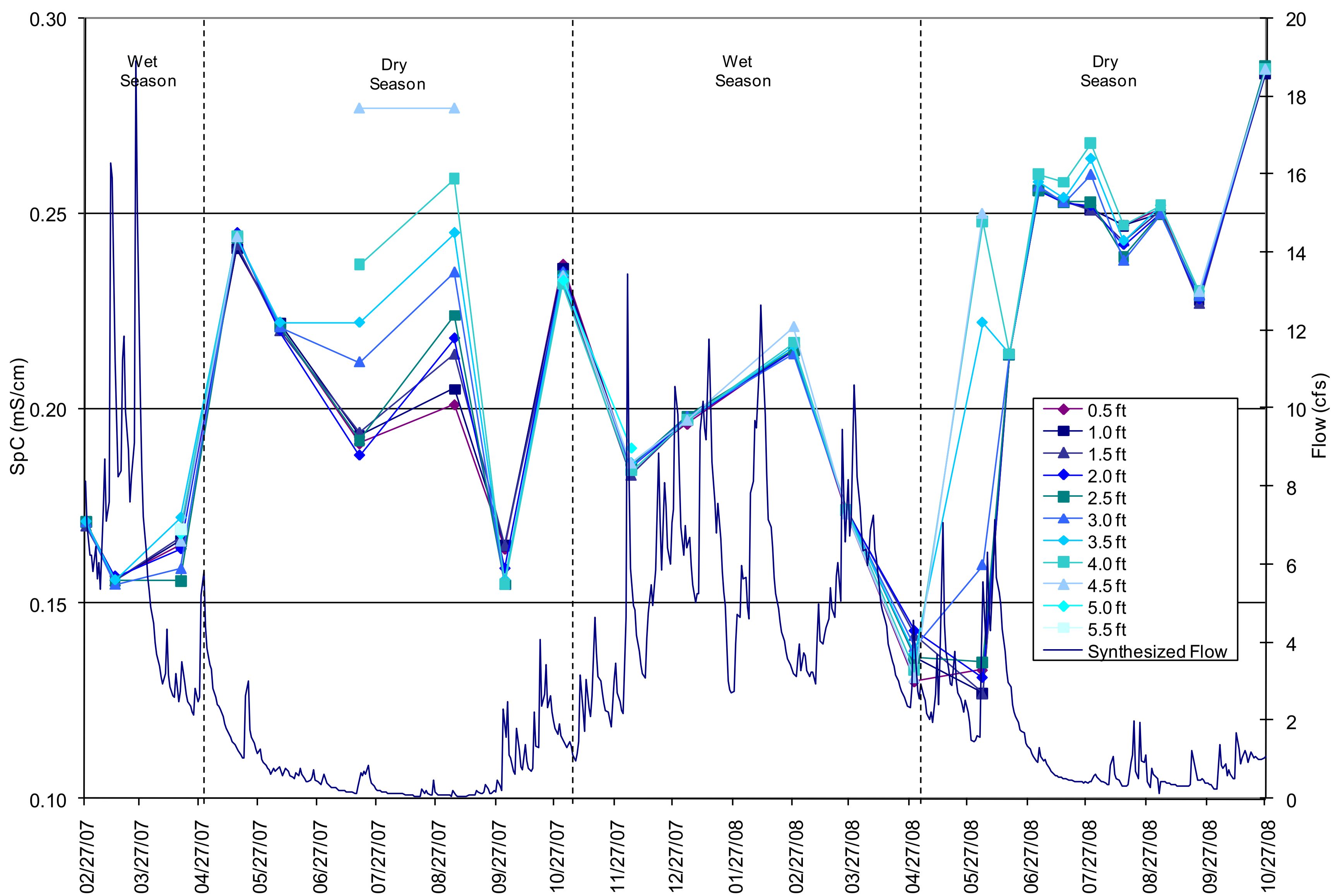
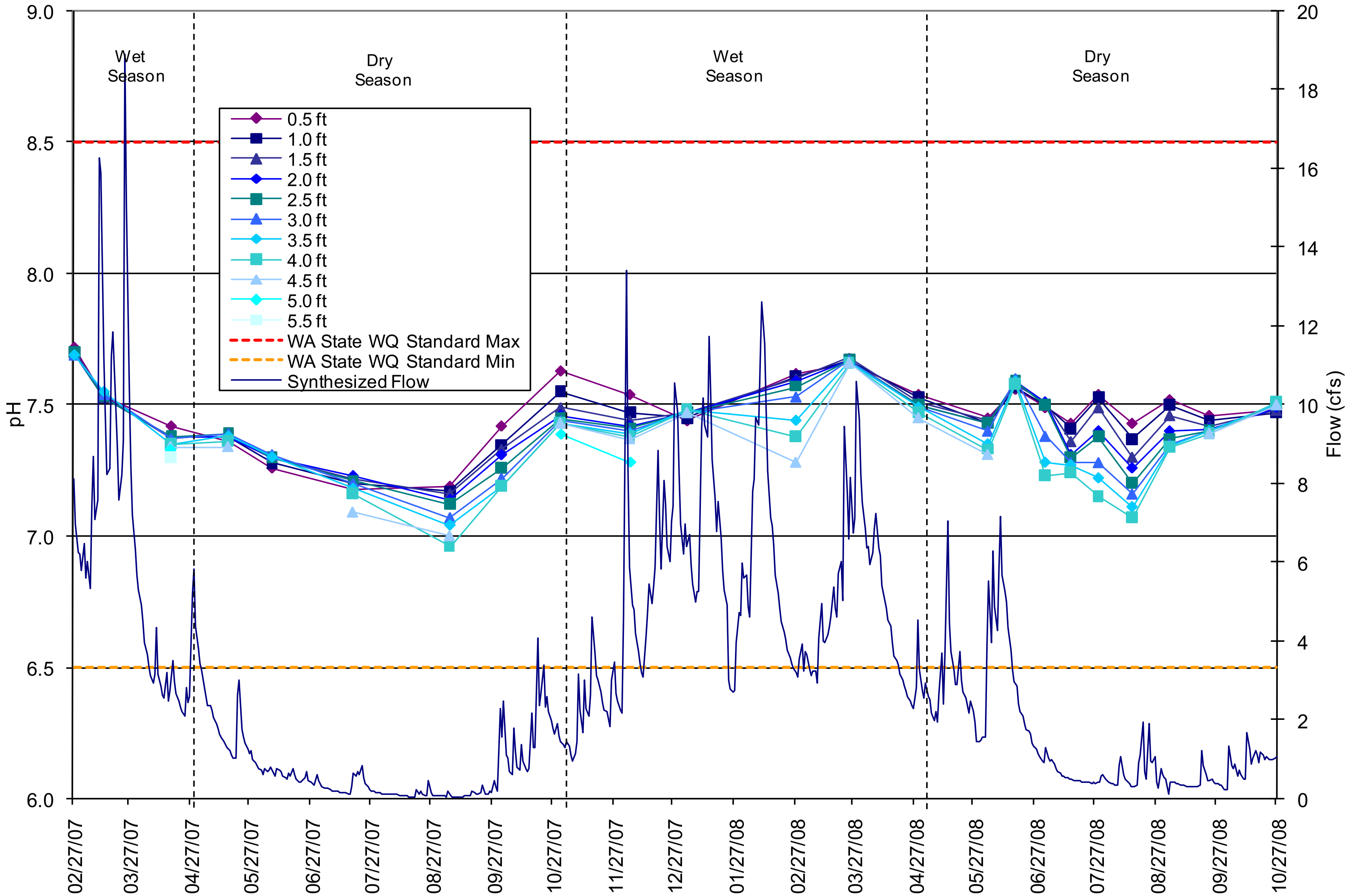


Figure 3-25. pH by date at 0.5 foot intervals in the South Pond at Station PWQ8.



3.2.4 Results and Discussion – Streams

The objective of monitoring stream locations at the Cemetery Creek restoration site 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 on page 83.

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 and parameter schematics. 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. According to depth profiles (presented in Appendix F), the 2.0 foot level has no noticeable outliers.

Representative pond values for graphs of parameter schematics: Parameter schematics 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 Temperature

Water temperatures generally corresponded with seasonal air temperature variations: colder in the winter and warmer in the summer (Figure 3-26). 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 2007, stream temperatures exceeded the standard on two consecutive testing dates (July 18 and September 5) at all stream sites except SWQ5 (the West Cemetery Creek inflow). SWQ5 did not exceed the state standard throughout 2007. In 2008, stream temperatures exceeded the standard on three consecutive testing dates (July 15 through August 15) at all stream sites except SWQ5. SWQ5 exceeded the state standard only once during 2008, and that exceedance was small (16.02 ºC on 8/15).

Instream water temperatures were as high as 18.02ºC in 2007 (at SWQ1, the Cemetery Creek outflow, on 7/18) and 18.73ºC in 2008 (at SWQ2, between North and West Ponds) on 8/15). In neither case would these temperatures have been lethal to fish.

Flow enters the project site from Cemetery Creek and West Cemetery Creek. In Cemetery Creek in 2007, temperatures varied by less than +/- 0.5ºC as water flowed through the reconfigured channel within the restoration site (from SWQ3 to SWQ4). However, the SWQ4 sampling site was almost always backwatered by the West Pond, resulting in values that may be influenced by the pond. SWQ4 was moved upstream beginning on sampling date 2/4/08. In 2008 temperatures increased by as much as 0.81ºC and decreased by as much as 1.81ºC 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 throughout the year (with one exception: 16.02ºC on 8/15/08). 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.

Temperature schematics of the Cemetery Creek system are presented below. Figure 3-27 illustrates changes in temperature through the restoration site on July 18, 2007, the warmest sampling date of that year. While the maximum daily air temperature recorded for July 18 was only 18.01ºC, the average maximum air temperatures for the previous two week were greater than 27ºC, with a maximum of 34.13ºC[8]. Inflow via Cemetery Creek (SWQ3) was above the temperature standard, with temperature increasing by 0.44ºC as water flowed through the site (SWQ4). The West Cemetery Creek inflow was below the state standard, with temperature increasing as it flowed through the South and West Ponds and toward SWQ2. The West Pond temperature clearly reflects the warmer and cooler inputs from Cemetery and West Cemetery Creeks, respectively. The North Pond did not noticeably affect water temperature, with a slight increase seen as water flowed out of the system (SWQ1). Overall there was a temperature increase of 0.62ºC from Cemetery Creek inflow to outflow and 2.04ºC from West Cemetery Creek inflow to outflow on July 18, 2007.

Figure 3-28 illustrates changes in temperature in the system on August 15, 2008, the warmest sampling period of that year. August 15, 2008 also represented the maximum daily air temperature for the year, with a recorded ambient air temperature of 31.49ºC at the North Pond[9]. The 2008 schematic includes point-measurement of temperatures at the inflow and outflow of each pond. Cemetery Creek inflow (SWQ3) was again above the temperature standard, but unlike July 2007, the water temperature cooled by 0.48ºC as it flowed through the restoration site (SWQ4). West Cemetery Creek inflow was slightly above the state standard (16.02ºC), with

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[8] Maximum air temperatures taken from a nearby continuous air temperature logger. Logger location was along Whatcom Creek in the Red Tail Reach project area, approximately 700 feet downstream of the confluence of Cemetery Creek and Whatcom Creek. Temperature loggers are installed and maintained by COB staff.
[9] Maximum air temperatures taken from continuous air temperature loggers installed near each pond at the Cemetery Creek restoration site.

temperature increasing as it flowed through the South and West Ponds and toward SWQ2. The North Pond was slightly cooler than SWQ2 and SWQ1. All pond inflows and outflows were cooler than the surface pond water. Overall there was a temperature decrease of 0.01ºC from Cemetery Creek inflow to outflow and a temperature increase of 2.64ºC from West Cemetery Creek inflow to outflow.

Overall, no temperatures higher than 19°C have been recorded during restoration monitoring in the Cemetery Creek system. 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 significant or persistent.

Urban Stream Monitoring: Water quality at the mouth of Cemetery Creek has been tested 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 (Table 3-8). The temperature maximums from 2007 and 2008 are within the range measured prior to construction. The USM program is continuing and results will be updated in subsequent reports.

Table 3-8. Maximum temperature (ºC) recorded for the year during Cemetery Creek water quality monitoring for the Urban Stream Monitoring program. Maximum air temperatures provided for reference.

Year	Maximum Water Temperature (ºC)	Maximum Air Temperature (ºC)[1]
1990	22.8	32.8
1991	16.0	31.1
1992	18.0	28.9
1993	15.0	31.1
1994	19.4	31.1
1995	17.5	31.1
2002	16.2	28.9
2003	16.6	30.6
2004	17.1	31.7
2005	15.4	28.9
2006	Restoration site construction	31.1
2007	17.8	33.9
2008	16.6	28.9

[1]Air temperatures taken at Bellingham International Airport.

Figure 3-26. Temperature (°C) at stream water quality stations and representative pond values (at 2.0 feet below the water surface).

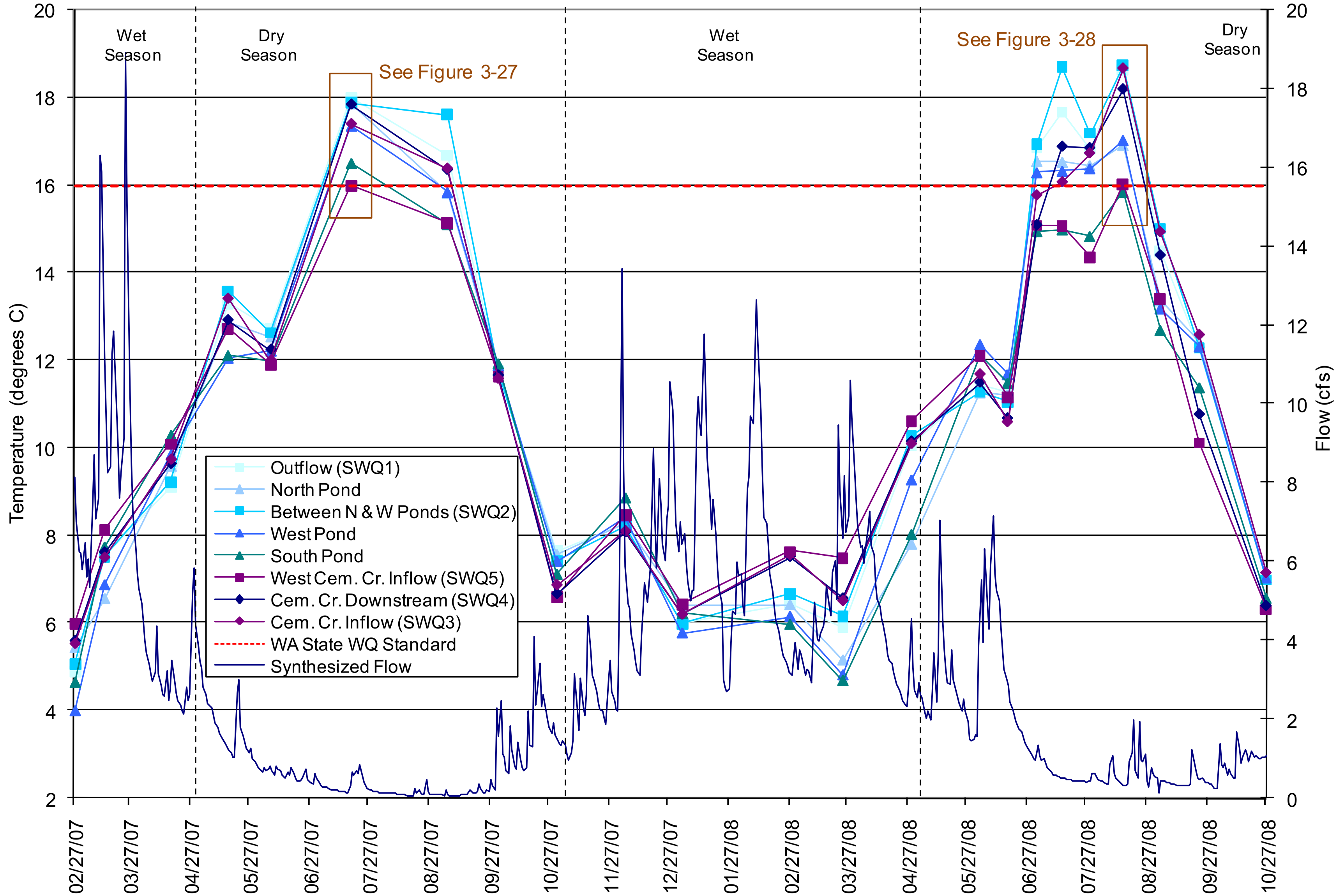


Figure 3-27. Temperature schematic of stream and representative pond values (at 0.5 feet below the water surface), July 18, 2007.

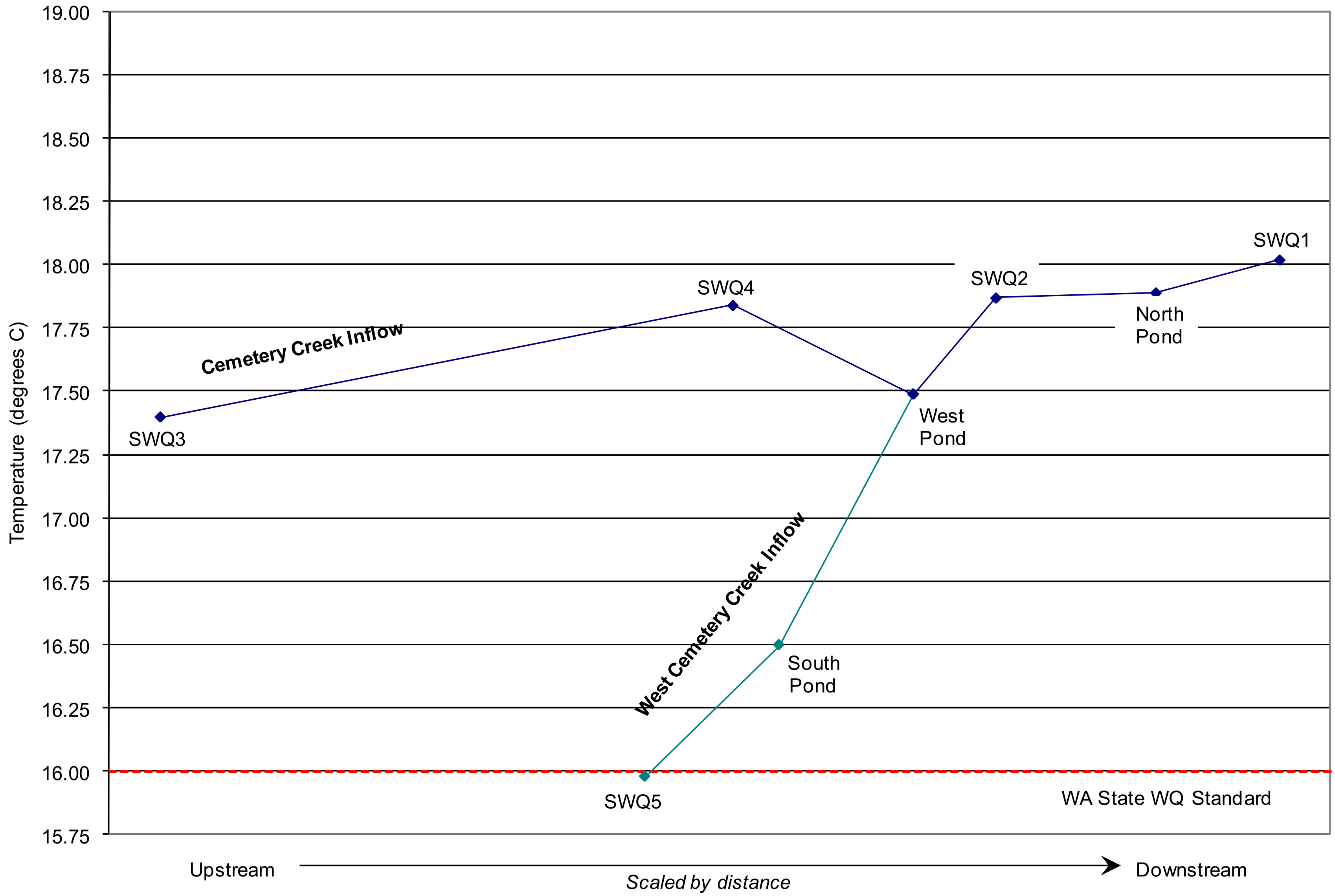
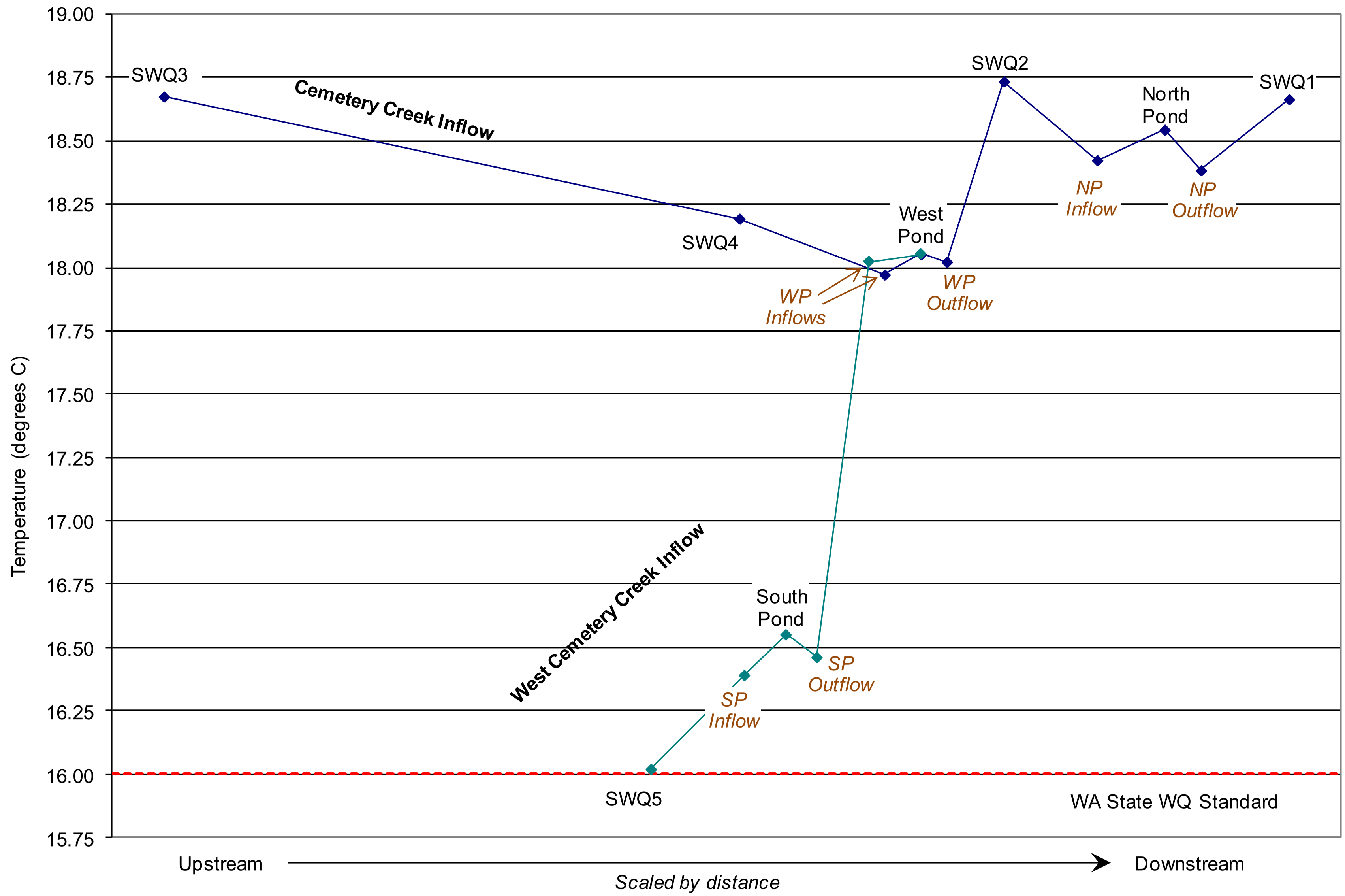


Figure 3-28. Temperature schematic of stream and representative pond values (at 0.5 feet below the water surface), August 15, 2008.



3.2.4.2 Dissolved Oxygen

Dissolved oxygen levels varied seasonally, being highest in the wet season, and lowest in the dry season (Figure 3-29). Dissolved oxygen levels met or were above the state standard (9.5 mg/L) at all stream sample sites during the wet seasons in 2007 and 2008. During the dry seasons, DO levels were frequently below the state standard.

In 2007, stream DO levels were below the standard on three consecutive testing dates (July 18 through October 1) at all stream sites, with one exception[10]. In 2008, stream DO levels were below the standard on six consecutive testing dates (July 2 through September 23) at all stream sites, with one exception[11].

Dissolved oxygen levels were as low as 3.19 mg/L in 2007[12] and 1.91 mg/L in 2008[13]. These DO levels, if widespread, are potentially lethal to fish (Spence et al. 1996). On both of these sampling dates 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 2007, DO increased by as little as 0.06 mg/L and decreased by as much as 2.16 mg/L as water flowed through the restoration site (from SWQ3 to SWQ4). However, the SWQ4 sampling site was almost always backwatered by the West Pond, resulting in values that may have been influenced by the pond. SWQ4 was moved upstream on February 4, 2008. In 2008 DO increased by as little as 0.79 mg/L and decreased by as much as 2.35 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 2007, the lowest DO value recorded at the West Cemetery Creek inflow (SWQ5) was 8.39 mg/L. In 2008, the lowest value was 8.05 mg/L. These values are greater than the level (5.0 mg/L) recognize as reducing salmonid growth (Spence et al. 1996).

Dissolved oxygen schematics of the Cemetery Creek system are presented below. Figure 3-30 illustrates changes in DO through the restoration site on July 18, 2007, the warmest sampling date of that year. Inflows at Cemetery Creek (SWQ3) and West Cemetery Creek (SWQ5) were below the DO standard, with values decreasing by 2.16 mg/L as water flowed

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[10] SWQ5, the West Cemetery Creek inflow, had a DO value of 9.71 mg/L on October 1, 2007.
[11] Again, SWQ5 had a DO value that met the state standard: 9.60 mg/L, on September 23, 2008.
[12] Measurement taken at SWQ4, the Cemetery Creek outflow, on September 5, 2007.
[13] Measurement taken at SWQ3, the Cemetery Creek inflow, on August 15, 2008.

through Cemetery Creek (SWQ3 to SWQ4)[14] and values decreasing by 6.46 mg/L from the West Cemetery Creek inflow (SWQ5) to the West Pond. Overall there was a DO decrease of 1.65 mg/L from Cemetery Creek inflow to outflow and a DO decrease of 5.12 mg/L from West Cemetery Creek inflow to outflow.

Figure 3-31 illustrates changes in DO through the restoration site on August 15, 2008 the warmest sampling date of that year. The 2008 schematic includes point-measurement of DO at the inflow and outflow of each pond. Cemetery Creek (SWQ3) and West Cemetery Creek (SWQ5) inflows to the restoration site were again below the state standard. However, DO levels increased slightly (by 0.29 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 North 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 15, 2008 sampling date there was a DO increase of 2.12 mg/L from Cemetery Creek inflow to outflow and a DO decrease of 4.03 mg/L from West Cemetery Creek inflow to outflow (Figure 3-31).

Overall, DO levels in the Cemetery Creek system are 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 3-29). Furthermore, point samples at pond inflows and some outflows show DO refuges in the ponds, even during warm periods (Figure 3-31). 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.

[14] The SWQ4 station was frequently backwatered by the West Pond during 2007 sampling dates; decreasing DO levels may be due to this West Pond influence.

Figure 3-29. Dissolved oxygen at stream water quality stations and representative pond values (at 2.0 feet below the water surface).

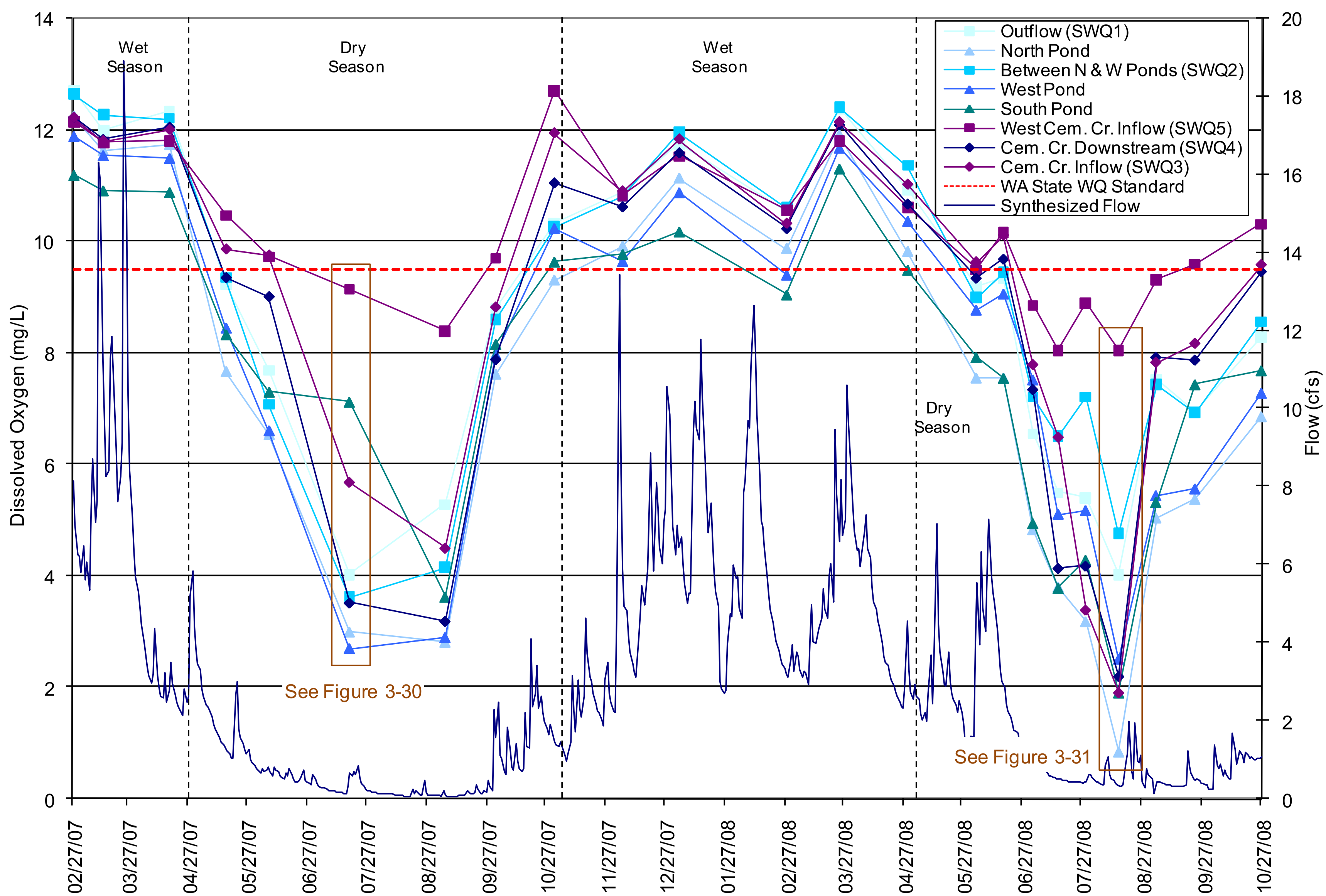


Figure 3-30. Dissolved oxygen schematic of stream and representative pond values (at 0.5 feet below the water surface), July 18, 2007.

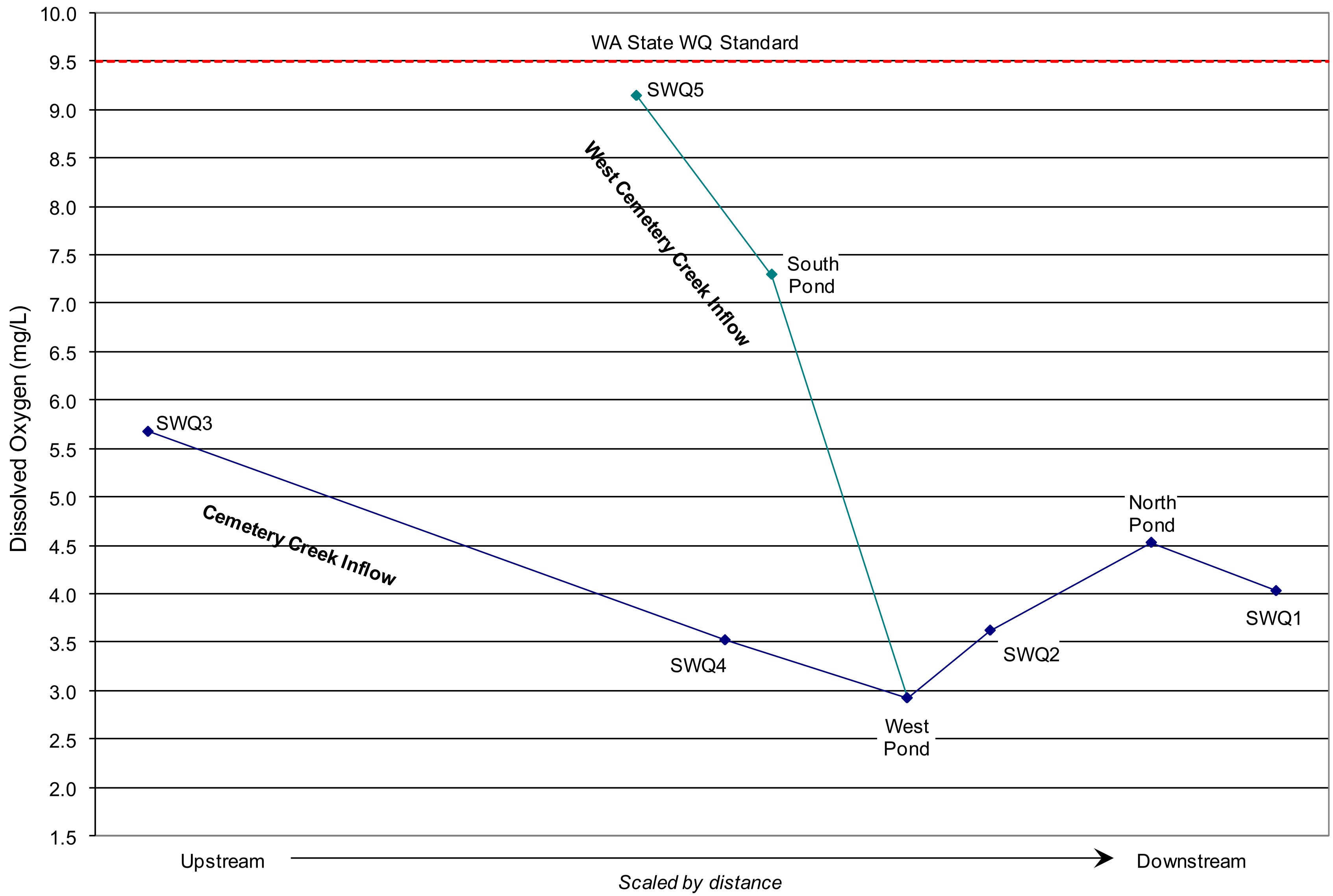
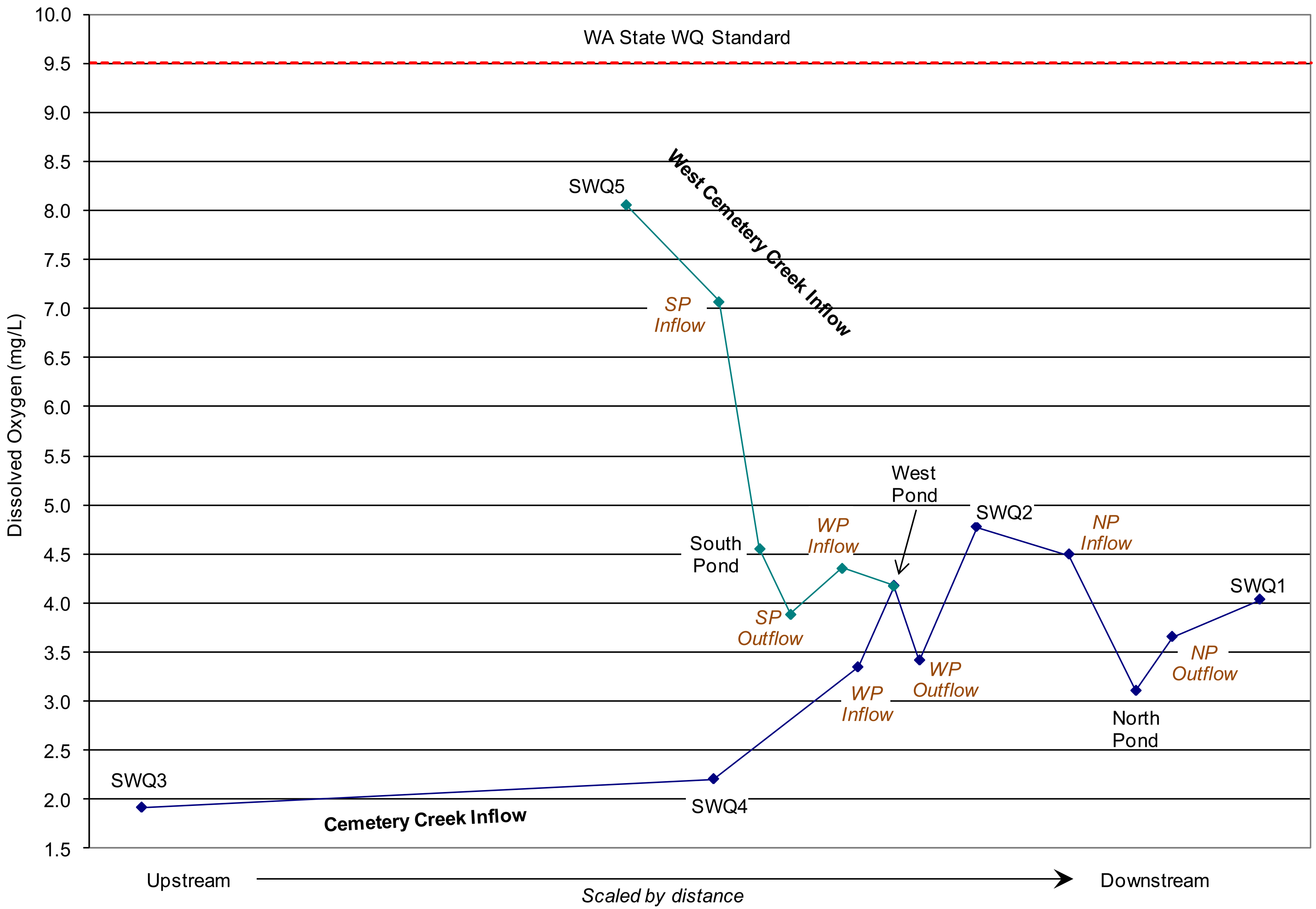


Figure 3-31. Dissolved oxygen schematic of stream and representative pond values (at 0.5 feet below the water surface), August 15, 2008.



Urban Stream Monitoring: Water quality at the mouth of Cemetery Creek has been tested 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 (Table 3-9). 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. However, the 2008 value was within the range of pre-project DO levels. The USM program is continuing and results will be updated in subsequent reports.

Table 3-9. Minimum dissolved oxygen (mg/L) recorded for the year during Cemetery Creek water quality monitoring for the Urban Stream Monitoring program. Maximum air temperatures provided for reference.

Year	Minimum Dissolved Oxygen (mg/L)	Maximum Air Temperature (ºC)[1]
1990	4.2	32.8
1991	3.5	31.1
1992	8.2	28.9
1993	6.0	31.1
1994	4.5	31.1
1995	5.7	31.1
2002	5.6	28.9
2003	4.1	30.6
2004	6.2	31.7
2005	5.2	28.9
2006	Restoration site construction	31.1
2007	1.8	33.9
2008	6.1	28.9

[1]Air temperatures taken at Bellingham International Airport.

3.2.4.3 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 3-32). This range is between .150 and .500 mS/cm (U.S. EPA 1997). The relatively higher SpC at the West Cemetery Creek inflow site (SWQ5) and the South Pond are likely a result of the groundwater influence of the large wetland upstream. A 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.

Isolated high values at the Cemetery Creek inflow site (SWQ3) in 2008 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.

Hydrolab drift was noted in the post-sampling audit on two sampling dates: 7/18/07 and 10/01/07.

3.2.4.4 pH

pH levels at all stream sites meet Ecology standards. There is no distinguishable pattern between pH levels at inflow and outflow (Figure 3-33).

3.2.4.5 Fecal Coliform

Fecal coliform (FC) samples were collected from eight sites in the restoration area (Figure 3-11, page 84). Generally, FC concentrations were lowest during the wet season. Fecal coliform was higher during the dry season, most likely due to concentration resulting from reduced flows. High-flow events (see sampling date 10/1/07 and 6/3/08), especially after long dry periods, resulted in the highest FC concentrations (Figure 3-34). The high level of urban development and impervious surfaces in the surrounding watershed are believed to be contributing factors to these FC concentrations. For more information, please refer to the Whatcom Creek Fecal Coliform Total Maximum Daily Load Study (Shannahan, et al. 2004).

Results indicate 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.

3.2.5 Recommendations

There are no recommended changes to the sampling protocol at this time.

Figure 3-32. Specific conductivity at stream water quality stations and representative pond values (at 2.0 feet below the water surface).

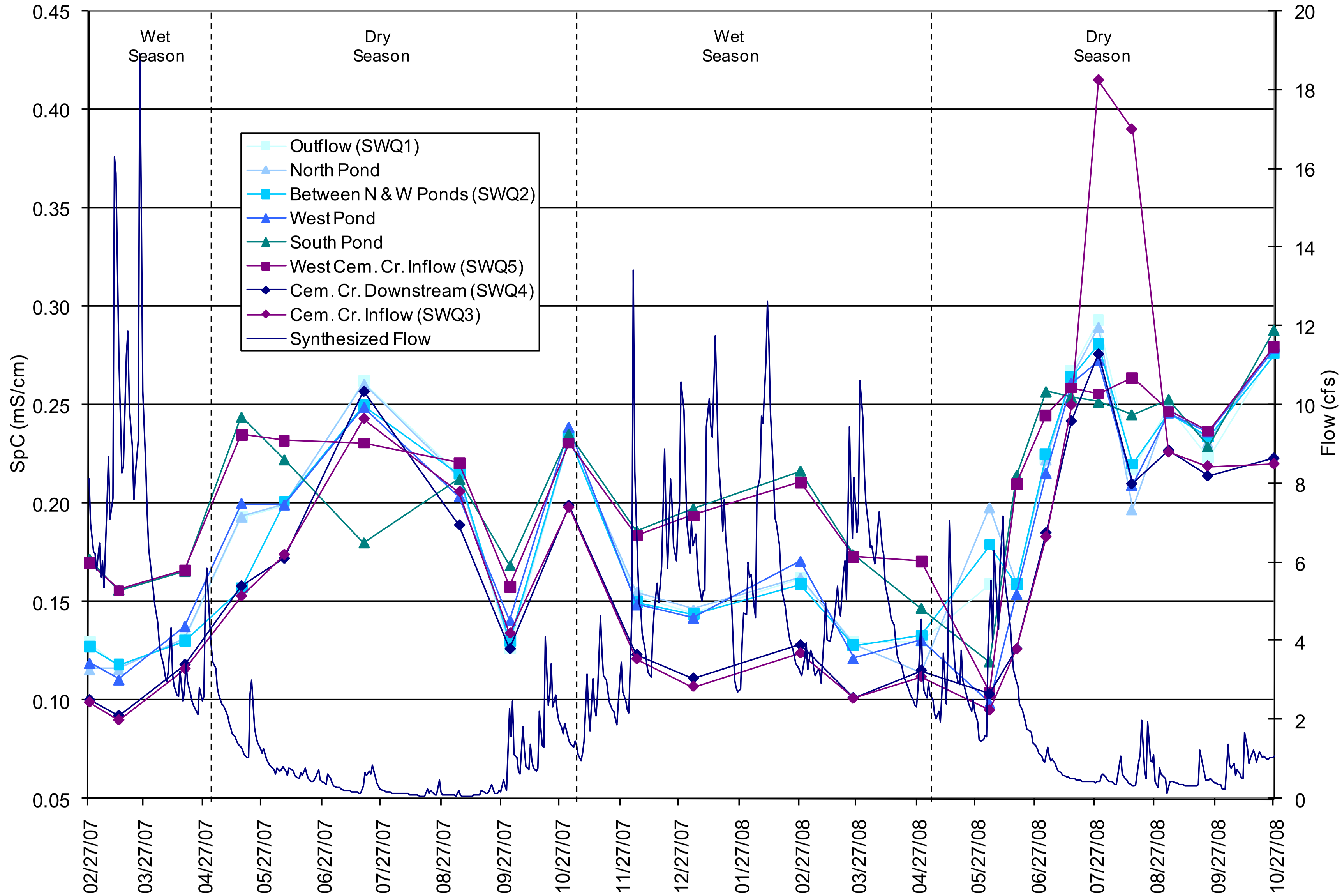


Figure 3-33. pH at stream water quality stations and representative pond values (at 2.0 feet below the water surface).

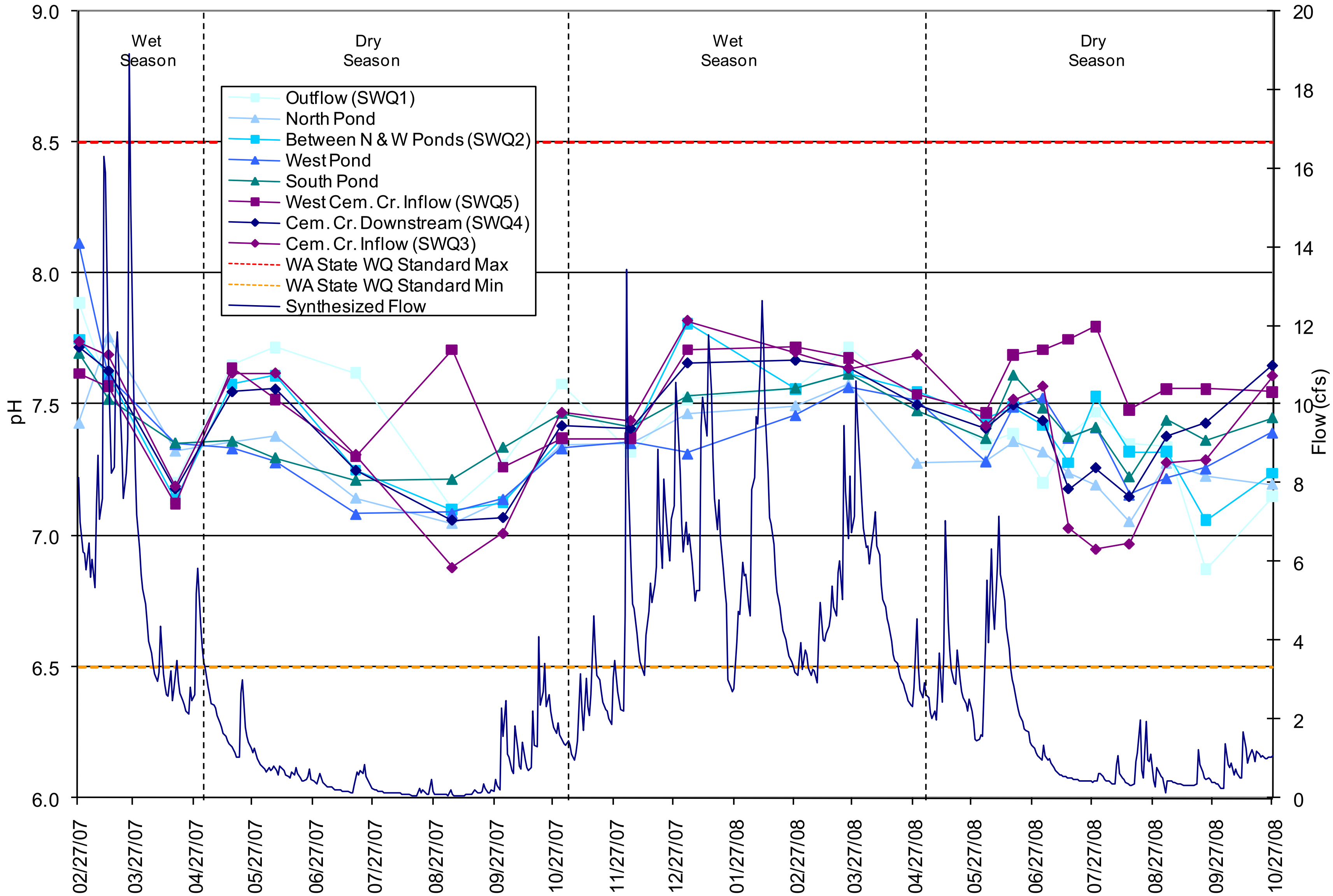
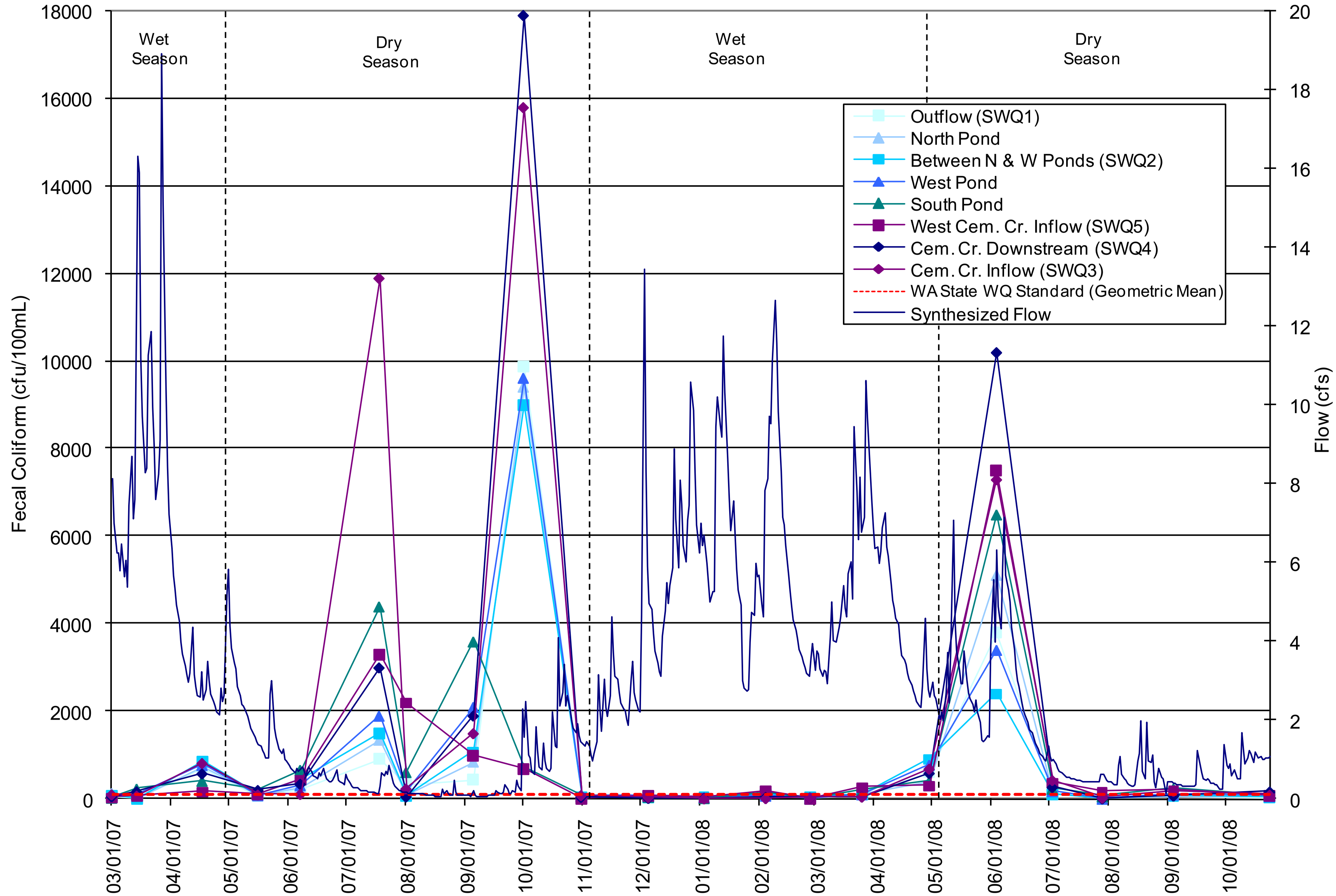


Figure 3-34. Fecal coliform concentrations (cfu/100ml) at stream and pond water quality stations.



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.

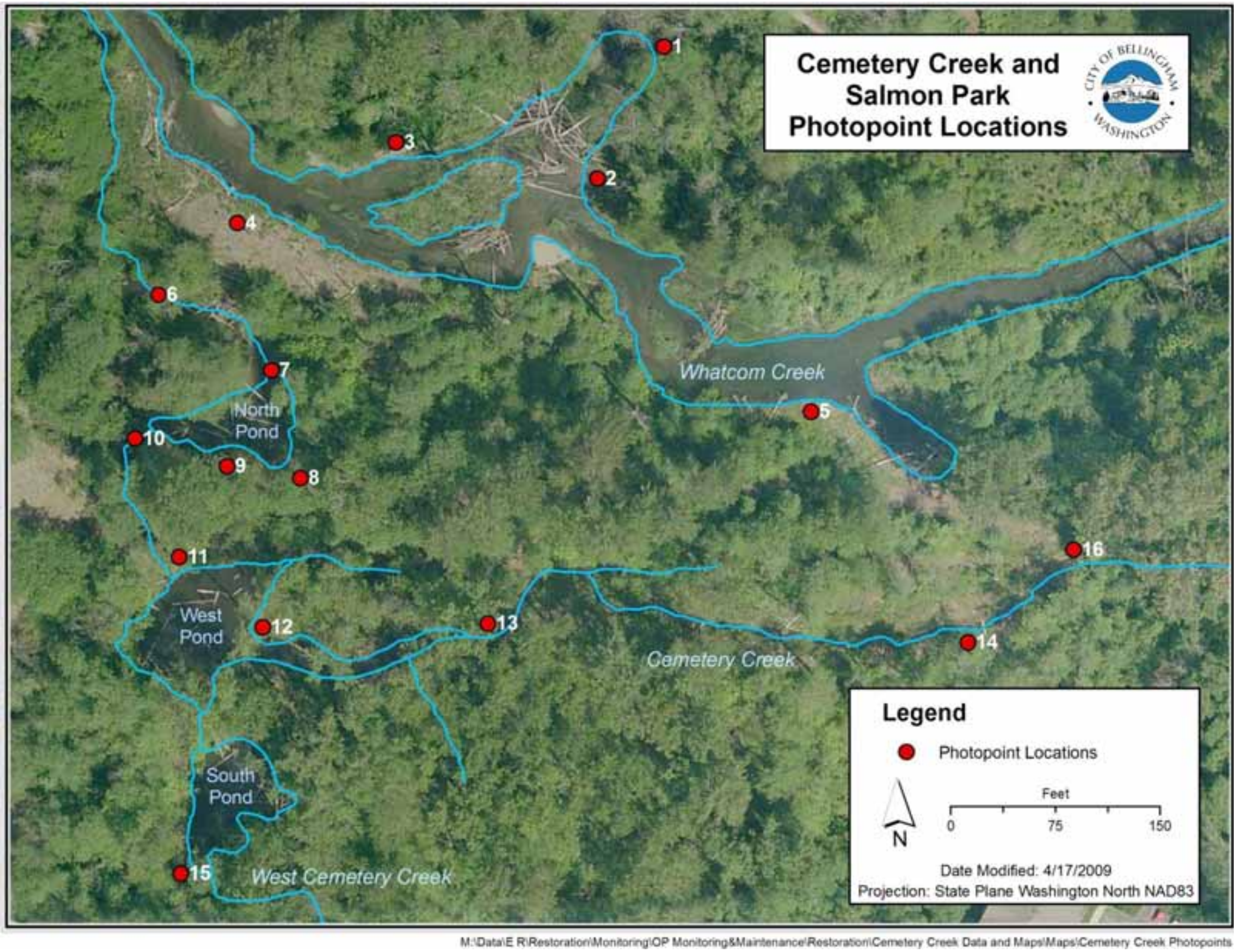
Photos are taken at each designated point using a digital camera. Photos are taken during July-September ("summer" or full canopy) and December-January ("winter" or after leaf fall).

4.3 RESULTS

Five photodocumentation periods have occurred during the report period. Find selected results below comparing winter photopoints from December 15, 2006, December 31, 2007, and January 20-26, 2009. Photopoints taken in January 2009 show the immediate effects of the flood event that occurred earlier that month.

Following winter comparisons, find selected results of summer photopoints taken August 13, 2007 and September 7, 2008. All photopoints from the survey period can be viewed in Appendix G.

Figure 4-1. Map of photopoint locations.



Photopoints December 2006 and 2007 and January 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 September 2008: 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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