Appendix C. Aquatic Plant Surveys

Appendix C.1. Parsons (2004)

Preliminary Summary of Aquatic Plant Data
Capitol Lake, Thurston County
Summer 2004

Aquatic plant frequency and biomass data were collected on July 11-12, 2004 by the Department of Ecology and September 13-16, 2004 by Thurston County. The lake was treated with the herbicide triclopyr (brand name Renovate®) on July 19, 2004 (south and middle basin) and July 29, 2004 (north basin). The target herbicide concentration was 2.5 ppm. The herbicide treatment was to control a burgeoning population of the invasive non-native aquatic plant Eurasian watermilfoil (*Myriophyllum spicatum*).

During both data collection periods, aquatic plant frequency data were collected at 188 points. The points were located on a 75 meter grid covering all lake basins and were located in the field with a Global Positioning Unit. At each point a plant sampling rake was tossed two times from the side of a boat. All species recovered were recorded. The data were analyzed using Chi square two-by-two analysis for the common species.

Biomass data were collected at randomly selected points from the same grid used for the frequency data collection. During the July sampling 29 samples were collected, in September 30 samples were collected. Each time samples were collected by a scuba diver using a 0.1 m^2 frame. Only the above sediment portions of the plants were collected. The samples were sorted by species and dried to a constant weight at 70° C in a forced air drying oven. The samples were weighed to 0.01 g. The data were analyzed using Analysis of Variance on log + 1 transformed data.

Results

A total of 12 aquatic plant species were found in Capitol Lake, excluding emergent shoreline vegetation (Table C1-1).

The frequency data results from common species are summarized in Table C1-2, biomass data results from common species are summarized in Table C1-3.

Table C1-1. Submersed and floating plant species list, Capitol Lake

Scientific name	Common name	Growth-form
Azolla sp.	water-fern	Floating, not rooted
Ceratophyllum demersum	Coontail; hornwort	Submersed, not-rooted
Elodea sp.	waterweed	Submersed, rooted
Lemna sp.	duckweed	Floating, not rooted
Myriophyllum spicatum	Eurasian water-milfoil	Submersed, rooted
Nitella sp.	stonewort	Submersed, not rooted
Nymphaea odorata	fragrant waterlily	Floating, rooted
Potamogeton crispus	curly leaf pondweed	Submersed, rooted
Potamogeton praelongus	whitestem pondweed	Submersed, rooted
Potamogeton sp (thin leaved)	thin leaved pondweed	Submersed, rooted
Spirodela polyrrhiza	great duckweed	Floating, not rooted
Stuckenia sp.	pondweed	Submersed, rooted

Table C1-2. Frequency data Chi square analysis results, numbers are the percent of points where the plant was found. Significance level $p < .05$, significant differences indicated in bold.

	July % present	September % present	P value
Eurasian milfoil (*Myriophyllum spicatum*)	**44**	**3**	**0.000**
waterweed (*Elodea* sp)	69	73	0.306
coontail (*Ceratophyllum demersum*)	21	27	0.147
stonewort (*Nitella* sp)	**2**	**9**	**0.004**
curly-leaf pondweed (*Potamogeton crispus*)	**5**	**11**	**0.033**
thin-leaf pondweed (*Potamogeton* sp)	29	26	0.489
No Plants	20	16	0.421

Table C1-3. Biomass data ANOVA results. Significance level $p < .05$, significant differences indicated in bold.

	July mean biomass (g/m^2)	September mean biomass (g/m^2)	p-value
Eurasian milfoil (*Myriophyllum spicatum*)	**54.8**	**0.5**	**0.01**
waterweed (*Elodea* sp)	**3.0**	**47.7**	**0.038**
coontail (*Ceratophyllum demersum*)	5.9	9.1	0.878
stonewort (*Nitella* sp)	0.7	0.3	0.782
curly-leaf pondweed (*Potamogeton crispus*)	0.04	0.2	0.401
thin-leaf pondweed (*Potamogeton* sp)	0.8	0.4	0.381
total all species	65.3	63.1	0.954

Results from the frequency data show that Eurasian watermilfoil was the only plant to decrease significantly. Stonewort and curly-leaf pondweed both increased significantly. The other common plants maintained about their same level of frequency throughout the summer.

Results from the biomass data show that Eurasian milfoil biomass decreased significantly. Biomass of waterweed (*Elodea* sp) increased significantly. The biomass of other species, including total biomass for the whole lake, did not change significantly during the study period.

Conclusions

- Both the frequency of occurrence and biomass of the target plant, Eurasian watermilfoil were reduced significantly after treatment with the herbicide Triclopyr. However, patches of this weed persisted in the lake, especially in the south basin, so continued control will be required to prevent additional spread and increased dominance.

- The increase of curly leaf pondweed should be monitored. This is also a non-native plant that can be invasive, and causes acute problems for lake managers in mid-western states.

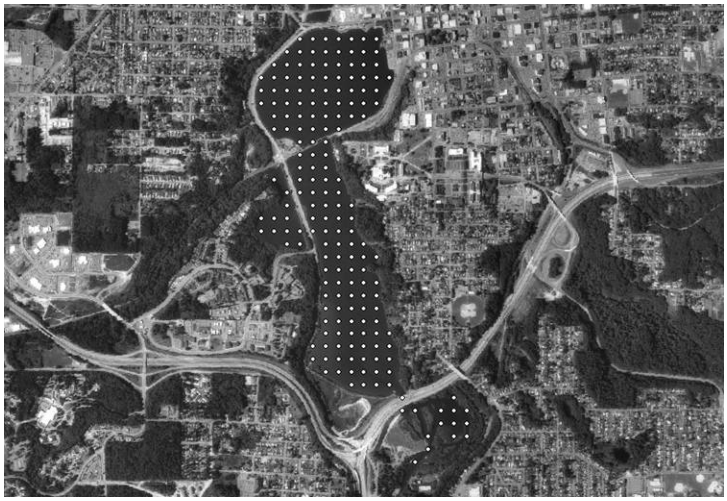
- Additional aquatic plant data will be collected during the summer of 2005 to look at the longer term impacts of the herbicide on the plant community.

Appendix C.2. Parsons (2005)

Preliminary Summary of Aquatic Plant Data
Capitol Lake, Thurston County
Fall 2005

Aquatic plant frequency and biomass data were collected on July 11-12, 2004 by the Department of Ecology and September 13-16, 2004 and July/August 2005 by Thurston County. The lake was treated with the herbicide triclopyr (brand name Renovate®) on July 19, 2004 (south and middle basin) and July 29, 2004 (north basin). The target herbicide concentration was 2.5 ppm. The herbicide treatment was to control a burgeoning population of the invasive non-native aquatic plant Eurasian watermilfoil (*Myriophyllum spicatum*).

Aquatic plant frequency data were collected at 188 points during both sampling periods in 2004 and 187 points in 2005. The points were located on a 75 meter grid covering all lake basins and were located in the field with a Global Positioning Unit (Figure 1). At each point a plant sampling rake was tossed two times from the side of a boat. All species recovered were recorded. The data were analyzed using Chi square two-by-two analysis for the common species.



Biomass data were collected at randomly selected points from the same grid used for the frequency data collection. During July 2004, 29 samples were collected, in each of September 2004 and August 2005, 30 samples were collected. Samples were collected by a scuba diver using a 0.1 m^2 frame. Only the above sediment portions of the plants were collected. The samples were sorted by species and dried to a constant weight at 70° C in a forced air drying oven. The samples were weighed to 0.01 g. The data were analyzed using Analysis of Variance on log + 1 transformed data.

Results

A total of 12 aquatic plant species were found in Capitol Lake, excluding emergent shoreline vegetation (Table C2-1).

The frequency data results from submersed species are summarized in Tables C2-2 and C2-3. Biomass data results are summarized in Table C2-4.

Table C2-1. Submersed and floating plant species list, Capitol Lake

Scientific name	Common name	Growth-form
Azolla sp.	water-fern	Floating, not rooted
Ceratophyllum demersum	Coontail; hornwort	Submersed, not-rooted
Characeae	macroalgae	Submersed, not rooted
Elodea sp.	waterweed	Submersed, rooted
Lemna sp.	duckweed	Floating, not rooted
Myriophyllum spicatum	Eurasian water-milfoil	Submersed, rooted
Nymphaea odorata	fragrant waterlily	Floating, rooted
Potamogeton crispus	curly leaf pondweed	Submersed, rooted
Potamogeton praelongus	whitestem pondweed	Submersed, rooted
Potamogeton sp (thin leaved)	thin leaved pondweed	Submersed, rooted
Spirodela polyrrhiza	great duckweed	Floating, not rooted
Stuckenia sp.	pondweed	Submersed, rooted

Table C2-2. Frequency data results, numbers are the percent of points where the plant was found.

	% present		
	July 04	Sept 04	July 05
Ceratophyllum demersum	21	27	7
Characeae	2	9	4
Elodea	69	73	16
Myriophyllum spicatum	44	3	0.5
No Plants	20	16	68
Potamogeton (thin leaf)	29	26	12
Potamogeton crispus	5	11	6
Potamogeton praelongus	0.5	2	2
Stuckenia sp	0.5	0	0

Table C2-3. Frequency analysis results of Chi square analysis. Significance level is $p<0.017$ due to multiple comparisons. Significant differences indicated in bold.

	P-value		
	July 04-Sept 04	July 04-July 05	Sept 04-July 05
Ceratophyllum demersum	0.147	**0.000**	**0.000**
Characeae	**.004**	0.354	0.036
Elodea	0.306	**0.000**	**0.000**
Myriophyllum spicatum	**0.000**	**0.000**	0.057
No Plants	0.421	**0.000**	**0.000**
Potamogeton (thin leaf)	0.489	**0.000**	**0.000**
Potamogeton crispus	0.033	0.637	0.094
Potamogeton praelongus	0.177	0.175	0.994
Stuckenia sp	Too few records for analysis		

Table C2-4. Mean biomass with standard deviation in parentheses and ANOVA results from common submersed species.

	Mean biomass (g/m^2)		
	July 04	Sept 04	Aug 05
Ceratophyllum demersum	5.9 (21.8)	9.1 (47.3)	8.5 (41.8)
Characeae	0.7 (3.9)	0.3 (1.1)	0
Elodea sp	3.0 (4.8)	47.7 (122.7)	15.1 (24.2)
Myriophyllum spicatum	54.8 (173.5)	**0.5 (2.4)***	**0***
Potamogeton crispus	0.04 (0.2)	0.2 (0.6)	5.0 (16.9)
Potamogeton praelongus	0	5.0 (27.2)	0
Potamogeton sp (thin leaf)	0.8 (2.2)	0.4 (0.8)	0.8 (3.3)
Stuckenia pectinata	0	0	0.3 (1.8)
TOTAL all species	65.3 (173.3)	63.1 (130.7)	29.7 (63.9)

* significantly different from pretreatment biomass (July 04).

Results from the frequency data show that Eurasian watermilfoil frequency was significantly reduced both 3 months and 1 year after treatment compared with pretreatment levels. Of the other species, the plant community appears to have been reduced in 2005 compared with 2004, as several of the species were found significantly less often in 2005 compared with both pre and post treatment sampling events in 2004.

Results from the biomass data show that Eurasian milfoil biomass decreased significantly both three months and one year after treatment compared with pretreatment levels. None of the other species, including total biomass for the whole lake, changed significantly during the study period.

Conclusions

In both the frequency of occurrence and biomass of the target plant, Eurasian watermilfoil were reduced significantly both three months and one year after treatment with the herbicide Triclopyr. However, small patches of this weed persisted in the lake, so continued control will be required to prevent additional spread and increased dominance. The whole plant community was reduced in 2005 compared with 2004, but this is likely due to weather conditions or some other factor that can affect aquatic plant abundance from year to year.

Appendix D. Station Identifiers

Table D-1. Station locations in the study area.

Station ID	Description
13-ADA-00.5	Adams Creek at mouth
13-ADA-UNK	Adams Creek-- unknown source
13-AYE-00.0	Ayer Creek at Boston Harbor Road
13-BLA-00.0	Black Lake Ditch at confluence with Percival Creek
13-BLA-02.3	Black Lake Ditch at Belmore Road
13-BUT-00.1	Butler Creek at French Loop Road
13-BUT-NW	Butler Creek-- northwest branch
13-BUT-SE	Butler Creek-- southeast branch
13-BUT-SW	Butler Creek-- southwest branch
13-CAP-00.0	Capitol Lake at dam
13-CAP-00.4	Capitol Lake at railroad trestle
13-CAP-01	Capitol Lake in south basin
13-CAP-02	Capitol Lake in middle basin (east)
13-CAP-03	Capitol Lake at railroad trestle
13-CAP-04	Capitol Lake at dam
13-CAP-05	Capitol Lake in middle basin (southwest)
13-CAP-06	Capitol Lake at Percival Cove outlet
13-CAP-07	Capitol Lake in north basin (west)
13-CAP-08	Capitol Lake in north basin (east)
13-CPFX1A	Capitol Lake benthic flux station 1A
13-CPFX1B	Capitol Lake benthic flux station 1B
13-CPFX2A	Capitol Lake benthic flux station 2A
13-CPFX2B	Capitol Lake benthic flux station 2B
13-CPFX3A	Capitol Lake benthic flux station 3A
13-CPFX3B	Capitol Lake benthic flux station 3B
13-CHA-00.1	Chambers Creek near mouth
13-DES-00.5	Deschutes River at E Street bridge
13-DES-02.7	Deschutes River at Henderson Blvd SE
13-DES-05.5	Deschutes River at Riverlea Drive (private property)
13-DES-06.8	Deschutes River near Oly Fuel and Asphalt
13-DES-09.2	Deschutes River near Rich Road
13-DES-14.5	Waldrick Road
13-DES-19.1	Deschutes River at Military Road
13-DES-20.5	Deschutes River at Route 507
13-DES-24.9	Deschutes River at Vail Loop Road/USGS
13-DES-25.8	Deschutes River at Woodbrook
13-DES-28.6	Deschutes River at Vail Cutoff Road SE
13-DES-30.2	Deschutes River at Reichel Road SE (private property)
13-DES-32.3	Deschutes River at Old Camp Lane
13-DES-37.4	Deschutes River at 1000 Rd
13-DES-42.3	Deschutes River near upper falls
13-ELL-00.0	Ellis Creek at East Bay Drive
13-ELL-33RD	Ellis Creek at 33rd Ave NE
13-FAL-00.3	Fall Creek at 1000 Road

Station ID	Description
13-HAR-00.3	Hard Creek above confluence with upper Deschutes
13-HPC-00.0	Hull/Pipeline Creeks at 1000 Rd
13-HUC-00.3	Huckleberry Creek near mouth
13-IND-00.2	Indian Creek at Quince Avenue
13-IND-12TH	Indian Creek at 12th Ave
13-IND-BOUL	Indian Creek path east of Boulevard Rd
13-IND-FRED	Indian Creek at Frederick Street
13-IND-MART	Indian Creek at Martin Way
13-IND-SBAY	Indian Creek at South Bay Rd/5th Avenue
13-IND-WHEE	Indian Creek at Wheeler Avenue
13-JOH-00.1	Johnson Creek at 3000 Rd
13-LAK-00.0	Capitol Lake outlet
13-LIN-00.0	Lincoln Creek above confluence with upper Deschutes
13-LIT-00.2	Little Deschutes River above confluence with upper Deschutes
13-LLT-00.0	Lake Lawrence tributary near Vail Loop Road SE
13-MIS-00.1	Mission Creek at East Bay Drive
13-MIS-BETH	Mission Creek at N Bethel Street
13-MIS-ETHR	Mission Creek at Ethridge Ave
13-MIT-00.2	Mitchell Creek at 1000 Road
13-MOX-00.0	Moxlie Creek at East Bay Drive
13-MOX-00.6	Moxlie Creek at Plum Street and Henderson
13-MOX-5TH	Moxlie Creek at 5th Avenue
13-MOX-8TH	Moxlie Creek at 8th Avenue
13-MOX-PARK	Moxlie Creek near Henderson Blvd in Watershed Park
13-MOX-PLUM	Moxlie Creek at Plum Street
13-PER-00.1	Percival Creek near mouth
13-PER-01.0	Percival Creek near Black Lake Ditch confluence
13-PER-02.4	Percival Creek at Sapp Road
13-PER-03.1	Percival Creek at Trosper Lane
13-PER-54TH	Percival Creek at 54th Avenue
13-REI-00.9	Reichel Creek at Vail Loop Road
13-SCH-00.1	Schneider Creek at West Bay Drive
13-SIL-00.4	Silver Spring
13-SP1-00.1	Spring at Route 507
13-SPU-00.0	Spurgeon Creek at Rich Road
13-SPU-EQUU	Spurgeon Creek at Equus Lane SE
13-SPU-LATI	Spurgeon Creek at Latigo St SE
13-SPU-MOOD	Spurgeon Creek off Rich Road
13-TEM-00.0	Tempo Lake tributary
13-THU-00.1	Thurston Creek at 3000 Road
CL1	Same as 13-CAP-01
CL2	Same as 13-CAP-02
CL3	Same as 13-CAP-03
CL4	Same as 13-CAP-04
CL5	Same as 13-CAP-05
CL6	Same as 13-CAP-06
CL7	Same as 13-CAP-07
CL8	Same as 13-CAP-08

Appendix E. Effective Shade Targets for the Deschutes River Watershed

Table E-1. Deschutes River shade targets.

Monitoring station	Distance from upstream boundary (km)	Current		Potential		Load targets	
		Reach-averaged effective shade	Reach-averaged solar heat load (W/m^2)	Mature vegetation and channel modifications	Reach-averaged solar heat load (W/m^2)	Recommended increase in effective shade (%)	Recommended decrease in solar load (W/m^2)
13-DES-42.3	0	89.1%	32	91.1%	26	2.0%	6
	1	79.7%	59	92.3%	22	12.6%	37
	2	34.4%	192	82.1%	52	47.7%	140
	3	51.3%	142	81.5%	54	30.3%	88
	4	49.1%	149	89.8%	30	40.7%	119
	5	44.7%	162	87.2%	37	42.5%	125
	6	46.8%	156	76.3%	70	29.5%	86
	7	51.0%	144	75.5%	72	24.6%	72
	8	56.0%	129	83.3%	49	27.4%	80
13-DES-37.4	9	46.7%	156	87.5%	37	40.8%	119
	10	53.1%	138	85.9%	41	32.8%	96
	11	25.8%	217	79.0%	61	53.2%	155
	12	15.7%	247	82.7%	51	67.0%	196
	13	29.0%	208	81.7%	54	52.7%	154
	14	49.7%	148	82.1%	53	32.4%	95
	15	43.1%	167	85.7%	42	42.6%	125
	16	62.8%	109	83.8%	47	21.1%	62
13-DES-32.3	17	27.3%	213	89.2%	32	61.9%	181
	18	44.8%	161	86.3%	40	41.4%	121
	19	14.8%	249	74.4%	75	59.7%	174
	20	61.3%	113	87.4%	37	26.1%	76
	21	67.7%	94	87.8%	36	20.1%	59
	22	20.8%	231	77.5%	66	56.7%	165
13-DES-28.6	23	57.7%	124	84.7%	45	27.0%	79
	24	85.1%	44	96.4%	10	11.3%	33
	25	86.2%	40	92.6%	22	6.4%	19
	26	62.8%	109	87.3%	37	24.5%	72
	27	58.2%	123	86.3%	40	28.1%	82
13-DES-26.2	28	72.4%	81	90.2%	29	17.8%	52
13-DES-24.9	29	48.6%	151	87.1%	38	38.5%	113
	30	60.9%	114	83.0%	50	22.0%	65
	31	62.5%	110	89.6%	31	27.1%	80
	32	38.5%	181	82.5%	51	44.0%	129
	33	56.0%	129	89.6%	30	33.6%	99
	34	43.4%	166	82.5%	51	39.1%	115
	35	32.6%	198	80.5%	57	47.9%	141
13-DES-20.5	36	21.4%	230	74.7%	74	53.3%	156
	37	63.3%	108	91.0%	26	27.7%	81
	38	55.6%	130	88.1%	35	32.4%	95

Monitoring station	Distance from upstream boundary (km)	Current		Potential		Load targets	
		Reach-averaged effective shade	Reach-averaged solar heat load (W/m^2)	Mature vegetation and channel modifications	Reach-averaged solar heat load (W/m^2)	Recommended increase in effective shade (%)	Recommended decrease in solar load (W/m^2)
13-DES-19.1	39	66.9%	97	93.5%	19	26.6%	78
	40	51.4%	143	88.5%	34	37.2%	110
	41	58.5%	122	86.9%	38	28.5%	84
	42	47.9%	153	84.3%	46	36.5%	107
	43	34.5%	192	86.1%	41	51.6%	151
	44	53.3%	137	89.3%	31	35.9%	106
	45	47.7%	154	85.2%	43	37.6%	110
13-DES-14.5	46	28.7%	209	70.5%	87	41.7%	122
	47	66.6%	98	87.5%	37	20.9%	61
13-DES-13.4	48	42.4%	169	79.8%	59	37.4%	110
	49	34.9%	191	85.9%	41	51.0%	150
	50	40.7%	174	86.2%	41	45.5%	134
	51	45.8%	159	83.1%	50	37.3%	109
	52	45.2%	161	88.4%	34	43.2%	127
	53	39.7%	177	78.4%	63	38.7%	114
	54	51.2%	143	80.2%	58	29.0%	85
13-DES-9.2	55	54.7%	133	85.1%	44	30.3%	89
	56	30.0%	205	79.1%	61	49.1%	144
	57	30.5%	204	70.0%	88	39.5%	116
	58	15.7%	246	79.0%	61	63.4%	185
13-DES-6.8	59	32.7%	197	66.3%	99	33.6%	99
13-DES-5.8	60	43.9%	164	72.9%	79	29.0%	85
	61	30.2%	205	78.9%	62	48.7%	143
	62	26.1%	217	79.0%	62	52.9%	155
	63	19.1%	237	82.0%	53	63.0%	185
	64	26.0%	217	77.5%	66	51.6%	151
13-DES-2.7	65	26.2%	216	64.5%	104	38.2%	112
	66	46.7%	157	83.2%	49	36.5%	107
	67	38.0%	182	87.8%	36	49.7%	146
	68	30.3%	204	60.3%	116	30.0%	88
13-DES-0.5	69	84.4%	46	95.4%	14	11.0%	33

Appendix F. Effective Shade Targets for the Percival Creek Watershed

Table F-1. Percival Creek shade targets.

STATION	Distance from upstream boundary to end of reach (km)	River mile from mouth of Percival Creek (mi)	Current reach-averaged effective shade (%)	Current reach-averaged solar heat load (W/m^2)	Potential reach-averaged effective shade (%)	Potential reach-averaged solar heat load (W/m^2)	Load Target: Recommended increase in effective shade (%)	Load Target: Recommended decrease in solar load (W/m^2)
13PER03.3	0.0	3.4	98%	8	99%	2	**2%**	**6**
	0.5	3.1	70%	99	96%	11	**26%**	**87**
	1.0	2.8	81%	49	96%	13	**14%**	**36**
13PER02.4	1.5	2.5	69%	85	93%	21	**25%**	**64**
	2.0	2.2	54%	143	99%	2	**45%**	**141**
13PER02.0	2.5	1.9	98%	5	99%	2	**1%**	**3**
13PER01.6	3.0	1.6	99%	3	99%	2	**0%**	**1**
13PER01.1	3.5	1.2	99%	3	99%	2	**0%**	**2**
13PER00.9	4.0	0.9	84%	50	99%	3	**15%**	**47**
	4.5	0.6	96%	13	99%	4	**3%**	**9**
	5.0	0.3	90%	31	99%	4	**9%**	**27**
13PER00.1	5.5	0.0	67%	97	99%	4	**32%**	**93**

Table F-2. Black Lake Ditch shade targets.

STATION	Distance from upstream boundary to end of reach (km)	River mile from mouth of Percival Creek (mi)	Current reach-averaged effective shade (%)	Current reach-averaged solar heat load (W/m^2)	Potential reach-averaged effective shade (%)	Potential reach-averaged solar heat load (W/m^2)	Load Target: Recommended increase in effective shade (%)	Load Target: Recommended decrease in solar load (W/m^2)
13BLA02.3	0.0	3.4	26%	233	81%	61	**55%**	**172**
	0.5	3.1	25%	235	76%	73	**52%**	**162**
	1.0	2.8	46%	170	83%	53	**38%**	**117**
13BLA01.5	1.5	2.4	77%	72	87%	41	**10%**	**31**
	2.0	2.1	28%	225	78%	69	**50%**	**156**
	2.5	1.8	9%	286	77%	73	**68%**	**213**
	3.0	1.5	73%	84	92%	25	**19%**	**59**
13BLA00.0	3.5	1.2	92%	23	99%	2	**8%**	**21**