New Zealand Mudsnail Surveys at Lower Columbia River Basin National Fish Hatcheries 2008

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Introduction

The New Zealand mudsnail (*Potamopyrgus antipodarum*) is an aquatic snail species naturally occurring in New Zealand and nearby islands. However, during the last 150 years the New Zealand mudsnail has been introduced to other parts of the world including the United States (U.S.). In the U.S., the New Zealand mudsnail was first documented in south-central Idaho in the Snake River system in 1987 by D.W. Taylor near Hagerman, Idaho during summer mollusc surveys in The Nature Conservancy's Thousand Springs Preserve adjacent to the Upper Salmon Falls Dam impoundment (Bowler 1991). Although speculative, the origin of these New Zealand mudsnails is likely commercial movement of aquaculture products such as trout eggs or live fish from Australia or New Zealand.

In 2002, the New Zealand mudsnail was first discovered at a National Fish Hatchery (Hagerman National Fish Hatchery in Idaho). With this discovery, New Zealand mudsnails became a new management issue for National Fish Hatchery (NFH) managers because hatchery fish transplants are a potential mechanism by which to spread the invader (Aitkin 2006). Bowler and Frest (1992) state that the occurrence of New Zealand mudsnails in Idaho's middle Snake River basin, makes transplanting trout or other species outside the sub-basin risky.

Regarding hatchery effluent, generally depressed populations of native snails exist downstream of fish hatcheries; however, in some Snake River tributaries, dense populations of New Zealand mudsnails exist in the waters downstream of aquaculture facilities (Bowler 1991). Frest and Bowler (1993) noted the New Zealand mudsnail "appears to build larger populations in polluted mainstem river settings or below fish hatcheries on tributaries and is less prolific in springs above pollution sources".

Distribution

Currently, New Zealand mudsnails in the U.S. occur in three main, genetically distinct groups of different origin. One group exists in the Great Lakes region and the other two groups exist in the western states where one group dominates. This dominant group is now present in 10 western states (Figure 1) and continues to spread rapidly where they invade estuaries, lakes, rivers and streams; with several new populations being discovered every year (Montana State University 2008; NZMMCPWG 2007).

To track the latest populations and research the Department of Ecology at Montana State University-Bozeman hosts a New Zealand mudsnail database website (http://www.esg.montana.edu/aim/mollusca/nzms/) funded by the United States Fish and Wildlife Service (USFWS). The "Status & Maps" link has current dot and Hydrologic Unit Code (HUC) summary maps showing New Zealand mudsnail distribution for each state or region (Figure 1).

Biology and Ecology

New Zealand mudsnail range expansion is driven by the snails small size (< 5 mm), color, and ability to survive for days out of water by closing their operculum effectively sealing themselves up to avoid drying out. These characteristics make the New Zealand mudsnail an effective "hitchhiker" (Oregon State University 2006). For example, a major pathway of spread appears to be anglers fishing gear, especially waders and wading boots. (NZMMCPWG 2007; Oregon State University 2006). Once introduced to new areas the snail is a successful invader because a single individual can found a new population (Bowler and Frest 1992). Specifically, in the western U.S. the New Zealand mudsnails are almost all females which reproduce by cloning themselves (parthenogenesis). Unfertilized eggs give rise only to female embryos. Females are live bearing (ovoviviparous), and male New Zealand mudsnails are present only rarely in North America. (Bowler 1991, Oregon State University 2006).

This reproductive strategy allows for extraordinary population building by the New Zealand mudsnail. For example, Bowler et al. (1993) state that within three years of the Snake River New Zealand mudsnail discovery, "a remarkable expansion in enormous populations of the New Zealand mudsnail" occurred. Also, densities of New Zealand mudsnails reached >500,000 snails/m2 in some locations but can fluctuate widely. Even following New Zealand mudsnail population crashes, large populations rapidly recover (Bowler 1991). Such large New Zealand mudsnail numbers could indicate a potential forage source for other animals; however, because the snails are capable of passing through the fish's digestive system alive and intact, fish derive little or no energy from eating snails (NZMMCPWG 2007).

In addition to reproductive biology, other factors that make New Zealand mudsnails effective colonists are as follows: 1) exploit both eutrophic and oligotrophic water; 2) utilize wide variety of micro-habitat and substrates from sand/silt littoral sediments to rocky bottoms to aquatic vegetation (especially algae); 3) once present in a watershed, disperse easily by diverse means; 4) withstand the wetting and drying of its habitat such as those due to man-caused water fluctuations; 5) live out of water for weeks in only moist conditions; 6) survive a six hour passage through the gut of a trout and give birth immediately afterward; and 7) climb vertical surfaces (Bowler 1991).

Given such traits, the snail can rapidly outnumber native molluscs with which it co-exists and contribute to the decline of native fauna (Bowler et al. 1993; Bowler and Frest 1992). For example, Frest and Bowler (1993) state that the New Zealand mudsnail is "now by far the most abundant species encountered in nearly all habitats" and the "dominate mollusc in the middle Snake River". However, they acknowledge these changes were due in part to water quality degradation.

Although little study of potential competition between New Zealand mudsnails and native snail species exists, potential threats include New Zealand mudsnail domination of habitat, covering of egg sites and masses, and attraction of predators. Also, more subtle competition and interaction could be occurring (Bowler 1991). Once well established, the New Zealand mudsnail has been impossible to eradicate, thus prevention is the most effective means to stop their spread (Oregon State University 2006).

Impacts

In addition to biological and ecological impacts, New Zealand mudsnail invasions have national policy implications. For example, such invasions and subsequent effects on native freshwater molluscs have had important Endangered Species Act implications (Bowler 1991, Bowler et al. 1993; Frest and Bowler 1992, 1993; USFWS 2008). Bowler (1991) noted the New Zealand mudsnail competed for habitat in southern Idaho's Snake River with native molluscs six of which were candidate endangered species. In 1992 the Idaho springsnail (*Pyrgulopsis idahoensis*) was listed as endangered. Reasons for listing the snail included the appearance of the invasive New Zealand mudsnail. The Idaho springsnail was subsequently removed from the list of endangered wildlife in 2007 following DNA genetic analysis (USFWS 2008). Given these examples, economic impacts of New Zealand mudsnail invasions are relevant as well.

Prevention and Control Efforts

National policy prevents federal agencies from authorizing, funding, or carrying out actions that are "likely to cause or promote the introduction or spread of invasive species" (except under certain conditions). Also under certain conditions, transport of New Zealand mudsnails between states that restrict possession of this species can violate the Lacey Act of 1900.

The basis for New Zealand mudsnail prevention and control programs at federal fish hatcheries, federally-funded state fish hatcheries and other facilities is Executive Order 13112 which was signed in 1999 by President Clinton.

To coordinate national efforts to prevent the introduction and spread of aquatic invasive species including New Zealand mudsnails, the Aquatic Nuisance Species Task Force (ANSTF) was established in 1990 as an intergovernmental entity. The USFWS and the National Oceanic and Atmospheric Administration (NOAA) co-chair the ANSTF. The ANSTF was established under the Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990, as amended by the National Invasive Species Act of 1996 (NZMMCPWG 2007).

Early detection of the New Zealand mudsnail at our national fish hatcheries will help delay or prevent their spread to other areas (Allard and Olhausen 2007).

In fiscal year 2005 the Columbia River Fisheries Program Office (CRFPO) received funds to begin intermittent monitoring for New Zealand mudsnails at lower Columbia River basin National Fish Hatcheries. In 2006 New Zealand mudsnail surveys were conducted at Carson, Little White Salmon, Spring Creek and Warm Springs NFHs as well as Willapa Bay National Wildlife Refuge. In 2007, New Zealand mudsnail surveys were conducted at Eagle Creek and Willard NFHs (Allard and Olhausen 2007a, 2007b).

Funding for the New Zealand mudsnail surveys continued in 2008. This report presents results of those surveys conducted by USFWS CRFPO personnel.

Methods

Six National Fish Hatcheries in the lower Columbia River basin were surveyed for New Zealand mudsnails including: Carson, Eagle Creek, Little White Salmon, Spring Creek, Warm Springs and Willard (Figure 2).

Surveys were performed from November 21 to December 4, 2008 to determine visually identifiable New Zealand mudsnail presence. All water inflows and the downstream most water outflows at each hatchery were surveyed if possible. Otherwise the closest nearby accessible location was surveyed. Hatchery personnel identified inflow and outflow locations and were interviewed regarding additional survey sites such as pollution abatement ponds, raceways and hatchery plumbing where New Zealand mudsnails might exist. These additional recommended sites were subsequently surveyed.

For a given habitat, such as a riffle with cobble substrate, an overhanging bank with aquatic vegetation or a hatchery settling pond, inspection for New Zealand mudsnails was conducted by both ocular inspection and by hand while flipping rocks or pulling apart vegetation. In deeper water, an Aqua Scope II™ underwater viewing scope was used to view substrate and vegetation for New Zealand mudsnails. Surveys were performed at each sample site for approximately 15 minutes. Sample locations were photographed and logged using a global positioning system (GPS; Trimble GeoExplorer) to serve as baseline survey points for future surveys.

Voucher snail specimens were collected at all hatcheries except Eagle Creek NFH. Collected snail voucher specimens were returned to the laboratory and examined with a dissecting microscope to determine if they were New Zealand mudsnails. Magnified photographs were made of all voucher specimens and identification was confirmed by Robin Draheim of Portland State University Center for Lakes and Reservoirs. For future reference, voucher specimens were preserved in 200 proof, non-denatured ethanol and stored in glass vials at the CRFPO laboratory.

Results

No New Zealand mudsnails were found during field surveys or laboratory inspections of voucher specimens. Table 1 lists sample date, time, locality descriptions, voucher specimen collections, New Zealand mudsnail survey results and GPS coordinates for individual sample sites at the six hatcheries surveyed. During the sampling period, stream discharges were near summer low flow conditions and water clarity was excellent at all sites. Collected voucher specimens were easily identifiable from New Zealand mudsnails because of shell type, size, shape and whorl number and orientation. Sample locations for each hatchery are shown in figures three to eight.

Carson NFH

Three inflow and three outflow sites were inspected including Tyee Springs, the headwaters of the hatchery source water. Outflow sample sites included the pollution abatement pond and the confluence of hatchery discharge water channel and the Wind River.

Eagle Creek NFH

Two sites in Eagle Creek were surveyed for New Zealand mudsnails. Because the water intake grate was inaccessible due to scaffolding and tight canyon walls, the first stream water settling pond approximately 100m downstream of the water intake grate was sampled. Outflow sampling was conducted in riffle habitat immediately downstream of the raceway outflow and fish ladder entrance. Also inspected was a floor drain inside the hatchery building or egg house.

Little White Salmon NFH

Among eight inflow sites surveyed, six included roadside or hillside springs as well as a water filtering facility. The two remaining inflow sites were both downstream from the inaccessible water inflow grate where ninety percent of hatchery water is gathered. One sample site was at rivers edge and the other was an off channel settling pond. Outflows sampled were the concrete raceway outflow above the fish ladder entrance and downstream at the hatchery building outflow.

Spring Creek NFH

The sole source of inflow water for the hatchery consists of five hillside springs on the north side of Washington State Highway Fourteen. Each of these was inspected as well as two outflow points. The outflow points inspected were at the fish ladder entrance/raceway outflow on the Columbia River and downriver approximately 1,000 m west at the pollution abatement ponds exit.

Willard NFH

Three sites were surveyed including habitat surrounding the water intake grate and the bedrock substrate along the water stream of the downstream most water outflow pipe where river access was not possible in the large bedrock pool. Also sampled was the lining of aquatic vegetation along the water discharge exit of the North bank of raceways.

Warm Springs NFH

One inflow and four outflow sites were surveyed. The inflow sample site was along the northwest river edge approximately 30 m upstream of the water intake grate. Outflow sample sites included the pollution abatement pond outflow standpipe and the river edge discharge point as well as the top surface of the raceway outflow grate next to the fish ladder entrance.

Discussion

The surveys conducted during 2008 were designed to determine if visually identifiable New Zealand mudsnails were present, and none were found. Such surveys are crucial and should continue because early detection may prevent the spread of New Zealand mudsnails.

Very small New Zealand mudsnails have been overlooked in the Deschutes River, Oregon, during initial visual field inspections and later detected through a more careful visual analysis of sieved substrate samples in the laboratory (V. Brenneis, Portland State University, personal communication). To address such problems development of new New Zealand mudsnail population detection methods is a key objective of the ANSTF (NZMMCPWG 2007).

As suggested by one hatchery manager, several white tile or polyvinyl chloride (PVC) pieces placed and attached in key sample areas may allow for more frequent New Zealand mudsnail surveys with little time commitment. For example, hatchery staff could quickly view these pieces for presence and absence at suitable designated time intervals.

Snorkel surveys would allow for more thorough inspection of underwater sites, and dry suits would allow access to some of the inaccessible sites such as above the water intake grate at Eagle Creek NFH. Such techniques are recommended for future surveys.

Although some of the national fish hatcheries surveyed collect their water from adjacent springs, those with river source water may be at risk from upstream areas contaminated with New Zealand mudsnails. For example, fish stocking by the Washington Department of Fish and Wildlife occurs upstream of both Willard NFH and Little White Salmon NFH both located on the Little White Salmon River (WDFW 2008) which could serve as a pathway for invasion. This and other pathway risks could be outlined by tools such as Hazard Analysis and Critical Control Point Planning (NZMMCPWG 2007). However, such measures require additional funding.

Acknowledgements

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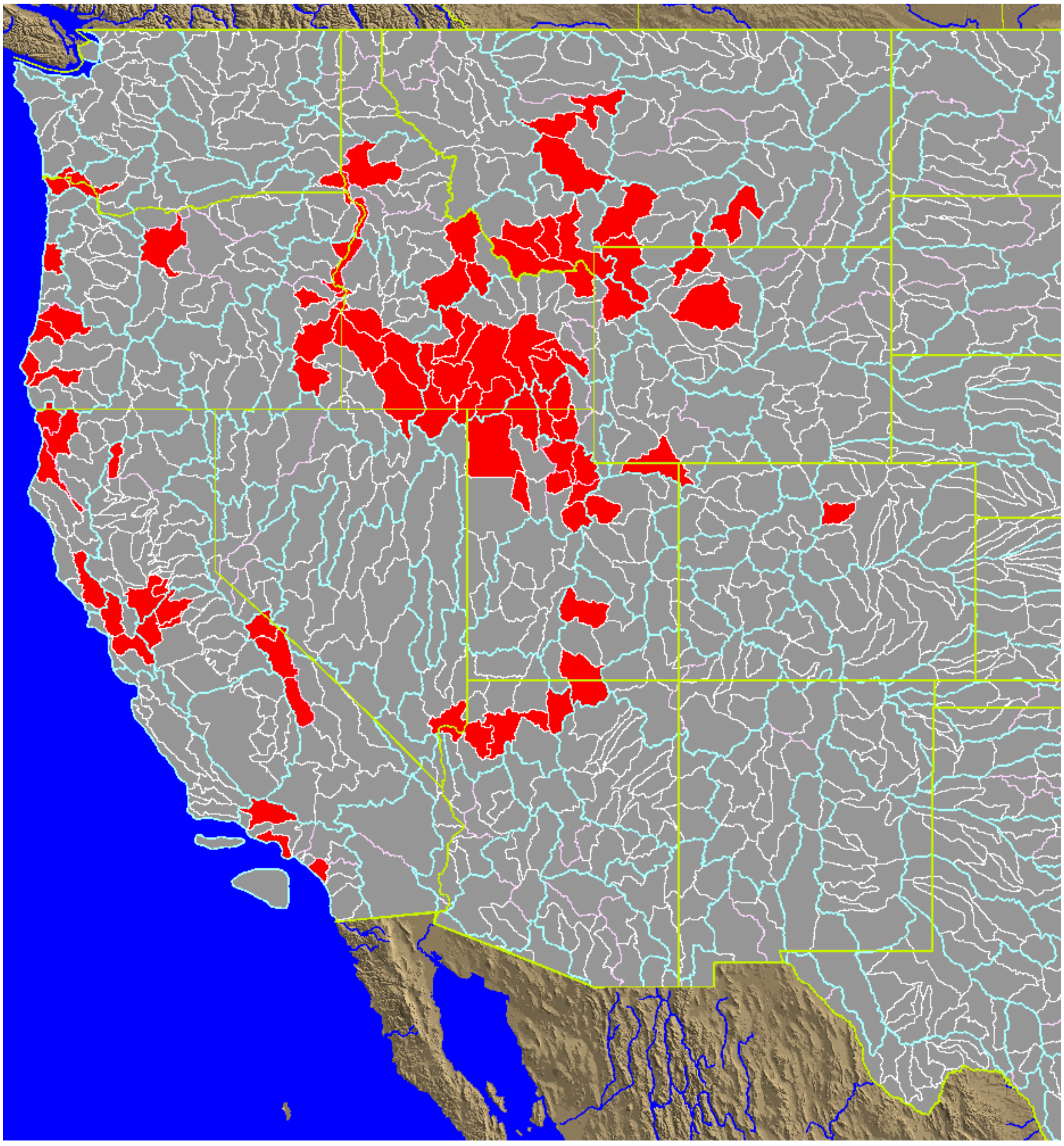

Figure 1. HUC map display of February 2009 New Zealand mudsnail distribution in the western U.S. (Montana State University 2008).

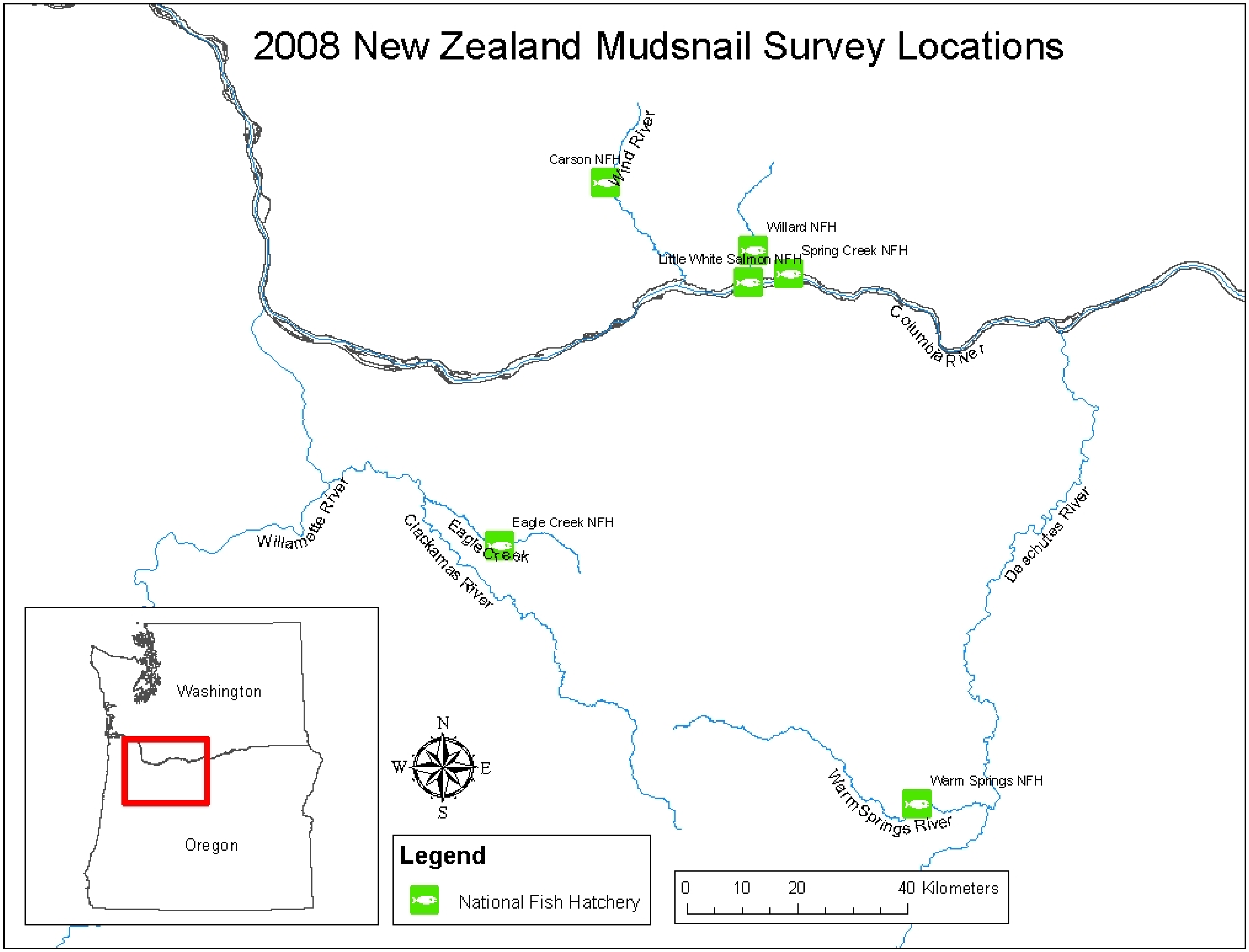

Figure 2. Map of USFWS lower Columbia River basin National Fish Hatcheries surveyed for New Zealand mudsnails during 2008.

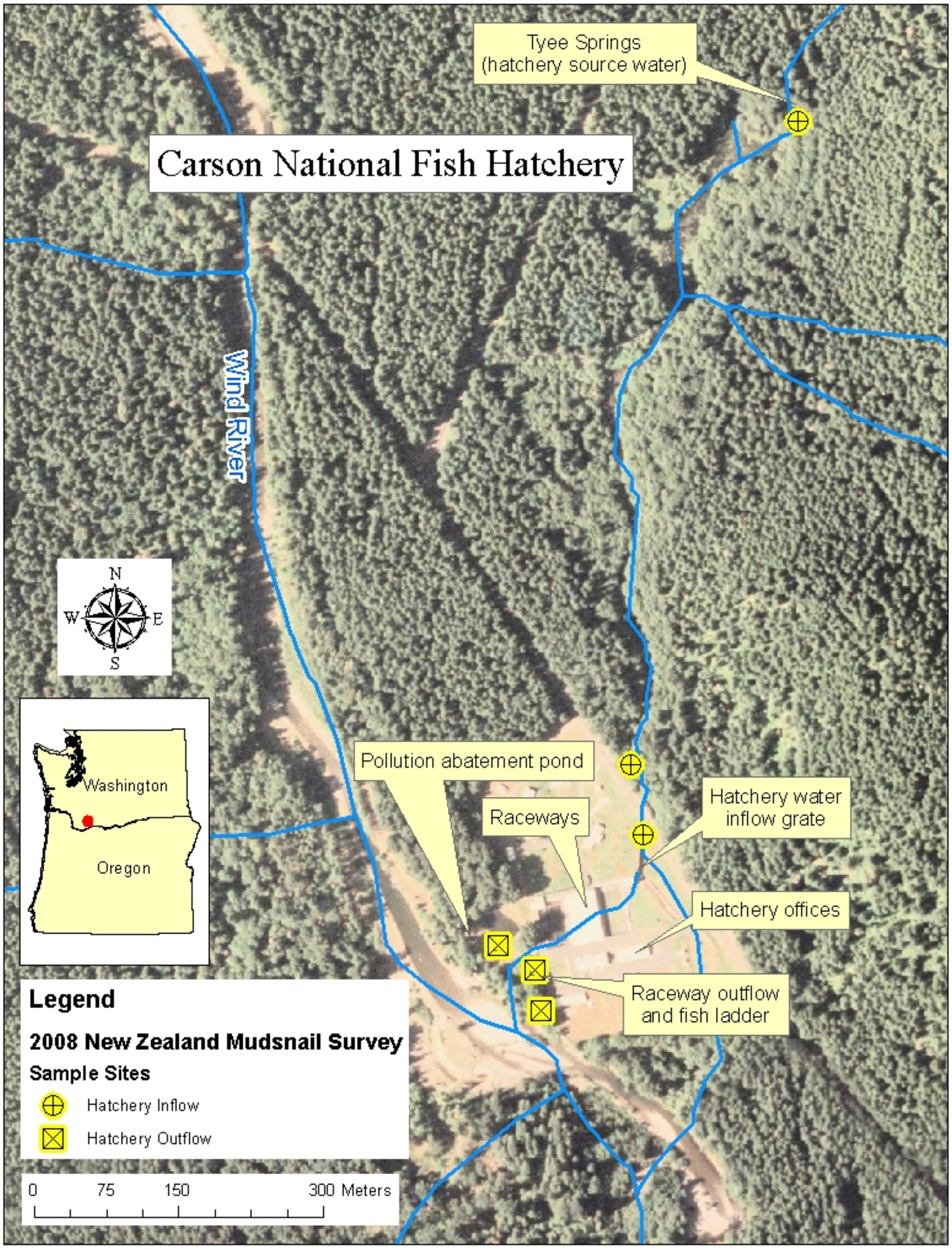

Figure 3. Carson NFH 2008 New Zealand mudsnail survey sample sites.

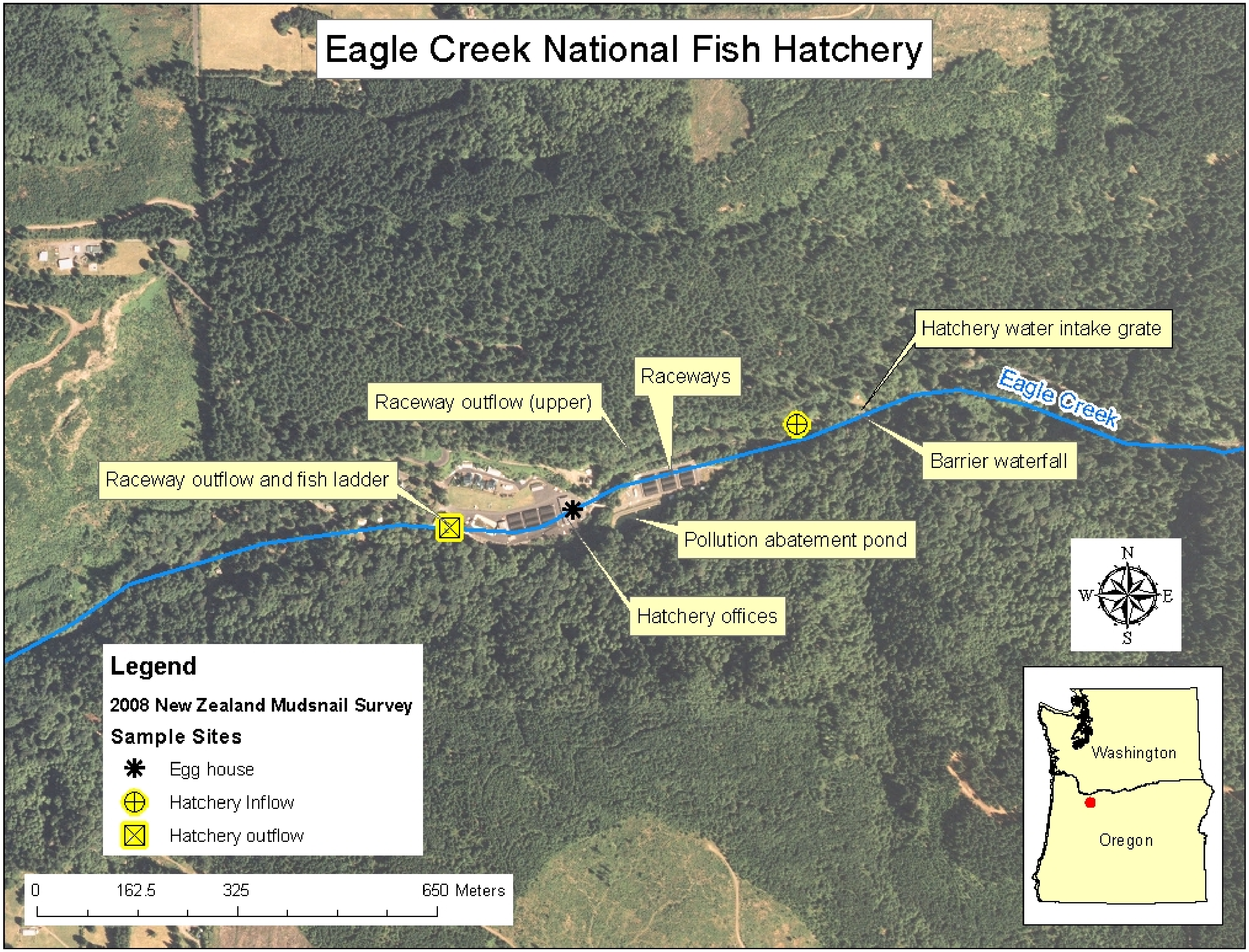

Figure 4. Eagle Creek NFH 2008 New Zealand mudsnail survey sample sites.

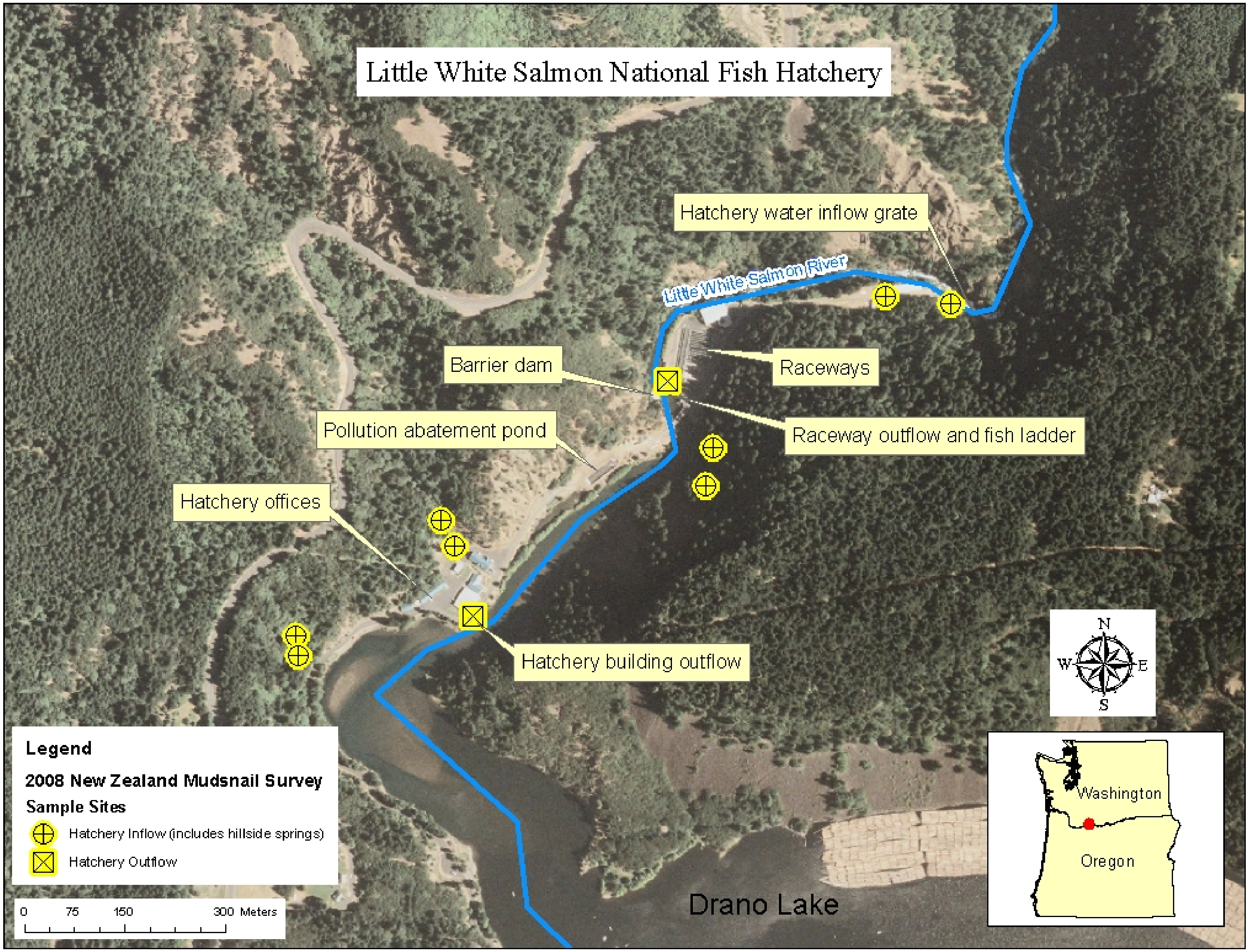

Figure 5. Little White Salmon NFH 2008 New Zealand mudsnail survey sample sites.

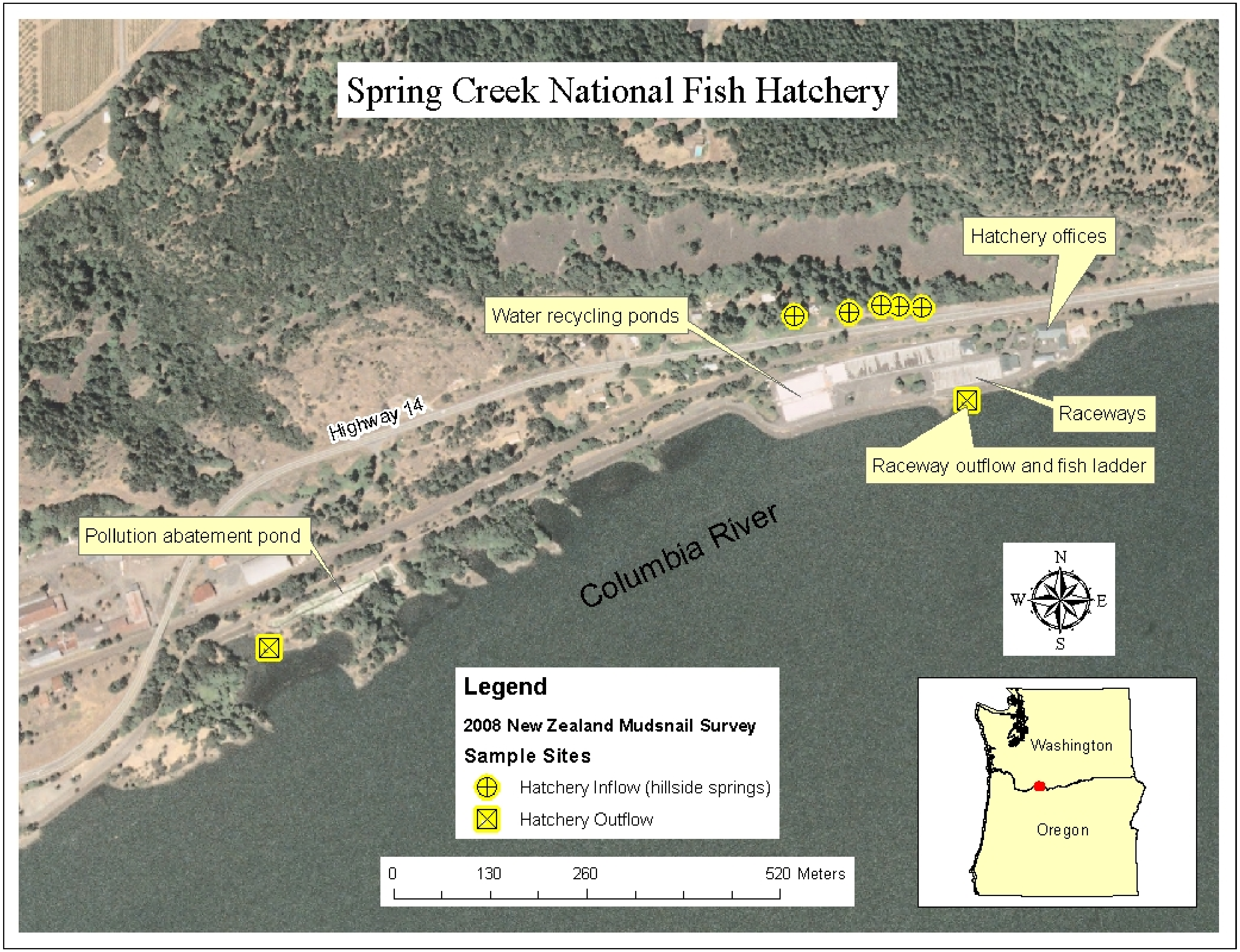

Figure 6. Spring Creek NFH 2008 New Zealand mudsnail survey sample sites.

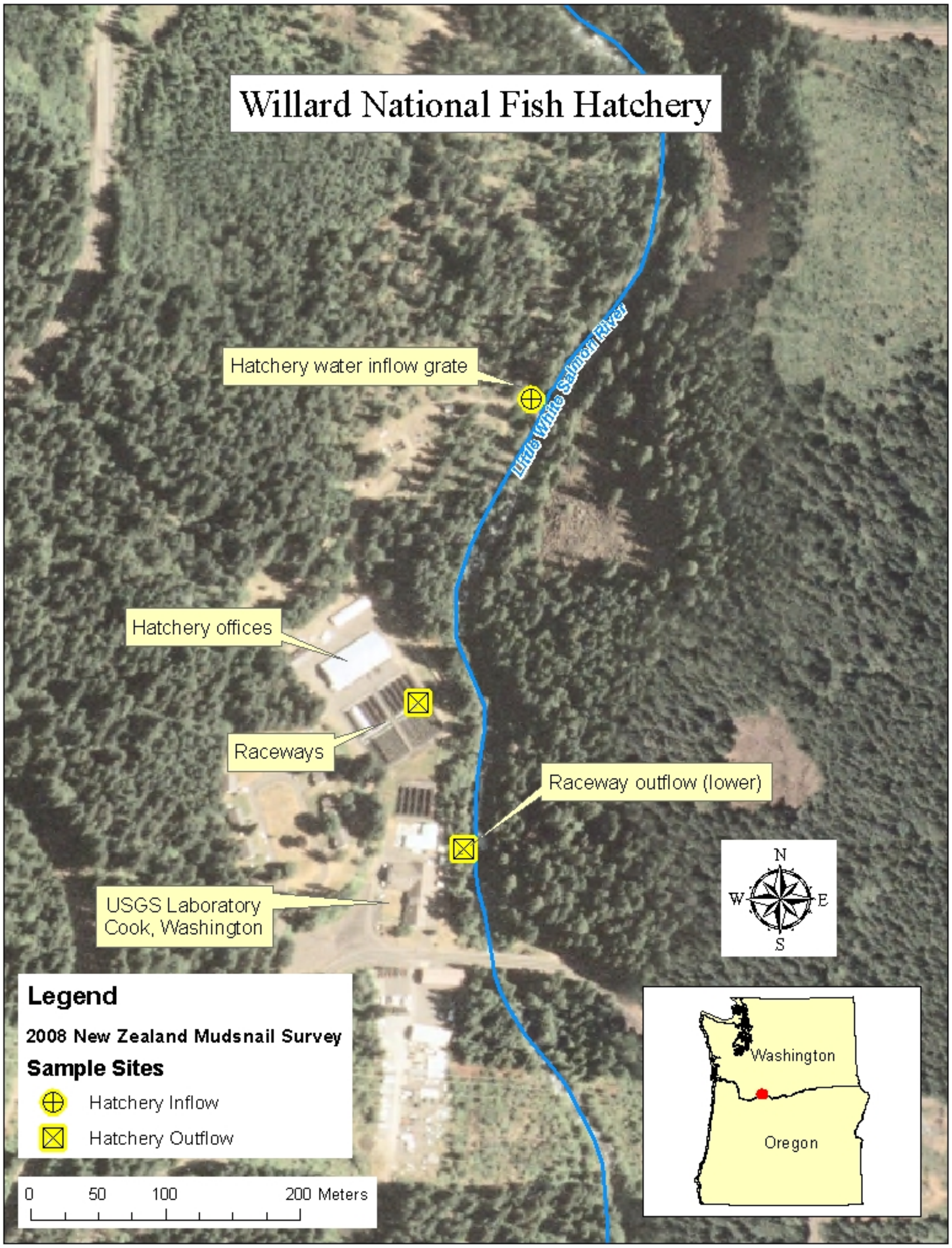

Figure 7. Willard NFH 2008 New Zealand mudsnail survey sample sites.

Figure 8. Warm Springs NFH 2008 New Zealand mudsnail survey sample sites.

Table 1. Results of 2008 New Zealand mudsnail (NZMS) surveys of lower Columbia River basin national fish hatcheries.

Date	Time	National Fish Hatchery	Locality	Voucher Specimens Collected	NZMS Found	GPS Coordinate System: UTM			
						Zone	Datum	northing	easting
11/20/2008	12:57:25 PM	Eagle Creek	Outflow - raceway outflow and fish ladder entrance	None	No	10	NAD 1983 (Conus)	5013910.55	562421.97
11/20/2008	2:29:27 PM	Eagle Creek	Inflow - settling pond 100m below hatchery water intake grate	None	No	10	NAD 1983 (Conus)	5014080.07	562984.65
11/20/2008	3:04:46 PM	Eagle Creek	Egg house outflow	None	No	10	NAD 1983 (Conus)	5013939.98	562621.84
11/25/2008	10:24:23 AM	Little White Salmon	Inflow - roadside #1 spring	None	No	10	NAD 1983 (Conus)	5063661.87	605226.52
11/25/2008	10:40:42 AM	Little White Salmon	Inflow - roadside #2 spring	Sample 1	No	10	NAD 1983 (Conus)	5063632.70	605230.85
11/25/2008	11:02:19 AM	Little White Salmon	Inflow - hillside micro-filter house	None	No	10	NAD 1983 (Conus)	5063797.16	605462.90
11/25/2008	11:04:47 AM	Little White Salmon	Inflow - hillside spring	Sample 2	No	10	NAD 1983 (Conus)	5063834.01	605442.15
11/25/2008	11:28:18 AM	Little White Salmon	Inflow - upper #1 spring	None	No	10	NAD 1983 (Conus)	5063942.15	605847.28
11/25/2008	11:34:39 AM	Little White Salmon	Inflow - upper #2 spring	None	No	10	NAD 1983 (Conus)	5063886.40	605836.41
11/25/2008	11:51:09 AM	Little White Salmon	25m downstream from hatchery water intake grate	None	No	10	NAD 1983 (Conus)	5064156.15	606200.55
11/25/2008	11:56:45 AM	Little White Salmon	Inflow - 1st sediment settling pond	None	No	10	NAD 1983 (Conus)	5064168.69	606104.00
11/25/2008	12:05:45 PM	Little White Salmon	Outflow - raceway outflow and fish ladder entrance	None	No	10	NAD 1983 (Conus)	5064042.58	605779.45
11/25/2008	12:34:21 PM	Little White Salmon	Outflow - hatchery building	None	No	10	NAD 1983 (Conus)	5063692.56	605489.29
11/25/2008	2:12:50 PM	Willard	Inflow - hatchery water intake grate	None	No	10	NAD 1983 (Conus)	5069173.19	606562.02
11/25/2008	2:35:50 PM	Willard	Outflow - north bank raceways	None	No	10	NAD 1983 (Conus)	5068947.30	606477.07
11/25/2008	3:01:28 PM	Willard	Outflow - lower pipe	None	No	10	NAD 1983 (Conus)	5068839.35	606511.56
12/1/2008	12:48:59 PM	Carson	Inflow - Tyee Springs headwaters (hatchery water source)	Sample 3	No	10	NAD 1983 (Conus)	5080750.95	579851.59
12/1/2008	1:33:37 PM	Carson	Inflow - upstream of road crossing	None	No	10	NAD 1983 (Conus)	5080083.17	579677.30
12/1/2008	1:54:36 PM	Carson	Inflow - downstream of road crossing	None	No	10	NAD 1983 (Conus)	5080010.90	579690.02
12/1/2008	2:08:53 PM	Carson	Outflow - raceway outflow and fish ladder entrance	Sample 3	No	10	NAD 1983 (Conus)	5079870.63	579577.96
12/1/2008	2:23:00 PM	Carson	Outflow - pollution abatement pond	None	No	10	NAD 1983 (Conus)	5079895.00	579539.98
12/1/2008	2:47:20 PM	Carson	Outflow - Wind River confluence	None	No	10	NAD 1983 (Conus)	5079827.38	579584.42
12/2/2008	1:31:57 PM	Spring Creek	Inflow - spring 1	Sample 4	No	10	NAD 1983 (Conus)	5064910.57	613055.38
12/2/2008	1:47:22 PM	Spring Creek	Inflow - Spring 2	None	No	10	NAD 1983 (Conus)	5064916.47	613128.84
12/2/2008	1:55:30 PM	Spring Creek	Inflow - Spring 3	None	No	10	NAD 1983 (Conus)	5064925.91	613172.58
12/2/2008	2:01:44 PM	Spring Creek	Inflow - Spring 4	None	No	10	NAD 1983 (Conus)	5064924.61	613196.38
12/2/2008	2:09:28 PM	Spring Creek	Inflow - Spring 5	None	No	10	NAD 1983 (Conus)	5064922.11	613226.16
12/2/2008	2:33:27 PM	Spring Creek	Outflow - pollution abatement pond	Sample 5	No	10	NAD 1983 (Conus)	5064464.17	612348.88
12/2/2008	2:55:25 PM	Spring Creek	Outflow - raceway outflow and fish ladder entrance	Sample 6	No	10	NAD 1983 (Conus)	5064797.17	613287.73
12/4/2008	12:43:56 PM	Warm Springs	Inflow - 30m upstream of hatchery water intake grate	Sample 7	No	10	NAD 1983 (Conus)	4968935.03	638627.80
12/4/2008	1:13:34 PM	Warm Springs	Outflow - inside pollution abatement pond	None	No	10	NAD 1983 (Conus)	4969154.25	638730.71
12/4/2008	1:25:25 PM	Warm Springs	Outflow - outside pollution abatement pond at river	None	No	10	NAD 1983 (Conus)	4969160.12	638763.37
12/4/2008	1:45:41 PM	Warm Springs	Outflow - 15m downstream of fish ladder entrance	Sample 8	No	10	NAD 1983 (Conus)	4968986.29	638664.42
12/4/2008	1:58:15 PM	Warm Springs	Outflow - raceway outflow and fish ladder entrance	None	No	10	NAD 1983 (Conus)	4968973.84	638656.66