YELLOWSTONE NATIONAL PARK 2010

RED- RIMMED MELANIA SURVEY REPORT

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INTRODUCTION

In December 2009, an aquatic invasive snail, the red- rimmed melania (*Melanoides tuberculata*) was found at the confluence of the Boiling River and Gardiner River in Mammoth Hot Springs, Yellowstone National Park. A park-wide survey was designed and implemented to inventory and locate the distribution of the red- rimmed melania snails and aquatic native species of Yellowstone National Park. This survey also incorporates the collection of basic water quality information and native gastropod population inventories to evaluate the potential impacts red -rimmed melania may have on native fauna.

The red- rimmed melania is native to the subtropical waters of Asia, Africa and Australia. It was introduced into North America in the 1930's through the aquarium trade and populated local watersheds from the discarding of aquarium owners. The red- rimmed melania is primarily nocturnal and buries itself up to 1' deep in sediment during the daytime. These snails are asexual and can reproduce by parthenogenesis, which allows them to reproduce from a single organism and reach very high densities. They are known to populate in high densities and compete and/or replace native snails and other aquatic invertebrates. In addition to the potential ecological impacts, the red- rimmed melania is known to be a host of trematode parasites that are harmful to certain fish species and humans. These snails have a hard spiral shell which makes it a poor food source for fish. These snails also have an operculum which acts as a cover to store water, help prevent desiccation, and allow them to survive out of water for several days. Both the hard shell and operculum predispose these snails to inadvertent transportation by unwary anglers and other park visitors who utilize aquatic areas. These snails can tolerate water temperatures that range between 18-32^{o}C and prefer areas with fine sediments and aquatic vegetation. These conditions make thermal hot springs in YNP suitable habitat for this species.

Sampling sites for this survey were selected based on hot spring soaking areas with the most visitor usage. The *Melanoides tuberculatus* found in the Boiling River was most likely introduced unintentionally by a "soaker" or angler who transported these snails or a single snail from a nearby contaminated hot spring. This initial survey was designed to get baseline data on the distribution of red - rimmed melania in the park. Other surveys may be designed to monitor the spread of these snails in the future.

SURVEY SITES

Yellowstone National Park contains numerous extraordinary geothermal features and hot springs. Some of these hot springs are utilized by many visitors for soaking and bathing. Soaking in hot springs can be both enjoyable and relaxing. For many people, soaking in hot springs is a hobby and takes pleasure in touring different "soakies" in this region. However, many exotic species can be unintentionally transported into these hot springs by "hitchhiking" a ride on clothes and footwear.

When deciding which hot springs to survey in YNP, park agency staff was consulted for ideal hot spring soaking area locations. *Touring Montana and Wyoming Hot Springs*, A Falcon Guide (Birkby 1999), was also used to assist with identifying well established hot spring soaking areas. The study sites were

selected based on the most popular hot spring bathing areas in and around YNP. Sites were then prioritized by the areas with most visitor usage and most likely to be contaminated. The study sites are divided based on major watershed drainages. These drainages consist of the Madison River and Upper Snake River.

Hot spring soaking areas in YNP are primarily composed of thermal surface runoff that meets the cold water of rivers and streams. These areas usually have some human influence that include small rock walls built up to enclose the warm water of the springs and to keep out portions of cold water from the stream. Other soaking areas include thermal creeks and thermal backwater in streams. Streams such as Witch Creek, Silver Scarf Falls, and Mountain Ash Creek contain thermal springs in their headwaters, causing the downstream water to have higher temperatures. Certain pools within these streams are ideal for soaking and attract visitors to their warm waters. The Firehole River, Madison River and Ferris Fork (also called "Mr. Bubbles") contain natural hot spring "soakies" where thermal runoff mixes with cold stream water in side channels and backwater areas.

This survey included a total of 19 high priority sites. The hot spring sites included in this survey are listed with location in Table 1 and maps of major drainages and site locations are shown in Figures 1-4. Pictures and descriptions of each site can be found in Appendix A.

Drainage	**SITE NAME**	**UTM E**	**UTM N**
Madison River	Madison Campground	510212	4943159
	Firehole 1	513220	4934064
	Firehole - 2	513220	4934064
	The Reservoir	522960	4951780
	Lonestar	515125	4918093
Snake River	Dunanda Falls -1	497923	4899245
	Dunanda Falls -2	497959	4899248
	Dunanda Falls -3	498067	4899346
	Dunanda Falls -4	498059	4899348
	Ouzel Pool	509669	4893620
	Silver Scarf Falls	498431	4899367
	Mr. Bubbles	509668	4903799
	Shoshone East	515886	4910977
	Witch Creek	538658	4905031
	Witch Creek	539326	4904314
	Huckleberry	525054	4884691
	Polecat Lower	524733	4884249
	Crawfish	524785	4889162
Gardner River	Boiling River	524497	4981414

Table 1. Sampling site names and locations.

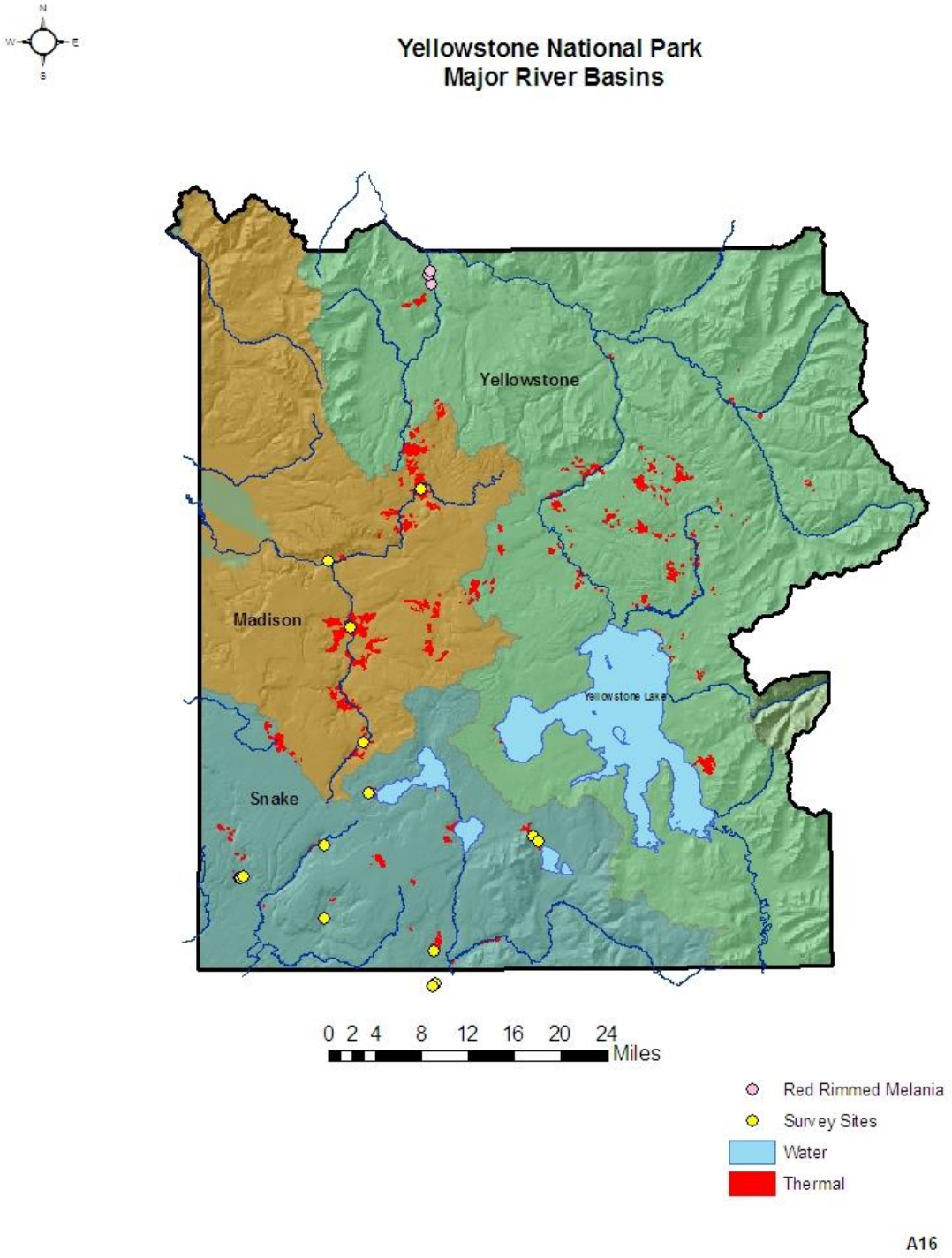

Figure 1. Map of Yellowstone National Park showing major river basins, sample locations and sites where red-rimmed melania were found.

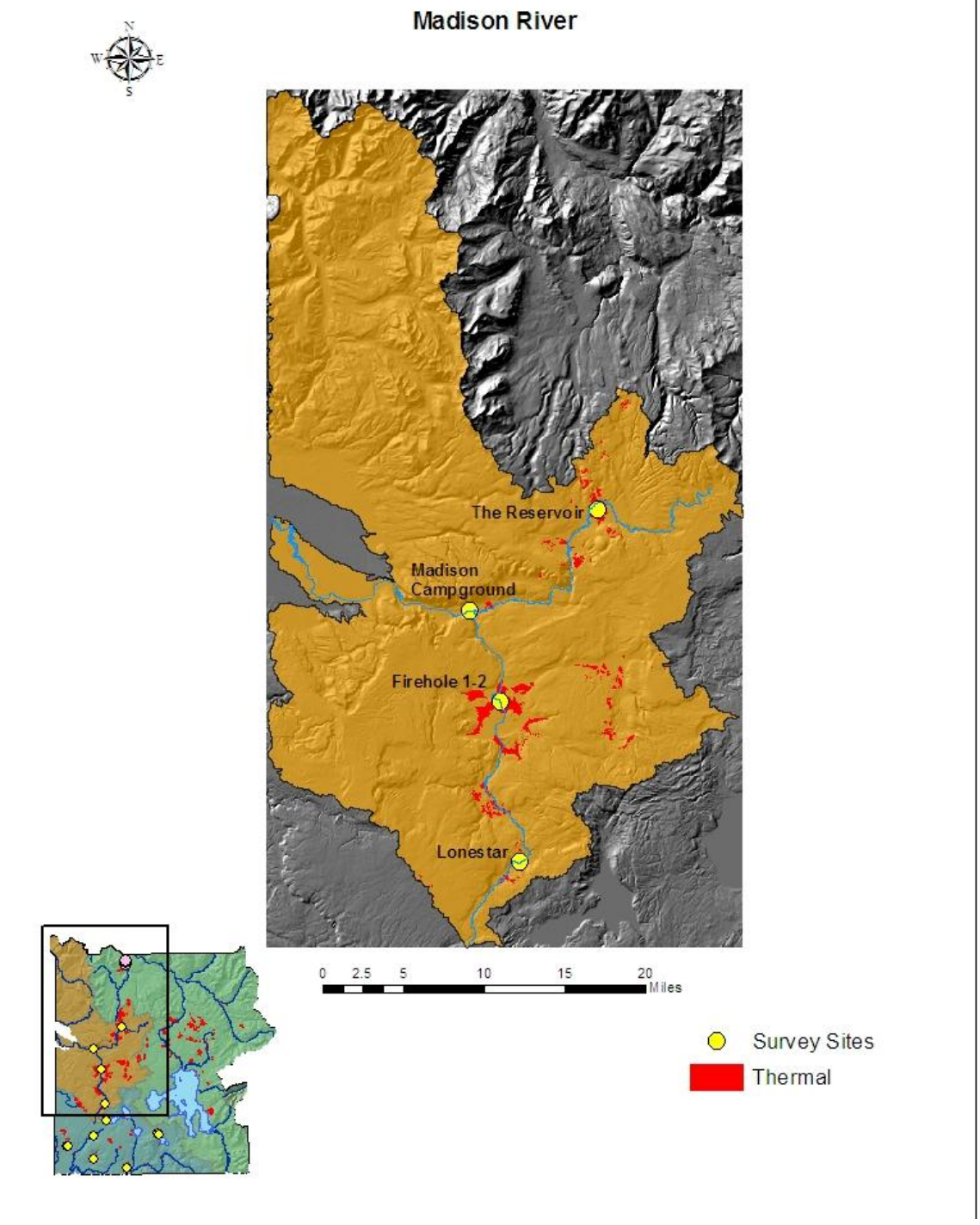

Figure 2. Illustration of Madison River drainage and locations sampled for red-rimmed melania, Yellowstone National Park, Wyoming.

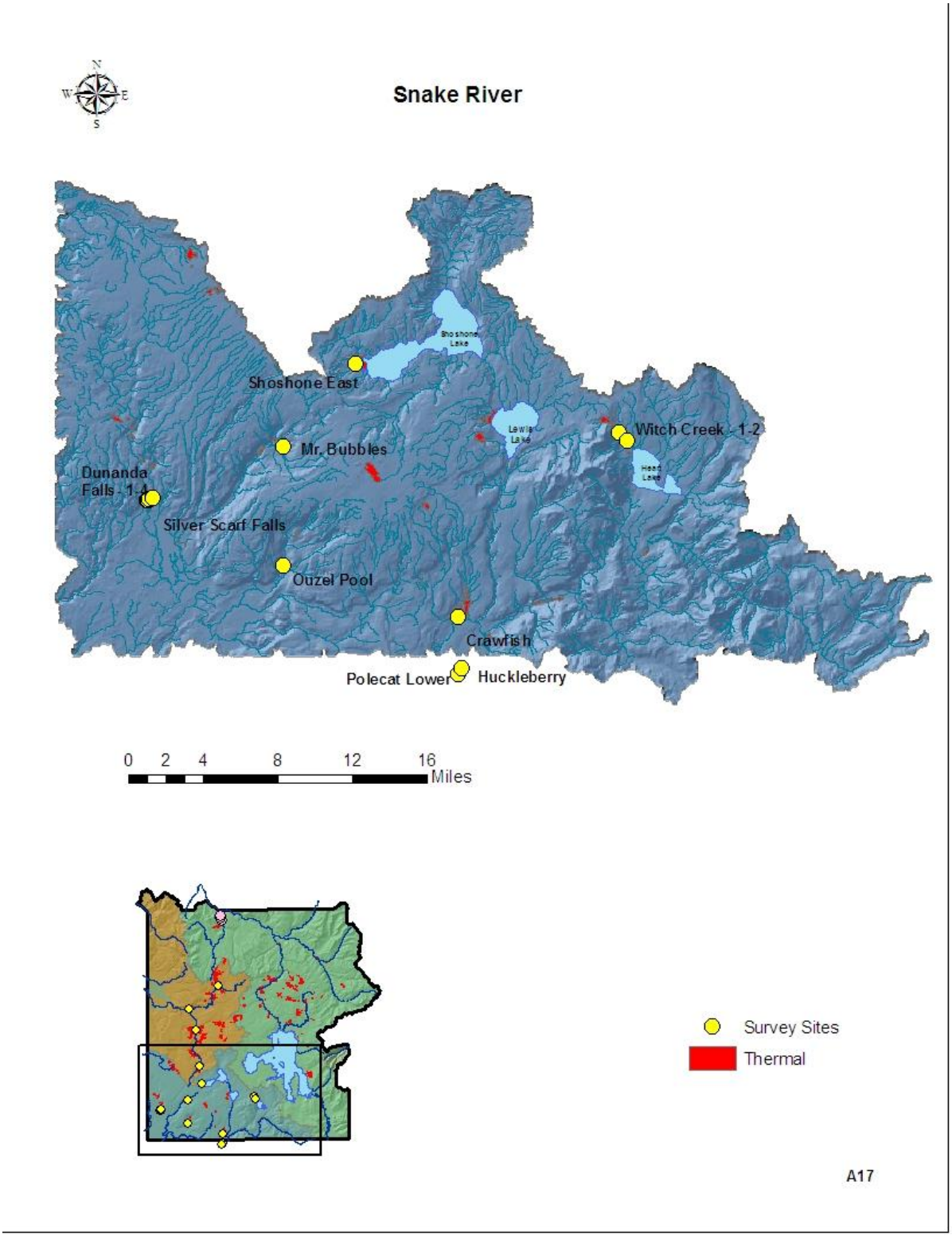

Figure 3. Illustration of Snake River drainage and locations sampled for red-rimmed melania, Yellowstone National Park, Wyoming.

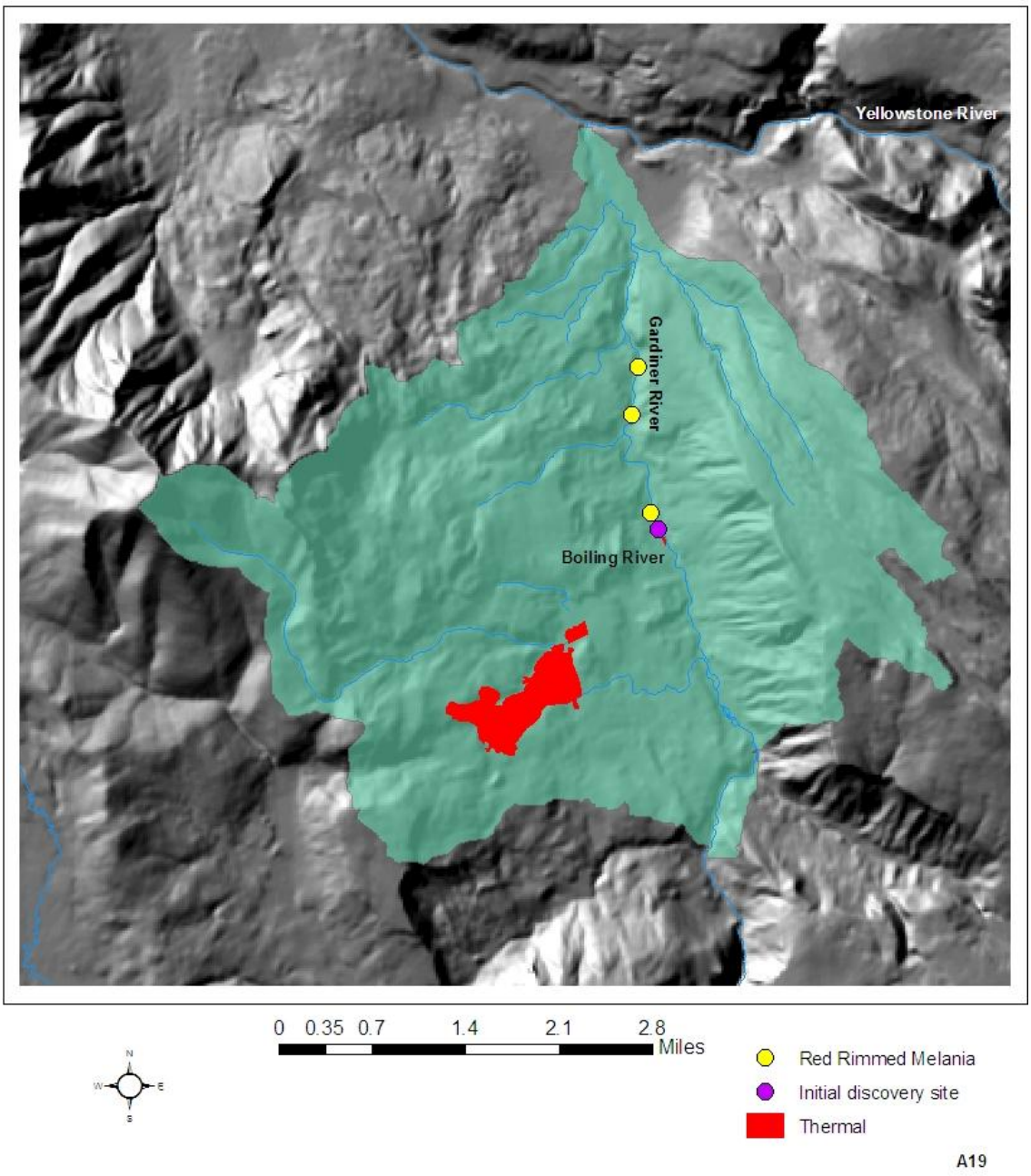

Figure 4. Illustration of Gardner River drainage and locations sampled for red-rimmed melania and site of initial discovery, Yellowstone National Park, Wyoming.

METHODS

Research for a protocol and sampling design began during the months of May and June of 2010. Red-rimmed melania surveys were commenced on July 27, 2010 and ended September 29, 2010. Surveys were conducted for an average duration of 61 minutes at each sampling site. Prior to field collect, members of the field crew received training in snail identification, safety in the backcountry and proper gear disinfection. Many sampling sites were located in the backcountry; thus a USGS topographic map and GPS were used to assist with locating and navigating to each hot spring.

Prior to surveying, UTM coordinates and a photograph were taken at each site with a Garmin GPS handheld unit and digital camera. Water temperature along with other water quality parameters were also measured at each site. Water quality measurements were collected using a HydroLab® Minisonde 4a water quality Mulitiprobe (Hach Environmental, Loveland, CO). The different parameters measured consist of: water temperature, pH, specific conductivity and (occasionally) dissolved oxygen. The dissolved oxygen sensor stopped working part way through the field surveys and therefore, that parameter measurement was discontinued.

During the surveys, the start and stop times were recorded as well as the date and substrate type at each site. The sampling was conducted with a 20" wide D-frame net and 1/16th nylon mesh fabric. The net was jabbed up to 6" into the soft substrate and sorted through in a 500um size sieve. Sandy substrate and vegetated areas with detritus material were targeted. Areas composed of cobble, boulders and bedrock were avoided at larger sites. This process was continued until 50-100% of the sampling site area was covered. All data was recorded on the **Survey Data Sheet for GYE Amphibians** listed in the appendix.

Thermal creek site surveys consisted of sorting through vegetation and fine sediments while wading upstream. Any noticeable, ideal pool for soaking was further surveyed with the standard hot spring sampling protocol. Any snail specimens observed were collected and stored in plastic bottles filled with 70% EtOH. The samples were then labeled inside and outside with waterproof paper and taken back to the lab for further identification. Label information included:

- Site and water body
- Date
- Time
- UTM coordinates
- Names of collectors

RESULTS AND DISCUSSION

Of the 19 surveyed sites, red -rimmed melania were not observed. However, red- rimmed melania were found in the Gardiner River about 100 meters downstream of their initial discovery. These snails were located on a 60 meter stretch along the west bank of the Gardiner River in submerged aquatic vegetation and algae. The red- rimmed melania in the Gardiner River were observed during an AIS sampling survey on September 8, 2010 in very large masses. They were also found 1 mile downstream of the Boiling River and Gardiner River confluence in a much smaller quantity.

Figure 5. Red rimmed melania from the Gardiner River.

There were a total of 2210 minutes (36 hours) of surveying time at all sites combined. This project consisted of only 2 surveyors; as a result, each person surveyed a total of 18 hours. The substrate varied at each site and consisted of: sand, mud, silt/vegetation, gravel, cobble, and boulder. The average water temperature for all sites surveyed was 33.5^{o}C. The average conductivity was 913µm and the average ph was 7.4 for all sites. The average duration of the conducted surveys was 61 minutes; the longest was 150 minutes while the shortest was only 19 minutes of surveying time.

The presence of New Zealand mudsnails was observed in a few streams just outside of the sampling sites. These snails were found in the Madison River, Firehole River, and Polecat Creek. Other native snail specimens were collected, bottled and labeled. Many of these specimens were recognized as snails belonging to the family of Planorbidae and *Physa* genus. These samples are in the process of being sent to an external laboratory for further identification to the species level.

The red -rimmed melania prefer shallow, slower moving water and a temperature range of 16-32^{o}C. The ideal habitat for these snails includes areas wealthy in detritus, silt and heavily vegetated streams. They also hide underneath rocks and other debris and submerge themselves into sandy sediments during the diurnal hours (UDWR 2009). These habitat and temperature requirements match those of the Gardiner River below the Boiling River. When compared to the Gardiner River, many of the other survey sites did not contain all of the same habitat characteristics. Sampling sites such as Witch Creek, Silver Scarf Falls, Crawfish Creek and Firehole River all had very similar characteristics to the Gardiner River. These streams were composed of sandy substrate, slow flowing water, temperatures within the preferred range and contained a great deal of aquatic vegetation and detritus material. On the other hand, these streams may experience a very significant decline in water temperature and heavy flows during the winter and spring months and may not support the introduction of the red -rimmed melania.

CONCLUSION AND RECOMMENDATIONS

The source of the introduction of red -rimmed melania in the Boiling River is unknown. One theory explains that soakers from Kelly Warm Springs in Grand Tetons NP may have unintentionally brought them into the Boiling River. This speculation could be true due to the fact that the Boiling River and Kelly Warm Springs are both very popular soaking areas, close to the road and to each other, and that these particular snails can survive out of water for several days.

Red- rimmed melania snails were not found in any other surveyed hot spring in Yellowstone NP other than the Gardiner River/Boiling River. Many of these hot springs meet the optimal habitat conditions for the survival and colonization of *Melanoides tuberculatus*. Some hot springs may have supported the introduction of these snails in the past but the change in water temperature and flows during the colder months could have exterminated them. However, the presence of live or dead shells was not found during the hot spring surveys and opposes this theory.

As a result of this survey, red -rimmed melania are known only to exist in the Gardiner and Boiling Rivers within Yellowstone National Park. With this information, preventive actions should be made to reduce the risk of spreading these snails into other bodies of water. The most important method is to educate the public of the risk of this species and the importance of decontaminating clothing and equipment (UDWR 2009). To exterminate these snails completely from the park, one recommendation would be to remove the artificial rock wall and close the Boiling River to visitors during the spring months. This would allow low temperatures from spring run-off and high stream flows to wash away the existing red rimmed melania population.

The following paragraph is adapted from Mitchell and Brandt (2005):

"Under constant temperature conditions in the laboratory, all red-rimmed melania (15-25 mm shell height, SH) were killed by exposure to 5°C for 1 d, 9°C for 2 d, 11°C for 8 d, and 13°C for 12 d. At 17°C and 32.5°C, about 10% of the snails died within 27 d indicating sub-optimal temperature conditions for the snail. Constant temperature springs that are <18°C or >32°C will probably not support red-rimmed melania. All snails (10-20 mm SH) died within 10 h at 40°C and within 20 min at 45°C. Red-rimmed melania will probably also not survive in waters that drop below 5°C for 24 h or rise above

40°C for 12 h. At 50°C, all snails =42 mm SH succumbed within 2.5 min, with the smallest (1 to 4 mm SH) lasting less than 0.5 min. A 4 to 5-min exposure to 50°C water should be sufficient to kill all red-rimmed melania on dip nets and other fisheries equipment".

Without the rock wall holding in thermal water, the cold temperatures from spring run-off should kill these snails after several days. Park -wide distribution surveys are also recommended every few years to monitor new introductions to heavily utilized hot springs.

LITERATURE CITED

Benson, A.J. 2010. *Melanoides tuberculatus*. USGS Nonindigenous Aquatic Species Database, Gainesville, FL. http://nas.er.usgs.gov/queries/Factsheet.aspx?speciesID=1037 RevisionDate: 4/24/1006

Mitchell, A.J., Brandt, T. 2005. Temperature tolerance of the red-rim melania Melanoides tuberculatus, an exotic aquatic snail established in the United States. American Fisheries Society Transaction. 134:126-131.

(UDWR) Utah Division of Wildlife Resources. January 2009. Red Rimmed Melania *Melanoides tuberculatus*. Utah Aquatic Invasive Species Management Plan. Publication No. 08-34.

SAMPLING SITES

Madison River Drainage

SITE NAME	SUBSTRATE	WATER TEMP ^{o}C	CONDUCT.	pH	DESCRIPTION
Madison Campground- HS	Algae, gravel	36.2	13.73	6.1	Side channel of Madison River with thermal runoff influence

SITE NAME	SUBSTRATE	WATER TEMP ^{o}C	CONDUCT.	pH	DESCRIPTION
Firehole HS - 1	Boulder,gravel,cobble	29.9	696	8.7	Side-channel of Firehole River with thermal run-off influence

SITE NAME	SUBSTRATE	WATER TEMP ^{O}C	CONDUCT.	pH	DESCRIPTION
Firehole HS - 2	Sand	27.6	586	8.1	Backwater from Firehole River mixing with thermal run-off

SITE NAME	SUBSTRATE	WATER TEMP ^{o}C	CONDUCT.	pH	DESCRIPTION
Shoshone East - HS	Gravel,cobble	32	564	8.2	Built rock wall collecting thermal runoff in Shoshone Creek

SITE NAME	SUBSTRATE	WATER TEMP °C	CONDUCT.	pH	DESCRIPTION
Lonestar HS	Mud/silt., bedrock	16.3	165	7.2	Built rock/log wall downstream of Lonestar Geyser in Firehole River

SITE NAME	SUBSTRATE	WATER TEMP ^{O}C	CONDUCT.	pH	DESCRIPTION
The Reservoir HS	Mud, sand	33.1	2326	3.13	Large and very deep thermal pool in Norris Geyser Basin. Nicknamed “The Reservoir”

Snake River Drainage

SITE NAME	SUBSTRATE	WATER TEMP ^{o}C	CONDUCT.	pH	DESCRIPTION
Dunanda Falls -1 - HS	Gravel,boulder,sand	29.2	259	7.4	Hot spring with built rock wall downstream of Dunanda Falls

SITE NAME	SUBSTRATE	WATER TEMP ^{o}C	CONDUCT.	pH	DESCRIPTION
Dunanda Falls -2- HS	Cobble,gravel	37.3	356	7.4	Hot spring with built rock wall downstream of Dunanda Falls

SITE NAME	SUBSTRATE	WATER TEMP ^{o}C	CONDUCT.	pH	DESCRIPTION
Dunanda Falls -3-HS	Gravel,cobble,sand	36.4	290	6.6	Hot spring with built rock wall downstream of Dunanda Falls

SITE NAME	SUBSTRATE	WATER TEMP ^{o}C	CONDUCT.	pH	DESCRIPTION
Dunanda Falls -4-HS	Cobble,gravel	38.9	321	6.7	Hot spring at base of Dunanda Falls

SITE NAME	SUBSTRATE	WATER TEMP ^{o}C	CONDUCT.	pH	DESCRIPTION
Ouzel Pool AIS/HS	Cobble,gravel	26.8	514	8.7	Warm water pool on Mountain Ash Creek

SITE NAME	SUBSTRATE	WATER TEMP °C	CONDUCT.	pH	DESCRIPTION
Silver Scarf Falls HS	Sand,bedrock,gravel	31.9	740	8.7	Warm water pool above Silver Scarf Falls

SITE NAME	SUBSTRATE	WATER TEMP °C	CONDUCT.	pH	DESCRIPTION
Mr. Bubbles HS	Sand,gravel,cobble	24.7	281	7	Thermal pool in backwater of Ferris Fork

SITE NAME	SUBSTRATE	WATER TEMP ^{o}C	CONDUCT.	pH	DESCRIPTION
Huckleberry HS	Gravel, algae	43.3	767	7	Thermal creek with possible built log/rock wall

SITE NAME	SUBSTRATE	WATER TEMP ^{o}C	CONDUCT.	pH	DESCRIPTION
Polecat HS - Lower	Silt,sand	40.6	938	8	Hot spring with built rock/log dam above Polecat Creek

SITE NAME	DATE	DURATION (Minutes)	SUBSTRATE	WATER TEMP ^{o}C	CONDUCT.	pH	COMMENTS (present/absent)
Madison Campground- HS	7/28/2010	71	Algae, gravel	36.2	13.73	6.1	Absent
Firehole HS - 1	8/11/2010	61	Boulder,gravel, cobble	29.9	696	8.7	Absent
Firehole HS - 2	8/11/2010	63	Sand	27.6	586	8.1	Absent
Dunanda Falls -1 - HS	8/19/2010	28	Gravel,boulder, sand	29.2	259	7.4	Absent
Dunanda Falls -2- HS	8/19/2010	35	Cobble,gravel	37.3	356	7.4	Absent
Dunanda Falls -3- HS	8/19/2010	35	Gravel,cobble,sand	36.4	290	6.6	Absent
Dunanda Falls -4- HS	8/19/2010	19	Cobble,gravel	38.9	321	6.7	Absent
Ouzel Pool AIS/HS	8/17/2010	42	Cobble,gravel	26.8	514	8.7	Absent. Stream Very inaccessible. Must travel around (2) waterfall, very rough, dense riparian zone. There is not a defineable pool upstream of Ouzel Pool (high velocity).
Mr. Bubbles HS	8/22/2010	150	Sand,gravel,cobble	24.7	281	7	Absent. Water temp. varies throughout pool. Cooler temps. near bottom. No snails or other fauna found. Very

							high visitor use.
Shoshone East - HS	8/24/2010	64	Gravel,cobble	32	564	8.2	Absent. Small soakie; about 6' X 20'. About 16" deep. Rock wall has been built up around thermal source. Very little aquatic vegetation.
Lonestar HS	9/1/2010	46	Mud/silt., bedrock	16.3	165	7.2	Absent. Small soakie and shallow. Very silty substrate on top of bedrock. Water temp. does not mix well (2 extremes).
The Reservoir HS	9/2/2010	120	Mud, sand	33.1	2326	3.13	Absent. Large thermal pool in Norris Geyser Basin. Substrate is very muddy.

							Absent. A visual survey was conducted from Lower Geyser Basin to Bridge at Middle Geyser Basin. Survey consisted of walking in and beside stream, scraping through vegetation and sediment at a distance of 1.25 linear km. The measurements from this page were taken from a series of pools downstream of the bridge. Very little to no vegetation and small amount of fine sediment was found at the site.
Witch Creek -1 HS	9/14/2010	41	Boulder,cobble, gravel	39.07	726.7	9	
Witch Creek -2 HS	9/14/2010	45	Silt/vegetation	31	719.7	8.9	Absent
Huckleberry HS	9/28/2010	49	Gravel, algae	43.3	767	7	Absent

Polecat HS - Lower	9/28/2010	67	Silt,sand	40.6	938	8	Absent. Very little vegetation present in pool. NZMS were found in Polecat Creek below hot spring.
Crawfish HS	9/29/2010	118	Sand,silt/veg.,gravel	31.3	754	8.7	Absent. A visual survey was conducted from the mouth of the Crawfish Cr. Confluence upstream about 200 m. Two ideal pools were sampled for about 30 minutes each.
Silver Scarf Falls HS	8/19/2010	51	Sand,bedrock,gravel	31.9	740	8.7	Absent. High gradient stream. No clear defineable soakies/pools. Water not very hot.

YELLOWSTONE NP 2010 AIS SAMPLING PROTOCOL

This protocol is designed to inventory and locate the distribution of aquatic invasive species and aquatic native species of Yellowstone National Park. The main focus of this survey is the red rimmed melania snail (*Melanoides tuberculata)*. These snails can tolerate water temperatures that range between 18-32°C, which make thermal hot springs in YNP suitable habitat for this species. The red rimmed melania is primarily nocturnal and buries itself over an inch deep in fine sediments during the day time. The majority of the selected study sites for this survey are conducted around popular bathing areas and marinas in the park. Prior to field collection, members of the field crew will receive training on AIS identification and safety in the back country. Any specimens collected during the surveys are stored in plastic bottles with an outside and inside label.

Sampling sites are selected based on popular hot spring bathing areas, fishing access points and marinas in YNP. Sites are then prioritized by the areas with the most visitor usage and most likely to be contaminated. Once all sites are selected and prioritized, UTM coordinates are taken with a GPS unit. Water temperature along with other water quality parameters are measured at each site. Water temperature as well as stream substrate will determine if further sampling will be required for the red rimmed melania. Sampling in different aquatic habitats requires diverse sampling techniques; these techniques are described for each species or habitat being inventoried. Water temperature and other water quality measurements will be the first step of the sampling procedure. Water quality measurements are primarily conducted with the HydroLab® Multiparameter probe. The HydroLab will be calibrated before and after measurements are taken. The different parameters being measured consist of water temperature, dissolved oxygen, pH, and specific conductivity.

Red Rimmed Melania

Sites are sampled for red rimmed melania only if the water temperature is between 18-32°C (68-100°F) and the stream substrate is composed of sand and/or detritus material. If the site meets these basic requirements, the sampling is conducted with a 20" wide D-frame net and 1/16th nylon mesh fabric. The net is jabbed up to 6" into the soft substrate and sorted through in a 500um size sieve. This process is continued until 50-100% of the sampling site area is covered. A start time and end time is also recorded at the beginning and end of each survey. If extremely small snails are collected and field identification is difficult, substrate and snails will be collected in (2) 1-liter plastic bottles. Fill each bottle about half full with sediments and fill the remaining bottle with 70% EtoH. Once snails are collected, store several into a plastic bottle filled with 70% EtOH. If the site does not meet the basic requirements for red rimmed melania, continue with the snails and aquatic species sampling design.

Equipment Needed:

- D-frame/Dip Net
- 500um sieve
- Several plastic sampling jars
- Alcohol
- HydroLab
- GPS

Snails and Aquatic Species in Stream Habitat

This survey is conducted at all sampling sites regardless if the site meets the red rimmed melania basic requirements. Visually survey the stream reach on each side of the channel moving upstream and record the start and end time. Visual surveys include turning over rocks and other substrate to look for aquatic species attached to or hiding under the substrate. Surveys also include sifting through aquatic vegetation with dip nets and sorting through the collected material. A bottom viewer may also be used to assist in surveying in deeper pool areas of the stream. Observe mussel middens lying on surrounding stream banks. Any snails or crayfish and only 2 mussel specimens observed should be collected by hand or dip net and stored in a plastic jar with 70% EtOH. Aquatic plants are stored in a sealable plastic bag filled with water.

Equipment Needed:

- D-frame/Dip Net
- 30 mesh sieve
- Several plastic sampling jars
- Alcohol
- HydroLab
- GPS
- Sealable plastic bags

Snails and Aquatic Species in Lake Habitat

Aquatic invertebrate benthos are collected using bottom dredges. Samples are collected in various parts of Yellowstone and Lewis Lakes around the marinas. Contents from dredge will be dumped into a screen bottom bucket with a mesh size of 500-590um and rinse with water. Sort through the sample with a no. 30 sieve (590um). Samples that contain snails and exotic species should be preserved in a plastic jar with 70% EtoH and labeled correctly.

Submerged aquatic plants are collected with a rake sampler tossed from a boat or shore. A total of 30 samples/tosses should be collected from each marina sampling site. The plant samples should be collected randomly from various sections of the littoral area of lake. Samples that contain exotic or invasive plants should be stored in a sealable plastic bag filled with water.

Equipment Needed:

- Bottom dredge
- Boat
- Screen bottom bucket
- 30 mesh sieve
- Rake sampler
- Several plastic jars
- GPS
- Alcohol
- Sealable plastic bags
- HydroLab

Label Information

Any bottles that contain collected specimen should include an inside and outside label. Inside labels should be written on "Rite in the Rain"® paper with pencil and will include the following information:

- Site and/or water body
- Date
- Time
- UTM Coordinates
- Names of Collectors

DISINFECTION PROTOCOL

In order to prevent the spread of Aquatic Nuisance Species (ANS) we must take special care to clean and disinfect all equipment when moving between water bodies. This does not mean at the end of the day, but after each sampling event. We currently ask all water users in the park to help stop the spread of ANS by cleaning and scrubbing off all equipment when moving from water to water, we need to do the same.

Equipment needed:

- Scrub brush
- 10% bleach solution (bucket or spray bottle)
- Rinse water (several gallons)
- Gallon of bleach

At the end of each sampling event, before driving to a new location, all waders need to be cleaned. All mud, debris, and vegetation should be removed from the waders and boots. Boots should be removed, treated with the bleach solution, scrubbed, and rinsed with clean water. Waders should be treated with the bleach solution, scrubbed, and rinsed with clean water. If sandals are worn in lieu of waders and wading boots, they will need to be removed, treated with bleach, scrubbed, and rinsed with clean water. Net material should not be cleaned with bleach.

Sampling gear will need to be cleaned. Buckets should be rinsed with clean water, scrubbed, and rinsed again. The same should be done with turbidity vials. The Hydrolab should be thoroughly rinsed with DI-water between sites.

While in the backcountry, all equipment and waders should be cleaned before entering another body of water. All mud, debris, and vegetation should be removed from the waders and boots. Boots should be removed, sprayed with the bleach solution, scrubbed, and rinsed with clean water. Waders should be sprayed with the bleach solution, scrubbed, and rinsed with clean water.