PREVENTING SPREAD OF AQUATIC INVASIVE ORGANISMS COMMON TO THE SOUTHWESTERN REGION

TECHNICAL GUIDELINES FOR FIRE OPERATIONS

The following technical guidelines were developed to assist fire personnel in reducing the potential for the spread of aquatic invasive species during fire management and suppression activities. These technical guidelines are intended for use by Resource Advisors (READs), biologists, and other resource specialists and supplement the two page "Operational Guidelines for Aquatic Invasive Species Prevention and Equipment Cleaning" prepared for fire managers in the southwestern U.S. These recommendations were patterned after guidance developed by the Forest Service's Intermountain Region, but have been modified to address aquatic invasive species of the Southwest. The aquatic invasive species considered here were selected based on their current significance in the Southwest. Because of the large expanses over which fire crews and their equipment travel, the potential for firefighters to serve as vectors for invasive species is significant. These guidelines are based on what we know about prevention methods for common species at this time and will be refined and revised over time as needed.

Aquatic Invasive Species

Invasive species are organisms that are introduced into a non-native ecosystem and that cause, or are likely to cause, harm to the economy, environment, or human health. Many of these invasive species come from outside the U.S.; the nonnative quagga mussel from eastern Europe is pervasive throughout the lower Colorado River system, and zebra mussels and New Zealand mudsnails are significant threats in the southwestern U.S. Giant salvinia is a serious threat along the lower Colorado River, and golden alga is an invasive microscopic invasive algal cell that now occurs throughout much of the world. There are also many species native to other areas within the U.S. that are invasive in the Southwest; examples include green sunfish, bullfrogs, and crayfish. Aquatic invasive species are organisms that occur in aquatic, riverine, or wetland environments and can be spread by fire equipment including boats, barges, vehicles, water buckets, water tanks, hoses, and other equipment. The Nonindigenous Aquatic Nuisance Species Control and Prevention Act of 1990 (P.L. 101-646) highlights the concern for adverse impacts to native aquatic species from nonindigenous species. Executive Order 13112 (February 3, 1999) directs all Federal agencies to ensure that their actions do not promote the introduction or spread of invasive species.

Invasive plants and animals have many impacts on fish and wildlife resources and native environments. Invasive species degrade, change, or displace habitats and compete with our native fish, wildlife, and plant resources. In addition, many of these aquatic invasive organisms can damage or destroy fire supression equipment by clogging valves, pumps, motors, etc. The prevention and sanitation guidelines presented here can help prevent the spread of these organisms to other environments and help to ensure that fire suppression equipment remains operational.

Administration

READs are commonly assigned to fire incidents from the local land management agency in order to advise the Incident Commander of resource concerns and issues. As such, READs are a vital

link in implementing these guidelines during fire incidents. READ training occurs periodically and may be offered on a unit-specific, agency-specific, or interagency basis. In addition, some units or agencies offer annual READ refresher classes, and all fire personnel must attend an annual fireline refresher. These Fire Incident Resource Advisor classes and refreshers are the primary venue for training READs (and other fire personnel) on the use of these guidelines. With or without formal training, personnel expected to serve as READs during fire season should be familiar with the Technical Guidelines and the companion Operational Guidelines, as well as the distribution of aquatic invasive species on their local units.

READs should routinely be assigned to fire incidents on their local units according to the criteria established by the unit's Fire Management Plan or agency policy. When a fire incident exceeds the local unit's capacity for management and is transitioned to a Type I, II, or III incident management organization, READ(s) should also be assigned to the incident management team and continue to advise on issues related to aquatic invasive species. Additionally, the Operational Guidelines, the companion document to these Technical Guidelines, should be incorporated by reference into the Delegation of Authority from the Agency Administrator to the Incident Commander.

Preventing Spread

Preventing introductions of potentially harmful species is the most efficient way to reduce the threat of aquatic invasive species. These species can be spread by vehicles and equipment that come into contact with any wetted area. Firefighter and public safety are always the first priority, but wherever possible, applying the following guidelines will help to prevent the spread of these organisms.

1) For all operations, assume that aquatic invasive species could be present in any water body. If available, obtain maps with local presence of these organisms' distributions within watersheds where fire management operations will take place. Local land management agencies may have GIS shape files of individual species that are accessible to resource advisors, biologists, and fire personnel. Species-specific information, some distribution maps, and links to web sites are included in Appendix A and on the internet at the following sites:

   - USGS Nonindigenous Aquatic Species website: http://nas.er.usgs.gov (includes real time maps of distribution of several species)
   - Forest Service Intermountain Region Aquatic Invasive Species website: http://www.fs.fed.us/r4/resources/aquatic/index.shtml
   - Additional information regarding selection of water bodies may be found in Forest Service guidance at the following website: http://www.fs.fed.us/eng/pubs/pdf/WaterToolkit/o1_06251806.pdf

   Although distribution information at these web sites is kept as current as possible, a lack of mapped locations within the fire management area does not necessarily mean the species does not occur there. Apply the following steps, regardless of whether or not the species has been documented from the area.

2) Avoid driving through water bodies or contacting mud and aquatic plants with any vehicles or equipment. Vehicles and equipment can carry these organisms from one place to another if they come in contact with water or any substrate containing these organisms. Organisms such as quagga mussels can survive for up to 30 days out of water in some areas of the Southwest, depending on temperature and humidity.

3) Avoid transferring water between drainages by dumping water from one drainage into another or moving water between unconnected water bodies within the same drainage. Some organisms such as quagga mussels have microscopic life stages that are not readily apparent when water is drafted and are small enough to pass through screens.

4) Avoid obtaining water from multiple sources during a single operational period unless drafting/dipping equipment is sanitized between sources. Any wetted surface can carry some of these organisms and spread them from one water body to another.

5) Use screens when drafting and avoid sucking organic and bottom material when drafting from streams, ponds, or stock tanks. Screens are important to avoid transporting fish, amphibians, and crayfish between water bodies. Water drafting operations have the potential to spread aquatic invasive species through pumps and equipment. As stated above, pre-field review of potential aquatic invasive species within the watershed can identify the risk level. Water source specifications may include screen location and orientation, approach velocity, sweeping velocity, minimum screen size, screen mesh size, shape and material type, and bypass facilities. Other direction may provide information on pumping rates and draw-down of upstream or downstream pools or lakes and ponds where potential impacts to aquatic species may exist. See http://swr.nmfs.noaa.gov/habitat.htm http://www.fs.fed.us/eng/pubs/pdf/WaterToolkit/01_06251806.pdf

Cleaning and Sanitizing Vehicles and Equipment

1) Any equipment that comes into contact with raw water (water other than from a treated community or domestic water source) should be sanitized (Table 1). Microscopic larvae of zebra and quagga mussels (veligers) can be transported in tanks, buckets, hoses, bilges, and any other equipment that holds water. Minute parts of the invasive plant giant salvinia transported to uninfected areas can grow and spread.

2) Drying alone may be effective in some situations, depending upon the target species, types of equipment, temperature, and relative humidity. A quarantine time calculator for zebra/quagga mussels is available at the 100th Meridian website: http://100thmeridian.org/Emersion.asp. See Table 1 for specific-species considerations if using this option.

3) Clean and/or sanitize all vehicles and equipment before moving from one incident to another or when moving between watersheds. Cleaning and sanitizing equipment as described here will be necessary before use as well as after use if equipment has been obtained from a source where sanitizing history is unknown. While operational quality control is beyond the scope of this guidance, using an equipment check-in system where sanitizing could be documented and guaranteed with certification or tagging would be extremely valuable.

4) In coordination with the READ, establish sanitation areas where there is no potential for runoff into storm drains, waterways, or sensitive habitats. Be sure that wash water will not contaminate another water source.

5) Remove all visible plant parts, soil, and other materials from external surfaces of vehicles, gear, and equipment. Powerwash all accessible surfaces with clean, hot water (≥140°F, if possible); weed washers can be used. Powerwashing will greatly reduce the likelihood that aquatic invasive species are present, and chemical sanitation of external surfaces is not necessary (see Table 1 for water temperature/wash time recommendations for specific species). New Zealand mudsnails can insert themselves into small crevices and resist flushing; avoid driving through streams and scraping up bottom sediments when dipping to reduce the likelihood of picking up this species.

6) Intake hoses, pumps, and tanks can become contaminated with infected water or by sucking the organisms up from the bottom of a stream or pond. Disinfect tanks after each incident, and disinfect tanks before use if previous sanitation of the equipment has not occurred or is unknown. Set up a portable disinfection tank (e.g. "pumpkin," fold-a-tank, 55 gallon barrel, 5 gallon bucket, etc. depending on the cleaning capacity needed) using a 5% cleaning solution of quaternary ammonium compound. This is a common cleaning agent used in homes, swimming pools, and hospitals, and is safe when used at the recommended concentration. Using liquid bleach (such as Clorox) is not recommended because it evaporates quickly and damages gaskets and canvas gear. Do not mix bleach with quaternary ammonium compound. Quaternary ammonium compounds [brand names *Quat 128* (by Waxie) and *Sparquat*] need to be ordered or purchased from a local supplier or GSA, but solutions are safe for gear and remain effective for about one week if not overly diluted or muddied (see Testing the Solution, below).

   Recipe for 5% cleaning solution using either *Quat128®* ***or*** *Sparquat 256®*
   Disinfection with quaternary ammonium compounds is the recommended treatment for most aquatic invasive species found in the Southwest. These products are labeled for use as fungicides/virucides. Be sure to follow individual agency integrated pest management requirements, including pesticide use proposals. Species-specific concentrations and alternatives for hot water power washing, drying, and bleach solutions are in Table 1.

Volume of tap water	**Volume of *Quat128®***	**Volume of *Sparquat 256®***
100 ml water	4.63 ml	3.00 ml
1 gallon water	6.35 liquid oz.	4.12 liquid oz.
1 gallon water	12.7 tbsp	8.2 tbsp
1 gallon water	0.79 cups	0.51 cups
100 gallons water	4.96 gallons	3.22 gallons
1000 gallons water	49.6 gallons	32.2 gallons

   Empty the tank and flush tanks and hoses with clean water, then circulate the 5% cleaning solution for at least10 minutes. Float portable pumps in the disinfection tank and pump cleaning solution through for 10 minutes. Pump the solution through the hose, then rinse with water. Discharge used cleaning solution back into the disinfection tank for re-use.

Testing the Solution

To determine if the solution has been diluted below the 5% concentration, use "Quat Chek 1000" test papers. These can be purchased from the cleaning compound supplier. The used solution must be diluted to about 600 parts per million (ppm) of ammonium compound for proper testing.

1) Take **one** cup of used *Sparquat 256*® cleaning solution, pour into a bucket. Add **5** cups of water. Mix. OR
2) Take **one** cup of used *Quat128*® cleaning solution, pour into a bucket. Add **4** cups of water. Mix.

Test the diluted solution with "Quat Chek" Test Paper. Match up the color of the paper with the ppm on the color chart. For optimal disinfection, the diluted solution should have a concentration between 600 and 800 ppm. If it is too dilute, dispose of properly (see below) and mix a new cleaning solution.

Disposal

Use caution when disposing the used cleaning solution and follow all federal, state, and local regulations. Do not dump cleaning solution into any stream or lake, or on areas where it can migrate into any stormdrain, waterbody, or sensitive habitat. Small quantities may be disposed of down sanitary drains into a municipal sewer system. Larger quantities may need to be transported to a municipal wastewater treatment facility. Consult the facility operator/manager prior to disposal.

Used cleaning solution may or may not be suitable for disposal in on-site septic systems. Consult the local agency's utilities supervisor or facilities manager prior to disposal.

It may be possible to dispose of used cleaning solution over open land or on roadways where there is no potential for runoff into stormdrains, waterways, or sensitive habitats. Consult the READ for appropriate locations before using this method and check with the appropriate state or county authority as state or local permits may be required.

Within Arizona, if necessary, disposal of used cleaning solution can be done over open land and away from any waterbodies with a temporary emergency waiver from the Arizona Department of Environmental Quality (ADEQ). Please use other disposal methods first, if possible. Notify ADEQ, using the template letter that is attached in Appendix C, as soon as possible following any discharge of solution.

Safety

At the recommended dilution, ammonium quaternary compounds are safe for use. However, personal protective equipment (PPE) should always be used when working with these compounds and when handling the concentrated product. Use protective, unlined rubber gloves and splash goggles or a face shield when handling the cleaning solution, and take extra precautions when handling undiluted chemicals. Have eye wash and clean water available on-site to treat accidental exposure. Respiratory protection is not normally required if there is good ventilation.

Always use these products in accordance with label instructions. Never mix quaternary ammonium compounds with bleach; toxic fumes may result. Consult the product label and Material Safety Data Sheets (http://www.fs.fed.us/r4/resources/aquatic/guidelines/index.shtml) for additional information.

Hot water at 140ºF can pose a significant scalding risk. When using hot water or steam in power washers as a disinfection option, be sure to use appropriate PPE such as protective gloves and clothing to avoid scalding or burning skin.

Storage

Sparquat 256® and *Quat128*® can be stored for up to two years in an unopened container without losing their effectiveness. Both should be stored in a cool dry place, out of direct sunlight. The manufacturer recommends storage temperatures between 32º to 110º F.

Purchase

Both products are available from GSA (https://www.gsaadvantage.gov) and are commonly available through local janitorial and swimming pool chemical suppliers.

- *Quat 128*® by Waxie's Enterprises Inc.; GSA (NSN No. 170304) =$36/case (4 gal); EPA registration number 1839-166-14994.
  Additional information can be found at http://www.waxie.com
- *Sparquat 256*® by Spartan Chemical Company; GSA (NSN No. 1025-04) = $54/case (4 gal); EPA registration number 5741-9. Additional information can be found at http://www.spartanchemical.com

Remember to buy "Quat Chek 1000" test papers when you purchase the chemicals.

Table 1. Effective treatments for aquatic invasive species found in the Intermountain West and Southwest. For more information about specific organisms, see Appendix A.

Aquatic Invasive Species	**Wash and remove organics (e.g. mud)**	**Temperature**	**Drying**	**Bleach (e.g. Clorox®) 6% sodium hypochlorite** (NaClO)	**Quaternary ammonium compounds** [e.g. n-alkyl dimethyl benzyl ammonium chloride (ADBAC); didecyl dimethyl ammonium chloride (DDAC)]
Whirling Disease	Yes	90 °C (195 ° F);10 min	Be dry for 24 h, in sunlight best	For 10 min: 1% bleach solution (1 oz/1gal water)	For 10-15 minutes: Quat 128 (6oz/1gal), Sparquat 256 (4.3oz/1gal)
Viral Hemorrhagic Septicemia (VHS), other viruses	Thoroughly wash	46°C (120°F); 5 min Inactive after 24 hours at 20°C (68° F)	Be dry for 24 h, in sunlight best	For 10 min soak or circulate: 1% bleach solution (1 oz/1gal water)	Unknown, but likely effective. For 10-15 minutes soak or circulate: Quat 128 (6oz/1gal), Sparquat 256 (4.3oz/1gal)
Amphibian Chytrid Fungus	Yes	60°C (140°F); 5 min	Be dry for 3 hr, in sunlight best	For 30 sec: 20% solution (22oz/1 gal) -or- for 10 min: 7% solution 9oz/1gal	For 30 sec: Quat 128 (1/8 tsp/1gal)
New Zealand Mudsnails	Yes	46°C (120°F); 5 min	Be dry for 48 hr, in sunlight best	Not effective	For 10-15 minutes: Quat 128 (6oz/1gal), Sparquat 256 (4.3oz/1gal)
Zebra/Quagga Mussels	Yes, pressure wash flushes veligers	≥140°F water	3-30 days, in sunlight best	For 1 min: 0.5% bleach solution (1/2 oz/1gal water)	Preliminary data shows that contact for a minimum of 10 minutes at 5% Sparquat 256 (4.3 oz/gal) is effective in killing veligers within1 hour after treatment.~~No data, but likely effective~~
Didymo	Yes	60°C (140°F); 1 min	Be dry for 48 h, in sunlight best	For 1 min: 2% bleach solution (2 oz/1gal water)	No data, but likely effective
Golden Alga	Thoroughly wash	>104°F	Be dry for 2-3 days in direct sunlight	For 24 h at 62.5-500 mg/l (0.01-0.07 oz/gal); 1 h at 3,125 mg/l (0.42 oz/gal); or 15 min at 12,500 mg/l (1.67 oz/gal).	No data, but likely effective
Giant Salvinia	Yes	>43°C (109°F) or < -3°C (26 °F) for > 2 hours	Uncertain, but dry at least 48 h, in sunlight best	No data, but likely effective.	No data, but likely effective

Aquatic Invasive Species	Wash and remove organics (e.g. mud)	Temperature	Drying	Bleach (e.g. Clorox®) 6% sodium hypochlorite (NaClO)	Quaternary ammonium compounds [e.g. n-alkyl dimethyl benzyl ammonium chloride (ADBAC); didecyl dimethyl ammonium chloride (DDAC)]
Eurasian Watermilfoil and Parrot Feather	No data but likely killed with>60°C (140°F)	Uncertain, but completely dry at least 48 h, in sunlight best	No data, but likely effective.	No data, but likely effective	No data but likely effective
Hydrilla	Yes	No data but likely killed with>60°C (140°F)	Uncertain, but dry at least 48 h, in sunlight best	No data, but likely effective.	No data, but likely effective
Fish & Amphibians	Yes	≥140°F water	Be dry for 3 hr, in sunlight best	For 30 sec: 20% solution (22oz/1 gal)	Acute toxicity (EPA)
Crayfish	Yes	≥140°F water	Be dry for 3 hr, in sunlight best	For 30 sec: 20% solution (22oz/1 gal)	No data, but likely effective as ADBAC is toxic to most aquatic organisms
Other	(Similar species of snails, plants, pathogens, and vertebrate and invertebrate invasive species) No data but treatments for whirling disease and/or New Zealand mudsnails are likely effective				

FEEDBACK

These guidelines were developed by an interagency group including representatives from Bureau of Land Management, National Park Service, U.S. Fish and Wildlife Service, U.S. Forest Service, Arizona Game and Fish Department, and New Mexico Department of Game and Fish. These guidelines will be revised as needed, based on new information and suggestions from fire managers, READs, biologists, and others involved in their implementation. Please report use of these guidelines and suggestions for improvements to your agency contact.

Agency Contacts

Bureau of Indian Affairs	Leon Ben, Jr. Western Regional Office, Phoenix, AZ (602) 379-6798 Leon.Ben@bia.gov Jason Greenlee Navajo Area Office, Gallup, NM Jason.Greenlee@bia.gov Cal Pino Southwest Regional Office, Albuquerque, NM 505-563-3385 Cal.Pino@bia.gov
Bureau of Land Management	Kelly Castillo 602-417-9550 Kelly_Castillo@blm.gov Darren Mathis 602-417-9308 Darren_Mathis@blm.gov Arizona State Office, Phoenix, AZ Hector Madrid New Mexico State Office, Santa Fe, NM 505-438-7430 Hector_Madrid@blm.gov Dave Bott New Mexico State Office, Santa Fe, NM 505-438-7580 Dave_Bott@blm.gov

National Park Service	Myron Chase Intermountain Region, Denver, CO 303-969-2863 Myron_Chase@nps.gov Erv Gasser Pacific West Region, Seattle, WA 206-220-4263 Erv_Gasser@nps.gov
U.S. Fish and Wildlife Service	Mark Kaib Southwestern Regional Office, Albuquerque, NM 505-248-6819 Mark_Kaib@fws.gov Brenda Smith Arizona Ecological Services Office, Flagstaff, AZ 928-226-0614 x101 Brenda_Smith@fws.gov
U.S. Forest Service	Marsha Kearney Southwestern Region, Albuquerque, NM 505-842-3350 mkearney@fs.fed.us
State of Arizona	Tom McMahon Arizona Game and Fish Department, Phoenix, AZ 623-236-7271 TMcMahon@azgfd.gov
State of New Mexico	Barbara Colter New Mexico Department of Game and Fish, Santa Fe, NM 505-476-8188 Barbaraj.colter@state.nm.us

REFERENCES

Cope, W. G., Newton, T. J., and C.M. Gatenby. 2003. Review of techniques to prevent introduction of zebra mussels (D*reissena polymorpha*) during native mussel (Unionoidea) conservation activities. Journal of Shellfish Research 22(1): 177–184.

Elwell, L. 2006. (Draft) Increase in nuisance blooms and geographic expansion of the freshwater diatom *Didymosphenia geminata*: Recommendations for response, International *Didymosphenia* Symposium, Western Division American Fisheries Society Meeting, Bozeman, Montana.

Hosea, R. C. and B. Finlayson. 2005. Controlling the spread of New Zealand mud snails on wading gear, California Fish and Game, Office of Spill Prevention and Response Administrative Report 2005-02, Rancho Cordova, CA.

Johnson, M. L., Berger, L., Philips, L., and R. Speare. 2003. Fungicidal effects of chemical disinfectants, UV light, desiccation and heat on the amphibian chytrid *Batrachochytrium dendrobatidis*. Diseases of Aquatic Organisms 57: 255–260.

Langeland, K.A. 1996. *Hydrilla verticillata* (L.F.) Royle (Hydrocharitaceae), The Perfect Aquatic Weed. Castanea 61:293-304.

Madsen, J. D., and D. H. Smith. 1997. Vegetative spread of Eurasian watermilfoil colonies. J. Aquat. Plant Manage.35: 63-68.

Richards, D., O'Connell, P., and D. C. Shinn. 2004. Simple control method to limit the spread of the New Zealand mudsnail *Potamopyrgus antipodarum.* North American Journal of Fisheries Management 24:114-117.

Schisler, G. J., Walker, P. G., and R. Knox. (unpubl. ms.). Efficacy of Formula 409® and Sparquat 256® for control of New Zealand Mud Snails, Colorado Division of Wildlife, Aquatic Research Section, Fort Collins, CO.

Smith, C. S., and J. W. Barko. 1990. Ecology of Eurasian watermilfoil. J. Aquat. Plant Manage. 28:55-64.

Wagner, E. 2002. Whirling disease prevention, control, and management: a review. American Fisheries Society Symposium 29:217-225.

APPENDIX A

SPECIES SPECIFIC INFORMATION ON IMPACTS, DISTRIBUTION, SPREAD AND TREATMENTS

WHIRLING DISEASE

Whirling disease is caused by a microscopic parasite called *Myxobolus cerebralis*. The parasite was introduced to the United States from Europe in the 1950s and has spread to many streams across the U.S. All species of trout and salmon can be infected with the parasite, but not all species will develop whirling disease. Native species of trout and salmon are more susceptible than nonnative brown trout. Once established in a stream, the parasite cannot be eradicated, nor can its worm host, without significantly damaging the ecosystem. Whirling disease has no known human health effects.

Tubifex worms (*Tubifex tubifex)* are the required invertebrate hosts for the parasite. They are very small (about ½-inch in length) and are common and widespread around the world. They live in sediments of lakes and streams and thrive in areas with abundant fine sediment and rich organic material. There are two infective spore forms, the myxospore and the triactinomyxon (TAM). The myxospore is a very small, round, durable spore that infects the Tubifex worm while in the sediment of a stream. The more vulnerable TAM attaches to the fish's skin and injects the parasite into the fish's body.

How is whirling disease spread? Whirling disease is transmitted mainly by infected fish and fish parts. It may also be transmitted by birds, and it is possible anglers can carry the parasite on fishing equipment. Transfer of organic sediments in or on fire equipment is a potential vector. For more information, see the following link: http://whirlingdisease.montana.edu/

Where is whirling disease found in the West? The whirling disease parasite has been found in wild fish and fish hatcheries in 25 states. Whirling Disease has been detected in many drainages in the Intermountain West and in parts of the Southwest. It is best to treat all water sources as potentially contaminated. For interactive maps at the HUC-8 level, see the following link: http://bsi1.msu.montana.edu/whirlingdisease/default.aspx

Treatments effective on both stages of the parasite: the mature spore and the TAM

Wash and remove organics (e.g. mud)	**Temperature**	**Drying**	**Bleach (e.g. Clorox®) 6% sodium hypochlorite** (NaClO)	**Quaternary ammonium compounds** [e.g. n-alkyl dimethyl benzyl ammonium chloride (ADBAC); didecyl dimethyl ammonium chloride (DDAC)]
Thoroughly wash and scrub with stiff brush: Spores and TAMS	90 °C (195 ° F);10 min; Spores and TAMS	Be dry for 24 h, in sunlight best; TAMS only	Soak or circulate for 10 min: 1% bleach solution (1 oz/1gal water); Spores and TAMS	Soak or circulate for 10-15 min: Quat 128 (6oz/1gal), Sparquat 256 (4.3oz/1gal); Spores and TAMS

General considerations: The principle vector for spread of whirling disease is contaminated fish parts; it is not typically spread through fire activities. Avoiding and removing organics (the spores reside in mud), power washing, and flushing will greatly reduce or eliminate spores on external gear surfaces. However, wet internal tanks and hoses should be decontaminated with very hot water or a quaternary ammonium compound, such as *Quat128,* used to decontaminate equipment for amphibian chytrid fungus and viral hemorrhagic septicemia. Whirling disease and New Zealand mudsnails are the most difficult organisms to kill. Treatment for these species will be effective for all other species as well.

VIRAL HEMORRHAGIC SEPTICEMIA (VHS) and other viruses

Viral hemorrhagic septicemia (VHS) (*Novirhabdovirus sp.)* is indigenous to eastern and western Europe, Japan, and the Pacific (California to Alaska) and Atlantic coasts of North America. The clinical signs of VHS differ depending on the course of infection. In the latent manifestation of the disease, some mortality may occur and fish become hyperactive, sometimes displaying nervous symptoms such as twisting of the body and behavior that involves swimming erratically in circles or in a corkscrew pattern. In the acute form of the disease, fish become lethargic, dark, and anemic, with bulging eyes, congested kidneys, mottled liver, and with hemorrhaging in the eyes, skin, gills, fin bases, skeletal muscle and viscera. Mortality is very high, and the disease is short-lived. However, some fish are carriers and show no symptoms. Survivors of infection can be carriers of the virus throughout the rest of their lives. Nearly 50 species of fish are known to be susceptible to VHS. The virus was first isolated from most of these species only within the past two decades. Susceptible fishes include several species of commercial importance [e.g. lake trout (*Salvelinus namaycush)*, rainbow trout (*Oncorhynchus mykiss)*, brook trout (*Salvelinus fontinalis*), and coregonids (*Coregonus* spp)]. Fish mortality from VHS is greatest at 3–12ºC and is very rare above 15ºC. For more information, visit this link:
http://www.glerl.noaa.gov/res/Programs/ncrais/docs/factsheets/novirhabdovirus.html

How is VHS spread? It is not known how VHS was initially introduced to the Great Lakes-St. Lawrence River system; however, genetic evidence suggests that the virus originated from the Atlantic coast of North America, possibly via transport in ballast water or infected migratory fishes. Aquaculture activities are implicated in the spread of the virus. The virus can be spread by live or dead bait fish, demonstrated by the virus' recovery in cell culture from frozen Pacific herring (*Clupea pallasi*) after two freeze/thaw cycles in a conventional freezer. Waterfowl may also play a role in transmitting the virus.

Where is VHS found in the West? VHS is not yet found in the interior western U.S. VHS virus has been present in the Great Lakes since at least 2003. The North American strain of VHS virus is present in Lake Huron, Lake St. Clair, Lake Erie, Lake Ontario, the St. Lawrence River, and the Ohio River.

Treatments Effective on VHS and other viruses

Wash and remove organics (e.g. mud)	**Temperature**	**Drying**	**Bleach (e.g. Clorox®) 6% sodium hypochlorite** (NaClO)	**Quaternary ammonium compounds** [e.g. n-alkyl dimethyl benzyl ammonium chloride (ADBAC); didecyl dimethyl ammonium chloride (DDAC)]
Thoroughly wash	46°C (120°F); 5 min Inactive after 24 hours at 20°C (68° F)	Be dry for 24 h, in sunlight best	Soak or circulate for 10 min: 1% bleach solution (1 oz/1gal water)	Unknown, but likely effective. Soak or circulate for 10-15 min: Quat 128 (6oz/1gal), Sparquat 256 (4.3oz/1gal)

General considerations: Although VHS has not yet been found in the West, the high mortality it causes in susceptible species is of great concern for declining native and endangered species of the desert Southwest. Although quaternary compounds have not been tested on VHS, these products are used for anti-viral cleaning in hospitals. Treatment for VHS is should also be effective for whirling disease and New Zealand mudsnails.

AMPHIBIAN CHYTRID FUNGUS

The amphibian chytrid fungus (*Batrachochytrium dendrobatidis)* (commonly referred to as "Bd") attacks amphibians and can kill entire populations of frogs, toads and salamanders in a short time, although some individuals are resistant and serve as harbors for the fungus. Bd has been found to affect at least 93 amphibian species from the orders Anura (frogs and toads) and Caudata (salamanders) in all continents except Asia. It is believed to be one of the main causes of the global decline in frog populations since the 1960s and the dramatic population crashes from the 1970s onwards. Bd kills frogs within 10 to 18 days, although it is not known how. It may be physical, affecting respiration by altering the frog's skin, or the fungus may give off a toxin. For a summary on the impacts of *B. dendrobatidis,* please follow this link: http://www.issg.org/database/species/reference_files/batden/batdenimp.pdf

Where is amphibian chytrid fungus found in the West? Occurrences of Bd have been identified in many locations around the West including Arizona, New Mexico, Colorado, and California. All water sources should be treated as potential sources of contamination. There is no detailed map, but distribution information can be found at: http://www.issg.org/database/species/distribution.asp?si=123&fr=1&sts=&lang=EN

How is amphibian chytrid fungus spread? The infective stage of *Batrachochytrium dendrobatidis* is the zoospore, and transmission of the disease requires water as the zoospore is not tolerant to dehydration. *B. dendrobatidis* remains viable in tap water for up to 3 weeks, in deionized water for up to 4 weeks, and in lake water for even longer. Infection with extremely small inocula (100 zoospores) can prove fatal. The fungus can exist in water or mud and can be spread by humans with wet or muddy boots, vehicles, cattle, and other animals moving among aquatic sites; during scientific sampling of fish, amphibians, or other aquatic organisms; or fire suppression activities. Bd could be carried on mud clinging to wheel wells or tires, or on shovels or other equipment.

Treatments effective on all stages of chytrid fungus

Wash and remove organics (e.g. mud)	**Temperature**	**Drying**	**Bleach (e.g. Clorox®) 6% sodium hypochlorite** (NaClO)	**Quaternary ammonium compounds** [e.g. n-alkyl dimethyl benzyl ammonium chloride (ADBAC); didecyl dimethyl ammonium chloride (DDAC)]
Yes – completely remove all debris	60°C (140°F); 5 min	Be dry for 3 hr, in sunlight best	For 30 sec: 20% solution (22oz/1 gal); or for 10 min: 7% solution (9oz/1gal)	For 30 sec: Quat 128 (1/8 tsp/1gal)

General considerations: Fortunately, Bd is vulnerable to many treatments. Drying, high temperatures, and low concentrations of chlorine or quaternary ammonium compounds are effective treatments. Avoiding organics, power washing, flushing, and letting equipment dry in the sun for 3 hours (if possible) will reduce risk of transfer on external surfaces. However, wet internal tanks and hoses should be decontaminated with a quaternary ammonium compound, such as *Quat128*. While only 1/8 teaspoon per gallon of water is required for Bd, a higher concentration (6.4oz/gal) would also effectively remove whirling disease and /or New Zealand mudsnails.

NEW ZEALAND MUDSNAIL

The New Zealand mudsnail [*Potamopyrgus antipodarum* (Gray)] is a medium-sized hydrobiid snail native to New Zealand, but has also been established throughout waters in Europe, Asia, and Australia since the mid 1800s. In about the last 15 years, it has invaded North American waters and is now well established in several of the major river drainages throughout the western U.S., including the headwaters of the Missouri and Columbia Rivers and Yellowstone National Park. Until recently, the impacts of the New Zealand mudsnail on aquatic ecosystems in the U.S. have been unknown but were anticipated to be great due to its ability to attain extremely high densities.

Where are New Zealand mudsnails found in the West? The New Zealand mudsnail is now reported from all western states except New Mexico. It is concentrated in tailwater rivers below dams. The Snake River in Idaho is heavily infested, as is the Colorado River below Glen Canyon Dam in Arizona, and the Green River below Flaming Gorge Dam in Utah. Up-to-date maps can be found at this link: http://www.esg.montana.edu/aim/mollusca/nzms/status.html

How are New Zealand mudsnails spread? Their large populations at many sites, small body size, and broad environmental tolerance make the New Zealand mudsnail well adapted to accidental transport by humans on muddy equipment or in containers such as bait buckets or water tenders. As an asexual live-bearer, a single individual can start a new population. Birds can also be transporters because the snails are not digested in the gut and often pass through alive.

Treatments effective for New Zealand mudsnail

Wash and remove organics (e.g. mud)	**Temperature**	**Drying**	**Bleach (e.g. Clorox®) 6% sodium hypochlorite** (NaClO)	**Quaternary ammonium compounds** [e.g. n-alkyl dimethyl benzyl ammonium chloride (ADBAC); didecyl dimethyl ammonium chloride (DDAC)]
Yes, power wash is best	46°C (120°F); 5 min	Be dry for 48 hr, in sunlight best	Not effective	For 10-15 minutes: Quat 128 (6oz/1gal), Sparquat 256 (4.3oz/1gal)

General considerations: New Zealand mudsnails are resistant to treatment and may insert themselves in small crevices and resist flushing. However, unless vehicles are driving through streams or buckets scrape up bottom sediments, they are unlikely to pick up snails on external surfaces. Avoiding organics, power washing, flushing, and drying gear in the sun for 48 hours (if possible) will reduce risk. Wet internal tanks and hoses should be decontaminated with a quaternary ammonium compound, such as *Quat128,* at a concentration of 6.4oz/gal. This concentration will also kill whirling disease spores and amphibian chytrid fungus.

ZEBRA/QUAGGA MUSSELS

Zebra *(Dreissena polymorpha)* and quagga mussels (*Dreissena rostriformis bugensis)* are small bivalves native to Eastern Europe. They were introduced to the Great Lakes in North America via ballast water dumped from ocean-going ships. Zebra mussels, discovered in 1988, followed by quagga mussels, rapidly spread throughout many major river systems and the Great Lakes, causing substantial ecological and environmental impacts. Zebra mussels prefer warm, eutrophic, shallow water; quaggas prefer shallow, warm water to deep, oligotrophic, cold-water habitats. Both the quagga mussel and zebra mussel are prolific breeders, possibly contributing to their spread and abundance. A fully mature female mussel is capable of producing up to one million eggs per season. Pelagic microscopic larvae, or veligers, develop within a few days and can drift with the currents for three to four weeks before finding suitable substrata to settle upon. Their recent introduction and rapid spread in the West is cause for concern for environmental and infrastructure impacts. Controlling the spread is imperative, since they cannot be eradicated once established. For more information: http://nas.er.usgs.gov/taxgroup/mollusks/zebramussel/

Where are Zebra/Quagga mussels found in the West? Quagga mussels were discovered in Lake Mead in 2006. They have since spread throughout the lower Colorado River aqueduct system in Arizona, California, and Nevada, and to the upper Colorado River above Lake Powell in Lake Granby, Colorado. Zebra mussels are established in Pueblo Reservoir in eastern Colorado, and both species now occur in western Colorado in Grand Lake. Efforts to control the spread of these invasive mussels were quickly implemented in all states including boat washing and inspection stations at many major reservoirs, and an education blitz of billboards, public announcements, websites, and free literature. For frequently updated maps of distribution see: http://nas.er.usgs.gov/taxgroup/mollusks/zebramussel/maps/current_zm_quag_map.jpg

How are they spread? Dreissenid mussels are usually spread by boats trailored between waters, as well as downstream transport from infested water. A boat that has spent more than a few hours in infested water could carry attached mussels too small to see as well as veligers in live wells, bilges, and other areas that hold water. Mussels can survive several days out of water in cool temperatures. During fire suppression activities, veligers could be transported by water tenders or other water carrying equipment.

Treatments for zebra and quagga mussels

Wash and remove organics (e.g. mud)	**Temperature**	**Drying**	**Bleach (e.g. Clorox®) 6% sodium hypochlorite** (NaClO)	**Quaternary ammonium compounds** [e.g. n-alkyl dimethyl benzyl ammonium chloride (ADBAC); didecyl dimethyl ammonium chloride (DDAC)]
Yes, pressure wash flushes veligers	≥140°F water	3-30 days, in sunlight best	For 1 min: 0.5% bleach solution (1/2 oz/1gal water)	No data, but likely effective

General considerations: Except for boats used for fire suppression, fire management activities are unlikely to spread adult mussels. However, it is possible that water used for these activities or surfaces of gear may become contaminated with the microscopic veliger stage. Pressure washing and strong flushing of tanks and hoses should be sufficient to remove these organisms. The chemical treatments for whirling disease and New Zealand mudsnails should be effective against the juvenile and adult stages of the mussels. Air-drying the equipment for at least fifteen days before use in any other waterway is effective only for exterior surfaces. Drying time for summer and winter season is recommended at 5 and 15 days, respectively.

DIDYMO

Didymosphenia geminata, commonly referred to as "didymo", is a freshwater microscopic diatom. It is found in streams and rivers in much of North America. Didymo increasingly poses a threat to aquatic ecosystems because it forms extensive mats on stream beds. Didymo attaches to the streambed by a stalk. These stalks have a rough texture similar to wet wool and mimic strands of toilet paper, as opposed to other algal species, which feel "slimy". Didymo is an invasive freshwater alga that can form massive blooms. Didymo can smother streambeds and adversely affect freshwater fish, plant, and invertebrate species by depriving them of habitat and can also impact recreational opportunities. It is not considered a significant human health risk, but in recent years has been spreading to previously unaffected areas in North America, Europe, and Asia, and has been detected in New Zealand. This species historically formed blooms in fast-flowing, cold, clean waters, but now didymo is increasing its ecological range. Recent research shows that many countries across the globe provide suitable habitat for didymo to thrive. For more information visit http://www.epa.gov/region8/water/didymosphenia/

Where is didymo found in the West? Didymo has been reported from the states of Alaska, Washington, Idaho, Montana, Wyoming, Utah, Colorado, and California. However, Colorado has the most reported occurrences of didymo. It is most commonly found in its invasive form in tailwaters below dams. For a distribution map, follow this link: http://www.epa.gov/region8/water/didymosphenia/na_dis.map.pdf

How is didymo spread? Didymo can be spread by recreational and fire suppression equipment, including wet or muddy boots, vehicles, or during scientific sampling of fish, amphibians, or other aquatic organisms, or fire suppression activities. Didymo can remain viable for several days if kept moist, and can be transferred in microscopic form on equipment to new waterways. Infection may only need a single cell. It is not possible to eliminate didymo from a waterway once it has become affected. Decontaminating equipment between uses in different freshwater systems is the key to preventing further spread.

Treatments for didymo

Wash and remove organics (e.g. mud)	**Temperature**	**Drying**	**Bleach (e.g. Clorox®) 6% sodium hypochlorite** (NaClO)	**Quaternary ammonium compounds** [e.g. n-alkyl dimethyl benzyl ammonium chloride (ADBAC); didecyl dimethyl ammonium chloride (DDAC)]
Yes	60°C (140°F); 1 min	Be dry for 48 h, in sunlight best	For 1 min: 2% bleach solution (2 oz/1gal water)	No data, but likely effective

General Considerations

Didymo is a native diatom that erupts into high densities in special habitats, such as tailwaters below dams. Avoiding contaminated water sources and organics, power washing, and flushing would likely reduce risk of transfer on fire equipment. For waders, routine protocols for amphibian chytrid fungus or whirling disease may apply for this species.

GOLDEN ALGA

The golden alga or algae (*Prymnesium parvum*) is a freshwater microscopic algal cell. It is found principally in lakes and impoundments and has a preference for waters of higher salinities and higher alkalinities, which describes many of the lakes in the Southwest. First described in 1937 from England, it is widely distributed on every continent except Antarctica and is known from at least 14 countries. It was first reported in New Mexico and Texas waters in the 1980s, but may have been present in the Pecos River since the 1960s. Golden alga produces a toxin that is lethal to gill-breathing organisms (larval insects, mollusks, crustaceans, fish, amphibians), resulting in suffocation. Blooms usually occur in winter and early spring. On large water bodies, it is virtually impossible to eradicate. It has no reported human health risks.

Where is golden alga found in the West?
This species is most often associated with estuarine or marine waters, but can exist in inland waters such as ponds, reservoirs, streams, and rivers. In the West, golden alga has been reported from Texas, California, Arizona, New Mexico, Colorado, Wyoming, and Oklahoma. However, New Mexico and Texas have the most frequently reported occurrences.

How is golden alga spread? Transfer of water containing viable algal cells can introduce golden alga to new water bodies. It can be spread by recreational and fire suppression equipment, including wet or muddy boots; vehicles; during scientific sampling of fish, amphibians, or other aquatic organisms; or fire suppression activities. It may spread through water along river or canal pathways; by water birds; by humans transporting water in live wells, bilge tanks, or minnow buckets; or businesses trucking products in water. Golden alga has a "resting stage" that may allow for dried cells or cysts to persist for long periods in dried lake or bank sediments, affording the opportunity for dispersal with equipment and perhaps even aerial distribution. Infestation may only need a single cyst. It is virtually impossible to eliminate golden alga from a waterway once it has become affected. Decontaminating equipment between uses in different freshwater systems is the key to preventing further spread.

Treatments for Golden alga

Wash and remove organics (e.g. mud)	**Temperature**	**Drying**	**Bleach (e.g. Clorox®) 6% sodium hypochlorite** (NaClO)	**Quaternary ammonium compounds** [e.g. n-alkyl dimethyl benzyl ammonium chloride (ADBAC); didecyl dimethyl ammonium chloride (DDAC)]
Thoroughly wash	>104°F	Be dry for 2-3 days in direct sunlight	Soak or circulate for 24 h at 62.5-500 mg/l (0.01-0.07 oz/gal); 1 h at 3,125 mg/l (0.42 oz/gal); or 15 min at 12,500 mg/l (1.67 oz/gal). Higher concentrations can be used to disinfect equipment but are likely to be harmful to fishes.	No data, but likely effective

General considerations: Golden alga is a native diatom that erupts into high densities in special habitats, such as impounded waters above dams. Avoiding contaminated water sources, power washing, and flushing would likely reduce risk of transfer on fire equipment to acceptable levels. It is also susceptible to algicides containing chelated copper compounds. For boots or waders, routine protocols for amphibian chytrid fungus or whirling disease may apply for this species.

GIANT SALVINIA

Giant salvinia (*Salvinia molesta*), also known as Kariba weed, African pyle, aquarium watermoss, koi kandy, or simply salvinia, is an aquatic plant native to freshwaters of South America. It was likely introduced into the United States for use as an ornamental plant in fish aquariums and ponds. Salvinia is a floating, rootless aquatic fern that reproduces through vegetative means with a high potential for rapid growth. It occupies lakes, ponds, oxbows, ditches, swamps, marshes, rice fields, and slow-flowing streams and rivers. It reproduces asexually; fragments of the plant can regenerate into viable plants. It is a prodigious reproducer, and growth can double within days. The plant forms dense mats up to several feet thick and strong enough to support a concrete block. Its rapid growth, vegetative reproduction, and tolerance to environmental stress make it an aggressive, competitive species capable of covering the entire surface of water bodies, causing large economic losses and a wide range of ecological problems to native species and communities. It also provides habitat for vectors of human disease. Giant salvinia is susceptible to freezing; a strong freeze can cause the plant to die back; however it is rarely eliminated. Fragments of giant salvinia can remain viable out of water for some time, especially if kept moist or insulated from thorough drying.

Where is giant salvinia found in the West? Salvinia has been reported in Arizona, California, Texas, Oklahoma, and Hawaii. The most severe infestation of salvinia in the U.S. was recently discovered in east Texas and Oklahoma where an estimated 1,000 acres of waterfowl habitat has been heavily impacted and degraded. It was detected in Arizona and California along the lower Colorado River in 2000. In the Colorado River, it does not thrive in the main channel of the river but establishes patches in slack water areas and is common in "drift" in the river currents. Giant salvinia has spread down the Colorado River into Mexico where it has been diverted into canals and aqueducts. Occurrence in New Mexico has not been documented. Distribution maps may be found at: http://www.fws.gov/texascoastalprogram/giant_salvinia.htm

How is giant salvinia spread? Salvinia is spread within and between aquatic systems mainly by people. It is spread accidentally when equipment or boats are moved. It can also be carried by animals as they move between infested and non-infested waters. Salvinia plant fragments can be carried by fire suppression equipment, including wet or muddy boots and vehicles. Removing mud and debris from personal and fire suppression equipment, or decontamination between uses in different freshwater systems, can assist in preventing the further spread of salvinia.

Treatments for giant salvinia

Wash and remove organics (e.g. mud)	**Temperature**	**Drying**	**Bleach (e.g. Clorox®) 6% sodium hypochlorite** (NaClO)	**Quaternary ammonium compounds** [e.g. n-alkyl dimethyl benzyl ammonium chloride (ADBAC); didecyl dimethyl ammonium chloride (DDAC)]
Yes	>43°C (109°F) or < -3°C (26 °F) for > 2 hours	Uncertain, but dry at least 48 h, in sunlight best	No data, but likely effective.	No data, but likely effective

General considerations: Salvinia is considered by some to be the world's worst invasive plant. It possesses the capability of doubling its surface in 5-7 days and can overwhelm aquatic ecosystems. The spread of salvinia may be limited by the plant's lack of tolerance to freezing water. Preventing spread of this invasive can be accomplished easily by removing all aquatic plants from equipment and thoroughly power washing, flushing, and drying equipment.

EURASIAN WATERMILFOIL AND PARROT'S FEATHER

Eurasian watermilfoil (*Myriophyllum spicatum*) and the closely related parrot's feather (*M. aquaticum*) are submerged aquatic plants that can quickly take over lakes, rivers, irrigation canals, farm ponds, and other slow-moving waters. They crowd out desirable native vegetation, clog irrigation systems, and make waterways unsuitable for boating, fishing, and swimming. Although very similar species, the Eurasian watermilfoil is native to Europe, Asia, and northern Africa, while the parrot's feather is native to South America. Eurasian watermilfoil was first documented in 1942 from a pond in Washington D.C. and was probably intentionally introduced to the United States. Spread occurred as the species was planted into lakes and streams across the country. It is now one of the most widely distributed of all nonindigenous aquatic plants. It has been confirmed in 45 U.S. states and in the Canadian provinces of British Columbia, Ontario, and Quebec. Parrot's feather is not nearly as widespread and occurs in warmer climates in the southern U.S. and further north along the coasts in milder climates. For more information and distribution of both species, visit: http://nas.er.usgs.gov/taxgroup/plants/docs/my_spica.html or http://ucce.ucdavis.edu/datastore/detailreport.cfm?usernumber=64&surveynumber=182

Where is the Eurasian watermilfoil and parrot's feather found in the West? Eurasian watermilfoil is present in most of the western states except Montana and Wyoming. It tends to colonize slow-moving or still water. It occurs in shallow water where it is rooted to the substrate and is able to survive over winter in colder climates. It is particularly troublesome in waterbodies that have experienced disturbances such as nutrient loading, intense plant management, or abundant motorboat use. Parrot's feather also occurs in slow-moving or still water throughout much of the West except the interior states. However, while it seems to grow best in shallow water, it also occurs as a floating plant in deeper water of nutrient-enriched lakes. The emergent stems can survive on wet bands of rivers and lake shores, so it is well adapted to moderate water level fluctuations. Parrot's feather is unable to survive in northern climates where winters are more severe.

How does Eurasian watermilfoil and parrot's feather spread? Both species spread by the transport of plant fragments or propagules. If plant parts are maintained in equipment, containers, clothing, boat trailers, etc., they can be introduced to new sites. Animals are also capable of transporting plant parts that may establish new populations. Once introduced to a new drainage, these species can spread throughout the drainage by water currents.

Treatments effective for Eurasian watermilfoil and parrot's feather

Wash and remove organics (e.g. mud)	**Temperature**	**Drying**	**Bleach (e.g. Clorox®) 6% sodium hypochlorite** (NaClO)	**Quaternary ammonium compounds** [e.g. n-alkyl dimethyl benzyl ammonium chloride (ADBAC); didecyl dimethyl ammonium chloride (DDAC)]
Yes	No data but likely killed with>60°C (140°F)	Uncertain, but completely dry at least 48 h, in sunlight best	No data, but likely effective.	No data, but likely effective

General considerations: Little information is available for controlling the spread of Eurasian watermilfoil or parrot's feather except that it is important to remove debris and plant parts from all pieces of equipment. They are susceptible to drying and likely can be killed when exposed to treatment water used for control of other species. Power washing and flushing to ensure the removal of all plant parts will prevent transport on external and internal gear.

HYDRILLA

Hydrilla (*Hydrilla verticillata*) or water thyme is a submersed aquatic invasive plant native to the warmer regions of Asia. It grows at water depths from a few inches to 20 feet, and its long stems and small leaves form dense mats of vegetation, crowding out native aquatic plants. Hydrilla reproduces rapidly, mainly by regrowth of stem fragments; it also reproduces by growth of axillary buds (turions) and subterranean tubers. Tubers can remain viable for 4 to 7 years, and a single tuber can grow to produce more than 6,000 new tubers per square meter. Hydrilla can grow in almost any freshwater area or water with low salinity (up to 7%), and in areas with very low (1% of full) sunlight. It can tolerate oligotrophic (low nutrient) to eutrophic (high nutrient) conditions. It can grow in temperate areas and is somewhat winter-hardy; U.S. southern populations overwinter as perennials; northern populations overwinter and regrow from tubers. It was first discovered in the U.S. in 1960, likely introduced through the aquarium trade. It is now found in all of the Gulf Coast states, Atlantic Coast states north to Connecticut, and in the West in Arizona, California, and Washington. When hydrilla invades, native submersed plants are shaded out by hydrilla's thick mats or are simply outcompeted. It reduces water storage and water movement, clogs water control structures and hydroelectric generators, interferes with boating and fishing, damages fish and wildlife habitat, and produces mosquito breeding habitat.

Where is hydrilla found in the West? Hydrilla was introduced to California as a contaminant of water lily rhizomes and was likely similarly introduced into a small lake system in Washington. It was eradicated from two ponds near Phoenix, Arizona, in the 1980s and no longer occurs in Arizona, but is a "state-listed" noxious weed. It has been successfully controlled with aquatic herbicides and is highly preferred by grass carp. Distribution is at: http://pest.ceris.purdue.edu/searchmap.php?selectName=PCHAFBA

How is hydrilla spread? Hydrilla is spread within and between aquatic systems mainly by people. It is spread accidentally when equipment or boats are moved. It can also be carried by animals as they move between infested and non-infested waters. Hydrilla plant fragments can be carried by fire suppression equipment, including wet or muddy boots and vehicles. Removing mud and debris from personal and fire suppression equipment, or decontamination between uses in different freshwater systems, can assist in preventing the further spread of hydrilla.

Treatments for Hydrilla

Wash and remove organics (e.g. mud)	**Temperature**	**Drying**	**Bleach (e.g. Clorox®) 6% sodium hypochlorite** (NaClO)	**Quaternary ammonium compounds**[e.g. n-alkyl dimethyl benzyl ammonium chloride (ADBAC); didecyl dimethyl ammonium chloride (DDAC)]
Yes	No data but likely killed with>60°C (140°F)	Uncertain, but dry at least 48 h, in sunlight best	No data, but likely effective.	No data, but likely effective

General considerations: Hydrilla is considered the world's worst submersed weed. It grows up to an inch per day. Hydrilla infestations are not apparent until it fills the lake or river that it infests, "topping out" at the surface. Human transport on boats and wetted equipment is the main vector for spread of this species. Preventing spread of this invasive can be accomplished by removing all aquatic plants from equipment and thoroughly power washing, flushing, and drying equipment.

FISH, AMPHIBIANS, AND CRAYFISH

Nonnative fish, amphibians, and crayfish have been documented to impact native species and ecosystems throughout the west. Potential impacts include competition with native species for food and habitat, reduction of natives by predation, transmission of diseases or parasites, and habitat alteration. Nonnative fish species present in the West are too numerous to list but include species such as small-mouth bass, green sunfish, and red shiner. While many water bodies have already suffered invasion, the remaining waters are proportionately more deserving of protection. All water bodies are potentially affected, including reservoirs, rivers, streams, springs, and ponds. Nonnative amphibians include bullfrogs (*Rana catesbeiana*). Nonnative crayfish have also been implicated in the decline of native fish and amphibians in the Southwest. The most common species include the virile crayfish (*Orconectes virilis)* and the rusty crayfish (*Orconectes rusticus)*. There are few native crayfish species in the Intermountain West, and their distribution is limited. There are no crayfish native to Arizona.

Where are nonnative fishes, amphibians, and crayfish found in the west? Nonnative fishes are found in many locations throughout the west. Larger bodies of water and rivers tend to hold greater abundance and diversity of nonnatives, while smaller high elevation or isolated bodies of water, if not already invaded, are more vulnerable to accidental transfer. Nonnative amphibians and crayfish are less well distributed; however, they are more likely to survive accidental transfer, and pristine areas are highly vulnerable to impacts due to invasion. Bullfrog and crayfish distribution maps can be found at:
http://nas.er.usgs.gov/ARCIMS/interactive/interactive.asp?SpeciesID=71 , and
http://nas.er.usgs.gov/taxgroup/Crustaceans/crayfish.html

How are nonnative fishes, amphibians and crayfish spread? Common methods of introduction include intentional and accidental stocking, release of bait fish, release of unwanted aquarium fish, escape from aquaculture facilities, and discharge of ballast water. Accidental live transfer by fire suppression activities is most likely via bucket dipping from shallow lakes, ponds and streams. Many of these organisms live near the bottom of water bodies, so avoiding shallow areas where equipment scrapes the bottom will help prevent accidental transfer. Screening of intake pumps is also effective.

Treatments for fish, amphibians, and crayfish

Wash and remove organics (e.g. mud)	**Temperature**	**Drying**	**Bleach (e.g. Clorox®) 6% sodium hypochlorite** (NaClO)	**Quaternary ammonium compounds** [e.g. n-alkyl dimethyl benzyl ammonium chloride (ADBAC); didecyl dimethyl ammonium chloride (DDAC)]
Yes	≥140°F water	Be dry for 3 hr, in sunlight best	For 30 sec: 20% solution (22oz/1 gal)	Acute toxicity to fish and amphibians (EPA). No data on crayfish, but likely effective as ADBAC is toxic to most aquatic organisms.

General considerations: Both impacts to native fishes and amphibians and potential transfer of nonnative fishes and amphibians should be considered. Live transfer is possible via bucket dipping from shallow lakes, ponds and streams. To avoid live transfer, avoid dumping water from one water body into another. Dip from deeper portions of lakes and ponds where possible. Decontamination procedures for amphibian chytrid fungus should be adequate for all developmental stages of fish, amphibians and crayfish.

APPENDIX B

This appendix is taken from the U.S. Forest Service, Intermountain Region document "Preventing Spread of Aquatic Invasive Organisms Common to the Intermountain Region, Guidance for 2008 Fire Operations, Appendix".

USING CHLORINE BLEACH

Important note: Mixing any chlorine-containing compounds (including any form of household bleach or dry form of chlorine) with any ammonia-containing compounds (including fire retardant mixes or residues) can lead to extreme health and safety hazards, including the release of chlorine gas.

Liquid bleaches, such as household bleach, are a 5-8% solution of sodium hypochlorite, a stabilized form of chlorine. Bleaches can be very corrosive to fabrics, plastics, rubber, and metal, and disinfectant properties will dissipate quickly when exposed to air.

Dry bleach products

Many dry forms of chlorine are available that would offer advantages for transport and storage. Products such as DryTec or CCH are granular 68% calcium hypochlorite (Arch Chemicals, Inc., manufacturer of both products, 800-478-5727). Granular calcium hypochlorite (68%) can also be ordered from GSA (NSN No. KE0472). The sanitizing active agent in liquid chlorine bleach is the chlorine (Cl^-) produced when dry bleach is added to water. The accompanying Technical Chemical Information spreadsheet shows how much dry calcium hypochlorite to mix per gallon of water to obtain the desired concentration. The spreadsheet will automatically calculate dilutions if the dry form of chlorine you purchase has a different percentage of hypochlorite (other than 68%). Just type in the percentage hypochlorite in the yellow cell.

[Note: The Technical Chemical Information spreadsheet can be downloaded from: http://www.fs.fed.us/r4/resources/aquatic/guidelines/index.shtml*]*

Lithium hypochlorite is also available in dry form but provides less than half the available chlorine per volume compared to calcium hypochlorite, and is much more expensive.

Do NOT use any pool chemicals that contain something called "trichlor", which is very commonly used as a swimming pool chlorinator. It is trichloro-s-triazinetrione, which includes cyanuric acid to extend its photostability. Following the recent retardant-sodium ferrocyanide decisions, a great deal of caution would be advised before recommending any compounds containing any form of cyanide-containing compound, regardless of its expected safety.

Similarly, do not use chemicals containing "dichlor", or dichloro-s-triazinetrione, another member of the chlorinated iso-cyanurate family that is very commonly used in swimming pools. Caution is advised for the same reason as trichlor.

USING QUATERNARY AMMONIUM COMPOUNDS

Quaternary ammonium compounds, or 'quats', are common disinfectants with an array of uses, from killing algae in swimming pools to sanitizing workout equipment at the gym. They are relatively nontoxic and do not damage fabric, metals, or gaskets. Solutions of quat compounds

retain their effectiveness over days and can be reused if not excessively diluted. These compounds exist as a family with various ratios of carbon to nitrogen and chlorine. There are hundreds, but much of research for their effectiveness against aquatic invasive species has focused so far on one of the alkyl dimethyl benzyl ammonium chlorides, abbreviated as ADBAC, the active ingredient in Formula 409®. Formula 409® was selected to test against whirling disease and New Zealand mudsnails because it was thought to be easy to obtain for anglers, but this household product is not practical for land management use. However, ADBAC, along with other quaternary ammonium compounds, also occurs in Quat 128®, Sparquat 256®, Bioguard Algicide®, and other commercial disinfectants.

Another quaternary ammonium compound, didecyl dimethyl ammonium chloride, or DDAC, was tested against chytrid fungus and found to be effective (see below). DDAC also occurs in Quat 128®, Sparquat 256®, and Bioguard Algicide®.

Whirling disease and quaternary ammonium compounds

The effectiveness of quaternary ammonium compounds against whirling disease spores is based on research (in review) by Ronald Hedrick of University of California-Davis. He tested the active ingredient in Formula 409® (ADBAC), and found it to efficiently kill spores in 10 minutes at a concentration of 1500 ppm. The commercial quaternary ammonium products recommended in this guidance contain ADBAC as well as other quaternary compounds which may be quite good at killing spores but that have not been tested. Hedrick (pers. comm.) assumes that the other compounds would function similarly with respect to damaging the spores and thus provide an additive effect in a mixed formulation such as Quat 128®, but because his testing was limited specifically to ADBAC, there is currently no proof that the other compounds would have the same effects as ADBAC. *Consequently, two concentrations of quaternary ammonium products are given in this guidance for whirling disease.* One ("low risk") is conservative and based only on the amount of ADBAC in the product. The other concentration ("unknown level of risk"), which is less than half the concentration of the first, assumes that all the quaternary ammonium compounds in Quat 128® or Sparquat 256® are equally effective; however, this assumption has not yet been tested.

Chytrid fungus and quaternary ammonium compounds

The quaternary ammonium compound used as the active ingredient against chytrid fungus was a different one than was tested for whirling disease. For chytrid, Johnson et al. (2003) used DDAC. Both DDAC and the compound tested for whirling disease and New Zealand mudsnails, ADBAC, occur together in Quat 128® and Sparquat 256® (Sparquat has some other quat compounds as well). Consequently, the technical information and calculations for chytrid fungus are derived from DDAC and are shown separately on the spreadsheet.

Using swimming pool algicides in place of Quat 128® or Sparquat 256®

Swimming pool chemicals used to kill algae and that have the proper quaternary ammonium compounds as their active ingredients may be substituted for Quat or Sparquat at almost HALF the cost. One example of a pool chemical is BioGuard Algicide28-40® , which is 40% ADBAC, the same active ingredient found in Quat and Sparquat but at a much higher concentration. Dilution formulas for BioGuard Algicide28-40® are calculated for you on the accompanying Excel spreadsheet. If you are looking at other brands of quaternary ammonium products and want to calculate concentrations, type in the % of the active ingredient in the yellow cell under Bioguard, and the spreadsheet will automatically recalculate the dilutions and costs. Bioguard

products (BioLab Inc) are available from local pool vendors and are listed at http://www.bioguard.com/msds.cfm

As the concentration of ADBAC increases, so do the occupational health and safety hazards (irreversible eye damage, skin burns, respiratory irritation) and importance of adhering to personal protective equipment requirements when handling the concentrated product. Check the MSDS's:

Quat 128®: http://online.waxie.com/Attachments/attachments/files/pdfs/msds/170304.pdf
Sparquat 256®: http://www.spartanchemical.com/web/webhome.nsf

APPENDIX C

Use this format to request a temporary emergency waiver from Arizona Department of Environmental Quality in the event that used decontamination solution is discharged over open land. Please attach the appropriate MSDS from the link on page 26.

Field Cod

Agency/Fire #

Date, Year

Ms. Carrolette Winstead
Arizona Department of Environmental Quality
1110 West Washington Street, Mailcode 5415B-3
Phoenix, Arizona 85007

Dear Ms. Winstead:

We are requesting that Arizona Department of Environmental Quality's Water Quality Division grant a Temporary Emergency Waiver for the purpose of discharging water used in decontaminating fire-fighting equipment to prevent cross-contamination of water bodies within the State of Arizona. Decontamination is accomplished using a 5% solution of quaternary ammonium compound (Quat128® or Sparquat 256®) and water in engines, pumps, or other equipment that has been wetted by any raw (non-domestic or treated) water during fire operations. The solution is re-used until testing indicates it is muddied or diluted. Used cleaning solution is disposed of over open land where there is no potential for runoff into stormdrains, waterways, or sensitive habitats.

(Fill in information in italics, below)

- The discharge occurred during management of the *(Name)* Fire during the period *(date or dates of discharge)*, located in an area *(describe general area using roadways, communities, or landmarks)*. The approximate location of the discharge is *(UTM coordinates or legal description)*.

- The discharge consisted of approximately *(volume)* gallons of water from *(water body or other source)* containing approximately 5% *(identify either Quat128® or Sparquat 256®)*.

- The discharge did not occur in or near a water of the U.S., or in an area where runoff could occur into stormdrains or waterways. *(This is essential. If runoff into a water body is unavoidable, do not dispose of solution in the area and truck to a municipal treatment plant.)*

- The Material Safety Data Sheet for the compound discharged is enclosed.

If you have any questions, please contact *(Name)* at *(Phone)*. Thank you for your assistance.

Sincerely,

(Agency Administrator)
(Title)

Enclosure (MSDS)

cc: Assistant Field Supervisor, Fish and Wildlife Service, Flagstaff, AZ (email: brenda_smith@fws.gov)
(Your agency FMO)
(Others?)