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July 2, 2009

MEMORANDUM

TO: Council members

FROM: Jim Ruff -- Manager, Mainstem Passage and River Operations

SUBJECT: Presentation on U.S. Bureau of Reclamation's experience with invasive mussels in the West

Background

Quagga mussels (*Dreissena bugensis*) were first detected in the western United States at Lake Mead in January 2007. Within two years, this destructive aquatic invasive species has spread into the states of Nevada, California, Arizona, Utah and Colorado. These western states now face implementing multimillion-dollar control and mitigation programs to protect their water systems, irrigation and hydropower infrastructure. Moreover, these invasive mussels, which can be unknowingly spread by contaminated recreational watercraft, are getting closer and closer to Columbia basin waters. Currently, only eight states in the western U.S. do not have either species of *Dreissena* mussels (zebras or quaggas), including the four Pacific Northwest states.

The State of Idaho has stated that, should invasive mussels enter Idaho waters, the adverse impacts would be extreme -- affecting drinking water, irrigation, hydropower and recreational pursuits such as fishing and boating. Idaho has estimated recently that to try to control these mussels, should they become established in state waters, would cost the state roughly \$100 million annually.

In addition, the Corps of Engineers (the Corps) has estimated recently that, should invasive mussels become established in Lake Tahoe, Nevada, it could cost that area's tourism-dependent economy more than \$22 million per year. Similarly, a 2005 report by the Pacific States Marine Fisheries Commission (PSMFC) found the cost for installing invasive mussel control systems at mainstem Columbia-Snake river hydroelectric projects could range from the hundreds of thousands of dollars to over a million dollars per facility. That report estimated the cost for a hypothetical *Dreissena* mussel mitigation strategy, based on two response scenarios (a sodium

hypochlorite¹ injection system and use of anti-fouling paint), at 13 selected federal hydropower projects in the Columbia Basin would be over \$23.6 million.

Council Meeting Presentation

Mr. Fred Nibling, Jr. is a research botanist in the Ecological Research and Investigations Group of the Technical Service Center for the U.S. Bureau of Reclamation in Denver. He will present the latest information to the Council about the Bureau's experiences in controlling zebra/quagga mussels in the West, and in particular, the Colorado River (at Hoover Dam and Lake Mead). His main talking points will address mussel impacts and threats (to hydropower facilities, fish screens and irrigation intakes); ongoing research and development efforts to control invasive mussels; boat inspections; and the costs of these efforts.

There is considerable regional interest in this presentation. I expect representatives from the federal action agencies, NOAA, USFWS, the states, regional utilities and utility groups, and aquatic nuisance coordinators to be in attendance to hear this discussion.

¹ The use of sodium hypochlorite as a tool to control invasive mussels at mainstem Columbia-Snake river hydropower dams could be problematic due to the expense for the chlorine and buffering system as well as the environmental scoping that would need to be undertaken as required by NEPA and the Endangered Species Act protections and requirements for listed salmonids.

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Managing Water in the West

Invasive Mussels in Reclamation Water Systems



Zebra Mussel

Quagga Mussel



U.S. Department of the Interior
Bureau of Reclamation

Zebra vs. Quagga

Dreissena polymorpha

(Zebra mussel)

(Actual size = 15 mm)



Sits flat on ventral side

Triangular in shape

Color patterns vary

Dreissena rostriformis bugensis

(Quagga mussel)

(Actual size = 20 mm)



Will not sit flat on ventral side, topples over

Rounded in shape

Dark concentric rings on shell

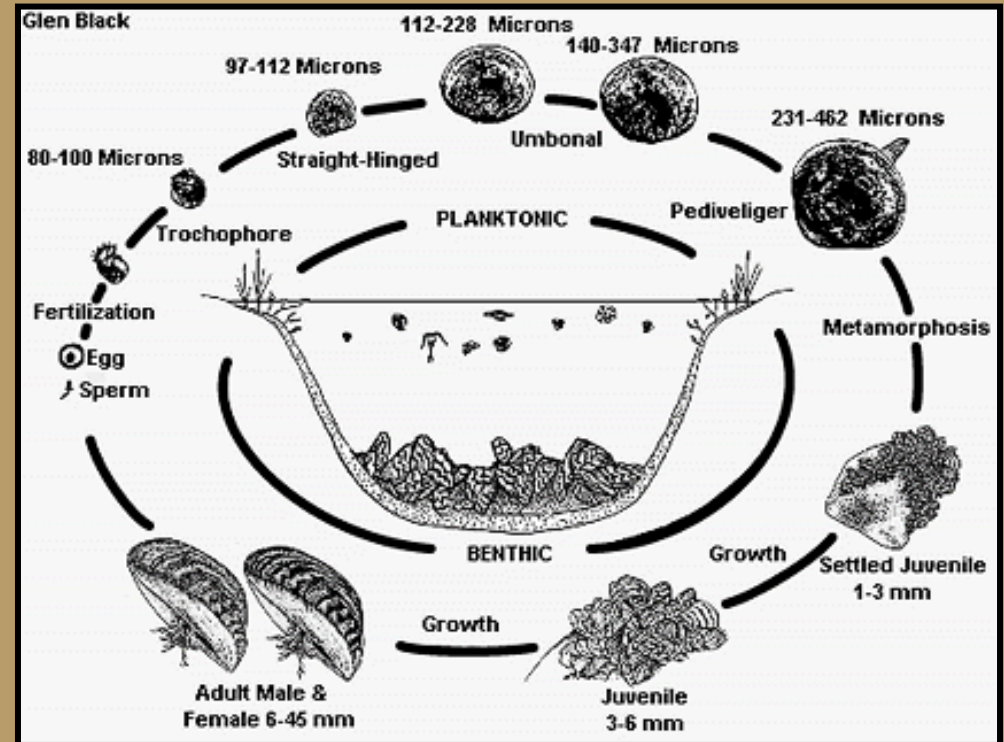
Paler in color near the hinge

U.S. Geological Survey

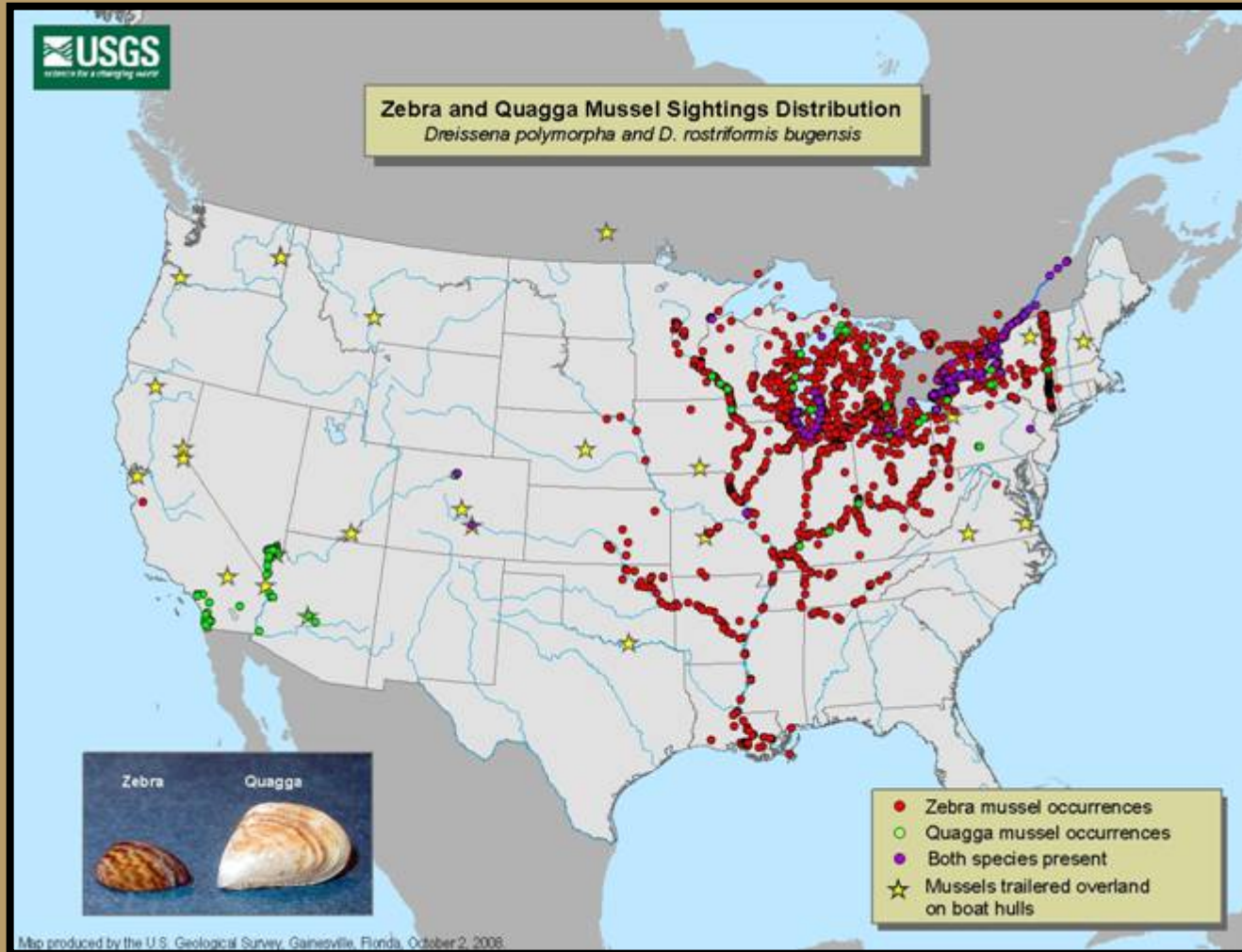
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Why are They Problem Species?

- Non-native
- Broad environmental tolerances
- Reproduction
 - Early sexual maturity
 - High fecundity (30 thousand eggs/cycle)
 - Good dispersal mechanism
- Epifaunal mode of life



Current Distribution – Oct. 2008



How Do They Spread?

- **Adults Attached to Movable Surfaces**
 - Boat Hulls
 - Dirty Anchors, etc
 - Aquatic Plants
- **Being Carried by Water Currents**
 - Natural Water Courses
 - Man-made Conveyances



Cleaning Quagga mussels on Houseboat
Lake Mead – Mar. 2009

How Do They Spread?

- **Attached to Movable Surfaces**
 - Boat Hulls
 - Dirty Anchors, etc
 - Aquatic Plants
- **Larvae Being Carried by Water Currents**
 - Natural Water Courses
 - Man-made Conveyances



200 μm

Velum

Davis Dam Spillway Gate



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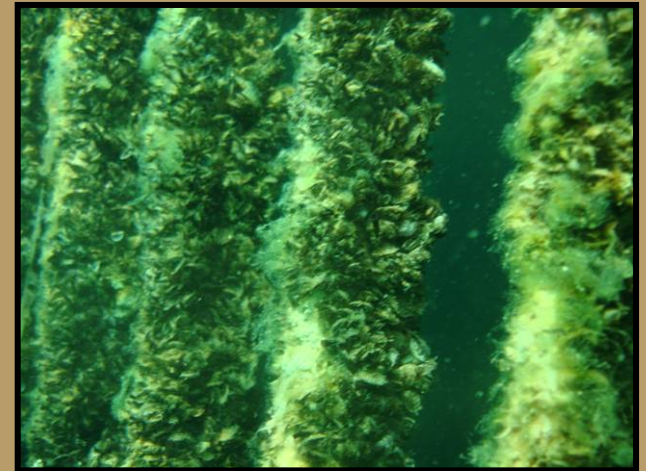
What Forms of Problems Are Caused?

- **Flow restriction**
 - Roughening (Friction loss)
 - Blockage
- **Chemical degradation**
- **Mechanical Damage**
 - Abrasion
 - Lifting coatings when removed
- **Biological/Environmental**
 - Food chain
 - Habitat damage
 - Water quality
 - Water resource industry
 - Toxic accumulations



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Intake Trashracks – Davis Dam



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Trashracks – Hoover Dam



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Penstocks – Hoover Dam



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Dead Mussel Debris in Cooler Unit – Ontario Hydro



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What Forms of Problems Are Caused?

- Flow restriction
 - Roughening (Friction loss)
 - Blockage
- Chemical degradation
- Mechanical Damage
 - Abrasion
 - Lifting coatings when cleaned
- Biological/Environmental
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 - Water quality
 - Fish passage and protection
 - Toxic accumulations



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Substrate Preference

Least preferred (top) to more preferred (bottom)

- Copper
- Galvanized Iron
- Aluminum
- Acrylic
- PVC
- Teflon
- Vinyl
- Black Steel
- Polypropylene
- Asbestos
- Stainless Steel
- Concrete



Kerr Lock and Dam (COE),
Tulsa OK

Source - Kilgour and Mackie, 1993

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Control Methods Available

Source: ZM Control Handbook - Corps of Engineers

- **Preventive**

- Repellents (Antifouling, Foul-release, and Thermal Spray Coatings)
- Thermal Treatments
- Mechanical Filtration

- **Reactive**

- Mechanical Cleaning
- High-pressure Water Jet Cleaning
- Carbon Dioxide Pellet Blast Cleaning
- Freezing/Desiccation (Thermal)
- Backwash of Water Supply Piping
- Biocides

(continued on next slide)



Control Methods, cont'd

Source: ZM Control Handbook - Corps of Engineers

- **Redesign**
 - Water intake retrofit
 - Infiltration intakes
 - Acoustics
 - Electric Fields
 - Ultraviolet (UV) Light



BSF - 40 MICRON SELF CLEANING FILTER

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Self Cleaning Filter at Parker Dam Power Plant



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Evaluating Coatings to Prevent Mussel Attachment

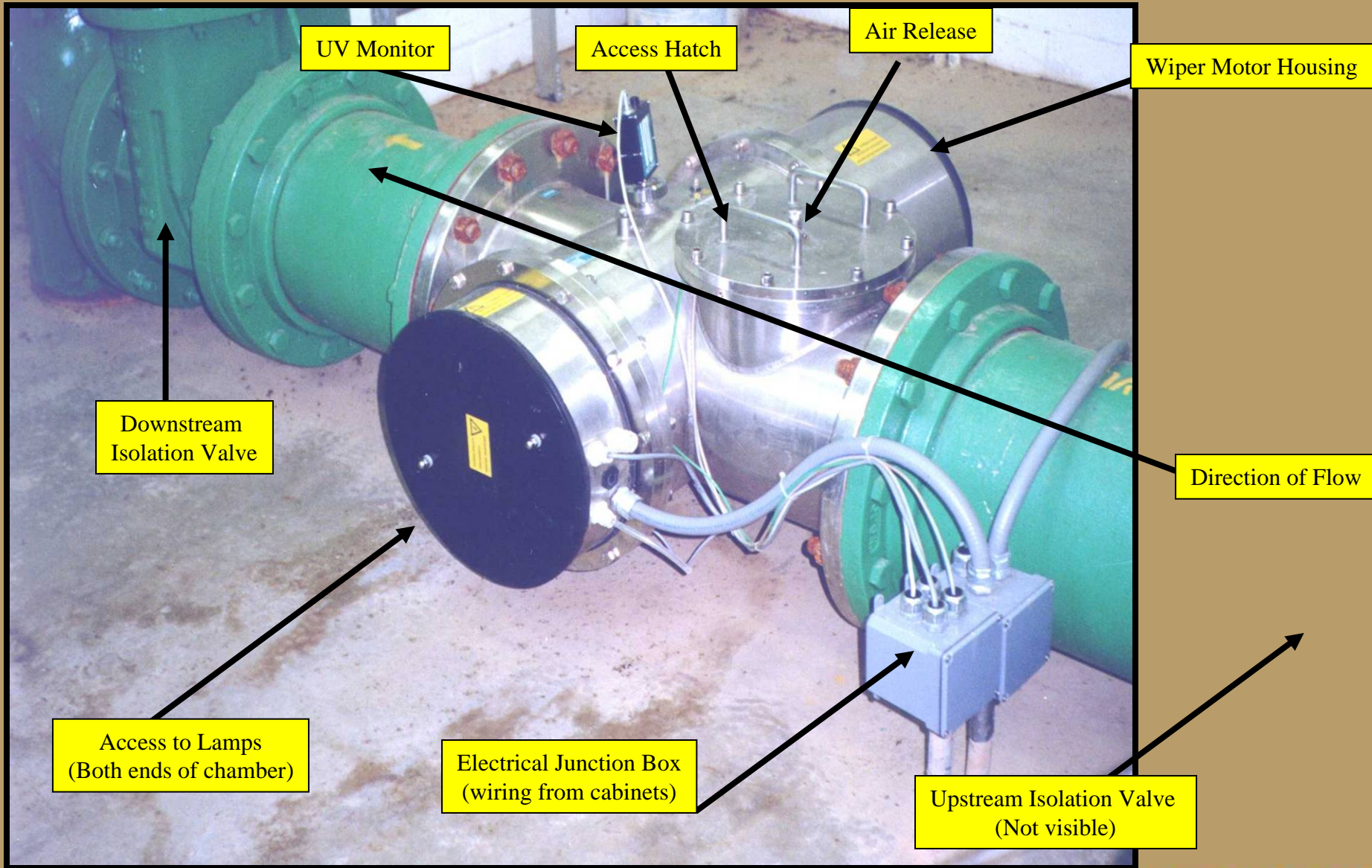


Untreated after 7 months

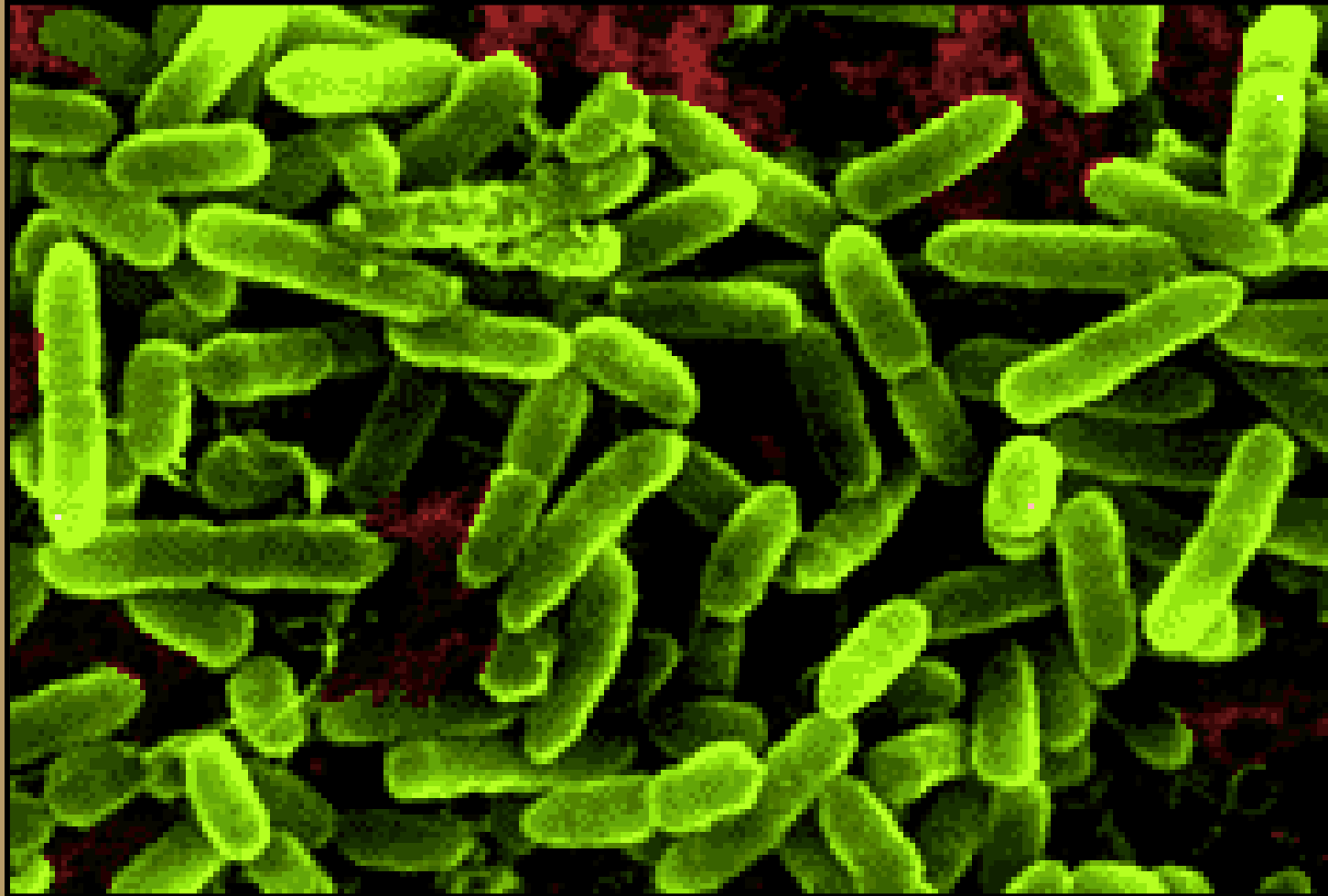


Nontoxic Foul Release Coated

In Line Pipeline UV Installation



Emerging Options – *Pseudomonas fluorescens*



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Emerging Options

- Bacterial product (Developed at NY State Museum and commercially developed by Marrone Organic Innovations), zebra mussel specific chemical....being tested on Quagga now
- How does it work?

The bacteria produce natural compounds that kill the mussels when ingested. It destroys the mussels' digestive system.



New York State Museum



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Water Jetting Equipment



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Pressure Wash - Domestic Water Pipe at Davis Dam

Before



After



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Impacted Systems

(Source ACOE – ZMIS)

Piping	Circulating water systems	Service water systems
Traveling screens	Once through	Pumps
Water towers	Pumps	Piping
Trash racks	Piping	Raw water makeup
Trash bars	Condenser water boxes	Heat exchangers
Forebays	Condenser tubes	Emergency systems
Holding ponds	Fire protection systems	Area coolers
Storage tanks	Main pumps	Seal water systems
Wet wells	Jockey pumps	Strainers
Pump wells	Submerged pumps	Drag valves
Pump suction chambers	Intake structures	Makeup demineralizers
Lift pumps	Intake screens	Circulation systems
Pump bell housings	Intake tunnels	Emergency water systems
Screen wash systems		

Special Considerations



Instrumentation



Fish Protection Facilities, PNR

Animas-La Plata Fish Screen



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Evaluating Mussel Fouling Potential of Cu-Ni Fish Screen Material (4 mo)



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Conclusions

- **Western watersystems differ from eastern:**
 - **Long, continuously managed reaches of flowing water**
 - **Systems designed for water dispersal**
- **Structures often lack designs and management plans to contend with quaggas and zebras**
- **New issues and problems are apparent requiring new management techniques**



Questions?



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