Treatment Technologies and Management Techniques to Limit Exposures to Selenium

November 2004

Overview of Presentation

- **Potential selenium risk issues were discussed at September 8 Advisory Committee meeting**
- **May be a need to treat or manage selenium under some of the alternatives**
- **This presentation describes a variety of treatment technologies and bird management techniques to reduce selenium exposure**

Treatment Technologies

- **Physical (Engineering)**
  - Reverse Osmosis
  - Nanofiltration
  - Evaporation
- **Biological**
  - Anaerobic Bacterial Removal
  - Algal Bacterial Removal
  - Agroforestry
  - Constructed Wetlands
- **Chemical**
  - Ferrous Hydroxide

Reverse Osmosis

- **Description**
  - Water is forced through a membrane against a concentration gradient, separating constituents like selenium out of the water
- **Application**
  - Salton Sea water or drainage water
- **Cost**
  - $185 to $568 per acre-foot of treated water

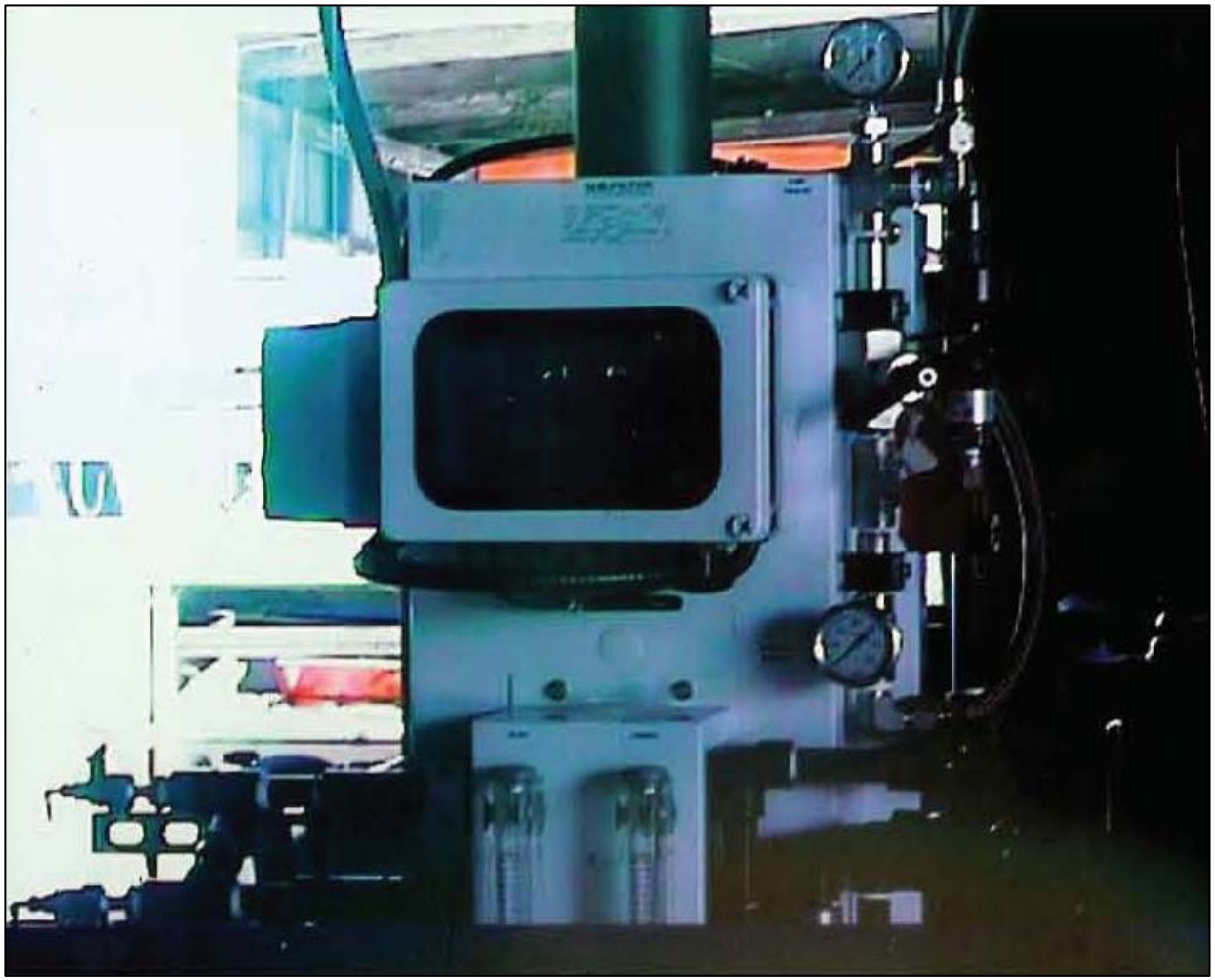
Reverse Osmosis

PROS	CONS
Produces high quality treated water	Requires pretreatment
Demonstrated technology; used in large scale desalination projects	High energy costs
	Brine waste (5-20% of treated volume)
	Filter clogging

Nanofiltration

- **Description**
  - Membrane filters are used to separate different fluids or ions
- **Application**
  - Salton Sea water or drainage water
- **Cost**
  - $~600 to $1,000 per acre-foot of treated water (includes amortized construction and O&M costs)

Nanofiltration Unit



Source: Imperial Valley Drainwater Reclamation and Reuse Study, 2002
US Bureau of Reclamation

Nanofiltration

PROS

- **Up to 95% removal of Selenium from drainage waters in SJV**
- **Demonstrated effectiveness in pilot scale plants for Imperial Valley**
- **Higher water recoveries, lower pressure, less pretreatment, more cost efficient that Reverse Osmosis**

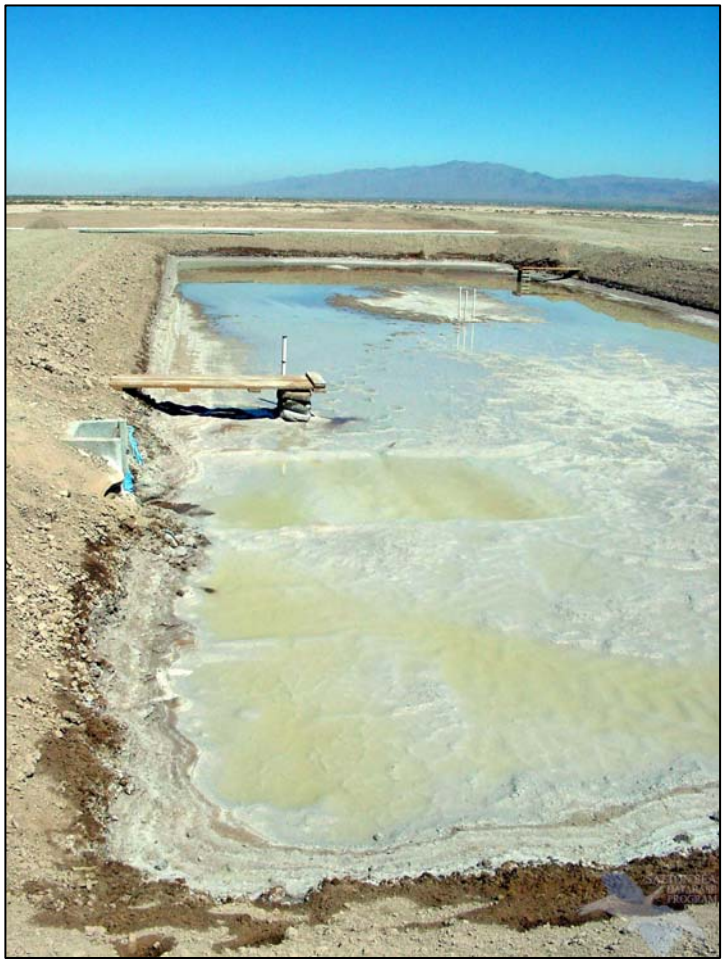
CONS

- **Expensive technology**
- **Brine waste disposal required**
- **Does not remove all small molecules, e.g., NaCl**

Evaporation Ponds

- **Description**
  - Water is diverted to ponds, where solar energy is used to evaporate water and precipitate out salts, including Selenium
- **Application**
  - Salton Sea water or drainage water
- **Cost**
  - $630 per acre-foot of treated water (+2.8M/yr for O&M at SJV facility)

Evaporation Ponds



(Photo: Salton Sea Authority website, 2004)

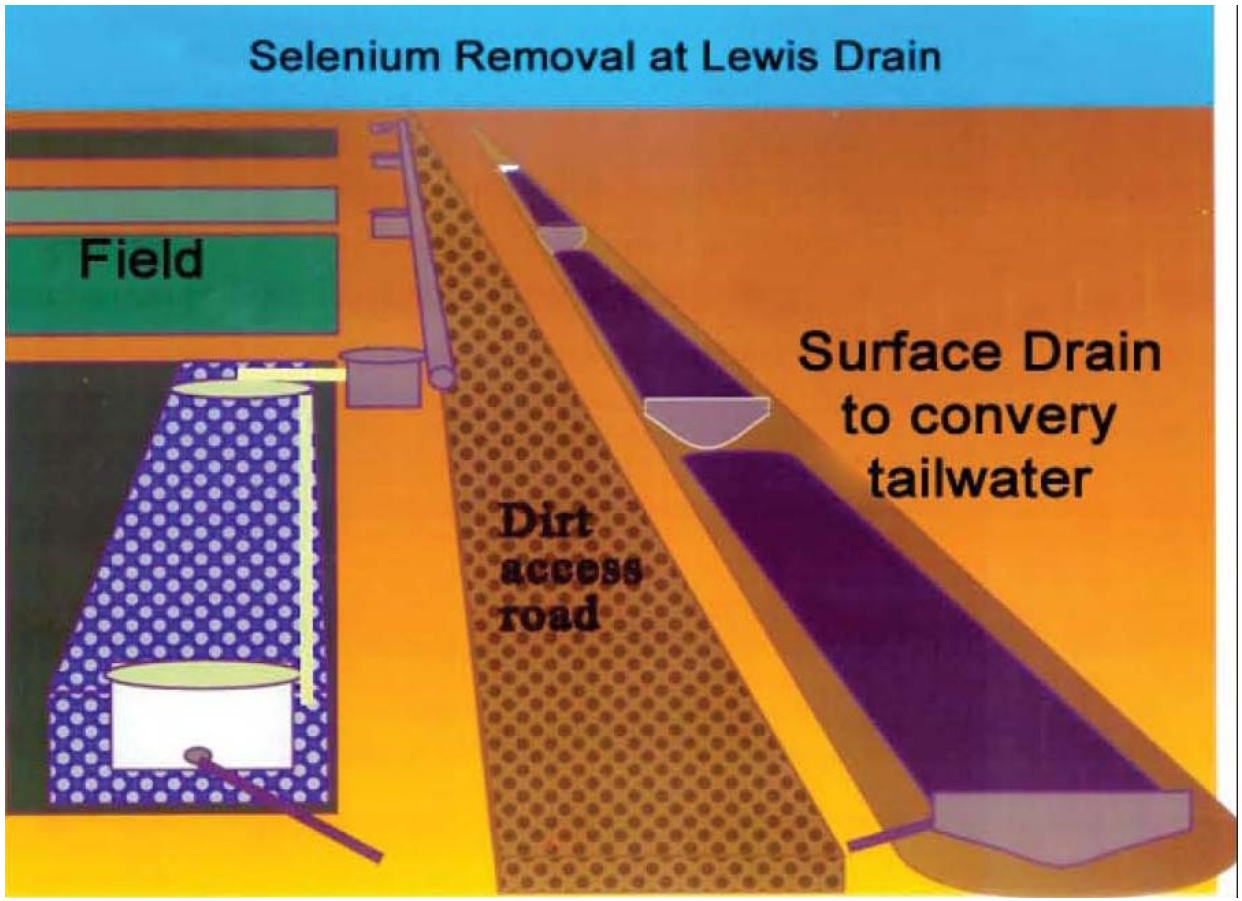
Evaporation Ponds

PROS	CONS
◆ Hot and dry conditions of Salton Sea favor evaporation	◆ Potential groundwater contamination and wildlife exposures
◆ Evaporation rates can be accelerated with enhanced evaporation systems (EES)	◆ Reduces water flow into Salton Sea
	◆ Land requirements
	◆ Requires brine/waste disposal

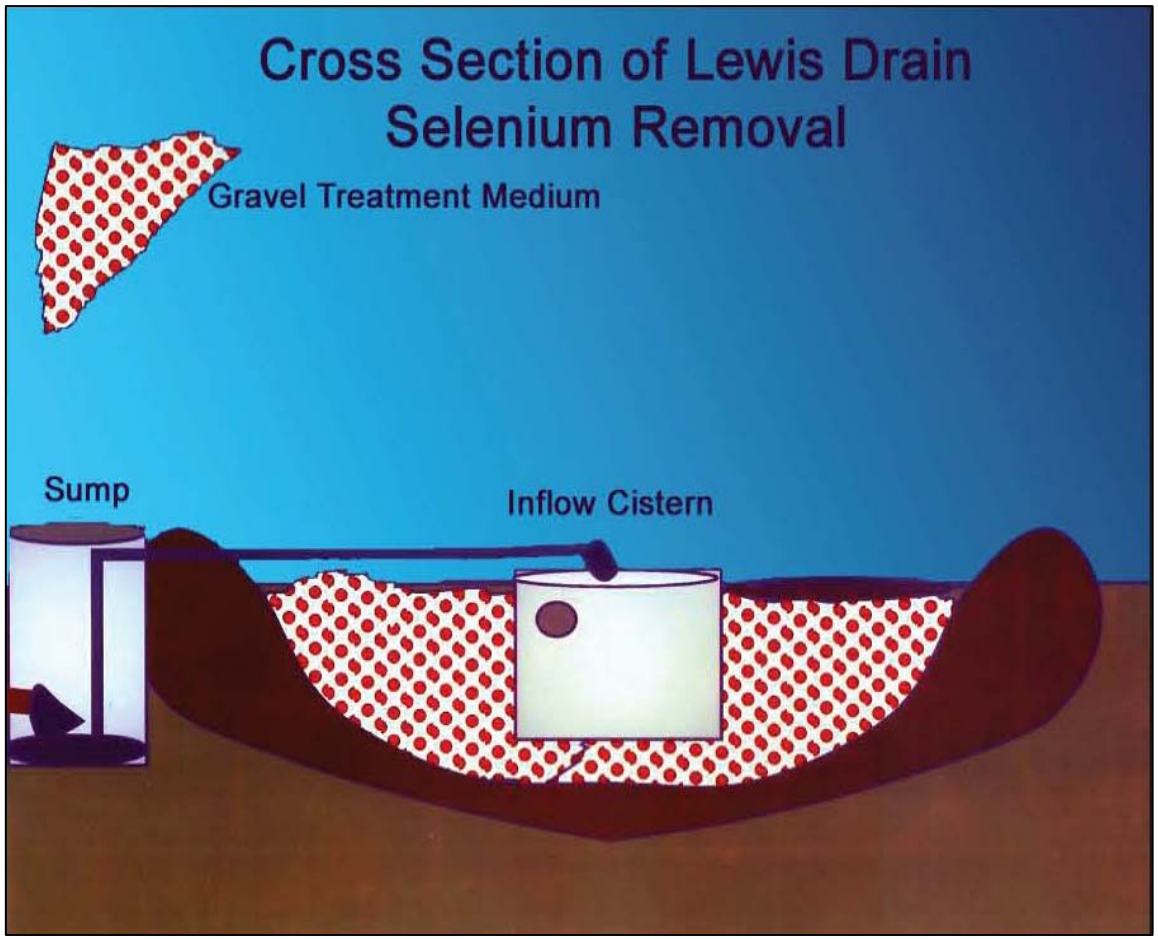
Anaerobic Bacterial Removal

- **Description**
  - Water is diverted to lagoons that support anaerobic bacteria which remove Selenium from treated waters
- **Application**
  - Inflow and drainage waters
- **Cost**
  - $~200 to $500 per acre-foot of treated water (includes capital and O&M costs)

Bacterial Removal



Bacterial Removal



Anaerobic Bacterial Removal

PROS	CONS
Pilot scale facilities at Murietta Farms reduced Selenium concentrations by one order of magnitude	**Requires land for treatment lagoons**
Bacterial cultures can be optimized for site-specific conditions	**Exposure risks to wildlife**
	Biological sludge will require removal and disposal

Algal-Bacterial Removal

- **Description**
  - Similar to anaerobic bacterial technology except that algae are added to provide an additional carbon source and increase Selenium removal efficiency
- **Application**
  - Inflow and Salton Sea waters
- **Cost**
  - $104 to $272 per acre-foot of treated water

Algal Ponds

Source: Imperial Valley Drainwater Reclamation and Reuse Study, 2002
US Bureau of Reclamation

Algal-Bacterial Selenium Removal

PROS

- **Pilot scale facilities in Mendota reduced Selenium concentrations by more than one order of magnitude, and another pilot study in the Panoche WD achieved Selenium removal rates of 40-80%**
- **Bench-scale and pilot studies of controlled eutrophication process at Salton Sea use algal flocculation to remove Selenium**

CONS

- **While the Panoche ABSR system reduced total Selenium, treatment increased concentrations of bioavailable forms in effluent**
- **Requires land for treatment lagoons**
- **Exposure risks to wildlife**
- **Biological sludge will require removal and disposal**

Agroforestry

- **Description**
  - Managed cropping that re-uses agricultural drainage water in a sequence utilizing uptake capabilities of salt tolerant crops; salts and selenium are taken up by tolerant plants and concentrated at the end of the crop sequence
- **Application**
  - Inflows and Salton Sea waters
- **Cost**
  - $150 per acre-foot of treated water

Agroforestry

PROS

- **Can use drainage water to produce marketable crops.**
- **Could possibly enhance Selenium removal through volatilization**

CONS

- **Large land requirements for crop lands**
- **Need market for salt tolerant crops**
- **Exposure risks to wildlife**
- **Potential for localized groundwater degradation**
- **No existing information on effectiveness for Selenium removal**

Constructed Wetlands

- **Description**
  - Flow-through wetlands promote formation of insoluble forms of Selenium that are deposited in sediments and/or volatilized by plants
- **Application**
  - Inflow waters
- **Cost**
  - $~50 - $330 per acre-foot of treated water (straw bale amendment adds $80 per acre-foot)

Constructed Wetlands

Source: New River Wetlands Project
http://www.newriverwetlands.com

Constructed Wetlands

PROS

- **Bench-scale systems have indicated high Selenium removal**
- **Addition of straw bales to flow-through system support growth of selenium reducing bacteria**

CONS

- **Efficiency of Selenium removal in treatment scale facilities difficult to measure**
- **Land requirements**
- **Treatment efficiency suboptimal when temperatures <15°C**
- **Potential risks to wildlife**

Ferrous Hydroxide

- **Description**
  - Waters are diverted to a lagoon system and ferrous hydroxide is added to precipitate reduced forms of Selenium from water
- **Application**
  - Inflow or Salton Sea waters
- **Cost**
  - $270 per acre-foot of treated water

Ferrous Hydroxide

PROS	CONS
◆ Pilot study at Murietta Farms achieved 90% reduction in selenate concentration	◆ Requires lime addition to raise pH to 9
◆ Technology can represent a beneficial and cost-effective final polishing step following microbial treatment	◆ Requires pretreatment to optimize Selenium removal potential
	◆ Requires disposal of precipitate

Wildlife Management

- **Physical Barriers**
- **Deterrent Devices**
- **Pyrotechnic Dispersal**

Conclusions

- **If selenium treatment is needed under an alternative, there are a variety of treatment technologies and management techniques that could perhaps be considered**
- **Costs will vary depending upon water quality constituents and sizes for each alternative**
- **Experience with most full-scale treatment technologies is limited**