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ENVIRONMENTAL CONTAMINANTS PROGRAM
OFF-REFUGE INVESTIGATIONS SUB-ACTIVITY

INTERIM REPORT
NV - Assessment of Wildlife Hazards Associated With Mine Pit Lakes

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by

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INTRODUCTION

Background and Justification

Several open pit mines in Nevada and other western states lower groundwater, typically by aggressive pumping, to mine ore below the water table (Miller et al. 1996). After mining, the remaining pits partially fill with groundwater to form pit lakes. In the foreseeable future, more than 35 such pit lakes will exist in Nevada. Sizes of the pit lakes will vary from less than one acre to more than 900 acres. Water quality in the pit lakes is, or will be, affected by the quality of inflowing ground water, outflow of groundwater, atmospheric precipitation, sulfide oxidation in surrounding rock, dissolution of metals, precipitation of metals, and evaporative concentration. In many cases, water contained in pits is, or is expected to be, of poor quality and may contain concentrations of metals or other inorganic constituents that greatly exceed water quality standards and published wildlife effect levels. For example, pit lake water in Nevada has been found to contain mercury at concentrations exceeding 80 µg/L and selenium exceeding 120 µg/L. The current mercury standard for protection of aquatic life is 0.012 µg/L. Mercury also strongly accumulates and magnifies in biological systems and low concentrations in water may be concentrated to hazardous levels in higher trophic levels (Zillioux et al. 1993). Waterborne selenium concentrations $\geq$ 2 Fg/L are considered hazardous to the health and long-term survival of fish and wildlife (Lemly 1996) with water with more than 20 Fg/L considered hazardous to aquatic birds (Skorupa and Ohlendorf 1991). Geochemical modeling efforts to predict water quality at some future pit lakes have predicted long-term degradation of pit lake water quality. In some cases, water quality continued to deteriorate for the time period that the model was run (as long as 300 years).

Wildlife use and the degree of threat presented by inorganic contaminants in pit lakes is uncertain. It is assumed that riparian and aquatic communities will become established in most pit lakes. However, the nature of these communities is questionable. Water contained in mine pits may be nutrient-poor or may contain elevated concentrations of contaminants which may restrict productivity. Mine pit lakes will typically be deep and steep sided, thereby limiting riparian and shallow lentic habitat. However, benches and ramps in the mine pit, along with erosion of pit walls, may provide limited areas where shallow lentic or riparian communities may become established. Similarly, wildlife use and fish introductions over the long-term are uncertain. Wildlife using pit lakes may be exposed to hazardous levels of environmental contaminants. In an extreme case (Berkeley Pit near Butte, Montana), a large-scale avian die-off has been attributed to poor quality pit lake water. In this incident, the death of 342 snow geese was attributed to acute metal toxicosis and sulfuric acid exposure resulting from exposure to, and consumption of poor quality pit water (Hagler Bailly Consulting, Inc. 1996). Under less extreme conditions, exposure to inorganic contaminants may occur through exposure to water and consumption of contaminated foods from the pit lake. In the latter, bioaccumulation and biomagnification become important factors affecting contaminant uptake.

In 1997, the University of Nevada, Reno was awarded a 3-year, $968,000 Partnership for Environmental Research Grant from the National Science Foundation and the Environmental Protection Agency to assess geochemical, biological, and economic effects of arsenic and other oxyanions on a mining impacted watershed in Nevada. Much of this work focuses on mine pit lakes. Research authorized under this grant will provide a sound science on which to base long-term policy decisions. However, biological research authorized under this grant is limited to genotoxic and developmental responses of aquatic organisms exposed to pit water. Additional information is needed to better understand potential long-term risk to migratory birds and resident wildlife by poor-quality mine pit lakes.

In 1998, the Nevada Fish and Wildlife Office formed a team consisting of representatives from the Nevada Division of Wildlife, Nevada Division of Environmental Protection, the Bureau of Land Management, U.S. Forest Service, U.S. Geological Survey, and the Environmental Protection Agency to identify biological concerns and information needs associated with mine pit lakes. This proposed investigation is an outcome of this Interagency Team. The proposed investigation would expand research activities of the University of Nevada, Reno, to ensure that migratory birds and resident wildlife are considered during long-term policy formulation. This proposed investigation would include two phases. Activities during the first phase (fiscal year 2000) would include characterization of physical and biological conditions, wildlife use, and contaminant partitioning in environmental compartments in existing pit lakes in Nevada. If it is determined during the first phase of the investigation that pit lakes provide suitable wildlife habitats and food resources, the second phase of the investigation would directly assess contaminant uptake and biological effects at one representative pit lake. To accomplish this task, captive waterfowl and fish would be introduced to the pit lake.

Scientific Objectives

Currently, little is known about biological or chemical characteristics of mine pit lakes. As a result, the ultimate hazards of these lakes are poorly understood. The first phase of this investigation would provide information on habitat and community development, habitat quality, wildlife use, and inorganic contaminant behavior and partitioning, and the potential for wildlife exposure to contaminants in mine pit lakes. The second phase of the investigation, if pursued, would directly assess the effects of contaminants in a mine pit lake to fish and wildlife.

METHODS

Data Collection and Analysis

The study will include two phases. The objectives in the first phase will be to characterize biological attributes of pit lakes and potential wildlife exposure to inorganic contaminants in existing pit lakes in Nevada. The objective of the second phase of the study will be to evaluate contaminant exposure to, uptake by, and effects to captive fish and birds introduced to a representative pit lake.

Phase One - Biological Characteristics of Mine Pit Lakes

Biological characteristics will be assessed twice (Fall and Spring) at three selected pit lakes. Parameters to be monitored include: 1) Concentrations of major and trace constituents in water;

2) limnological characteristics of mine pit lakes; 3) aquatic vegetation and invertebrate occurrence and relative abundance; 4) riparian vegetation occurrence and relative abundance; 5) migratory bird and resident wildlife use; and 6) metal and trace element concentrations in aquatic organisms and wildlife using pit lakes.

Chemical characteristics of water will be obtained from pit water monitoring required by the Nevada Division of Environmental Protection. Quarterly visits to pit lakes will be coordinated with collection of water quality samples for required monitoring. During each visit, vertical profiles of temperature, dissolved oxygen, pH, specific conductance, and salinity will be assessed. These parameters will be measured at 5 m intervals at three locations in each of the three lakes.

Aquatic plant and invertebrate occurrence and relative abundance in each pit lake will be assessed during each visit. In each pit lake, five shallow (<10m) and five deep water sites (>10 m) will be selected at random. Deep water sites will be sampled with five 10-m vertical tows of a plankton net and a 12-hour set (overnight) of an invertebrate light trap. Shallow sites will be sampled using similar effort with plankton nets and invertebrate light traps. Additionally, three artificial substrate samplers will be placed at each of the shallow water sites to assess periphyton and invertebrate colonization. Artificial substrate samplers will be constructed and processed as specified in American Public Health Association (1985). Artificial substrate samplers will be placed in the water at least six weeks prior to the initial quarterly sampling period and will be removed and replaced at consecutive quarterly sampling periods. Invertebrates collected for community assessment will be preserved in 40% ethanol, and identified to a family level and enumerated in the laboratory at a later date. Phytoplankton occurring in plankton samples will be quantified. Additionally, floating vegetation (i.e., algae) or rooted emergent or submergent vegetation will be noted.

Species composition and relative abundance of vegetation occurring around the lake perimeter at each of the three lakes will be noted. Migratory bird and resident wildlife use will be determined through systematic observation over a one and one-half day period (including at least 2 sunrise or sunset periods) during each visit. Animal tracks and other signs around pit lakes will be noted. The use of sonic detectors to assess bat occurrence and use of pit lakes will be investigated.

To assess potential wildlife exposure to inorganic contaminants, three samples each of aquatic vegetation (or algae if submergent vegetation is not available) and aquatic invertebrates will be collected from each pit lake during the fall sampling period for analysis of metals (Table III.1). If sufficient vegetation and invertebrates are available, samples will be composites of 5 or more subsamples collected around each of the three lakes. Plant and invertebrate samples will include only representatives from one family. It is anticipated that similar invertebrates (hemipteran) will be available at all three pit lakes. Aquatic vegetation will be collected by gloved hand. Invertebrate and vegetation samples will be placed in 60 ml acid-washed glass containers, stored on ice in the field, and frozen upon return to the laboratory. These samples will consist of a minimum of 15 grams of material. If available, up to five eggs and livers of aquatic or insectivorous birds nesting around each of the three pit lakes will be collected for metal and trace element residue analysis. To confirm on-site exposure, pre-flighted juvenile birds are preferred for liver samples. If juveniles are not available, adult birds will be taken. Birds will be collected with a shotgun using steel shot and livers will be removed using acid-rinsed stainless steel instruments.

Samples would be submitted to the Fish and Wildlife Service Patuxent Analytical Control Facility (PACF), Laurel, Maryland, and their contract laboratories. Analytical Quality Assurance/Quality Control procedures are given in PACF (1990). All gear used for contaminant sample collection would be thoroughly washed with an appropriate cleaner prior to use in each pit lake. All gear would be washed with site water and a brush between collection sites in each pit lake. The gear would then be rinsed with deionized water before each use.

Table.1. Number of samples for phase 1 of this proposed investigation.

Type of Samples	Number of Samples
vegetation	9
invertebrate	9
avian egg	15
avian liver	15
TOTAL	48

Phase Two - Inorganic Contaminant Exposure and Uptake

If it is determined during the first year of the investigation that pit lakes provide suitable wildlife habitats and food resources, the second year of the investigation will assess contaminant uptake and biological effects from one representative pit lake. To accomplish this task, waterfowl (captive mallards) and fish (hatchery stock centrarchids) will be introduced to the pit lake for a six-week period. Three samples each of water, aquatic vegetation, and aquatic invertebrates will be collected for metal scans at the start and end of the study period. Individual mallards will be wing-clipped, weighed, marked, and physical condition will be assessed prior to release. Fish will be weighed and measured prior to introduction to plastic mesh cages in the pit lake. Three waterfowl and fish will be sacrificed prior to release and at two-week intervals thereafter. If waterfowl had lost a significant percentage of their body weight at the end of the first two-week period, all remaining waterfowl will be collected immediately. Sacrificed waterfowl will be submitted to the Wildlife Health Research Center, Biological Resources Division, U.S. Geological Survey, for full necropsies, including histology of kidney, liver, and gonads. Stomach content will be examined to determine dietary habits. Samples of muscle and liver will be submitted for metal residue analysis (metal scans). Sacrificed fish will be submitted to the California-Nevada Fish Health Center for full necropsies, including histology of kidney, gill, and gonads. Fish will also be sacrificed for whole body metal residue analysis.

Table 2. Number of samples for phase 2 of this proposed investigation.

Type of Samples	Number of Samples
water	6

vegetation	6
invertebrate	6
fish tissues	12
avian tissues	24
TOTAL	48

Proposed Schedule of Milestones

The Interagency team will convene to select study pit lakes and coordinate field components of this investigation. Field work will be conducted in May and September, 2001. Samples will be submitted for chemical residue analysis within four weeks following field collections. A draft report of findings of the first year will be completed within 90 days from receipt of analytical results. A second year of field investigation will be pursued and the field component of the study will be initiated in July, 2001. Samples will be submitted for chemical analyses within 10 weeks following collection. A draft report of investigation findings will be completed within 90 days following receipt of chemical and necropsy results. A final report will be completed within 60 days following receipt of comments from report reviewers.

RESULTS

Results to Date

In FY 2000, the Service identified 18 existing pit lakes in Nevada. Water quality data was obtained for 12 of the existing lakes (Table A). Of the pit lakes for which data was available, four were slightly acidic to acidic. Water quality modeling predicted at least two of the pit lakes will not remain acidic over the long-term (David Gaskin, Nevada Division of Environmental Protection, pers. comm., 2000). All pit lakes for which water quality data was obtained contained at least one trace element at concentrations that are potentially toxic to aquatic life or wildlife. Aquatic life effect concentrations were exceeded for arsenic (0.04 mg/L; USEPA 1985), cadmium (0.001 mg/L; Hughes 1973), and chromium (0.021 mg/L; Birge et al. 1979) in two of the twelve pit lakes for which water quality data were available. Copper concentrations exceeded an aquatic life effect level (0.011 mg/L; Finlayson and Ashuckian 1979) in at least six pit lakes. Mercury was detected in four pit lakes. All concentrations exceeded aquatic life and wildlife effect concentrations (~0.00064 µg/L; Schwarzbach 1998). However, detection level used for mercury in the remaining pit lakes were greater than wildlife effect concentrations. Selenium exceeded a wildlife effect concentration (0.003 mg/L; Skorupa 1998) in six pit lakes. Zinc exceeded an aquatic life effect concentration (0.032 mg/L; USEPA 1987) in six pit lakes.

In FY 2000, the Service initiated a reconnaissance of pit lakes in May, 2000. After reconnaissance was complete, a total of five pit lakes were selected as having potential for wildlife use and sample collection of biota (Table 3.). Field data collection for FY2000 was initiated in May and completed by July, 2000. Water quality data was collected at each pit lake at 10 meter increments. Sample collections of biota were attempted at each pit lake. The total number of samples collected during this sampling period is summarized in Table 4 and will be submitted for analysis in August 2001.

Table 3. Summary of sampling conducted at pit lakes in FY2000 and number of samples collected.

Pit Lake	Limnological Characteristics	Major & Trace Elements in Water	Metal and Trace Elements in Biota	Aquatic Vegetation and Invertebrate Occurrence & Abundance	Riparian Vegetation Occurrence and Abundance	Migratory Bird and Resident Wildlife Use
Yerington	Y	Y*	Y	Y	Y	Y
Tuscarora	Y	Y*	Y	Y	Y	Y
Clipper	Y	Y*	NC	Y	Y	Y
Aurora	Y	Y*	NC	Y	Y	Y
Buena Vista	Y	Y*	NC	Y	Y	Y

Y= sample collected
NC= sample not collected
* = collected by NDEP

Table 4. Type and number of samples collected at pit lakes in FY2000.

Pit Lake	H20 measurement	Plankton	Aquatic Vegetation	Aquatic Invertebrates	Fish Tissue	Avian Egg
Yerington	Y	3	4	4	NC	3
Tuscarora	Y	NC	3	3	3	NC
Clipper	Y	NC	NC	1	NC	NC

Y= measurements collected
NC= sample not collected

Significant Changes to Previous Proposal

Changes that occurred in FY2000 from the previous proposal were minimal. The placement of artificial substrate samplers at each of the shallow water sites to assess periphyton and invertebrate colonization was eliminated from data collection activities. Samples of aquatic vegetation or algae and aquatic invertebrates were collected from two pit lakes instead of the proposed three due to lack of habitat and/or amount of biota required for a minimum sample size. Data previously uncollected in FY2000 will be attempted again in FY2001.

REFERENCES

American Public Health Association. 1985. Standard methods for the examination of water and wastewater. American Public Health Association, Washington, D.C., 1268 pp.

Birge, W.J., J.A. Black, A.G. Westerman, and J.E. Hudson. 1979. Aquatic toxicity tests on inorganic elements occurring in oil shale. Pages 519-534 in C. Gale (ed.). Oil Shale

Symposium: Sampling, Analysis, and Quality Assurance. U.S. Environmental Protection Agency Report 600/9-80-022.
Finlayson, B.J., and S.H. Ashuckian. 1979. Safe zinc and copper levels from the Spring Creek drainage for steelhead trout in the upper Sacramento River, California. California Fish and Game 65:80-99.
Hagler Bailly Consulting, Inc. 1996. Supplemental Injury Assessment Report: Clark Fork River NPL Sites NRDA; Lethal injuries to snow geese, Berkeley Pit, Butte, MT. Hagler Bailly Consulting, 34 pp. plus appendices.
Hughes, J.S. 1973. Acute toxicity of thirty chemicals to striped bass (Morone saxatilis): Proceedings of the Western Association of State Game and Fish Commissions, 53:399-413.
Lemly, A.D. 1996. Selenium in aquatic organisms. Pages 427-445 *in* W.N. Beyer, G.H. Heinz, and A.W. Redmon-Norwood (eds.). Environmental contaminants in wildlife: Interpreting tissue concentrations. Lewis Publishers, Boca Raton, Florida.
Miller, G.C., W.B. Lyons, and A. Davis. 1996. Understanding the water quality of pit lakes. Environmental Science and Technology/News 30:118-123.
Patuxent Analytical Control Facility. 1990. Reference Manual: U.S. Fish and Wildlife Service, Patuxent Analytical Control Facility, Laurel, Maryland.
Schwarzbach, S. 1998. Mercury. Pages 91-114 *in* National Irrigation Water Quality Program Information Report Number 3, 198 p. plus appendices.
Skorupa, J.P. 1998. Selenium. Pages 139-184 *in* National Irrigation Water Quality Program Information Report Number 3, 198 p. plus appendices.
Skorupa, J.P., and H.M. Ohlendorf. 1991. Contaminants in drainage water and avian risk thresholds. Pages 345-368 *in* A. Dinar and D. Zilberman (eds.). The economics and management of water and drainage in agriculture. Kluwer Academic Publishers.
U.S. Environmental Protection Agency. 1985. Ambient water quality criteria for arsenic - 1984. EPA 440/5-84-033.
_____. 1987. Ambient water quality criteria for zinc - 1987. EPA 440/5-87-003.
Zillioux, E.J., D.B. Porcella, and J.M. Benoit. 1993. Mercury cycling and effects in freshwater wetland ecosystems. Environ. Toxicol. Chem. 12:2245-2264.

Table A. Water quality data from existing mine pit lakes in Nevada, 1999-2000.

			concentration (mg/L)								
Name	County	pH	TDS	F	As	Cd	Cr	Cu	Hg	Se	Zn
Liberty Pit[1]	White Pine	3.2	6,240	18.5	<0.005	0.647	0107	37.1	<0.002	<0.005	280
Kimberly[1]	White Pine	7.6	3,580	3.0	<0.005	<0.005	0.059	0.061	<0.002	<0.005	52.1
Yerington	Lyon	8.5	631	1.4	0.003	<0.001	<0.005	0.16	<0.001	0.13	0.01
Getchell South	Humboldt	6.0	2,110	2.4	0.009	<0.005	<0.02	0.04	<0.2	<0.002	0.33
Getchell Center	Humboldt	5.3	2,140	2.4	0.008	<0.005	<0.02	0.04	<0.2	<0.002	0.4
Getchell North	Humboldt	7.7	2,420	1.6	0.38	<0.005	<0.02	<0.005	<0.2	0.003	0.02
Cortez	Lander	8.7	432	2.4	0.038	-	-	-	0.0005	-	0.002
Aurora	Mineral	7.6	478	0.6	0.009	<0.002	<0.003	<0.005	0.00003	0.011	<0.004
Boss	Nye	8.3	12,400	<2.5	1.57	<0.002	<0.003	<0.003	0.00005	0.082	0.255
Sleeper	Humboldt	6.7	3,410	1.6	0.076	0.021	0.002	0.02	0.0004	0.002	2.53
Big Springs SWX	Elko	8.2	1,130	0.45	0.008	<0.001	<0.001	<0.001	<0.0005	0.009	0.02
Big Springs 303	Elko	8.2	1,040	0.29	0.009	<0.001	<0.001	<0.001	<0.0005	0.010	0.03
Tuscarora	Elko	7.5	350		0.005						
Adelaide Crown	Humboldt										
Lady Bryan	Lyon										
Cyprus Tonopah	Nye										
Ketchup Flat	Nye										
Manhattan	Nye										

[1] Data are from 1991. The pit lakes were dewatered in 1992 to facilitate mining and began to refill in 1997 following mining.