RECONNAISSANCE INVESTIGATION OF IRRIGATION DRAINAGE IN THE SAN JUAN RIVER AREA, SAN JUAN COUNTY, NORTHWESTERN NEW MEXICO

EXECUTIVE SUMMARY

February 15, 1991

BACKGROUND INFORMATION

Location

The San Juan River study area is located in San Juan County, northwestern New Mexico (fig. 1). The area includes an approximately 100-mile reach of the San Juan River valley from navajo Dam, about 33 miles upstream fran the city of Farmington, to the mouth of the Mancos River, about 25 miles downstream from the town of Shiprock. Four Department of Interior-sponsored irrigation projects are located in this part of the San Juan River Valley: the Hammond, Fruitland, Hogback, and Cudai projects (fig. 1). The study area also includes the upland area south of the San Juan River valley, approximately bounded by the Chaco River on the west, Hunter Wash on the south, and New Mexico State Highway 44 on the east. The Navajo Indian irrigation Project (NIIP), also sponsored by the Department of Interior, is located in this part of the study area (fig. 1).

Geology and Soils

Several formations of Tertiary and Cretaceous age compose the consolidated geology in the study area (fig. 2). The-Nacimiento Formation. of Tertiary age underlies the soils and crops out along nearly all of the reach of the San Juan River valley east of Farmington. The Kirtland Shale/Fruitland Formation and the Mancos Shale, all of Cretaceous age, underlie the soils and crop out along about three-fourths of the reach from Farmington to the western boundary of the study area. Several alternating sandstone and shale formations of Cretaceous age crop out in an approximately 5-mile wide band at The Hogback. All of the shales of Cretaceous age consist at least in part of gray arid black shale and are potential sources of selenium. and other trace elements. The Nacimiento Formation and the Kirtland Shale/Fruitland Formation underlie tile soils and compose the outcrop in most of the upland area south of the San Juan River (fig. 2).

The San Juan River valley is composed in part of unconsolidated sand, gravel, silt, clay, and terrace gravel and boulder deposits, all of Quaternary age. The sand, gravel, silt, and clay deposits probably do not exceed 100 feet in thickness, and the terrace deposits generally do not exceed 30 feet in thickness. Soils in the valley typically are derived from sandstone, shale, siltstone, and mudstone; are alkaline; range from poorly- to well-drained; and range in permeability from moderately rapid to moderately slow. Soils in the upland area where the NIlP is located typically are derived from colian and alluvial material, are deep and are well- to excessively-drained. Permeability ranges from moderately rapid to rapid.

See Table/Figure

Figure 1.--Study Area and Department of Interior-Sponsored Irrigation Projects.

(SEE ORIGINAL)

See Table/Figure

Figure 2.--Geology of the Study Area.

(SEE ORIGINAL)

Surface Water

Navajo Dam and Reservoir are about 33 miles upstream from Farmington (fig. 1). The average flow in the San Juan River near Archuleta, New Mexico, about 8 miles downstream from Navajo Darn, is about 1,250 cfs; average flow in the San Juan River at Shiprock, New Mexico, about 65 miles further downstream, is about 2,240 cfs. The Animas and La Plata Rivers join the San Juan River in Farmington; average flows from these tributaries are about 930 cfs and 30 cfs, respectively. Other perenial tributaries and their average flows are the Chaco River (51 cfs) and Shumway Arroyo (1.6 cfs).

Fish and Wildlife Populations

About 100 species of mammals, 300 species of birds, and 50 species of fish inhabit the San Juan Basin. Between 250,000 and 500,000 waterfowl winter and (or) breed along the San Juan River. Four federally endangered species (Bald Eagle, Peregrine Falcon, Whooping Crane, and Colorado Squawfish) and 17 state endangered species inhabit the area. The state endangered species include 3 mammals, 3 birds, 4 fish, and 2 amphibians.

Water Use

About 78 percent of the water used in San Juan County is for irrigation, about 10 percent is used for power generation, and about -2 percent is used for municipal supply. The city of Shiprock (population about 7,000) obtains part of its municipal water supply fran the San Juan River. The San Juan River supports sport fishing throughout its reach in the study area, and is occasionally used for swimming, bathing, and clothes-washing.

Irrigation Projects

Irrigable acreages in the Hammond, Fruitland, Hogback, and Cudai projects are about 4,000, 3,300, 4,500, and 540 acres, respectively (fig. 1). In 1989, about 48,000 acres were irrigated on the NIIP (fig.1). When the NIIP is completed, about 110,000 acres will be irrigated.

All five DOI-assisted irrigation projects obtain water fran the San Juan River. Following use, part of the water is returned either by drains or by seepage to the San Juan River or to the ground-water system of the San Juan River valley. The Hammond, Fruitland, Hogback and Cudai projects consist of a diversion darn, a main canal, and a series of field laterals. The NIIP consists of a reservoir, a network of main canals and tunnels, laterals, and pumping stations. Return flow for the Fruitland, Hogback, and Cudai projects is by seepage. Return flow for the NIIP and the Harunond project is by seepage and drains. When the NIIP is completed, irrigation return flow from the NIIP is expected to constitute as much as 15 percent of the annual flow of the San Juan River.

4

TRACE ELEMENTS AND PESTICIDES IN THE SAN JUAN RIVER AREA

Data-collection activities and interpretive studies addressing contamination in the San Juan River area have been conducted by several Department of Interior agencies. These agencies include the U.S. Bureau of Reclamation (BOR), the U.S. Bureau of Land Management (BLM), the U.S. Bureau of Indian Affairs (BIA), the U.S. Fish and Wildlife Service (FWS), and the U.S. Geological Survey (USGS). Larger-than-expected concentrations of trace elements have been reported by each agency. In addition, the USGS and the FWS have reported detectable concentrations of pesticides in water and biota.

The BOR has reported high levels of arsenic, cadmium, copper, iron, lead, manganese, mercury, silver, and zinc in the San Juan River drainage (U.S. Bureau of Reclamation, 1980), and the BLM also has reported high levels of aluminum, chromium, and selenium in drainage water (U.S. Bureau of Land Manageinent, 1984). The BIA has monitored ground-water quality on the NIIP since 1985 and has reported Concentrations of selenium as large as 180 micrograms per liter (ug/L) (Robert Krakow, U.S. Bureau or Indian Affairs, oral commun, 1990).

Water-quality data collected by the USGS in the San Juan River area indicate that selenium was present in concentrations larger than) ug/L in samples collected from 16 of 24 surface-water quality stations, from 7 of 35 miscellaneous surface-water sites, and from 4 of 38 miscellaneous ground-water sites. Several other trace elements- were present in concentrations larger than U.S. Environmental Protection Agency rational Primary Drinking-Water Standard Maximum Contaminant Levels in samples collected from surface water and(or) ground water sites.

The FWS has reported high or elevated levels of cadmium, copper, iron, and selenium in bird tissue and high residual levels of chromium, copper, lead, and selenium in fish tissue (O'Brien, 1987). Comparison of data collected in 1973 and 1984 also indicated that residual levels or many of these elements gradually may be increasing with tine.

Concentrations of selenium in six fish samples were above the 85th percentile concentration of samples from the National Contaminant

Biomonitoring Program, and four other samples were between the geometric mean and the 85th percentile (O'Brien, 1987). These concentrations are large encugh to suggest that they may cause reproductive impairment.

Water-quality data collected by the USGS indicate that 2,4,-D has been present in concentrations larger than the laboratory reporting level of 0.01 ug/L in water collected from the San Juan River at Shiprock, New Mexico. The FWS has detected residual levels of DDE in starlings and PCB's in fish (O'Brien, 1987); however, concentrations of all other organochlorine compounds were less than detectable concentrations or at very low levels compared with results in the National Contaminant Biomonitoring Program.

The extent to which DOI-sponsored irrigation contributes to contamination in the San Juan River area is not known. Several potential sources of contamination other than DOI-sponsored irrigation projects are present in the area. These include oil and gas exploration, extraction, arid processing; and coal mining and electric power generation (figure 3). Another potential source of contamination is irrigation not sponsored by DOI, located on the north side of the San Juan River Valley upstream of The Hogback.

OBJECTIVES OF THE STUDY

There were three primary objectives of this reconnaissance study. These objectives were: (1) to determine if DOI-sponsored irrigation projects contribute to contamination in the San Juan River area, and if so, what part of the entire contamination problem is attributable to DOI-sponsored irrigation activities; (2) to determine which of the DOI-sponsored irrigation projects are the source of contamination; and (3) to determine if and to what degree human health and wildlife are affected by contamination contributed by DOI-sponsored irrigation activity, both on the irrigation projects and on adjacent lands and waters.

APPROACH: SAMPLE COLLECTION AND ANALYSIS

Water, bottom sediment, aquatic Plants and animals, and(or)birds were collected for chemical analysis at twenty-five sites on the various irrigation projects and 11 sites on the San Juan River, its perennial tributaries, and municipal or irrigation diversions. Fish were collected fran eleven reaches of the San Juan River. The irrigation-project sites are shown in figure 4 and listed in table 1. The San Juan River sites and reaches are shown in figure 5 and listed in table 2.

Water samples were collected prior to or at the beginning of, during, and after the 1990 irrigation season; bottom-sediment samples were collected after the irrigation season; aquatic plants and animal samples were collected in the summer during maximum metabolic activity; fish samples were collected in the spring and fall; and bird samples were collected in late spring and early summer, during the nesting season.

Collection of water and bottom sediment were conducted according to procedures outlined in Edwards and Glysson, 1988; and in Severson, Wilson, and McNeal, 1988. About ten percent of samples collected were used for quality assurance and quality control. These samples included replicate samples, split samples and blanks. Collection of biological samples was conducted according to procedures outlined in the U.S. Fish and Wildlife Service Resource Contaminant Assessment Division "Field Onerations Manual for Resource Contaminant Assessment".

6

See Table/Figure

Figure 3.--Energy Resourse Areas and Production Activities in the Study Area.

(SEE ORIGINAL)

See Table/Figure

Figure 4.--Sampling Sites on Department of Interior-sponsored Irrigation Projects.

(SEE ORIGINAL)

See Table/Figure

Figure 5.--Sampling Reaches and Sites on the San juan River and Perennial Tributary Streams.

(SEE ORIGINAL)

Table 1.--Water, bottom-sediment, aquatic plaut, invertebratel, and amphibian sampling sites located on irrigation projects

NAVAJO INDIAN IRRIGATION PROJECT

Gallegos Canyon Drainage
I- 1. South pond-Gallegos Canyon Drainage
I- 2. Middle Pond-Gallegos Canyon Drainage
I- 3. North Pond-Gallegos Canyon Drainage
I- 4. Gallegos Canyon 2 miles North of Navajo Highway 3003

Ojo Amarillo Canyon Drainage
I- 5. Ojo Amarillo canyon 3/4 Miles North of Navajo Highway 3003
I- 6. Ponds-Ojo Amarillo Canyon Tributary Drainage (1 Mile North of Navajo Highway 3003)
I- 7. Ojo Amarillo Canyon 2 1/4 Miles North of Navajo Highway 3003
I- 3. Ojo Anaritlo Canyon 4 Miles North of Navajo Highway 3003

ponds in Enclosed Drainages
I- 9. Hiddey Pond
I-10. Avocet Pond
I-11. West Avocet Pond
I-12. Northwest Pond-Block 3

Chinde Wash Drainage

I-13. Southwest Pond-Chinde Wash Drainage
I-14. Southeast Pond-Chinde Wash Drainage
I-15. Chinde Wash at Navajo Highway 5005

HAMMOND PROJECT

East Hammond Project
I-16. East Hammond East Drain and Wetland (about 8 miles east of New Mexico Highway 44)
I-17. East Hammond West Drain and Wetland (about 3 1/2 miles east of New Mexico Highway 44)
I-18. East Hammond Pond 1/10 Mile North of West Drain (Red Pond)
I-19. East Hammond Pond 4/10 Mile Northwest of West Drain (adjacent to oil production facility)
West Hammond Project
I-20. West Hammond Pond (about 2 1/2 miles west of New Mexico Highway 44)

FRUITLAND PROJECT

I-21. Fruitland Project Site

HOGBACK PROJECT

I-22. Hogback Project-East Site (about 2 3/4 Miles West of the Hogback)
I-23. Hogback Marsh (about 1 1/2 miles southeast of Shiprock)
I-24. Hoghack Project-West Site (about 3 miles northwest of Shiprock)

10

Table 2.--San Juan River reaches From which fish were collected, and water and bottom-sediment sampling sites within each river reach

A. Hammond Diversion to Blanco
  R- 1. San Juan River at Hammond Project fliversion

B. Bloomfield to Lee Acres

C. Lee Acres to Farmington
  R- 2. San Juan River 1 Mile Upstream from Mouth of Gallegos Canyon
  R- 3. Animas River at Mouth

  R- 4. Fruitland Project Diversion (a)

D. La Plata River to Ojo Amarillo Canyon
  R- 5. La Plata River at Mouth

E. Fruitland to Hogback
  R- 6. San Juan River 1/2 Mile Downstream from Fruitland Bridge
  R- 8. Hogback Project Diversion (a)
  R- 9. Chaco River 112 Mile Upstream front Mouth (a)
  R-10. San Juan at Shiprock Municipal DIversion (a)

F. Shiprock to Cudei

G. Cudei to Mancos River
R-11. San Juan River 3 Miles Downstream from Cudei

(a): Water and bottom-sediment sampling site is outside of river reaches from which fish were collected.

All water-sample analyses were conducted by the USGS Water Resources Division National Water Quality Laboratory in Arvada Colorado. Bottom-sediment samples were analyzed for inorganic constituents by the USGS Geologic Division Laboratory in Lakewood, Colorado, and analyzed for pesticides by the USGS Water Resources Division National Water Quality Laboratory in Arvada, Colorado. Analysis of samples for inorganic constituents was according to procedures outlined in Fishman and Friedman (1985); analysis of samples for pesticides was according to procedures outlined in Wershaw and others (1987); analysis of samples for uranium was according to procedures outlined in Thatcher and others (1977). Laboratory quality control and quality assurance procedures were those described in Friedman and Erdmann (1982).

Analysis of biological samples was conducted by laboratories under contract to the U.S. Fish and Wildlife Service Patuxent Analytical Control Facility, Patuxent, Maryland. Analyses were conducted according to procedures outlined in the "Patuxent Analytical Control Facility Reference Manual".

11

SUMMARY OF RESULTS OF INVESTIGATION

Water and Bottom Sediment

Prepared by Paul J. Blanchard
U.S. Geological Survey
Albuquerque, New Mexico

12

The following discussion includes results of analyses of water samples collected prior to or at the beginning of the irrigation season and during the irrigation season. Results of analyses of water samples collected following the irrigation season arid of all botton-sediment samples have not been received.

Trace Elements

Results of analyses of water samples for trace elements are summarized in table 3. Maximum concentrations of each trace element in each of three environments- irrigatton project, San Juan River tributaries, and San Juan River Mainstem and diversions, are shown in table 4.

The concentrations of arsenic, cadmium, chromium, rercury, and lead were at or less than the reporting level in at least three-fourths of the analyzed samples, indicating that the lower quartile value, the median value, and the tupper quartile value are all equal to the reporting level. Except for arsenic, the largest concentrations of these trace elements was at or near the reporting level. Arsenic concentration was larger than 3 ug/L at 2 sites: Avocet Pond (I-10) and the southwest pond in Chinde Wash Drainage (I-13). Both of these sites are stock-watering poonds filled with irrigation water; concentrations of aresenic increase with time after these ponds are filled because of evapotranspiration.

Table 3.--Summary of results of analysis for trace-metal concentrations

Constituent	Number of samples (N)	Reporting level (ug/L)	Range of concentrations (ug/L)	Number of samples less than or equal to reporting level
Arsenic	60	1	<1 to 48	48
Cadminm	60	1	<1 to 2	58
Chromium	60	1	<1 to 3	47
Copper	60	1	<1 to 32	25
Lead	60	1	<1 to 1	60
Mercury	60	0.1	<0.1 to 0.2	46
Molybdenum	60	1	<1 to 11	34
Selenium	60	1	<1 to 42	25
Vanadium	57	1	<1 to 27	18
Zinc	60	10	<3 to 20	21

Concentrations of copper, molybdenum, vanadium, and zinc were less than the reporting level in about one-third to one-half of the samples. Boxplots of concentrations of copper and vanadium are shown in figure 6 arid those of molybdenum and zinc are shown in figure 7.

See Table/Figure

Figure 6.--Concentrations of Cu and V

(SEE ORIGINAL)

See Table/Figure

Figure 7.--Concentrations of Mo and Zn

(SEE ORIGINAL)

Table 4.--Maximum concentrations of trace elements in water from irrigation project sites, from tributaries to the San Juan River, and from San Juan River mainstem and diversions

Maximum concentration (ug/L)

Trace element	Irrigation Project sites	San Juan River sites Tributaries	San Juan River sites Mainstem and diversions
Arsenic	48	1	1
Cadmium	2.0	1.0	1.0
Chromium	2	3	2
Copper	32	12	8
Lead	1	<1	1
Mercury	0.2	0.2	0.2
Molybdenum	11	6	6
Selenium	42	4	2
Vanadium	27	7	2
Zinc	20	10	11

All of the maximum reported concentrations and all or the outlying values and far-outlying values ror copper, molybdenum, vanadium, and zinc except two values for copper were at sites on the NIIP. The largest concentrations of these elements in water from the San Juan River and tributaries was about one-fourth to one-half of the maxinum concentrations (table 4).

Concentrations of selenium were larger than 3 ug/L in 3 areas: the Gallegos Canyon area and Ojo Amarillo Canyon on the NIIP, and the east site area of the Hogback Project. Four sites are located in the Gallegos Canyon area (I-1 through I-4) two sites are located in Ojo Amarillo Canyon (I-7 and I-8) and two sites are located in the east site area of the Hogback project (I-22a). All of thte outlying values and far-outlying values are located at these sites (fig. 8).

Sites in the Gallegos Canyon area consist of 3 ponds created by damming incised drainages tributary to Gallegos Canyon, and one site in Gallegos Canyon downstream from irrigation on the NIIP. Ranges of concentrations of selenium at each of these sites and at monitoring wells in the Gallegos Canyon area are shown in figure 9.

South Pond (Site I-1) receives substantial surface runoff from irrigated areas, and discharge from the pond varied from 1/2 gallon per minute (gal/min) on April 14, 1990; to 120 gal/min on August 4, 1990; to 6 gal/min on December 3, 1990. Concentrations of selenium decreased from 7 ug/L on April 14, 1990 to less than 1 ug/L on August 4, 1990.

16

See Table/Figure

Figure 8.--Concentrations of Selenium

(SEE ORIGINAL)

See Table/Figure

Figure 9.--Surface- and Ground-water sampling sites in the Gallegos Canyon area.

(SEE ORIGINAL)

Middle Pond (Site I-2) receives surface runoff from irrigated areas, and also receives substantial ground-water inflow throughout the year, and discharge decreased during the summer when evapotranspiration rates are high. Discharge varied from about 75 gal/min on April 14, 1990; to 30 gal/min on August 4, 1990; to about 110 gal/min on December 3, 1990. Concentrations of selenium decreased from 25 ug/L on April 14, 1990 to 16 ug/l on August 4, 1990.

North Pond (I-3) receives runoff from irrigated areas; irrigation water also occasionally is added to keep the pond full. There is no point of discharge from North Pond; water loss is by seepage and evapotranspiration. Concentrations fo selenium decreased from 5 ug/l on April 16, 1990 to 2 ug/l on August 6, 1990. The water level in the pond was higher in August than in April, indicating the irrigation supply water was probably added to the pond between April and August.

Gallegos Canyon receives water from South and Middle Ponds and from other springs and seeps discharging within the NIIP. Streamflow during sample collection at Site I-4 was estimated to be less than 20 cfs; concentrations of selenium were 8 ug/L on April 16, 1990 and 12 ug/L on August 2, 1990.

Ojo Amarillo Canyon receives overland runoff from irrigated fields and also receives ground-water inflow throughout the year. Ranges of concentrations of selenium at all sites and monitoring wells outside the Gallegos Canyou area, including Sites I-7 and I-8, area are shown in figure 9. Discharge at Site I-8 varied from 1.4 (cfs) on April 15, 1990, to no flow in August 1990, to 1.3 cfs on November 17, 1990. Site I-7 was substituted for Site I-8 in August 1990; discharge at Site I-7 was 0.4 cfs on August 1, 1990. Concentrations of selenium were 33 ug/L on April 15, 1990 at Site I-8 and 42 ug/L on August 1, 1990 at Site I-7 (fig. 10).

The East Hogback (Site I-22) in the Hogback Project is on an irrigation drainage canal that discharges into the San Juan River (fig. 11). Discharge was .07 cfs on April 17, 1990: 0.68 cfs on August 1, 1990: and .08 cfs on November 16, 1990. Concentrations of selenium at Site I-22A were 21 ug/L on April 17, 1990 and 11 ug/L on August 1, 1990.

Pesticides

Twelve triazine and other nitrogen-containing herbicide compounds and six chlorophenoxy acid herbicide compounds were analyzed for in water samples collected from seven sites on the NIIP. Of these compounds, the following were present in concentrations at or larger than the reporting level: cyanazine at three sites in the Gallegos Canyon area, dicamba at one site in the Gallegos Canyon area, and 2,4-D at one site in the Gallegos Canyon area and two sites in the Ojo Amarillo Canyon area.

See Table/Figure

Figure 10.--Surface- and Ground-water sampling sites in the Ojo Amarillo Canyon and the Chinde Wash areas.

(SEE ORIGINAL)

See Table/Figure

Figure 11.--Surface-water sampling sites at the east Hogback site.

(SEE ORIGINAL)

Ten carbamate insecticide compounds were analyzed for in water from seven sites and seven organophosphorus insecticide compounds were analyzed for in water from six sites. None of these compounds were present in concentrations at or larger than the reporting level at any of the sampled sites.

SELECTED REFERENCES

Edwards, T.K., and Glysson, G.D., 1988, Field methods for measurement of fluvial sediment: U.S. Geological Survey Open-File Report 86-531, 118 p.

Eisler, Ronald, 1986, Chromium hazards to fish, wildlife, and invertebrates--a synoptic review: Contaminant Hazard Reviews, report no. 76, Fish and Wildlife Service Biological Report 85(1.6), p. 60.

Fishman, M.J., and Friedman, L.C., editors, Methods for determination of inorganic substances in water and fluvial sediments: Techniques of Water-Resources Investigations of the U.S. Geological Survey Book 5, Chapter A 1, 709 p.

Friedman, L.C., and Erdmann, D.E., 1982, Quality assurance practices for the chemical and biological analyses of water and fluvial sediments: Techniques of Water-Resources Investigations of the U.S. Geological Survey Book 5, Chapter A 6, 181 p.

Lowe, T.P., Mav, T.W., Brumbaugh, W.G., and Kane, D.A., 1985, National Contaminants Biomonitoring Program--Concentrations of seven elements in freshwater fish, 1978-1981: Arch. Environ. Contam. Toxicol. 14, p. 363-388.

O'Brien, T.F., 1987, Organochlorine and heavy metal contaminant investigation, San Juan River Basin, New Mexico: U.S. Fish and Wildlife Service, Albuquerque, New Mexico.

Roybal, F.E., md others, 1983, Hydrology of Area 60, Northern Great Plains and Rocky Mountain Coal Provinces, New Mexico, Colorado, Utah, and Arizona: U.S. Geological Survey Water Resources Investigations Open-File Report 83-203, 80 p.

Schmitt, C.G., 1973, Summer birds of the San Juan Valley, northwestern

New Mexico: Las Cruces, New Mexico State University, M.S. thesis, 57 p.

Schmitt, C.J., Zajicek, J.L., and Robick, M.A., 1985, National Pesticide Monitoring Program--Residues of organochloririe chemicals in freshwater fish, 1980-81: Arch. Environ. Contam. Toxicol. 14, p. 225-260.

22

Severson, R.C., Wilson, S.A., and McNeal, J.M., 1988, Analysis of bottom material collected at nine areas in the Western United States for the DOI irrigation drainage task group: U.S. Geological Survey Open-File Report 87-490, 24 p.

Thatcher, L.L., Janzer, V.J., and Edwards, K.W., 1977, Methods for determination of radioactive substances in water and fluvial sediments: Techniques of Water-Resources Investigations of the U.S. Geological Survey Book 5, Chapter A 5, 95 p.

U.S. Bureau of Land Management 1984, Final San Juan River regional coal environmental impact statement: Albuquerque District Office, Albuquerque, New Mexico.

U.S. Bureau of Reclamation, 1980, Final environmental statement, Animas-La Plata project: Colorado-New Mexico Upper Colorado Region.

Walker, C.R., 1976, Polychlorinated biphenyl compounds (PCB's) and fishery resources: Fishery, v. 1, no. 4, p. 19-23.

Walsh, D.F., Berger, B.L., and Bean, J.R., 1977, Mercury, arsenic, lead, cadmium, and selenium rasidues in fish, 1971-73 National Pesticide Monitoring Program: Pesticide Monitoring journal, v. 10, no. 1, June 1976, p. 10-17.

Wershaw, R.L., Fishman, M.J., Grabbe, R.R., and Lowe, L.E., 1987, editors, Methods for determination or organic substances in Water and fluvial sediments: Techniques of Water-Resources Investigations of the U.S. Geological Survey Book 5, Chapter A 3, 80 p.

White, D.H., Bean, J.R., and Longcore, J.R., 1977, Nationwide residues of mercury, lead, cadmium, arsenic, and selenium on starlings, 1973: Pesticide Monitoring Journal, v. II, no. 1, June 1977, p. 35-39.

Wilson, Brian, 1986, Water use in New Mexico: New Mexico State Engineer Office Technical Report 46, 84 p.

23

SUMMARY OF RESIDUE ANALYSIS OF BIOTA COLLECTED FOR

THE DEPARTMENT OF THE INTERIOR

RECONNAISSANCE INVESTIGATION OF IRRIGATION DRAINAGE IN THE SAN JUAN RIVER AREA, NORTHWESTERN NEW MEXICO

BY

THOMAS F. O'BRIEN
RICHARD ROY
U.S. FISH AND WILDLIFE SERVICE
ECOLOGICAL SERVICES
ALBUQUERQUE, NEW MEXICO

INTRODUCTION: During the spring,summer, and early fall of 1990, samples of aquatic invertebrates and plants, fish, amphibians, adult migratory birds, mallard ducklings, and bird embryos were collected in an 80-mile stretch of the San Juan River in New Mexico. The San Juan River supports a remnant reproducing population of the Federally endangered Colorado squawfish, candidate razorback sucker, wintering bald eagles, and thousands of migratory waterfowl.

The study focused on the San Juan River and wetlands that were created or enhanced by irrigation drainage from four DOI sponsored irrigation projects: the Hammond, Navajo Indian, Fruitland, and Hogback. Complete analytical results are available for both the Hammond Project and Navajo Indian Irrigation Project (NIIP). The Fish and Wildlife Service is awaiting the analytical results of aquatic invertebrates, plants, and fish collected from wetland sites on the Fruitland and Hogback Projects. These data should be received within the next several weeks.

METHODS: Fish in the river were captured by electrofishing. Fish in drains or wetlands were captured by seining and using light traps. Water dogs (tiger salamanders) were captured ny seining, light traps, or minnow traps. Aquatic plants were handpicked. These samples were then composited according to species and location. Adult birds and mallard ducklings were collected using a shotgun with steel shot. Embryos were collected by searching for nests and determining embryo development by the egg flotation method (Westerkov 1950). If embryo development had proceeded to within 2 to 3 days of hatching, they were collected. If they had not developed enough to determine deformities (clubfeet, curved bills, etc.), then the hatch date was estimated and the nest marked. We would return several days before the estimated hatch date and collect an embryo. After the eggs were collected, the shell was opened in order to examine the embryo for deformities. the embryo was then submitted for whole-body chemical analysis. Livers and kidneys from:, adult birds and mallard ducklings were either submitted individually or composited for inorganic analysis. Carcasses were submitted individually for organochlorine analysis. Blood serum and brains from adult male mallards and brains from -ales of other snakiest were submitted for acetyl or butyl cholinesterase inhibition analysis to determine exposure to organophosphate/carbamate pesticides.

RESULTS: Results from six composite fish samples from six different river sites and 53 bird carcasses (samples consisting of adults and juveniles) collected form 23 sites revealed little evidence of organocholorine contamination. However, traces of PCBS's and chlordane metabolites were consistently found in fish samples, but all were less than .50 ug/g wet weight. Out of the 35 bird carcasses analyzed the only organochlorine compound that was consistently detected was p,p'-DDE. Only six samples were >1.0 ug/g wet weight and p,p'-DDE was not detected in the four mallard duckling carcasses. Interestingly, the six carcasses that were >1.0 ug/g wet weight (maximum concentration 2.4 ug/g wet weight) were adult killdeer.

Brain and serum cholinesterase assays of 35 birds also revealed that they were not being exposed to harmful levels of op/ca pesticides. Only two mallards exhibited inhibited brain cholinesterase (Table 1).

Inorganic results from whole-body fish samples (carp, flannelmouth suckers, channel catfish) were compared to National Contaminant Biomonitoring Program (NCBP) data (Schmitt and Brumbaugh 1990). This comparison revealed that fish in the San Juan River are accumulating five of the seven elements analyzed in NCBP to higher levels than fish nationwide. Only mercury and arsenic were below the NCBP standard, arsenic being detected in only one sample (Table 2). In addition, several of the geometric means calculated for each of the three species for each element exceeded the 85th percentile concentrations for fish nationwide (Table 2).

Comparisons of six of the NCBP element scans between carp and flannelmouth sucker to river reach revealed a very consistent trend. Typically, copper, cadmium, mercury, selenium, and zinc were found in maximum concentrations at Station A (Hammond Diversion to Blanco, New Mexico) and Station B (Fruitland, New Mexico, to Hogback Diversion) (Figures 1-6).

At this time, it appears that the element of concern in wetland biota is selenium. Samples from four of the eight sites on NIIP had elevated levels of selenium in water dogs and aquatic invertebrates (Figure 7). The maximum concentrations of selenium in aquatic biota were detected at Gallegos Canyon Middle and South Ponds (sites 2 and 3) and at Ojo Amarillo Canyon Big and Upper Ponds (sites 4 ad 5). There was also a dramatic difference in selenium concentration in aquatic invertebrates, plants, mosquito fish and killifish between East Hammond and West Hammond Projects (Figure 8). It is apparent from these data that prey items from several wetland sites have selenium concentrations above the 4-8 ug Se/g threshold that Heinz et al. (1989) considered sufficient to impair reproduction in mallards.

Selenium also appears to be the element of concern in migratory bird samples. The maximum concentration of selenium in bird embryos (17.6 ug/g dry weight) was found in a mallard embryo collected from a nest in Ojo Amarillo Canyon. The embryo itself appeared to be physically normal, although the selenium concentration falls in the mid-range of that found in duck embryos at Kesterson National Wildlife Refuge (Ohlendorf et al. 1986). Avocet embryos (Figure 9) had selenium concentrations in the lower range of that Knapton et al. (1933) found at Sun River, Montana. Coot embryos also had selenium values in the lower range of that found in coot embryos at Sun River, Montana (Knapton et al. 1988).

Mallard ducklings were collected only from the NIP. Several of these ducklings had selenium residue in excess of what was found in adult mallards from the study area. In fact, the highest concentration of selenium found in mallard ducks was from a composite duckling sample in Ojo Amarillo Canyon (Figure 10). Adult mallards were collected throughout the study area. Out of the 11 adults collected, only two were below the range (4.4-8.8 ug/g dry weight) that Ohlendorf et al. (1986) considered to be normal (Figure 11).

Adult killdeer also had elevated levels of selenium. All had selenium concentrations above 10 ug/g dry weight. The maximum concentration of selenium detected in biotic samples, 103 ug/g dry weight, was from a killdeer composite sample from Gallegos Canyon (Figure 12).

Red-winged and yellow-headed blackbirds were collected from wetland sites at each project. Three of the samples appear to be elevated (Figure 13). According to King (personal communication), red-winged blackbirds collected near a lignite-fired power plant in Texas had a mean concentration of 33.1 ug Se/g dry weight in kidneys. Red-winged blackbirds from a control area had a mean selenium concentration of 7.7 ug/g dry weight in kidneys.

Adult avocets from NIIP also had elevated levels of selenium (Figure 14). Some of the selenium concentration detected were above those found in avocets from Sun River, Montana (Knapton et al. 1988).

Teal were collected throughout the study area. With the exception of a green-winged teal collected on NIIP Gallegos Canyon, all were cinnamon teal. Of the eight samples, five were above the range that Ohlendorf et al. (1986) considered to be normal. The maximum concentration of selenium detected in teal species was from the green-winged teal collected on NIIP (Figure 15).

Adult coots were collected from two sites on NIIP and from the Relict wetland on the Hogback Project. The maximum concentration of selenium detected was from a coot collected on North Pond at Gallegos Canyon (Figure 16).

Polycyclic aromatic hydrocarbons (PARs), naphthalene, phenanthrene, and benzo (a) pyrene), were analyzed in bile samples from fish and birds. The purpose for analyzing for these compounds is that oil/gas exploration, development, and refining occurs within the four irrigation projects and irrigation water may serve as a transport mechanism.

The highest concentration of PAHs in fish was found in a composite carp sample collected from station B (Bloomfield to Lee Acres) (Table 3). This study reach has several refineries that are situated near the San Juan River. The highest concentration of PAHs in birds was found in an avocet from NIIP. Similar concentrations were found in a composite coot sample from the Hogback Project (Table 3).

According to Dr. Margaret Krahns, National Marine Fisheries Service, Seattle, Washington (personal communication), these data strongly suggest that the San Juan River Basin is heavily impacted by PAHs. She stated that normal concentrations of PAHs in fish bile should be less than 10,000 ng naphthalene/g wet weight, less than 3,000 ng phenanthrene/g wet weight, and less than 100 ng benzo (a) pyrene/g wet weight. Unfortunately, there are no data for normal concentrations of PAHs in bird bile. However, Dr. Krahns believed that the data support the fish bile data of the San Juan River. Presently, the Fish and Wildlife Service is awaiting the results of analyses of bile samples collected from reference specimens.

Microtox bioassays were conducted 149 times on 22 sites. Seven sites were found to cause a toxic response to the photobacteria at least once. The sites that were typically toxic were the wetland sites on the Hammond Project (Table 4).

SUMMARY: Preliminary indications are that fish inhabiting the San Juan River are exposed to and accumulating several heavy metals and trace elements above

the NCBP 85th percentile. In addition, fish in the river appear to be exposed to elevated levels of PAHs.

In wetland sites on the irrigation projects, the element of concern is selenium. Typically, the highest concentrations of selenium found in aquatic plants, invertebrates, amphibians, and migratory birds were found at wetlands located in the Gallegos Canyon or Ojo Amarillo Canyon Drainages. Migratory birds also appear to be exposed to high levels of PAHs.

During the upcoming field season, the Fish and Wildlife Service biologists will be concluding the study of PAH effects on fish and migratory birds in the project area. The biologists will attempt to correlate the sediment pore-water concentrations of PAHs to concentrations of PAHs in fish and bird bile to liver neoplasia in fish and cytochrome P-450 induction in birds.

The biologists will also be conducting bioassays of return flow and seepage water on Daphnia magna, fathead minnow sac-fry, and Colorado squawfish sac-fry. The biologists believe that the data generated from the bioassays will greatly enhance the study team's ability to determine the effects of irrigation return flows upon native fishes.

Literature Cited

Heinz, 0. H., D. H. Hoffman, and L. 0. Gold. 1988. Toxicity of organic and inorganic selenium to mallard ducklings. Arch. Environ. Contam. Toxicol. 17:561-568.

Khrans, M. National Marine Fisheries Service, Northwest and Alaska Fisheries Center, Seattle, Washington. Conversations. 1990.

King, K. U.S. Fish and Wildlife Service, Phoenix, Arizona. Conversations. 1991.

Knapton, J. R., W. E. Jones, and J. W. Sutpin. 1988. Reconnaissance investigation of water quality, bottom sediment, and biota associated with irrigation drainage in the Sun River area, west-central Montana, 1986-87. U.S. Geological Survey, Water Resources Investigations Report 87-4244.

Ohlendorf, H. M., D. J. Hoffman, M. K. Saiki, and T.W. Aldrich. 1986. Embryonic mortality and abnormalities of aquatic birds: apparent impacts of selenium from irrigation drainwater. Sci. of the Total Environ. 51:49-63.

Schmitt, C. J., and W. 0. Brumbaugh. 1990. National contaminant biomonitoring program: concentrations of arsenic, cadmium, copper, lead, mercury selenium, and zinc in U.S. freshwater fish, 1976-1984. Arch. Environ. Contam. Toxicol. 19:731-747.

See Table/Figure

Cd and Hg CONCENTRATIONS (ug/g WET WT)

IN CARP

(SEE ORIGINAL)

See Table/Figure

Cd and Hg CONCENTRATIONS (ug/g WET WT)

IN FLANNELMOTH SUCKERS

(SEE ORIGINAL)

See Table/Figure

COPPER CONCENTRATIONS (ug/g WET WT)

IN CARP AND FLANNELMOUTH SUCKERS

(SEE ORIGINAL)

See Table/Figure

LEAD CONCENTRATIONS (ug/g WET WT)

IN CARP AND FLANNELMOUTH SUCKER

(SEE ORIGINAL)

See Table/Figure

SE CONCENTRATIONS (ug/g WET WT)

IN CARP AND FLANNELMOUTH SUCKERS

(SEE ORIGINAL)

See Table/Figure

ZINC CONCENTRATIONS (ug/g WET WT)

IN CARP AND FLANNELMOUTH SUCKERS

(SEE ORIGINAL)

See Table/Figure

Selenium Concentrations in biota

Collected at NAPI

(SEE ORIGINAL)

See Table/Figure

SE CONCENTRATION (ug/g DRY WT)

IN AQUATIC BIOTA FROM THE HAMMOND PROJ.

(SEE ORIGINAL)

See Table/Figure

SELENIUM CONCENTRATIONS (ug/g DRY WT)

IN AVOCET EMBRYOS

(SEE ORIGINAL)

See Table/Figure

SE CONCENTRATIONS (ug/g DRY WT)

IN MALL. DUCKLING LIVER/KIDNEYS

(SEE ORIGINAL)

See Table/Figure

SE CONCENTRATIONS (ug/g DRY WT)

IN MALLARD LIVER/KIDNEYS

(SEE ORIGINAL)

See Table/Figure

SE CONCENTRATIONS (ug/g DRY WT)

IN KILLDEER LIVER/KIDNEYS

(SEE ORIGINAL)

See Table/Figure

SE CONCENTRATIONS (ug/g DRY WT)

IN "BLACKBIRD" LIVER/KIDNEYS

(SEE ORIGINAL)

See Table/Figure

SELENIUM CONCENTRATIONS (ug/g DRY WT)

IN ADULT AVOCET LIVER /KIDNEYS

(SEE ORIGINAL)

See Table/Figure

SE CONCENTRATIONS (ug/g DRY WT)

IN TEAL LIVER/KIDNEYS

(SEE ORIGINAL)

See Table/Figure

SE CONCENTRATIONS (ug/g DRY WT)

IN COOT LIVER KIDNEYS

(SEE ORIGINAL)

Table 1. NCBP (1990) Trace Element Comparison Between Fish from the San Juan River and Nationwide (Schmitt and Brumbaugh 1990).

	Cd	Cu	Pb	Zn	As	Hg	Se
Carp[sup]1	0.05	1.20	0.19	29.54	ND	0.06	0.85
Channel catfish[sup]1	0.07	0.74	0.36	24.89	ND	0.09	0.61
Flannelmouth sucker[sup]1	0.08	1.10	0.38	34.28	ND	0.08	0.83
NCBP[sup]1 for 1984	0.03	0.65	0.11	21.70	0.14	0.10	0.42
NCBPý for 1984	0.05	1.00	0.22	34.20	0.27	0.17	0.73

[sup]1 Geometric mean
ý85th Percentile

Table 2. Mean Cholinesterase Activity in Several Species of Birds Collected for the San Juan River DOT Study Compared to Normal Wild Birds.

Species	n	$\bar{x}$	sd	Lower Diagnostic Bound
American Coot	6	22.7	1.23	20.2
Killdeer	14	18.7	2.10	14.5
Mallard[sup]1	8	10.3	1.44	7.4
Mallardý	6	11.0	0.50	10.0
Mallard[sup]3	11	12.0	1.30	9.0
Coot[sup]1	5	18.0	1.5	15.0

[sup]1 Comparison between all specimens including two mallards with apparently depressed ChE.
ýComparison between selected specimens excluding two mallards with apparently depressed ChE.
[sup]3 From Hill 1988.

See Table/Figure

TABLE 3

TITLE: SAN JUAN RIVER IRRIGATION DRAINWATER STUDY-90

(SEE ORIGINAL)

Table : 4 Microtox Result summary, Location, Effective Concentration that Affects 50% of the population of Bacteria. San Juan DOI study, 7/30/90 to a/30/90.

Site #	Location Name	Test Result (# toxic/total)	EC50 % Sample (if calculable)
I-01	3/4 pivot pond	0 out of 9	No EC
I-02	7Dead Cow Pond	0 out of 4	No EC
I-03	Big Pond	1 out of 9	> 100%
I-04	Gallegos Wash	0 out of 6	No EC
I-05	Ojo Wash	0 out of 1	No EC
I-06	Ojo Big Pond	0 out of 7	No EC
I-07	Ojo Wash +3mi	0 out of 2	No EC
I-08	Ojo Wash +4mi	0 out of 0	___
I-09	Hidden Pond	0 out of 0	___
I-10	Avocet Pond	0 out of 9	No EC
I-11	West Avocet	1 out of 8	> 100%
I-12	Mine Pond	1 out of 7	> 185%
I-13	C West Pond	0 out of 5	No EC
I-14	C South Pond	0 out of 4	No EC
I-15	Chinde Wash	2 out of 6	> 100%
I-16	E Hammond 1186	0 out of 6	No EC
I-17	EH Drain/Marah	1 out of 5	72%
I-18	EH Red Pond E	6 out of 6	5%, 73%, >100%
I-19	EH Red Pond W	10 out of 11	30%, 42%, >100%
I-20	West Hammond	0 out of 4	No EC
I-21	Fruitland	0 out of 4	No EC
I-22	Hogback Ditch	0 out of 5	No EC
I-23	H Relict Marsh	0 out of 8	No EC
I-24	H Irrigation	0 out of 5	No CE
7 sites tested toxic to Microtox		22 out of 149 tested toxic	EC50 >100% sample are astimated