Metals Transport in the Sacramento River, California, 1996–1997

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FOREWORD

The mission of the U.S. Geological Survey (USGS) is to assess the quantity and quality of the earth resources of the Nation and to provide information that will assist resource managers and policymakers at Federal, State, and local levels in making sound decisions. Assessment of water-quality conditions and trends is an important part of this overall mission.

One of the greatest challenges faced by water-resources scientists is acquiring reliable information that will guide the use and protection of the Nation's water resources. That challenge is being addressed by Federal, State, interstate, and local water-resource agencies and by many academic institutions. These organizations are collecting water-quality data for a host of purposes that include: compliance with permits and water-supply standards; development of remediation plans for specific contamination problems; operational decisions on industrial, wastewater, or water-supply facilities; and research on factors that affect water quality. An additional need for water-quality information is to provide a basis on which regional- and national-level policy decisions can be based. Wise decisions must be based on sound information. As a society we need to know whether certain types of water-quality problems are isolated or ubiquitous, whether there are significant differences in conditions among regions, whether the conditions are changing over time, and why these conditions change from place to place and over time. The information can be used to help determine the efficacy of existing water-quality policies and to help analysts determine the need for and likely consequences of new policies.

To address these needs, the U.S. Congress appropriated funds in 1986 for the USGS to begin a pilot program in seven project areas to develop and refine the National Water-Quality Assessment (NAWQA) Program. In 1991, the USGS began full implementation of the program. The NAWQA Program builds upon an existing base of water-quality studies of the USGS, as well as those of other Federal, State, and local agencies. The objectives of the NAWQA Program are to:

- Describe current water-quality conditions for a large part of the Nation's freshwater streams, rivers, and aquifers.
- Describe how water quality is changing over time.
- Improve understanding of the primary natural and human factors that affect water-quality conditions.

This information will help support the development and evaluation of management, regulatory, and monitoring decisions by other Federal, State, and local agencies to protect, use, and enhance water resources.

The goals of the NAWQA Program are being achieved through ongoing and proposed investigations of 59 of the Nation's most important river basins and aquifer systems, which are referred to as study units. These study units are distributed throughout the Nation and cover a diversity of hydrogeologic settings. More than two-thirds of the Nation's freshwater use occurs within the 59 study units and more than two-thirds of the people served by public water-supply systems live within their boundaries.

National synthesis of data analysis, based on aggregation of comparable information obtained from the study units, is a major component of the program. This effort focuses on selected water-quality topics using nationally consistent information. Comparative studies will explain differences and similarities in observed water-quality conditions among study areas and will identify changes and trends and their causes. The first topics addressed by the national synthesis are pesticides, nutrients, volatile organic compounds, and aquatic biology. Discussions on these and other water-quality topics will be published in periodic summaries of the quality of the Nation's ground and surface water as the information becomes available.

This report is an element of the comprehensive body of information developed as part of the NAWQA Program. The program depends heavily on the advice, cooperation, and information from many Federal, State, interstate, Tribal, and local agencies and the public. The assistance and suggestions of all are greatly appreciated.

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CONVERSION FACTORS, VERTICAL DATUM, ACRONYMS and ABBREVIATIONS, and CHEMICAL NOTATION

Conversion Factors

Multiply	By	Obtain
acre-foot (acre-ft)	1,233	kiloliter
foot per second (ft/s)	0.3048	meter per second
cubic foot per second (ft^3/s)	28.32	cubic liter per second
inch (in.)	2.54	centimeter
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
square mile (mi^2)	2.590	square kilometer
cubic yard (yd^3)	0.7646	cubic meter

Temperature is given in degrees Celsius (°C), which can be converted to degrees Fahrenheit (°F) by the following equation:

$$°F=1.8(°C)+32.$$

Vertical Datum

Sea level: In this paper, “sea level refers to the National Geodetic Vertical Datum of 1929—a geodetic datum derived from a general adjustment of the first-order level nets of the United States and Canada, formerly called Sea Level Datum of 1929.

Acronyms and Abbreviations

(Additional information given in parenthesis)

μg, microgram
μg/g, microgram per gram
μg/L, microgram per liter
μm, micrometer
μS/cm, microsiemens per centimeter at 25° Celsius
MΩ-cm, megohm centimeter
σ, sigma

cm, centimeter
cm^2, square centimeter
cP, centipoise
g, gram
g, gravitational constant
g/L, gram per liter
in./yr, inch per year
km, kilometer
km^2, square kilometer
L, liter
L/min, liter per minute
kHz, kilohertz
m, meter
mg, milligram

mg/g, milligram per gram
mg/L, milligram per liter
mL, milliliter
mm, millimeter
mW, milliwatt
ng, nanogram
ng/L, nanogram per liter
nm, nanometer

Ax, axial
BOR, Bureau of Reclamation
BTD&Q, Branch of Technical Development and Quality Systems
CDEC, California Data Exchange Center
CV–AFS, cold vapor-atomic fluorescence spectrometer
DIFF, diffraction
DL, detection limit
DOC, dissolved organic carbon
EPA, U.S. Environmental Protection Agency
F, fractionation factor
HDPE, high density polyethylene
IC, iron chromatography
ICP–AES, inductively coupled plasma–atomic emission spectrometry
ICP–MS, inductively coupled plasma–mass spectrometry
M, Molar
MPV, most probable value
n, number of observations, number of duplicate samples
N, Normal
NAWQA, National Water-Quality Assessment (Program)
NIST, National Institute of Standards and Technology
NMWL, nominal molecular weight limit
NRP, National Research Program
NWQL, National Water Quality Laboratory
PFA, perfluoroalkoxy
PTFE, polytetrafluoroethylene
PUB, published concentration value for standard reference material
PVC, polyvinyl chloride
QAPP, Quality Assurance Project Plan
QAQC, quality assurance and quality control
REC, percentage recovery
rms, root mean squared
RPD, relative percentage difference
RSD, Relative Standard Deviation
SCDD, Spring Creek Debris Dam
SCPP, Spring Creek Power Plant
SD, standard deviation
SOC, suspended organic carbon
SRM, standard reference material
SWRS, standard reference water sample
TDS, total dissolved solids
USGS, U.S. Geological Survey
UV–vis, ultraviolet–visible spectroscopy
WPPES, Water Pollution Performance Evaluation Study
WSPES, Water Supply Performance Evaluation Study
wt, weight

Chemical Notation

Elements

Ag, silver
Al, aluminum
Ar, argon
As, arsenic
Au, gold
B, boron
Ba, barium
Be, beryllium
Bi, bismuth
Br, bromine
C, carbon
Ca, calcium
Cd, cadmium
Ce, cerium
Cl, chlorine
Co, cobalt
Cr, chromium
Cs, cesium
Cu, copper
Dy, dysprosium
Er, erbium
Eu, europium
F, fluorine
Fe, iron
Fe(II), ferrous iron
Fe(III), ferric iron
Gd, gadolinium
H, hydrogen
Hg, mercury
In, indium
Ir, iridium
Ho, holmium
K, potassium
La, lanthanum
Li, lithium
Lu, lutetium
Mg, magnesium
Mn, manganese
Mo, molybdenum
N, nitrogen
Na, sodium
Nd, neodymium
Ni, nickel
O, oxygen
P, phosphorous
Pb, lead
Pr, praseodymium
Rb, rubidium
Re, rhenium
Rh, rhodium

S, sulfur
Sb, antimony
Se, selenium
Si, silicon
Sm, samarium
Sn, tin
Sr, strontium
Tb, terbium
Te, tellurium
Th, thorium
Ti, titanium
Tl, thallium
Tm, thulium
U, uranium
V, vanadium
W, tungsten
Y, yttrium
Yb, ytterbium
Zn, zinc
Zr, zirconium

Compounds, Ions, and Minerals

Cl, chloride
$CaCO_3$, calcium carbonate; calcite (or aragonite)
CO_2, carbon dioxide
$CuFeS_2$, chalcopyrite
F^-, fluoride
FeS_2, pyrite
HBr, hydrobromic acid
HCl, hydrochloric acid
HF, hydrofluoric acid
$HgCl_2$, mercuric chloride
HNO_3, nitric acid
H_2SO_4, sulfuric acid
$K_2Cr_2O_7$, potassium dichromate
MMHg, monomethylmercury (CH_3Hg^+)
N_2, nitrogen gas
NaN_3, sodium azide
$NH_2(CHOH)_3$ HCl, tris hydrochloride
NH_3, ammonia
NO_2^-, nitrite
NO_3^-, nitrate
SiO_2, silica (or quartz)
$SnCl_2$, stannous chloride
SO_4^{2-}, sulfate
(Zn,Fe,Cd)S, sphalerite