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USGS Toxic Substances Hydrology Program, 2000

The U.S. Geological Survey (USGS) Toxic Substances Hydrology (Toxics) Program provides unbiased scientific information on the behavior of toxic substances in the Nation's hydrologic environments. Program contributions improve contaminated-site management and remediation, and enable informed decisions by industry, management and regulatory agencies, and the public.

The objectives of Program activities are to:

- Develop methods to measure contaminants and their degradation products at levels low enough to characterize environmental transport and fate;
- Quantify the physical, chemical, and biological processes that affect contaminant migration, transformation, and degradation in the environment;
- Understand the ultimate fate of contaminants in hydrologic systems and the potential long-term implications for human and environmental health;
- Describe the effects of contaminants on organisms, ecosystems, and the food chain; and
- Develop simulation models to assess potential exposure to contaminants and to design waste-disposal facilities, monitoring networks, and remediation strategies.

Investigations of representative types of environmental contamination are being conducted across the Nation and focus on:

Point-source subsurface contamination, and

Watershed- and regional-scale contamination.

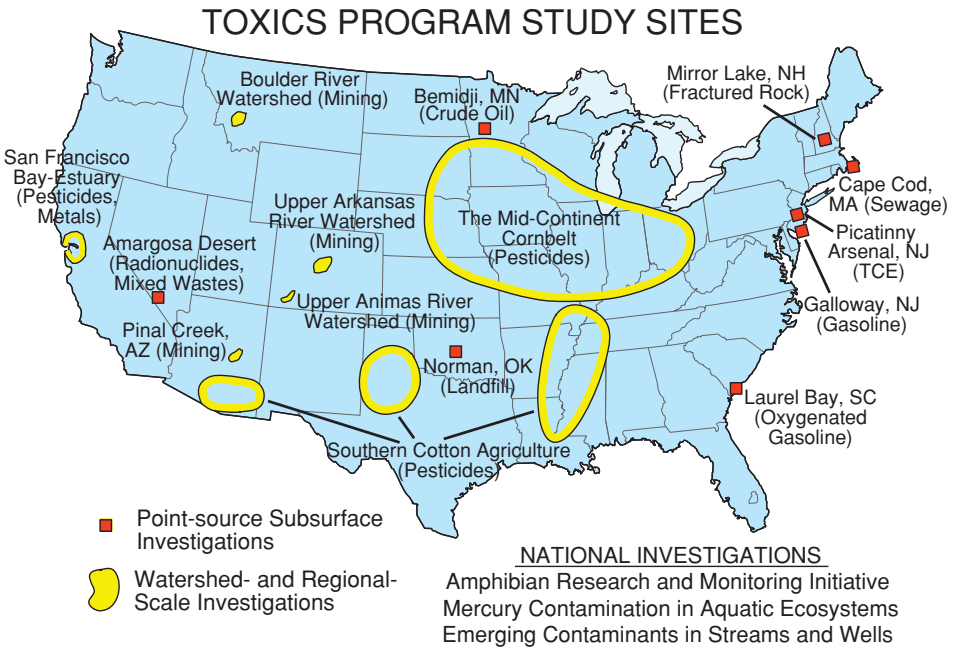
The Toxics Program coordinates with federal land-management, regulatory, and science agencies to ensure that current and future science needs are being met. The Program complements the water-quality monitoring and assessment programs of the USGS, states, and others by identifying new issues and emerging contaminants, and by developing the knowledge and methods needed to meet future monitoring needs. Scientists from universities, other federal agencies, and industry actively participate in the Program's activities.

Investigations of Point-Source Subsurface Contamination

Point-source subsurface investigations are conducted at sites representative of common contamination problems and geohydrologic settings. These investigations are long-term, field-based studies conducted by interdisciplinary research teams.

Comprehensive physical, chemical, and microbial characterizations of the sites establish field-laboratory conditions that provide fundamental knowledge of the processes that control specific types of contamination problems. This fundamental process knowledge is generalized to a wide range of field conditions by specific field and laboratory experiments at other sites with varied conditions and properties. The resulting knowledge and methods improve the effectiveness of and reduce the cost of characterization and remediation at contaminated sites across the Nation.

A unifying theme of these investigations is characterization of the natural response of hydrologic systems to contamination. This makes them ideally suited for assessing potential long-term impacts, evaluating the potential and limitations of remediation by natural attenuation, and designing remediation-performance monitoring.



Point-source subsurface investigations include:

- **Ground-Water Flow and Transport in Fractured Rock - Mirror Lake, New Hampshire.** Research develops methods for defining the movement of water and contaminants in fractured-rock aquifers. Contaminant transport and fate is fundamentally different in fractured rock than in unconsolidated (sand and gravel) aquifers. In many cases, remedial action is delayed or stymied by the complexity of these problems.

- **Landfill Leachate - Norman Municipal Landfill, Norman, Oklahoma.** Leachate from thousands of active and closed landfills across the Nation may pose a threat to ground water and its receiving waters. This research is defining the biogeochemical controls on the migration and fate of the complex mixture of chemicals found in landfill leachate.

An array of vertical multi-point sampling devices installed to monitor small-scale subsurface geochemical heterogeneities in a contaminant plume at the Cape Cod, Massachusetts, research site. Knowledge and models developed at this site are employed at many sites with sparse data.

Vertical shaft (5 feet in diameter and 45 feet deep) installed at the Amargosa Desert Research Site provides access to measure movement of moisture and contaminants in the dry zone above the water table.

- **Subsurface Contamination by Chlorinated Solvents - Picatinny Arsenal, New Jersey.** Knowledge gained from this research of the physical, chemical, and biological processes that affect transport and fate of contaminants has improved options for effective remediation of chlorinated solvents in the subsurface. Studies at the Picatinny Arsenal and at other sites have defined a range of natural microbial processes that transform chlorinated solvents to less toxic chemicals.

- **Waste Disposal and Contaminant Migration in the Arid Southwest - Amargosa Desert, Nevada.** The movement of moisture and radioactive and organic contaminants in the thick zone between the land surface and the water table is being studied. Such sites have been selected for waste disposal in arid areas. Research is improving knowledge of the potential and the mechanisms for contaminant migration in these environments.

- **Crude Oil Contamination in the Shallow Subsurface - Bemidji, Minnesota.** Knowledge gained at this site of the processes that control migration and fate of hydrocarbons in the subsurface has facilitated adoption of natural bioremediation as a widely accepted remediation alternative for hydrocarbon contamination.

- **Subsurface Gasoline Spills** may be the most frequently cited cause of ground-water contamination.
  - Conventional Gasoline -Galloway Township, New Jersey. Models and field methods have been developed to quantify natural attenuation of contaminants by biodegradation and volatilization, and to enhance natural attenuation using vapor extraction.
  - Oxygenated Gasoline - Laurel Bay, South Carolina. Use of Methyl tert-butyl ether (MTBE) as a fuel oxygenate challenges the natural attenuation paradigm for remediation of gasoline spills. MTBE is resistant to degradation and moves readily in ground water. Research has documented how MTBE persists in the subsurface and is focusing on the limits of natural attenuation and alternative remedial strategies.

- **Sewage-Contaminated Ground Water-Massachusetts Military Reservation, Cape Cod, Massachusetts.** A plume of sewage-tainted ground water downgradient of a sewage disposal site is being studied. Measurements of very small-scale variations in contaminant concentrations and results of field tracer experiments are being used to improve models of how complex mixtures of contaminants move and attenuate naturally in the subsurface.

Investigations of Watershed- and Regional-Scale Contamination

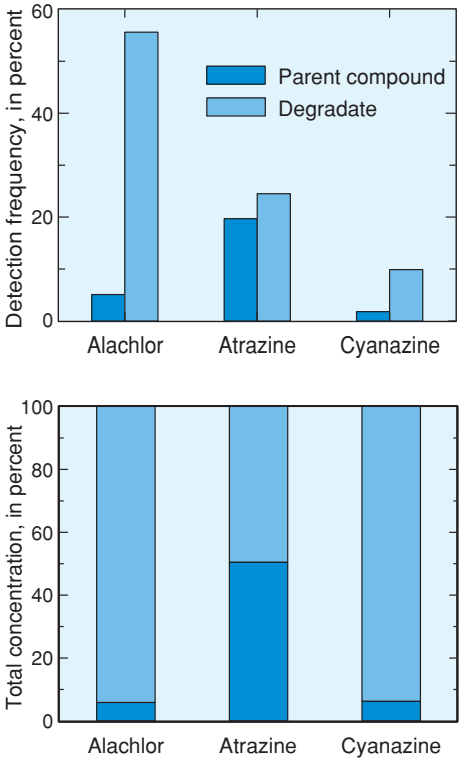
Watershed- and regional-scale investigations address contamination problems typical of specific land uses or human activities that may pose a threat to environmental and human health throughout significant parts of the Nation. These studies involve characterizing contaminant sources and their mechanisms for affecting aquatic ecosystems, such as watersheds affected by abandoned mines. These studies involve widespread detection of compounds released to the environment through common use, such as use of agricultural chemicals. Contaminants and degradation products are measured at levels below existing water-quality standards to assess whether they are actually entering the environment and to define the mixtures in which they occur. The information provided by these studies is used for developing regulatory policies and standards, for registering the use of new chemicals, for decisions on what chemicals to manufacture, and for development of usage guidelines.

San Francisco Bay is affected by urban runoff, industrial and municipal discharges, and agricultural runoff from nearby fertile river valleys. (Landsat-7 image distributed by USGS EROS Data Center, Distributed Active Archive Center.)

Investigations of watershed- and regional-scale contamination include:

- **Contamination from Agricultural Chemicals** - These investigations address large-scale agricultural activities with similar crops and/or farming practices. They focus on characterizing processes that affect dispersal of chemicals in the atmosphere, ground water, and surface water; identifying persistent degradation products; and developing methods to measure these compounds in water samples at environmentally relevant concentrations. Results are used by manufacturers, farmers, regulators, and the public. Two investigations are under way.
  - The Midwest Corn Belt -This area extends across parts of 12 states and accounts for about 65 percent of the total harvested cropland and 60 percent of herbicide use in the Nation. The project focuses on characterizing the occurrence, transport, and fate of corn and soybean herbicides and herbicide degradation products in streams, reservoirs, ground water, rainwater, and air. Results of the study have influenced agricultural chemical-use practices.
  - Cotton Agriculture Across the Southern U.S. - Pesticide usage for cotton farming typically is three to five times that for corn or soybeans. The areas of intense cotton growing under investigation–the Mississippi Embayment, the High Plains of Texas, southern Arizona, and southern California–have varied hydrologic settings and very different mechanisms for contaminant migration in the environment.

- **Human Influences on San Francisco Bay** - Like all urban estuaries in the world, San Francisco Bay receives toxic substances from a variety of natural and human sources. Studies here focus on characterizing the interrelated physical, chemical, and biological processes that affect contamination within the Bay and the delta ecosystems. Results of these studies are providing an understanding of the effects of contamination on species throughout the food chain and of the effectiveness of resource-management strategies.



More than 800 samples from 303 wells in the twelve “corn belt” states indicate that analyzing for herbicide degradates is essential for accurate estimation of the total mass and frequency of detection of total herbicide compounds.

- **Contamination from Hard Rock Mining** - Thousands of historical hard-rock mines (such as gold, copper, and zinc mines) exist across the Western United States. Mine dumps, tailing piles (the residue after ore processing), and unmined mineral deposits often contaminate the surrounding watershed and ecosystems when weathering of exposed minerals results in acid drainage and metals-enriched waters. Research is focusing on the processes that affect migration of contamination within the watershed and the resulting effects on the ecosystem. Studies are under way in two areas with differing climate and hydrologic settings. The results and methods developed at these sites are being used and demonstrated through the USGS Abandoned Mine Lands Initiative.

- **Historical Hard-Rock Mining in Rocky Mountain Terrain** - Characterizing mining contamination in mountain streams is often confounded by the facts that numerous sources can take obscure pathways to the stream, and much streamflow can occur within the coarse gravel streambed. Stream tracer methods, which were developed and tested in the **upper Arkansas River, Colorado**, have enabled identification of specific sources of stream contamination.

- Historical Hard-Rock Mining in Southwest Alluvial Basins - In this arid area, contaminants often are transported great distances by ground water, and may threaten regional water supplies. At **Pinal Creek, Arizona**, scientists are studying the geochemical evolution of a plume of metals-laden ground water and its ultimate interaction with Pinal Creek. The goal is to develop and test improved models of surface- and ground-water interaction, and ground-water transport that are transferable to other areas with different physical and chemical characteristics.

Clean sampling techniques enable measurement of mercury species at sub-nanogram per liter concentrations–essential for understanding environmental cycling and bioaccumulation in aquatic ecosystems.

Silverton, Colorado, at the mouth of the upper Animas River and its watershed in the background, where over 1,500 abandoned mine sites affect water and ecosystem quality.

- USGS Abandoned Mine Lands (AML) Initiative - The goal of this Initiative is to develop a watershed- and science-based strategy for cost-efficient cleanup of AML. The Initiative is under way in two pilot watersheds—the **Upper Animas River, Colorado**, and the **Boulder River, Montana**. USGS is working with federal land managers to clean up abandoned mines on or adjacent to public lands. The watershed approach has enabled remedial actions to target the most serious contamination sources.

- **A National Assessment of Mercury in Aquatic Ecosystems** - Recent dramatic increases in fish-consumption advisories that now are issued in 40 states demonstrate that mercury is a national concern. Aquatic ecosystems across the Nation are being studied to identify the controls on accumulation of mercury to toxic levels in the food chain. Ecosystems are being studied that are affected by varied sources (mining, natural, and atmospheric sources) and have varying potential to convert mercury to its most toxic form, methylmercury.

- **Amphibian Research and Monitoring Initiative** - Program scientists are providing information on hydrology, ambient water quality, and occurrence of contaminants in support of this national multi-agency Initiative. Monitoring is being conducted in seven regions. Information will be used to quantify amphibian population declines and to identify potential causes.

- **A National Reconnaissance of Emerging Contaminants** - New compounds continually enter the environment, either during intended use (such as pesticides and fumigants) or via industrial, human, or animal wastes (such as detergents, pharmaceuticals, antibiotics, and synthetic hormones). New low detection-level methods are being developed, and a national survey of susceptible streams and wells is under way. This effort will provide the first assessment of these compounds in the Nation's waters.

- Herbert T. Buxton

For more information on the activities of the Toxic Substances Hydrology Program, visit our web site at:

<http://toxics.usgs.gov/>

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