United States Environmental Protection Agency

Office Of Water (WH-553)

EPA841-F-93-003
November 1992
Number 3

EPA

TMDL Case Study

West Fork of Clear Creek

Key Feature: A seasonal TMDL using narrative standards for certain parameters

Project Name: West Clear Creek
Location: EPA Region VIII/Clear Creek County, Colorado/Woods Creek and the West Fork of Clear Creek
Scope/Size: Subwatershed area 19.8 mi^2
Land Type: High mountains
Type of Activity: Mine dewatering/metals mining, molybdenum
Pollutant(s): Toxics, metals
Program Integration: Regional/State/local
TMDL Development: PS, NPS
Data Sources: State and local
Data Mechanisms: Mass balance equation
Monitoring Plan: Yes
Control Measures: BMPs

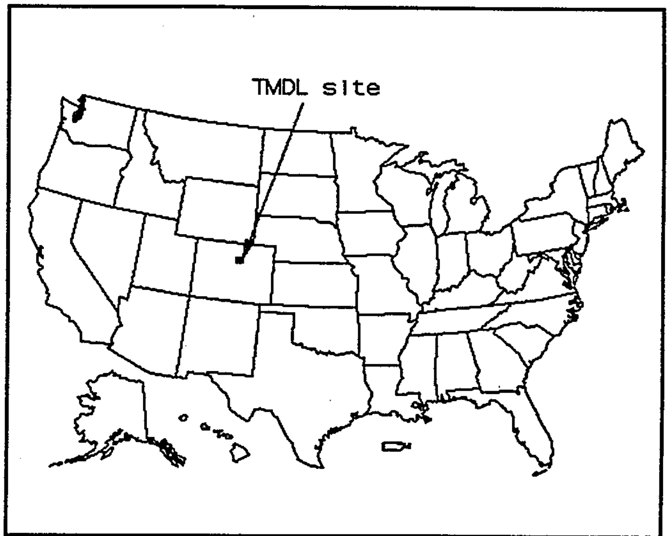

FIGURE 1. Location of the West Fork Watershed

Summary: The West Fork of Clear Creek (West Fork), impaired by trace metals from mining activities, is listed under Clean Water Act section 304(l) (USEPA, 1988). There are two mining sites along Woods Creek, which is in the West Fork drainage. The Urad mine is an inactive site, and the Henderson mine is an active site. Discharges from both mines are controlled through NPDES permits. Although the State of Colorado defined waste load allocations (WLAs) for the Urad mine and mill in 1989 (Colorado Department of Health, 1989a) and the Henderson mine and mill in 1990 (Colorado Department of Health, 1990), monitoring data collected by the mines to fulfill their permit requirements led EPA to conclude that implementation of the WLAs alone would not attain all applicable water quality standards (WQSs) for Woods Creek and the West Fork. EPA also believed that, while the State had established these WLAs, total maximum daily loads (TMDLs) had not been established. EPA fulfilled its responsibility under section 303(d) by establishing the necessary TMDLs itself. The TMDLs were calculated using a simple mass balance equation based on the effluent and stream flows and pollutant concentrations in the monitoring data. Ambient monitoring indicates that the most critical point for the metals contamination from the sites occurs close to the point of discharge. The metals concentrations tend to attenuate downstream from the source. Under these conditions the use of a mass balance equation is acceptable. The TMDLs were developed on a seasonal basis by using flows and concentrations specific to each season. This was done for economic reasons to minimize the treatment and control measures necessary to meet the specified WLAs. A combination of nonpoint and point source controls will be used to comply with permitted loads in order to meet instream water quality standards. The best management practices (BMPs) include plugging an inactive mine portal, installation of toe (groundwater) drains in the tailing piles, and construction of channels to divert runoff around the tailing piles. At the Urad site, active treatment of discharge combined with the BMPs will be the most likely means of achieving water quality standards. The Henderson site already employs active treatment, including chemical addition and settling. All water that is collected by these BMPs is treated before it is discharged to the creek. Waste loads have been allocated between the two facilities on an equal concentration basis with three seasonal allocation periods. Additional data gathering is required of the discharger to collect fate/transport data and to develop site-specific criteria for metals.

Contact: Bruce Zander, U.S. EPA Region VIII, Water Division, 999 18th St., Ste. 500, Denver, CO 80202-2406, phone (303)293-1580

BACKGROUND

Programmatic Issues

The State of Colorado defined waste load allocations (WLAs) of the pollutants listed in Table 1 for the Urad mine and mill in 1989 (Colorado Department of Health, 1989a) and the Henderson mine and mill in 1990 (Colorado Department of Health, 1990). Both of these facilities discharge tailings and water into Woods Creek, which flows into the West Fork as shown in Figure 2. Basinwide monitoring data collected by both of the mines to fulfill their permit requirements led EPA to conclude that implementation of the WLAs alone would not attain all applicable water quality standards (WQSs) for Woods Creek and the West Fork. EPA also believed that, while the State had established these WLAs for each discharger, total maximum daily loads (TMDLs) had not been established for either water body.

It is EPA's responsibility under section 303(d) of the Clean Water Act (CWA) to review and approve the TMDLs developed by a State to ensure that applicable WQSs will be met when the controls advocated by the TMDLs are implemented (USEPA, 1991a). Section 303(d) requires EPA to establish a TMDL when, after careful review, it disapproves of a TMDL that has been developed by a State. It is also appropriate for EPA to establish TMDLs where a State fails to do so in a timely fashion (see Scott vs. City of Hammond, 741 F.2d 992 (7th cir. 1984), cert.den.10S S.Ct.979). Since no approved State-developed TMDL existed for these sections of Woods Creek or the West Fork, EPA fulfilled its responsibility under section 303(d) by establishing the necessary TMDLs itself.

Since ample monitoring data were available for Woods Creek and the West Fork, and the data seemed sufficient to support determination of a TMDL that would meet water quality standards, a one-time calculation of the TMDL was planned and executed. Had there been serious doubt that the TMDL would result in the attainment of water quality standards, due to insufficient data about the resource or other reasons, a phased approach to TMDL development would have been chosen. The following sections describe the study area and the development of TMDLs by EPA.

The Resource

The Town of Empire, Colorado, is approximately 8 miles below the confluence of Woods Creek and the West Fork of Clear Creek in the southern Rocky Mountains (see Figure 2), an area characterized by high mountains and tablelands with high relief and boralf soils. Clear Creek eventually discharges into the South Platte River, downstream of Denver, Colorado. Pine, spruce, fir, bentgrass, sedge, fescue, and bluegrass are the dominant vegetation (Omernik, 1987). The land is kept primarily as forest and woodland, although there is some grazing.

TABLE 1. Colorado Numeric Water Quality Standards for Woods Creek and the West Fork of Clear Creek[a]

PARAMETER[b]	**WOODS CREEK** Segment 7	**WEST FORK** Segment 5 (below Woods Creek)
Classification	Aquatic Life (cold)/2 Recreation/2	Aquatic Life (cold)/1 Recreation/2 Agriculture
Numeric Standards		
Dissolved Oxygen:		
Normal	6.0	6.0
Spawning	7.0	7.0
pH	6.5 - 9.0	6.5 - 9.0
Fecal Coliform	2000/100 mL	2000/100 mL
Ammonia	0.02 un-ionized	0.02 un-ionized
TRC	0.003	0.003
Cyanide (free)	0.005	0.005
S as H_2S	0.002 (undis)	0.002 (undis)
Nitrite	0.05	0.05
Arsenic	0.05	0.05
Copper	0.023	0.023
Lead	0.025	0.025
Mercury	0.00005	0.00005
Nickel	0.1	0.1
Selenium	0.05	0.02
Silver	0.0001	0.0001
Zinc	0.1	0.1
Iron	1.0	1.0
Cadmium	0.002	0.003
Chromium (tri)	0.1	0.1
Chromium (tot)	0.025	0.025
Manganese (tot)	1.1	1.1
Boron		0.75
Temporary Modifications		
Cadmium	0.014	
Manganese	9.4	
Zinc	0.74	
Other Criteria		
Aluminum-chronic	0.150	0.150
Uranium-chronic	1.50	1.50
Radium 226/228	5.0 (pCi/L)	5.0

[a] Standards in effect when TMDL was established.
[b] Units in mg/L unless otherwise noted.

Average annual rainfall is approximately 30 inches, and average annual runoff approaches 20 inches (USGS, 1985).

The topography, land use, soil types, and relatively high rainfall and runoff combine to create a moderate to high erosion potential. While background contributions to

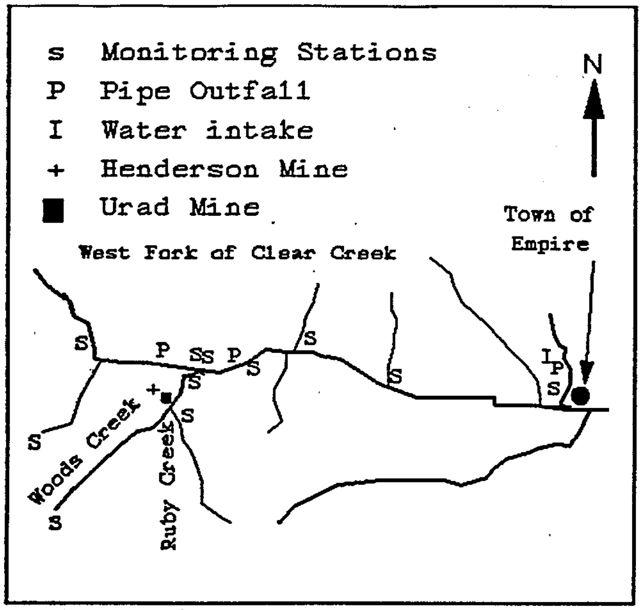

FIGURE 2. The West Fork of Clear Creek

instream pollution are small, flow conditions in the watershed significantly contribute to transport of pollutants within the watershed. Periods of high runoff can transport larger quantities of pollutants more quickly, while periods of low flow offer less instream dilution. This increases the potential impact of discharge from the mining operations.

Woods Creek is approximately 4.5 miles long, with a drainage of about 9.6 square miles. The West Fork of Clear Creek, above its confluence with Woods Creek, is approximately 4.25 miles long. Its drainage is about 10.2 square miles, and average annual discharge is approximately 1.3 cubic feet per second (cfs). West Fork flow ranges from 0.8 cfs in the winter to 4.0 cfs in the summer. Average annual flow in Woods Creek is slightly higher, averaging 2.06 cfs above the mine tailings discharges and 3.38 cfs at the mouth. Seasonal flow variations are similar for both.

Water in the upper reaches of Clear Creek is used primarily for cropland irrigation and municipal supply. The primary designated uses of the affected reaches are (1) cold water aquatic habitat and (2) recreation, although downstream uses include municipal water supply and irrigation. Most greatly threatened by metal-containing runoff from tailing piles along Woods Creek is the waterbody's use as a habitat for aquatic life.

ASSESSING AND CHARACTERIZING THE PROBLEM

Targeting and Prioritizing

Because the Urad mine and mill and the Henderson mine and mill are both located along Woods Creek, authorities suspected that priority pollutants might be present in the water column and in the bottom sediments, as well. Monitoring supported this speculation, indicating that designated uses along the upper reaches of Clear Creek, which includes the West Fork, were impaired by concentrations of trace metals originating from the mines' tailing piles. The presence of these pollutants in the West Fork caused it to be placed on the State's 304(l) list of impaired waters. Since it was on the 304(l) list and there was also a need to reissue NPDES permits for Henderson and Urad, West Fork became a high priority for TMDL development.

Monitoring and Data Bases

A number of organizations conduct monitoring along the West Fork and Woods Creek. Both the Urad mine and the Henderson mine voluntarily monitor water quality at their discharges to facilitate reissuance of their NPDES permits. The U.S. Forest Service, the U.S. Geological Survey, and the Colorado Departments of Health and Natural Resources also monitor water quality at stations along the affected reaches.

A good data base is one that has a long period of record, broad spatial coverage, and consistency in sampling and analytical methods (USEPA, 1991b). The West Fork data base is considered to have a fair period of record, broad spatial coverage within the subwatershed, and relatively good consistency in sampling and analytical methods since most of the data used to develop the TMDLs were collected by the dischargers.

The past monitoring programs for this area were not specifically designed to support development of a watershed TMDL. Nevertheless, they have proven very useful. The data were and are used to determine whether water quality standards are being met, to indicate water quality trends, to increase the accuracy of modeling, and to provide better information to revise established TMDLs, if necessary.

TMDL DEVELOPMENT

Determining the Load/Waste Load Allocation Scheme

The objective of a TMDL is to allocate loads among all of the pollutant sources throughout a watershed so that appropriate control measures can be implemented and water quality standards achieved. The numeric water quality criteria used to develop TMDLs for Woods Creek and the West Fork of Clear Creek were presented in Table 1. In addition to current Colorado Standards, numeric criteria for aluminum (Al), radium (Rd), and uranium (U) were included in the table. Since there were no numeric standards for Al, Rd, or U in effect for Woods Creek or the West Fork, criteria from the State's *Basic Standards and Methodologies for Surface Water 3,1,0 (5 CCR 102-8)* (Colorado Department of Health, 1989b) were used.

Once the physical and chemical attributes of the West Fork and Woods Creek were examined and the targeted pollutants determined, the assimilative capacity of the water bodies was estimated. The load of pollutants that may enter these or any other water bodies without violating water quality standards depends on the physical attributes of the water body, such as flow and temperature, and its chemical characteristics, such as instream concentrations of metals and hardness.

Critical, or design, flows were chosen to ensure that water quality excursions would not exceed an acceptable frequency. The 30E3 flow (30-day, 3-year, biologically-based low flow) was chosen for Woods Creek. Biologically-based flows are preferable to hydrologically-based flows, when available. The 7Q10 flow (7-day, 10-year, hydrologically-based low flow) was chosen for the West Fork, because the 30E3 flow was not available.

Upstream, or background, loadings were determined next, and all sources contributing to the load were identified. The Urad and Henderson mines are the primary sources of pollution in the area. Since there is little human activity upstream, it was not surprising to find that background concentrations of metals in Woods Creek and the West Fork are low when compared with the loadings attributed to the two mines. Efforts to control pollutant loadings, therefore, focused on the mines.

A series of data pertaining to critical stream flows, effluent discharge, and pollutant concentrations was used by EPA to define the TMDLs. EPA relied, for the most part, on data reported in the draft Henderson permit (Colorado Department of Health, 1990) and a simple mass balance equation that is used by the State of Colorado to define water quality-based effluent limits. A margin of safety (MOS), which is required within each TMDL, was incorporated through conservative assumptions. If these assumptions had been deemed insufficient, an additional MOS could have been added as a separate component of the TMDL. Figure 3 illustrates the design flows that were used and the location of the various discharges.

The TMDLs for Woods Creek and the West Fork were developed on a seasonal basis by using flows and concentrations specific to each season within the mass balance equation. The most stringent discharge limits apply only when the receiving waters are least able to safely accommodate pollutant loadings (e.g., during critical low flows). This was done for economic reasons to minimize the treatment and control measures necessary for the mines to meet their specified waste load allocations. In addition, the CWA calls for the consideration of seasonality when establishing TMDLs (see section 303(d) of the CWA). Though seasonal allocations were more cost-effective for the mine

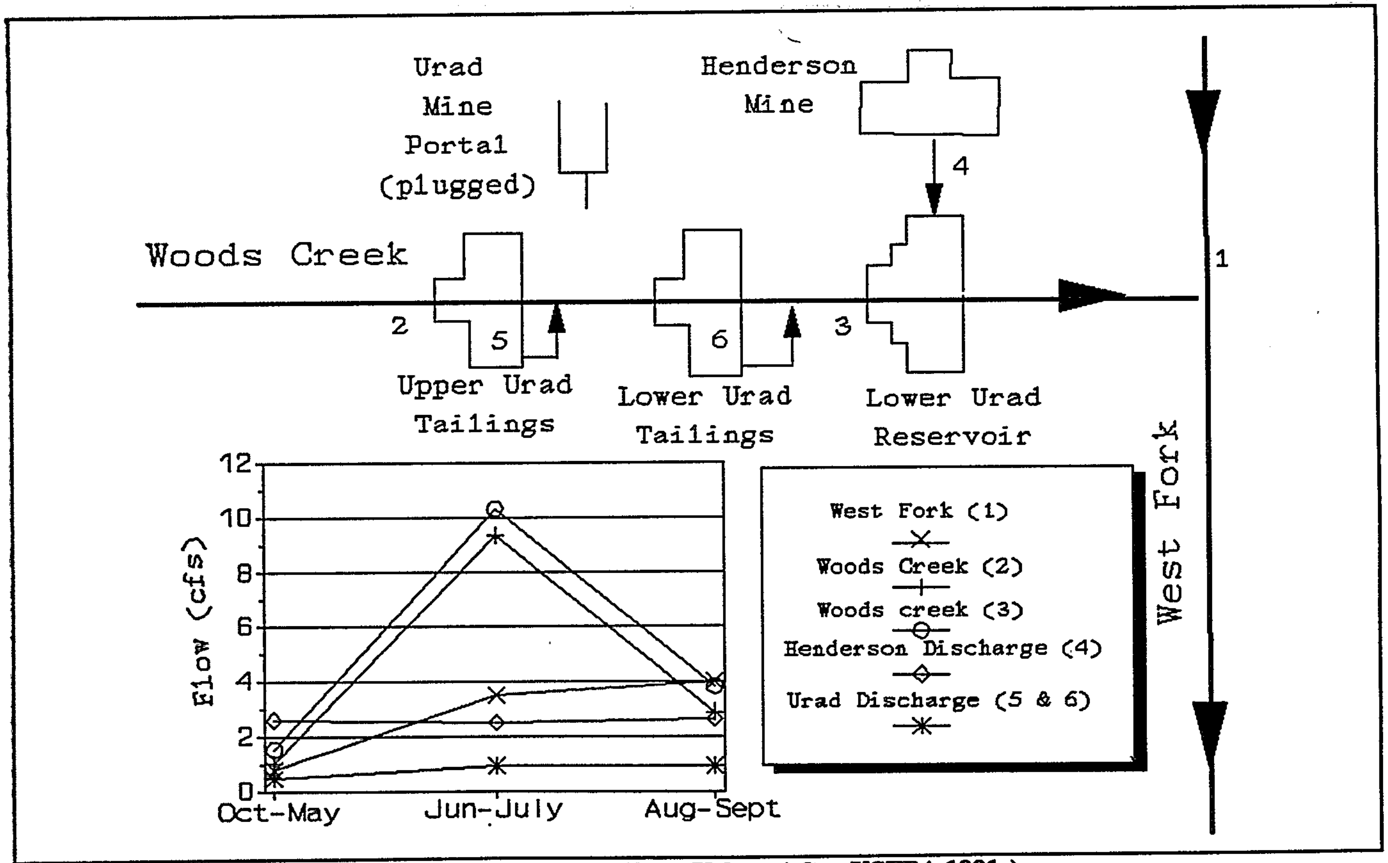

FIGURE 3. Critical Flow Values (after USEPA,1991c)

dischargers, the complexity of determining a seasonal control program increased difficulties with program administration and tracking of permit compliance.

Seasonal fluctuations in the assimilative capacity of a water body vary greatly under different conditions and need to be carefully examined when developing a seasonal TMDL. Three seasonal divisions were chosen for the West Fork. Calculations were then made for each of the parameters listed in Table 1. Figure 3 shows the relation of stream flow, in this case the critical flow, to mine discharge for the winter, summer, and fall. Discharges were based on the mean flow values reported in the State's permit rationales (Colorado Department of Health, 1989a and 1990), except for the Urad winter low flow. The winter flow was based on observed flows coming from the underdrains, as well as unaccounted inflows around the tailings, when stream flow was at its lowest (December through February). EPA allocated waste loads for cadmium, manganese, and zinc at the Urad and Henderson mines from TMDLs that were based on WQSs for the West Fork. Waste loads for the other parameters were allocated from TMDLs based on the WQSs specifically set for Woods Creek. EPA proposed that the facility discharges be allocated equivalent discharge concentrations, even though the volume of discharge differs.

Calculations were performed for each parameter to determine the effluent limits that would meet water quality standards. The most stringent limits are in place during October through May, when stream flows are lowest. From June to July stream flow for this area tends to be highest and the assimilative capacity of the stream is also increased; therefore, a larger waste load was allocated. Table 2 presents the seasonal TMDL for zinc in order to demonstrate how the total load was divided both seasonally and between the dischargers. The zinc TMDL for the West Fork was used to determine the permitted zinc WLAs for the two facilities.

IMPLEMENTATION OF POLLUTION CONTROLS

A combination of best management practices (BMPs) and point source controls was used to implement the TMDLs for Woods Creek and the West Fork. The in-place and proposed BMPs that constitute the current plan include the plugging of the inactive Urad mine portal, isolation of the tailings from runoff, and installation of toe (groundwater) drains in the tailing piles (Zander, telephone contact, May 20, 1992). Plugging the mine portal stopped flow from the mine to Woods Creek, effectively ending pollution loadings from this source. As water levels in the mine rise, the flow will redirect to the Henderson mine area, where it will receive treatment. Collection channels are some of the BMPs designed to divert runoff away from the tailing piles in order to reduce flow through them. Toe drains collect water that does pass through the tailing piles so that it can be treated to acceptable levels before it is discharged to Woods Creek. The Henderson site currently treats discharged water by chemical addition and settling. Active treatment is also being considered for the Urad site.

Ongoing studies are evaluating the most effective combination of point source and nonpoint source controls, and the current plan may be reevaluated based on the results of these studies. Initial costs for implementation of the currently proposed BMPs and point source controls, for both sites, have been estimated at less than $2 million. Cost estimates for other plans under consideration are not currently available.

FOLLOW-UP

Monitoring

Follow-up monitoring is necessary to indicate whether a TMDL adequately protects water quality and the aquatic community and to better quantify loads, verify models, and evaluate the effectiveness of controls. Point source dischargers are required to provide periodic reports regarding NPDES permit compliance. The permittee is responsible for implementing the monitoring plan and ensuring that water quality, hydrologic, and biological information is obtained. Monitoring requirements can be put into a permit as long as the data are gathered for the purpose of writing the permit limit. Although the Urad and Henderson permits do not contain specific TMDL monitoring requirements, the monitoring that is

TABLE 2. Total Maximum Daily Load for Zinc to Achieve Instream Water Quality Standards[a] (after USEPA,1991c)

	TMDL at Mouth of Woods Creek	LA Background in Woods Creek	WLA for Urad	WLA for Henderson	West Fork TMDL below Woods Creek	West Fork LA Background Above Woods Creek
Oct-May	2.53	0.06 (10.0)	0.40 (147)	2.07 (147)	2.68 (100)	0.15 (34.0)
Jun-July	8.14	0.50 (10.0)	2.13 (411)	5.51 (411)	8.79 (100)	0.64 (34.0)
Aug-Sep	4.91	0.16 (10.0)	1.27 (246)	3.49 (246)	5.65 (100)	0.73 (34.0)

[a] All values given in pounds per day with g/L in parenthesis.

conducted by the facilities to fulfill requirements for permit compliance also provides information that is useful for evaluating the effectiveness of the TMDL. The data will also enable EPA to determine what changes occur in the stream as a result of BMP installation and how long it takes the stream to react. Specifically, changes in stream flow, effluent discharge, and water quality due to plugging of the mine portal will be monitored, and new discharges, such as those from the toe drains, will be monitored to determine discharge characteristics. Since the TMDL process is iterative and monitoring data are crucial to updating and, if necessary, revising TMDLs, future planning activities will benefit from these data.

Monitoring on West Fork, immediately below Woods Creek, has already shown that plugging the Urad mine portal has resulted in improved stream biology. A dramatic increase in the density and variety of macroinvertebrate populations and sharp growth in the trout population are a strong indication that the BMP is helping to achieve water quality objectives.

Considerations

A TMDL is based on a specific set of water quality and flow data and on State water quality standards. When water quality standards are modified or additional data become available, it may be necessary to revise the TMDL to reflect these changes. When there is more information on the upper West Fork drainage, more sophisticated modeling that can account for metals speciation and partitioning, the role of the lower Urad Reservoir, and variations in loading over time is planned.

Recently gathered data have already indicated that the seasonal delineation should be modified, changing the grouping of months to more closely reflect the hydrologic cycle of the Woods Creek basin. The State recently developed updated TMDLs for metals in the West Fork based on revised water quality standards and re-evaluated design flows. The level of point source treatment that is called for in the updated TMDLs is particularly intense because of more stringent standards for the receiving water due to limited dilution at low flow. The seasonal delineation has not been redefined by the State's TMDLs. These TMDLs were incorporated into an updated permit for the Urad site that became effective June 1, 1992 (Colorado Department of Health, 1992). A petition may be submitted to open the Henderson permit for re-evaluation based on the more recent water quality criteria.

REFERENCES

Colorado Department of Health. 1989a. NPDES Permit Number CO-0041467. Water Quality Control Division, Colorado.

Colorado Department of Health. 1989b. *Basic Standards and Methodologies for Surface Water 3.1.0 (5 CCR 1002-8)*. Water Quality Control Division, Colorado.

Colorado Department of Health. 1990. Draft NPDES Permit Number CO-0000230, Public Notice. Water Quality Control Division, Colorado.

Colorado Department of Health. 1992. NPDES Permit Number CO-0041467 (Amended). Water Quality Control Division, Colorado.

Omernik, J.M. 1987. Ecoregions of the conterminous United States. *Annals of the Association of American Geographers* 77(1):118-125.

USEPA. 1988. *Final guidance for implementation of requirements under section 304(l) of the Clean Water Act as Amended.* U.S. Environmental Protection Agency, Office of Water Regulations and Standards and Office of Water Enforcement and Policy. Washington, DC.

USEPA. 1991a. *Guidance for water quality-based decisions: The TMDL process*. U.S. Environmental Protection Agency, Office of Water, Washington, DC.

USEPA. 1991b. Workshop on the water quality-based approach for point and nonpoint source controls. Meeting summary. U.S. Environmental Protection Agency, Office of Water, Washington, D.C.

USEPA. 1991c. NPDES and statement of basis for permit number CO-0041467 for Climax Molybdenum Company - Urad Mine and Mill. U.S. Environmental Protection Agency, Office of Water, Washington, DC.

USGS. 1985. *National water summary for 1985*. U.S. Geological Survey. Water-Supply Paper 2300.

This case study was prepared by Tetra Tech, Inc., Fairfax, VA, in conjunction with EPA Office of Wetlands, Oceans and Watersheds, Watershed Management Section. To obtain copies, contact your EPA Regional 303(d)/TMDL Coordinator.