



NONPOINT SOURCE SUCCESS STORY

Arizona

Private Landowner Helps Control Mine Waste, Restoring Mule Gulch

Waterbodies Improved

Polluted runoff from historic mining introduced metals and acidic water into Mule Gulch, causing metal concentrations and pH levels to fail state water quality standards. As a result, two segments of Mule Gulch were added to the state's impaired waters list for pH and metal impairment in 1998. Remediation efforts conducted in the early 2000s reduced acid mine drainage (AMD) and improved pH and metal levels. Due to this improvement, Arizona removed four pollutants along two segments of Mule Gulch from the impaired waters list in 2014.

Problem

Mule Gulch is in Bisbee, Arizona, in southeastern Arizona. Mule Gulch flows east from the Mule Mountains towards Whitewater Draw (Figure 1).

Mine tailing waste piles, tainted road surfaces, stream sediment and smelter fallout caused increased metal concentrations and low pH levels in Mule Gulch. Mule Gulch first appeared on Arizona's 1998 List of Water Quality Limited Waters as having specific water quality violations due to dissolved copper, cadmium, dissolved zinc and pH (low). Arizona Department of Environmental Quality's Total Maximum Daily Load Unit sampled the stream during 1998 and 1999, and the data obtained supported this assessment of impaired water quality in Mule Gulch.

Because of rapid changes in water quality and flow observed during a July 1999 precipitation event, an intensive sampling and monitoring system (e.g., stream gages, data loggers, probes) was established in late 1999 and early 2000 (Figure 2).

In 2002 Reach 090A (headwaters to Bisbee WWTP) was added to the 303(d)-list for dissolved copper and zinc. Dissolved copper was as high as 12,000 micrograms per liter ($\mu\text{g/L}$) (185 times the aquatic and wildlife standard) and exceeded standards in 20 of 36 samples (55 percent) in Mule Gulch. Dissolved zinc was as high as 3760 $\mu\text{g/L}$ (10 times the aquatic and wildlife standard) and exceeded standards in 14 of 36 samples (about 40 percent). Water quality standards for cadmium, zinc and copper are hardness dependant, while standards for pH require values between 6.5 and 9. In 2004 the existing segments were further separated into Reach 90A (headwaters to above Lavender Pit), Reach 90B (Lavender Pit to Bisbee WWTP), and Reach 90C (Bisbee WWTP to Hwy 80 Bridge).

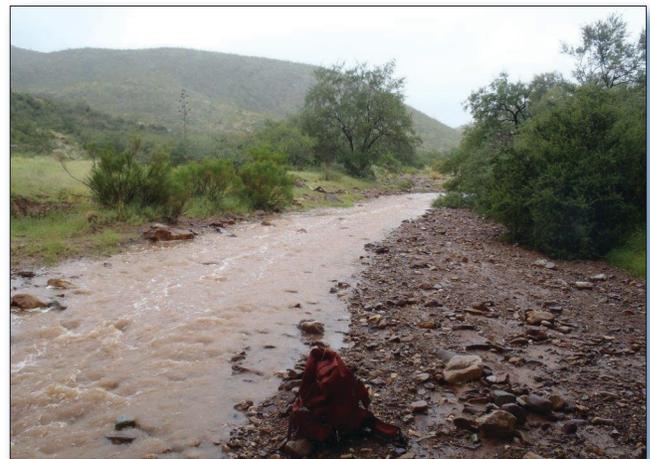


Photo by Jason Sutter, AZ DEQ (9/2016)

Figure 1. Mule Gulch is near Arizona's southern border.

Project Highlights

The following restoration projects were implemented by Freeport McMoRan Corporation (FMC), a private mining company:

1. Lower Mule Gulch (2003). Activities included removing sulfidic materials from drainage, capping sulfidic slopes with inert fill, and constructing riprap and grouted riprap channels for erosion control.
2. Upper Mule Gulch (2004). Activities included capping of sulfidic fill with inert cover and placement of low flow interceptor on north side of channel.
3. "C" Canyon (2006). Mine stockpiles were removed and the footprint was covered with inert capping.
4. Mission Canyon (2007). A center dividing wall was constructed in a concrete culvert to divert mine-contacted water from Mule Gulch flows. The mine-contacted waters are confined to the north side of the channel and are then diverted to the Lavender Pit by a 60-inch diameter pipe under Highway 80.

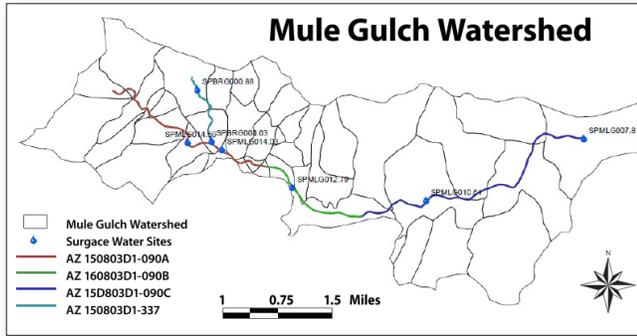


Figure 2. Seven water monitoring sites were established to assess water quality in Mule Gulch.

5. Mule Gulch at NW #7 (2009). Activities included removal of stained sediments in channel, removal of sulfidic stormwater management berms and replacement with inert fill, and placement of riprap and grouted riprap for erosion control.
6. Dubacher Canyon (2012). Activities included removal of sulfidic stockpile from Dubacher Canyon, and channeling of stormwater flows from Dubacher Canyon to the Lavender Pit.
7. Soils VRP (2014). Activities included removal of smelter fallout and other mine-related waste from the soils of privately held properties, and the placement of clean backfill.

FMC actions have included removing contaminated material, adding erosion control measures, capping

waste, and rerouting stormwater. All have had a net effect of improving water quality in Mule Gulch as discussed below.

Results

FMC has implemented several projects within the last decade that have improved conditions in Mule Gulch (Table 1). Through this work, zinc, cadmium and pH are now meeting water quality standards in two Mule Gulch segments, 15080301-090B and 15080301-090C, prompting Arizona to remove them from its impaired waters list in 2014.

The Upper and Lower Mule Gulch and Mission Canyon projects described above had the most impact by keeping stormwater runoff from mineralized areas from entering Mule Gulch. Although significant reductions in dissolved copper concentrations have occurred, the copper impairments will remain for three Mule Gulch reaches in the watershed.

Partners and Funding

The restoration of Mule Gulch was funded by FMC; these actions have had a net effect of improving water quality in Mule Gulch. Arizona Department of Environmental Quality supported water quality monitoring and reporting.

Table 1. Post-restoration data^{a,b} on reaches 90B and 90C (sampling sites SPMLG012.79 and SPMLG07.81, respectively).

Date	Reach 90B pH	Reach 90C pH	Reach 90C Dissolved Cadmium (mg/L)	Reach 90C Dissolved Zinc (µg/L)
9/7/16	7.95	8.23	0.072	6
8/9/07	8.13 (8.2)	No data	1.88	120
7/31/07	8.00	8.00	ND (ND)	ND (ND)
7/20/07	7.08 (6.8)	7.17 (6.9)	ND	ND
3/23/07	7.16	No data	ND	ND

^a ND = nondetect; below method reporting limit

^b Data in parentheses indicate duplicate samples



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