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Analysis of the Transport and Fate of Metals Released from the Gold King Mine in the Animas and San Juan Rivers

EXECUTIVE SUMMARY

Executive Summary

On August 5, 2015, a field investigation of the Gold King Mine (GKM) near Silverton, CO, inadvertently triggered an estimated release of 3 million gallons of acidic, mine-impacted waters into the Animas River. These waters had been dammed by a collapsed mine structure and rock at the mine entrance, causing the waters to back up and become pressurized. This report is a scientific evaluation that focuses on understanding the river conditions before the GKM release; the movement of the GKM release through the river system; and what has happened to the river since the time of the event.

Specifically, EPA looked at: (a) the GKM effects on water quality after the release; (b) whether or not the water quality returned to pre-event conditions; (c) whether or not there was a second wave of contamination following storms and/or spring snow melt when high flows could remobilize deposits; and (d) whether or not any remaining GKM impacts could be detected given the legacy contamination from historic mining in the region.

The initial GKM release first flowed into nearby Cement Creek. Cement Creek flows 12.5 km (8 mi) into the Animas River near Silverton, CO. The Animas River then flows 203 km (126 mi) where it joins the San Juan River near Farmington, NM. The San Juan river flows 347 km (215 mi) until it flows into Lake Powell in Utah. The GKM release crossed three state lines and three tribal lands over a 9-day period for an approximate total distance of 550 km (342 mi). This river system has a long history of leaking mine waste contamination from hundreds of old and abandoned mines throughout the region. Acid mine waste contamination historically has settled along these river banks and in the sediment beds. High river flow or snow melt can remobilize the contaminants, impacting water quality throughout the river system to Lake Powell.

Historically, mine waste had been piled up outside the Gold King mine entrance for many years. The initial load of metals contained in the GKM release increased significantly as the mine water traveled down the hillslope and along Cement Creek, picking up additional metals from the waste pile and streambed along the way. EPA estimates that approximately 490,000 kg (close to 540 tons) of metals, mostly iron and aluminum, entered into the Animas River over the 9-hour period of the release.

GKM Release

9 hours of pressurized mine impacted waters scoured the hillside with approximately **1% total metal load** coming from inside the mine and **99% total metal load** from a waste pile located on the hillslope outside the mine.

EPA estimates that **approximately 490,000 kg (close to 540 tons) of metals**, dominated by iron and aluminum, entered into the Animas River over the 9-hour period of the release.

The total amount of metals entering the Animas River following the release was comparable to the amount of metals carried by the river in one to two days of high spring runoff.

Historical Sampling Data

EPA researchers analyzed hundreds of water quality samples and approximately 50 sediment samples provided by USGS

Post Gold King Mine Release Data

EPA researchers analyzed:

- 1758 total and dissolved water samples collected by EPA, states and tribes through August 2016
    - Approximately 56% of samples came from the Animas River and 44% from the San Juan River
- 963 sediment samples collected by EPA, states and tribes through September 2016
    - Approximately 66% of samples came from the Animas River and 34% from the San Juan River and Lake Powell
- Samples were collected from 294 sites throughout the total River system.

Animas River in Colorado
(River km 0 to 150):

- returned to pre-event levels in the weeks after the release
- stayed at pre-event levels through the winter

Animas River in New Mexico
(River km 150 to 192):

- Initially returned to pre-event levels after 15 days
- Most dissolved metals increased after the August 2015 storm

San Juan River
(River km 193 to 540)

- Increased Aluminum and Iron in Animas were carried into San Juan

The iron and aluminum reacted with the river water to cause the characteristic bright yellow color that was visible for days as the plume traveled down the river system.

EPA estimates that one percent of the metals came from inside the mine itself while 99 percent of the metals were scoured from the waste pile on the hillslope and the Cement Creek streambed. Approximately 15,000 kg, or 3 percent, of the original total metal mass was initially in dissolved form and 475,000 kg was in a fine, clay-like solid form. Generally, dissolved metals are considered more toxic, more reactive, and more mobile than solid metals.

EPA analyzed data from samples collected by EPA, states and tribes from the affected rivers during and after the GKM release to estimate where and when the plume passed, and what happened to the metal contaminants as it flowed, like historic acid mine contamination, through the river system to Lake Powell. To allow for a robust comparison to historic conditions, EPA scientists reviewed U.S. Geological Survey (USGS) historic studies of acid mine drainage under similar high flow scenarios. According to the analysis, the volume of the GKM release was equivalent to four to seven days of ongoing GKM acid mine drainage. The total amount of metals entering the Animas River following the release was comparable to the amount of metals carried by the river in one to two days of high spring runoff; however, the concentration of metals during the peak of the plume passage was much higher than historic spring runoff conditions.

As the plume traveled downstream, the metal concentrations within the plume decreased as it was diluted by river water and as some of the metals in the plume settled to the river bed. EPA estimates that approximately 90 percent of the solid metal load initially settled in the Animas River bed and that dissolved metal concentrations decreased to pre-event conditions by the time the plume flowed into the San Juan River. Although the GKM metal deposits were highly visible as a bright yellow color, they were on average similar to existing metal concentrations stored in the river sediments from years of mining activity in the region.

The GKM plume flowed into the sediment-rich San Juan River where the small amount of remaining solid metals mixed with the large existing sediment load. The San Juan River bed naturally has low metal concentrations; however, the river has a very large amount of mobile sediment during storms and

high flow events. Because of this, water quality in the San Juan River is strongly related to the amount of sediment in the water; the concentrations of metals in the sediment in the San Juan River can exceed the concentrations of all the metals found in the GKM plume. On the day the GKM plume passed, lead and arsenic were found to be elevated relative to background levels of the San Juan River. Relatively higher levels of lead, and to a lesser extent arsenic, were characteristic of the GKM release metals. Although elevated, these metals were not uniquely higher than what is typically seen in high flow periods such as a major storm or spring snowmelt.

Data indicate that water quality returned to pre-event conditions within two weeks after the GKM plume passed. Three weeks after the mine release, a large storm centered in Aztec, NM, flushed some of the deposited GKM metals from the lower Animas River and the San Juan River to Lake Powell. After the storm flushed these deposits, water sampling showed elevated levels of dissolved aluminum and iron in both rivers that persisted through the 2015 fall months. During this time, the dissolved metals exceeded tribal aluminum human contact-related criteria, and Utah aquatic chronic criteria, and New Mexico irrigation criteria.

Samples collected did not exceed EPA's recreational screening levels. Some metal concentrations contributed to sporadic exceedances of state and tribal water quality criteria at times for nine months in some locations. EPA and states establish water quality standards based on the use of the water to protect human health and aquatic life. In addition to these factors, tribal standards also consider tribal cultural uses, and are often more stringent than state or federal standards. Thus, tribal standards were exceeded more often, even during average flow periods because of historical background contamination. Metals from the GKM release also may have contributed to some exceedances during the 2016 spring snow melt. Other exceedances may reflect longstanding issues of mining wastes in the region as well as natural levels of common elements such as aluminum and iron in soils and rocks in the area. EPA will continue to work with states and tribes to interpret and respond to these findings.

There were no reported fish kills in the affected rivers, and post release surveys by multiple organizations have found that other aquatic life do not appear to have suffered harmful short-term effects from the GKM plume. Longer-term monitoring continues to evaluate potential chronic impacts from the GKM release deposits that may have been added to ongoing impairment from legacy mining activity.

As part of the monitoring study, EPA explored whether or not the metals from the GKM release could have potentially contaminated water supply wells in the floodplain aquifers of the Animas. There are hundreds of water supply wells located in the floodplain of the Animas River in Colorado and New Mexico. EPA analysis showed that only a small number of wells potentially draw in water from the river because groundwater in this area generally flows into the river, rather than the river water flowing into the wells. The concentrations of metals in well-water samples collected after the plume passed did not exceed federal drinking water standards.

The 2016 spring snowmelt period remobilized metals that had settled in the sediment in the river system. EPA's analysis showed concentrations of metals in the water and sediment were elevated throughout the Animas and San Juan Rivers. While some of the metals in the upper Animas were expected from regional acid mine drainage contamination as established by the USGS in earlier studies, there was strong evidence that a portion of the metals came from recent streambed

deposits associated with the GKM release. Concentrations were low, but the duration of snowmelt strongly implies that the mass of GKM metals that had settled in the river beds was moved downstream to Lake Powell by the end of the snowmelt period. Monitoring through the summer and fall of 2016 shows that metal concentrations in water and sediment have returned to pre-event conditions throughout the Animas and San Juan Rivers. Monitoring throughout spring 2017 should confirm our finding that, similar to historic acid mine contamination, the remaining contamination from GKM has flowed through the river system to Lake Powell. The USGS and state partners will be studying core samples from Lake Powell to evaluate metal contamination in the sediments.

Summary of key findings from the fate and transport of the GKM event:

- This river system has a long history of leaking mine waste contamination from hundreds of old and abandoned mines throughout the region.
- EPA analysis indicates as of Fall 2016 contamination of metals from the GKM release have been transported through the Animas and San Juan River system to Lake Powell.
- The GKM release included aluminum, iron, manganese, lead, copper, arsenic, zinc, cadmium, and a small amount of mercury.
- The Gold King Mine release was equivalent to four to seven days of ongoing GKM acid mine drainage. The total amount of metals entering the Animas River following the 9-hour release was comparable to the amount of metals carried by the river in one to two days of high spring runoff. However, the concentrations of metals were higher than historical acid mine drainage.
- Samples collected did not exceed EPA's recreational screening levels. Some metal concentrations contributed to exceedances of state and tribal water quality criteria at times for 9 months in some locations. EPA and states establish water quality standards based on the use of the water to protect human health and aquatic life. In addition to these factors, tribal standards also consider tribal cultural uses, and are often more stringent than state or federal standards. Thus, tribal standards were exceeded more often, even during average flow periods because of historical background contamination. Metals from the GKM release also may have contributed to some exceedances during the 2016 spring snow melt. Other exceedances may reflect longstanding issues of mining wastes in the region as well as natural levels of common elements such as aluminum and iron in soils and rocks in the area. EPA will continue to work with states and tribes to interpret and respond to these findings.
- The 2016 spring snowmelt remobilized the metals that had settled in the sediment throughout the river system. This was expected based on historic observations. Some of the metals were due to the GKM release. Concentrations of metals in both sediment and water returned to pre-event concentrations by the end of the snowmelt period.
- Ground water modeling suggests that a few wells located in the floodplain within 100 meters of the Animas River had the potential to draw river water, possibly including dissolved metals, during the time the GKM release plume passed. Most ground water in the affected area flows towards the river rather than from the river toward the wells. The

concentrations of metals in well-water samples collected after the plume passed did not exceed federal drinking water standards.

- Results from this analysis will inform future monitoring by EPA, states and tribes, including decisions about what is monitored; where monitoring takes place; and when monitoring takes place.
- EPA is committed to working with States and Tribes in the areas affected by the Gold King Mine release to ensure the protection of public health and the environment.