# Toxicity of the Creeks and Rivers of the Animas River Valley

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# Abstract

The Gold King Mine "blowout" of August 2015 created a lot of tension for the cities of Silverton and Durango. The Gold King Mine blowout was a giant problem for the cities of Silverton and Durango, and even temporarily effected Farmington's amount of power. Up to three million gallons of mine water was released, all of which was full of iron oxyhydroxide that flowed all the way into Utah. The water even turned orange, bringing a lot of national attention to the Animas River, the river that was affected greatly by this spill.

In this project, I will test the water from various creeks with *Daphnia magna* and lettuce seeds from water bodies around Durango and Silverton, *Daphnia* being small crustaceans that are usually used in feeding aquarium fish. Along with these tests, I will find the PH and TDS of the samples. *Daphnia magna* and lettuce seeds are commonly used in bioassays for water quality and toxicity. I expected to discover that the water bodies with mine water feeding into them would be toxic, and this hypothesis has proven to be accurate.

My results showed the Gold King Mine output, Cement Creek, and Mineral Creek grew short lettuce seed roots, did not support suitable life for *daphnia magna*, had low PH, and had high TDS. These water bodies had mines feeding into them, which supports my hypothesis. My results also showed that the least toxic water bodies were Junction Creek, Cascade Creek, and Deer Creek. Likewise, all of these creeks had long lettuce seed roots, supported suitable life for *Daphnia magna*, had high PH, and had low TDS. These creeks had very few mines feeding into them.

# Introduction

In this project, I will be finding the toxicity of 10 various creeks around the Animas River Valley, from above Silverton to Durango. (although it may affect cities south of it that are connected to the Animas River)

I will be using lettuce seeds, *Daphnia magna*, a TDS meter, and a PH meter as testers in this project. *Daphnia magna*, or water fleas are going to be one of the things that I will test with in this project. *Daphnia* are small crustaceans that are usually used for feeding aquarium fish, and they will be used to find if the samples are suitable for animal life. *Daphnia* and lettuce seeds are popular to use in bioassays. A bioassay is an experiment that is used to test the amount of something in a water sample using plants or animals.

These results will show me which creeks in the Animas River Valley are potentially toxic. These creeks and rivers are the Gold King Mine Output, Cement Creek, the Animas River before Cement Creek, Mineral Creek, Deer Creek, Cascade Creek, Hermosa Creek, Junction Creek, Lightner Creek, and the Animas River in Durango for my control. My hypothesis is that the creeks with mines feeding into them will be more toxic than the others because of the metals and chemicals from the mines.

# Hypothesis

If I test for the toxicity of the various creeks in the Animas River Valley with *Daphnia magna* and lettuce seeds, then I will find that the creeks and rivers with mines feeding into them will be more toxic than the others because of the chemicals and minerals that feed into them.

# Research Paper

On August 5, 2015, just north of Silverton, Colorado, the Gold King Mine released up to three million gallons of water rich in iron oxyhydroxide into Cement Creek, which later flowed into the Animas River. The high-mineral content water was so rich with chemicals that the water appeared as bright orange. The Animas River, which received the water from Cement Creek was greatly affected by this "mine blowout" and the river flowed all the way into Lake Powell, Utah.

This blowout was also investigated by the Environmental Protection Agency, or EPA, and was a major problem for the cities of Silverton, Durango, and Farmington, for they depend on the Animas River for clean water. It was also a problem for the Four Corners Power Plant, which receives it's water from Morgan Lake. Morgan Lake received it's water from The San Juan River. The San Juan River then received it's water from the Animas. But, the problem was, the Four Corners Power plant did not take any water from Morgan Lake when there was anything wrong with the water's quality, therefore it was even a problem for Farmington's electricity as well.

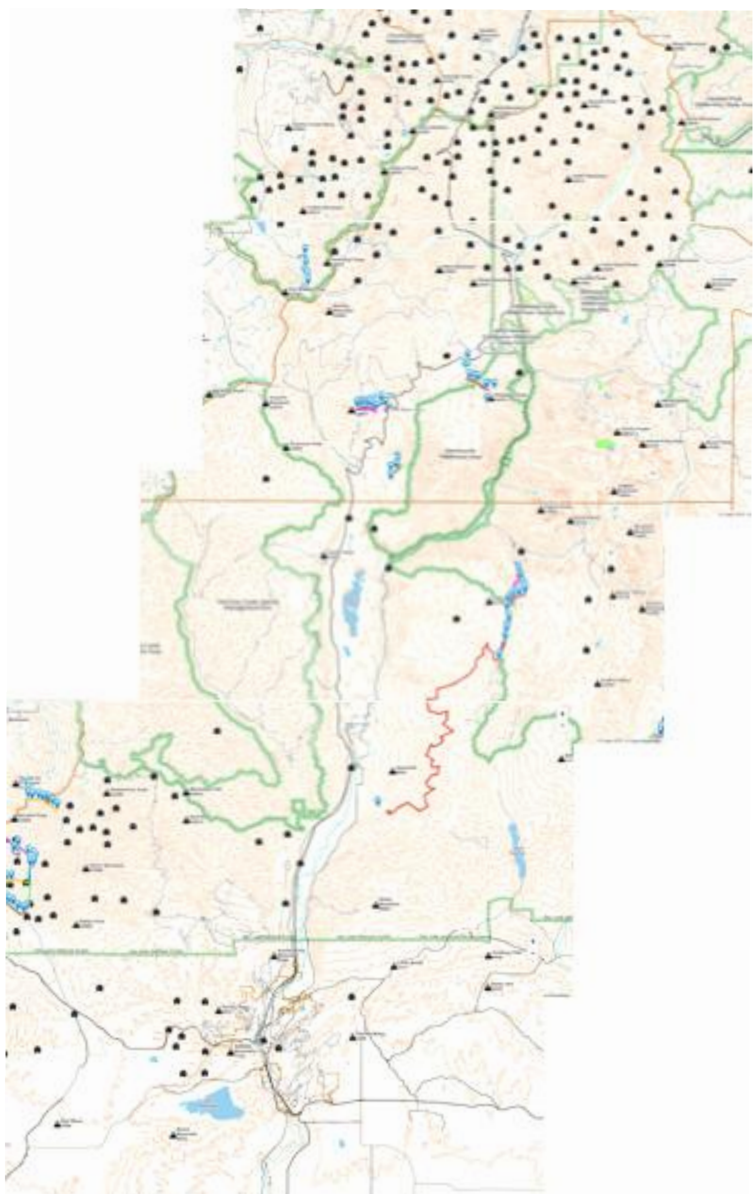
The Gold King Mine blowout was fixed as well as caused by the EPA. The EPA had previously been damming the water seeping from the mine. But when all the water was coming to be too much for the dam, it burst and the mine water got swept into the Animas River. This release of mine water was partly caused by a series of problems that had been happening to the mine for the past several decades, but this had been the biggest outburst yet. Over years, this toxic water had seeped out little by little, but at this particular event, it had reached it's worst. This is one reason that finding the toxicity of the creeks and rivers flowing into the Animas River Valley is important towards the cities of Silverton, Durango, and Farmington.

Mining cannot only harm us as humans, but is also a major issue to the wildlife of the area. Plants and animals also depend on the water they drink and use to grow with to be clean. Some wildlife species may have a strong immune system, for they may be able to adapt to the water's quality. But this is a different story when it comes to blowouts like the Gold King Mine.

One common chemical distributed by mines that can be poisonous to plants and animals is cyanide.

According to "Cyanide Hazards to Plants and Animals from Gold Mining and Related Water Issues," "…All these cyanide-containing water bodies are hazardous to wildlife, especially migratory waterfowl and bats, if not properly managed. Accidental spills of cyanide solutions into rivers and streams have produced massive kills of fish and other aquatic biota. Freshwater fish are the most cyanide-sensitive group of aquatic organisms tested…"

The concentration of mines in a particular area can sometimes contribute to the toxicity of a certain body of water. The Gold King Mine incident is a great example of this. Mines can contribute to the toxicity of water bodies by contaminating the water with harmful chemicals that had seeped from the mine, then flowing them further and further downstream. According to a map of the Animas River Valley on Gaia GPS, some of the larger concentrations of mines in the Animas River Valley include large areas above Silverton, Colorado. Below is a map of the Animas River Valley from Gaia GPS (The small black dots or mine cart symbols on the map represent mines.)



Luckily, blowouts like the Gold King Mine are being treated with care. Where the mine flows into Cement Creek, there is a station provided by the EPA where the water is being treated even today, before it flows any further downstream. There are many ways that this can be treated, such as capturing drainage water, allowing water to evaporate in ponds, recycling water used to process ore, installing covers and liners on the waste rock, or intercepting and diverting surface water.

According to "miningfacts.org, "There are a number of different treatment technologies available to clean contaminated water; these technologies can be described as either active or passive. Active treatment technologies require the input of energy and chemicals, and passive treatment use only natural processes such as gravity, microorganisms, and/or plants in a system, any one of which requires infrequent but regular maintenance."

In this project, I am going to be finding the toxicity of the various creeks that flow into the Animas River in the Animas River Valley. (I am going to be using *Daphnia magna* and lettuce seeds in a bioassay format to determine the toxicity of these creeks.) My hypothesis to this project is that if I test for the toxicity of the various creeks in the Animas River Valley with *Daphnia magna* and lettuce seeds, then I will find that the creeks and rivers with mines feeding into them will be more toxic than the others because of the chemicals and minerals that feed into them.

# Materials

- 23 8.5 inch petri dishes
- 11 small mason jars with lids
- Water from various creeks (Lightner Cr, Hermosa Cr, etc)
- 1 gallon of distilled water
- 1 gallon of bleach
- 1 small ruler
- 1 pair of tweezers
- 11 pipettes
- TDS meter
- PH meter
- Thermometer
- Waders (optional)
- Lettuce seeds (at least 22 count)
- *Daphnia magna*
- 1 roll of paper towel
- Scissors
- Sharpie (permanent marker)

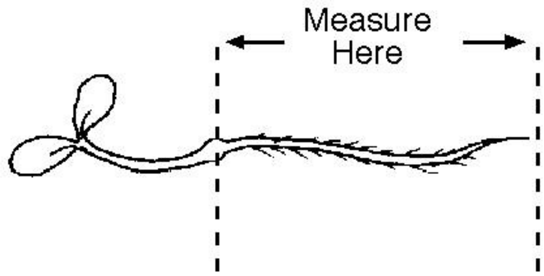
# Procedure

1. Get materials (mason jars, TDS and PH meters, etc)
2. Label the mason jars from numbers 1-10 on the lids and jars.
3. Go to various creeks and rivers and do the following:
    A. Wade out to the middle of the creek or river and fill the jar with water.
    B. Wade back to the shore and set the jar on a level or flat surface.
    C. With the water still fresh, use the PH meter to find the PH of the water and record data (keep in mind that the PH meter must be calibrated before use)
    D. Use the TDS meter to find the total dissolved solids of the water and record data.
    E. Record the following: time, GPS coordinates, and temperature in Fahrenheit.
4. Once you have retrieved the water samples, complete the two following tests with lettuce seeds and *daphnia magna* (aka water fleas)

## Lettuce Seeds

1. Get materials (distilled water, petri dishes, lettuce seeds, etc)
2. Use pair of tweezers to place the lettuce seeds in a petri dish and fill the dish with 1 ml of bleach and 9 ml of distilled water.
3. After the solution with the lettuce seeds sets for 20 minutes, rinse 5 times with distilled water. This process removes any fungi that may have formed on the seeds.
4. Rip off 1 piece of the paper towel and cut it into 16 rectangular pieces each of which are the same size with scissors.
5. Using the tweezers, put two lettuce seeds on each piece of paper towel and fold the paper towel over, covering the seeds.
6. Put each of the paper towels with seeds in a petri dish and number the petri dishes corresponding to the numbers for the various water samples. Then add the water in the corresponding dish (add 5 ml of river water per dish)
7. Put all of the petri dishes in a plastic container (1.5ft x 1ft) and let the seeds sit in a dark place for 5 days.

8. After 5 days, check the seeds and how much they grew in mm (be sure to check their length




from the seed to the end of the tail and not the stem as shown in the drawing below)
9. Finally, find the average between the two seed lengths and analyze the results.

## *Daphnia Magna* (aka Water Fleas)

1. Get materials (mason jars, *Daphnia magna*, petri dishes, etc) Keep in mind that the *Daphnia* will need to be submerged in water at all times.
2. Fill the mason jars with 20 ml of river water according to the corresponding number.
3. Carefully transfer *Daphnia* into a mason jar (if you had not done so already)
4. Choose 110 *Daphnia* (not resting with eggs) in which to conduct the experiment.
5. Fill and label the petri dishes, corresponding to the water samples.
6. Use a pipette to select the *Daphnia* and place them in the petri dishes ( Put 10 *Daphnia* in each, under the water's surface) Be sure to have only 3 ml of the water in which the daphnia came in so that it does not create any flaw in the experiment.
7. Record data for the *Daphnia* after 20 minutes, 1 hour, 4 hours, 24 hours and 48 hours to see how many *Daphnia* are alive. DO NOT feed the *Daphnia* while testing.
8. Average and analyze the results.

# Results

Table 1 (Observations from sample locations)

| Number # | Creek or River | PH | TDS | Temp in Fahrenheit | Time | GPS Coordinates |
|---|---|---|---|---|---|---|
| 1 | GKM Output | 6.06 | 768 | 42.8˚F | 11:20 AM | 37˚53’22” N<br>107˚39’13” W |
| 2 | Cement Creek | 4.03 | 528 | 50.9˚F | 11:50 AM | 37˚48’55” N<br>107˚39’43” W |
| 3 | Animas River 1 | 7.50 | 129 | 50.5˚F | 12:01 AM | 37˚48’40” N<br>107˚39’33” W |
| 4 | Mineral Creek | 6.38 | 212 | 51.0˚F | 12:49 AM | 37˚48’10” N<br>107˚40’21” W |
| 5 | Deer Creek | 8.26 | 78 | 47.4˚F | 1:15 PM | 37˚48’8” N<br>107˚45’23 W |
| 6 | Cascade Creek | 8.12 | 112 | 49.8˚F | 1:39 PM | 37˚39’36” N<br>107˚48’43” W |
| 7 | Hermosa Creek | 8.16 | 182 | 57.3˚F | 2:12 PM | 37˚24’52” N<br>107˚50’10” W |
| 8 | Junction Creek | 8.45 | 127 | 55.7˚F | 2:50 PM | 37˚19’53” N<br>107˚54’9” W |
| 9 | Lightner Creek | 8.42 | 287 | 59.7˚F | 3:20 PM | 37˚16’8” N<br>107˚53’1” W |
| 10<br>(Control) | Animas River 2 | 8.17 | 312 | 56.4˚F | 3:21 PM | 37˚16’8” N<br>107˚53’1” W |

The table above shows the PH, TDS, time, temp, and GPS coordinates of each water sample when it was retrieved. A low PH in a water sample can sometimes indicate a high toxicity in a water sample, or a lesser chance to support life. The TDS in a sample shows the amount of total dissolved solids, such as metals or salts in the water. A high TDS can be suitable or not suitable for life, depending on the dissolved solid. The time can also be important to the toxicity of the water. For example, if two samples were retrieved at very different times and dates, one may have more snowfall/rainfall than the other, making that sample less toxic because it has a lower concentration of any metals or salts that would make the water toxic. In this experiment, 1, 2, and 4 showed to have the worst PH and TDS, showing that they were toxic.

Table 2 (*Daphnia magna*)

| Creek or River | *Daphnia* alive (20 min) | *Daphnia* alive (1 hour) | *Daphnia* alive (4 hours) | *Daphnia* alive (24 hours) | *Daphnia* alive (48 hours) |
|---|---|---|---|---|---|
| GKM Output | 10 | 10 | 8 | 1 | 0 |
| Cement Creek | 9 | 9 | 9 | 0 | 0 |
| Animas 1 | 10 | 10 | 10 | 10 | 9 |
| Mineral Creek | 10 | 10 | 9 | 9 | 6 |
| Deer Creek | 10 | 9 | 9 | 9 | 9 |
| Cascade Creek | 9 | 9 | 9 | 9 | 9 |
| Hermosa Creek | 10 | 9 | 9 | 9 | 9 |
| Junction Creek | 10 | 10 | 10 | 10 | 10 |
| Lightner Creek | 9 | 9 | 9 | 9 | 8 |
| Animas 2 | 10 | 10 | 10 | 9 | 8 |

Observations for *Daphnia magna*:

- In 1, 2, and 4, the *Daphnia* turned a bright orange (perhaps from the iron sulfide rich water inherited from mines)
- In 7 and 8, the *Daphnia* were most active.

In the experiment with *Daphnia magna*, a low amount of *Daphnia* that survived would show that the water was not suitable for animals. Likewise, a high amount of *Daphnia* that survived would show that the water is suitable for animals. In this experiment, I found that in samples 1 and 2, all *Daphnia* died at 48 hours showing that the water was extremely unhealthy for animals. In sample 4, 4 *Daphnia* died showing that it was moderately unhealthy. In samples 3, 5, 6, 7, 8, 9, and 10 no *Daphnia* died showing that they were very healthy for aquatic life.

Table 3 (Lettuce Seeds)

| Creek or River | Seed 1 (in mm) | Seed 2 (in mm) | Average |
|---|---|---|---|
| GKM Output | 10 mm | 7 mm | 8.5 mm |
| Cement Creek | 10 mm | 6 mm | 8 mm |
| Animas 1 | 8 mm | 9 mm | 8.5 mm |
| Mineral Creek | 8 mm | 6 mm | 7 mm |
| Deer Creek | 22 mm | 3 mm | 12.5 mm |
| Cascade Creek | 9 mm | 10 mm | 9.5 mm |
| Hermosa Creek | 11 mm | 9 mm | 10 mm |
| Junction Creek | 9 mm | 6 mm | 7.5 mm |
| Lightner Creek | 6 mm | 10 mm | 8 mm |
| Animas 2 | 12 mm | 9 mm | 10.5 mm |
| Distilled Water | 8 mm | 9 mm | 8.5 mm |

Observations for Lettuce Seeds:

- In 5, the water grew the longest and shortest seed roots.

In the experiment with lettuce seeds, a short lettuce seed root length would show that the water was not suitable for plants. Likewise, a long lettuce seed root length would show that the water is suitable for plants. In this experiment, I found that all samples were suitable for plant life. The lettuce seed roots, however, did not grow as long in Mineral Creek and Junction Creek.

# Discussion

## Gold King Mine Output (1)

Number of Mines: 1
PH: 6.06
TDS: 768
*Daphnia magna* alive at 48 hours: 0
Lettuce Seed Average Length: 8.5 mm
Observations: *Daphnia* turned bright orange in color after 24 hours.
Aerial Photo:


Landscape Photo:

Analysis: The Gold King Mine Output's PH, TDS, and results with *Daphnia* and lettuce seeds show that it was very toxic and not very suitable for wildlife, showing that it was greatly contributing to the toxicity of Animas River.

## Cement Creek (2)

Number of Mines: 11
PH: 4.03
TDS: 528
*Daphnia magna* alive at 48 hours: 0
Lettuce Seed Average Length: 8 mm
Observations: *Daphnia* turned bright orange in color after 24 hours.
Aerial Photo:


Landscape Photo:

Analysis: Cement Creek's PH, TDS, and results with *Daphnia* and lettuce seeds show that it was very toxic and not very suitable for wildlife, showing that it was greatly contributing to the toxicity of Animas River.

## Animas River 1 (3)

Number of Mines: 18
PH: 7.50
TDS: 129
*Daphnia magna* alive at 48 hours: 9
Lettuce Seed Average Length: 8.5 mm
Observations: None
Aerial Photo:


Landscape Photo:

Analysis: The high PH and low TDS of the Animas River before Cement Creek joining it makes it suitable for life.

Mineral Creek (4)

Number of Mines: 20
PH: 6.38
TDS: 212
*Daphnia magna* alive at 48 hours: 6
Lettuce Seed Average Length: 7 mm
Observations: *Daphnia* turned bright orange in color after 24 hours.
Aerial Photo:


Landscape Photo:

Analysis: Mineral Creek's PH, TDS, and results with *Daphnia* and lettuce seeds show that it was toxic and not very suitable for wildlife, showing that it was partly contributing to the toxicity of Animas River.

Deer Creek (5)

Number of Mines: 0
PH: 8.26
TDS: 78
*Daphnia magna* alive at 48 hours: 9
Lettuce Seed Average Length: 12.5 mm
Observations: This water grew the longest and shortest lettuce seed roots.
Aerial Photo:


Landscape Photo:

Analysis: The high PH, low TDS, and overall good results of Deer Creek make it a very clear, clean creek that is suitable for animal and plant life.

Cascade Creek (6)

Number of Mines: 0
PH: 8.12
TDS: 112
*Daphnia magna* alive at 48 hours: 9
Lettuce Seed Average Length: 9.5 mm
Observations: None
Aerial Photo:

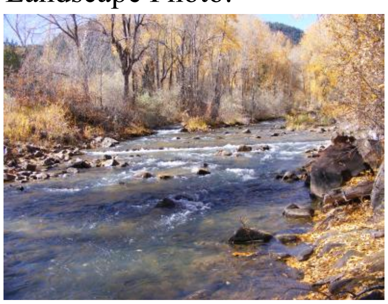

Landscape Photo:

Analysis: The high PH and low TDS of Cascade Creek makes it suitable for life.

Hermosa Creek (7)

Number of Mines: 0
PH: 8.16
TDS: 182
*Daphnia magna* alive at 48 hours: 9
Lettuce Seed Average Length: 10 mm
Observations: None
Aerial Photo: N/A

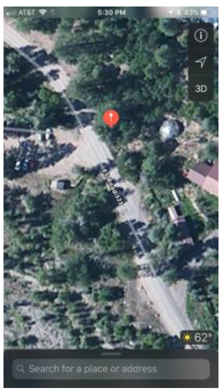
Landscape Photo:



Analysis: The results of Hermosa Creek show that it is a heathy creek for plants and animals and shows that it does not majorly contribute to the toxicity of the Animas River.

Junction Creek (8)

Number of Mines: 0
PH: 8.47
TDS: 127
*Daphnia magna* alive at 48 hours: 10
Lettuce Seed Average Length: 7.5 mm
Observations: None
Aerial Photo:




Landscape Photo:

Analysis: The results for Junction Creek show that it is safe and not contributing to the Animas River's toxicity.

## Lightner Creek (9)

Number of Mines: 5
PH: 8.42
TDS: 287
*Daphnia magna* alive at 48 hours: 8
Lettuce Seed Average Length: 8 mm
Observations: None
Aerial Photo:


Landscape Photo:

Analysis: Lightner Creek's water is very suitable for life, regardless of the 5 mines that flow into it.

## Animas River 2: Control (10)

Number of Mines: N/A
PH: 8.17
TDS: 312
*Daphnia magna* alive at 48 hours: 8
Lettuce Seed Average Length: 10.5 mm
Observations: None
Aerial Photo:


Landscape Photo:

Analysis: N/A

# Conclusion

In conclusion, the toxic water bodies in the Animas River Valley include those of which have mines flowing into them. These water bodies include the Gold King Mine output, Cement Creek, and Mineral Creek. This shows that my hypothesis was accurate.

According to my results, the Gold King Mine output, Cement Creek, and Mineral Creek grew short lettuce seed roots, did not support suitable life for *daphnia magna*, had low PH, and had high TDS. These water bodies had mines feeding into them, except for the Animas River 1 (before Cement Creek joins) which had many mines, but turned out to be suitable for life. This may have been the fact that particles and sediment would be swept up in the fast-moving river before it could move any further downstream. This could also be that there are many other creeks without mines flowing into the river, keeping the water neutral.

In the future, if this project were to be continued, a greater sample size could be used with lettuce seeds. This applies for Deer Creek water on lettuce seeds, as one grew 22 mm and the other only grew 3 mm. The seed that grew 3 mm may have been a defective seed, showing that a greater sample size could have been needed.

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- Interview with Scott Roberts, Aquatic Ecologist at the Mountain Studies Institute

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