Alaska Department of Environmental Conservation
Draft Waterbody Determination Paper
Gold Creek, Coldfoot, Alaska
Turbidity Determination

Recommendation

Waterbody Name: Gold Creek

Category Recommendation: 5

Water Quality Standard Affected: Turbidity

Designated Uses Affected:

- Water Supply: Drinking, culinary and food processing water supply; aquaculture water supply;
- Water Recreation: Contact recreation; secondary recreation;
- Growth and propagation of fish, shellfish, other aquatic life, and wildlife.

Pollutant: Turbidity

Executive Summary

The purpose of this document is to describe the data collection, data analysis, and conclusions reached in evaluating Gold Creek for the 2020 Integrated Report (IR). Gold Creek was not included in previous IRs. Gold Creek is located just north of Coldfoot, Alaska. A watershed wide assessment was conducted by the Bureau of Land Management[1] (BLM) from 2015-2018 to address turbidity impairments related to historic and current placer mining. Based on the data analysis below, Gold Creek is found to be impaired for the turbidity standard for several designated uses (Table 2). Gold Creek is recommended for inclusion in Category 5 of the 2020 IR.

Basic Waterbody Information

Table 1. Basic Waterbody Information

Assessment Unit ID	AK_R_9010105_007
Assessment Unit Name	Gold Creek
Location description	North of Coldfoot; HUC10 1909010105
Water Type	Stream
Water Size (units)	10.23 miles
Area of impairment	10.23 miles

[1] Davis and Gold Creeks in the Koyukuk Watershed, Water Quality Monitoring Quality Assurance Project and Sampling Plan. Bureau of Land Management. April 2017.

Time of impairment	Open water

Pollutant Status

Table 2. Alaska's Water Quality Standards at 18 AAC 70(12) turbidity for fresh water uses[2]:

Use	**Criteria**	**Status**
(A) Water Supply (i) drinking, culinary, and food processing	May not exceed 5 nephelometric turbidity units (NTU) above natural conditions when the natural turbidity is 50 NTU or less, and may not have more than 10% increase in turbidity when the natural turbidity is more than 50 NTU, not to exceed a maximum increase of 25 NTU.	Not supporting
(A) Water Supply (ii) agriculture, including irrigation and stock watering	May not cause detrimental effects on indicated use.	Supporting
(A) Water Supply (iii) aquaculture	May not exceed 25 NTU above natural conditions. For all lake waters, may not exceed 5 NTU above natural conditions.	Not supporting
(A) Water Supply (iv) industrial	May not cause detrimental effects on established water supply treatment levels.	Supporting
(B) Water Recreation (i) contact recreation	May not exceed 5 NTU above natural conditions when the natural turbidity is 50 NTU or less, and may not have more than 10% increase in turbidity when the natural turbidity is more than 50 NTU, not to exceed a maximum increase of 15 NTU. May not exceed 5 NTU above natural turbidity for all lake waters.	Not supporting
(B) Water Recreation (ii) secondary recreation	May not exceed 10 NTU above natural conditions when natural turbidity is 50 NTU or less, and may not have more than 20% increase in turbidity when the natural turbidity is greater than 50 NTU, not to exceed a maximum increase of 15 NTU. For all lake waters, turbidity may not exceed 5 NTU above natural turbidity.	Not supporting
(C) Growth and Propagation of Fish, Shellfish, Other Aquatic Life, and Wildlife	Same as (12)(A)(iii).	Not supporting

[2] Alaska Department of Environmental Conservation. 2018. 18 AAC 70.010 Water Quality Standards. Amended as of April 6, 2018

Impairment Evaluation

Data Sources

BLM observed exceedances of the turbidity criteria during site visits dating back to 2011. In 2014, BLM observed exceedances 11 times. BLM collected continuous monitoring data for turbidity on Gold Creek from 2015-2018. Continuous turbidity data (10 minute intervals) was collected at five sites (Figure 1). Total suspended solids grab samples and stream stage/discharge were also measured. The most recent three years of continuous turbidity data (2016-2018) was used in the impairment determination.

Figure 2. Sampling site locations

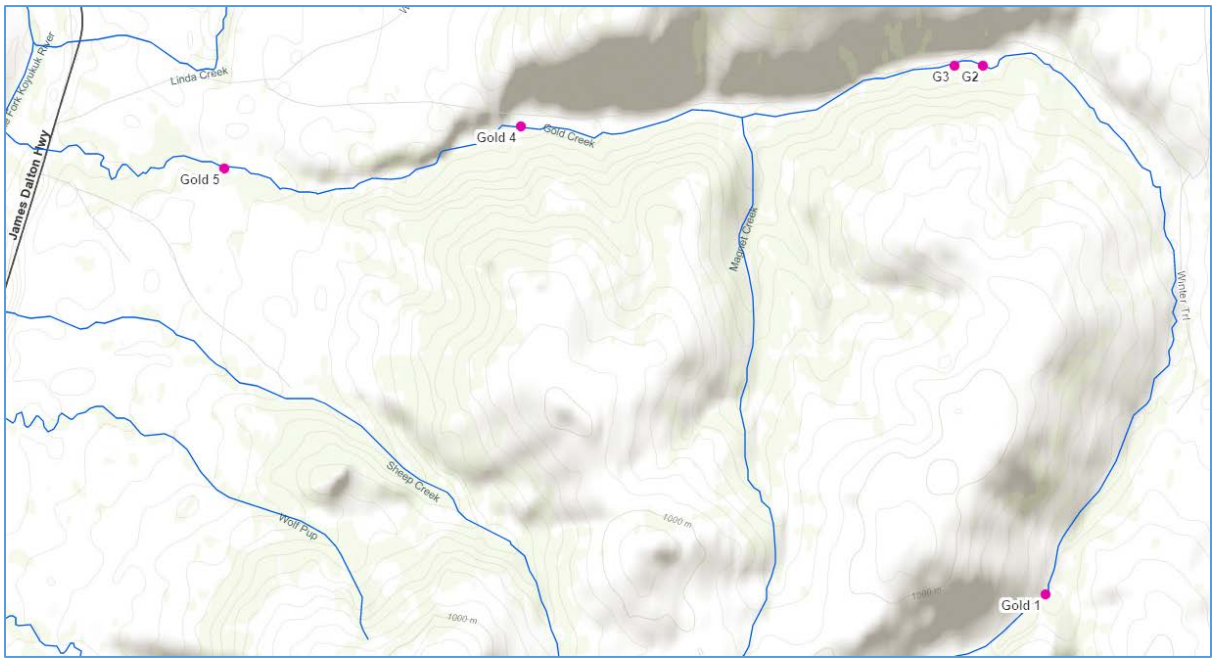


Table 3. Sampling site coordinates

Site Number	Latitude	Longitude
Gold 1	N 67.482	W 149.677
Gold 2	N 67.518	W 149.688
Gold 3	N 67.518	W 149.693
Gold 4	N 67.515	W 149.769
Gold 5	N 67.511	W 149.821

Data Evaluation

Methods

The Alaska Department of Environmental Conservation (DEC) Turbidity Listing Methodology[3] was applied to the recent data collected in Gold Creek to evaluate impairment. The data set includes an upstream reference site (Gold 1) which represents the natural condition. The reference site data was collected concurrently with data at downstream impacted sites (Gold 2, 3, 4 and 5).

For this type of dataset, the listing methodology recommends a binomial statistical significance test. For paired datasets that were collected concurrently, the raw exceedance frequency is calculated by comparing the 24-hour daily averages of the impacted site dataset to the natural conditions dataset. If the daily average at the impacted site exceeds the natural conditions site by more than 5, 10, or 25 NTU, then it is counted as a raw exceedance. If the raw exceedance frequency exceeds 10% at the impacted site, then the binomial test is conducted. A full description of the inputs, outputs, and decisions of the test can be found in the DEC Turbidity Listing Methodology[3].

Hypothesis Test

The DEC Turbidity Listing Methodology was applied to evaluate the turbidity data. The impairment threshold criteria statement is:

- The 24-hour daily average (duration)
- may not exceed 5, 10 or 25 NTU above natural conditions (magnitude)
- during more than 10% of the days sampled (frequency).

The final result from the Binomial test will be used to determine if the turbidity significantly exceeds or attains the 10% frequency threshold.

Table 4. Null and alternate hypothesis tests

Null Hypothesis	Waterbody is not impaired	Exceedance Frequency ≤ 10%
Alternative Hypothesis	Waterbody is impaired	Exceedance Frequency > 10%

For Gold Creek:

- The continuous data was aggregated into daily averages.
- The three years of data were combined to form one complete dataset.
- Data from Gold 1 (reference site) was compared to the Gold 5 (lowermost impacted site) for impairment analysis using the binomial test.

[3] 2016. Alaska Department of Environmental Conservation. Listing Methodology for Determining Water Quality Impairments from Turbidity. Guidance, Final.

Results

The Raw results summary (Table 5) shows the raw data in daily averages compared between years for Gold 1 (reference) and Gold 5 (furthest downstream impacted site). Comparison of Gold 1 with sites in between (Gold 2-4) showed similar exceedance results as those described for Gold 5.

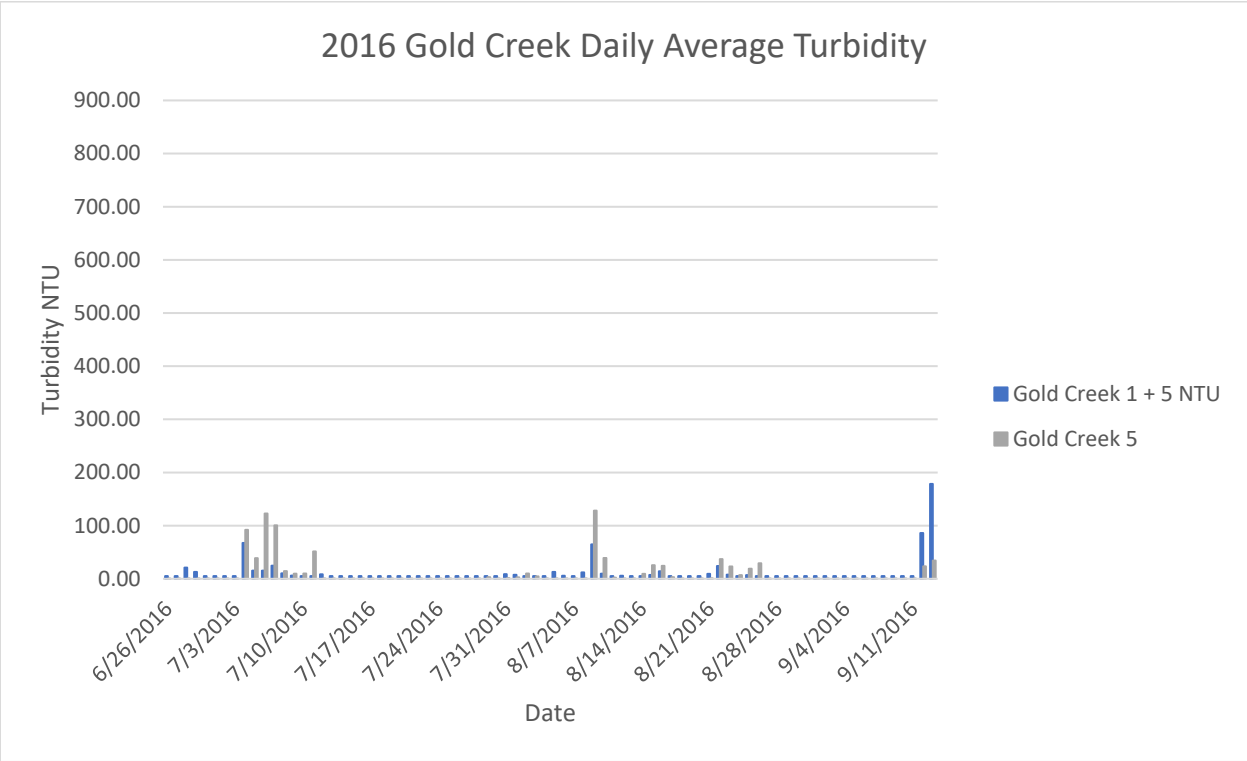
In 2016 and 2017, the 90th percentile at the impacted site was higher than at the reference site. In 2018, the 90th percentile at the reference site was higher than at the impacted site. During 2018 there was significant mass wasting above the reference site (personal communication with BLM hydrologist Erica Lamb).

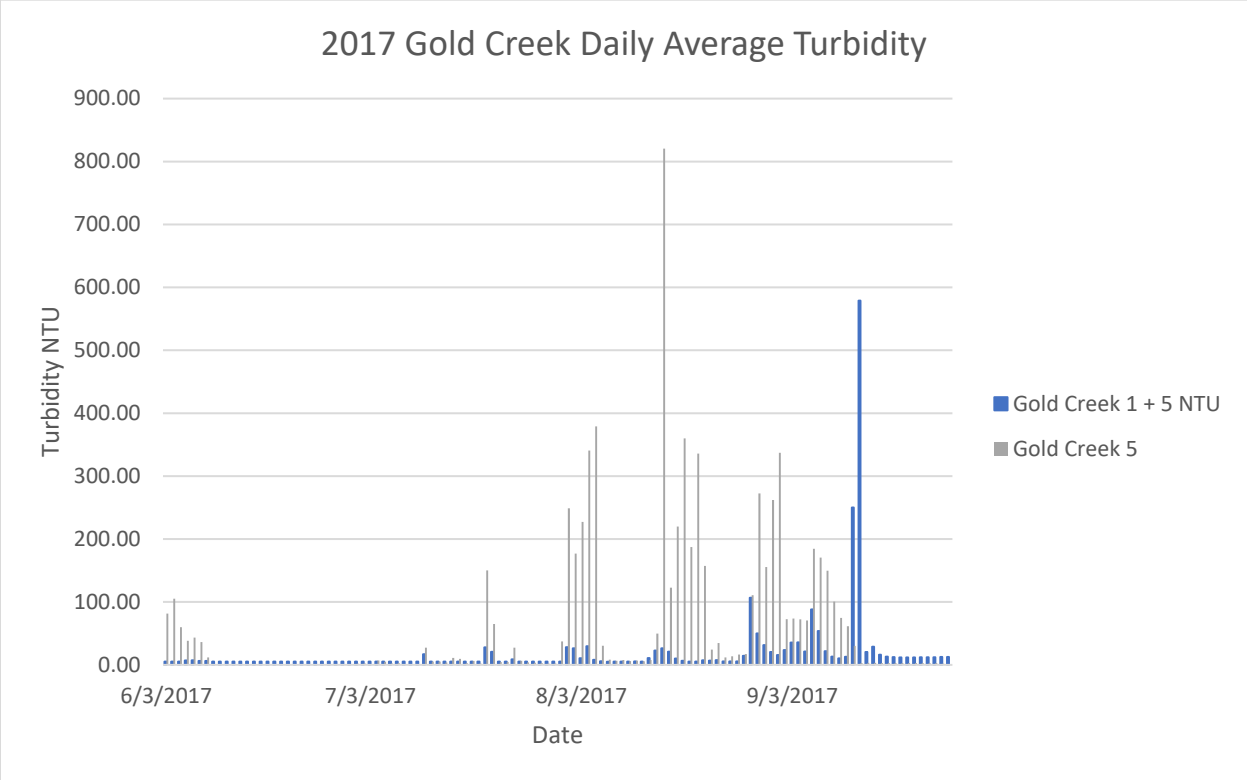
Figure 2 shows a time series plot of daily average results between the reference site (plus 5 NTU) and impacted site by year. Higher daily average turbidity was frequently observed at the impacted site.

Table 5. Raw results summary

	Gold 1 (reference)	**Gold 5 (impacted)**	**Gold 1 (reference)**	**Gold 5 (impacted)**	**Gold 1 (reference)**	**Gold 5 (impacted)**
Year	2016		2017		2018	
Total Data Points (daily averages)	80		116		70	
Average	6.5	10.9	14.2	59.1	18.5	18.4
50th Percentile	0.1	0.1	0.4	6.1	0.3	1.2
90th Percentile	10.4	34.5	22.9	185.9	44.2	28.7

Figure 2. Gold Creek 1 (+5 NTU) and Gold Creek 5 (impacted) daily average turbidity by year





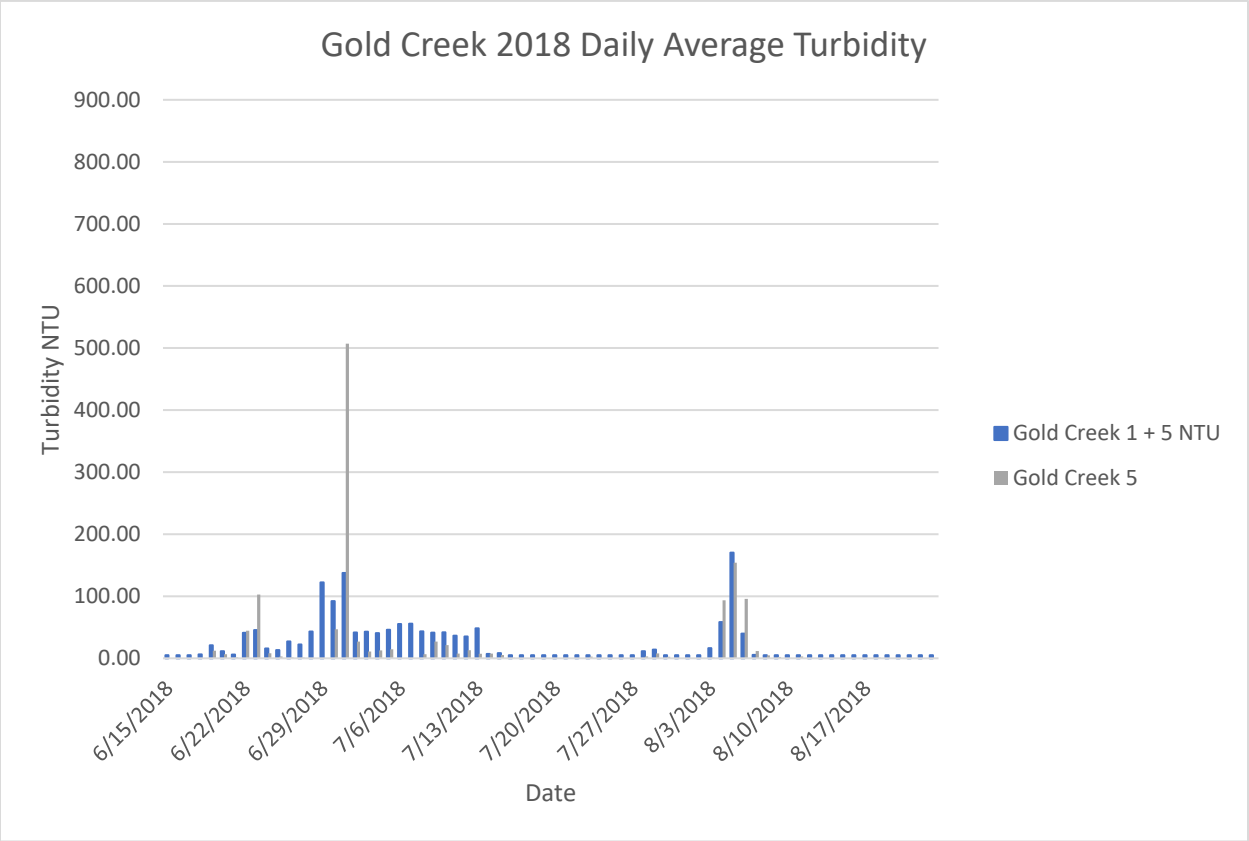


Table 6 shows the raw total exceedances and exceedance frequencies by designated use (magnitude of 5, 10 and 25 NTU).

All of the raw exceedance frequencies were above the minimum 10% for impairment, so a Binomial statistical test was conducted for each of these designated uses. Table 6 also shows the minimum raw exceedance frequency for impairment based on the Binomial statistical test for this dataset. Gold Creek exceeded the minimum frequency for impairment for the designated uses in the table. Table 7 shows the details of the Binomial test inputs and outputs.

Table 6. Total Exceedances and Exceedance Frequencies by Designated Use.*

	Drinking water, contact recreation (natural conditions + 5 NTU)	**Secondary recreation (natural conditions + 10 NTU)**	**Growth and propagation of fish, shellfish, other aquatic life and wildlife (natural conditions + 25 NTU)**	***Minimum to Impair***
Total exceedances	86	64	50	*32*
Raw exceedance frequency	32%	24%	19%	*13%*

*The total number of samples was 266

Table 7. Binomial test inputs and outputs

	Description	Value	Comments
Input	Total Exceedances by designated use (see Table 7)	86, 64, 50	Number of downstream samples greater than criterion
	Total Trials	266	Number of comparisons of downstream site to the criterion obtained from the natural condition site. Equals number of matched pairs.
	Raw Exceedance Frequency by designated use (see Table 7)	32%, 24%, 19%	Calculated as Exceedances/Trials
	Target Type I Error (α)	0.1	α = 0.2 for trials < 40, α = 0.1 for trials > 40. Alternate values of α considered to balance or improve statistical power of test.
	Allowed Exceedance Rate	10%	Allowed by US EPA guidance for conventional pollutants
Output	Minimum Exceedances to Reject	34	Number of exceedances needed to reject null hypothesis at the acceptable Type 1 error level.
	Minimum Frequency to Impair	13%	Minimum frequency needed to reject null hypothesis at the acceptable Type 1 error level.
	Binomial Test Statistic (P)	0.000	p-value, or attained significance level, of Binomial Test.
Final Result	Impaired?	**Yes**	If p-value < Target Type 1 error, then reject null hypothesis and conclude waterbody exceeds criterion greater than 10% of the time.

Pollutant Sources

Gold Creek is located in the Koyukuk mining district and has a history of placer mining activity since the early 1900s. Historic mining activity was mainly drift mining using manual labor to move material. Later operations from the 1930's through today have included mechanical mining in various forms

Currently, approximately 60% of the stream channel is non-functioning due to degradation from historic mining activities. There are currently active mines, mine sites under reclamation, and abandoned and areas of historic disturbance within the watershed. Turbidity pollution is likely from a combination of nonpoint and point sources.

Conclusion

Results of the Binomial test analysis indicate that Gold Creek significantly exceeded the 10% frequency threshold for turbidity at the 5, 10, and 25 NTU magnitude for the drinking water and contact recreation; secondary recreation; and growth and propagation of fish, shellfish, other aquatic life and wildlife designated uses respectively.

Gold Creek is recommended for listing as impaired in Category 5 in the 2020 IR. Recent data shows that the creek is exceeding the water quality standard for turbidity.

Appendix A

Daily average data for Gold 1 (reference) and Gold 5 (impacted) sites for 2016, 2017, and 2018.

Date	Gold 1 (reference)	Gold 5 (impacted)		Date	Gold 1 (reference)	Gold 5 (impacted)
2016						
6/26/2016	0.10	0.10		7/28/2016	0.10	0.10
6/27/2016	0.10	0.10		7/29/2016	0.10	3.00
6/28/2016	15.96	0.10		7/30/2016	0.10	0.10
6/29/2016	7.99	0.10		7/31/2016	3.63	0.97
6/30/2016	0.10	0.10		8/1/2016	2.45	2.85
7/1/2016	0.10	0.10		8/2/2016	0.10	9.86
7/2/2016	0.10	0.10		8/3/2016	0.10	4.60
7/3/2016	0.10	0.10		8/4/2016	0.10	0.10
7/4/2016	62.32	92.11		8/5/2016	7.93	0.10
7/5/2016	10.44	38.98		8/6/2016	0.72	0.10
7/6/2016	10.43	122.75		8/7/2016	0.10	0.10
7/7/2016	19.63	100.55		8/8/2016	7.05	0.10
7/8/2016	5.19	14.50		8/9/2016	59.87	128.35
7/9/2016	0.92	9.69		8/10/2016	4.77	39.07
7/10/2016	0.10	10.09		8/11/2016	0.10	2.07
7/11/2016	0.10	51.44		8/12/2016	0.69	0.10
7/12/2016	3.57	0.10		8/13/2016	0.10	0.10
7/13/2016	0.10	0.10		8/14/2016	0.10	9.44
7/14/2016	0.10	0.10		8/15/2016	2.13	25.60
7/15/2016	0.10	0.10		8/16/2016	9.13	24.25
7/16/2016	0.10	0.10		8/17/2016	0.10	3.01
7/17/2016	0.10	0.10		8/18/2016	0.10	0.09
7/18/2016	0.10	0.10		8/19/2016	0.10	0.10
7/19/2016	0.10	0.10		8/20/2016	0.10	0.10
7/20/2016	0.10	0.10		8/21/2016	4.31	0.65
7/21/2016	0.10	0.10		8/22/2016	19.03	37.00
7/22/2016	0.10	0.10		8/23/2016	2.83	23.19
7/23/2016	0.10	0.10		8/24/2016	0.10	6.80
7/24/2016	0.10	0.10		8/25/2016	2.05	19.06
7/25/2016	0.10	0.10		8/26/2016	0.10	29.16
7/26/2016	0.10	0.10		8/27/2016	0.10	0.10
7/27/2016	0.10	0.10		8/28/2016	0.10	0.10

Date	Gold 1 (reference)	Gold 5 (impacted)		Date	Gold 1 (reference)	Gold 5 (impacted)
2016						
8/29/2016	0.10	0.10		9/6/2016	0.10	0.10
8/29/2016	0.10	0.10		9/7/2016	0.19	0.10
8/30/2016	0.10	0.10		9/8/2016	0.10	0.10
8/31/2016	0.10	0.10		9/9/2016	0.10	0.10
9/1/2016	0.10	0.10		9/10/2016	0.10	0.10
9/2/2016	0.10	0.10		9/11/2016	0.10	0.10
9/3/2016	0.10	0.10		9/12/2016	81.24	23.46
9/4/2016	0.10	0.10		9/13/2016	173.51	34.28
9/5/2016	0.10	0.10				
2017						
6/3/2017	0.10	81.47		7/2/2017	0.10	2.28
6/4/2017	0.10	105.26		7/3/2017	0.10	1.40
6/5/2017	0.12	59.94		7/4/2017	0.10	7.06
6/6/2017	2.05	38.39		7/5/2017	0.10	4.88
6/7/2017	2.31	43.40		7/6/2017	0.10	2.09
6/8/2017	1.37	36.37		7/7/2017	0.10	2.92
6/9/2017	1.25	11.79		7/8/2017	0.10	1.19
6/10/2017	0.10	0.82		7/9/2017	0.10	0.50
6/11/2017	0.10	0.10		7/10/2017	0.10	0.75
6/12/2017	0.10	0.44		7/11/2017	12.03	27.24
6/13/2017	0.10	0.13		7/12/2017	0.10	5.15
6/14/2017	0.10	0.10		7/13/2017	0.10	5.30
6/15/2017	0.10	0.08		7/14/2017	0.10	3.66
6/16/2017	0.10	0.27		7/15/2017	0.10	11.17
6/17/2017	0.10	0.04		7/16/2017	0.10	9.64
6/18/2017	0.10	0.35		7/17/2017	0.10	2.79
6/19/2017	0.10	0.09		7/18/2017	0.10	6.18
6/20/2017	0.10	0.22		7/19/2017	0.10	2.23
6/21/2017	0.10	0.26		7/20/2017	22.74	150.27
6/22/2017	0.10	0.28		7/21/2017	15.82	64.94
6/23/2017	0.10	0.55		7/22/2017	0.10	4.53
6/24/2017	0.10	0.19		7/23/2017	0.10	4.79
6/25/2017	0.10	0.28		7/24/2017	3.88	27.27
6/26/2017	0.10	0.18		7/25/2017	0.10	6.61
6/27/2017	0.10	0.36		7/26/2017	0.10	3.91
6/28/2017	0.10	0.21		7/27/2017	0.10	3.53
6/29/2017	0.10	0.66		7/28/2017	0.10	2.90
6/30/2017	0.10	1.34		7/29/2017	0.10	2.09

Date	Gold 1 (reference)	Gold 5 (impacted)		Date	Gold 1 (reference)	Gold 5 (impacted)
2017						
7/1/2017	0.10	1.82		7/30/2017	0.10	2.11
7/31/2017	0.10	37.25		8/29/2017	45.03	272.54
8/1/2017	23.12	248.77		8/30/2017	26.32	155.48
8/2/2017	21.32	176.96		8/31/2017	15.55	261.95
8/3/2017	5.64	227.14		9/1/2017	10.61	337.07
8/4/2017	24.70	340.61		9/2/2017	18.45	72.67
8/5/2017	3.09	378.96		9/3/2017	30.40	73.62
8/6/2017	0.82	30.47		9/4/2017	30.67	72.33
8/7/2017	0.07	8.23		9/5/2017	16.24	70.66
8/8/2017	0.10	6.49		9/6/2017	83.12	184.52
8/9/2017	0.10	7.86		9/7/2017	48.89	170.47
8/10/2017	0.10	6.00		9/8/2017	16.64	149.69
8/11/2017	0.45	6.77		9/9/2017	8.08	100.70
8/12/2017	0.28	5.61		9/10/2017	5.31	74.72
8/13/2017	5.90	7.67		9/11/2017	7.86	61.32
8/14/2017	17.66	49.63		9/12/2017	245.03	30.03
8/15/2017	21.22	820.40		9/13/2017	573.91	2.93
8/16/2017	16.01	122.76		9/14/2017	15.51	3.10
8/17/2017	5.15	219.95		9/15/2017	23.92	3.30
8/18/2017	1.41	359.93		9/16/2017	11.23	2.89
8/19/2017	0.10	187.31		9/17/2017	8.12	2.89
8/20/2017	0.10	335.90		9/18/2017	7.30	2.89
8/21/2017	2.18	157.34		9/19/2017	6.90	2.88
8/22/2017	1.84	24.36		9/20/2017	6.86	2.88
8/23/2017	2.53	34.82		9/21/2017	6.92	2.89
8/24/2017	0.46	11.76		9/22/2017	7.02	2.88
8/25/2017	0.50	13.68		9/23/2017	7.09	2.88
8/26/2017	0.53	16.32		9/24/2017	7.21	2.88
8/27/2017	9.35	17.26		9/25/2017	7.49	2.02
8/28/2017	101.69	110.74		9/26/2017	7.64	1.23
2018						
6/15/2018	0.03	0.21		6/24/2018	10.87	8.17
6/16/2018	0.10	0.10		6/25/2018	8.28	2.87
6/17/2018	0.10	0.10		6/26/2018	22.08	1.38
6/18/2018	1.33	0.49		6/27/2018	17.40	1.21
6/19/2018	16.09	12.19		6/28/2018	38.09	0.15
6/20/2018	6.42	6.52		6/29/2018	117.39	0.09
6/21/2018	0.99	1.42		6/30/2018	87.12	46.79

Date	Gold 1 (reference)	Gold 5 (impacted)		Date	Gold 1 (reference)	Gold 5 (impacted)
2018						
6/22/2018	36.21	44.36		7/1/2018	132.57	507.01
6/23/2018	40.60	102.77		7/2/2018	36.63	26.89
7/3/2018	37.85	10.94		7/29/2018	9.03	7.97
7/4/2018	35.54	12.83		7/30/2018	0.01	2.57
7/5/2018	41.07	14.50		7/31/2018	0.10	0.16
7/6/2018	50.18	0.10		8/1/2018	0.10	0.07
7/7/2018	50.83	0.10		8/2/2018	0.10	0.10
7/8/2018	38.49	6.47		8/3/2018	11.49	1.24
7/9/2018	36.40	27.00		8/4/2018	53.33	93.42
7/10/2018	36.94	21.31		8/5/2018	165.18	153.99
7/11/2018	31.46	7.67		8/6/2018	34.90	95.83
7/12/2018	30.09	12.95		8/7/2018	0.66	11.85
7/13/2018	43.34	7.39		8/8/2018	0.10	4.65
7/14/2018	2.10	7.66		8/9/2018	0.10	2.13
7/15/2018	3.39	5.28		8/10/2018	0.10	0.59
7/16/2018	0.10	0.83		8/11/2018	0.10	2.86
7/17/2018	0.10	0.13		8/12/2018	0.10	0.10
7/18/2018	0.10	0.10		8/13/2018	0.10	0.10
7/19/2018	0.10	0.10		8/14/2018	0.10	0.10
7/20/2018	0.10	0.03		8/15/2018	0.10	0.10
7/21/2018	0.10	0.02		8/16/2018	0.10	0.10
7/22/2018	0.10	0.10		8/17/2018	0.10	0.50
7/23/2018	0.02	2.72		8/18/2018	0.10	1.13
7/24/2018	0.10	0.03		8/19/2018	0.10	0.03
7/25/2018	0.10	0.10		8/20/2018	0.10	0.05
7/26/2018	0.10	0.10		8/21/2018	0.10	0.05
7/27/2018	0.09	0.29		8/22/2018	0.10	0.01
7/28/2018	6.46	3.06		8/23/2018	0.10	0.10