

TECHNICAL MEMORANDUM

Utah Coal Regulatory Program

January 11th, 2018

TO: The Utah Board of Oil, Gas, and Mining

THRU: Dana Dean, Associate Director
Daron Haddock, Program Manager

FROM: Arati Umarvadia, Hydrologist

RE: Crandall Canyon Mine Discharge Water Board Update, Docket No. 2010-026, Cause No. C/015/0032

SUMMARY:

Attached please find the Division of Oil, Gas and Mining's six month update report on the total iron concentrations in the mine discharge water at the Crandall Canyon Mine. This report is submitted in compliance with the January 28, 2013 Board Order.

Crandall Canyon Mine Hydrologic Evaluation Update January 2018

Background

The Division of Oil, Gas and Mining (DOGGM) completed a Hydrologic Evaluation of the Crandall Canyon Mine Water Discharge in May 2010. Since that time, numerous reports have been prepared by the Division and Genwal Resources, Inc. (Genwal) that examine the raw mine discharge water at Crandall Canyon. In compliance with the January 28, 2013, Board of Oil, Gas and Mining (the Board) Order¹, the following report presents an update on the data collected through December 2017. The report will focus on data collected since approximately January 2010 (after total iron concentrations in the discharge peaked). Sections of this updated report describe the data currently being collected; plots which have been prepared to examine the data; and a recent data evaluation.

The Utah Division of Water Quality recently renewed Genwal's Utah Pollutant Discharge Elimination System (UPDES) permit on May 1st, 2016. The DWQ effluent limit for total iron concentration at Genwal continues to be at 1.24 mg/L.

Genwal continues to perform monthly sampling and analysis of the raw mine water discharge in accordance with the Crandall Canyon Mining and Reclamation Plan (MRP). In addition, Genwal occasionally conducts laboratory and total iron field analysis on mine discharge samples more frequently than required by the MRP. All sampling is conducted to evaluate the need for continued treatment of the mine discharge water in order to meet the 1.24 mg/L maximum daily effluent limitation (MDEL) for total iron concentration in accordance with their Utah Pollutant Discharge Elimination System (UPDES) permit. The treatment is required for compliance with the narrative standard of Section I.C of the UPDES permit. Sampling in this report focuses on raw mine discharge water entering the treatment system in order to evaluate the continued need for treatment facilities. The raw water sampling takes place at a continuous flow sampling port. The original port, used from October 2012 to March 2013, was destroyed by a highwall rock fall. In March 2013, a new port was installed and has since been used for all sampling. In this report, data from both continuous flow sampling ports will be reviewed as equivalent.

Results of UPDES Monitoring Activities

Total iron concentrations measured in Pre-002, before treatment, of Crandall Canyon Mine Discharges through November 2017 are presented in Table 1, with sampler (Genwal or DOGM) identified. Sampling at Crandall Canyon is conducted as split sampling with Genwal and DOGM collecting separate samples to be sent to different labs. This sampling method provides verifiable sampling results.

A plot of total iron concentrations with Genwal and DOGM samples identified is presented in

Figure 1. A plot of monthly average total iron concentration in untreated mine discharge since 2010 is presented in Figure 2. A comparison of monthly total iron concentration values received by Genwal and DOGM during split sampling is presented in Figure 3. A plot of monthly average total iron concentration in untreated mine water, sampled from the continuous flow port, is presented in Figure 4. A plot of monthly average mine discharge rates with average total iron concentration in untreated water are presented in Figure 5.

Observed Total Iron Concentration Trends

Table 1 tabulates the mine water data from January 2007 to November 2017. The table includes raw iron concentration for both Genwal and Division data, monthly average iron concentration, and monthly average flow.

Exhibit 1 presents the untreated total iron concentrations sampled by Genwal and DOGM from January 2007 through November 2017. The figure distinguishes Genwal samples between the two ports used during this period. The iron concentration peaked in 2010-2012 and has steadily declined. Beginning in October 2015, the average raw iron concentration stayed below the 1.24 mg/L UPDES limit until July 2017. Between July and November 2017, raw iron concentrations hovered around 1.24 mg/L, with Genwal samples exceeding the limit and DOGM sample concentrations below the limit.

July 2017 Total Iron Concentration

In July 2017, Genwal samples reported a raw iron concentration of 1.68 mg/L, well above the UPDES limit of 1.24 mg/L. The DOGM split sample taken at the same date/time reported raw iron concentration at 0.883 mg/L. The Division requested both July samples to be rerun by the testing laboratories. The rerun samples returned similar results with Genwal reporting 1.30 mg/L, and DOGM reporting 0.997 mg/L. The Genwal field sample, taken at the same date/time, closely matches the Genwal lab results. Therefore, due to the large discrepancy between the DOGM and Genwal split samples, and given field sample result, the Division believes the July 2017 sample is compromised and not an accurate measurement of July 2017 total iron concentrations.

Exhibit 2 presents the monthly average of untreated total iron concentrations between January 2010 (discharge peak) and November 2017. Over time, average raw iron concentration has continually decreased. Beginning in April/May 2017, average raw iron concentrations increased slightly with two UPDES exceedances in February (1.35 mg/L) and July (1.28 mg/L).

Exhibit 3 shows the trend in raw iron concentrations between split samples taken by Genwal and the Division. Overall, Genwal and Division split samples follow closely in monthly raw iron concentrations with the exception of July 2017 (explanation above). Between July and November 2017, 12 individual samples were completed by Genwal and the Division. The raw

iron concentrations hovered around 1.24 mg/L. Genwal samples exceeded the UPDES limit five times and all Division sample concentrations were below the limit.

Exhibit 4 presents average monthly raw iron concentrations for samples taken from the continuous flow sampling port, October 2012 to November 2017. Over time, average raw iron concentration has continually decreased, with a slight increase seen in April/May 2017.

Exhibit 5 presents the monthly flow and total raw iron average between July 2011 and November 2017. There is a notable correlation between the mine discharge rate and total iron concentration. As the monthly average and 6-month flow average for mine discharge has notably decreased with time, so has the total raw iron concentration. If this trend continues, iron concentration should continue to decrease with mine drainage flow. To date, mine drainage has not shown seasonal fluctuation. Between June 2017 and November 2017, mine discharge has increased, as has total iron concentrations.

Summary Statistics of Recent Data- June 2017 - November 2017

The summary statistics for our current report are presented in the table below.

Total Iron Concentrations of Averaged Samples	
Untreated, 6 month, Jun – Nov 2017	T-Fe in mg/L
Max	1.28 (July)
Min	1.08 (November)
Average	1.214
Standard Deviation	0.046
Untreated, 12 month, Dec 2016 – Nov 2017	
Max	1.35 (February)
Min	1.0 (March)
Average	1.17
Standard Deviation	0.107
Treated, 6 month, Jun – Nov 2017	
Average	0.195
Treated, 12 month, Dec 2016 – Nov 2017	
Average	0.292

The average total iron concentrations collected from June 2017 to November 2017 have fluctuated from a low concentration of 1.08 mg/L (November 2017) to a high of 1.28 mg/L (July 2017). The overall average concentration for the June 2017 – November 2017 period is 1.214 mg/L (standard deviation of 0.046). The average total iron concentration for the last 12 months, December 2016 to November 2017 is 1.167 mg/L (standard deviation of 0.107).

Of the individual 12 raw mine discharge water samples collected by Genwal and DOGM separately from June 2017 through November 2017, five exceeded the 1.24 mg/L effluent

limitation, as defined in Genwal's Utah Pollutant Discharge Elimination System (UPDES) permit for total iron. These included Genwal samples from July, August, September, October, and November. However, the split samples taken by the Division during the same sampling event reported total iron values below the UPDES limit. All other samples reported total raw iron concentrations at or below effluent limits. Overall, 23 raw mine discharge water samples from that past 12 months have been collected by Genwal and DOGM. Of these 23, eight samples exceeded the UPDES limit. Of the 12 averaged raw mine discharge split, only three samples, December 2016, February 2017, and July 2017, exceeded the UPDES limit.

All raw mine discharge moves through a treatment system prior to discharging into Crandall Creek. The treatment system continues to consistently lower the total iron concentrations to well below the UPDES limit prior to discharging into Crandall Creek. The post-treatment mine discharge iron concentration averaged 0.195 mg/L for the 6-month June 2017 to November 2017 time period, and 0.292 for the 12-month December 2016 to November 2017 time period.

Conclusion

With the exception of the July 2017 sampling, every averaged monthly sampling event from June 2017 to November 2017 produced a total raw iron concentration at or below the UPDES limit of 1.24 mg/L. However, of the 12 individual sampling events, Genwal exceeded the limit five times in July, August, September, October, and November. Each DOGM split sample taken during the same sampling event was below the limit.

Overall, the iron concentration observed in the mine discharge since December 2016 show signs of steady decline. However, the Division feels that it is prudent to continue data collection to support accurate evaluations of total iron trends. As seen during this six-month evaluation period, iron concentrations tend to fluctuate. It is possible the increase in iron concentration seen this period is related to the increased mine discharge. Winter 2016 was an especially wet water year and the increased flow values may be correlated to spring snowmelt.

The Division recommends continued sampling of total raw iron concentrations with an evaluation of newly available data conducted every six months. The Division also recommends treatment of the raw mine discharge water to continue. The next mine discharge water evaluation report will be distributed to the Board in July 2018.

References

1. Board of Oil, Gas and Mining., Findings of Fact, Conclusions of Law and Order, Docket No. 2010-026, Cause No. C/0150032, January 28, 2013.
2. Petersen, E.C. 2011. Investigation of Iron Concentration in the Genwal Resources, Inc. Crandall Canyon Mine Discharge Water, November 7, 2011
3. Gilbert, R.O., 1987. Statistical methods for environmental pollution monitoring. Van Nostrand Reinhold, New York.

4. Perry and Rauch. Estimating Water Quality Trends in Abandoned Coal Mine-pools, Presented at West Virginia Mine Drainage Task Force Meeting (sourced online as a white paper), March 26-27, 2013, Morgantown, WV

EXHIBIT 1: Crandall Mine - Untreated Mine Water - Total Iron

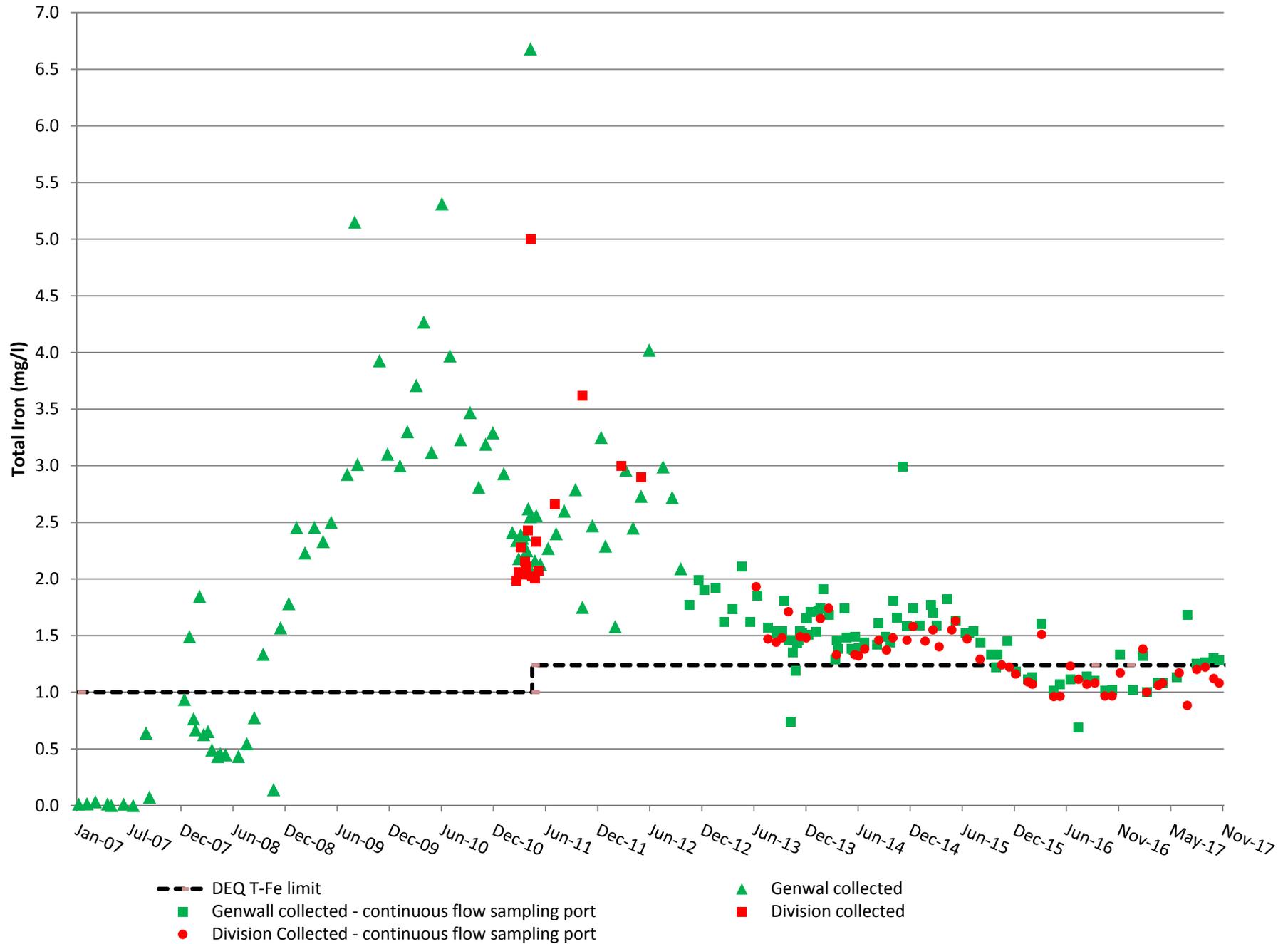


EXHIBIT 2: Crandall Mine - Untreated Mine Water - Total Iron Monthly Average

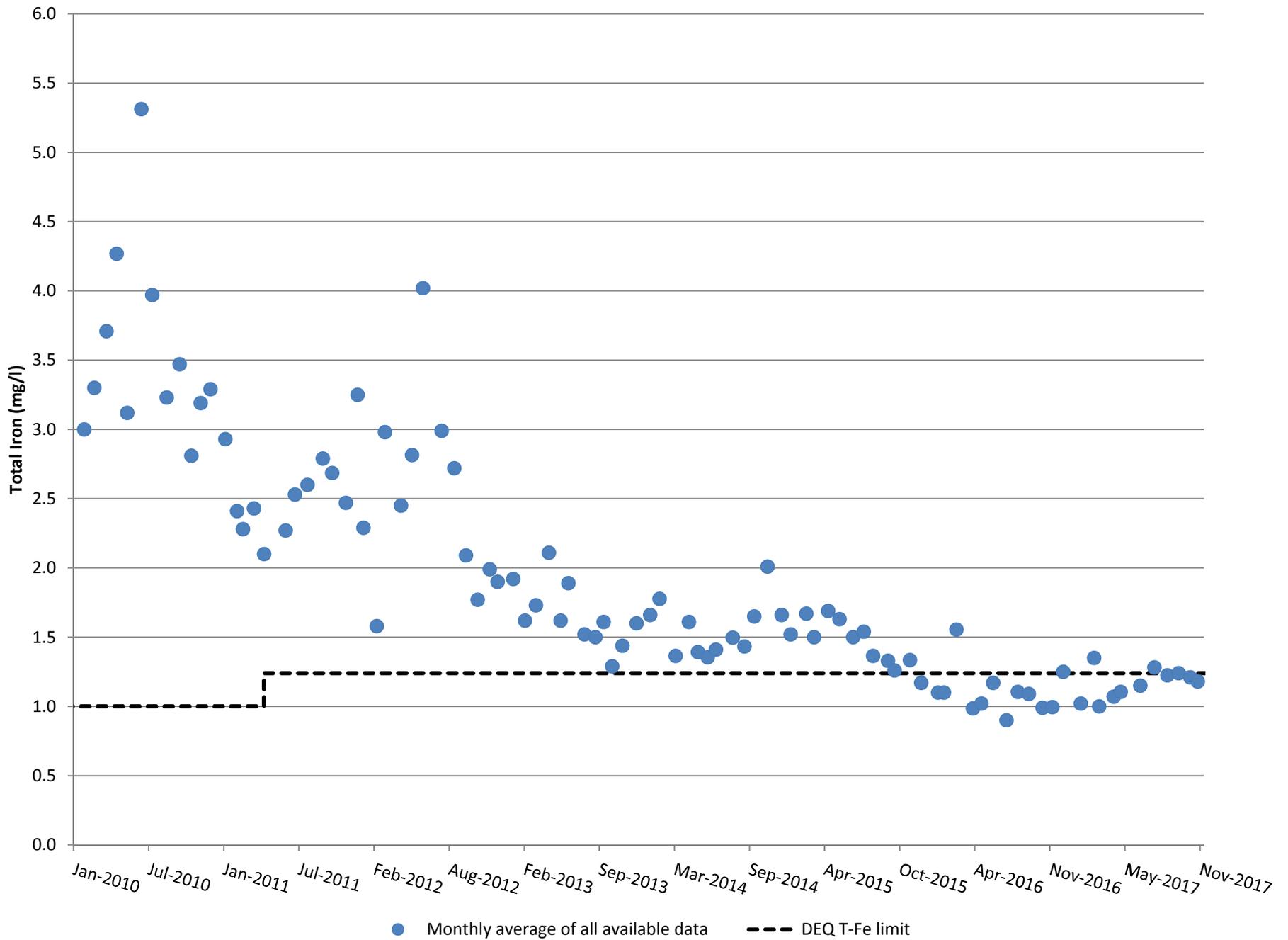


EXHIBIT 3: Crandall Mine - Untreated Mine Water Genwal and Division T-Fe Results- Continuous Flow Sampling Port

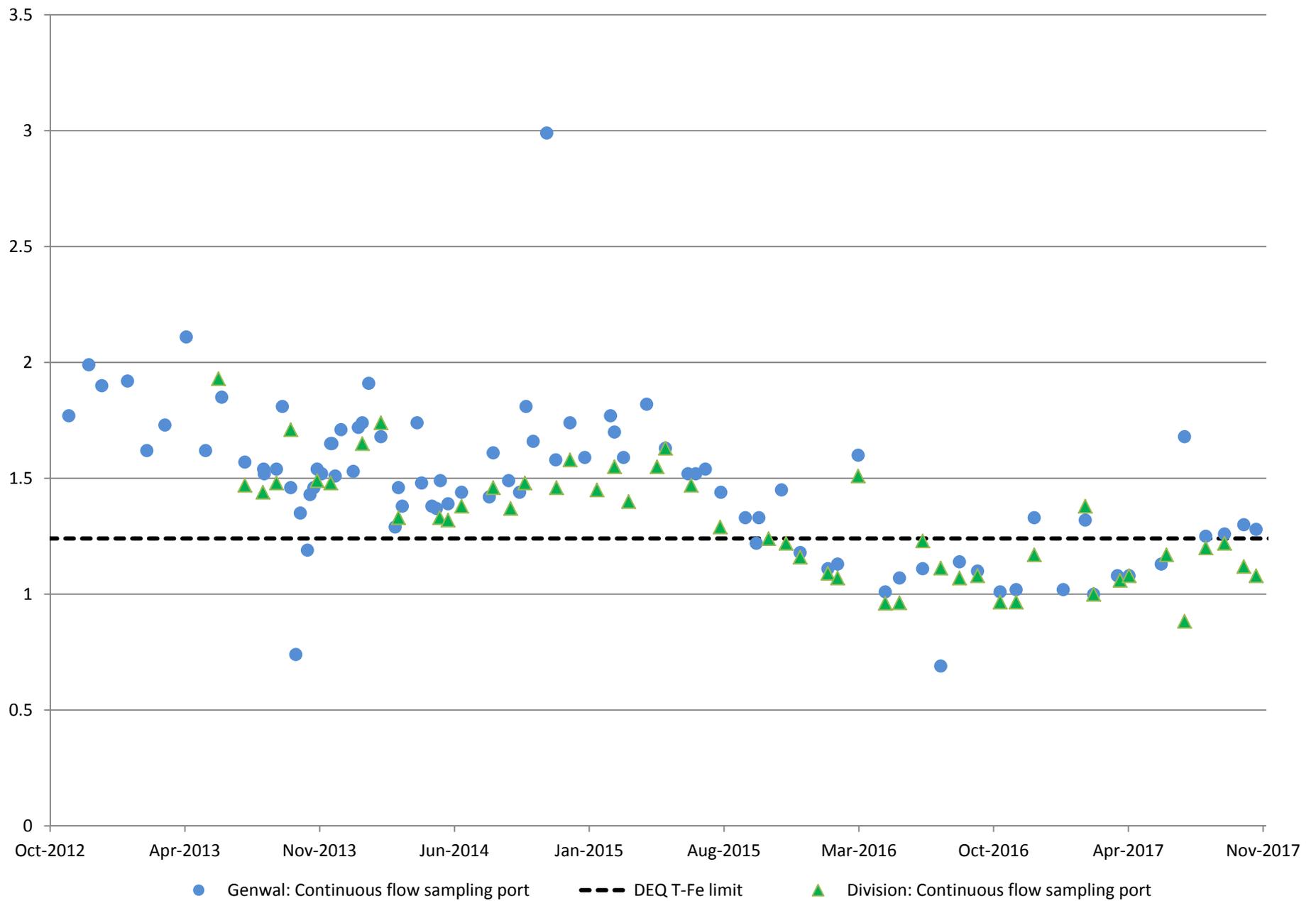


EXHIBIT 4: Crandall Mine - Untreated Mine Water Monthly Median - Continuous Flow Sampling Port

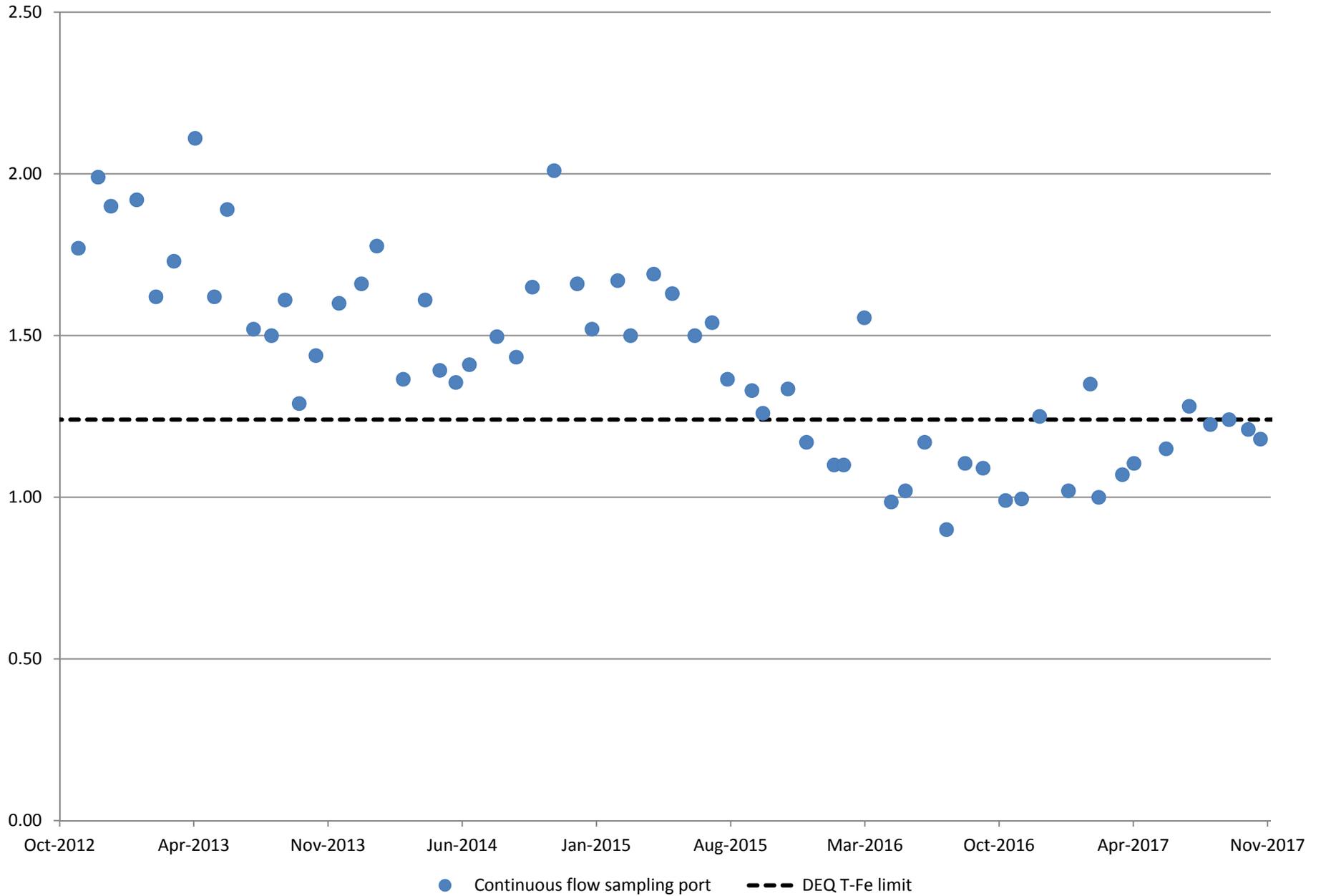


EXHIBIT 5: Mine Discharge

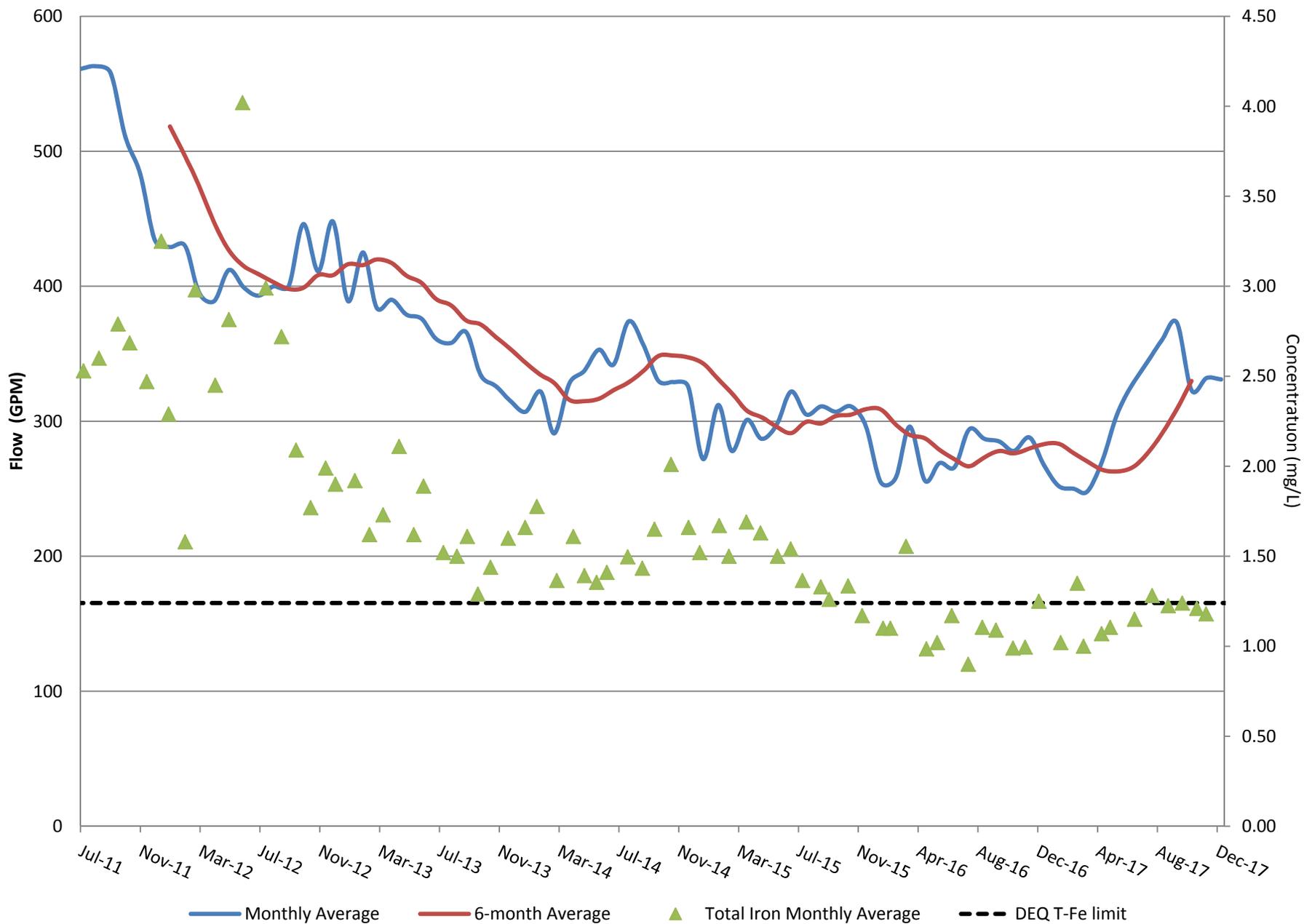


Table 1: Raw data of Genwal and Division Total Iron Concentrations, Monthly Average of Split Samples, and Monthly Average Flow *UPDES Exceedances in Red, >1.24 mg/L T-Fe

Sample Date	Continuous Flow Sampling Port	Genwal (G) or Division (D) Sample	Monthly Median	Monthly Average Flow
total iron (mg/L)				(gpm)
1/8/2007	0.012	G		
2/6/2007	0.015	G		
3/7/2007	0.033	G		
4/18/2007	0.013	G		
5/1/2007	< .005	G		
6/13/2007	0.012	G		
7/16/2007	< .01	G		
8/30/2007	0.64	G		
9/11/2007	0.073	G		
10/15/2007	no flow	G		
11/15/2007	no flow	G		
12/15/2007	no flow	G		
1/10/2008	0.937	G		
1/28/2008	1.491	G		
2/11/2008	0.765	G		
2/18/2008	0.668	G		
3/3/2008	1.846	G		
3/17/2008	0.626	G		
4/1/2008	0.653	G		
4/15/2008	0.491	G		
5/5/2008	0.433	G		
5/14/2008	0.457	G		
6/1/2008	0.448	G		
7/16/2008	0.434	G		
8/14/2008	0.546	G		
9/9/2008	0.775	G		
10/10/2008	1.335	G		
11/15/2008	0.141	G		
12/9/2008	1.569	G		
1/7/2009	1.78	G		
2/3/2009	2.45	G		
3/4/2009	2.23	G		
4/6/2009	2.455	G		

Sample Date	Continuous Flow Sampling Port	Genwal (G) or Division (D) Sample	Monthly Median	Monthly Average Flow
total iron (mg/L)				(gpm)
5/6/2009	2.33	G		
6/3/2009	2.50	G		
7/29/2009	2.92	G		
8/24/2009	5.151	G	5.15	
9/3/2009	3.01	G	3.01	
10/28/2009	8.03	G	8.03	
11/18/2009	3.927	G	3.93	
12/16/2009	3.102	G	3.10	
1/28/2010	3.00	G	3.00	
2/23/2010	3.30	G	3.30	
3/26/2010	3.709	G	3.71	
4/21/2010	4.268	G	4.27	
5/18/2010	3.119	G	3.12	
6/23/2010	5.312	G	5.31	
7/21/2010	3.97	G	3.97	
8/27/2010	3.23	G	3.23	
9/29/2010	3.47	G	3.47	
10/29/2010	2.81	G	2.81	
11/22/2010	3.19	G	3.19	
12/17/2010	3.29	G	3.29	
1/24/2011	2.93	G	2.93	
2/23/2011	2.41	G	2.41	
3/10/2011	2.34	G	2.28	
3/10/2011	1.98	D		
3/17/2011	2.18	G		
3/17/2011	2.06	D		
3/24/2011	2.39	G		
3/24/2011	2.28	D		
3/28/2011	2.31	G		
3/30/2011	2.36	G		
3/30/2011	2.04	D		

Sample Date	Continuous Flow Sampling Port	Genwal (G) or Division (D) Sample	Monthly Median	Monthly Average Flow
total iron (mg/L)				(gpm)
4/7/2011	2.39	G	2.43	
4/7/2011	2.15	D		
4/14/2011	2.25	G		
4/14/2011	2.11	D		
4/19/2011	2.62	G		
4/19/2011	2.43	D		
4/26/2011	2.55	G		
4/27/2011	6.68	G		
4/27/2011	5.00	D		
5/3/2011	2.05	G	2.10	
5/3/2011	2.02	D		
5/12/2011	2.16	G		
5/12/2011	2.00	D		
5/17/2011	2.56	G		
5/17/2011	2.33	D		
5/25/2011	2.07	D		
5/31/2011	2.13	G		
6/27/2011	2.27	G	2.27	
7/21/2011	2.66	D	2.53	561
7/25/2011	2.40	G		
8/22/2011	2.60	G	2.60	563
9/30/2011	2.79	G	2.79	558
10/24/2011	1.75	G	2.69	511
10/25/2011	3.62	D		
11/28/2011	2.47	G	2.47	483
12/28/2011	3.25	G	3.25	434
1/12/2012	2.29	G	2.29	429
2/15/2012	1.58	G	1.58	430
3/7/2012	3.00	D	2.98	395
3/23/2012	2.96	G		
4/17/2012	2.45	G	2.45	389

Sample Date	Continuous Flow Sampling Port	Genwal (G) or Division (D) Sample	Monthly Median	Monthly Average Flow
total iron (mg/L)				(gpm)
5/15/2012	2.73	G	2.82	412
5/15/2012	2.90	D		
6/12/2012	4.02	G	4.02	399
7/30/2012	2.99	G	2.99	393
8/31/2012	2.72	G	2.72	400
9/30/2012	2.09	G	2.09	400
10/30/2012	1.77	G	1.77	446
11/30/2012	1.99	G	1.99	411
12/20/2012	1.90	G	1.90	448
1/29/2013	1.92	G	1.92	389
2/28/2013	1.62	G	1.62	425
3/28/2013	1.73	G	1.73	384
4/30/2013	2.11	G	2.11	390
5/30/2013	1.65	G	1.62	379
6/19/2013	1.93	D	1.89	376
6/24/2013	1.85	G		
7/30/2013	1.47	D	1.52	361
7/30/2013	1.57	G		
8/27/2013	1.44	D	1.49	358
8/28/2013	1.54	G		
8/29/2013	1.52	G		
9/17/2013	1.48	D	1.51	366
9/17/2013	1.54	G		
9/26/2013	1.81	G		
10/9/2013	1.71	D	1.59	334
10/9/2013	1.46	G		
10/17/2013	0.74	G		
10/24/2013	1.35	G		

Sample Date	Continuous Flow Sampling Port	Genwal (G) or Division (D) Sample	Monthly Median	Monthly Average Flow
total iron (mg/L)				(gpm)
11/4/2013	1.19	G	1.31	326
11/8/2013	1.43	G		
11/14/2013	1.46	G		
11/19/2013	1.49	D		
11/19/2013	1.54	G		
11/26/2013	1.52	G		
12/10/2013	1.65	G	1.60	315
12/10/2013	1.48	D		
12/12/2013	1.65	G		
12/17/2013	1.51	G		
12/26/2013	1.71	G		
1/14/2014	1.53	G	1.66	307
1/22/2014	1.72	G		
1/28/2014	1.74	G		
1/28/2014	1.65	D		
2/7/2014	1.91	G	1.78	322
2/26/2014	1.68	G		
2/26/2014	1.74	D		
3/20/2014	1.29	G	1.37	291
3/25/2014	1.46	G		
3/25/2014	1.33	D		
3/31/2014	1.38	G		
4/23/2014	1.74	G	1.61	328
4/30/2014	1.48	G		
5/16/2014	1.38	G	1.39	337
5/23/2014	1.37	G		
5/28/2014	1.33	D		
5/29/2014	1.49	G		
6/10/2014	1.39	G	1.36	353
6/10/2014	1.32	D		

Sample Date	Continuous Flow Sampling Port	Genwal (G) or Division (D) Sample	Monthly Median	Monthly Average Flow
total iron (mg/L)			(gpm)	
7/1/2014	1.44	G	1.41	342
7/1/2014	1.38	D		
8/13/2014	1.42	G	1.5	374
8/19/2014	1.61	G		
8/19/2014	1.46	D		
9/12/2014	1.49	G	1.43	356
9/15/2014	1.37	D		
9/29/2014	1.44	G		
10/7/2014	1.48	D	1.65	330
10/9/2014	1.81	G		
10/20/2014	1.66	G		
11/10/2014	2.99	G	2.01	329
11/24/2014	1.58	G		
11/25/2014	1.46	D		
12/16/2014	1.58	D	1.66	326
12/16/2014	1.74	G		
1/8/2015	1.59	G	1.52	272
1/27/2015	1.45	D		
2/17/2015	1.77	G	1.67	312
2/23/2015	1.55	D		
2/23/2015	1.70	G		
3/9/2015	1.59	G	1.50	278
3/17/2015	1.40	D		
4/14/2015	1.82	G	1.69	301
4/30/2015	1.55	D		
5/13/2015	1.63	D	1.63	287
5/13/2015	1.63	G		
6/17/2015	1.52	G	1.50	297
6/22/2015	1.47	D		
6/29/2015	1.52	G		

Sample Date	Continuous Flow Sampling Port	Genwal (G) or Division (D) Sample	Monthly Median	Monthly Average Flow
total iron (mg/L)				(gpm)
7/14/2015	1.54	G	1.54	322
8/6/2015	1.29	D	1.37	305
8/7/2015	1.44	G		
9/14/2015	1.33	G	1.33	311
10/1/2015	1.22	G	1.26	307
10/5/2015	1.33	G		
10/20/2015	1.24	D		
11/9/2015	1.45	G	1.34	311
11/16/2015	1.22	D		
12/8/2015	1.18	G	1.17	297
12/8/2015	1.16	D		
1/20/2016	1.11	G	1.10	255
1/20/2016	1.09	D		
2/4/2016	1.13	G	1.10	258
2/4/2016	1.07	D		
3/7/2016	1.60	G	1.56	296
3/7/2016	1.51	D		
4/18/2016	1.01	G	0.99	256
4/18/2016	0.96	D		
5/10/2016	1.07	G	1.02	269
5/10/2016	0.96	D		
6/15/2016	1.11	G	1.17	266
6/15/2016	1.23	D		
7/13/2016	0.69	G	0.90	294
7/13/2016	1.11	D		
8/11/2016	1.14	G	1.105	287
8/11/2016	1.07	D		
9/8/2016	1.10	G	1.09	285
9/8/2016	1.08	D		
10/13/2016	1.01	G	0.99	278
10/13/2016	0.97	D		
11/7/2016	1.02	G	0.995	288
11/7/2016	0.97	D		

Sample Date	Continuous Flow Sampling Port	Genwal (G) or Division (D) Sample	Monthly Median	Monthly Average Flow
total iron (mg/L)				(gpm)
12/5/2016	1.33	G	1.25	268
12/5/2016	1.17	D		
1/19/2017	1.02	G	1.02	252
2/22/2017	1.32	G	1.35	250
2/22/2017	1.38	D		
3/7/2017	1.00	G	1.00	248
3/7/2017	1.00	D		
4/13/2017	1.08	G	1.07	271
4/17/2017	1.06	D		
5/1/2017	1.08	G	1.13	305
5/1/2017	1.13	D		
6/20/2017	1.08	D	1.15	327
6/28/2017	1.17	D		
7/26/2017	1.68	G	1.28	343
7/26/2017	0.883	D		
8/28/2017	1.25	G	1.225	360
8/28/2017	1.20	D		
9/26/2017	1.26	G	1.24	373
9/26/2017	1.22	D		
10/26/2017	1.30	G	1.21	323
10/26/2017	1.12	D		
11/14/2017	1.28	G	1.18	332
11/14/2017	1.08	D		