Outgoing
C0150032
cc: Daron
Steve C.

GARY R. HERBERT
Governor
GREGORY S. BELL
Lieutenant Governor

State of Utah
DEPARTMENT OF NATURAL RESOURCES
MICHAEL R. STYLER
Executive Director
Division of Oil, Gas and Mining
JOHN R. BAZA
Division Director

August 24, 2012

Ken Walker, Chief
Western Region
Office of Surface Mining
Reclamation and Enforcement
P.O. Box 46667
Denver, CO 80201-6667

SUBJECT: CRANDALL CANYON WATER QUALITY

Dear Mr. Walker:

As per your request, please find enclosed an update on the Crandall Canyon water quality. This updates the available information through June 2012 and provides a statistical analysis of the water quality trend. The total iron concentration has fluctuated between 1.58 mg/L and 4.02 mg/L from July 2011 to June 2012, but statistical analysis shows there is no trend for that period, in contract to a downward trend from January 2010 to March 2011. Six-month averages of the total iron concentration for the June 2011 to July 2012 period have fluctuated between 2.34 mg/L and 2.68 mg/L.

If you have any questions, please contact Dana Dean at (801) 538-5320.

Sincerely,

John R. Baza
Director

JRB:dd/ear
Enclosure

cc: BOGM
Denise Dragoo
David Hibbs

Crandall Canyon Mine Hydrologic Evaluation Update
August 13, 2012

Introduction

The Division of Oil, Gas and Mining (the Division) completed a Hydrologic Evaluation of the Crandall Canyon Minewater Discharge in June 2010. Since that time, numerous reports have been prepared by the Division and Genwal Resources, Inc. (Genwal) that examine the mine water discharge at Crandall Canyon. The reports have generally agreed that the source of the elevated iron concentrations in the minewater discharge is most likely the oxidation of sulfide minerals (e.g., pyrite). The oxidation of pyrite (FeS_2) in an oxygenated aqueous environment proceeds according to the following reaction:

$$FeS_2 + {}^7/_2O_2 + H_2O = Fe^{2+} + 2SO_4^{2-} + 2H^+$$

The reaction above shows that when pyrite is oxidized, ferrous iron (Fe^{2+}), sulfate (SO_4^{2-}) and acidity (H^+) are released. Acidity generated by the reaction is consumed by excess alkalinity available from the dissolution of carbonate minerals, which are prevalent in the Wasatch plateau.

Board Decision

On March 6, 2012, the Board of Oil, Gas and Mining (the Board) found that "*the high iron concentrations at issue will not likely persist for more than three years, and that annual water treatment costs will be $240,000 per year over that timeframe*" and ordered additional bonding in the amount of $720,000. The Board further ordered that the "*$720,000 bond will be held undiminished until iron concentrations in the untreated discharge water have fallen below applicable UPDES discharge limits for a period of not less than six consecutive months, or such other period of time as the Board, based on evidence submitted by either the Division or Genwal, may find is sufficient to indicate that treatment is no longer required.*"[1]

Additionally, the Board Order stated, "*The Division shall review the water monitoring data annually or with such greater frequency as the Division deems appropriate in order to evaluate continuing changes in total iron concentration. Should the Division or Genwal, based on this monitoring, conclude that a bond adjustment (increase or decrease), or bond release, is warranted, it may petition the Board for a modification of this order and adjustment of the bond.*"[1] In compliance with the Board's Order, the following report presents an update on the data collected through June 2012. The report will focus only on data collected since January 2010 (after total iron concentrations in the discharge peaked). The following sections of this update report describe: the data currently being collected, plots which have been prepared to examine the data, and a data trend analysis.

Sampling

Genwal has continued to perform monthly sampling and analysis of the minewater discharge in accordance with the Crandall Canyon Mining and Reclamation Plan (MRP). The sampling is conducted to evaluate the need for continued treatment of the mine water discharge in order to meet the 1.24 mg/L maximum daily effluent limitation (MDEL) for total iron in accordance with their Utah Pollutant Discharge Elimination System permit (UPDES permit). The MDEL for total iron was raised from 1.0 mg/L to 1.24 mg/L during the UPDES permit renewal on May 1, 2011. In addition, treatment is required for compliance with the nuisances' standard of Section I.C. of the UPDES permit. Beginning in November 2011, Genwal changed

sampling protocol and began using a long purging period which is reflected in data collected from November 2011 to current.

Past Year's Data

Minewater chemistry analytical results from January 2010 to June 2012 are tabulated in Table 1. Over the past twelve months, July 2011 to June 2012, the individual total iron concentrations have fluctuated as low as 1.58 mg/L and as high as 4.02 mg/L. Monthly medians and 6 month rolling averages of monthly medians (6 month average) for total iron are tabulated in Table 2. The 6 month averages offer a more narrow view and have fluctuated between total iron concentrations of 2.34 mg/L and 2.68 mg/L over the past twelve months. Total iron concentrations and the 6 month averages from January 2010 through June 2012 are plotted in Figure 1. The first half of Figure 1 (January 2010 to April 2011) shows a decreasing total iron concentration, while the second half of Figure 1 (May 2011 to June 2012) shows a total iron concentration averaging around 2.5 mg/L.

In November 2011, the Board was presented an *Investigation of Iron Concentration in the Genwal Resources, Inc. Crandall Canyon Mine Discharge Water* by Genwal which presented data collected through October 18, 2011 and included a "*reasonable plausible decay curve*" (Genwal predicted decay curve) for future total iron concentrations.[2] A detailed comparison of the 6 month average with the Genwal predicted decay curve is shown in Figure 2. The Genwal predicted decay curve total iron concentration for June 2012 is approximately 1.8 mg/L; however, the actual measured total iron concentration for June 2012 was 4.02 mg/L and the calculated total iron 6 month average for June 2012 was 2.7 mg/L. The Genwal predicted decay curve results in approximately a 126% underestimate of the actual total iron concentration and approximately a 50% underestimate of the 6 month average.

The Division is concerned that the total iron concentration appears to be stabilizing at approximately 2.5 mg/L. This is well demonstrated by graphing the most recent twelve months of data and corresponding 6 month averages and adding a linear trend line as shown in Figure 3. The figure shows that the total iron concentrations may no longer be decreasing and indicates the total iron concentration may have entered a stable trend state.

Mann-Kendall Trend Analysis

Division staff performed a Mann-Kendall trend analysis to determine the status of the trend. The Mann-Kendall trend analysis is a very effective test for identifying trends in time series environmental data. The test is especially useful as it compares the relative magnitudes of samples rather than the measured values themselves. The comparison of relative magnitudes of samples is important as it makes the test not overly influenced by large spikes which can occur with environmental data. The test can also handle data measured over a varying frequency such as multiple results per time period by use of a time period median.[3] Thus the Division analysis was conducted using a monthly median calculated from the Division and Genwal sample results.

The Mann-Kendall trend analysis was performed on the untreated minewater discharge total iron monthly medians from July 2011 to June 2012 and is included as Table 3. The resulting S value was a positive 10 value which indicates an increasing trend. However, the corresponding Z value showed a 95% confidence was not met to indicate an increasing trend. It is thus concluded that the Mann-Kendall trend analysis of the total iron monthly medians from July 2011 to June 2012 indicates a stable or no trend condition.

Conclusions

Monitoring results show the total iron concentrations in the minewater discharge decreased from January 2010 to approximately March 2011. However, linear trend line analysis and Mann-Kendall trend analysis of the most recent twelve months of data (July 2011 to June 2012) indicate that a stable or no trend condition is currently occurring around a total iron concentration of 2.5 mg/L.

References

1. Board of Oil, Gas and Mining., Findings of Fact, Conclusions of Law and Order., Docket No. 2010-026., Cause No. C/0150032 F., March 6th, 2012.
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.

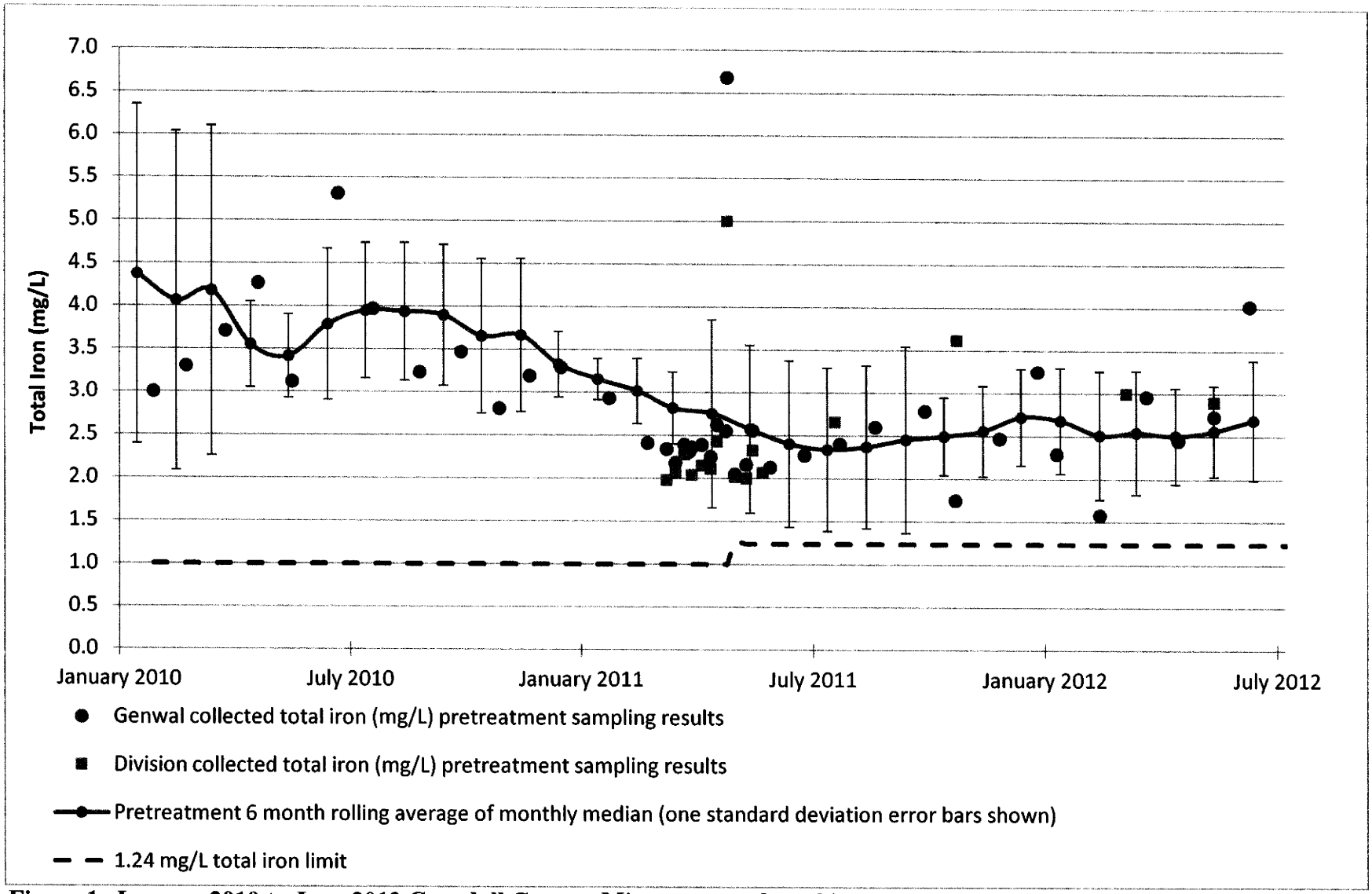

Figure 1: January 2010 to June 2012 Crandall Canyon Mine untreated total iron discharge

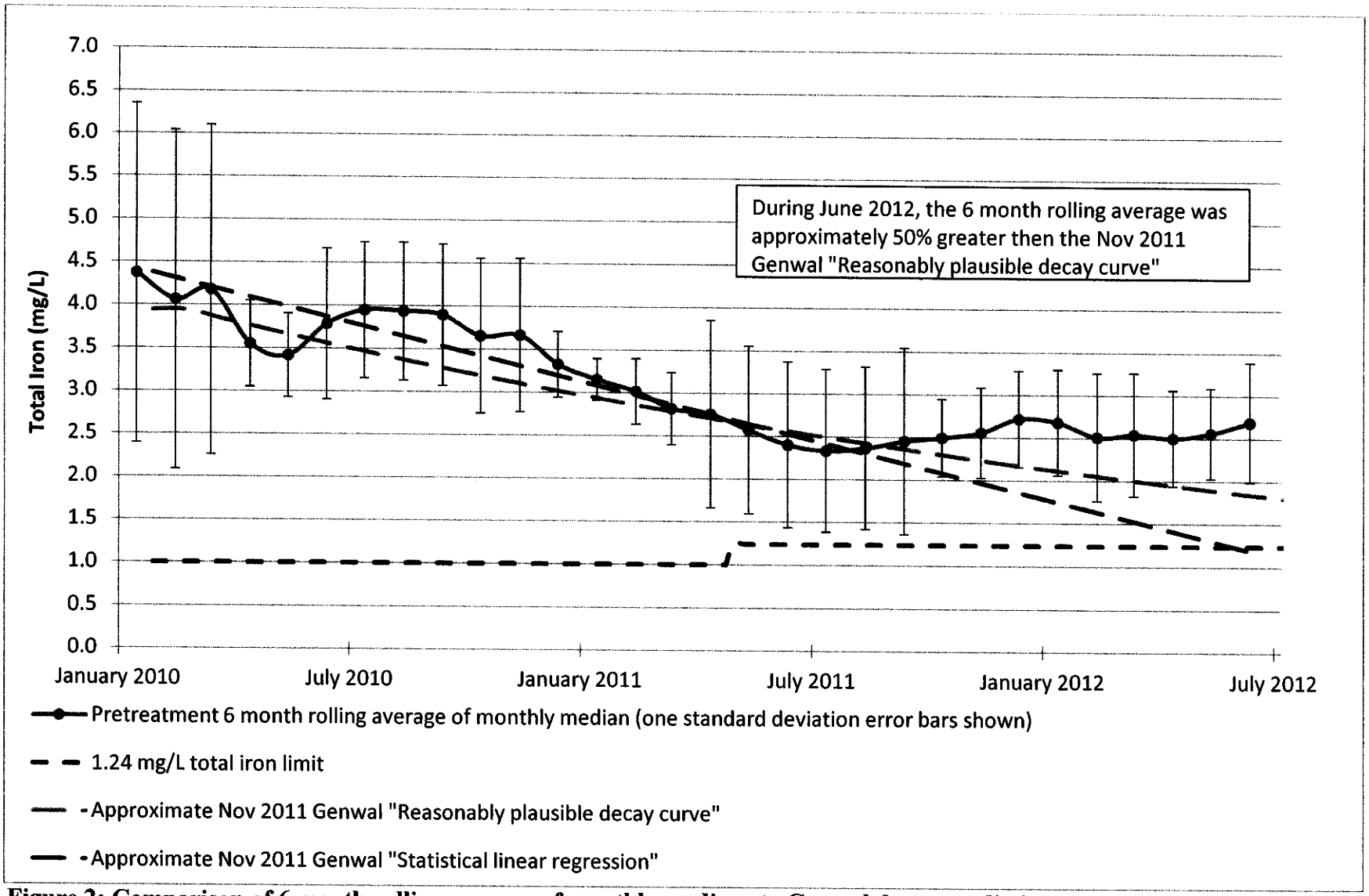

Figure 2: Comparison of 6 month rolling average of monthly medians to Genwal decay prediction

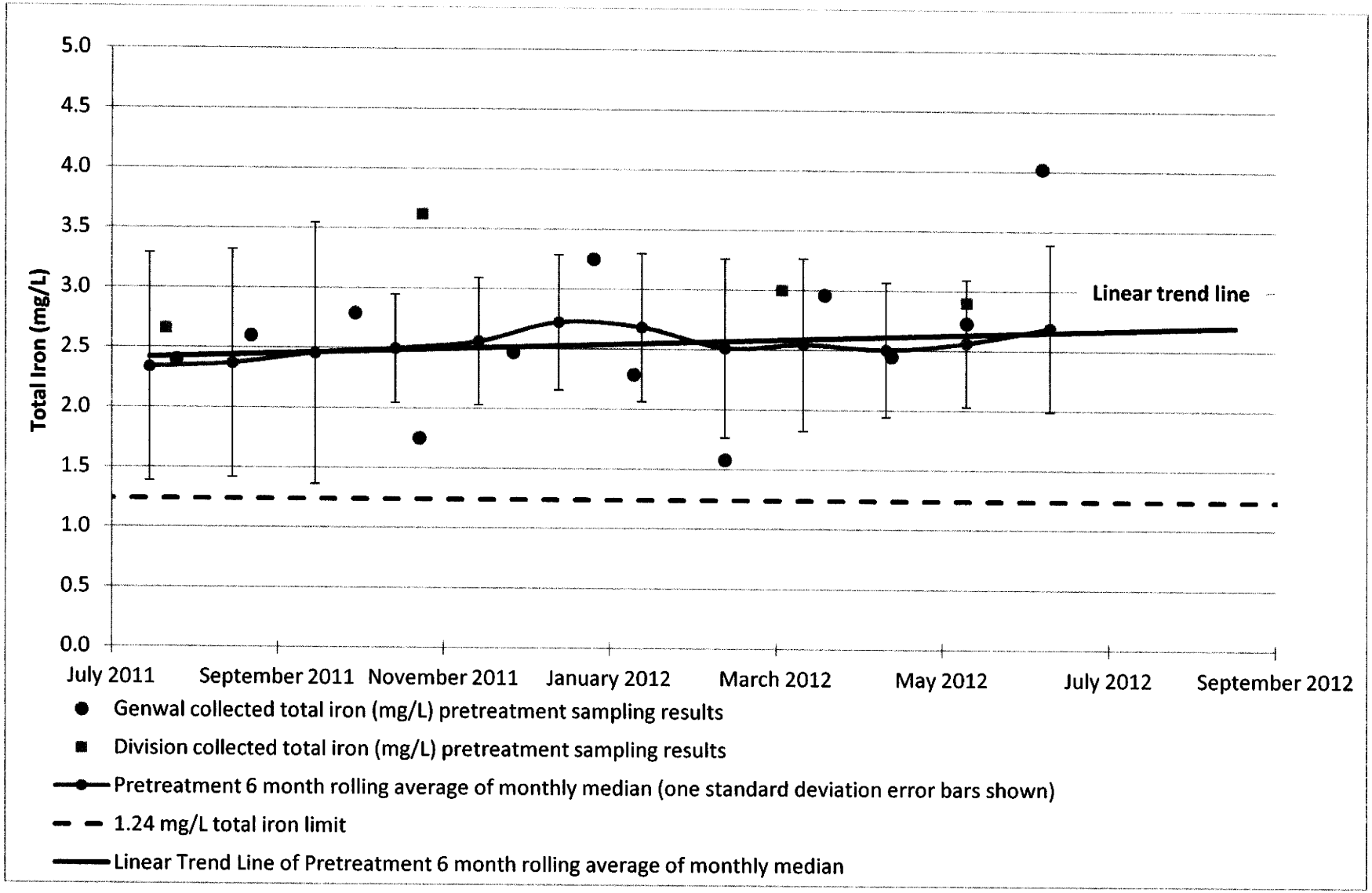

Figure 3: Twelve months of total iron data with linear trend line

Table 1: Genwal and Division total iron sampling results

	Genwal collected total iron pretreatment sampling results (mg/L)	Division collected total iron pretreatment sampling results (mg/L)
1/28/2010	3.00	
2/23/2010	3.30	
3/26/2010	3.71	
4/21/2010	4.27	
5/18/2010	3.12	
6/23/2010	5.31	
7/21/2010	3.97	
8/27/2010	3.23	
9/29/2010	3.47	
10/29/2010	2.81	
11/22/2010	3.19	
12/17/2010	3.29	
1/24/2011	2.93	
2/23/2011	2.41	
3/10/2011	2.34	1.98
3/17/2011	2.18	2.06
3/24/2011	2.39	2.28
3/28/2011	2.31	
3/30/2011	2.36	2.04
4/7/2011	2.39	2.15
4/14/2011	2.25	2.11
4/19/2011	2.62	2.43
4/26/2011	2.55	
4/27/2011	6.68	5.00
5/3/2011	2.05	2.02
5/12/2011	2.16	2.00
5/17/2011	2.56	2.33
5/25/2011		2.07
5/31/2011	2.13	
6/27/2011	2.27	
7/21/2011		2.66
7/25/2011	2.40	
8/22/2011	2.60	
9/30/2011	2.79	
10/24/2011	1.75	
10/25/2011		3.62
11/28/2011	2.47	
12/28/2011	3.25	
1/12/2012	2.29	
2/15/2012	1.58	
3/7/2012		3.00
3/23/2012	2.96	
4/17/2012	2.45	
5/15/2012	2.73	2.90
6/12/2012	4.02	

Table 2: Monthly median and 6 month rolling averages for total iron

	Monthly median total iron concentration (mg/L)	6 month rolling total iron average of monthly medians (mg/L)
January 2010	3.00	4.37
February 2010	3.30	4.06
March 2010	3.71	4.18
April 2010	4.27	3.55
May 2010	3.12	3.42
June 2010	5.31	3.78
July 2010	3.97	3.95
August 2010	3.23	3.93
September 2010	3.47	3.89
October 2010	2.81	3.65
November 2010	3.19	3.66
December 2010	3.29	3.33
January 2011	2.93	3.15
February 2011	2.41	3.02
March 2011	2.22	2.81
April 2011	3.13	2.86
May 2011	2.17	2.69
June 2011	2.27	2.52
July 2011	2.53	2.45
August 2011	2.60	2.49
September 2011	2.79	2.58
October 2011	2.69	2.51
November 2011	2.47	2.56
December 2011	3.25	2.72
January 2012	2.29	2.68
February 2012	1.58	2.51
March 2012	2.98	2.54
April 2012	2.96	2.59
May 2012	2.82	2.56
June 2012	4.02	2.69

Table 3: Mann-Kendall Trend: Twelve months of monthly medians

Contaminant: **Total Iron**

Count matches	
2 limit = 3	0
3 limit = 3	0
4 limit = 3	0
5 limit = 2	0
6 limit = 2	0

Formula	Wp
0	0
0	0
0	0
0	0
0	0
0	0
0	0
0	0
0	0
0	0
0	0
0	0
0	0
SUM	0

Evaluation

V(S)	212.666667
Z Well	0.61715293
Level of Significance	95%
Zalpha	1.645
Stable/No Trend/Exp	**Stable/No Trend**

S Value

Neg	Pos
28	38
S Value (Pos-Neg)	10

Mann-Kendall Trend: Samples > 10

	Month	Jul-11	Aug-11	Sep-11	Oct-11	Nov-11	Dec-11	Jan-12	Feb-12	Mar-12	Apr-12	May-12	Jun-12
Month	Data	2.53	2.60	2.79	2.685	2.47	3.25	2.29	1.58	2.98	2.45	2.82	4.02
July 2011	2.53		0.07	0.26	0.155	-0.06	0.72	-0.24	-0.95	0.45	-0.08	0.29	1.49
August 2011	2.60			0.19	0.085	-0.13	0.65	-0.31	-1.02	0.38	-0.15	0.22	1.42
September 2011	2.79				-0.105	-0.32	0.46	-0.5	-1.21	0.19	-0.34	0.03	1.23
October 2011	2.685					-0.215	0.565	-0.395	-1.105	0.295	-0.235	0.135	1.335
November 2011	2.47						0.78	-0.18	-0.89	0.51	-0.02	0.35	1.55
December 2011	3.25							-0.96	-1.67	-0.27	-0.8	-0.43	0.77
January 2012	2.29								-0.71	0.69	0.16	0.53	1.73
February 2012	1.58									1.4	0.87	1.24	2.44
March 2012	2.98										-0.53	-0.16	1.04
April 2012	2.45											0.37	1.57
May 2012	2.82												1.2
June 2012	4.02												
# 0s		0	0	0	0	0	0	0	0	0	0	0	0