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TECHNICAL MEMORANDUM

To: Project File

From: Chris Garrett, Project Manager

Date: January 3, 2019

Re: **Review of Hydrologic Trends in Devil's Canyon and on Oak Flat / SWCA Project No. 030951.04**

PURPOSE OF MEMO

The purpose of this memo is to document an examination of hydrologic trends from monitoring conducted over the last decade or more by Resolution Copper for Devil's Canyon and Oak Flat. Comments from the public have indicated the belief that ongoing dewatering pumping of the deep aquifer system has already affected water resources in both these areas.

APPROACH

Since natural systems exhibit large amounts of variation, wherever possible it is useful to take an objective statistical approach in order to discern true patterns in data over time. For monitoring conducted in Devil's Canyon, a variety of monitoring has occurred over a reasonably long time period, which is ideal for utilizing statistical techniques. For Oak Flat, monitoring has been conducted as well but not always in a quantitative manner, and analysis is more qualitative than statistical.

Available Data Sets

For Devil's Canyon, the following data sets were identified to analyze using statistical techniques:

- Baseflow at monitoring location DC-8.8C. Baseflow has been calculated using a variety of techniques, including the minimum of the November 7-day average streamflow. This data set has seven data points (2004-2006, 2012-2015).

- Baseflow at monitoring location DC-8.1C, using minimum of the November 7-day average streamflow. This data set has five data points (2011-2015).

- Baseflow at monitoring location DC-5.5C, using minimum of the November 7-day average streamflow. This data set has 11 data points (2003-2010, 2013-2015).

- Baseflow at monitoring location DC-5.5C, using the median daily streamflow. This data set has six data points (2004-2007, 2009, 2015).

- Manual flow measurements at spring DC-8.2W. This data set has 20 data points between 2003 and 2016.

- Manual flow measurements at spring DC-6.6W. This data set has 15 data points between 2003 and 2016.
- Manual flow measurements at spring DC-6.1E. This data set has 15 data points between 2004 and 2016.
- Manual flow measurements at spring DC-4.1E. This data set has 8 data points between 2014 and 2017.
- Measured saturated length of Devil's Canyon. This data set has 23 data points between 2002 and 2013. Because measurements are taken quarterly for some years and variations could occur seasonally, this data set was also analyzed using individual quarters (1Q = 6 data points; 2Q = 6 data points; 3Q = 6 data points; 4Q = 5 data points).

Sources

Baseflow calculations were derived from automated water level measurements captured with data sondes installed in the channel of Devil's Canyon, and then converted to streamflow using rating curves. Baseflow calculations are included in Montgomery & Associates 2017 (Table 8); the rating curves are derived in JE Fuller 2017.

Spring flow measurements are found in Montgomery & Associates 2018.

Saturated length measurements are found in Montgomery & Associates 2017a (Table 3).

Statistical Techniques

The goal of the statistical analysis is to identify whether there is, or is not, an upward or downward trend in the presence or amount of water over time. However, it is not necessary to rigorously quantify that trend or identify any correlations of water presence with other factors (like precipitation or snowpack). One useful technique commonly used for such hydrologic analyses is a Mann-Kendall trend analysis, which is a non-parametric technique. For non-parametric tests, the actual magnitude of the individual data points does not matter, just whether they are larger or smaller than preceding measurements (Helsel and Hirsch 2002). Corrections must be made where values are tied, and time gaps in the data set are acceptable.

The result of the Mann-Kendall test is the "tau" value. If positive, the tau value indicates an upward trend exists, and if negative the tau value indicates a downward trend exists. While the tau value does not provide a true slope through the plotted data, larger positive values indicate a stronger upward trend and more negative values indicate a stronger downward trend.

Statistical techniques always require a test for statistical significance, which gives assurance that the statistical results aren't just the product of random variation but represent a true trend. A commonly used threshold for statistical significance is a "p-value" of 0.05. The p-value is typically explained as the likelihood that the result being considered has arisen randomly from the data. Typically, any results with a p-value less than 0.05 are considered to be statistically significant, while those with larger p-values are not considered to represent "true" trends.

For data sets with less than 10 data points, the test for statistical significance has to be modified. The p-value is not calculated directly, but rather an interim statistics (the absolute value of the S statistic) is compared to a threshold (Smax) and the result is considered statistically significant if S>=Smax.

Qualitative Analysis

Qualitative analysis of surface water features on Oak Flat was conducted by Resolution Copper and included a variety of field measurements and visual surveys (including time-lapse photography) (Montgomery & Associates 2017b).

DEVIL'S CANYON STATISTICAL RESULTS

Calculations for all Mann-Kendall trend tests are included as Appendix A, and the results are summarized in table 1.

Table 1. Summary of results for Mann-Kendall tests on Devil's Canyon hydrologic data sets

Location	**Parameter**	**Number of Data Points**	**Tau value**	**p-value**	**Statistically significant (at 0.05)?**
DC-8.8C	Baseflow, minimum of November 7-day streamflow	7	-0.619	n/a	S = -13, absolute value of which is less than Smax = 15. Trend is not statistically significant
DC-8.1C	Baseflow, minimum of November 7-day streamflow	5	0.4	n/a	S = 4, which is less than Smax = 10. Trend is not statistically significant
DC-5.5C	Baseflow, minimum of November 7-day streamflow	11	-0.236	0.3524	Trend is not statistically significant
DC-5.5C	Baseflow, median daily streamflow	6	-0.2	n/a	S = -3, absolute value of which is less than Smax = 13. Trend is not statistically signficant
DC-8.2W	Manually measured spring flow	20	-0.221	0.1802	Trend is not statistically significant

Location	**Parameter**	**Number of Data Points**	**Tau value**	**p-value**	**Statistically significant (at 0.05)?**
DC-6.6W	Manually measured spring flow	15	0.114	0.5552	Trend is not statistically significant
DC-6.1E	Manually measured spring flow	15	0.238	0.2224	Trend is not statistically significant
DC-4.1E	Manually measured spring flow	8	-0.536	n/a	S = -15, absolute value of which is less than Smax = 18. Trend is not statistically significant
All of Devil's Canyon	Saturated length, all measurements	23	0.296	0.0512	Trend is not statistically significant
All of Devil's Canyon	Saturated length, First Quarter measurements only	6	0.2	n/a	S = 3, absolute value of which is less than Smax = 13. Trend is not statistically significant
All of Devil's Canyon	Saturated length, Second Quarter measurements only	6	0.2	n/a	S = 3, absolute value of which is less than Smax = 13. Trend is not statistically significant
All of Devil's Canyon	Saturated length, Third Quarter measurements only	6	0.333	n/a	S = 5, absolute value of which is less than Smax = 13. Trend is not statistically significant

Location	Parameter	Number of Data Points	Tau value	p-value	Statistically significant (at 0.05)?
All of Devil's Canyon	Saturated length, Fourth Quarter measurements only	5	0.8	n/a	S = 8, absolute value of which is less than Smax = 10. Trend is not statistically significant

Of the thirteen data sets analyzed, none show a statistically significant trend either upward or downward. The saturated length of Devil's Canyon would be significant if the threshold were adjusted slightly higher (p-value of 0.10), in which case it shows an upward trend not a downward trend. Overall, none of the direct field measurements taken between roughly 2003 and 2017 of hydrologic parameters along Devil's Canyon suggest that dewatering pumping is having a negative effect on natural stream or spring flow.

OAK FLAT QUALITATIVE ANALYSIS

Resolution Copper also undertook monitoring of surface water features on Oak Flat. Fourteen sites were observed between March and September 2017 within the drainage basins of Rancho Rio Canyon (a tributary to Devil's Canyon, Number 9 wash (a tributary to Queen Creek), and Oak Flat wash (also a tributary to Queen Creek).

The 14 monitoring sites were observed during three seasons: spring, summer (pre-monsoon and post-monsoon), and during the monsoon.

The study generally found:

> "Surface water is found across seasons and in many locations throughout Oak Flat. This study suggests that alluvial veneers are the main reason for the existence of surface water for prolonged periods on Oak Flat. These alluvial features retain precipitation derived surface water runoff, gradually releasing it over an extended period. Water released from the alluvium is conveyed in streams until it reaches bedrock pools, or tinajas that provide longer term storage of surface water. These bedrock pools are often deep and shaded, providing conditions that enable surface water to persist long into the dry, hot summer." (Montgomery & Associates 2017b)

While the results were useful for determining the hydrology and seasonal dynamics of these sites, the period of monitoring is insufficient to detect any long-term trends that may be associated with ongoing pumping. The most that can be said is that pumping (which re-started in 2009) has not resulted in complete drying of the 14 locations monitored, and that the reliance on storage of precipitation in near-surface alluvial veneers suggests that pumping would not affect these locations.

CONCLUSIONS

Substantial monitoring has taken place on Devil's Canyon since 2003, including a variety of hydrologic parameters (stream flow measured with automated sondes, manual spring flow measurements, saturated length measurements). Intensive monitoring has taken place on Oak Flat as well, but only for a short time period in 2017.

Based on the analyses in this memo, there are no objective indications from any of the data reviewed that surface water features have been impacted by ongoing dewatering pumping conducted by Resolution Copper.

REFERENCES

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JE Fuller Hydrology and Geomorphology, Inc. 2017. Surface Water Data Assessment. January 31, 2017.

Montgomery & Associates. 2017a. Surface Water Baseline Addendum: Upper Queen Creek, Devils Canyon, and Mineral Creek Watersheds. January 26, 2017.

Montgomery & Associates. 2017b. 2017 Oak Flat Surface Water Monitoring Program. November 13, 2017.

Montgomery & Associates. 2018. Spring and Seep Catalog, Resolution Copper Project Area, Upper Queen Creek and Devils Canyon Watersheds, Version 2.0. June 15, 2018.

APPENDIX A

Mann-Kendall Trend Test Calculations

MANN-KENDALL TREND TEST CALCULATIONS FOR DC-8.8C, MINIMUM NOVEMBER 7-DAY STREAMFLOW

		2004	2005	2006	2012	2013	2014	2015	
DATE	**Baseflow (cfs)**	0.488	0.331	0.688	0.082	0.282	0.024	0.041	
2004	0.488		-1	1	-1	-1	-1	-1	-4
2005	0.331			1	-1	-1	-1	-1	-3
2006	0.688				-1	-1	-1	-1	-4
2012	0.082					1	-1	-1	-1
2013	0.282						-1	-1	-2
2014	0.024							1	1
2015	0.041								

Statistic	Result	Formula
S	-13	
n	7	
t	-0.619048	S/(n*(n-1)/2)
V	44.33333	(n*(n-1))*(2n+5)/18
Zmk	-1.8	S>0=(S-1)/sqrt(V); S<0=(S+1)/sqrt(V)
Zmk for lookup	1.8	
p for n>10	n/a	
Smax for n<10	15	
Conclusion:	**Abs(S) < Smax; Not significant at a=0.05**	

MANN-KENDALL TREND TEST CALCULATIONS FOR DC-8.1C, MINIMUM NOVEMBER 7-DAY STREAMFLOW

		2011	2012	2013	2014	2015	
DATE	**Baseflow (cfs)**	0.006	0.002	0.031	0.051	0.01	
2011	0.006		-1	1	1	1	2
2012	0.002			1	1	1	3
2013	0.031				1	-1	0
2014	0.051					-1	-1
2015	0.01						

Statistic	Result	Formula
S	4	
n	5	
t	0.4	S/(n*(n-1)/2)
V	16.66667	(n*(n-1))*(2n+5)/18
Zmk	0.73	S>0=(S-1)/sqrt(V); S<0=(S+1)/sqrt(V)
Zmk for lookup	0.73	
p for n>10	n/a	
Smax for n<10	10	

Conclusion: Abs(S) < Smax; Not significant at a=0.05

MANN-KENDALL TREND TEST CALCULATIONS FOR DC-5.5C, MINIMUM NOVEMBER 7-DAY STREAMFLOW

		2003	2004	2005	2006	2007	2008	2009	2010	2013	2014	2015	
DATE	**Baseflow (cfs)**	0.002	0.201	0.056	0.197	0.038	0.007	0.011	0.204	0	0.038	0.002	
2003	0.002		1	1	1	1	1	1	1	-1	1	0	7
2004	0.201			-1	-1	-1	-1	-1	1	-1	-1	-1	-7
2005	0.056				1	-1	-1	-1	1	-1	-1	-1	-4
2006	0.197					-1	-1	-1	1	-1	-1	-1	-5
2007	0.038						-1	-1	1	-1	0	-1	-3
2008	0.007							1	1	-1	1	-1	1
2009	0.011								1	-1	1	-1	0
2010	0.204									-1	-1	-1	-3
2013	0										1	1	2
2014	0.038											-1	-1
2015	0.002												

Statistic	Result	Formula
S	-13	
n	11	
t	-0.236364	S/(n*(n-1)/2)
V	165	(n*(n-1))*(2n+5)/18
Zmk	-0.93	S>0=(S-1)/sqrt(V); S<0=(S+1)/sqrt(V)
Zmk for lookup	0.93	
p for n>10	0.3524	

Conclusion: p < 0.05; Not significant at a=0.05

MANN-KENDALL TREND TEST CALCULATIONS FOR DC-5.5C, MEDIAN DAILY STREAMFLOW

		2004	2005	2006	2007	2009	2015	
DATE	**Baseflow (cfs)**	0.153	0.154	0.312	0.329	0.056	0	
2004	0.153		1	1	1	-1	-1	1
2005	0.154			1	1	-1	-1	0
2006	0.312				1	-1	-1	-1
2007	0.329					-1	-1	-2
2009	0.056						-1	-1
2015	0							

Statistic	Result	Formula
S	-3	
n	6	
t	-0.2	S/(n*(n-1)/2)
V	28.33333	(n*(n-1))*(2n+5)/18
Zmk	-0.38	S>0=(S-1)/sqrt(V); S<0=(S+1)/sqrt(V)
Zmk for lookup	0.38	
p for n>10	n/a	
Smax for n<10	13	

Conclusion: Abs(S) < Smax; Not significant at a=0.05

MANN-KENDALL TREND TEST CALCULATIONS FOR DC-8.2W, MANUAL SPRING FLOW MEASUREMENTS

		5/20/2003	8/21/2003	11/12/2003	2/17/2004	5/21/2004	8/16/2004	11/16/2004	2/25/2005	5/11/2005	8/16/2005	11/5/2008	5/19/2009	11/10/2010	5/3/2012	2/27/2014	5/29/2014	9/3/2014	11/21/2014	10/14/2015	9/23/2016	
DATE	**Flow (gpm)**	11	11	8	11	12	9	2	3	10	1	1	10	0	5	2	2	5	5	15	5	
5/20/2003	11		0	-1	0	1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	1	-1	-13
8/21/2003	11			-1	0	1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	1	-1	-13
11/12/2003	8				1	1	1	-1	-1	1	-1	-1	1	-1	-1	-1	-1	-1	-1	1	-1	-5
2/17/2004	11					1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	1	-1	-12
5/21/2004	12						-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	1	-1	-13
8/16/2004	9							-1	-1	1	-1	-1	1	-1	-1	-1	-1	-1	-1	1	-1	-8
11/16/2004	2								1	1	-1	-1	1	-1	1	0	0	1	1	1	1	5
2/25/2005	3									1	-1	-1	1	-1	1	-1	-1	1	1	1	1	2
5/11/2005	10										-1	-1	0	-1	-1	-1	-1	-1	-1	1	-1	-8
8/16/2005	1											0	1	-1	1	1	1	1	1	1	1	7
11/5/2008	1												1	-1	1	1	1	1	1	1	1	7
5/19/2009	10													-1	-1	-1	-1	-1	-1	1	-1	-6
11/10/2010	0														1	1	1	1	1	1	1	7
5/3/2012	5															-1	-1	0	0	1	0	-1
2/27/2014	2																0	1	1	1	1	4
5/29/2014	2																	1	1	1	1	4
9/3/2014	5																		0	1	0	1
11/21/2014	5																			1	0	1
10/14/2015	15																				-1	-1
9/23/2016	5																					

Statistic	Result	Formula
S	-42	
n	20	
t	-0.22105	S/(n*(n-1)/2)
V	950	(n*(n-1))*(2n+5)/18
V corrected	932	((n*n-1)*(2n+5)-tie correction)/18
Zmk	-1.34	S>0=(S-1)/sqrt(V); S<0=(S+1)/sqrt(V)
Zmk for lookup	1.34	
p for n>10	0.1802	

Conclusion: p < 0.05; Not significant at a=0.05

Tie correction

Value	Tie	tp	tp-1	2tp+5	tp(tp-1)(2tp+5)
11	0	3	2	11	66
1	1	2	1	9	18
10	2	2	1	9	18
2	3	3	2	11	66
5	4	4	3	13	156
				Tie correction	324

MANN-KENDALL TREND TEST CALCULATIONS FOR DC-6.6W, MANUAL SPRING FLOW MEASUREMENTS

		5/29/2003	9/3/2003	11/4/2003	2/18/2004	5/4/2004	8/19/2004	11/12/2004	2/16/2005	5/17/2005	9/7/2005	5/4/2012	2/27/2014	9/25/2014	11/7/2014	2/17/2016	
DATE	**Flow (gpm)**	0	0	1	1	0	0	1	32	0	0	2	1	0.1	1	0	
5/29/2003	0		0	1	1	0	0	1	1	0	0	1	1	1	1	0	8
9/3/2003	0			1	1	0	0	1	1	0	0	1	1	1	1	0	8
11/4/2003	1				0	-1	-1	0	1	-1	-1	1	0	-1	0	-1	-4
2/18/2004	1					-1	-1	0	1	-1	-1	1	0	-1	0	-1	-4
5/4/2004	0						0	1	1	0	0	1	1	1	1	0	6
8/19/2004	0							1	1	0	0	1	1	1	1	0	6
11/12/2004	1								1	-1	-1	1	0	-1	0	-1	-2
2/16/2005	32									-1	-1	-1	-1	-1	-1	-1	-7
5/17/2005	0										0	1	1	1	1	0	4
9/7/2005	0											1	1	1	1	0	4
5/4/2012	2												-1	-1	-1	-1	-4
2/27/2014	1													-1	0	-1	-2
9/25/2014	0.1														1	-1	0
11/7/2014	1															-1	-1
2/17/2016	0																

Statistic	Result	Formula
S	12	
n	15	
t	0.114286	S/(n*(n-1)/2)
V	408.3333	(n*(n-1))*(2n+5)/18
V corrected	347.3333	((n*n-1)*(2n+5)-tie correction)/18
Zmk	0.59	S>0=(S-1)/sqrt(V); S<0=(S+1)/sqrt(V)
Zmk for lookup	0.59	
p for n>10	0.5552	

Conclusion: p < 0.05; Not significant at a=0.05

Tie correction

Value	Tie	tp	tp-1	2tp+5	tp(tp-1)(2tp+5)
0	0	7	6	19	798
1	1	5	4	15	300
				Tie correction	1098

MANN-KENDALL TREND TEST CALCULATIONS FOR DC-6.1E, MANUAL SPRING FLOW MEASUREMENTS

		5/20/2004	8/23/2004	11/18/2004	2/28/2005	5/24/2005	8/23/2005	8/7/2008	11/6/2008	5/20/2009	3/19/2010	10/19/2010	11/10/2010	8/15/2012	12/16/2015	7/19/2016	
DATE	Saturated Length	2	1	2	0	0	0	1	0	3	1	5	80	0	1.5	6	
5/20/2004	2		-1	0	-1	-1	-1	-1	-1	1	-1	1	1	-1	-1	1	-5
8/23/2004	1			1	-1	-1	-1	0	-1	1	0	1	1	-1	1	1	1
11/18/2004	2				-1	-1	-1	-1	-1	1	-1	1	1	-1	-1	1	-4
2/28/2005	0					0	0	1	0	1	1	1	1	0	1	1	7
5/24/2005	0						0	1	0	1	1	1	1	0	1	1	7
8/23/2005	0							1	0	1	1	1	1	0	1	1	7
8/7/2008	1								-1	1	0	1	1	-1	1	1	3
11/6/2008	0									1	1	1	1	0	1	1	6
5/20/2009	3										-1	1	1	-1	-1	1	0
3/19/2010	1											1	1	-1	1	1	3
10/19/2010	5												1	-1	-1	1	0
11/10/2010	80													-1	-1	-1	-3
8/15/2012	0														1	1	2
12/16/2015	1.5															1	1
7/19/2016	6																

Statistic	Result	Formula
S	25	
n	15	
t	0.238095	S/(n*(n-1)/2)
V	408.3333	(n*(n-1))*(2n+5)/18
V corrected	387	((n*n-1)*(2n+5)-tie correction)/18
Zmk	1.22	S>0=(S-1)/sqrt(V); S<0=(S+1)/sqrt(V)
Zmk for lookup	1.22	
p for n>10	0.2224	

Conclusion: p < 0.05; Not significant at a=0.05

Tie correction

Value	Tie	tp	tp-1	2tp+5	tp(tp-1)(2tp+5)
2	0	2	1	9	18
1	1	3	2	11	66
0	2	5	4	15	300

Tie correction 384

MANN-KENDALL TREND TEST CALCULATIONS FOR DC-4.1E, MANUAL SPRING FLOW MEASUREMENTS

		2/10/2014	5/20/2014	8/28/2014	11/25/2014	12/16/2015	5/24/2016	12/15/2016	3/31/2017	
DATE	Flow (gpm)	1.5	1.5	3	1	2	0.3	0.8	0.1	
2/10/2014	1.5		0	1	-1	1	-1	-1	-1	-2
5/20/2014	1.5			1	-1	1	-1	-1	-1	-2
8/28/2014	3				-1	-1	-1	-1	-1	-5
11/25/2014	1					1	-1	-1	-1	-2
12/16/2015	2						-1	-1	-1	-3
5/24/2016	0.3							1	-1	0
12/15/2016	0.8								-1	-1
3/31/2017	0.1									

Statistic	Result	Formula
S	-15	
n	8	
t	-0.535714	S/(n*(n-1)/2)
V	65.33333	(n*(n-1))*(2n+5)/18
Zmk	-1.73	S>0=(S-1)/sqrt(V); S<0=(S+1)/sqrt(V)
Zmk for lookup	1.73	
p for n>10	n/a	
Smax for n<10	18	

Conclusion: Abs(S) < Smax; Not significant at a=0.05

MANN-KENDALL TREND TEST CALCULATIONS FOR SATURATED LENGTH OF DEVIL'S CANYON - ALL QUARTERS

		2002 Q4	2003 Q2	2003 Q3	2004 Q1	2004 Q2	2004 Q3	2004 Q4	2005 Q1	2005 Q2	2005 Q3	2008 Q3	2008 Q4	2009 Q1	2009 Q3	2010 Q1	2010 Q2	2010 Q4	2011 Q1	2011 Q2	2014 Q1	2014 Q2	2014 Q3	2014 Q4	
DATE	**Saturated Length (mi)**	2.35	3.39	2.77	8.05	1.69	1.95	2.51	5.63	2.21	2.48	7.33	3.69	8.23	5.31	7.6	3.99	3.57	6.25	3.65	9.81	2.74	4.6	6.03	
2002 Q4	2.35		1	1	1	-1	-1	1	1	-1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	16
2003 Q2	3.39			-1	1	-1	-1	-1	1	-1	-1	1	1	1	1	1	1	1	1	1	1	-1	1	1	7
2003 Q3	2.77				1	-1	-1	-1	1	-1	-1	1	1	1	1	1	1	1	1	1	1	-1	1	1	8
2004 Q1	8.05					-1	-1	-1	-1	-1	-1	-1	-1	1	-1	-1	-1	-1	-1	-1	1	-1	-1	-1	-15
2004 Q2	1.69						1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	18
2004 Q3	1.95							1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	17
2004 Q4	2.51								1	-1	-1	1	1	1	1	1	1	1	1	1	1	1	1	1	12
2005 Q1	5.63									-1	-1	1	-1	1	-1	1	-1	-1	1	-1	1	-1	-1	1	-3
2005 Q2	2.21										1	1	1	1	1	1	1	1	1	1	1	1	1	1	14
2005 Q3	2.48											1	1	1	1	1	1	1	1	1	1	1	1	1	13
2008 Q3	7.33												-1	1	-1	1	-1	-1	-1	-1	1	-1	-1	-1	-6
2008 Q4	3.69													1	1	1	1	-1	1	-1	1	-1	1	1	5
2009 Q1	8.23														-1	-1	-1	-1	-1	-1	1	-1	-1	-1	-8
2009 Q3	5.31															1	-1	-1	1	-1	1	-1	-1	1	-1
2010 Q1	7.6																-1	-1	-1	-1	1	-1	-1	-1	-6
2010 Q2	3.99																	-1	1	-1	1	-1	1	1	1
2010 Q4	3.57																		1	1	1	-1	1	1	4
2011 Q1	6.25																			-1	1	-1	-1	-1	-3
2011 Q2	3.65																				1	-1	1	1	2
2014 Q1	9.81																					-1	-1	-1	-3
2014 Q2	2.74																						1	1	2
2014 Q3	4.6																							1	1
2014 Q4	6.03																								

Statistic	Result	Formula
S	75	
n	23	
t	0.296443	S/(n*(n-1)/2)
V	1433.667	(n*(n-1))*(2n+5)/18
Zmk	1.95	S>0=(S-1)/sqrt(V); S<0=(S+1)/sqrt(V)
Zmk for lookup	1.95	
p for n>10	0.0512	
Conclusion:	**p < 0.05; Not significant at a=0.05**	

MANN-KENDALL TREND TEST CALCULATIONS FOR SATURATED LENGTH OF DEVIL'S CANYON - FIRST QUARTER ONLY

		2004 Q1	2005 Q1	2009 Q1	2010 Q1	2011 Q1	2014 Q1	
DATE	**Saturated Length (mi)**	8.05	5.63	8.23	7.6	6.25	9.81	
2004 Q1	8.05		-1	1	-1	-1	1	-1
2005 Q1	5.63			1	1	1	1	4
2009 Q1	8.23				-1	-1	1	-1
2010 Q1	7.6					-1	1	0
2011 Q1	6.25						1	1
2014 Q1	9.81							

Statistic	Result	Formula
S	3	
n	6	
t	0.2	S/(n*(n-1)/2)
V	28.33333	(n*(n-1))*(2n+5)/18
Zmk	0.38	S>0=(S-1)/sqrt(V); S<0=(S+1)/sqrt(V)
Zmk for lookup	0.38	
p for n>10	n/a	
Smax for n<10	13	

Conclusion: Abs(S) < Smax; Not significant at a=0.05

MANN-KENDALL TREND TEST CALCULATIONS FOR SATURATED LENGTH OF DEVIL'S CANYON - SECOND QUARTER ONLY

		2003 Q2	2004 Q2	2005 Q2	2010 Q2	2011 Q2	2014 Q2	
DATE	**Saturated Length (mi)**	3.39	1.69	2.21	3.99	3.65	2.74	
2003 Q2	3.39		-1	-1	1	1	-1	-1
2004 Q2	1.69			1	1	1	1	4
2005 Q2	2.21				1	1	1	3
2010 Q2	3.99					-1	-1	-2
2011 Q2	3.65						-1	-1
2014 Q2	2.74							

Statistic	Result	Formula
S	3	
n	6	
t	0.2	S/(n*(n-1)/2)
V	28.33333	(n*(n-1))*(2n+5)/18
Zmk	0.38	S>0=(S-1)/sqrt(V); S<0=(S+1)/sqrt(V)
Zmk for lookup	0.38	
p for n>10	n/a	
Smax for n<10	13	

Conclusion: Abs(S) < Smax; Not significant at a=0.05

MANN-KENDALL TREND TEST CALCULATIONS FOR SATURATED LENGTH OF DEVIL'S CANYON - THIRD QUARTER ONLY

		2003 Q3	2004 Q3	2005 Q3	2008 Q3	2009 Q3	2014 Q3	
DATE	**Saturated Length (mi)**	2.77	1.95	2.48	7.33	5.31	4.6	
2003 Q3	2.77		-1	-1	1	1	1	1
2004 Q3	1.95			1	1	1	1	4
2005 Q3	2.48				1	1	1	3
2008 Q3	7.33					-1	-1	-2
2009 Q3	5.31						-1	-1
2014 Q3	4.6							

Statistic	Result	Formula
S	5	
n	6	
t	0.333333	S/(n*(n-1)/2)
V	28.33333	(n*(n-1))*(2n+5)/18
Zmk	0.75	S>0=(S-1)/sqrt(V); S<0=(S+1)/sqrt(V)
Zmk for lookup	0.75	
p for n>10	n/a	
Smax for n<10	13	

Conclusion: Abs(S) < Smax; Not significant at a=0.05

MANN-KENDALL TREND TEST CALCULATIONS FOR SATURATED LENGTH OF DEVIL'S CANYON - FOURTH QUARTER ONLY

		2002 Q4	2004 Q4	2008 Q4	2010 Q4	2014 Q4	
DATE	**Saturated Length (mi)**	2.35	2.51	3.69	3.57	6.03	
2002 Q4	2.35		1	1	1	1	4
2004 Q4	2.51			1	1	1	3
2008 Q4	3.69				-1	1	0
2010 Q4	3.57					1	1
2014 Q4	6.03						

Statistic	Result	Formula
S	8	
n	5	
t	0.8	S/(n*(n-1)/2)
V	16.66667	(n*(n-1))*(2n+5)/18
Zmk	1.71	S>0=(S-1)/sqrt(V); S<0=(S+1)/sqrt(V)
Zmk for lookup	1.71	
p for n>10	n/a	
Smax for n<10	10	

Conclusion: Abs(S) < Smax; Not significant at a=0.05