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Technical Report Overview

Report: Calcite Monitoring Program 2016 Report

Overview: This report presents the 2016 results of the calcite monitoring program required under Permit 107517. This report summarizes the degree and extent of calcite formation in specific stream reaches within the Elk Valley watershed.

This report was prepared for Teck by Lotic Environmental Ltd.

For More Information

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Future studies will be made available at **teck.com/elkvalley**

Teck Coal Ltd.
2016 Calcite Monitoring Annual Report

Elk Valley

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Definitions

- Degree – The amount of calcite deposition estimated by the level of concretion.
- Exposed – Stream locations with mine-influenced water. Areas downstream of mining.
- Extent – The spatial coverage of calcite deposition which can be expressed as an area covered at a specific location or linear coverage over a stream profile.
- Habitat unit – A distinct channel unit possessing homogeneous geomorphological characteristics (e.g., riffle, pool, glide, cascade). Also referred to as channel unit or mesohabitat.
- Reach – A relatively homogeneous section of stream in terms of channel morphology, riparian cover and flow (RISC 2001).
- Reference – An area without upstream mining activity.
- Sampling unit – A single unit used to describe a larger entity. For example, a site could be considered the sampling unit for estimating the average calcite coverage over an entire reach.
- Segment - Combines adjacent reaches that have similar calcite indexes identified from previous sampling and have the same exposure to mining.
- Site – A location within a reach where observations of calcite deposition were made. These are replicate observations (sample units) within the treatment unit (reach).

Executive Summary

In 2015, the Calcite Monitoring Program (the Program) study design was assessed to determine its effectiveness in monitoring calcite in streams associated with Teck's mine operations. The assessment included a detailed review of the data collected and collection methods used to date to inform updates to the monitoring program to meet the objectives of the Program (Robinson *et al.* 2016). The assessment identified elements that were working well and others that warranted updating. An updated Program for 2016-2018 was submitted to the BC Ministry of Environment and the Environmental Monitoring Committee as required Section 12.2 by the Environmental Management Act Permit 107517 (Robinson and Atherton 2016).

Recommendations were made to improve the efficiency in the field while retaining the ability to meet the objectives (Robinson and Atherton 2016). The Program is designed to provide spatial estimates of degree and extent of calcite deposition over a continuous stream network. An objective when designing the 2016 Program was to redistribute effort spatially from areas where calcite index (*CI)* variability was low to areas where *CI* variability was higher. This was accomplished by:

- Grouping like reaches (i.e. similar *CI*) into stream segments.
- Redistribute effort in terms of the number of sites per reach from reaches where *CI* variability was low to areas where *CI* variability was higher.
- No longer collect habitat unit or particle size data since neither of these two metrics were found to be significantly related to *CI.*

Sampling effort beyond the standard protocol was added to the 2016 monitoring program to support the understanding of calcite treatment (expected to be conducted in Greenhills Creek) and to provide more detailed monitoring downstream of new mining activity in Dry Creek (Line Creek Operations).

Data analyses continued to use both linear regression and ANOVA analyses as interim methods to investigate trends over time. It is likely that regression analysis alone could be used for trend analysis going forward. At request of the Environmental Monitoring Committee (EMC), a block design was added to the 2016 Program. The block design categorized reaches sampled into four block types (reference, historical exposure, recent exposure and treated). Linear regression was run within each "block type" to assess trends over time by type.

The 2016 Program was conducted from September 22 – November 10, 2016. The Program was completed as per the work plan with only minor changes to sites sampled. A total of 85 indicator reaches and 232 sites were surveyed in 2016 compared to the 124 stream reaches and 348 sites that were surveyed in 2015. Calcite distribution observed in 2016 was consistent with previous observations, with the majority of exposed stream kilometers in the 0.00-0.50 *CI* bin for both mainstem and tributary categories. All reference mainstem and tributary stream kilometers were classified into the 0.00-0.50 *CI* bin, similar to previous years.

Regression analysis was run on historical exposure, reference exposure, and treated blocks. *CI* was not found to be significantly predicted by Year for any of these three block types ($p=0.330$, $df=260$; $p=0.960$, $df=39$; $p=0.822$, $df=7$, respectively). Regression analysis was not run on the

"recent exposure" block type, as these *CI*-values were constantly 0.00 at all reaches for all years sampled.

A total of 57 indicator reaches showed variability in *CI* by year from 2013-2016, and were assessed using regression analysis. Ten reaches were found to significantly change over the four year period (α=0.10, df = 3). The rate of change (ΔCI/year) varied from -0.58 to 0.55.

ANOVA results showed the reach mean CI varied significantly by year in 18 reaches. Of these, only two reaches were also reported to have a significant change using regression. In nearly all reaches, the significant ANOVA results appear to be the results of one year having a significantly different CI score than the other three years. This suggests detection of outlier years, as opposed to actual trends over time.

Teck is aware of calcite measurements collected from other aquatic monitoring programs that have produced results that vary from those presented in this report, at a limited number of reaches. Teck is planning to investigate these observations and assess how the results of those investigations can inform this Program. While differences in calcite indices have been reported, it is worth noting that programs do differ in site location within a reach, methods for selection of site locations (systematic versus objective), and habitat types sampled (composite versus riffles only). One other potential difference is how other programs treat the sampling of fines (i.e., sand, silt, clay).

Calcite appeared in two of this Program's reference reaches for the first time (note, calcite has been reported in other reference streams in prior years of this Program, just not these two streams). It is worth noting that the 2013 Program began after a large regional flood event that resulted in a large amount of streambed movement. The Calcite Monitoring Program may now be documenting a return cycle to increasing calcite conditions resulting from smaller freshet events in recent years.

The recommended 2017 Calcite Monitoring Program is to repeat the sampling sites visited in 2016. The number of sites to be sampled will follow the protocol used in 2016 where the most recent *CI* will be used to determine the amount of effort (sites per indicator reach) required. The current sampling protocol will be assessed in 2018 and the appropriateness of using segments to interpolate *CI* over multiple reaches will be assessed by sampling all reaches initially sampled in 2013 - 2015 Programs again in 2018.

1 Introduction

In 2015, the Calcite Monitoring Program (the Program) study design was assessed to determine its effectiveness in monitoring calcite in streams associated with Teck's mine operations. The assessment included a detailed review of the data collected and collection methods used to date to inform updates to the monitoring program to meet the objectives of the Program (Robinson *et al.* 2016). The assessment identified elements that were working well and others that warranted updating. An updated Program for 2016-2018 was submitted to the BC Ministry of Environment and the Environmental Monitoring Committee as required Section 12.2 by the Environmental Management Act Permit 107517 (Robinson and Atherton 2016). This Program and the associated approval conditions defined the monitoring undertaken in 2016.

This report is being submitted to fulfill Permit 107517 Section 10.7 which states "A Calcite Monitoring (Section 9.5) Annual Report must be submitted to the Director by May 31, of each year following the data collection calendar year." Table 1 outlines the Permit 107517 Section 10.7 annual reporting requirements and which section of this report fulfills each requirement.

Table 1. Permit 107517 annual reporting requirements.

Requirement Number	Description	Report Section Reference
i	A map of monitoring locations	Appendix 3
ii	A summary of background information on that year's program, including discussion of program modifications relative to previous years	2.2
iii	Results of stream selection reassessment – highlight streams added/removed	2.3
iv	Summary of where sampling followed the methodology in the monitoring plan document, and details where sampling deviated from the approved methodology	3.1
v	Statement of results for the period over which sampling was conducted	3.1
vi	Reference to the raw data, provided as appendices	2.4
vii	General discussion of observations, including summary tables of sites with increasing and decreasing deposition indices	3.1, 3.3
viii	Interpretation of location, extent, and any other observations	3.1
ix	A summary of any QA/QC issues during the year	3.5
x	Recommendations for sites to add, sites to remove, modifications to methodology, monitoring frequency adjustments	5

1.1 *Program Objectives*

The objectives of the Teck 2016 - 2018 *Calcite Monitoring Program* (Robinson and Atherton 2016) are:

1. Document the extent and degree of calcite deposition in streams downstream of Teck's coal operations (e.g., streams influenced by mining, calcite treatment, water treatment and in reference streams);
2. Satisfy the requirements for annual calcite monitoring in Environmental Management Act Permit 107517; and,
3. Provide data to support the re-evaluation of Big Question 4 and specific Key Questions in Teck's Adaptive Management Plan as they relate to calcite.

1.2 *Linkage to Adaptive Management*

As required in Permit 107517 Section 11, Teck has developed an Adaptive Management Plan (AMP) to support implementation of the EVWQP, to achieve water quality targets including calcite targets, ensure that human health and the environment are protected, and where necessary, restored, and to facilitate continuous improvement of water quality in the Elk Valley. Teck has provided this section of Lotic's report in order to provide a consistent approach to describing linkages between Adaptive Management and related programs and reports.

Following an adaptive management framework, the AMP identifies six Big Questions that will be re-evaluated at regular intervals as part of AMP updates throughout the duration of EVWQP implementation. For each Big Question, the AMP describes how the Big Question will be periodically re-evaluated, and how the key uncertainties under the Big Question will be reduced. The AMP was submitted to the Environmental Monitoring Committee and MOE Director on July 30, 2016 as required. Study designs for many programs (including the 2016 - 2018 Calcite Monitoring Program) were established before the AMP was submitted. Teck is working to embed elements of the AMP within each program through reviews of monitoring programs at the study design and annual report stages. As the AMP is currently under review and in the process of being implemented, this is the first cycle where the monitoring programs are being reviewed to confirm required monitoring is included. Gaps identified in reviews of 2016 annual reports will inform future study design updates as required.

As defined in the July 30 2016 AMP, Big Question 4 ("Is calcite being managed effectively to meet site performance objectives and protect aquatic ecosystem health?") will be re-evaluated through periodic evaluation of monitoring results and treatment effectiveness on a three year timeframe as part of updates to the AMP. This process, as defined in the AMP, is outlined in Figure 1. In addition to the re-evaluation of Big Question 4, monitoring results from the Calcite Monitoring Program will be compared to future calcite Site Performance Objectives (SPOs) and Early Warning Triggers (EWT) if they can be developed through the reduction of AMP Key Question 4.4 ("Can EWTs be established for calcite that support calcite management?"). Calcite monitoring results are also utilized in the prioritization of streams for calcite management and in the periodic review and refinement of calcite SPOs.

The analysis of calcite monitoring data will also assist in addressing Key Uncertainty 4.1 ("Are calcite SPOs ecologically relevant and protective of fish and aquatic life?"), Key Uncertainty 4.2 ("What are the most effective management methods for calcite?") and Key Uncertainty 4.3 ("Are there interrelationships with calcite and cadmium in surface water that need to be considered when conducting calcite management?").

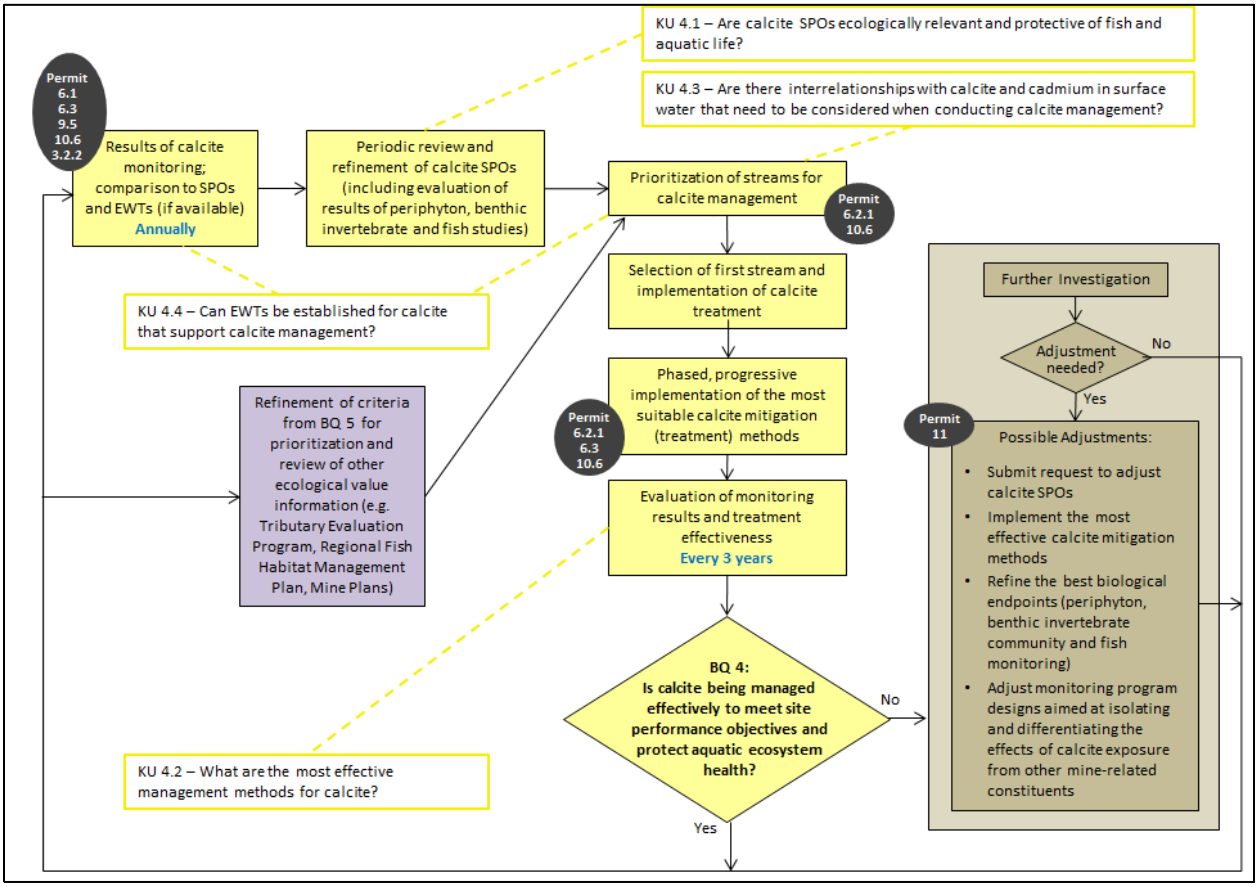

Figure 1. The process for re-evaluating the answer to Big Question 4 (Teck 2016, AMP Figure 14).

2 Methods

2.1 *Study area*

The study area was defined to include each of Teck's five coal mining operations in southern British Columbia (Figure 2). Sites are located throughout the Elk Valley to encompass areas downstream of Fording River Operations, Greenhills Operations, Line Creek Operations, Elkview Operations, and Coal Mountain Operations. The downstream study limit was Reach 8 of the Elk River, which extends to Fernie, BC. This study area is consistent with study areas for the 2013-2015 calcite monitoring field programs.

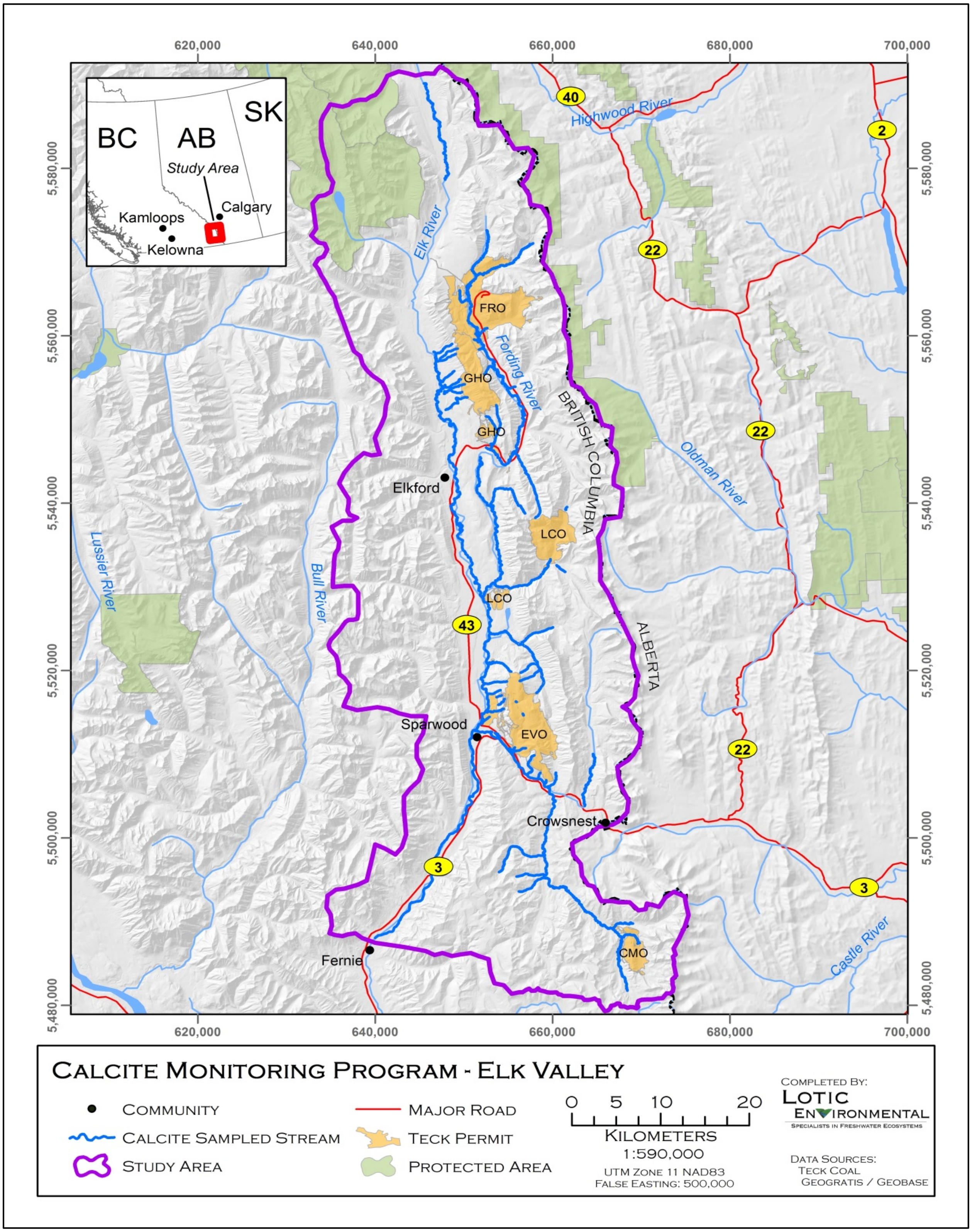

Figure 2. Elk River watershed study area map.

2.2 *Updates for 2016 - 2018 Program*

During the 2013 – 2015 Program the Elk River watershed was stratified into watersheds, streams, reaches, and ultimately sites, where observations are made on individual stream substrate particles. The observations were used to calculate a Calcite Index (*CI*) for each site. Changes in calcite deposition were assessed at a reach level by comparing *CI* by year. This 2013 – 2015 study design was assessed in 2015 based on statistical review of the data. Findings from the assessment were (Robinson and Atherton 2016):

- *CI* was a suitable and reproducible parameter for describing the degree and extent of calcite at multiple spatial scales.
- Stream reach was an appropriate morphologic unit over which to describe calcite deposition.
- Within-reach *CI* variability (and subsequently power to detect change) was a function of *CI,* with variation highest (and power lowest) at intermediate values.
- Within-site variability of *CI* was low.
- A 100-particle modified Wolman (1954) pebble count (pebble count) accurately described *CI* at a site-level.
- Year-to-year change in *CI* was found to be low.

Recommendations were made to improve the efficiency in the field while retaining the ability to meet the objectives (Robinson and Atherton 2016). The Program continues to be designed to provide spatial estimates of degree and extent of calcite deposition over a continuous stream network. An objective when designing the 2016 Program was to redistribute effort spatially from areas where *CI* variability was low to areas where *CI* variability was higher. Sites with high variability were found to be in the intermediate range (mean *CI* range = 1.00 - 2.00). This was accomplished by grouping like reaches, and reducing the number of sites at reaches with low variability and increasing the number of sites at reaches with high variability (Robinson and Atherton 2016). Like reaches are adjacent reaches that have similar calcite indexes identified from previous sampling and have the same exposure to mining. The 2016 Program then redistributed effort in the following ways:

- Grouping like reaches (i.e. similar *CI*) into stream segments.
- Redistribute effort in terms of the number of sites per reach from reaches where *CI* variability was low to areas where *CI* variability was higher.
- No longer collect habitat unit or particle size data since neither of these two metrics were found to be significantly related to *CI.*

2.2.1 Stream segment

The main changes incorporated into the 2016 Program were related to redistributing effort spatially from areas where *CI* variability was low to areas where *CI* was higher. This was accomplished in two ways (Robinson and Atherton 2016). First, sampling effort will be streamlined during annual monitoring by monitoring stream segments at a spatial scale similar to how a reach was used previously. A stream **segment** is defined as one or more contiguous reaches with: (1) Similar *CI* values observed during current monitoring; and, (2) a similar exposure to mining activity. The assumption, supported by 2013 - 2015 monitoring data, is that a segment is relatively homogenous in calcite deposition currently and should also be in any observed future trends. Therefore, calcite monitoring results collected from any reach within a segment can be used as an indicator of change of the entire segment. Segments will be monitored at an **indicator reach** (Table 2). The indicator reach for a segment was selected based on a combination of past monitoring results and logistical field sampling criteria (e.g., the reach needs to be long enough to accommodate multiple sites). Generally, the most downstream reach of a tributary has had the most opportunity for the water to reach equilibrium with the atmosphere (specifically, through the off-gassing of carbon dioxide and warming in the summer and fall seasons) and hence to be more likely to precipitate calcite, consistent with the conceptual model for calcite formation presented in Atherton (2016). Unless there is a reason for choosing otherwise, the most downstream reach has been selected as the indicator reach. Grouping by segments generated 86 segments from 120 reaches. The result was that sampling would occur at 86 indicator reaches as opposed to 124 reaches sampled from 2013 – 2015 (Table 2) (Note, Wheeler Creek, Carbon Creek, and Snowslide Creek associated with CMO2 project were not included in the 2016 Program, and the segment South Pit – Reach 2 (SPIT2) was dropped due to safety concerns). A complete list of sites sampled by program year is provided in (Appendix 1). Maps of reach locations are provided in Appendix 3.

Table 2. Summary of the segments created and the corresponding reaches.

Water feature	Segment Name	Reaches Included	Indicator Reach
Alexander	ALEX_A	ALEX3	ALEX3
Andy Good	ANDY_A	ANDY1	ANDY1
Aqueduct	AQUE_A	AQUE1, AQUE2, AQUE3	AQUE1
Balmer	BALM_A	BALM1	BALM1
Bodie	BODI_A	BODI1	BODI1
	BODI_B	BODI3	BODI3
Cataract	CATA_A	CATA1, CATA3	CATA1
Chauncey	CHAU_A	CHAU1	CHAU1
Clode West Infiltration	CLOW_A	CLOW1	CLOW1
Corbin	CORB_A	CORB1, CORB2	CORB1
Clode Pond Outlet	COUT_A	COUT1	COUT1
CCR Seep	CSEE_A	CSEE1	CSEE1
Dry (EVO)	DRYE_A	DRYE1, DRYE3, DRYE4	DRYE3
Dry (LCO)	DRYL_A	DRYL1	DRYL1
	DRYL_B	DRYL2	DRYL2
	DRYL_C	DRYL3	DRYL3
	DRYL_D	DRYL4	DRYL4
Elk	ELKR_B	ELKR11, ELKR12	ELKR12
	ELKR_D	ELKR15	ELKR15
	ELKR_A	ELKR8	ELKR8
	ELKR_C	ELKR9, ELKR10	ELKR9
Eagle Pond Outlet	EPOU_A	EPOU1	EPOU1
Erickson	ERIC_A	ERIC1, ERIC2, ERIC3, ERIC4	ERIC1
Feltham	FELT_A	FELT1	FELT1
Fennelon	FENN_A	FENN1	FENN1
Fording	FORD_G	FORD12	FORD12

Water feature	Segment Name	Reaches Included	Indicator Reach
	FORD_A	FORD1	FORD1
	FORD_B	FORD2, FORD 3	FORD2
	FORD_C	FORD4, FORD 5	FORD4
	FORD_D	FORD6	FORD6
	FORD_E	FORD7, FORD 8	FORD7
	FORD_F	FORD9, FORD 10, FORD11	FORD9
Fish Pond	FPON_A	FPON1	FPON1
Gardine	GARD_A	GARD1	GARD1
Gate	GATE_A	GATE2	GATE2
Goddard	GODD_A	GODD1	GODD1
	GODD_B	GODD3	GODD3
Grace	GRAC_A	GRAC1, GRAC2, GRAC3	GRAC1
Grassy	GRAS_A	GRAS1	GRAS1
Grave	GRAV_A	GRAV1, GRAV2	GRAV1
	GRAV_B	GRAV3	GRAV3
Greenhills	GREE_A	GREE1	GREE1
	GREE_B	GREE3	GREE3
	GREE_C	GREE4	GREE4
Harmer	HARM_A	HARM1	HARM1
	HARM_B	HARM3, HARM4, HARM5	HARM3
Henretta	HENR_A	HENR1, HENR2, HENR3	HENR1
Kilmarnock	KILM_A	KILM1	KILM1
Leask	LEAS_A	LEAS2	LEAS2
Lindsay	LIND_A	LIND1	LIND1
Line	LINE_A	LINE1, LINE2, LINE3	LINE1
	LINE_B	LINE4	LINE4
	LINE_C	LINE7	LINE7
Lake Mountain	LMOU_A	LMOU1, LMOU3, LMOU4	LMOU1
Michel	MICH_A	MICH1, MICH2	MICH1
	MICH_B	MICH3, MICH4	MICH4
	MICH_C	MICH5	MICH5
Mickelson	MICK_A	MICK1, MICK2	MICK1
Milligan	MILL_A	MILL1, MILL2	MILL1
North Thompson	NTHO_A	NTHO1	NTHO1
North Wolfram	NWOL_A	NWOL1	NWOL1
Otto	OTTO_A	OTTO1, OTTO3	OTTO1
Pengally	PENG_A	PENG1	PENG1
Porter	PORT_A	PORT1	PORT1
	PORT_B	PORT3	PORT3
Qualteri	QUAL_A	QUAL1	QUAL1
Sawmill	SAWM_A	SAWM1	SAWM1
	SAWM_B	SAWM2	SAWM2
Six Mile	SIXM_A	SIXM1	SIXM1
South Line	SLIN_A	SLIN2	SLIN2
South Pit	SPIT_A	SPIT1	SPIT1
	SPIT_B	SPIT2	SPIT2
Smith Pond Outlet	SPOU_A	SPOU1	SPOU1
Spring	SPRI_A	SPRI1	SPRI1
South Pond Seep	SPSE_A	SPSE1	SPSE1

Water feature	Segment Name	Reaches Included	Indicator Reach
Swift	SWIF_A	SWIF1, SWIF2	SWIF1
South Wolfram Creek	SWOL_A	SWOL1	SWOL1
Thompson	THOM_A	THOM1, THOM2, THOM3	THOM1
Thresher	THRE_A	THRE1	THRE1
Unnamed South of Sawmill	USOS_A	USOS1	USOS1
Willow Cr North	WILN_A	WILN2	WILN2
Willow Cr South	WILS_A	WILS1	WILS1
Wolf Creek	WOL1_A	WOL1	WOL1
Wolfram	WOLF_A	WOLF2	WOLF2
	WOLF_B	WOLF3	WOLF3

2.2.2 2016 Monitoring site locations

The second modification to improve sampling efficiency of the 2016 - 2018 Program, was to redistribute effort in terms of the number of sites per reach from reaches where *CI* variability was low to areas where *CI* variability was higher (areas with intermediate *CI* value). As described in Robinson and Atherton (2016) the number of sites visited for each segment was dependent on *CI* values observed from 2013 - 2015 (Table 3). The *CI* bins reflect the effort necessary to detect change, where the intermediate range of *CI*'s requires the greatest amount of effort (sites sampled within the reach) based on a *CI* versus *CI* variability relationship presented in Robinson *et al.* 2016.

Table 3. Number of sample sites per stream reach by CI bin (modified from Robinson and Atherton 2016).

***CI* Bin**	**N**
0.00-0.25	3*
0.25-1.00	3
1.00-1.50	6
1.50-2.00	6
2.00-2.50	3
2.50-3.00	3*

* Originally proposed as N=1 in Robinson and Atherton (2016); Study design approval letter dated October 21st 2016 included condition requiring a minimum of three sites which was incorporated in the 2016 study design.

The number of sites per reach was initially estimated based on the *CI* value from 2015. Field surveys were completed as described in the following section and the average *CI* value for the indicator reach was calculated after all sites were sampled. If the 2016 reach-average *CI* index had increased enough to move the segment into the next bin range, the crews would increase the number of sites at that time, to ensure the appropriate number of sites were sampled. This results-based field protocol could only be used to increase the number of sites and not decrease. For example, MILL2-0 had a 2015 *CI* = 0.00 but in 2016 average *CI* index was *CI* = 1.07 so six sites were completed instead of one.

2.2.3 Site-level changes

An update to the field survey methods was the removal of collecting habitat unit and particle diameter data. These were not collected since neither of these two metrics were found to be significantly related to *CI*.

2.3 *Additional sampling*

Sampling effort beyond the standard protocol was added to the 2016 monitoring program to support our understanding of calcite treatment (expected to be conducted in Greenhills Creek) and to provide more detailed monitoring downstream of new mining activity in Dry Creek (Line Creek). Sites FORD5-12.5, FORD5-25, and FORD5-50 were added even though FORD4 was supposed to be the indicator reach. This update will be continued for all monitoring within the 2016-2018 Program.

2.4 *Field surveys*

Field survey methods followed those reported in Robinson *et al.* (2013). In summary, the surveys began with a visual assessment of the streambed by wading through the stream and physically inspecting individual rocks for calcite over a minimum length of 100 m. Where calcite was observed, a modified Wolman pebble count (Wolman 1954) was conducted to quantify the degree of calcite presence using the two metrics used to calculate a site-specific *CI*:

- Calcite presence: $CI_p = Calcite\ Presence\ Score\ = \frac{Number\ of\ pebbles\ with\ calcite}{Number\ of\ pebbles\ counted}$
- Calcite concretion: $CI_c = Calcite\ Concretion\ Score = \frac{Sum\ of\ pebble\ concretion\ scores}{Number\ of\ pebbles\ counted}$
- Calcite index: $CI = Calcite\ Index = CI_p + CI_c$

Results were summarized for four stream categories: (1) Fording and Elk mainstems (reference), (2) tributaries (reference), (3) Fording and Elk mainstems (exposed), and (4) tributaries (exposed). Summary of *CI* for 2016 are provided in Appendix 2.

The same *CI* ranges or “bins” used in the previous years to report the distribution of *CI* by stream length were used. Six bins of 0.5 *CI* intervals were used to divide the range of *CI* scores from 0.00 – 3.00 (representing low to high calcite levels). Stream reach mean *CI* were mapped to depict the spatial distribution of calcite relative to each of the mines. Maps are provided in Appendix 3.

2.5 *Data analysis*

2.5.1 2016 Calcite Index and general distribution

CI values were calculated for indicator reaches sampled in 2016 and added to the long-term dataset (Appendix 1). Indicator reach values were assigned to the total length of the segment they represented. The 2016 *CI*, CI_p, and CI_c scores for indicator reaches are presented in Appendix 2. Maps of calcite distribution were prepared to provide a spatial reference to the 2016 Program results. Maps show the mean *CI* value for a segment, as calculated at the indicator reach for that segment. Maps are provided in Appendix 3.

2.5.2 Block design

At request of the Environmental Monitoring Committee (EMC), a block design was added to the 2016 Program. The block design categorized reaches sampled into four block types:

1. Reference – Reaches identified as reference for assessment in this Program.
2. Historical exposure – Reaches with mine exposure originating before the start of the regional calcite monitoring program (i.e., pre-2013).
3. Recent exposure - Reaches with mine exposure originating after the start of the regional calcite monitoring program (i.e., post-2013).
4. Treated – Reaches downstream of a water treatment facility to a point where stream order increases appreciably.

Linear regression was run within each "block type" to assess trends over time by type.

The EMC proposed a fifth block type, "Future exposure", defined as reaches currently in reference condition (as described above), but are expected to become exposed as a result of current mine extension plans. However, Wolf Creek Reach 1 was the only indicator reaches sampled in 2016 that fit this category. As this stream was only added in 2015, regression analysis could not be run on "Future exposure" block type.

2.5.3 Rate of change in calcite deposition

As outlined in Robinson and Atherton (2016) the 2016 Calcite Monitoring Program will continue to use both linear regression and ANOVA to assess changes over time, until one method proves to be superior. Rate of change analyses were only run on indictor reaches.

Regression
Regression analysis was run on all indicator reaches sampled from 2013 - 2016 to evaluate the relationship of *CI* versus time (year). Significance was conservatively set at an alpha value of $\alpha = 0.10$ when assessing slope (ΔCI/year) (Robinson and Atherton 2016). Setting $\alpha = 0.10$ relaxes the magnitude of change that would be required to be considered a statistically significant change. This was considered appropriate given that the data set of four years was relatively short for what would be desired for monitoring environmental change (i.e., >10 years). Regression results are provided in tabular form in Appendix 1 and mapped in Appendix 4.

Reaches with significant rates of change (Δ*CI*/year) were further explored at a site level. Sites were investigated by calculating the absolute change in *CI* from year to year to determine if the change appears uniform over the reach and time, or isolated to a single point spatially or temporally. Positive values indicate an increase in *CI*. Negative values indicate a reduction in *CI*. Reaches with statistically significant increases were mapped using red font, those with statistically significant decreases were colour coded on the maps in green font, and neutral sites remained in the traditional blue font (Appendix 5).

ANOVA
An ANOVA using *Year* as the independent variable was also run to evaluate the relationship of *CI* versus time (year) (2013 - 2016). A significant result would suggest that the difference in *CI* for at least one year-year pairing was greater than within-reach variability (Robinson and

Atherton 2016). Tukey's post hoc analysis was run where year was reported to be significant. An alpha value of α = 0.05 was used in this assessment (Robinson and Atherton 2016). Trends over time were qualitatively assessed by identifying sequential year-to-year changes in the same direction (i.e., increase or decrease). Appendix 6 provides bar graph representation of mean *CI* from 2013 – 2016.

2.5.4 Data quality assurance

Data quality assurance steps are as per earlier Programs (e.g., Robinson *et al.* 2016). Quality assurance steps included:

- Having field crews perform calcite measurements at multiple sites as a group during the onset of the Program. The exercise is used to calibrate observers, standardize collection methods, and review changes to the current Program.
- *CI* scores were calculated in the field to compare with previous CI scores and determine if more sampling sites needed to be added.
- A computer script using Python was written to check that cells were populated with values acceptable (e.g., calcite presence score can only be 0 or 1; concreted scores can only be 0, 1, or 2; concreted score must be 0 if calcite presence is 0). Any cells that had errors or were left blank were flagged and corrected.

3 Results

3.1 *2016 Calcite Index and general distribution*

The 2016 Program was conducted from September 22 – November 10, 2016. The Program was completed as per the work plan with only minor changes to sites sampled:

- On Elkview Operations (EVO), reach SPIT2 and sites SAWM2-75, USOS1-75, and THRE1-75 were dropped. SPIT2 was dropped by request from EVO due to safety concerns with working in that area due to the remoteness of the site. The others were dropped due to poor accessibility and all of these sites will be removed from future Programs.
- Recent spoil development at Greenhills Operations resulted in limiting the number of sites that could be sampled on SWOL1 and NWOL1 since SWOL1-50 and 75, and NWOL1-50 and 75 are all now buried under the new spoil.
- Also at Greenhills Operations WILN2-75, WILS1-75, and WOL1-75 were all dropped because of hillside stability issues and safety concerns.

A total of 85 indicator reaches and 232 sites were surveyed in 2016 compared to the 124 stream reaches and 348 sites that were surveyed in 2015. A total of 372.2 km of stream were assessed and mapped. A total of 308.8 km were considered exposed and downstream of mining activities (Table 4). A total of 63.4 km were considered reference. Results are presented by four stream categories as either mainstem Fording River and Elk River sections versus tributaries, and reference versus exposed.

Table 4. Stream calcite distribution (km) estimates for the four stream categories, by *CI* ranges for 2016.

	Reference				*Exposed*			
	Fording and Elk		*Tributaries*		*Fording and Elk*		*Tributaries*	
CI Range	***km***	***%***	***km***	***%***	***km***	***%***	***km***	***%***
0.00 - 0.50	21.8	100%	41.6	100%	123.4	81%	105.2	75%
0.51 - 1.00	0	0%	0	0%	29.6	19%	4.6	3%
1.01 - 1.50	0	0%	0	0%	0.0	0%	4.4	3%
1.51 - 2.00	0	0%	0	0%	0.0	0%	7.0	5%
2.01 - 2.50	0	0%	0	0%	0.0	0%	11.4	8%
2.51 - 3.00	0	0%	0	0%	0.0	0%	7.2	5%
Total 2016	**21.8**	**100%**	**41.6**	**100%**	**169.0**	**100%**	**139.8**	**100%**

Calcite distribution observed in 2016 was consistent with previous observations, with the majority of exposed stream kilometers in the 0.00-0.50 *CI* bin for both mainstem and tributary categories (Figure 3). The following changes are observational and do not indicate a statistically significant change. The Fording and Elk mainstem stream categories had 81% of exposed stream length occur in the 0.00-0.50 *CI* bin, which is lower than the 83% reported in 2015 (Robinson *et al.* 2016). The amount of exposed mainstem in the 0.51 – 1.00 *CI* bin increased from approximately 11.7% in 2015 to 19% in 2016. Comparably, 75% of tributary stream kilometers occurred in the 0.00-0.50 *CI* bin in 2016 versus 83% in 2015. The other bins were represented by less than 8% of the total tributary stream length surveyed. All reference mainstem and tributary stream kilometers were classified into the 0.00-0.50 *CI* bin, similar to previous years (Figure 4).

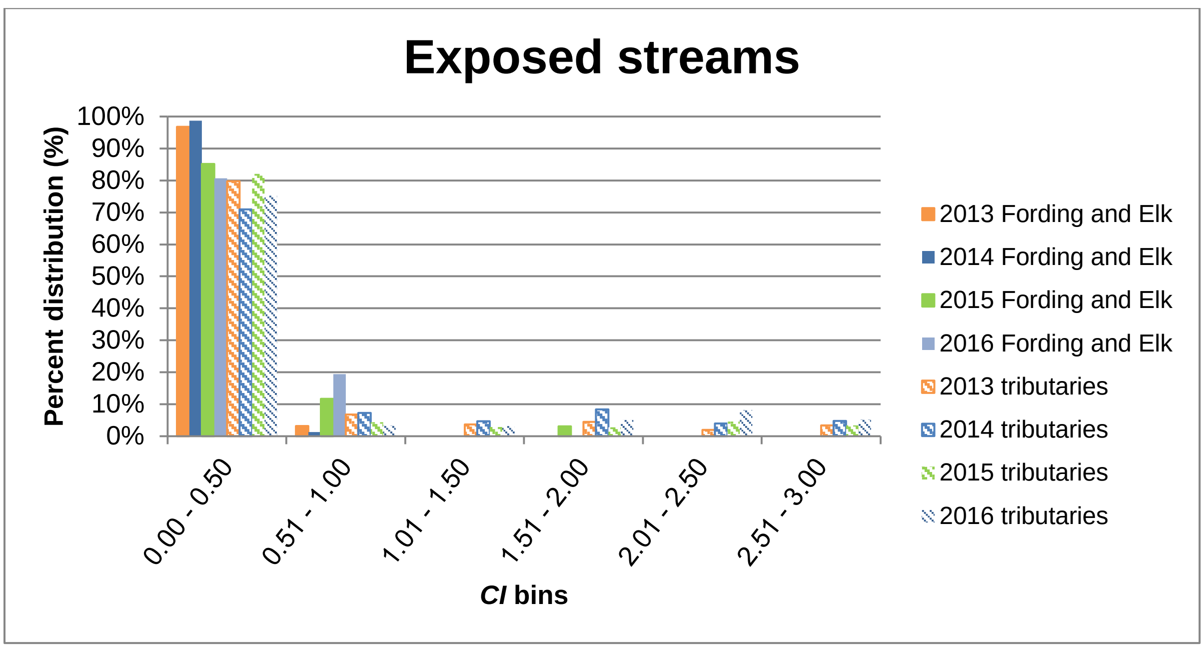

Figure 3. Percent distribution of exposed stream kilometers among *CI* bins by stream category and year (each year sum to 100% for the stream category).

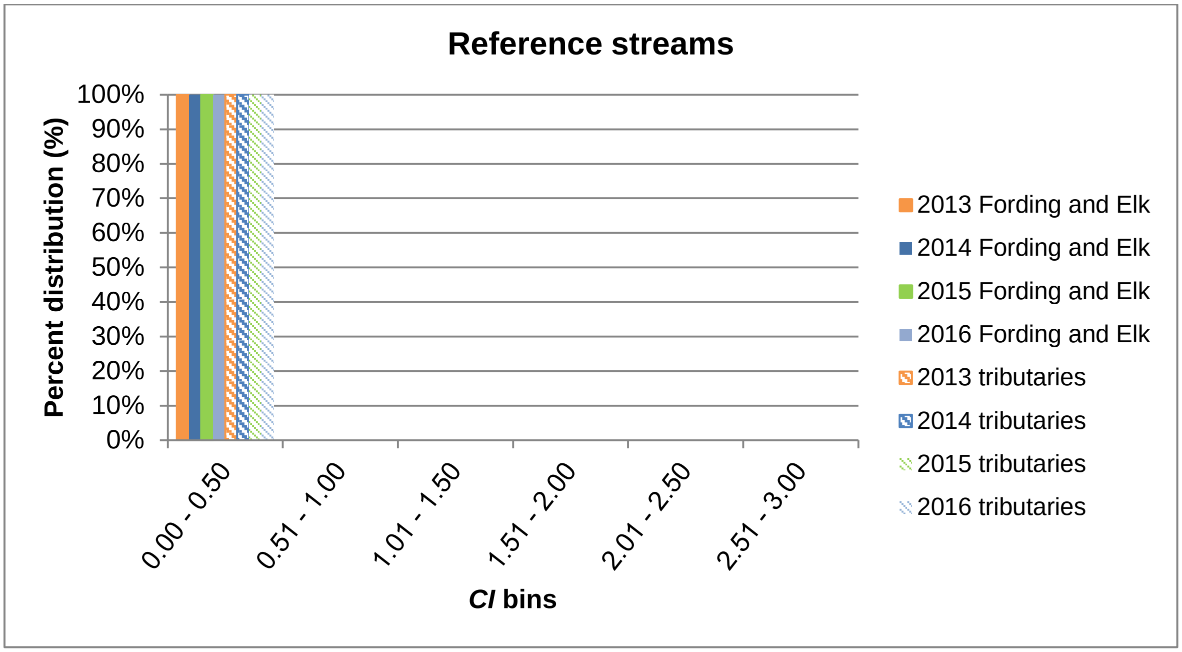

Figure 4. Percent distribution of reference stream kilometers among *CI* bins by stream category and year (each year sum to 100% for the stream category).

3.2 *Block design*

Regression analysis was run on Historical exposure, Reference exposure, and Treated blocks. *CI* was not found to be significantly predicted by Year for any of these three block types (p=0.330, df=260; p=0.960, df=39; p=0.822, df=7, respectively). Regression analysis was not run on the "Recent exposure" block type, as these *CI*-values were constantly 0.00 at all reaches for all years sampled.

Plotting mean *CI* by block, over time produced intuitive results (Figure 5). The highest mean *CI* values came from reaches exposed to mining for longer periods of time (i.e. historical). Treated streams also showed higher mean *CI* scores. Currently, this block only included indicator reaches of Line Creek reaches 1 and 4. The high variability comes from the fact that although these reaches were considered "treated", they do have quite different levels of calcite deposition. As indicated by non-significant regression analyses, all blocks show relatively consistent mean *CI* values over the period of record (2013-2016).

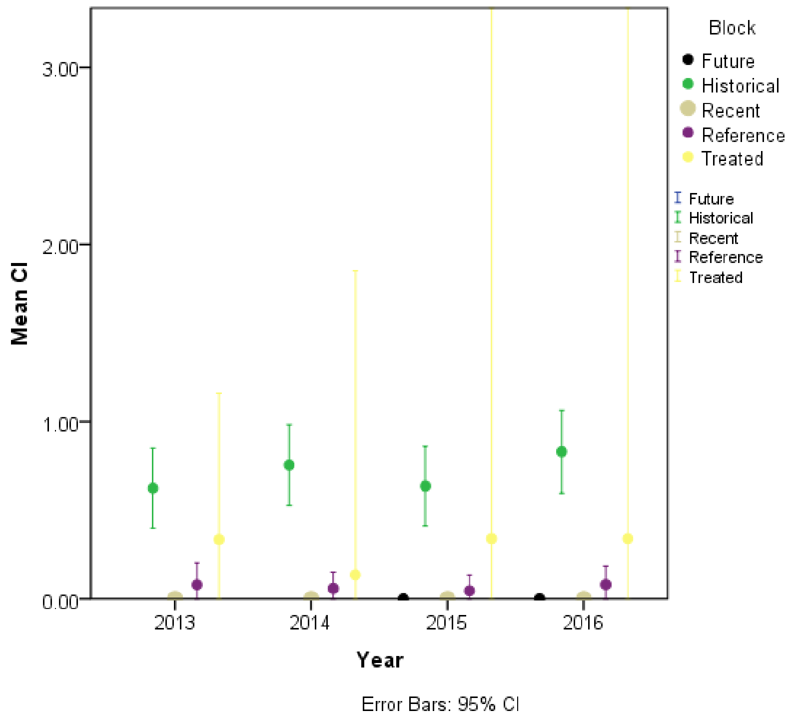

Figure 5. Regression plot of block design.

3.3 *Rate of change in calcite deposition*

3.3.1 Regression

Of the 85 indicator reaches sampled in 2016, 27 reaches had a constant value in all years of *CI* = 0.00, and 1 reach had a constant *CI* value of 3.00. These 28 reaches that have remained constant in all years were excluded from the regression analysis. Those indicator reaches were assigned a neutral rate of change (Δ*CI*/year = 0). The remaining 57 indicator reaches showed variability in *CI* by year, and were assessed using regression analysis. Ten reaches were found to significantly change over the four year period (α=0.10, df = 3) (Table 5). The rate of change (Δ*CI*/year) varied from -0.58 to 0.55.

Table 5. Reaches with significant changes from 2013 – 2016.

Reach	p-value	Slope (Δ*CI*/year)	Change
EPOU1 (Eagle Pond Outlet)	0.01	-0.58	Decrease
NWOL1 (North Wolfram)	0.02	-0.55	Decrease
PORT3 (Porter Creek)	0.06	-0.40	Decrease
GRAC1 (Grace Creek)	0.09	-0.08	Decrease
PORT1 (Porter Creek)	0.08	-0.05	Decrease
PENG1 (Pengally Creek)	0.09	-0.03	Decrease
WOLF2 (Wolfram Creek)	0.06	0.15	Increase
GATE2 (Gate Creek)	0.09	0.47	Increase
CSEE1 (CCR Seep)	0.05	0.50	Increase
SPIT1 (South Pit Creek)	0.06	0.55	Increase

Table 6 presents the reach mean *CI* values from 2013-2016 reaches with a statistically significant change (presented in Table 5). The rates of change were detected over a range of annual *CI* values from 0.00 – 2.78, and included one reference reach (Grace Creek; GRAC1) (Table 6).

Table 6. Mean *CI* values by year for reaches with significant changes.

Reach	Mean CI 2013	Mean CI 2014	Mean CI 2015	Mean CI 2016
EPOU1	1.90	1.31	0.58	0.20
NWOL1	0.70	1.33	0.21	0.14
PORT3	2.78	1.94	1.94	1.46
GRAC1	0.31	0.20	0.05	0.09
PORT1	0.92	0.84	0.85	0.75
PENG1	0.09	0.02	0.02	0.00
WOLF2	0.27	0.14	0.23	0.69
GATE2	0.15	0.00	0.74	1.47
CSEE1	0.00	0.00	0.85	1.40
SPIT1	0.00	0.00	1.14	1.59

Indicator reaches with significant regression results were investigated at a site level. *CI* scores were tabulated by sites within an indicator reach for years 2013 to 2016 (Table 7). Annual changes in *CI* were calculated for three time-steps: Change in *CI* 2013 to 2014, Change in *CI* 2014 to 2015, and Change in *CI* 2015 to 2016.

EPOU1 had a significant decrease in *CI* from 2013 to 2016. This reach is short and is only sampled at one site (EPOU1-0). The rate of change was -0.58 *CI*/year. The decrease was consistent over Programs completed from 2013 to 2016. It is suspected that this trend is likely occurring for the entire reach.

NWOL1 had a significant decrease in *CI* since 2013. Historically, the reach was sampled with three sites. However, a spoil was created there in 2015 and it is covering the upper two sites, therefore only NWOL1-25 could be sampled in 2016. The rate of change was calculated for this one site at -0.55 *CI*/year. In 2013, the *CI* value was 1.72 but in 2016 the *CI* value was 0.14.

Both PORT1 and PORT3 showed a significant decrease in *CI* from 2013 to 2016. PORT1 had a relatively low rate of change of -0.05 *CI*/year, while PORT3 had a higher rate of change of -0.40 *CI*/year. In 2016, PORT1-0, PORT3-25, and PORT3-50 all had a decrease in *CI* compared to 2015. This suggests that the change in calcite deposition is occurring along the entire reaches instead of at a specific site.

CI scores in GRAC1 were found to have significantly decreased from 2013 to 2016. The reach average rate of change was -0.08 *CI*/year. The significance likely came from all sites (GRAC1-25, GRAC1-50, and GRAC1-75) showing a drop in *CI* from 2014 to 2015.

PENG1 had a significant decrease in *CI* from 2013 to 2016. The rate of change is low at -0.03 *CI*/year. There is only one site on PENG1 and the *CI* value has decreased from 0.10 (2013) to 0.00 (2016). Pengally Creek is known to be ephemeral in nature and PENG1 was dry when it was visited in 2016.

Only WOLF2-75 was sampled in 2016, since WOLF2-25 and WOLF2-50 were both located in Wolfram Pond and sampling in lentic areas was dropped in the 2016 program. WOLF2-75 had a significant increase in *CI* with a rate of change of 0.15 *CI*/year. This increasing trend was observed from 2013 to 2015, while the *CI* values from 2015 (0.70) and 2016 (0.69) were similar.

CI scores in GATE2 were found to have significantly increased from 2013 to 2016 with a rate of change of 0.47 *CI*/year, on a reach average. All three sites sampled had an increase in *CI* for 2016 and this trend appears to be occurring over much of the reach. GATE2-25 had the largest increase in *CI* going from 0.00 in 2015 to 1.60 in 2016. Most of this increase appears to have occurred from 2014 to 2015.

CI in CSEE1 was found to have significantly increased from 2013 to 2016 with a rate of change of 0.50 *CI*/year, on a reach average. Calcite was first reported at CSEE1 in 2015 with a *CI* value of 0.85. This reach is a short seepage from the CCR dump at EVO and is only sampled at one site. It is suspected that this trend is likely occurring for the entire reach.

CI in SPIT1 was found to have significantly increased from 2013 to 2016 with a rate of change of 0.55 *CI*/year, on a reach average. Most of this increase appears to have occurred from 2014 to 2015. At all three sites had CI scores of 0.00 in 2013 and 2014, and now all have calcite documented at the sites.

Table 7. Site level *CI* values for the reaches with statistical change. Positive values indicate an increase.

Site	2013 CI	2014 CI	2015 CI	2016 CI	Change in CI (2013-2014)	Change in CI (2014-2015)	Change in CI (2015-2016)
EPOU1-0	1.90	1.31	0.58	0.20	-0.59	-0.73	-0.38
NWOL1-25	1.72	1.22	0.42	0.14	-0.50	-0.80	-0.28
PORT1-0	0.92	0.84	0.85	0.75	-0.08	0.01	-0.10
PORT3-25	2.33	1.34	0.92	0.70	-0.99	-0.42	-0.22
PORT3-50	3.00	1.74	2.07	1.71	-1.26	0.33	-0.36
PORT3-75	3.00	2.73	2.83	2.86	-0.27	0.10	0.03
GRAC1-25	0.39	0.07	0.04	0.06	-0.32	-0.03	0.02
GRAC1-50	0.24	0.25	0.02	0.08	0.01	-0.23	0.06
GRAC1-75	0.30	0.27	0.13	0.13	-0.03	-0.14	0.00
PENG1-0	0.10	0.03	0.03	0.00	-0.07	0.00	-0.03
WOLF2-75	0.27	0.42	0.70	0.69	0.15	0.28	-0.01
GATE2-25	0.29	0.00	0.00	1.60	-0.29	0.00	1.60
GATE2-50	0.00	0.00	1.31	1.44	0.00	1.31	0.13
GATE2-75	#N/A	0.00	0.91	1.37	#N/A	0.91	0.46
CSEE1-0	0.00	0.00	0.85	1.40	0.00	0.85	0.55
SPIT1-25	0.00	0.00	2.19	1.68	0.00	2.19	-0.51
SPIT1-50	0.00	0.00	0.24	2.21	0.00	0.24	1.97
SPIT1-75	0.00	0.00	0.00	0.66	0.00	0.00	0.66

3.3.2 ANOVA

Of the 85 indicator reaches sampled in 2016, 57 were sampled with two or more sites in all four years (2013 to 2016), facilitating assessment using ANOVA. Results showed the reach mean *CI* varied significantly by year in 18 reaches (Table 8): BOD1, BOD3, CHAU1, CORB1, FORD1, FORD6, FPON1, GATE2, GODD3, GRAC1, GREE3, GREE4, HARM1, LINE1, LINE4, MICK1, SIXM1, and WOLF3. Of these, GATE2 and GRAC1 were the only reaches reported to have a significant change using both regression and ANOVA methods. However, six of the other linearly significant reaches (CSEE1, EPOU1, NWOL, PENG1, PORT1, and WOLF2) were excluded from ANOVA as they were only sampled with one site per year.

In nearly all reaches, the significant ANOVA results appear to be the results of one year having a significantly different CI score than the other three years. FORD6 was an exception showing differences from 2014 to 2015 and 2015 to 2016. However, this was the result of a spike reported in 2015 and does not appear to be an increasing or decreasing trend. Indicator Reaches BOD1, CHAU1, FORD1, and MICK1 had calcite reported for the first time in 2016. Figures showing the *CI* values and the Tukey's post hoc results are given in Appendix 6.

Table 8. ANOVA results for reaches with significant effect of year. Significant year-year pairings identified from Tukey's HSD test are also indicated.

Reach	p-value	Tukey's HSD results
BODI1	0.001	2013<2016 (p=0.003) 2014<2016 (p=0.003) 2015<2016 (p=0.003)
BODI3	0.034	2013<2014 (p=0.029)
CHAU1	0.001	2013<2016 (p=0.002) 2014<2016 (p=0.002) 2015<2016 (p=0.002)
CORB1	0.015	2014<2015 (p=0.012)
FORD1	0.001	2013<2016 (p=0.001) 2014<2016 (p=0.001) 2015<2016 (p=0.001)
FORD6	0.028	2014<2015 (p=0.028) 2015>2016 (p=0.041)
FPON1	0.008	2013<2016 (p=0.012) 2015<2016 (p=0.012)
GATE2	0.008	2013<2016 (p=0.024) 2014<2016 (p=0.008)
GODD3	0.000	2013<2014 (p=0.000) 2013<2015 (p=0.000) 2013<2016 (p=0.000)
GRAC1	0.014	2013>2015 (p=0.016) 2013>2016 (p=0.029)
GREE3	0.002	2013<2014 (p=0.008) 2013<2015 (p=0.001) 2013<2016 (p=0.010)
GREE4	0.000	2013<2014 (p=0.001) 2013<2015 (p=0.000) 2013<2016 (p=0.002)
HARM1	0.003	2014>2015 (p=0.002)

Reach	p-value	Tukey's HSD results
		2015<2016 (p=0.048)
LINE1	0.006	2013>2014 (p=0.009) 2013>2015 (p=0.009) 2013>2016 (p=0.019)
LINE4	0.006	2014<2015 (p=0.011) 2014<2016 (p=0.016)
MICK1	0.000	2013<2016 (p=0.000) 2014<2016 (p=0.000) 2015<2016 (p=0.000)
SIXM1	0.012	2014>2015 (p=0.009) 2014>2016 (p=0.036)
WOLF3	0.000	2013>2014 (p=0.000) 2013>2015 (p=0.000) 2014>2015 (p=0.027) 2014<2016 (p=0.004) 2015<2016 (p=0.000)

* Tukey's post hoc adjusts p-values for multiple comparisons.

3.4 *Other Observations*

There were some sites that had calcite reported for the first time in 2016, but were not found to be significant with either an ANOVA or regression analysis. These sites included:

- FORD12 – which had a *CI* of 0.08, and is considered a reference site;
- GODD1-0 - which had a *CI* of 0.22, and was sampled at the pond outflow; and
- THOM1-0 – which had a *CI* of 0.22 and was sampled at the inflow of the wetland.

MILL2-0 had calcite reported for the first time in 2016 and had a *CI* value of 1.50 which meant that six sites needed to be sampled. From the six sites sampled the mean *CI* was 1.07. Historically only one site was sampled at MILL2-0 from 2013 – 2015, which meant that MILL2-0 could not be tested using ANOVA.

Teck is aware of calcite measurements collected from other aquatic monitoring programs that have produced results that vary from those presented in this report, at limited reaches (Table 9). Teck is planning to investigate these observations and assess how the results of those investigations can inform this Program. While differences in calcite indices have been reported, it is worth noting that programs do differ in site location within a reach, methods for selection of site locations (systematic versus objective), and habitat types sampled (composite versus riffles only). One potential difference (unknown at this time) is how other programs treat the sampling of fines (i.e., sand, silt, clay).

Table 9. Comparison of calcite index values from Regional Calcite Monitoring Program and Aquatic Effects Monitoring Programs

Biological Monitoring Area	Teck Water Station	Calcite Reach	Teck Regional Calcite Monitoring (Calcite Index – average of three sites within a reach)				Calcite Index at LAEMP Benthic Invertebrate Monitoring Areas	
			2013	2014	2015	2016	2015	2016
LI24	LC_LC1	LINE7	0.00	0.00	0.00	0.00	0.00	0.00
SLINE	LC_SLC	SLIN2	0.00	0.00	0.00	0.00	0.00	0.32
LILC3	LC_LC3	LINE4	0.40	0.27	0.68	0.65	1.00	1.06
LIDSL	LC_LCDSSLCC	LINE3-75	0.00	0.00	0.00	--	0.60	0.78
LI8	LC_LC4	LINE1-75	0.40	0.00	0.00	0.00	0.04	0.48
FRUL	LC_LC6	FORD2-25	0.00	0.00	0.00	0.00	0.00	0.01
FO23	LC_LC5	FORD1-50	0.00	0.00	0.00	0.20	0.93	0.37
FO26	FR_UFR1	FORD12	0.00	0.00	0.00	0.27	0.93	0.80
HENUP	FR_HC3	HENR3	0.00	0.00	0.00	--	0.14	0.00
FODHE	FR_FR1	FORD11	0.00	0.00	0.00	--	0.88	0.00
FOUKI	FR_FR2	FORD10	0.00	0.00	0.00	--	0.98	1.80
FOBKS	-	FORD9	0.00	0.00	0.00	--	0.92	2.00
FOBSC	FR_FR4						1.20	1.80
FOBCP	FR_FRCP1						1.30	1.60
FODPO	FR_FRABCH	FORD8	0.31	0.49	0.48	--	0.89	1.00
FOUEW	FR_FR5	FORD7/6	0.74	0.43	1.53	0.64	0.98	1.00

3.5 *Data quality assurance*

Data quality assurance steps were completed as described in Section. 2.5.4. Crews visited sites as a group on Greenhills and Fording River Operations to calibrate calcite observations and data collection. All raw pebble count data were screened for data entry errors using the Python computer script to confirm that cells were populated with acceptable (i.e., valid) values.

4 Discussion

The 2016 Sampling Program followed the methods outlined in the Teck Coal Ltd 2016 - 2018 Calcite Monitoring Program (Robinson and Atherton 2016) and the amended approval letter (Calcite 2016 study design approval letter, dated October 19, 2016). The use of stream segment sampling and adaptive sample size selection per reach were effective at streamlining the Program and in focusing more sampling into the areas that had higher calcite range variability. In 2016; there were 232 sites sampled instead of 348 sites in 2015.

The general observed deposition patterns for 2016 were slightly different than that reported in 2015 when combining the exposed mainstems and tributaries. In 2015, 84% of the exposed stream kilometers were classified in the low *CI* bin (0-0.5); as compared to 78% of exposed stream kilometers in the lowest bin for 2016. The 2016 exposed Fording and Elk sites in the 0.51-1.00 bin rose from 11.7% to 27%. It is possible that these changes are an artifact of extrapolating indicator reach values over an entire segment and do not represent true changes. However, the 2016 Program will be repeated in 2017 and the current sampling protocol will be assessed in 2018. The appropriateness of using segments to interpolate *CI* over multiple reaches will be assessed by sampling all reaches initially sampled in 2013 - 2015 Programs again in 2018.

Some of the significant changes in calcite deposition that were found on streams may be explained by changes to the mine activity in the watershed including new spoil development and increasing flows throughout the year from pit pumping. Tributaries in the Fording and Elk that received increased pit pumping volumes in 2016 include Mickelson Creek, Wolfram Creek, Bodie Creek, and Gate Creek. For example, the *CI* for MICK1 went from 0.00 in 2015 to 2.18 in 2016. At the time of sampling there were higher than normal flows because of increased volume being pumped into the creek. Mickelson Creek also has new spoiling in the headwaters. Dewatering at the Natal Pit on EVO is suspected to have contributed to changes observed in Bodie Creek and Gate Creek. Elkview operations (EVO) has been dewatering the Natal Pit into Gate Creek (through the Bodie rock drain) since 2015. This is a possible contributor to the observed increase.

Calcite appeared in two of this Program’s reference reaches for the first time (note, calcite has been reported in other reference streams in prior years of this Program). The upper Fording River (FORD12) and Chauncey Creek (CHAU1) both had sites with *CI* scores between 0.10 and 0.22. These are within the range of other scores reported for reference reaches. It is worth noting that the 2013 Program began after a large regional flood event that resulted in a large amount of streambed movement. The Calcite Monitoring Program may now be documenting a return cycle to increasing calcite conditions resulting from smaller freshet events in recent years.

A data analysis for 2016 was consistent with previous years of the program including both linear regression and ANOVA. Linear regression appears to be useful for comparison of data over a larger number of reaches. Trends over time can be assessed at shorter reaches that can only be sampled at one location as regression does not require within-year replication. ANOVA does require within-year replication and therefore excludes some reaches from trend analysis. One benefit to ANOVA is the ability to detect large changes in the current year relative to the historical values. An example is Mickelson Creek that had a significant increase in *CI* from 2015 to 2016, but did not have a significant regression slope. It would be expected however that a significant regression would result if the increase in CI was maintained into future years.

As reported above, Teck is aware of calcite measurements collected from other aquatic monitoring programs that have produced results that vary from those presented in this report, at a low number of reaches. Specifically, results generated from this Program are not entirely reproduced in regional and local aquatic effects monitoring sampling. These programs are similar in that they use a 100-particle pebble count to calculate a calcite index. Differences include sample location. This Program samples multiple habitat units over approximately 100 m long sites. Aquatic effects programs obtain calcite indices at benthic invertebrate sites, which are standardized to a single riffle habitat unit. Another notable difference is the site selection process. This Program samples systematically at set distances along a reach. Regional programs objectively select locations of interest throughout a watershed, but have some flexibility within a reach to select the habitat unit to sample. Conceivably, this could have a significant effect on observations of calcite deposition in reaches that are highly dominated by slow, low gradient habitat if one program is sampling slow deep glide habitat and another is targeting faster, turbulent water typically associated with calcite deposition. Another notable point, and unknown at this time, is how the various programs treat pebble counts that select fines (i.e., sands, silts, clays) during an individual count. This Program has the objective of accurately describing the habitat present and in proportions representative of the sample site, not just calcite deposition on particles larger than fines. This is imperative if the results are to be extrapolated to a reach scale. Consider a site with 90% fines without detectable calcite, and 10% larger particles all with detectable calcite (not an uncommon observation). The calcite indices generated from a representative sample would be notably different from that generated from just the larger particles. Teck has committed to investigate these differences and others to identify potential causes of the variable results between programs. The results of this investigation will be incorporated into this Program as suitable.

The block analysis was completed on the entire data set from 2013-2016. The analysis failed to detect a significant trend of calcite deposition over time in any of the blocks assessed. This suggests that where trends are occurring is likely to be quite reach specific and not occurring over larger blocks of streams types. This assessment could be repeated in future years once data have been collected over a longer period of time.

5 Future Monitoring

The recommended 2017 Calcite Monitoring Program is to repeat the sampling sites visited in 2016 (Table 9). The number of sites to be sampled will follow the protocol used in 2016 where the most recent CI will be used to determine the amount of effort (sites per indicator reach) required. This will include modifying some of the site selection protocols based on field logistics such as available stream length. For example, based on mean 2016 *CI*'s, BOD3, GATE2, LEAS2, and SWOL1 should have six sites for 2017. However, the reaches are not long enough for six sites so they will be kept at three. A total of 20 indicator reaches are too short to have multiple sites and will continue to be sampled at one site. The only change from 2016 based on *CI* score will be to reduce the number of sites at GODD3 from six sites to three.

Future monitoring will also include an investigation into the potential causes of variability in calcite indices reported by Teck' s complimentary monitoring programs.

Table 10. Recommended sampling sites for the 2017 Sampling Program.

Segment Name	Reaches Included	Indicator Reach	Mean 2016 CI	Number of sites sampled in 2016	Number of sites to be sampled in 2017
ALEX_A	ALEX3	ALEX3	0.46	3	3
ANDY_A	ANDY1	ANDY1	0.00	3	3
AQUE_A	AQUE1, AQUE2, AQUE3	AQUE1	0.00	1	1*
BALM_A	BALM1	BALM1	0.00	1	1*
BODI_A	BODI1	BODI1	0.79	3	3
BODI_B	BODI3	BODI3	1.77	3	3
CATA_A	CATA1, CATA3	CATA1	3.00	1	1*
CHAU_A	CHAU1	CHAU1	0.17	3	3
CLOW_A	CLOW1	CLOW1	0.50	1	1*
CORB_A	CORB1, CORB2	CORB1	2.21	3	3
COUT_A	COUT1	COUT1	1.21	1	1*
CSEE_A	CSEE1	CSEE1	1.40	1	1*
DRYE_A	DRYE1, DRYE3, DRYE4	DRYE3	2.51	3	3
DRYL_A	DRYL1	DRYL1	0.00	3	3
DRYL_B	DRYL2	DRYL2	0.00	3	3
DRYL_C	DRYL3	DRYL3	0.00	3	3
DRYL_D	DRYL4	DRYL4	0.00	3	3
ELKR_B	ELKR11, ELKR12	ELKR12	0.00	3	3
ELKR_D	ELKR15	ELKR15	0.00	3	3
ELKR_A	ELKR8	ELKR8	0.00	3	3
ELKR_C	ELKR9, ELKR10	ELKR9	0.00	3	3
EPOU_A	EPOU1	EPOU1	0.20	1	1*
ERIC_A	ERIC1, ERIC2, ERIC3, ERIC4	ERIC1	2.36	1	1*
FELT_A	FELT1	FELT1	0.00	3	3
FENN_A	FENN1	FENN1	0.00	3	3
FORD_G	FORD12	FORD12	0.08	3	3
FORD_A	FORD1	FORD1	0.37	3	3
FORD_B	FORD2, FORD 3	FORD2	0.00	3	3
FORD_C	FORD4, FORD 5	FORD4, FORD5	0.60, 0.58	6	6
FORD_D	FORD6	FORD6	0.64	6	6
FORD_E	FORD7, FORD 8	FORD7	0.63	3	3
FORD_F	FORD9, FORD 10, FORD11	FORD9	0.00	3	3
FPON_A	FPON1	FPON1	0.08	3	3
GARD_A	GARD1	GARD1	0.14	3	3
GATE_A	GATE2	GATE2	1.47	3	3

Segment Name	Reaches Included	Indicator Reach	Mean 2016 CI	Number of sites sampled in 2016	Number of sites to be sampled in 2017
GODD_A	GODD1	GODD1	0.22	1	1*
GODD_B	GODD3	GODD3	2.22	6	3
GRAC_A	GRAC1, GRAC2, GRAC3	GRAC1	0.09	3	3
GRAS_A	GRAS1	GRAS1	0.04	3	3
GRAV_A	GRAV1, GRAV2	GRAV1	0.14	3	3
GRAV_B	GRAV3	GRAV3	0.00	3	3
GREE_A	GREE1	GREE1	0.86	3	3
GREE_B	GREE3	GREE3	2.18	3	3
GREE_C	GREE4	GREE4	2.61	3	3
HARM_A	HARM1	HARM1	0.64	3	3
HARM_B	HARM3, HARM4, HARM5	HARM3	0.12	3	3
HENR_A	HENR1, HENR2, HENR3	HENR1	0.00	3	3
KILM_A	KILM1	KILM1	2.59	5	5
LEAS_A	LEAS2	LEAS2	1.82	3	3
LIND_A	LIND1	LIND1	0.19	3	3
LINE_A	LINE1, LINE2, LINE3	LINE1	0.03	3	3
LINE_B	LINE4	LINE4	0.65	3	3
LINE_C	LINE7	LINE7	0.00	3	3
LMOU_A	LMOU1, LMOU3, LMOU4	LMOU1	0.15	3	3
MICH_A	MICH1, MICH2	MICH1	0.00	3	3
MICH_B	MICH3, MICH4	MICH4	0.00	3	3
MICH_C	MICH5	MICH5	0.00	3	3
MICK_A	MICK1, MICK2	MICK1	2.18	3	3
MILL_A	MILL1, MILL2	MILL2	1.07	6	6
NTHO_A	NTHO1	NTHO1	1.54	6	6
NWOL_A	NWOL1	NWOL1	0.14	1	1*
OTTO_A	OTTO1, OTTO3	OTTO1	0.23	1	1*
PENG_A	PENG1	PENG1	0.00	1	1*
PORT_A	PORT1	PORT1	0.75	1	1*
PORT_B	PORT3	PORT3	1.46	6	6
QUAL_A	QUAL1	QUAL1	0.00	3	3
SAWM_A	SAWM1	SAWM1	0.00	1	1*
SAWM_B	SAWM2	SAWM2	0.00	2	2
SIXM_A	SIXM1	SIXM1	0.65	3	3
SLIN_A	SLIN2	SLIN2	0.00	3	3
SPIT_A	SPIT1	SPIT1	1.59	6	6
SPIT_B	SPIT2	SPIT2	N/A	dropped	dropped
SPOU_A	SPOU1	SPOU1	3.00	1	1*

Segment Name	Reaches Included	Indicator Reach	Mean 2016 CI	Number of sites sampled in 2016	Number of sites to be sampled in 2017
SPRI_A	SPRI1	SPRI1	0.12	1	1*
SPSE_A	SPSE1	SPSE1	0.00	1	1*
SWIF_A	SWIF1, SWIF2	SWIF1	2.43	1	1*
SWOL_A	SWOL1	SWOL1	1.86	4	4
THOM_A	THOM1, THOM2, THOM3	THOM1	0.22	1	1*
THRE_A	THRE1	THRE1	0.00	2	2
USOS_A	USOS1	USOS1	0.00	2	2
WILN_A	WILN2	WILN2	0.00	2	2
WILS_A	WILS1	WILS1	0.00	2	2
WOL1_A	WOL1	WOL1	0.00	2	2
WOLF_A	WOLF2	WOLF2	0.69	1	1*
WOLF_B	WOLF3	WOLF3	2.61	6	6

* Field logistics such as stream length preclude sampling at more sites.

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7 Appendices

Appendix 1. Sites visited by program year

Stream name	Reach Site Code	Site type	Block type	2013 CI	2014 CI	2015 CI	2016 CI	Linear Regression p-value (sig = 0.10)
Alexander	ALEX3	Reference	Reference	0.48	0.38	0.40	0.46	0.892
Andy Good	ANDY1	Reference	Reference	0.00	0.00	0.00	0.00	N/A
Aqueduct	AQUE1	Exposed	Historical	0.00	0.00	0.00	0.00	N/A
Balmer	BALM1	Exposed	Historical	0.00	0.00	0.00	0.00	N/A
Bodie	BODI1	Exposed	Historical	0.00	0.00	0.00	0.79	0.225
Bodie	BODI3	Exposed	Historical	1.16	2.47	N/A	1.77	0.813
CCR Seep	CSEE1	Exposed	Historical	0.00	0.00	0.85	1.40	0.051
Cataract	CATA1	Exposed	Historical	3.00	3.00	3.00	3.00	N/A
Chauncey	CHAU1	Reference	Reference	0.00	0.00	0.00	0.17	0.225
Clode Pond Outlet	COUT1	Exposed	Historical	0.00	1.01	1.03	1.21	0.142
Clode West Infiltration	CLOW1	Exposed	Historical	N/A	0.18	0.00	0.50	0.769
Corbin	CORB1	Exposed	Historical	1.95	1.71	2.62	2.21	0.466
Dry (EVO)	DRYE3	Exposed	Historical	2.20	2.40	2.48	2.51	0.368
Dry (LCO)	DRYL1	Proposed	Recent	0.00	0.00	0.00	0.00	N/A
Dry (LCO)	DRYL2	Proposed	Recent	0.00	0.00	0.00	0.00	N/A
Dry (LCO)	DRYL3	Proposed	Recent	0.00	0.00	0.00	0.00	N/A
Dry (LCO)	DRYL4	Proposed	Recent	0.00	N/A	0.00	0.00	N/A
Eagle Pond Outlet	EPOU1	Exposed	Historical	1.90	1.31	0.58	0.20	0.007
Elk	ELKR12	Exposed	Historical	0.00	0.00	0.00	0.00	N/A
Elk	ELKR15	Reference	Reference	0.00	0.00	0.00	0.00	N/A
Elk	ELKR8	Exposed	Historical	0.40	0.00	0.00	0.00	0.225
Elk	ELKR9	Exposed	Historical	0.00	0.00	0.00	0.00	N/A
Erickson	ERIC1	Exposed	Historical	2.29	2.59	2.77	2.36	0.925
Feltham	FELT1	Exposed	Historical	0.00	0.00	0.00	0.00	N/A
Fennelon	FENN1	Exposed	Historical	0.00	0.00	0.00	0.00	N/A
Fish Pond	FPON1	Exposed	Historical	0.00	0.03	0.00	0.08	0.282
Fording	FORD1	Exposed	Historical	0.00	0.00	0.00	0.37	0.225
Fording	FORD12	Reference	Reference	0.00	0.00	0.00	0.08	0.225
Fording	FORD2	Exposed	Historical	0.00	0.00	0.00	0.00	N/A
Fording	FORD4	Exposed	Historical	N/A	0.05	0.66	0.60	0.39
Fording	FORD5	Exposed	Historical	0.32	0.35	0.53	0.58	0.151
Fording	FORD6	Exposed	Historical	0.74	0.43	1.53	0.64	0.785
Fording	FORD7	Exposed	Historical	0.43	0.97	0.55	0.63	0.9
Fording	FORD9	Exposed	Historical	0.00	0.00	0.00	0.00	N/A
Gardine	GARD1	Exposed	Historical	0.29	0.70	0.32	0.14	0.55
Gate	GATE2	Exposed	Historical	0.15	0.00	0.74	1.47	0.089
Goddard	GODD1	Exposed	Historical	0.00	0.00	0.00	0.22	0.225
Goddard	GODD3	Exposed	Historical	0.00	1.90	1.97	2.22	0.152
Grace	GRAC1	Reference	Reference	0.31	0.20	0.05	0.09	0.093
Grassy	GRAS1	Exposed	Historical	0.00	0.09	0.00	0.04	0.909
Grave	GRAV1	Exposed	Historical	0.54	0.72	0.02	0.14	0.256
Grave	GRAV3	Reference	Reference	0.00	0.00	0.00	0.00	N/A
Greenhills	GREE1	Exposed	Historical	0.35	1.06	0.45	0.86	0.653
Greenhills	GREE3	Exposed	Historical	1.30	2.22	2.46	2.18	0.28

Stream name	Reach Site Code	Site type	Block type	2013 CI	2014 CI	2015 CI	2016 CI	Linear Regression p-value (sig = 0.10)
Greenhills	GREE4	Exposed	Historical	1.62	2.78	2.80	2.61	0.313
Harmer	HARM1	Exposed	Historical	0.58	1.08	0.07	0.64	0.741
Harmer	HARM3	Exposed	Historical	0.15	0.28	0.01	0.12	0.582
Henretta	HENR1	Exposed	Historical	0.00	0.00	0.00	0.00	N/A
Kilmamock	KILM1	Exposed	Historical	2.16	1.64	1.97	2.59	0.346
Lake Mountain	LMOU1	Exposed	Historical	0.00	0.33	0.00	0.15	0.901
Leask	LEAS2	Exposed	Historical	0.13	1.60	0.24	1.82	0.388
Lindsay	LIND1	Exposed	Historical	0.19	0.26	0.19	0.19	0.742
Line	LINE1	Exposed	Treated	0.27	0.00	0.00	0.03	0.289
Line	LINE4	Exposed	Treated	0.40	0.27	0.68	0.65	0.244
Line	LINE7	Reference	Reference	0.00	0.00	0.00	0.00	N/A
Michel	MICH1	Exposed	Historical	0.31	0.00	0.00	0.00	0.225
Michel	MICH4	Exposed	Historical	0.00	0.00	0.00	0.00	N/A
Michel	MICH5	Reference	Reference	0.00	0.00	0.00	0.00	N/A
Mickelson	MICK1	Exposed	Historical	0.01	0.00	0.00	2.18	0.228
Milligan	MILL2	Exposed	Historical	0.00	0.00	0.00	1.07	0.225
North Thompson	NTHO1	Exposed	Historical	1.24	2.39	1.18	1.54	0.956
North Wolfram	NWOL1	Exposed	Historical	0.70	1.33	0.21	0.14	0.015
Otto	OTTO1	Exposed	Historical	0.30	0.22	0.10	0.23	0.487
Pengally	PENG1	Exposed	Historical	0.09	0.02	0.02	0.00	0.087
Porter	PORT1	Exposed	Historical	0.92	0.84	0.85	0.75	0.075
Porter	PORT3	Exposed	Historical	2.78	1.94	1.94	1.46	0.062
Qualteri	QUAL1	Exposed	Historical	0.00	0.00	0.00	0.00	N/A
Sawmill	SAWM1	Exposed	Historical	0.00	0.00	0.00	0.00	N/A
Sawmill	SAWM2	Exposed	Historical	0.38	0.54	0.62	0.00	0.422
Six Mile	SIXM1	Exposed	Historical	0.80	1.19	0.49	0.65	0.505
Smith Pond Outlet	SPOU1	Exposed	Historical	2.61	2.24	2.24	3.00	0.584
South Line	SLINE2	Reference	Reference	0.00	0.00	0.00	0.00	N/A
South Pit	SPIT1	Exposed	Historical	0.00	0.00	1.14	1.59	0.056
South Pond Seep	SPSE1	Exposed	Historical	0.00	1.50	0.10	0.00	0.754
South Wolfram Creek	SWOL1	Exposed	Historical	1.97	1.97	0.28	1.86	0.502
Spring	SPRI1	Exposed	Historical	0.20	0.11	0.11	0.12	0.289
Swift	SWIF1	Exposed	Historical	2.58	2.18	2.39	2.43	0.812
Thompson	THOM1	Exposed	Historical	0.00	0.00	0.00	0.22	0.225
Thresher	THRE1	Exposed	Historical	0.00	0.00	0.00	0.00	N/A
Unnamed South of Sawmill	USOS1	Exposed	Historical	0.00	0.00	0.00	0.00	N/A
Willow North	WILN2	Exposed	Recent	N/A	N/A	0.00	0.00	N/A
Willow South	WILS1	Exposed	Recent	N/A	N/A	0.00	0.00	N/A
Wolf	WOL1	Reference	Future	N/A	N/A	0.00	0.00	N/A
Wolfram	WOLF2	Exposed	Historical	0.27	0.14	0.23	0.69	0.059
Wolfram	WOLF3	Exposed	Historical	2.93	2.07	1.60	2.61	0.686

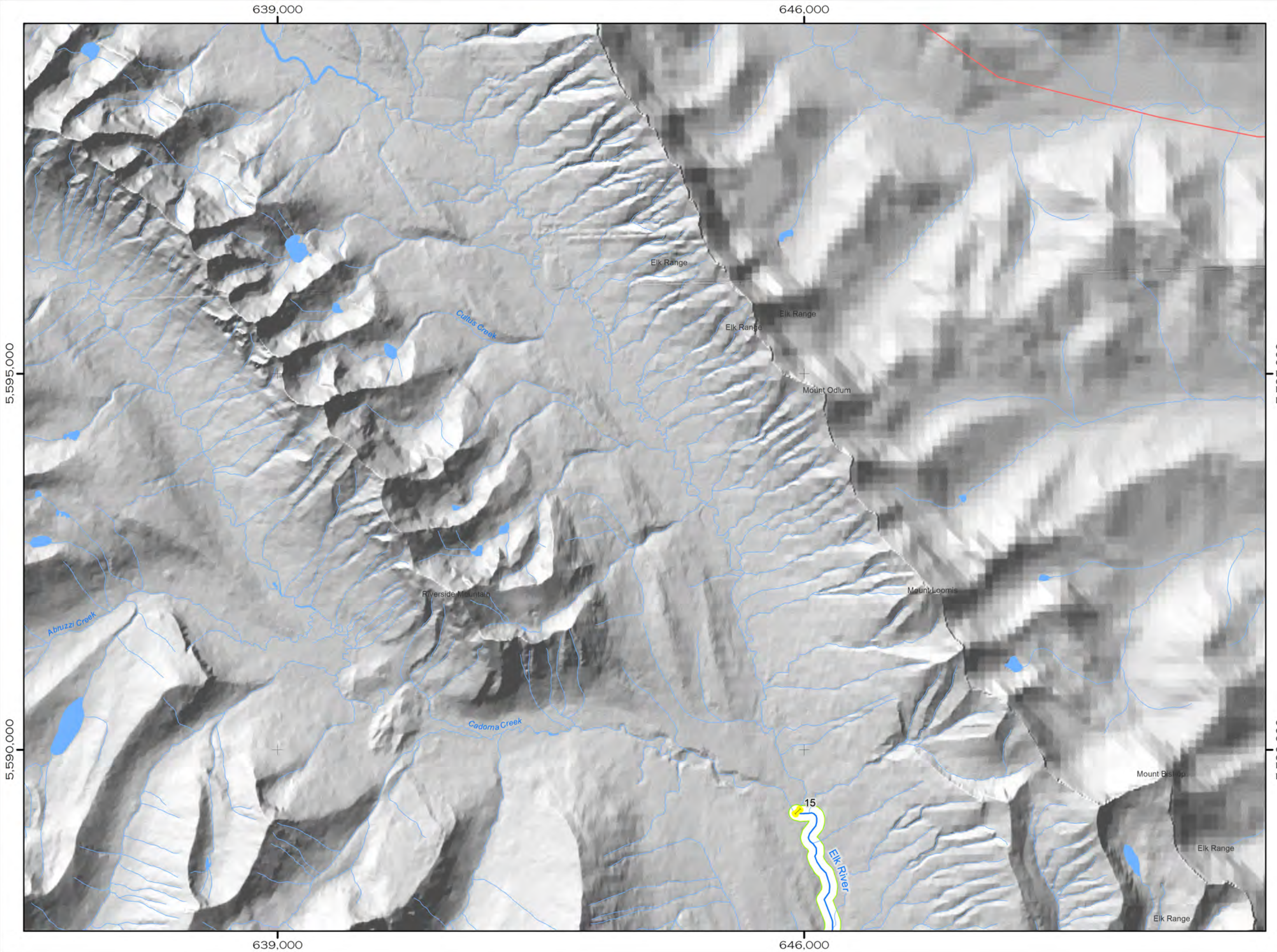
Highlighted rows are the sites with significant changes ($\alpha = 0.10$) in *CI* from linear regression in 2016

Appendix 2. 2016 Elk Valley calcite monitoring results by stream reach

Type (exposed or reference)	Stream	Reach	Mean CI_p Score (0-1)	Mean CI_c Score (0-2)	CI (C_p+C_c)
Reference	Alexander	ALEX3	0.44	0.02	0.46
Reference	Andy Good	ANDY1	0.00	0.00	0.00
Exposed	Aqueduct	AQUE1	0.00	0.00	0.00
Exposed	Balmer	BALM1	0.00	0.00	0.00
Exposed	Bodie	BODI1	0.65	0.14	0.79
Exposed	Bodie	BODI3	0.76	1.01	1.77
Exposed	CCR Seep	CSEE1	0.82	0.58	1.40
Exposed	Cataract	CATA1	1.00	2.00	3.00
Reference	Chauncey	CHAU1	0.16	0.01	0.17
Exposed	Clode Pond Outlet	COUT1	0.96	0.25	1.21
Exposed	Clode West Infiltration	CLOW1	0.50	0.00	0.50
Exposed	Corbin	CORB1	1.00	1.21	2.21
Exposed	Dry (EVO)	DRYE3	0.96	1.54	2.51
Proposed	Dry (LCO)	DRYL1	0.00	0.00	0.00
Proposed	Dry (LCO)	DRYL2	0.00	0.00	0.00
Proposed	Dry (LCO)	DRYL3	0.00	0.00	0.00
Proposed	Dry (LCO)	DRYL4	0.00	0.00	0.00
Exposed	Eagle Pond Outlet	EPOU1	0.14	0.06	0.20
Exposed	Elk	ELKR12	0.00	0.00	0.00
Reference	Elk	ELKR15	0.00	0.00	0.00
Exposed	Elk	ELKR8	0.00	0.00	0.00
Exposed	Elk	ELKR9	0.00	0.00	0.00
Exposed	Erickson	ERIC1	0.93	1.43	2.36
Exposed	Feltham	FELT1	0.00	0.00	0.00
Exposed	Fennelon	FENN1	0.00	0.00	0.00
Exposed	Fish Pond	FPON1	0.08	0.00	0.08
Exposed	Fording	FORD1	0.37	0.00	0.37
Reference	Fording	FORD12	0.03	0.00	0.03
Exposed	Fording	FORD2	0.00	0.00	0.00
Exposed	Fording	FORD4	0.54	0.06	0.60
Exposed	Fording	FORD5	0.58	0.00	0.58
Exposed	Fording	FORD6	0.62	0.02	0.64
Exposed	Fording	FORD7	0.63	0.01	0.63
Exposed	Fording	FORD9	0.00	0.00	0.00
Exposed	Gardine	GARD1	0.12	0.02	0.14
Exposed	Gate	GATE2	0.87	0.60	1.47
Exposed	Goddard	GODD1	0.20	0.02	0.22
Exposed	Goddard	GODD3	0.82	1.40	2.22
Reference	Grace	GRAC1	0.09	0.00	0.09
Exposed	Grassy	GRAS1	0.03	0.01	0.04
Exposed	Grave	GRAV1	0.14	0.00	0.14
Reference	Grave	GRAV3	0.00	0.00	0.00
Exposed	Greenhills	GREE1	0.59	0.27	0.86
Exposed	Greenhills	GREE3	0.95	1.23	2.18
Exposed	Greenhills	GREE4	0.96	1.64	2.61
Exposed	Harmer	HARM1	0.64	0.01	0.64
Exposed	Harmer	HARM3	0.11	0.01	0.12
Exposed	Henretta	HENR1	0.00	0.00	0.00

Type (exposed or reference)	Stream	Reach	Mean CI_p Score (0-1)	Mean CI_c Score (0-2)	CI (C_p+C_c)
Exposed	Kilmarnock	KILM1	0.95	1.64	2.59
Exposed	Lake Mountain	LMOU1	0.15	0.00	0.15
Exposed	Leask	LEAS2	0.79	1.02	1.82
Exposed	Lindsay	LIND1	0.18	0.02	0.19
Exposed	Line	LINE1	0.03	0.00	0.03
Exposed	Line	LINE4	0.65	0.00	0.65
Reference	Line	LINE7	0.00	0.00	0.00
Exposed	Michel	MICH1	0.00	0.00	0.00
Exposed	Michel	MICH4	0.00	0.00	0.00
Reference	Michel	MICH5	0.00	0.00	0.00
Exposed	Mickelson	MICK1	0.96	1.22	2.18
Exposed	Milligan	MILL2	0.59	0.48	1.07
Exposed	North Thompson	NTHO1	0.77	0.77	1.54
Exposed	North Wolfram	NWOL1	0.14	0.00	0.14
Exposed	Otto	OTTO1	0.21	0.02	0.23
Exposed	Pengally	PENG1	0.00	0.00	0.00
Exposed	Porter	PORT1	0.75	0.00	0.75
Exposed	Porter	PORT3	0.68	0.79	1.46
Exposed	Qualteri	QUAL1	0.00	0.00	0.00
Exposed	Sawmill	SAWM1	0.00	0.00	0.00
Exposed	Sawmill	SAWM2	0.00	0.00	0.00
Exposed	Six Mile	SIXM1	0.63	0.02	0.65
Exposed	Smith Pond Outlet	SPOU1	1.00	2.00	3.00
Reference	South Line	SLINE2	0.00	0.00	0.00
Exposed	South Pit	SPIT1	0.73	0.85	1.59
Exposed	South Pond Seep	SPSE1	0.00	0.00	0.00
Exposed	South Wolfram Creek	SWOL1	0.95	0.91	1.86
Exposed	Spring	SPRI1	0.12	0.00	0.12
Exposed	Swift	SWIF1	0.95	1.48	2.43
Exposed	Thompson	THOM1	0.22	0.00	0.22
Exposed	Thresher	THRE1	0.00	0.00	0.00
Exposed	Unnamed South of Sawmill	USOS1	0.00	0.00	0.00
Exposed	Willow North	WILN2	0.00	0.00	0.00
Exposed	Willow South	WILS1	0.00	0.00	0.00
Exposed	Wolf	WOL1	0.00	0.00	0.00
Exposed	Wolfram	WOLF2	0.49	0.20	0.69
Exposed	Wolfram	WOLF3	0.97	1.64	2.61

Appendix 3. Calcite distribution maps



2016 Calcite Monitoring Program

Elk Valley - Map # 1

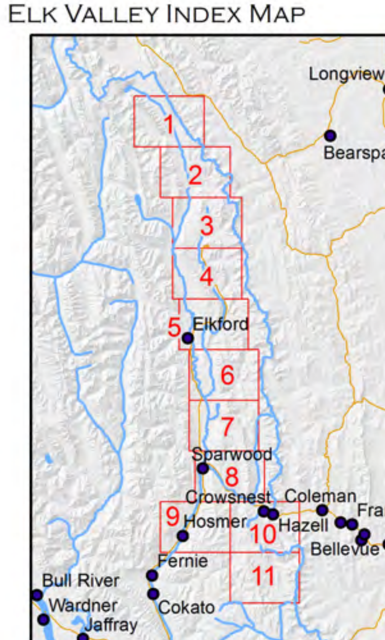
Reach Break
Reference Stream
Proposed Stream
Exposed Stream
Stream Segments
Road - Regional
Railway
Teck Coal Operations

Label Examples:

1.50 → Current Calcite Index (with neutral trend)
1.50 → Current Calcite Index (with increasing trend)
1.50 → Current Calcite Index (with decreasing trend)

0 1 2
Kilometers
1:50,000
UTM Zone 11 NAD83

Elk Valley Index Map

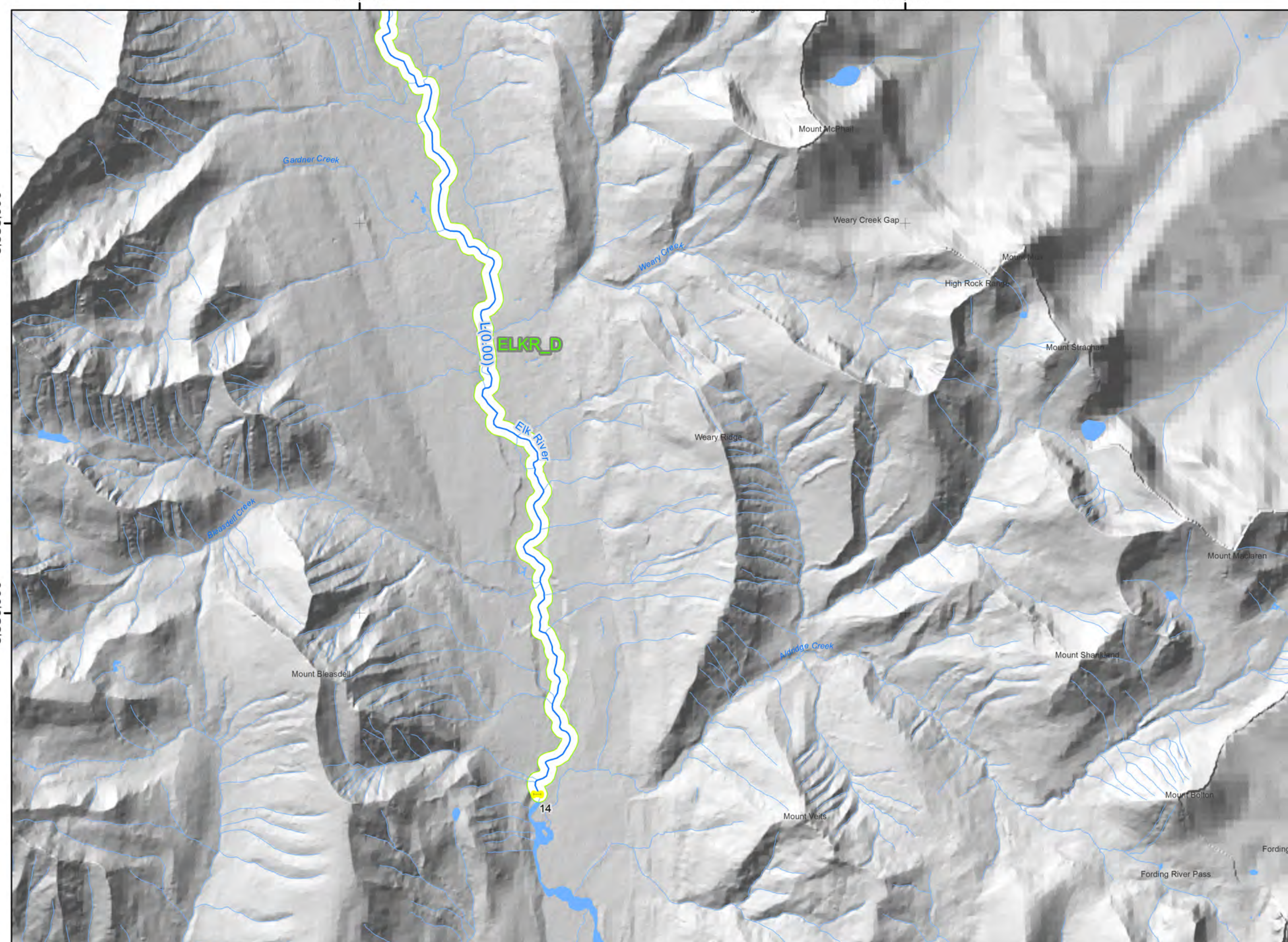


Client: Teck

Mapping by: Lotic Environmental

Data Sources:
- Stream / River - Teck Water Network
- Road / Rail - Teck Transportation
- Hillshade - GeoBase

Date Last Revised: Jan 30, 2017



2016 Calcite Monitoring Program

Elk Valley - Map #2

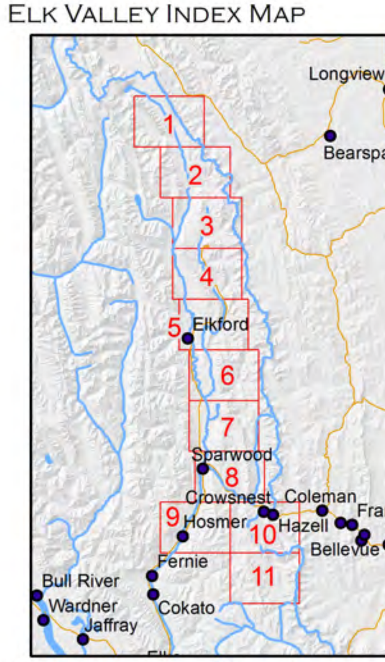
- Reach Break
- Reference Stream
- Proposed Stream
- Exposed Stream
- Stream Segments
- Road - Regional
- Railway
- Teck Coal Operations

Label Examples:

- 1.50 → Current calcite index (with neutral trend)
- 1.50 → Current calcite index (with increasing trend)
- 1.50 → Current calcite index (with decreasing trend)

0 1 2
Kilometers
1:50,000
UTM Zone 11 NAD83

Elk Valley Index Map

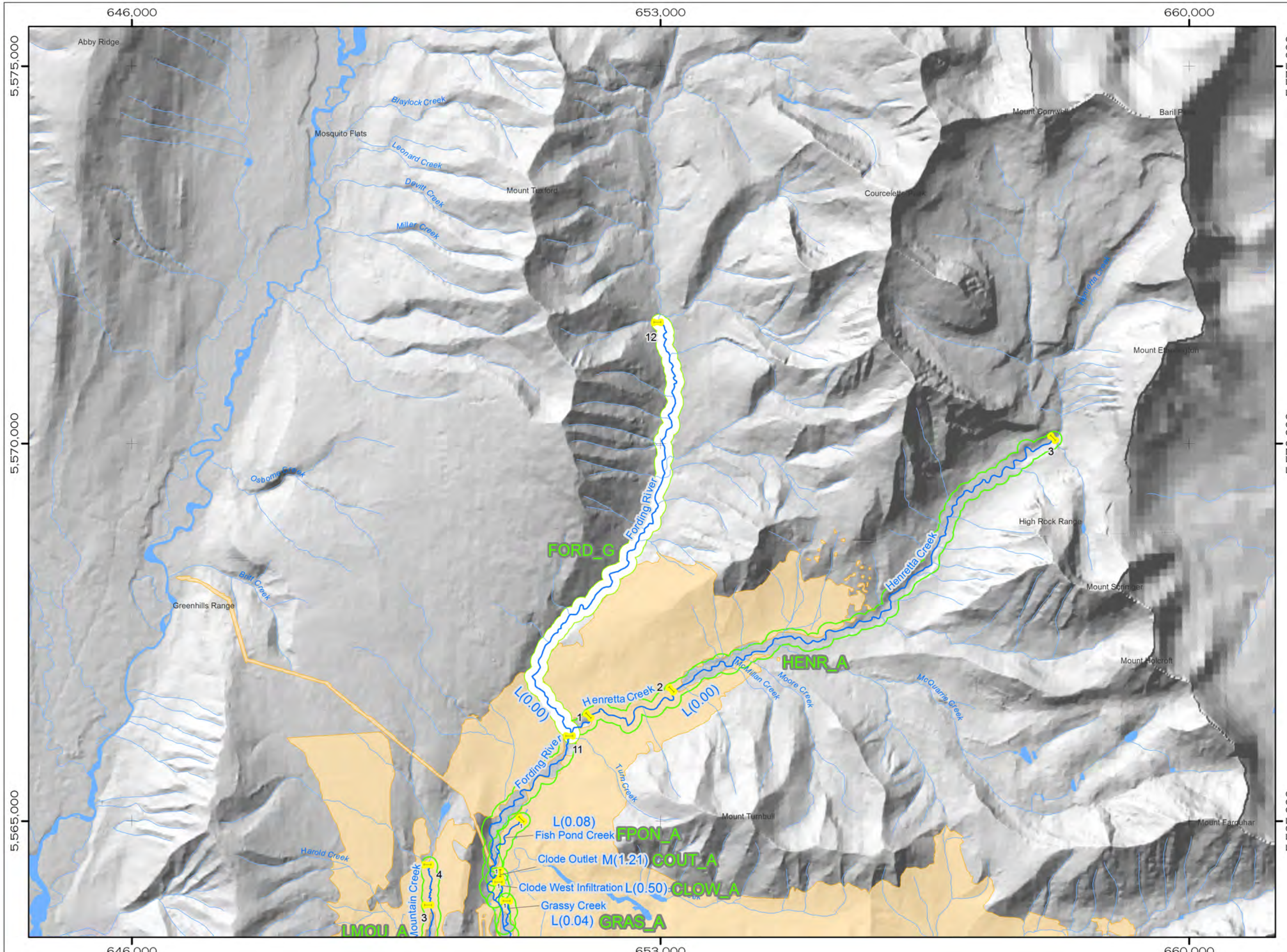


Client: Teck

Mapping by: Lotic Environmental

Data Sources:
- Stream / River - Teck Water Network
- Road / Rail - Teck Transportation
- Hillshade - GEOBASE

Date Last Revised: Jan 30, 2017



2016 Calcite Monitoring Program

Elk Valley - Map #3

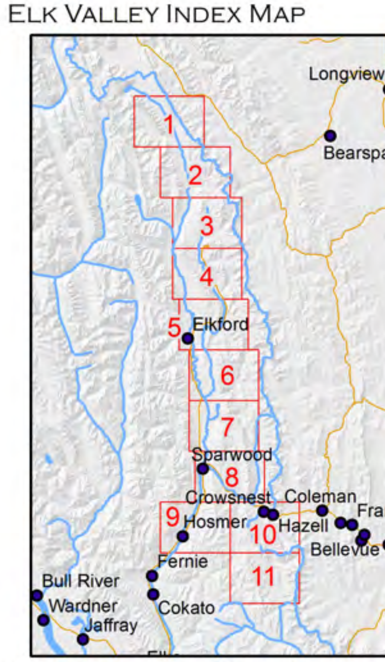
- Reach Break
- Reference Stream
- Proposed Stream
- Exposed Stream
- Stream Segments
- Road - Regional
- Railway
- Teck Coal Operations

Label Examples:

- 1.50 → Current calcite index (with neutral trend)
- 1.50 → Current calcite index (with increasing trend)
- 1.50 → Current calcite index (with decreasing trend)

0 1 2
Kilometers
1:50,000
UTM Zone 11 NAD83

Elk Valley Index Map

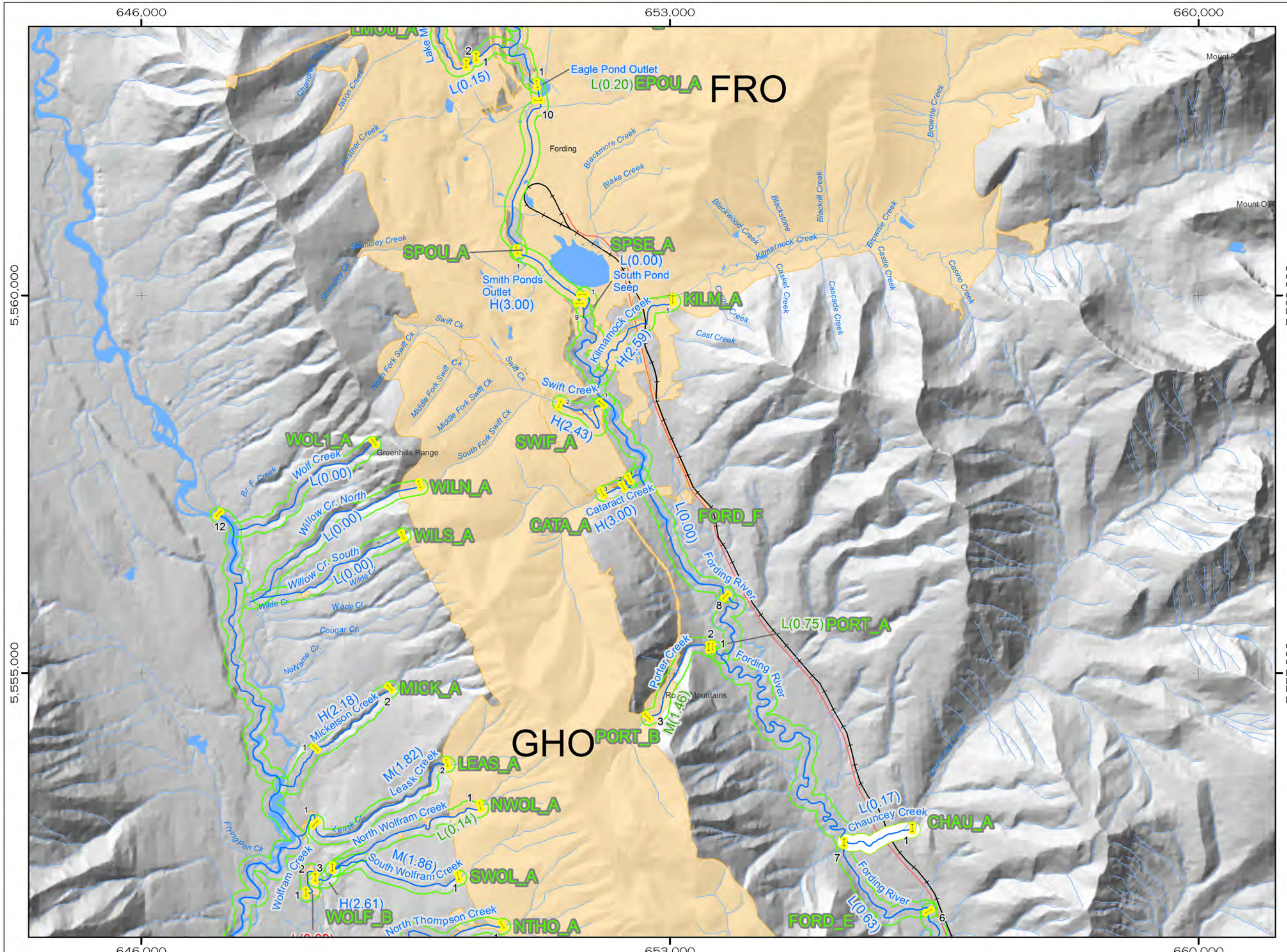


Client: Teck

Mapping by: Lotic Environmental

Data Sources:
- Stream / River - Teck Water Network
- Road / Rail - Teck Transportation
- Hillshade - GEOBASE

Date Last Revised: Jan 30, 2017



2016 Calcite Monitoring Program

Elk Valley - Map #4

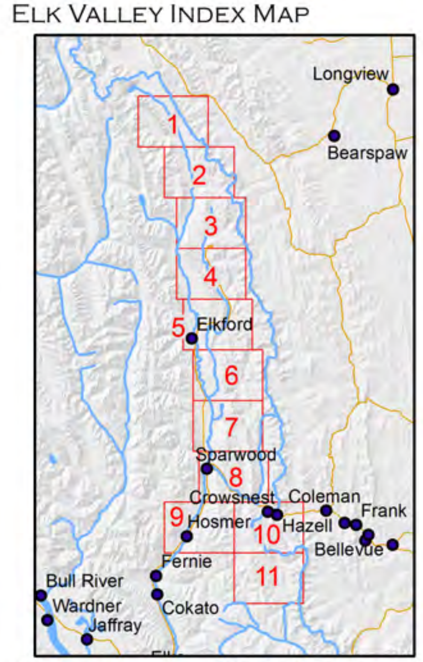
- Reach Break
- Reference Stream
- Proposed Stream
- Exposed Stream
- Stream Segments
- Road - Regional
- Railway
- Teck Coal Operations

Label Examples:

- 1.50 → Current calcite index (with neutral trend)
- 1.50 → Current calcite index (with increasing trend)
- 1.50 → Current calcite index (with decreasing trend)

0 1 2
Kilometers
1:50,000
UTM Zone 11 NAD83

Elk Valley Index Map

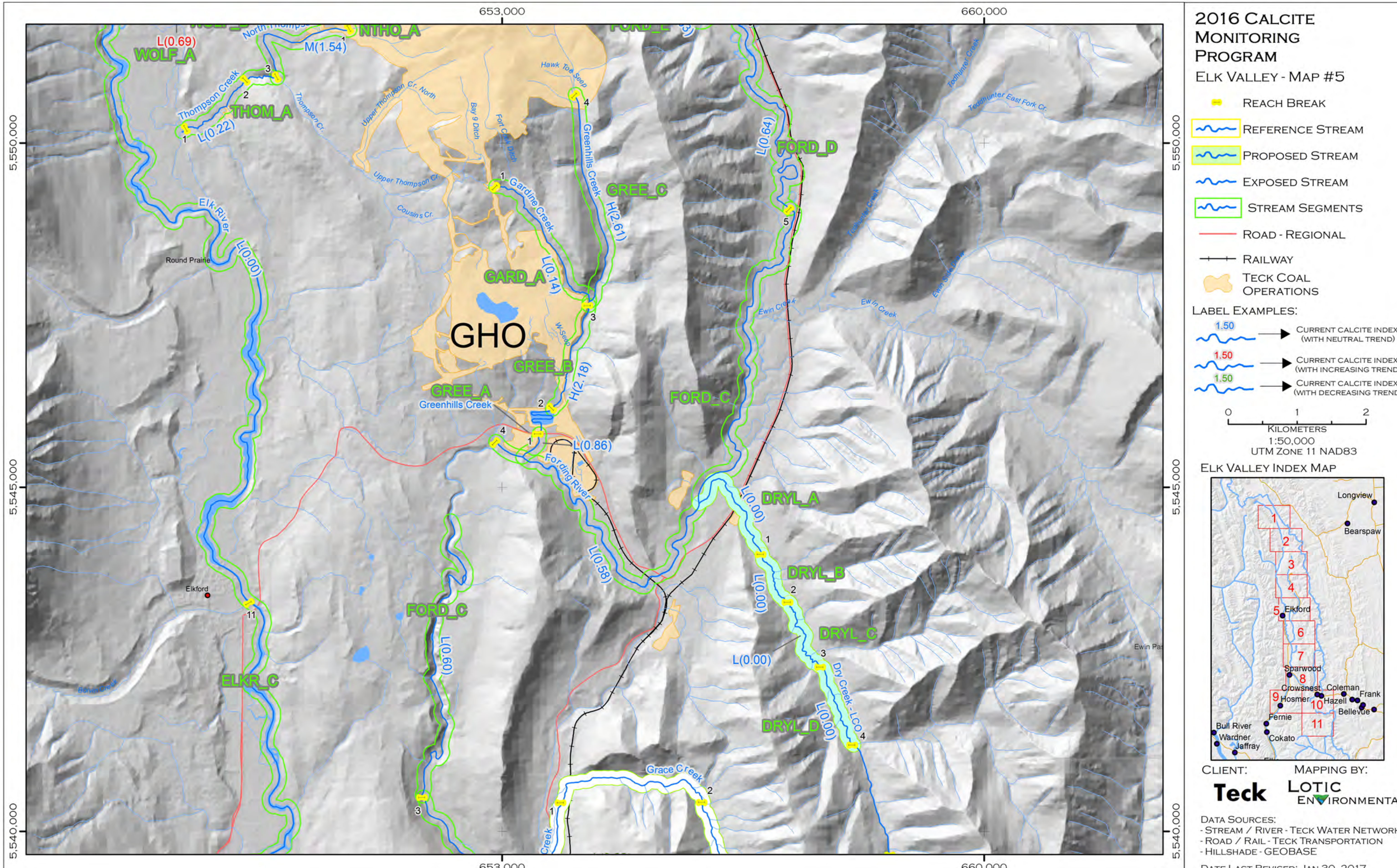


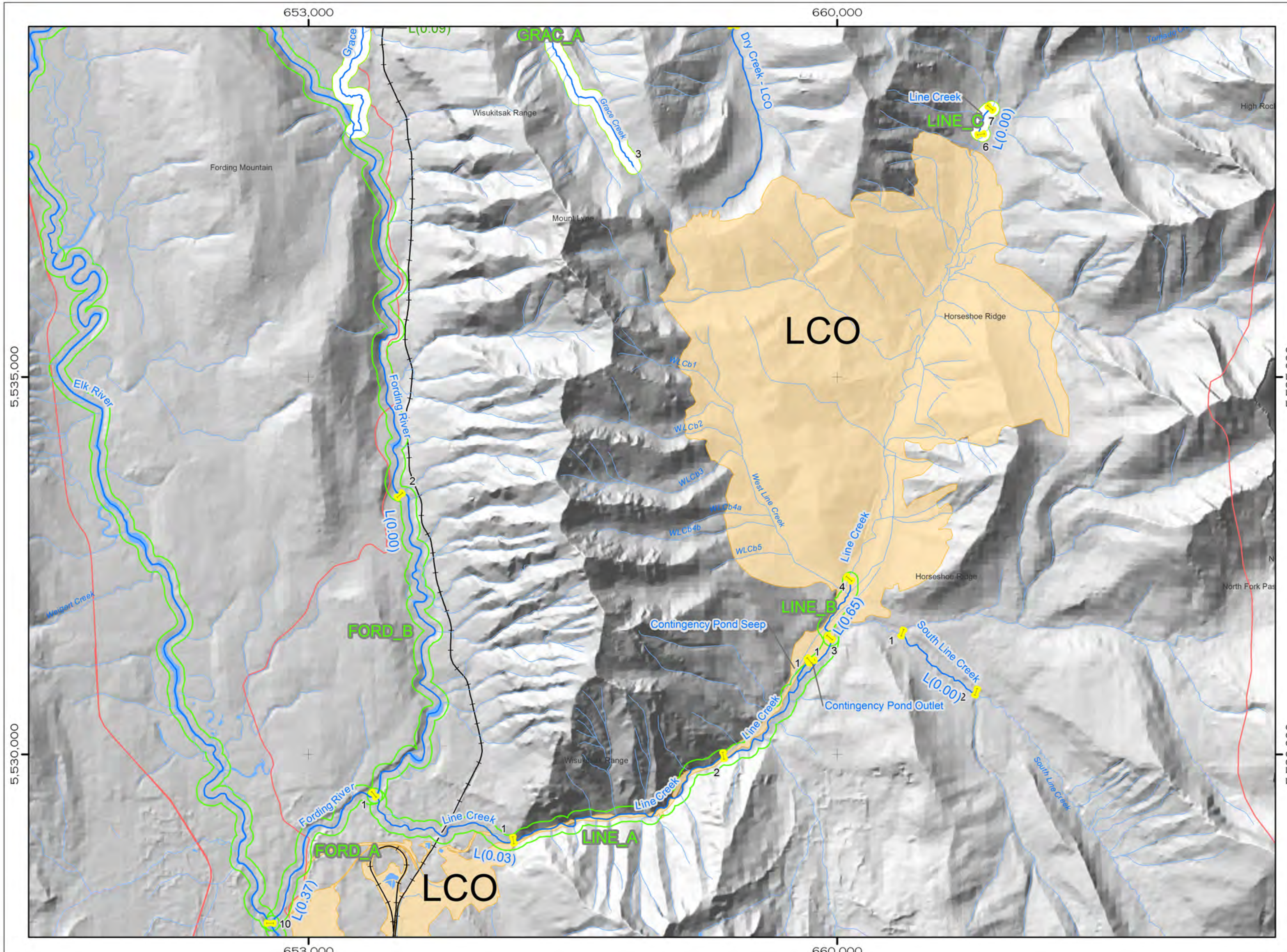
Client: Teck

Mapping by: Lotic Environmental

Data Sources:
- Stream / River - Teck Water Network
- Road / Rail - Teck Transportation
- Hillshade - GEOBASE

Date Last Revised: Jan 30, 2017


2016 Calcite Monitoring Program
Elk Valley - Map #5
Reach Break
Reference Stream
Proposed Stream
Exposed Stream
Stream Segments
Road - Regional
Railway
Teck Coal Operations
Label Examples:
1.50 Current calcite index (with neutral trend)
1.50 Current calcite index (with increasing trend)
1.50 Current calcite index (with decreasing trend)
0 1 2
Kilometers
1:50,000
UTM Zone 11 NAD83
Elk Valley Index Map
Longview
Bearspaw
Elkford
Sparwood
Crowsnest
Coleman
Frank
Hosmer
Hazell
Bellevue
Fernie
Bull River
Wardner
Jaffray
Cokato
1 2 3 4 5 6 7 8 9 10 11
Client:
Teck
Mapping by:
Lotic Environmental
Data Sources:
- Stream / River - Teck Water Network
- Road / Rail - Teck Transportation
- Hillshade - GEOBASE
Date Last Revised: Jan 30, 2017
653,000
660,000
5,550,000
5,545,000
5,540,000
GHO
WOLF_A
L(0.69)
NTHO_A
M(1.54)
THOM_A
L(0.22)
Thompson Creek
Thompson Cr.
Upper Thompson Cr. North
Upper Thompson Cr.
Cousins Cr.
Hawk Tea Seep
Bay 9 Ditch
Fort Cary Ditch
Gardine Creek
Greenhills Creek
GREE_C
H(2.61)
GARD_A
L(0.14)
W-Seep
GREE_B
H(2.18)
GREE_A
Greenhills Creek
L(0.86)
Fording River
L(0.58)
FORD_D
L(0.64)
FORD_C
Todhunter Creek
Todhunter East Fork Cr.
Ewin Creek
DRYL_A
L(0.00)
DRYL_B
DRYL_C
DRYL_D
Dry Creek - LCO
Elk River
L(0.00)
Round Prairie
Elkford
ELKR_C
FORD_C
L(0.60)
Grace Creek
Ewin Pass



2016 Calcite Monitoring Program

Elk Valley - Map #6

Reach Break

Reference Stream

Proposed Stream

Exposed Stream

Stream Segments

Road - Regional

Railway

Teck Coal Operations

Label Examples:

1.50 → Current calcite index (with neutral trend)

1.50 → Current calcite index (with increasing trend)

1.50 → Current calcite index (with decreasing trend)

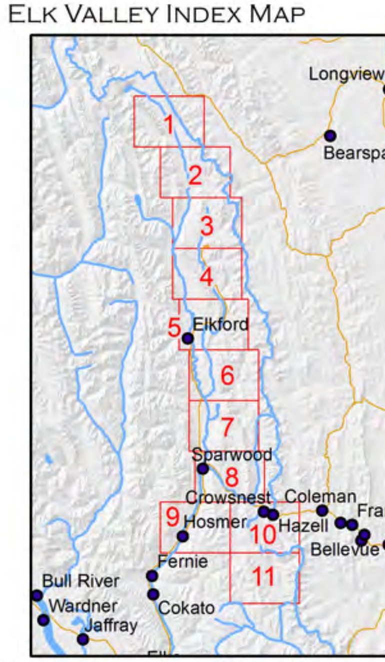
0 1 2

Kilometers

1:50,000

UTM Zone 11 NAD83

Elk Valley Index Map

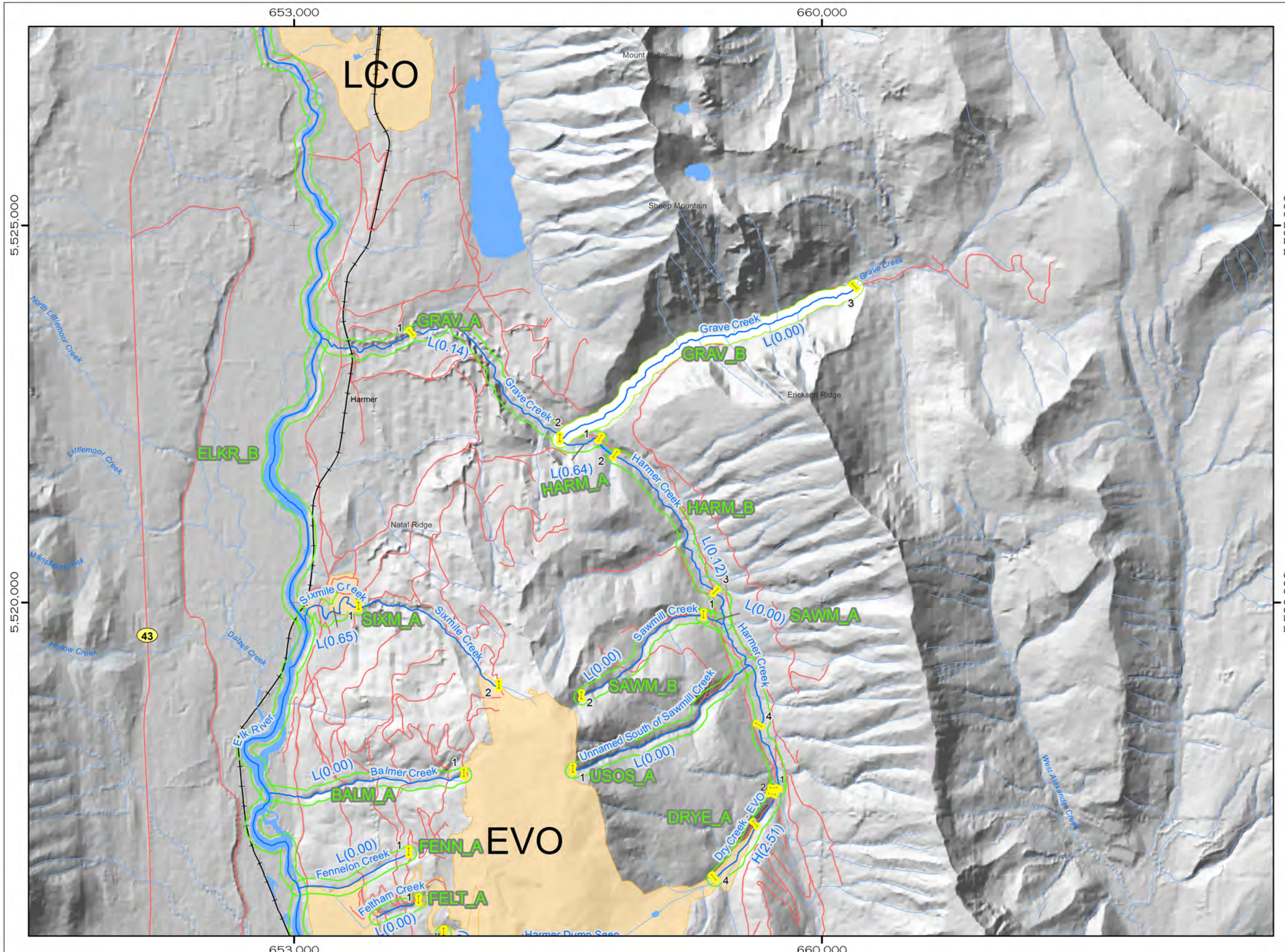


Client: Teck

Mapping by: Lotic Environmental

Data Sources:
- Stream / River - Teck Water Network
- Road / Rail - Teck Transportation
- Hillshade - GEOBASE

Date Last Revised: Jan 30, 2017



2016 Calcite Monitoring Program

Elk Valley - Map #7

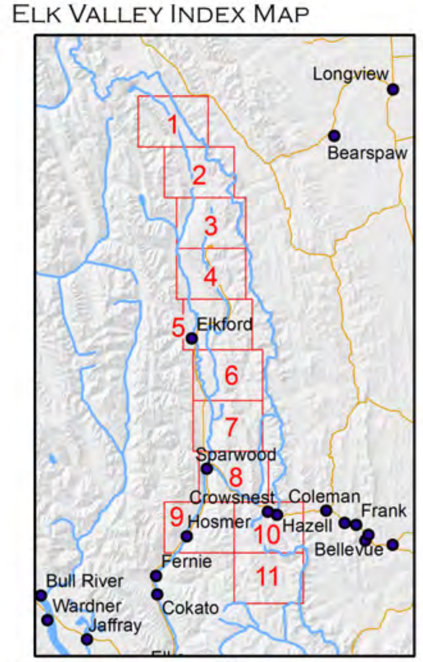
- Reach Break
- Reference Stream
- Proposed Stream
- Exposed Stream
- Stream Segments
- Road - Regional
- Railway
- Teck Coal Operations

Label Examples:

- 1.50 → Current calcite index (with neutral trend)
- 1.50 → Current calcite index (with increasing trend)
- 1.50 → Current calcite index (with decreasing trend)

0 1 2
Kilometers
1:50,000
UTM Zone 11 NAD83

Elk Valley Index Map

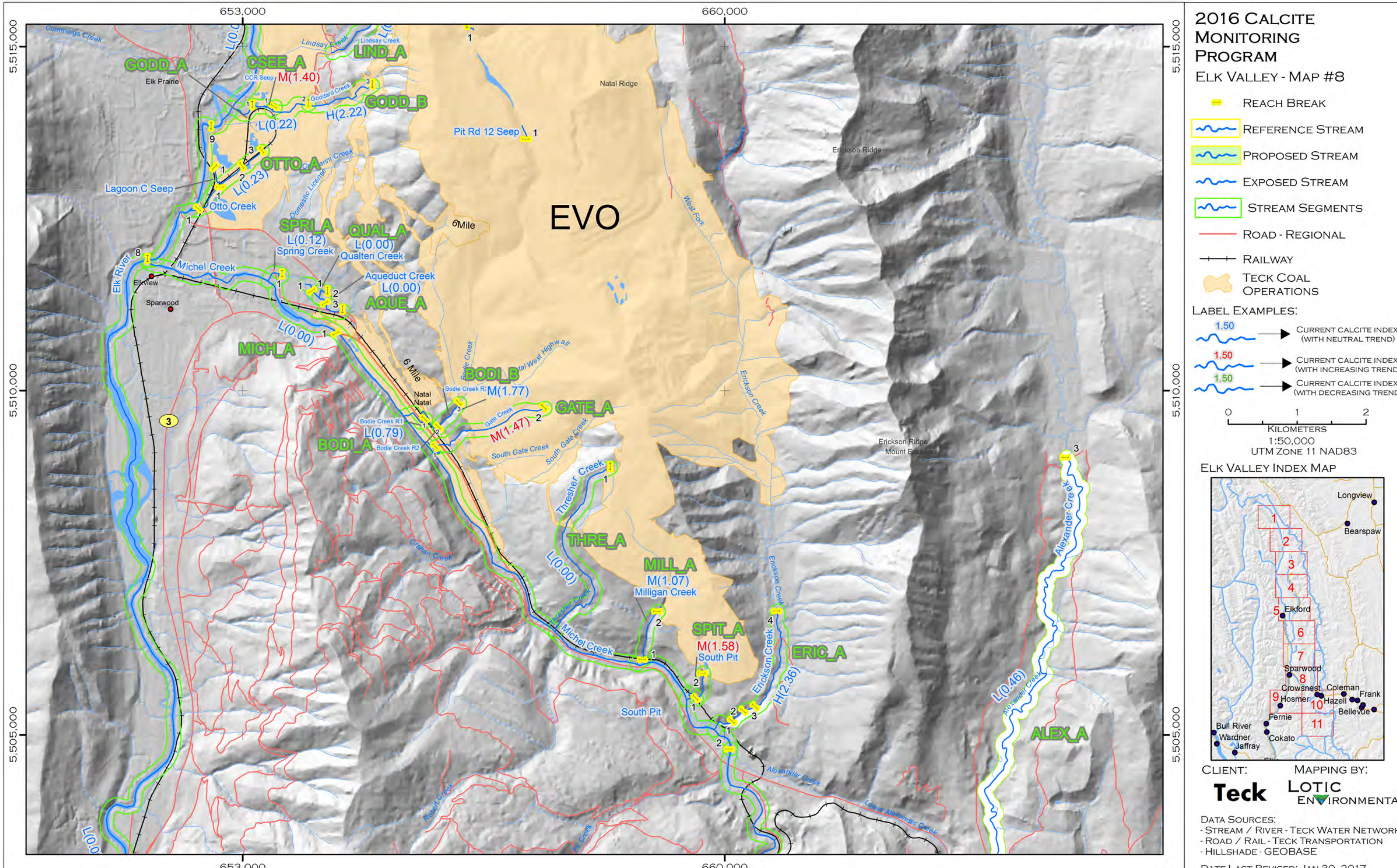


Client: Teck

Mapping by: Lotic Environmental

Data Sources:
- Stream / River - Teck Water Network
- Road / Rail - Teck Transportation
- Hillshade - GEOBASE

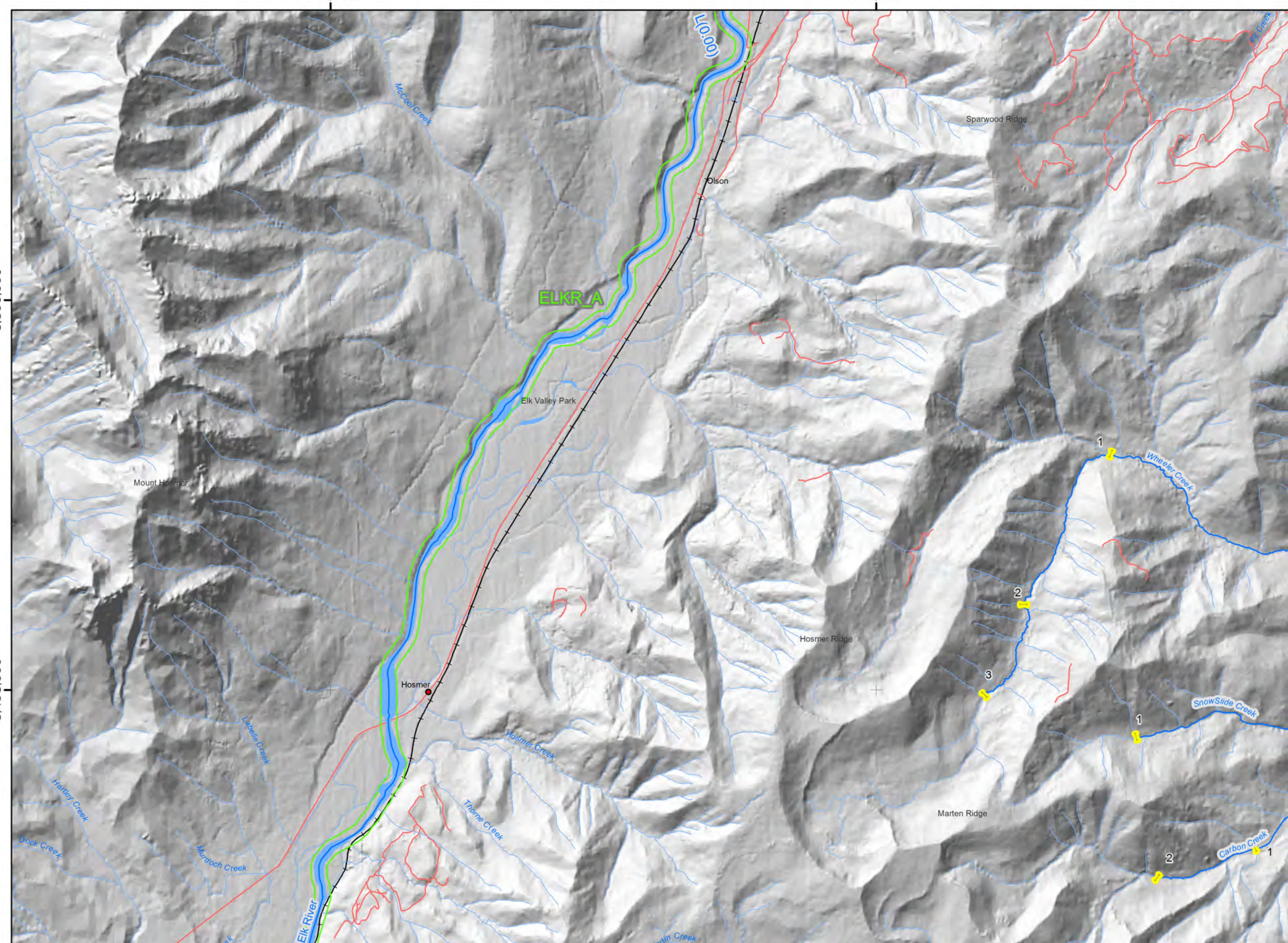
Date Last Revised: Jan 30, 2017



2016 Calcite Monitoring Program
Elk Valley - Map #8
Reach Break
Reference Stream
Proposed Stream
Exposed Stream
Stream Segments
Road - Regional
Railway
Teck Coal Operations
Label Examples:
1.50 Current calcite index (with neutral trend)
1.50 Current calcite index (with increasing trend)
1.50 Current calcite index (with decreasing trend)
0 1 2
Kilometers
1:50,000
UTM Zone 11 NAD83
Elk Valley Index Map
Longview
Bearspaw
Elkford
Sparwood
Crowsnest
Coleman
Frank
Hosmer
Hazell
Bellevue
Fernie
Bull River
Wardner
Jaffray
Cokato
Client:
Teck
Mapping by:
Lotic Environmental
Data Sources:
- Stream / River - Teck Water Network
- Road / Rail - Teck Transportation
- Hillshade - GEOBASE
Date Last Revised: Jan 30, 2017
653,000
660,000
5,515,000
5,510,000
5,505,000
EVO
GODD_A
CSEE_A
M(1.40)
LIND_A
GODD_B
H(2.22)
L(0.22)
OTTO_A
L(0.23)
Lagoon C Seep
Otto Creek
SPRI_A
L(0.12)
Spring Creek
QUAL_A
L(0.00)
Qualteri Creek
Aqueduct Creek
L(0.00)
AQUE_A
Michel Creek
Elk River
Elkview
Sparwood
Elk Prairie
Natal Ridge
Pit Rd 12 Seep
MICH_A
L(0.00)
BODI_B
M(1.77)
GATE_A
M(1.47)
BODI_A
L(0.79)
Bodie Creek R1
Bodie Creek R2
South Gate Creek
Gate Creek
Natal
6 Mile
Thresher Creek
THRE_A
L(0.00)
MILL_A
M(1.07)
Milligan Creek
SPIT_A
M(1.58)
South Pit
ERIC_A
H(2.36)
Erickson Creek
Erickson Ridge
West Fork
South Pit
Alexander Creek
L(0.46)
ALEX_A
Erickson Ridge

2016 Calcite Monitoring Program

Elk Valley - Map #9



Reach Break
Reference Stream
Proposed Stream
Exposed Stream
Stream Segments
Road - Regional
Railway
Teck Coal Operations

Label Examples:

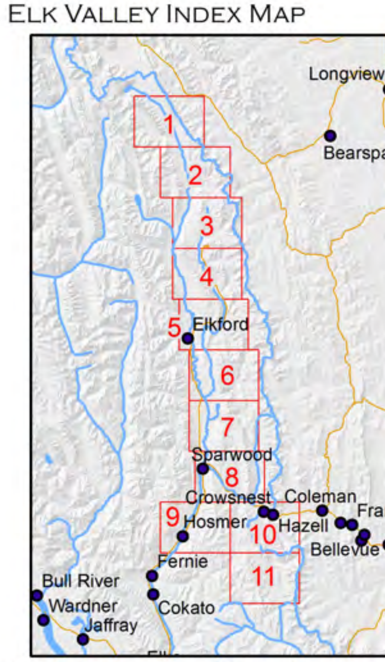
1.50 → Current calcite index (with neutral trend)

1.50 → Current calcite index (with increasing trend)

1.50 → Current calcite index (with decreasing trend)

0 1 2
Kilometers
1:50,000
UTM Zone 11 NAD83

Elk Valley Index Map

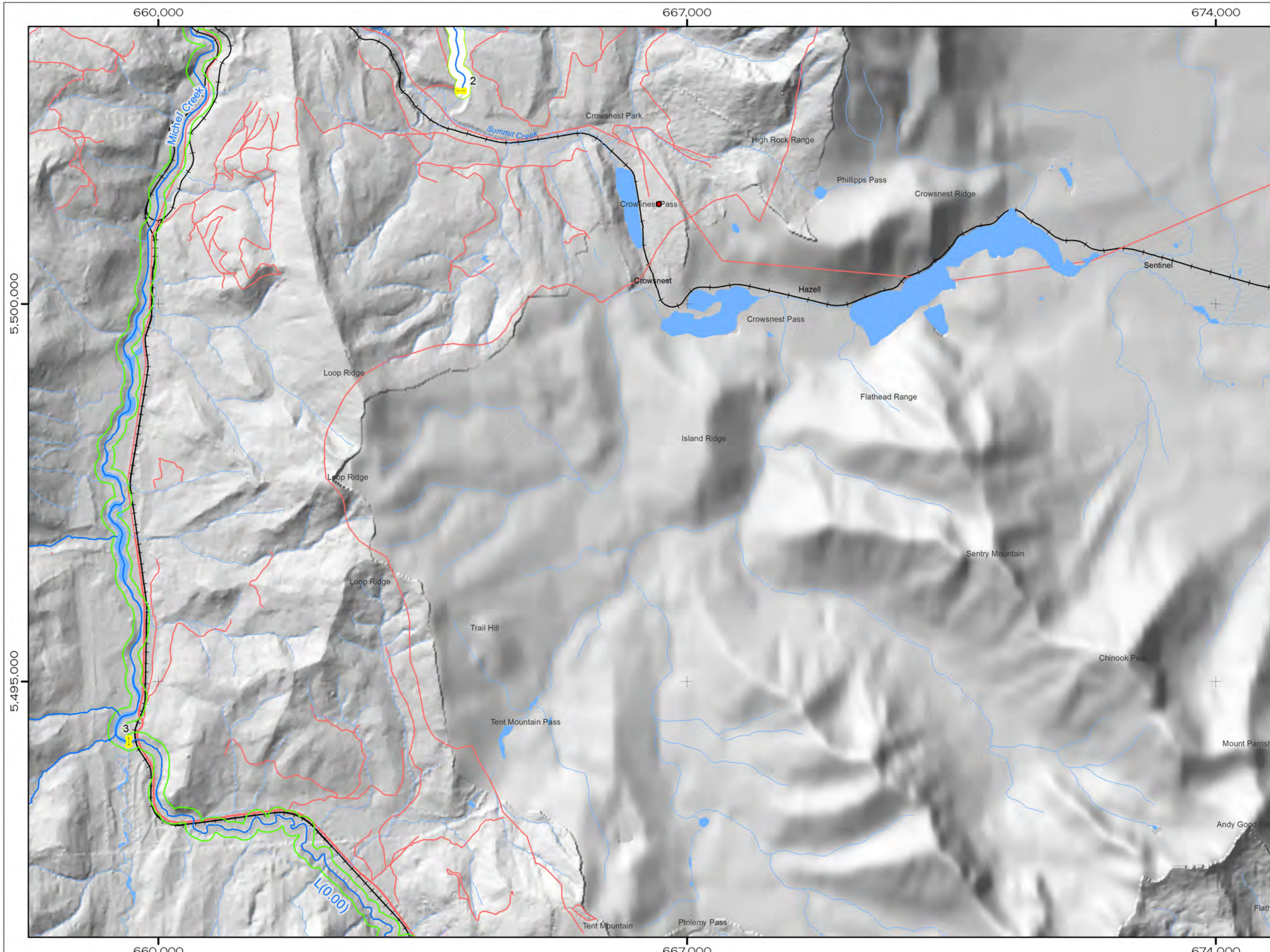


Client: Teck

Mapping by: Lotic Environmental

Data Sources:
- Stream / River - Teck Water Network
- Road / Rail - Teck Transportation
- Hillshade - GEOBASE

Date Last Revised: Jan 30, 2017



2016 Calcite Monitoring Program

Elk Valley - Map #10

Reach Break

Reference Stream

Proposed Stream

Exposed Stream

Stream Segments

Road - Regional

Railway

Teck Coal Operations

Label Examples:

1.50 → Current calcite index (with neutral trend)

1.50 → Current calcite index (with increasing trend)

1.50 → Current calcite index (with decreasing trend)

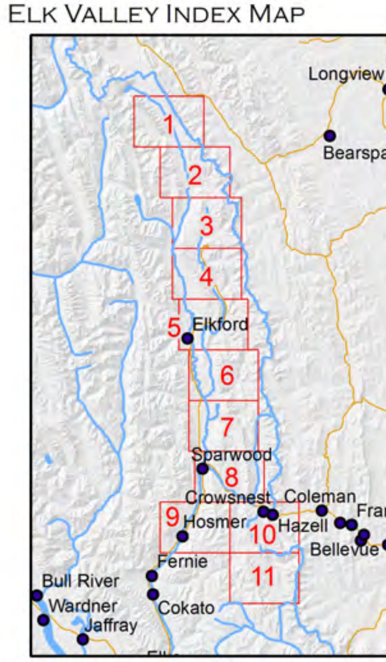
0 1 2

Kilometers

1:50,000

UTM Zone 11 NAD83

Elk Valley Index Map

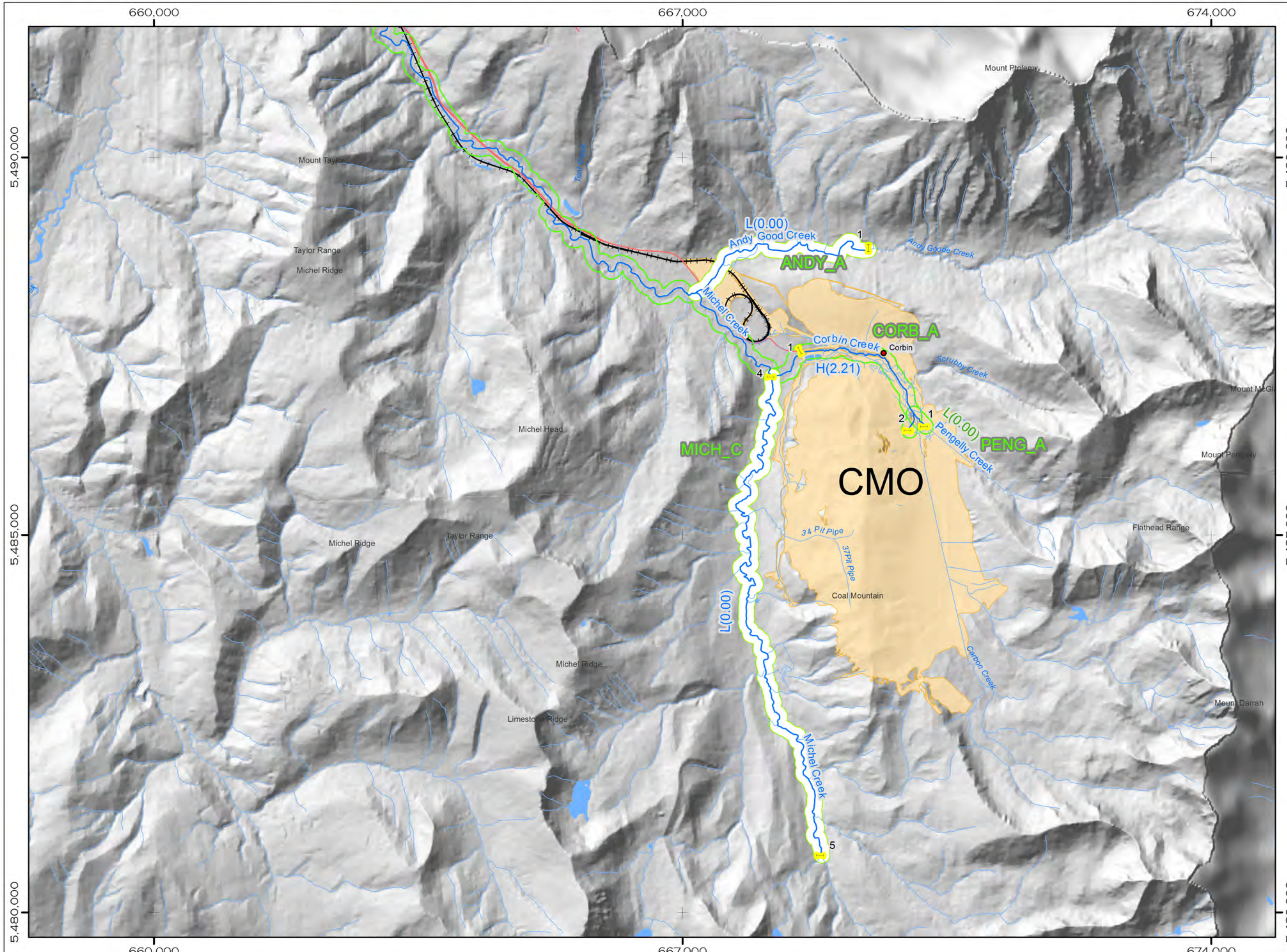


Client: Teck

Mapping by: Lotic Environmental

Data Sources:
- Stream / River - Teck Water Network
- Road / Rail - Teck Transportation
- Hillshade - GEOBASE

Date Last Revised: Jan 30, 2017



2016 Calcite Monitoring Program

Elk Valley - Map #11

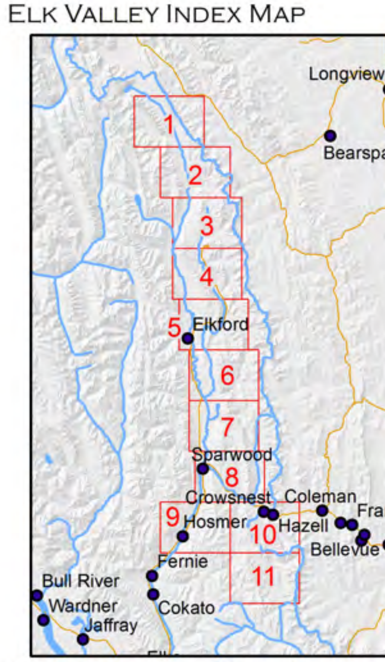
- Reach Break
- Reference Stream
- Proposed Stream
- Exposed Stream
- Stream Segments
- Road - Regional
- Railway
- Teck Coal Operations

Label Examples:

- 1.50 → Current calcite index (with neutral trend)
- 1.50 → Current calcite index (with increasing trend)
- 1.50 → Current calcite index (with decreasing trend)

0 1 2
Kilometers
1:50,000
UTM Zone 11 NAD83

Elk Valley Index Map



Client: Teck

Mapping by: Lotic Environmental

Data Sources:
- Stream / River - Teck Water Network
- Road / Rail - Teck Transportation
- Hillshade - GEOBASE

Date Last Revised: Jan 30, 2017

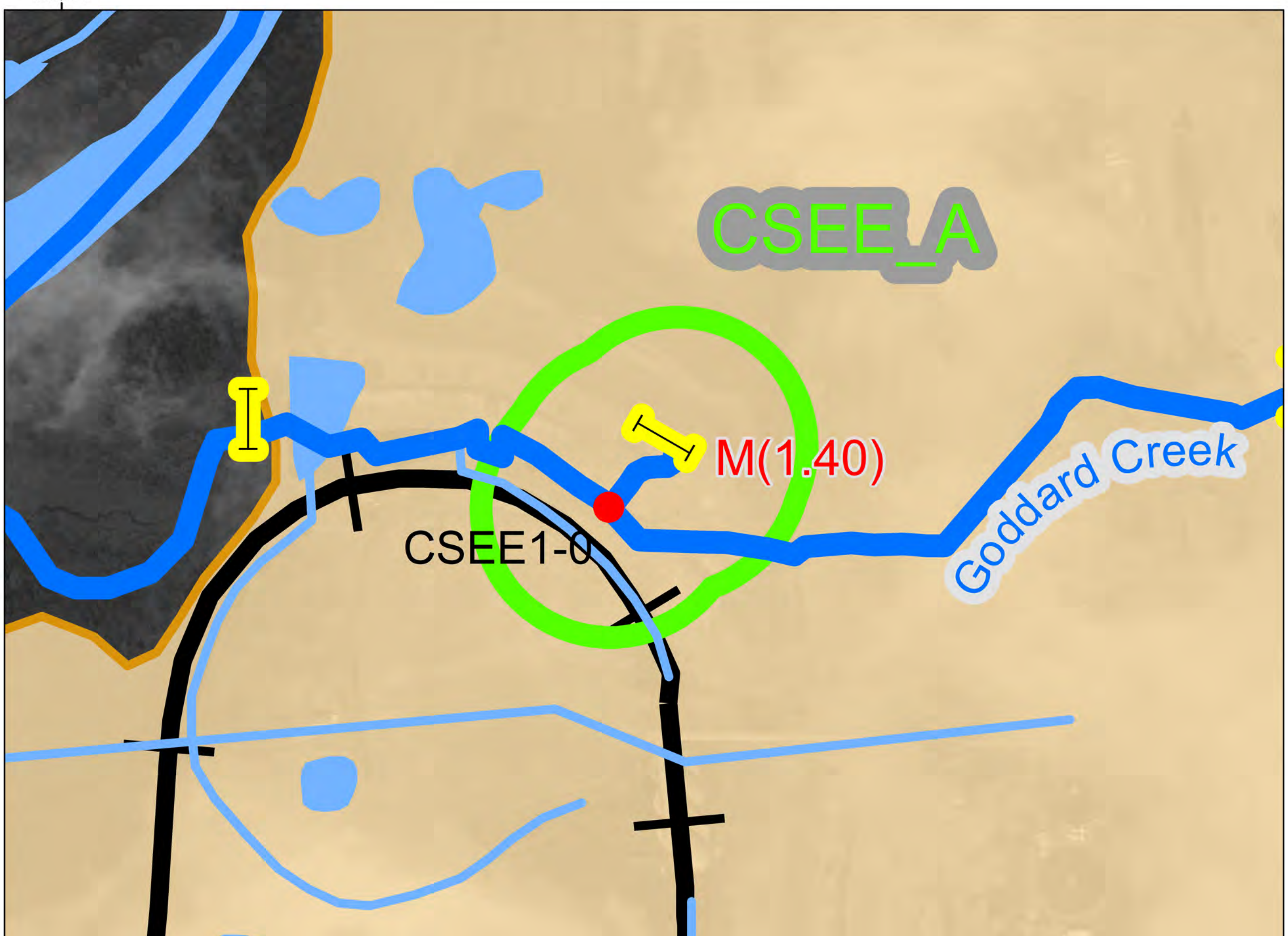
Appendix 4. Regression analysis results for reaches sampled in three or more years from 2013 - 2016.

Reach	p-value	Slope (CI/year)	Change
ALEX3	0.89	-0.04	Neutral
BODI1	0.23	0.24	Neutral
BODI3	0.81	0.12	Neutral
CHAU1	0.23	0.05	Neutral
CLOW1	0.77	0.09	Neutral
CORB1	0.47	0.18	Neutral
COUT1	0.14	0.37	Neutral
CSEE1	0.05	**0.50**	**Increase**
DRYE3	0.37	0.07	Neutral
ELKR8	0.23	-0.12	Neutral
EPOU1	**0.01**	**-0.58**	**Decrease**
ERIC1	0.93	-0.01	Neutral
FORD1	0.23	0.11	Neutral
FORD4	0.39	0.28	Neutral
FORD5	0.15	0.13	Neutral
FORD6	0.79	0.08	Neutral
FORD7	0.90	0.18	Neutral
FORD12	0.23	0.01	Neutral
FPON1	0.28	0.02	Neutral
GARD1	0.55	-0.08	Neutral
GATE2	**0.09**	**0.47**	**Increase**
GODD1	0.23	0.07	Neutral
GODD3	0.15	0.67	Neutral
GRAC1	**0.09**	**-0.08**	**Decrease**
GRAS1	0.91	0.03	Neutral
GRAV1	0.26	-0.19	Neutral
GREE1	0.65	0.91	Neutral
GREE3	0.28	0.30	Neutral
GREE4	0.31	0.30	Neutral
HARM1	0.74	-0.08	Neutral
HARM3	0.58	-0.04	Neutral
KILM1	0.35	0.21	Neutral
LEAS2	0.39	0.41	Neutral
LIND1	0.74	-0.07	Neutral
LINE1	0.30	-0.07	Neutral
LINE4	0.24	0.12	Neutral
LMOU1	0.90	0.01	Neutral
MICH1	0.23	-0.09	Neutral
MICK1	0.23	0.65	Neutral
MILL2	0.23	0.32	Neutral
NTHO1	0.96	-0.02	Neutral
NWOL1	**0.02**	**-0.55**	**Decrease**
OTTO1	0.49	-0.03	Neutral
PENG1	**0.09**	**-0.03**	**Decrease**
PORT1	**0.08**	**-0.05**	**Decrease**

Reach	p-value	Slope (CI/year)	Change
PORT3	**0.06**	**-0.40**	**Decrease**
SAWM2	0.42	-0.11	Neutral
SIXM1	0.51	-0.12	Neutral
SPIT1	**0.06**	**0.55**	**Increase**
SPOU1	0.58	0.12	Neutral
SPRI1	0.29	-0.02	Neutral
SPSE1	0.75	-0.14	Neutral
SWIF1	0.81	-0.02	Neutral
SWOL1	0.50	-0.33	Neutral
THOM1	0.23	0.07	Neutral
WOLF2	**0.06**	**0.15**	**Increase**
WOLF3	0.69	-0.14	Neutral
ANDY1	n/a*	0**	Neutral
AQUE1	n/a*	0**	Neutral
CATA1	n/a*	0**	Neutral
BALM1	n/a*	0**	Neutral
DRYL1	n/a*	0**	Neutral
DRYL2	n/a*	0**	Neutral
DRYL3	n/a*	0**	Neutral
DRYL4	n/a*	0**	Neutral
ELKR15	n/a*	0**	Neutral
ELKR12	n/a*	0**	Neutral
ELKR9	n/a*	0**	Neutral
FELT1	n/a*	0**	Neutral
FENN1	n/a*	0**	Neutral
FORD2	n/a*	0**	Neutral
FORD9	n/a*	0**	Neutral
GRAV3	n/a*	0**	Neutral
HENR1	n/a*	0**	Neutral
LINE7	n/a*	0**	Neutral
MICH4	n/a*	0**	Neutral
MICH5	n/a*	0**	Neutral
QUAL1	n/a*	0**	Neutral
SAWM1	n/a*	0**	Neutral
SLINE1	n/a*	0**	Neutral
THRE1	n/a*	0**	Neutral
USOS1	n/a*	0**	Neutral
WILN1	n/a*	0**	Neutral
WILS1	n/a*	0**	Neutral
WOL1	n/a*	0**	Neutral

Appendix 5. Calcite maps for significant reaches

653,000



653,000

2016 Calcite Monitoring Program

CCR Seep

- Site Code
- Reach Break
- Reference Stream
- Proposed Stream
- Exposed Stream
- Stream Segments
- Road - Regional
- Railway
- Teck Coal Operations

Label Examples:

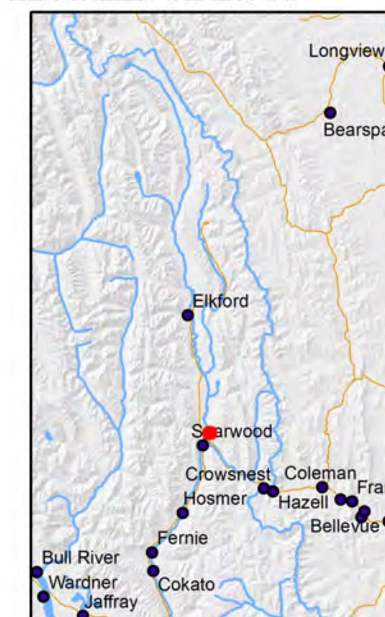
- 1.50 → Current Calcite Index (with neutral trend)
- 1.50 → Current Calcite Index (with increasing trend)
- 1.50 → Current Calcite Index (with decreasing trend)

0 25 50 100 M

1:3,000

UTM Zone 11 NAD83

Elk Valley Index Map

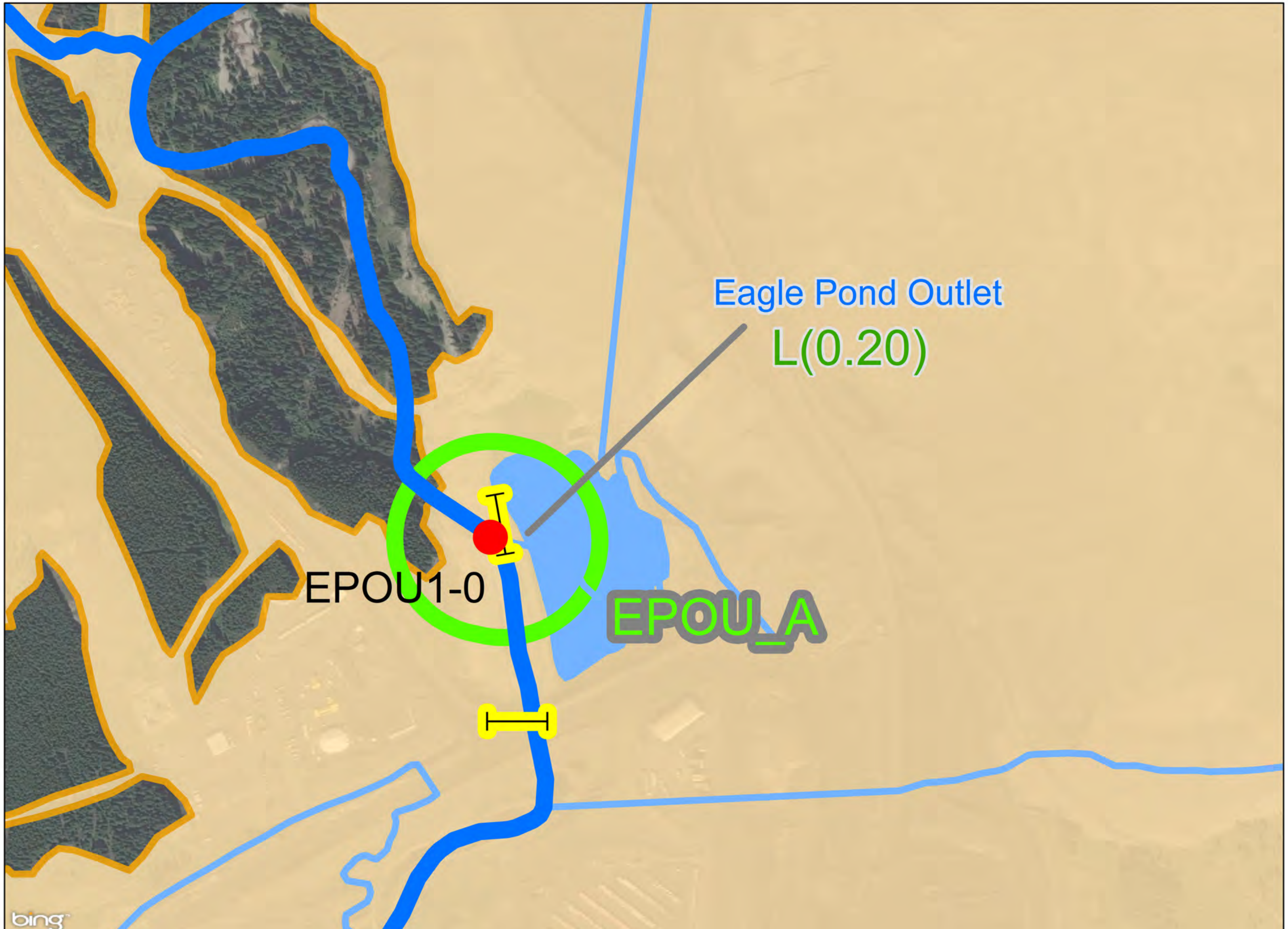


Client: Teck

Mapping by: Lotic Environmental

Data Sources:
- Stream / River - Teck Water Network
- Road / Rail - Teck Transportation
- Hillshade - GeoBase

Date Last Revised: Feb 08, 2017



2016 Calcite Monitoring Program

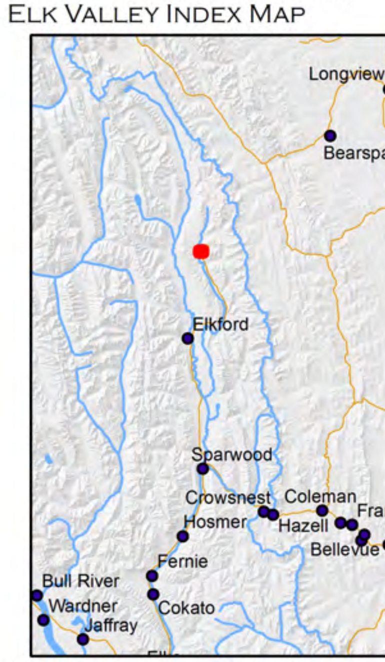
Eagle Pond Outlet

Site Code
Reach Break
Reference Stream
Proposed Stream
Exposed Stream
Stream Segments
Road - Regional
Railway
Teck Coal Operations

Label Examples:
1.50 Current calcite index (with neutral trend)
1.50 Current calcite index (with increasing trend)
1.50 Current calcite index (with decreasing trend)

0 35 70 140 M
1:4,000
UTM Zone 11 NAD83

Elk Valley Index Map



Client: Teck

Mapping by: Lotic Environmental

Data Sources:
- Stream / River - Teck Water Network
- Road / Rail - Teck Transportation
- Hillshade - GeoBase

Date Last Revised: Jan 30, 2017

2016 Calcite Monitoring Program

GATE - Reach 2

Site Code
Reach Break
Reference Stream
Proposed Stream
Exposed Stream
Stream Segments
Road - Regional
Railway
Teck Coal Operations

Label Examples:

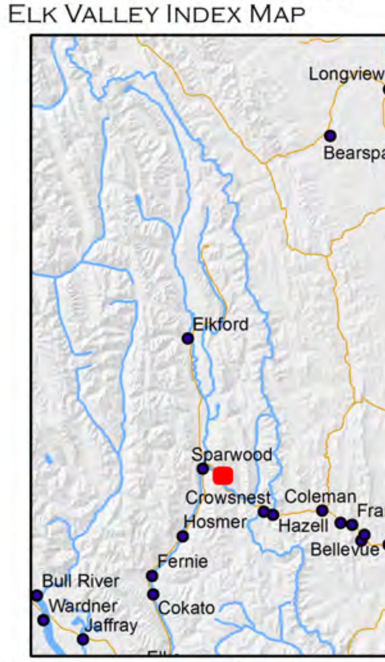
1.50 → Current calcite index (with neutral trend)
1.50 → Current calcite index (with increasing trend)
1.50 → Current calcite index (with decreasing trend)

0 62.5 125 250 M

1:7,000

UTM Zone 11 NAD83

Elk Valley Index Map

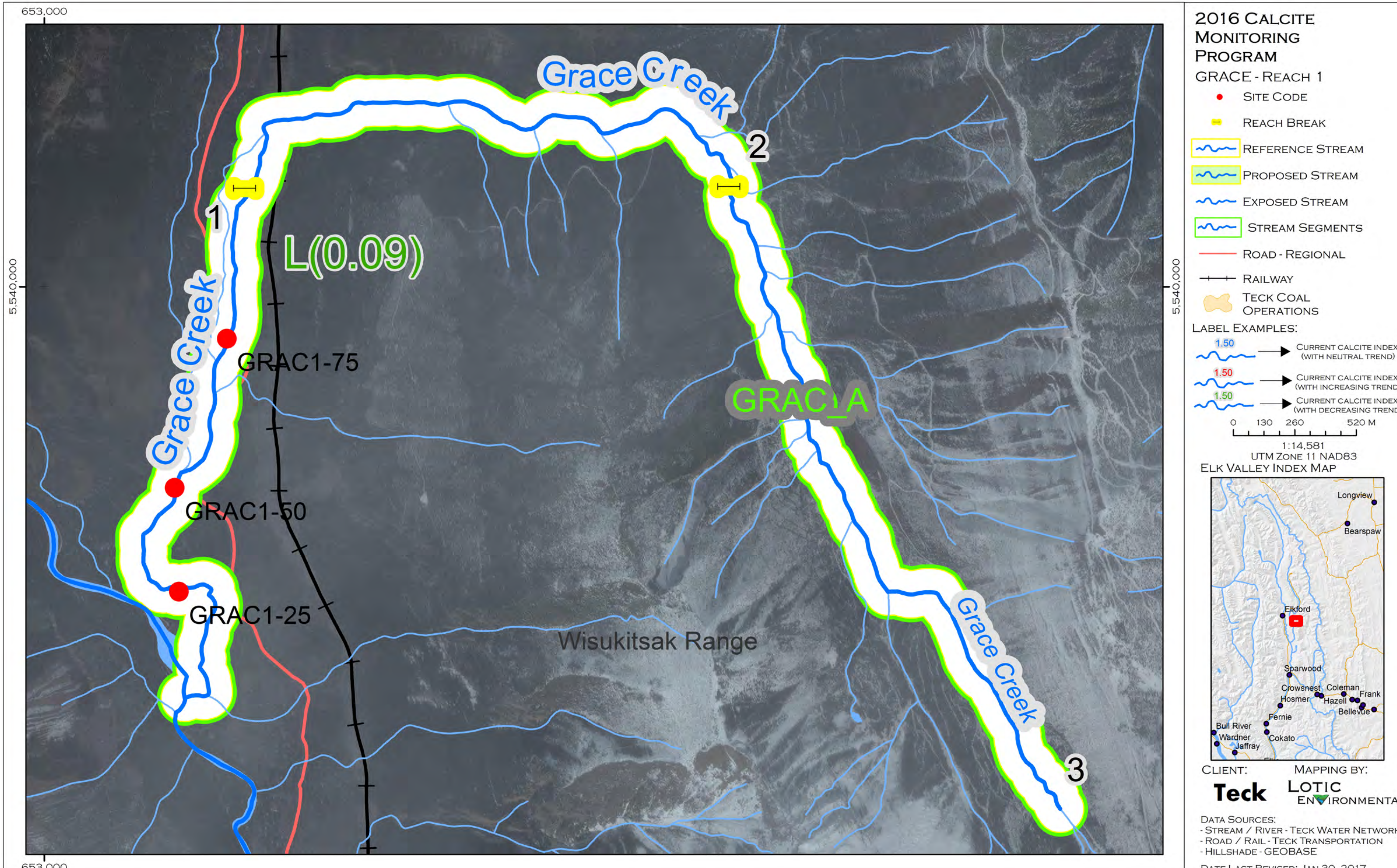


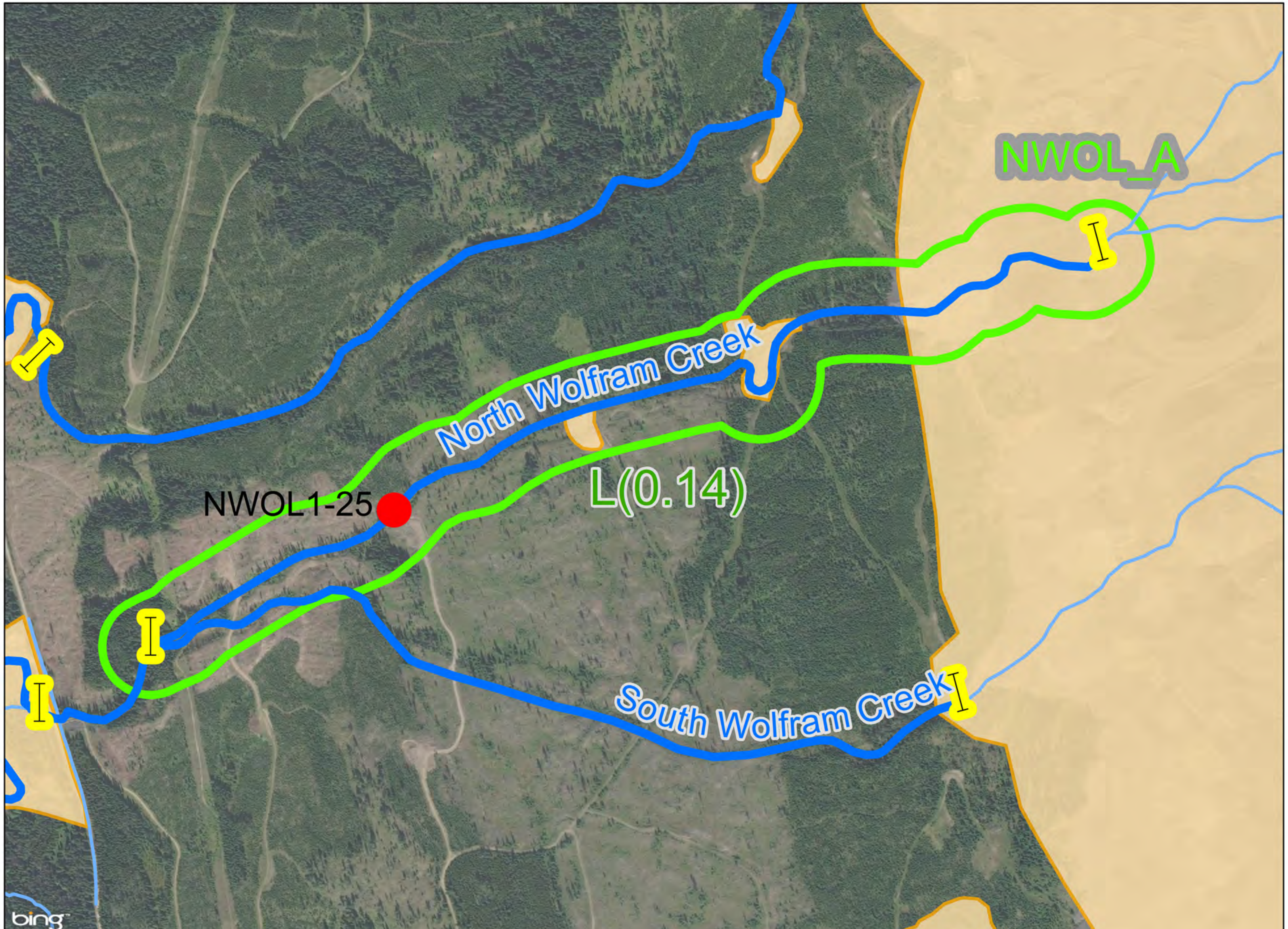
Client: Teck

Mapping by: Lotic Environmental

Data Sources:
- Stream / River - Teck Water Network
- Road / Rail - Teck Transportation
- Hillshade - GEOBASE

Date Last Revised: Jan 30, 2017


653,000
653,000
5,540,000
5,540,000
Grace Creek
Grace Creek
Grace Creek
1
2
3
L(0.09)
GRAC1-75
GRAC1-50
GRAC1-25
GRAC_A
Wisukitsak Range
2016 Calcite Monitoring Program
GRACE - Reach 1
Site Code
Reach Break
Reference Stream
Proposed Stream
Exposed Stream
Stream Segments
Road - Regional
Railway
Teck Coal Operations
Label Examples:
1.50
Current calcite index (with neutral trend)
1.50
Current calcite index (with increasing trend)
1.50
Current calcite index (with decreasing trend)
0 130 260 520 M
1:14,581
UTM Zone 11 NAD83
Elk Valley Index Map
Longview
Bearspaw
Elkford
Sparwood
Crowsnest
Coleman
Frank
Hosmer
Hazell
Bellevue
Fernie
Bull River
Wardner
Cokato
Jaffray
Client:
Teck
Mapping by:
Lotic Environmental
Data Sources:
- Stream / River - Teck Water Network
- Road / Rail - Teck Transportation
- Hillshade - GEOBASE
Date Last Revised: Jan 30, 2017



2016 Calcite Monitoring Program

N. Wolfram - Reach 1

- Site Code
- Reach Break
- Reference Stream
- Proposed Stream
- Exposed Stream
- Stream Segments
- Road - Regional
- Railway
- Teck Coal Operations

Label Examples:

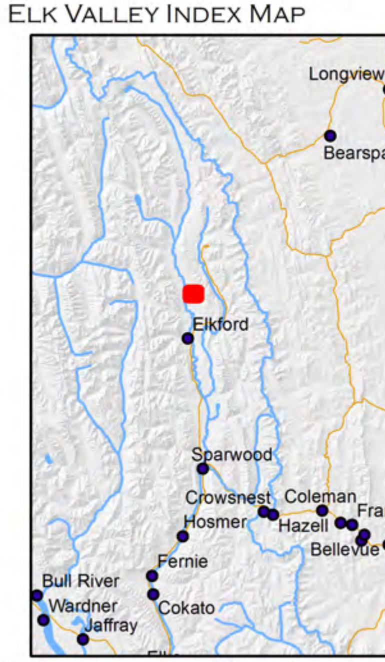
- 1.50 → Current calcite index (with neutral trend)
- 1.50 → Current calcite index (with increasing trend)
- 1.50 → Current calcite index (with decreasing trend)

0 70 140 280 M

1:8,000

UTM Zone 11 NAD83

Elk Valley Index Map

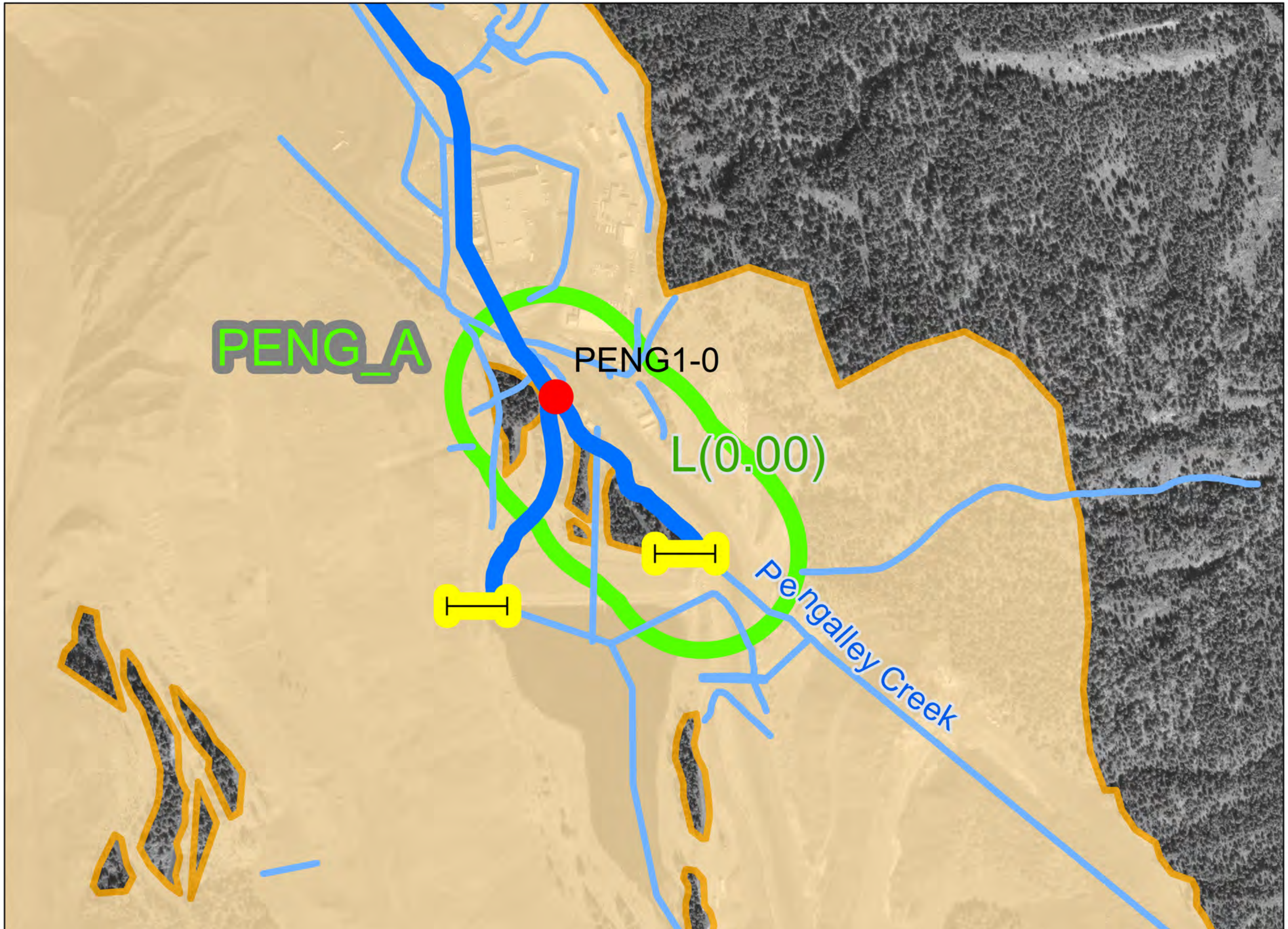


Client: Teck

Mapping by: Lotic Environmental

Data Sources:
- Stream / River - Teck Water Network
- Road / Rail - Teck Transportation
- Hillshade - GeoBase

Date Last Revised: Jan 30, 2017



2016 Calcite Monitoring Program

PENGALLEY - Reach 1

- Site Code
- Reach Break
- Reference Stream
- Proposed Stream
- Exposed Stream
- Stream Segments
- Road - Regional
- Railway
- Teck Coal Operations

Label Examples:

1.50 → Current calcite index (with neutral trend)

1.50 → Current calcite index (with increasing trend)

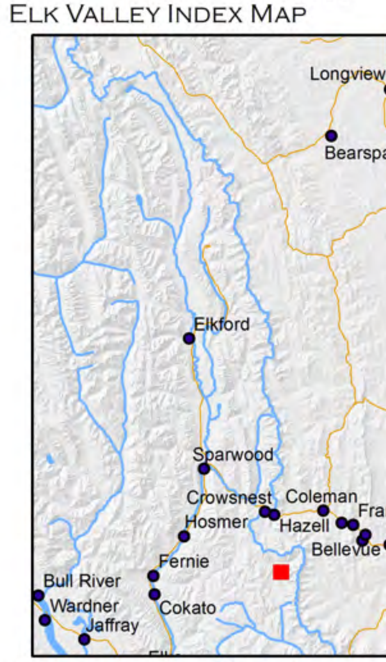
1.50 → Current calcite index (with decreasing trend)

0 35 70 140 M

1:4,000

UTM Zone 11 NAD83

Elk Valley Index Map

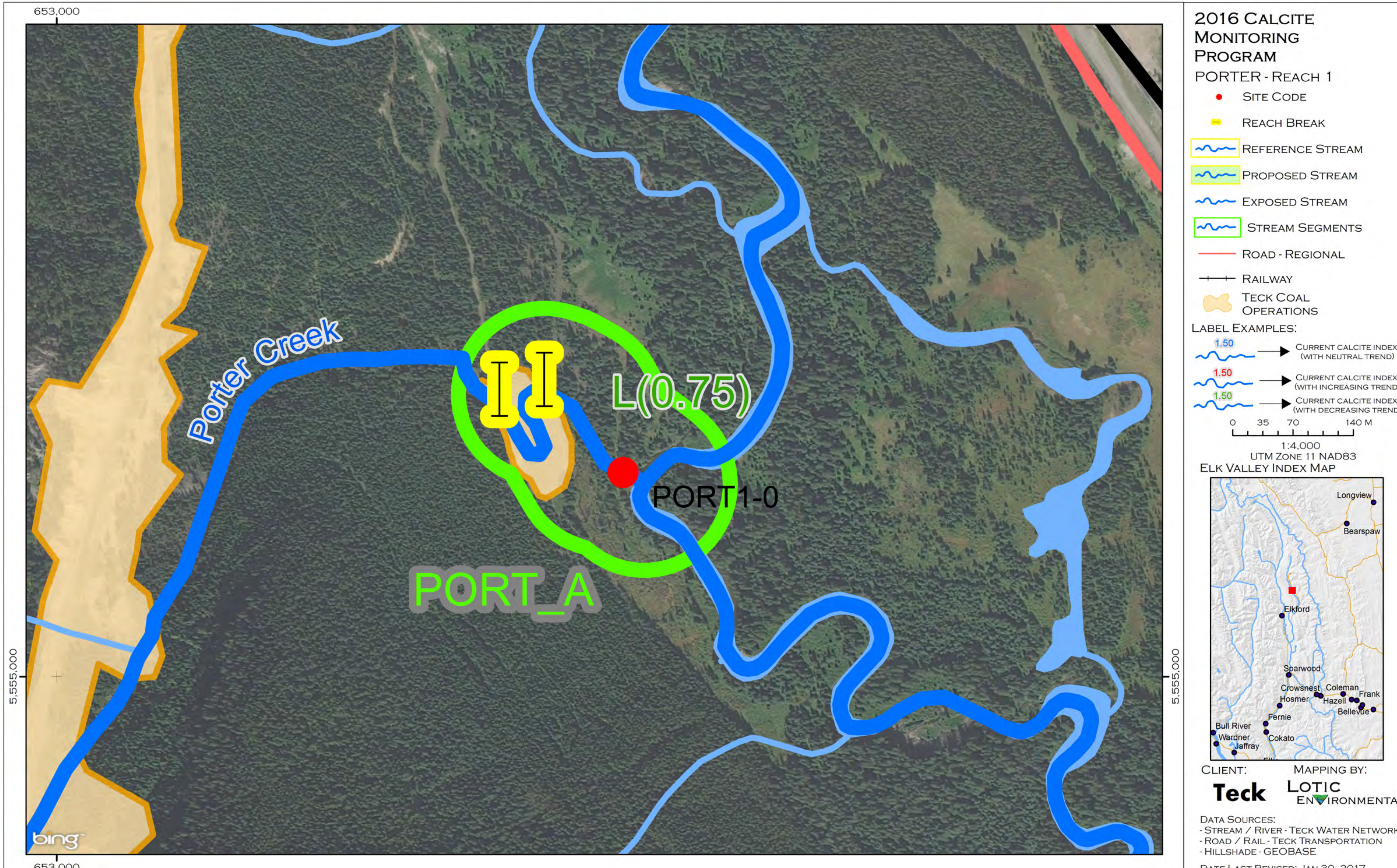


Client: Teck

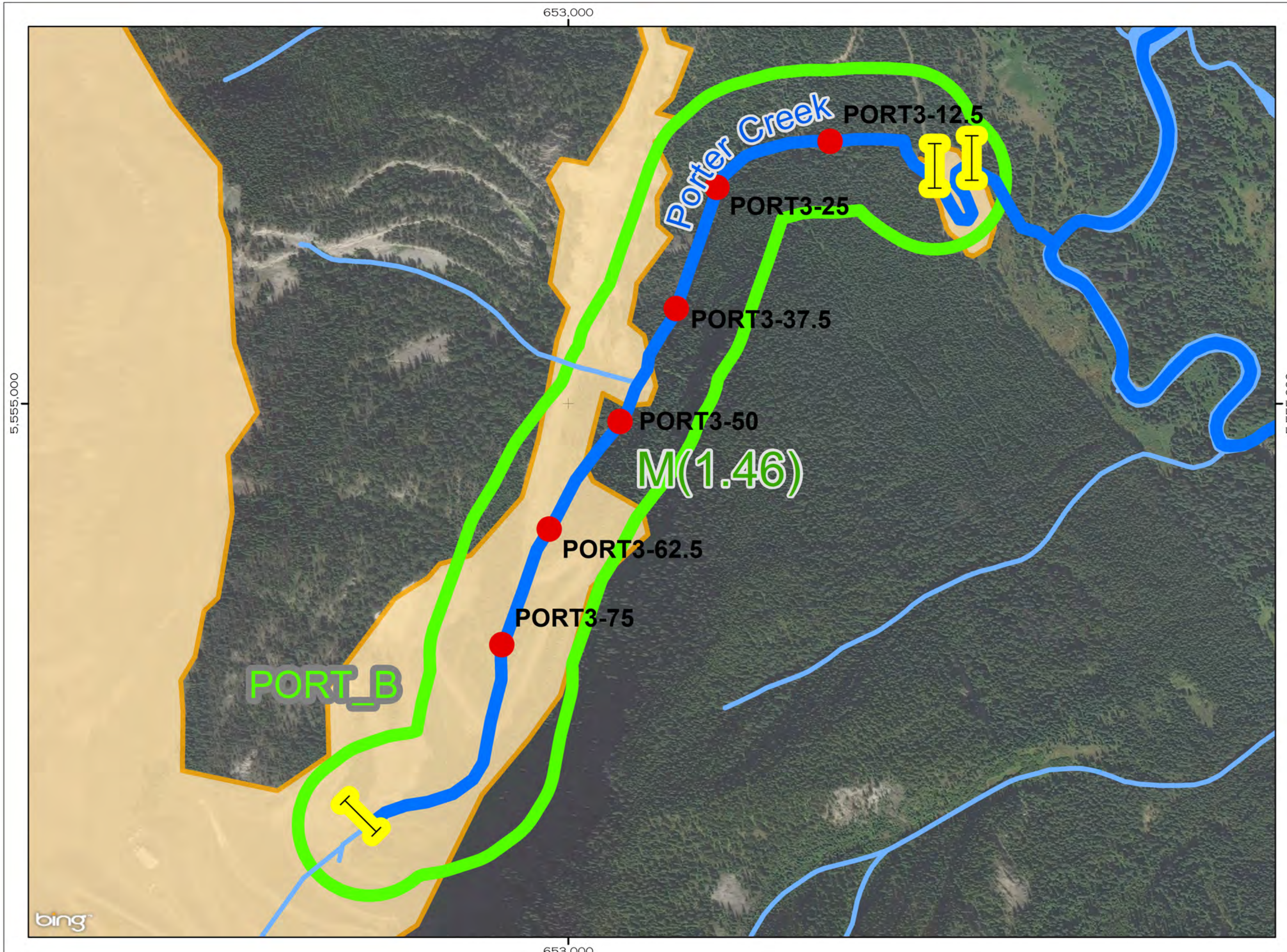
Mapping by: Lotic Environmental

Data Sources:
- Stream / River - Teck Water Network
- Road / Rail - Teck Transportation
- Hillshade - GEOBASE

Date Last Revised: Jan 30, 2017



653,000
653,000
5,555,000
5,555,000
Porter Creek
L(0.75)
PORT1-0
PORT_A
2016 Calcite Monitoring Program
PORTER - Reach 1
Site Code
Reach Break
Reference Stream
Proposed Stream
Exposed Stream
Stream Segments
Road - Regional
Railway
Teck Coal Operations
Label Examples:
1.50
Current calcite index (with neutral trend)
1.50
Current calcite index (with increasing trend)
1.50
Current calcite index (with decreasing trend)
0 35 70 140 M
1:4,000
UTM Zone 11 NAD83
Elk Valley Index Map
Longview
Bearspaw
Elkford
Sparwood
Crowsnest
Coleman
Frank
Hosmer
Hazell
Bellevue
Fernie
Bull River
Wardner
Cokato
Jaffray
Client:
Teck
Mapping by:
Lotic Environmental
Data Sources:
- Stream / River - Teck Water Network
- Road / Rail - Teck Transportation
- Hillshade - GEOBASE
Date Last Revised: Jan 30, 2017



2016 Calcite Monitoring Program

Porter - Reach 3

Site Code

Reach Break

Reference Stream

Proposed Stream

Exposed Stream

Stream Segments

Road - Regional

Railway

Teck Coal Operations

Label Examples:

1.50 → Current calcite index (with neutral trend)

1.50 → Current calcite index (with increasing trend)

1.50 → Current calcite index (with decreasing trend)

0 45 90 180 M

1:5,307

UTM Zone 11 NAD83

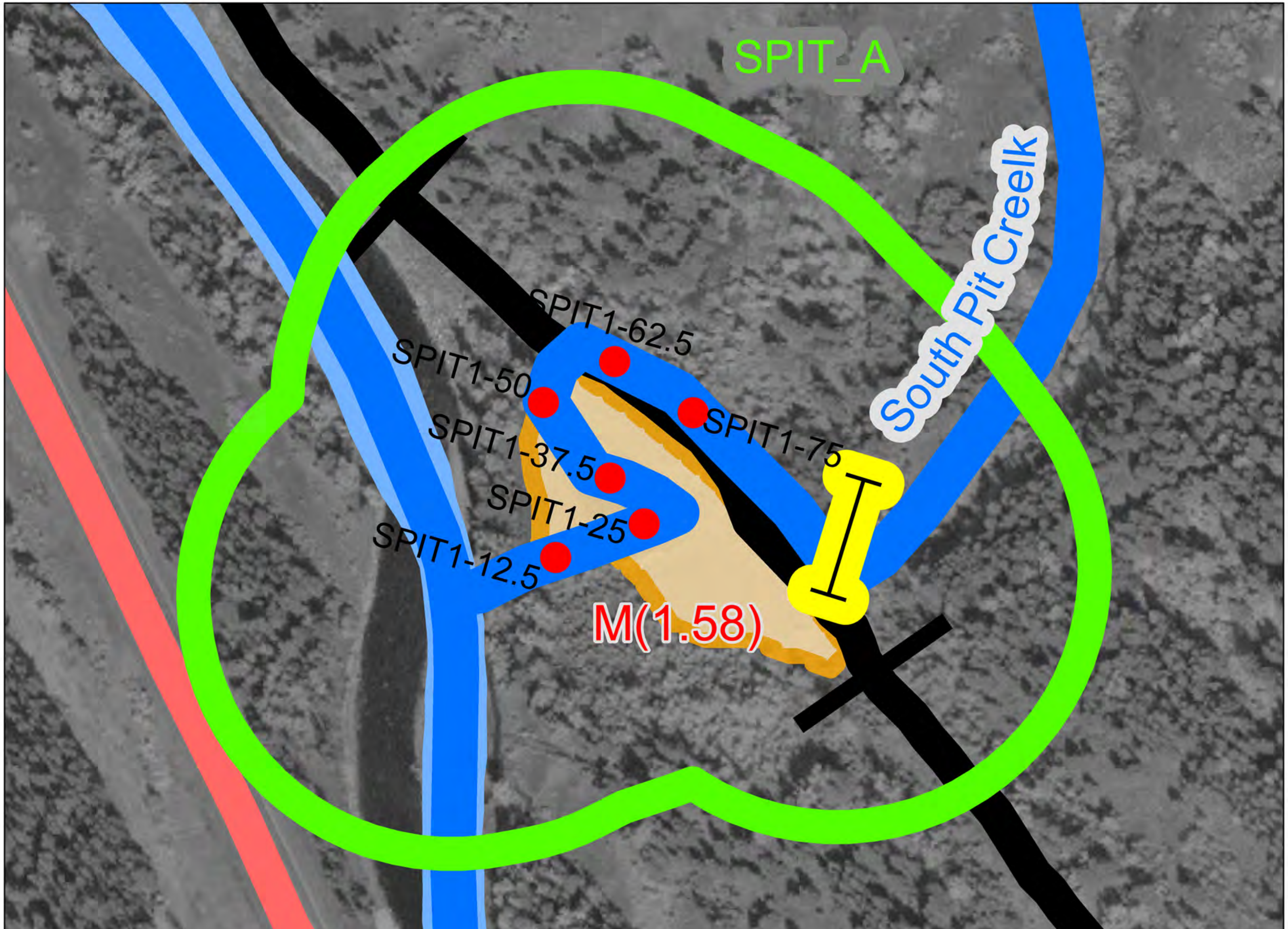
Elk Valley Index Map

Client: Teck

Mapping by: Lotic Environmental

Data Sources:
- Stream / River - Teck Water Network
- Road / Rail - Teck Transportation
- Hillshade - GEOBASE

Date Last Revised: Jan 30, 2017



2016 Calcite Monitoring Program

South Pit - Reach 1

- Site Code
- Reach Break
- Reference Stream
- Proposed Stream
- Exposed Stream
- Stream Segments
- Road - Regional
- Railway
- Teck Coal Operations

Label Examples:

- 1.50 → Current Calcite Index (with neutral trend)
- 1.50 → Current Calcite Index (with increasing trend)
- 1.50 → Current Calcite Index (with decreasing trend)

0 12.5 25 50 M

1:1,500

UTM Zone 11 NAD83

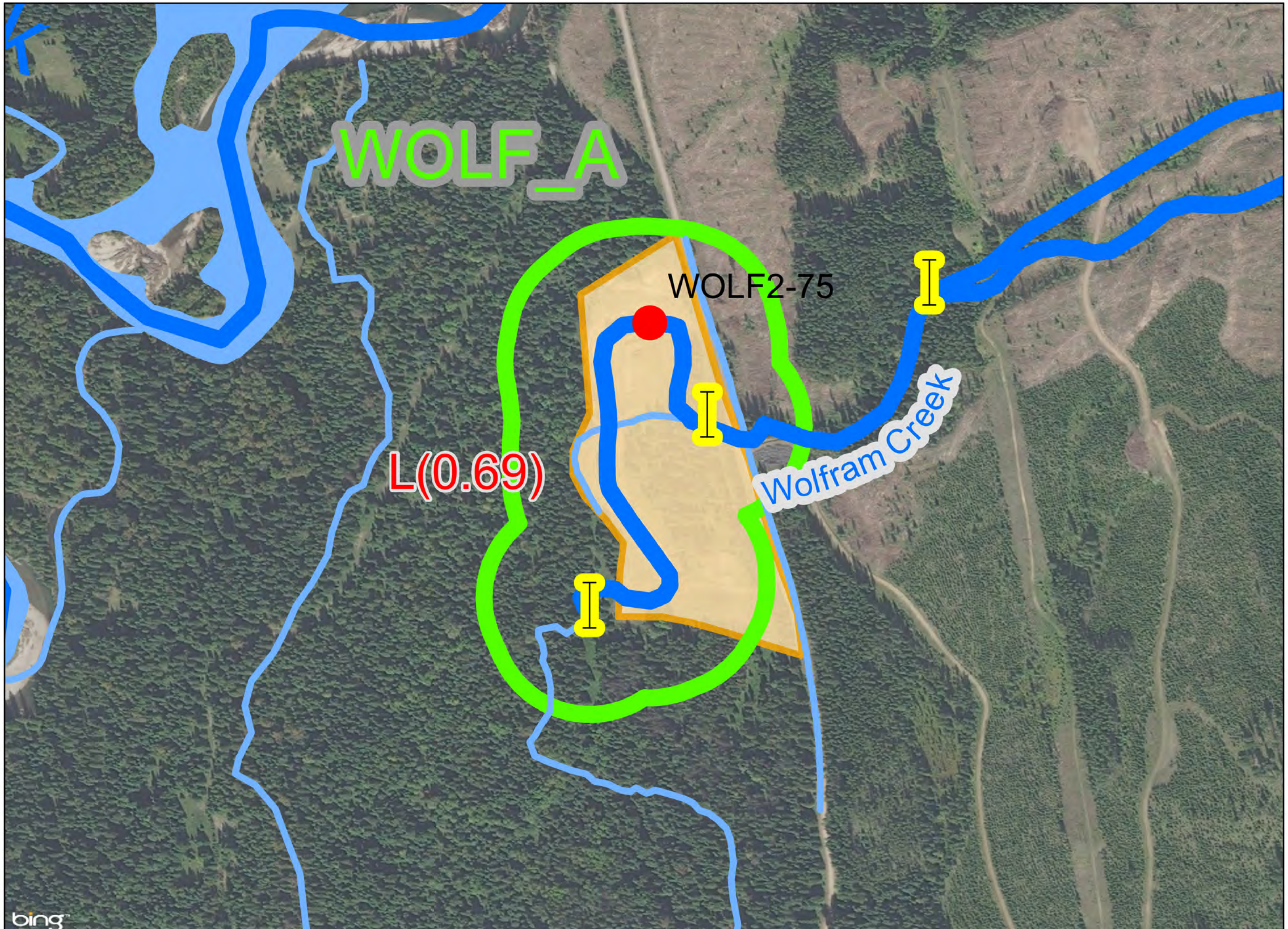
Elk Valley Index Map

Client: Teck

Mapping by: Lotic Environmental

Data Sources:
- Stream / River - Teck Water Network
- Road / Rail - Teck Transportation
- Hillshade - GEOBASE

Date Last Revised: Feb 08, 2017



2016 Calcite Monitoring Program

WOLFRAM - Reach 2

Site Code

Reach Break

Reference Stream

Proposed Stream

Exposed Stream

Stream Segments

Road - Regional

Railway

Teck Coal Operations

Label Examples:

1.50 → Current Calcite Index (with neutral trend)

1.50 → Current Calcite Index (with increasing trend)

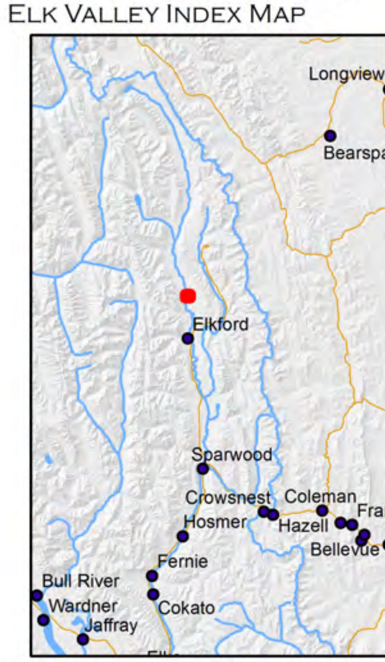
1.50 → Current Calcite Index (with decreasing trend)

0 35 70 140 M

1:4,000

UTM Zone 11 NAD83

Elk Valley Index Map



Client: Teck

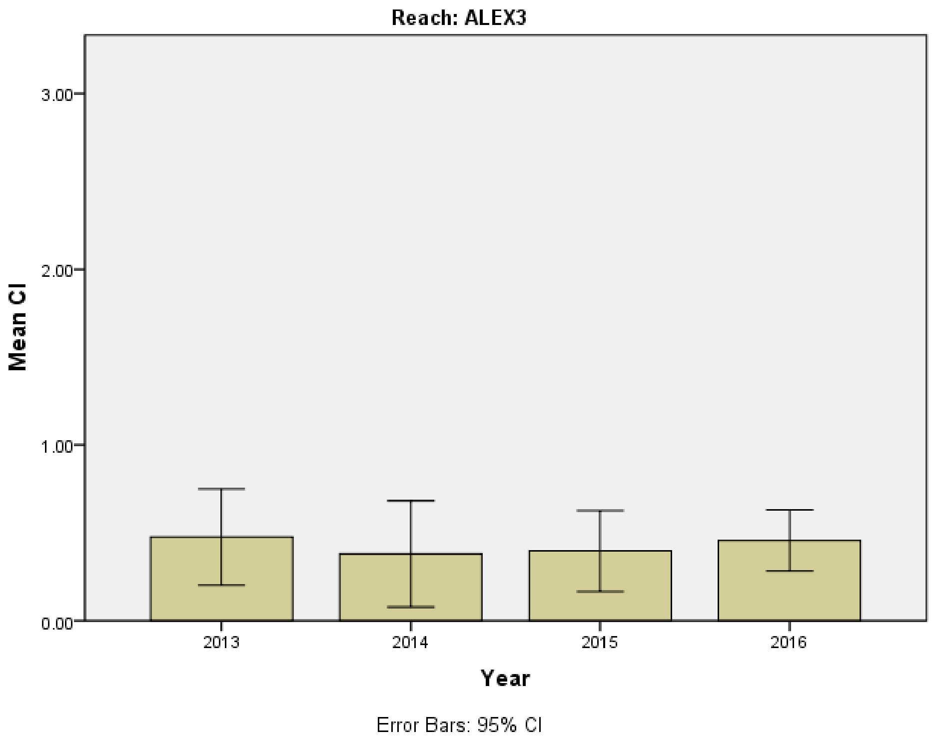
Mapping by: Lotic Environmental

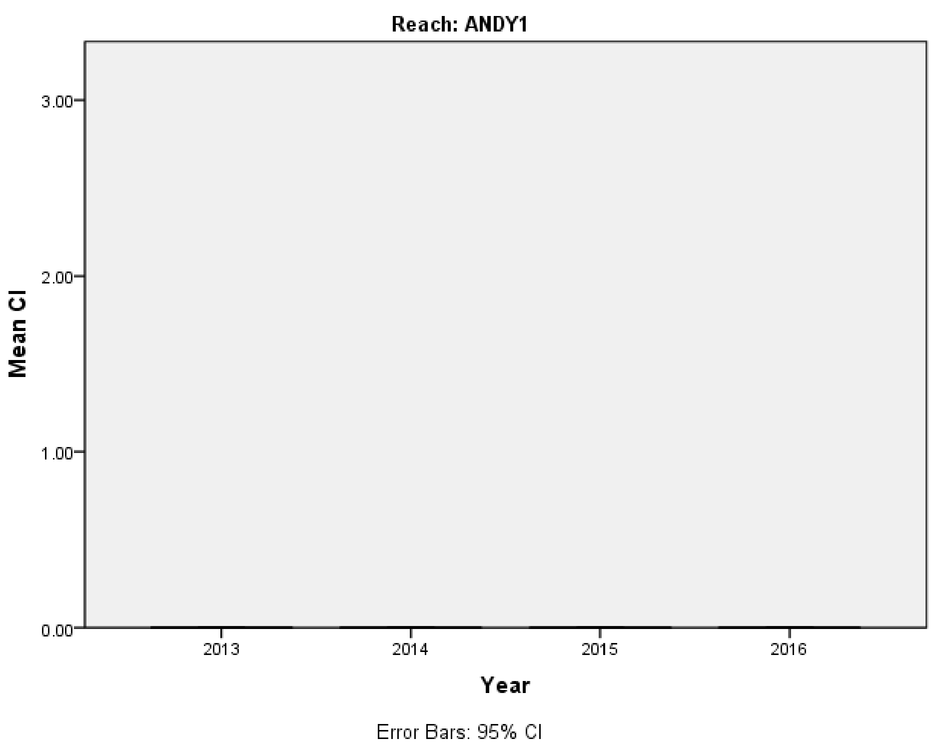
Data Sources:
- Stream / River - Teck Water Network
- Road / Rail - Teck Transportation
- Hillshade - GEOBASE

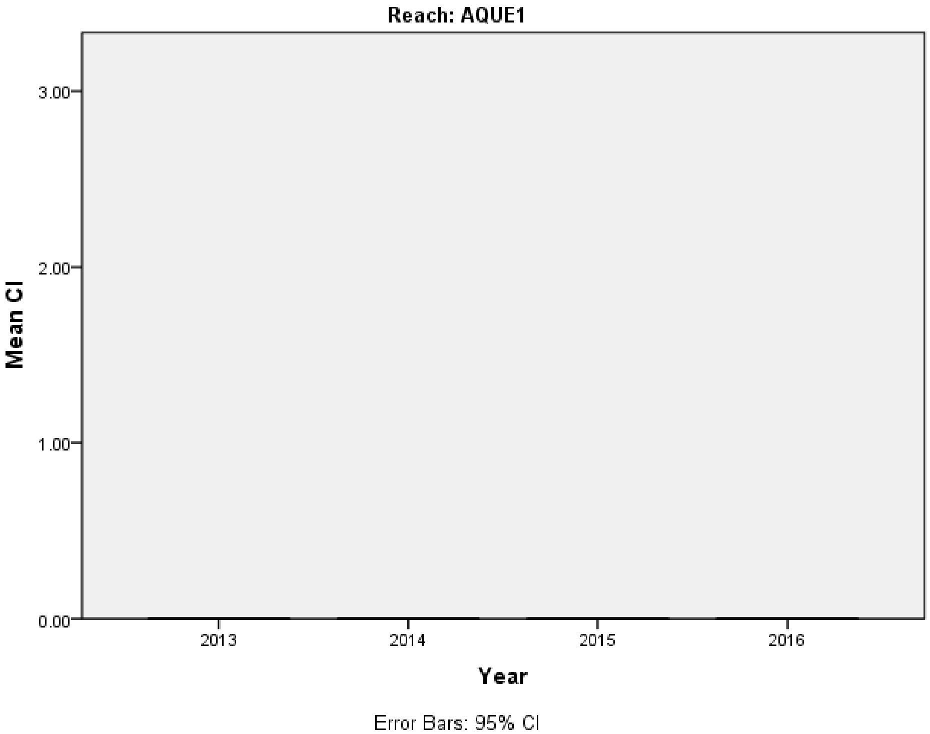
Date Last Revised: Feb 08, 2017

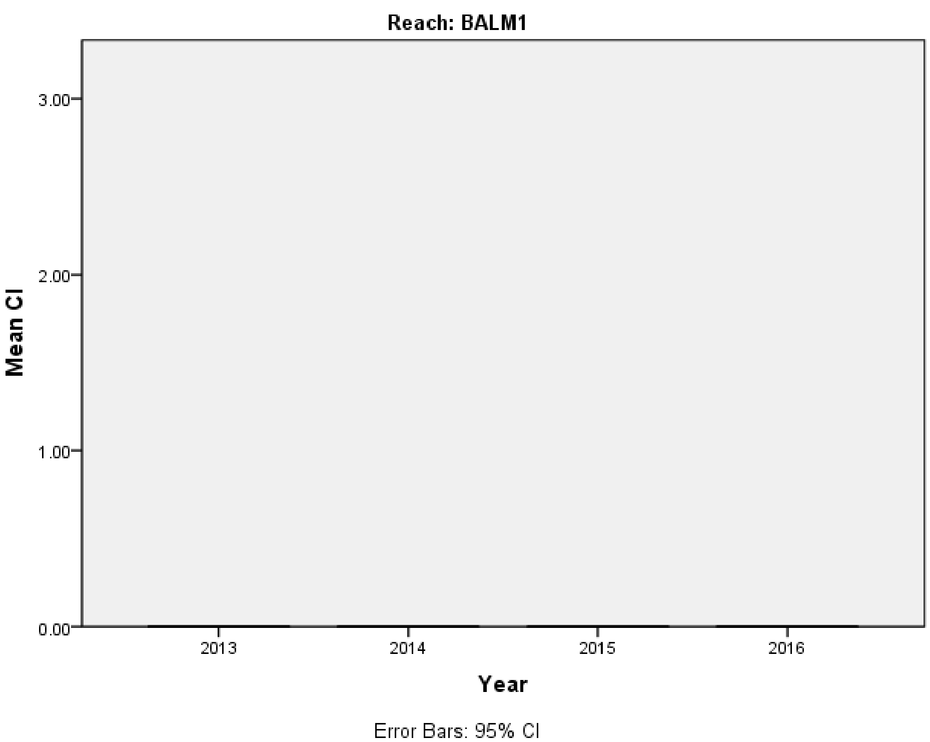
Appendix 6. Bar graphs (with 95% confidence intervals) of reach mean *CI* from 2013 – 2015.

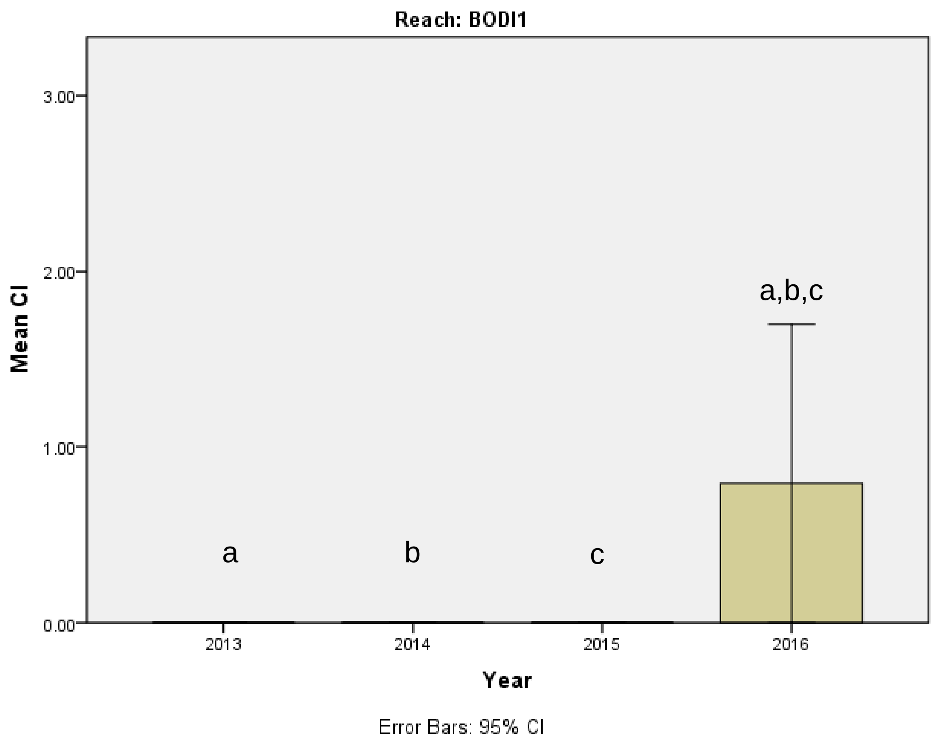
Note: Figures showing mean CI values by year for each reach. Letters above (or within) the bars were used to show the results of the Tukey's *post hoc* tests. Year-year pairs within each figure that were found to be significantly different (at an alpha level of 0.05) are denoted by the same letter.

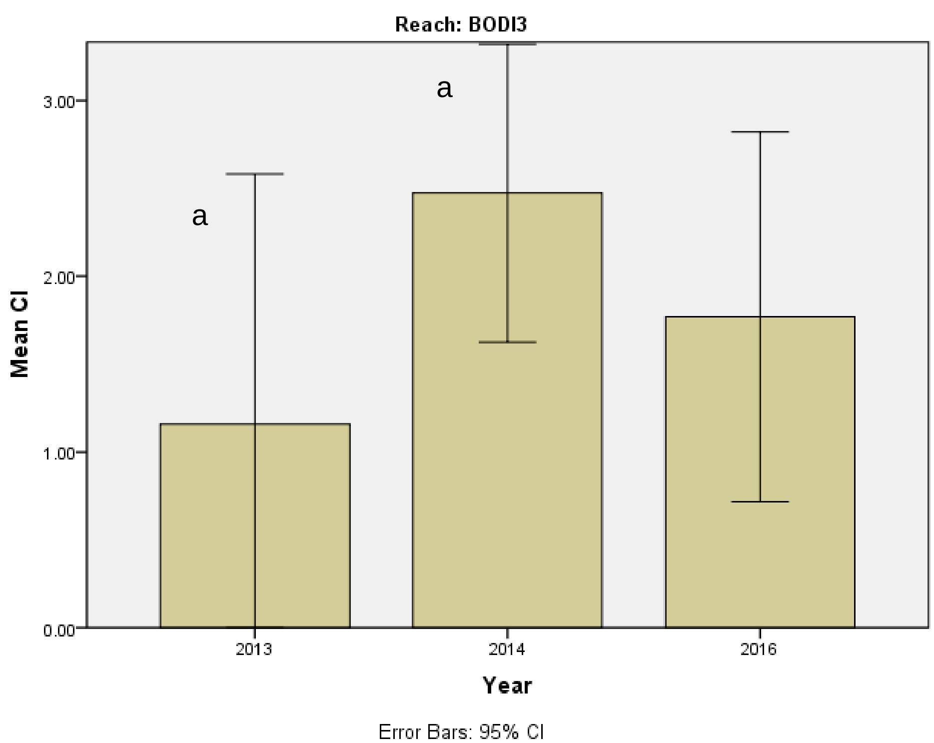

Reach: ALEX3
Mean CI
3.00
2.00
1.00
0.00
2013
2014
2015
2016
Year
Error Bars: 95% CI

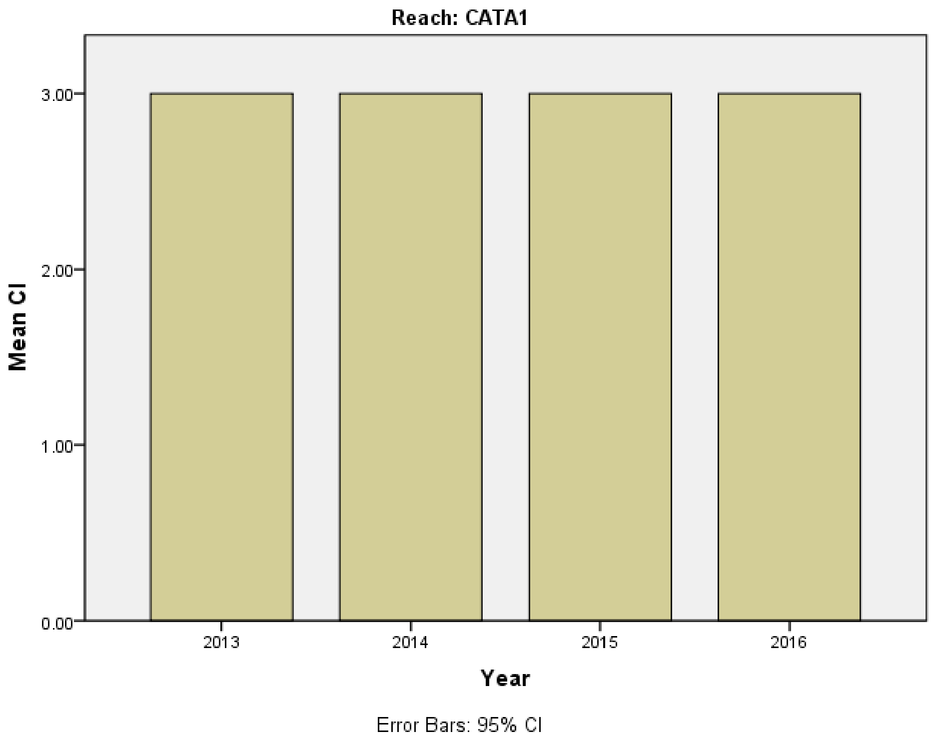

Reach: ANDY1
Mean CI
3.00
2.00
1.00
0.00
2013
2014
2015
2016
Year
Error Bars: 95% CI

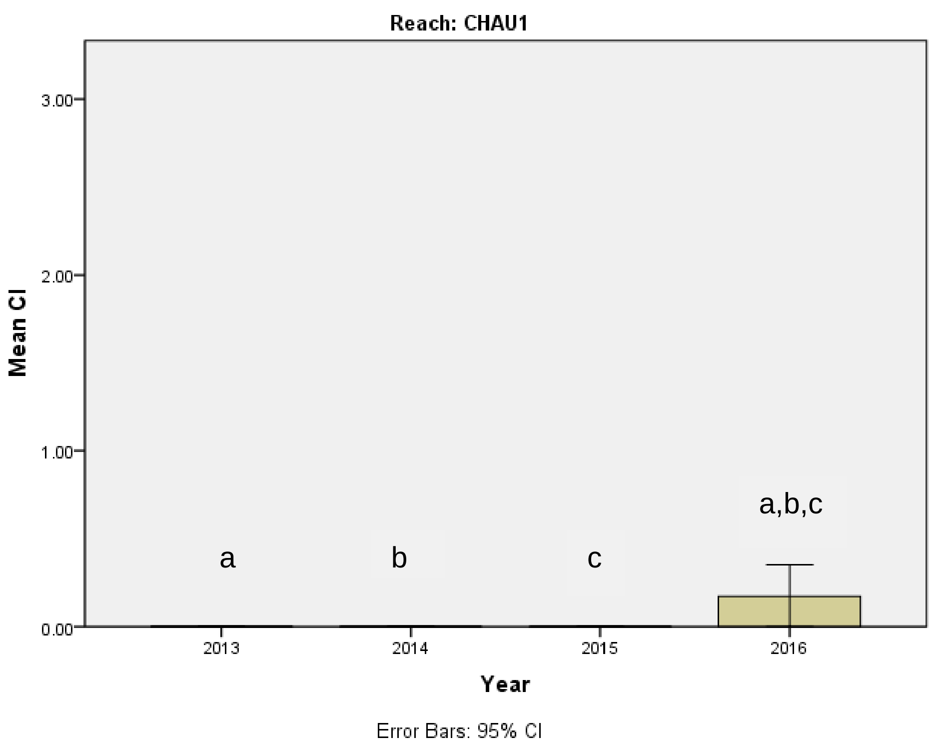

Reach: AQUE1
Mean CI
3.00
2.00
1.00
0.00
2013
2014
2015
2016
Year
Error Bars: 95% CI

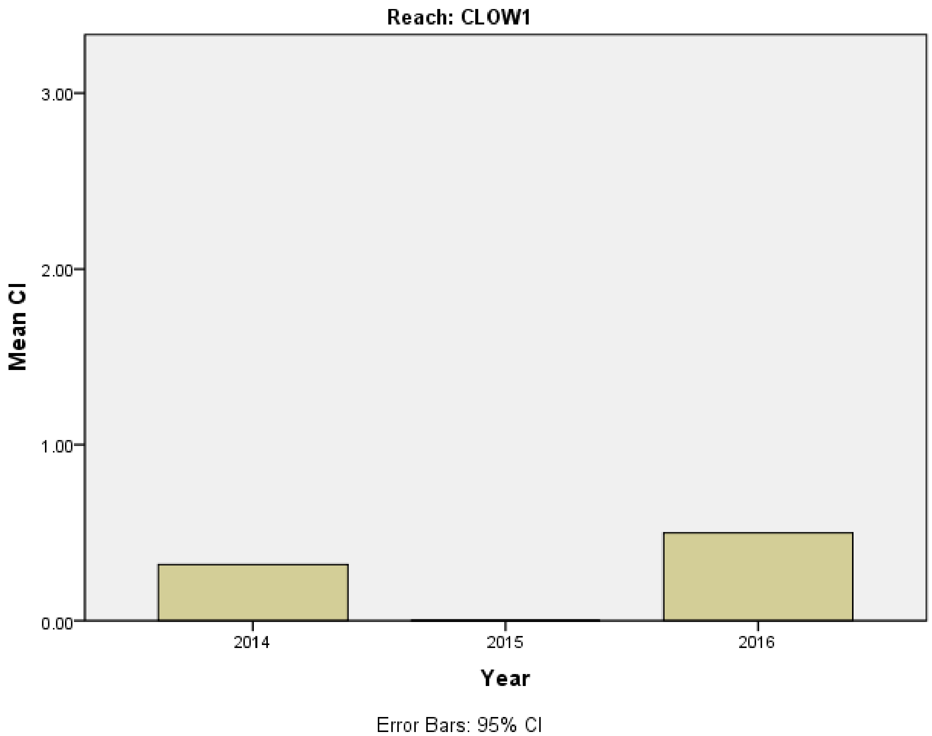

Reach: BALM1
Mean CI
3.00
2.00
1.00
0.00
2013
2014
2015
2016
Year
Error Bars: 95% CI

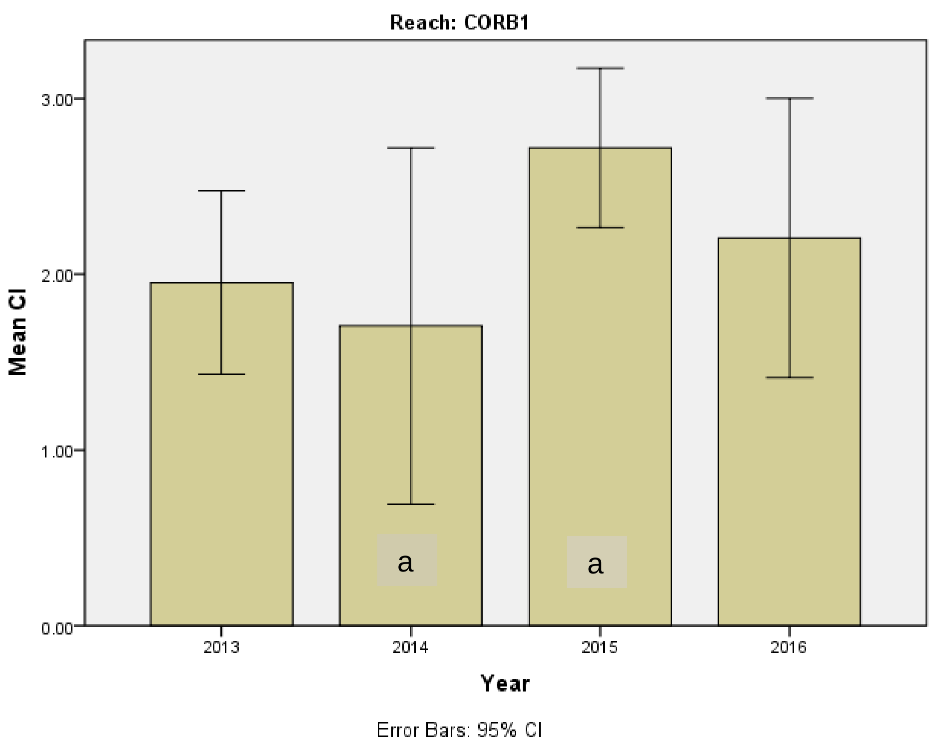

Reach: BODI1
Mean CI
3.00
2.00
1.00
0.00
a,b,c
a
b
c
2013
2014
2015
2016
Year
Error Bars: 95% CI

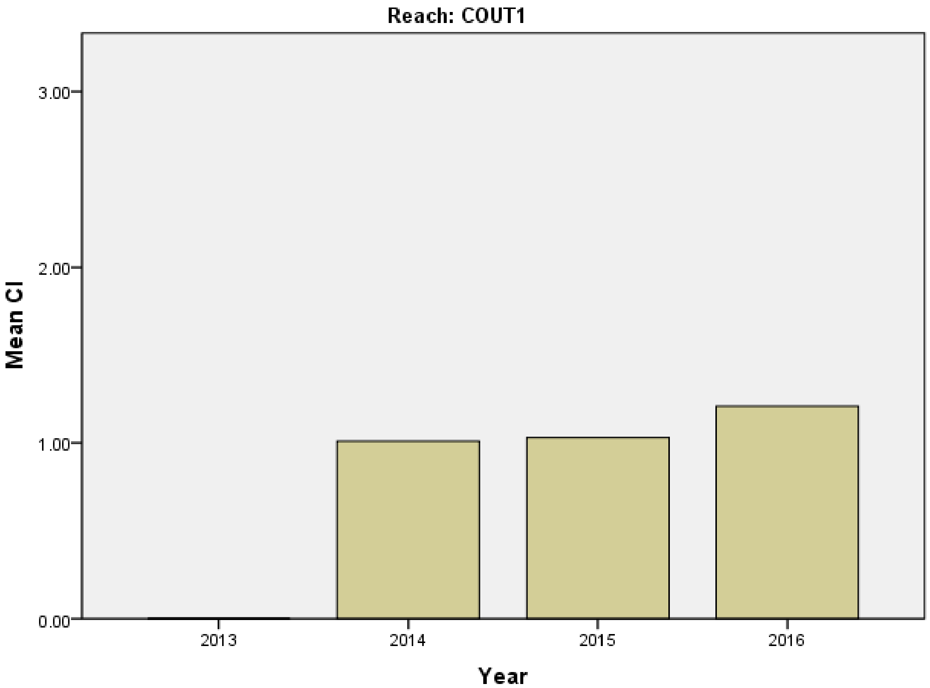

Reach: BODI3
Mean CI
3.00
2.00
1.00
0.00
a
a
2013
2014
2016
Year
Error Bars: 95% CI


Reach: CATA1
3.00
2.00
1.00
0.00
Mean CI
2013
2014
2015
2016
Year
Error Bars: 95% CI

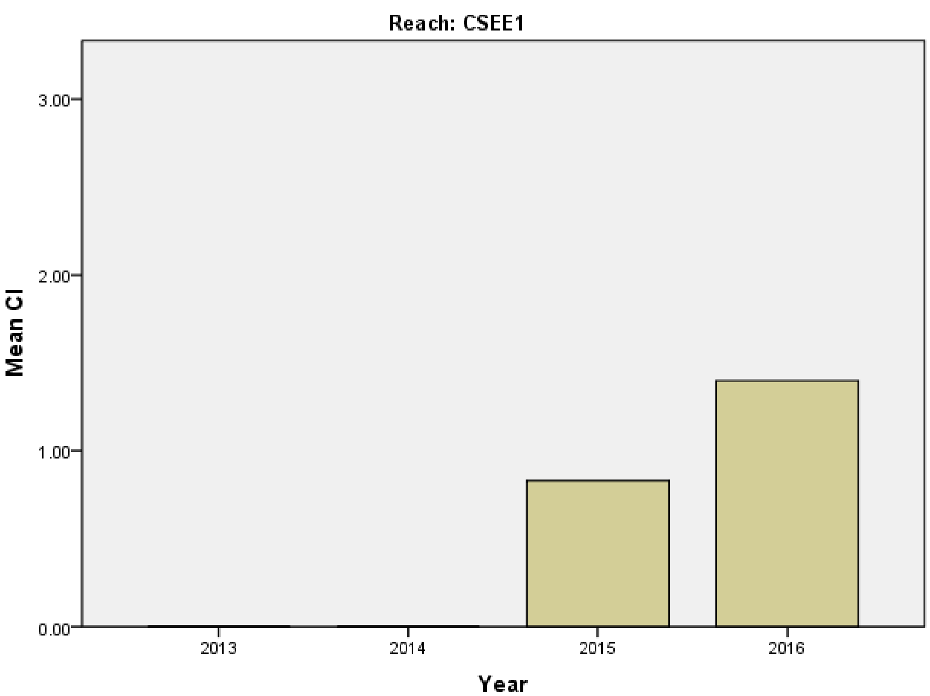

Reach: CHAU1
3.00
2.00
1.00
0.00
Mean CI
a
b
c
a,b,c
2013
2014
2015
2016
Year
Error Bars: 95% CI


Reach: CLOW1
Mean CI
3.00
2.00
1.00
0.00
2014
2015
2016
Year
Error Bars: 95% CI

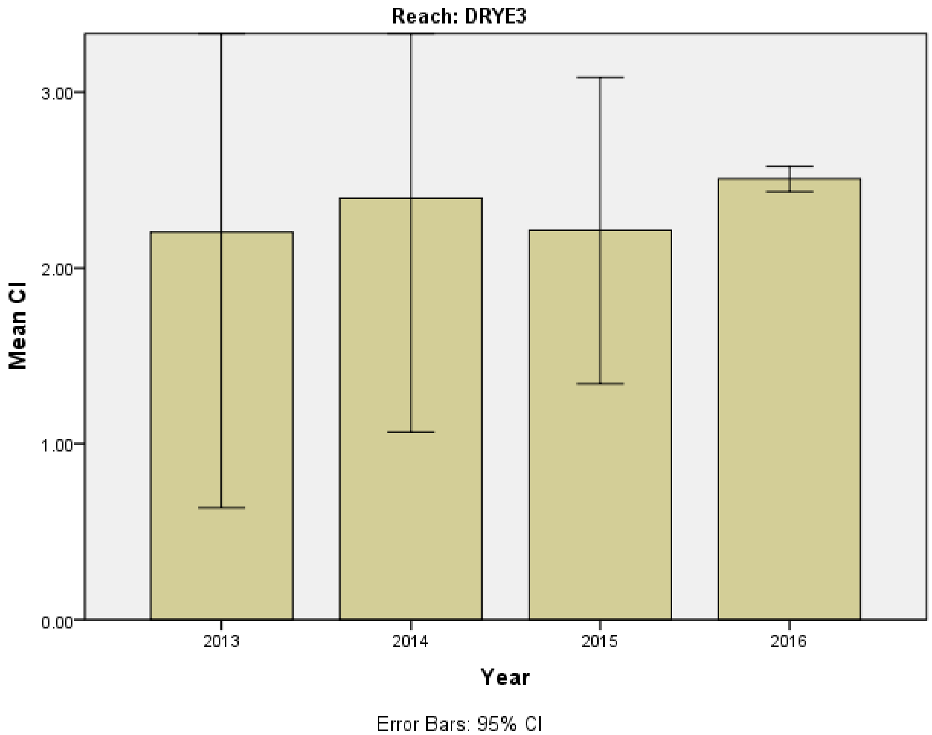

Reach: CORB1
Mean CI
3.00
2.00
1.00
0.00
a
a
2013
2014
2015
2016
Year
Error Bars: 95% CI

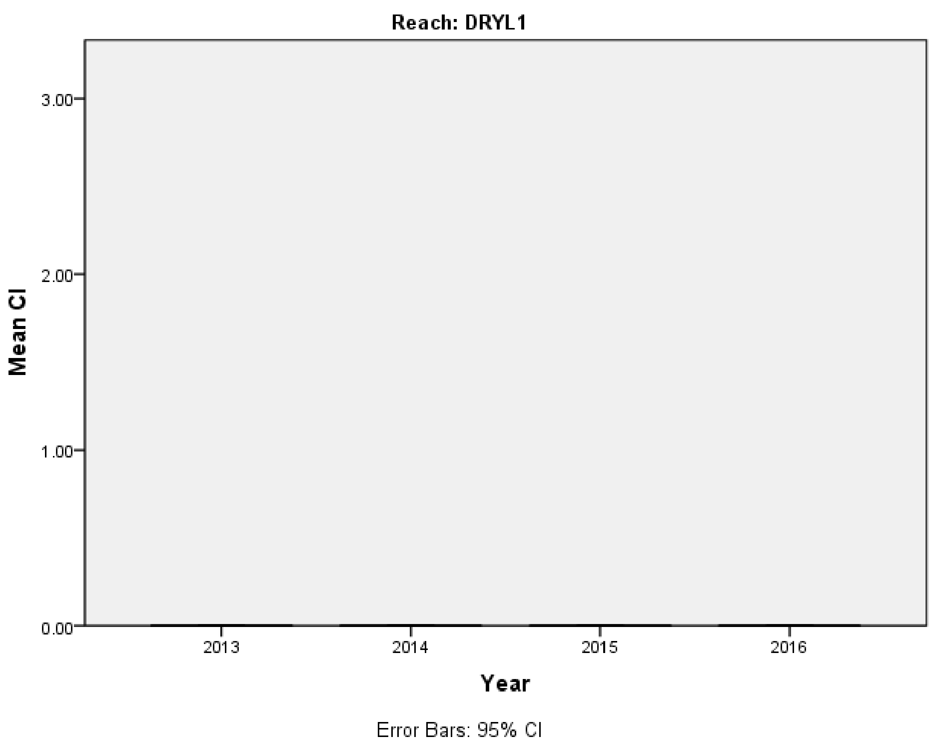


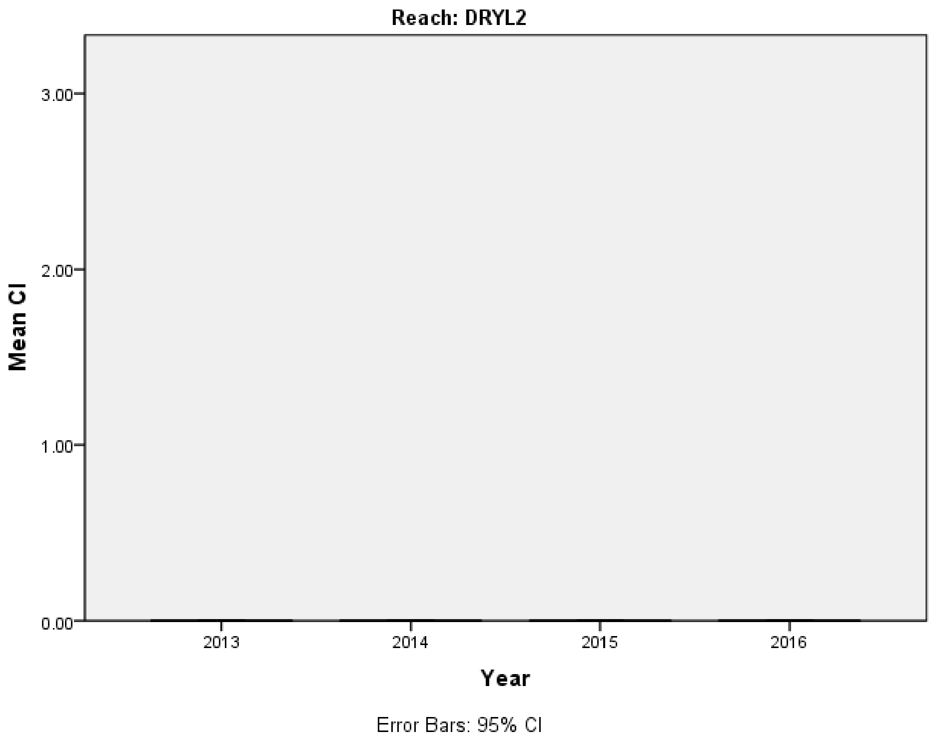
Error Bars: 95% CI

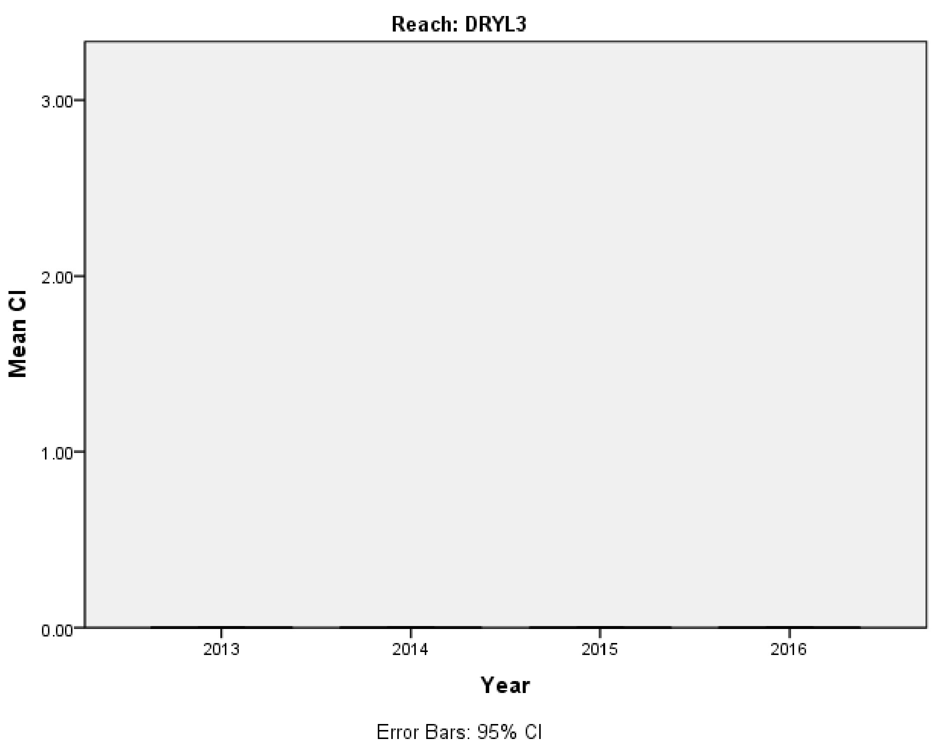


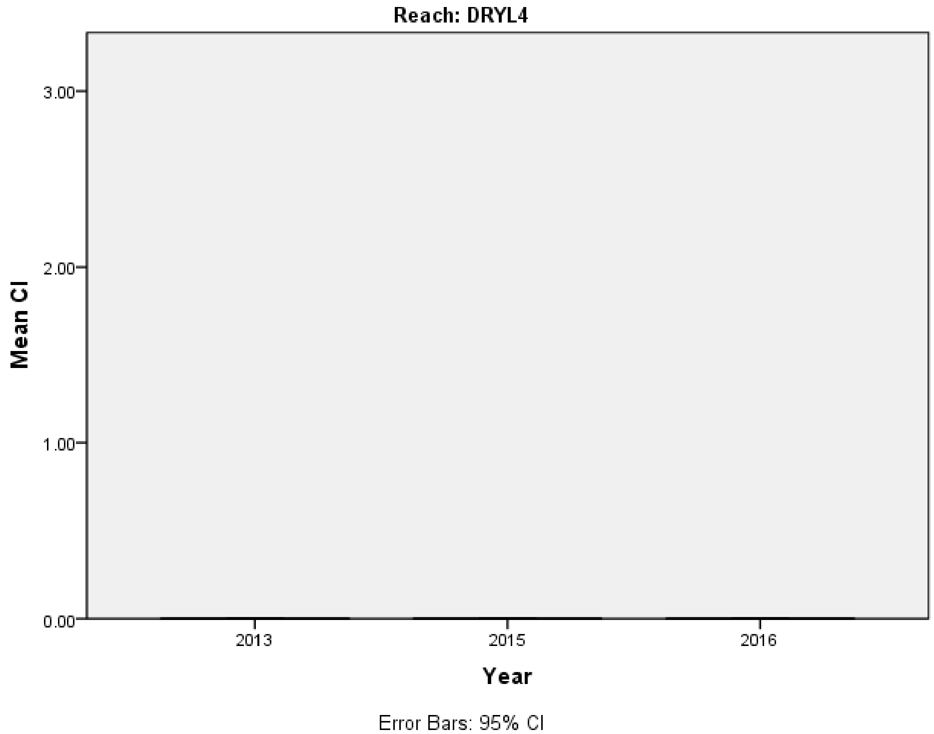
Error Bars: 95% CI

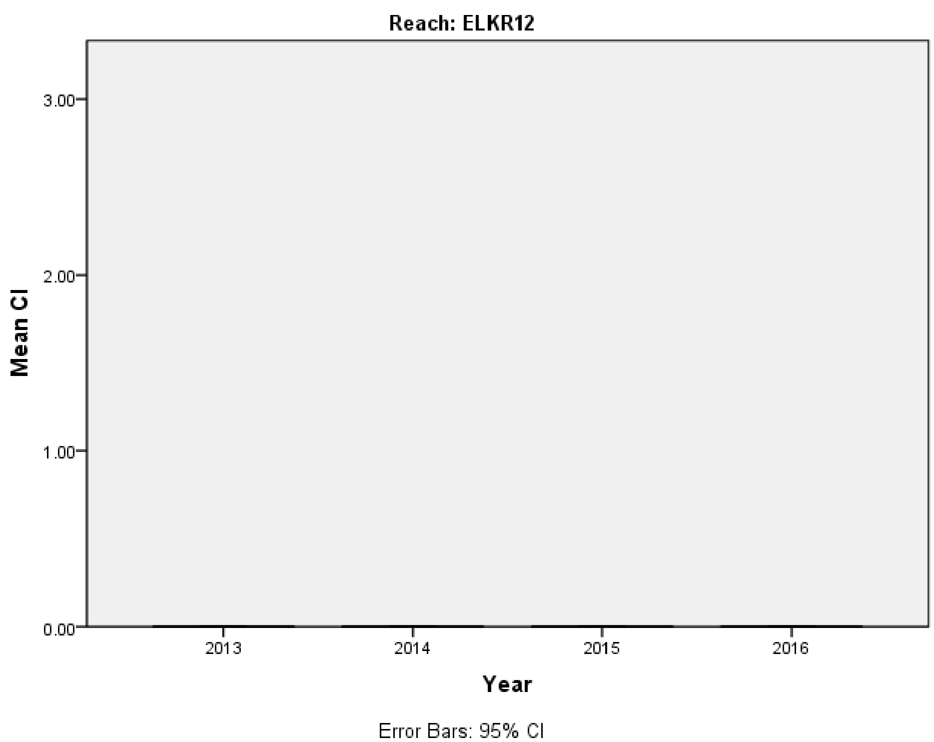

Reach: DRYE3
Mean CI
3.00
2.00
1.00
0.00
2013
2014
2015
2016
Year
Error Bars: 95% CI

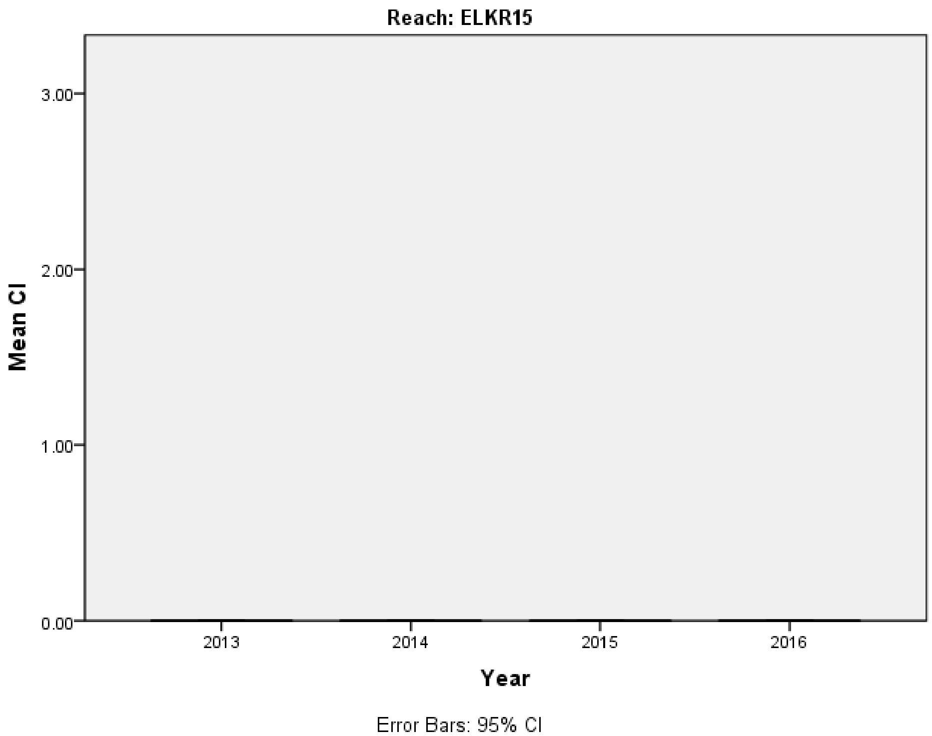

Reach: DRYL1
Mean CI
3.00
2.00
1.00
0.00
2013
2014
2015
2016
Year
Error Bars: 95% CI

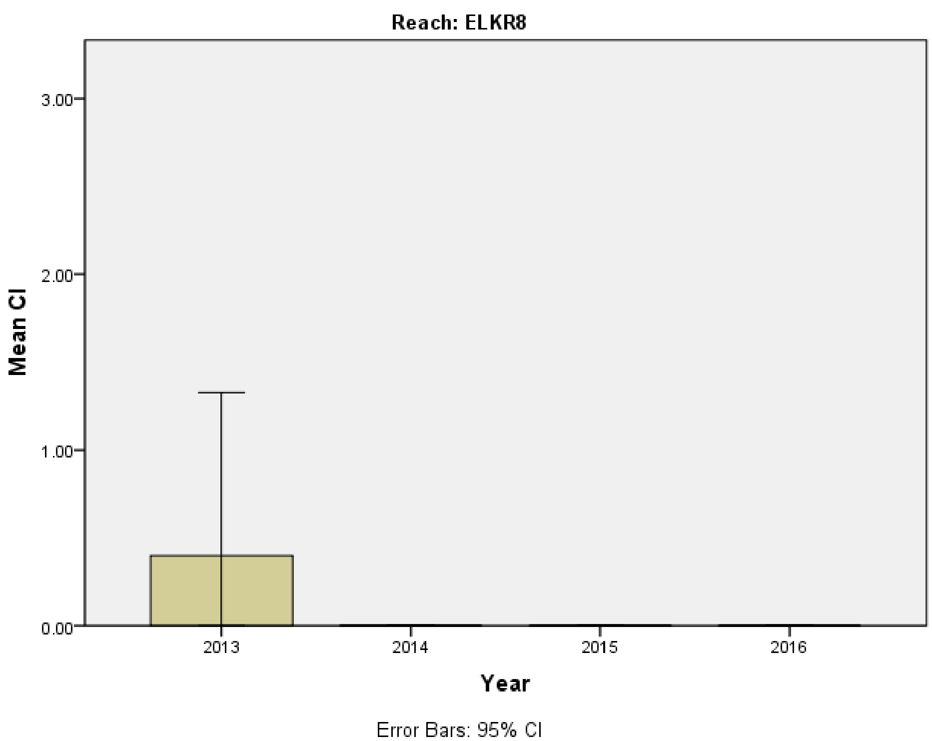

Reach: DRYL2
Mean CI
3.00
2.00
1.00
0.00
2013
2014
2015
2016
Year
Error Bars: 95% CI

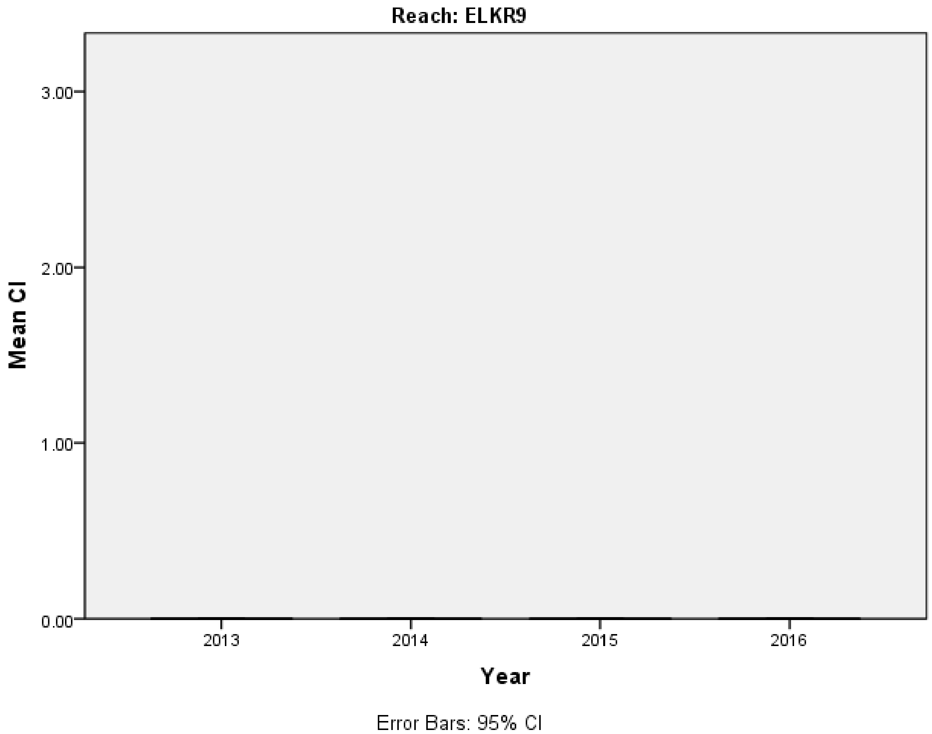

Reach: DRYL3
Mean CI
3.00
2.00
1.00
0.00
2013
2014
2015
2016
Year
Error Bars: 95% CI

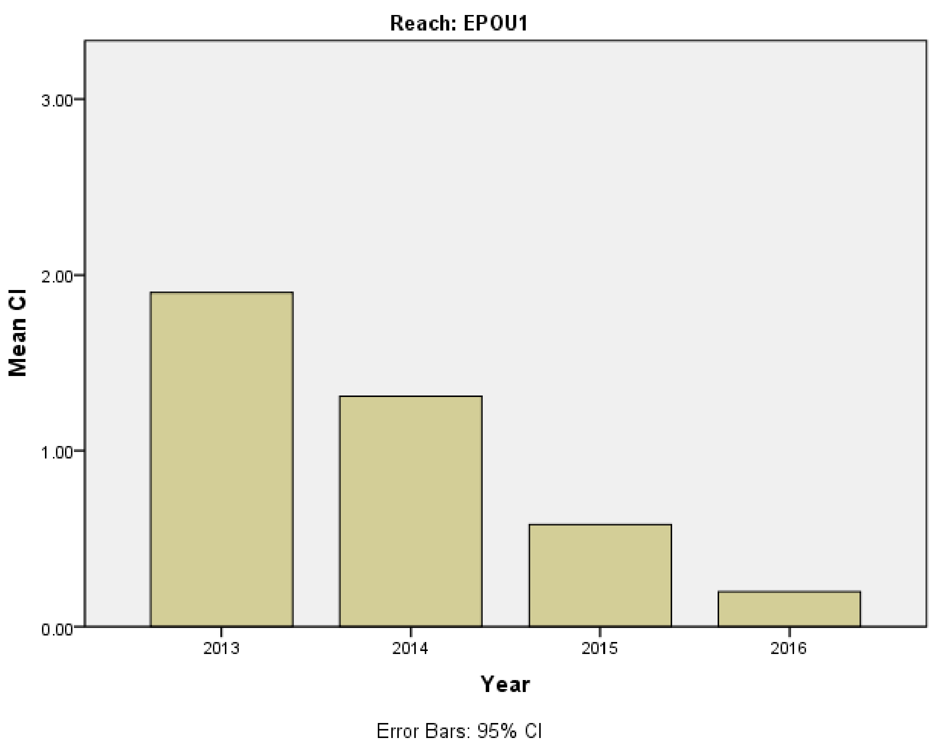

Reach: DRYL4
Mean CI
3.00
2.00
1.00
0.00
2013
2015
2016
Year
Error Bars: 95% CI

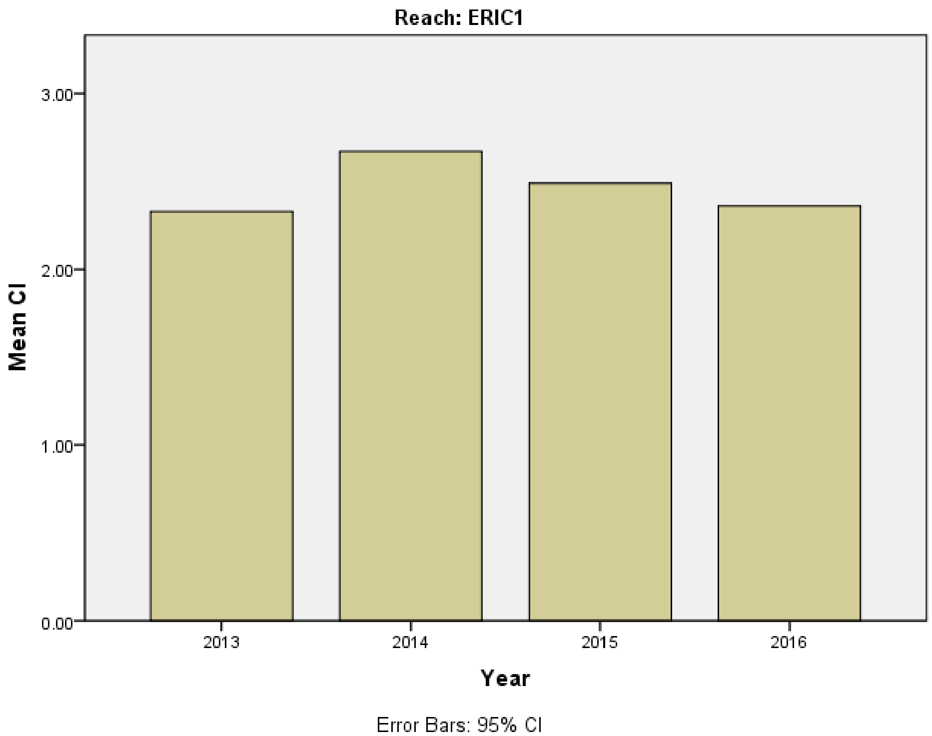

Reach: ELKR12
Mean CI
3.00
2.00
1.00
0.00
2013
2014
2015
2016
Year
Error Bars: 95% CI

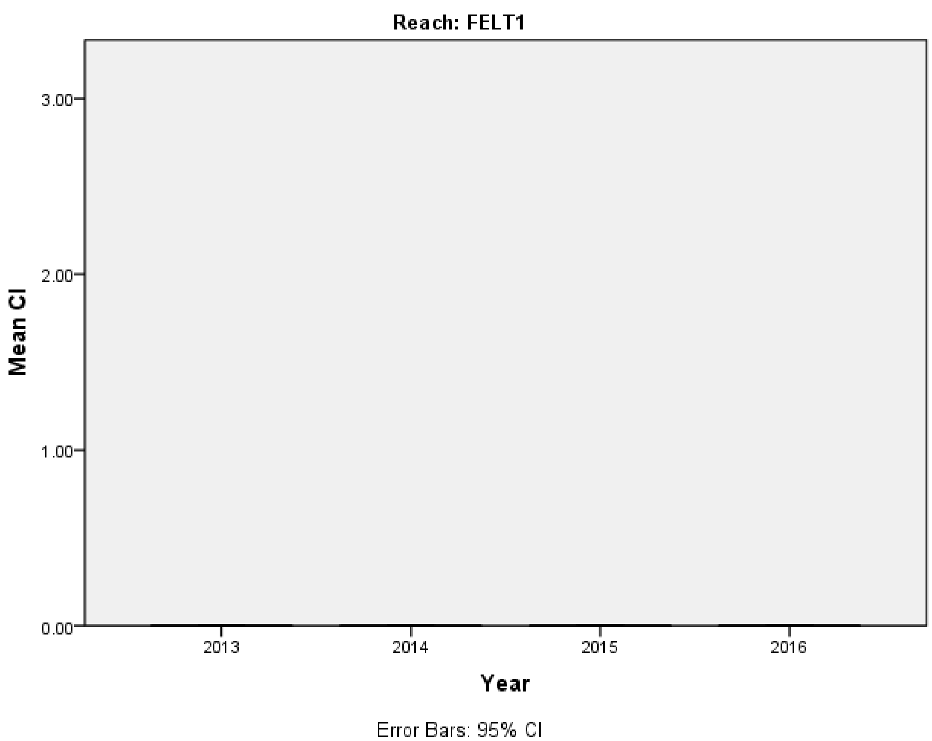

Reach: ELKR15
3.00
2.00
1.00
0.00
Mean CI
2013
2014
2015
2016
Year
Error Bars: 95% CI

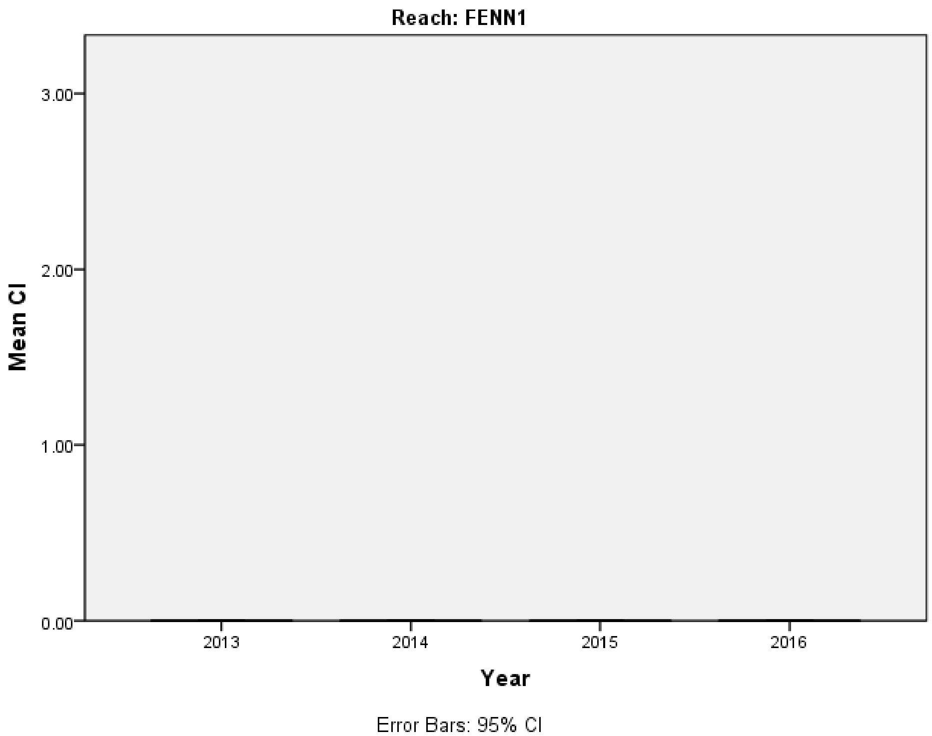

Reach: ELKR8
3.00
2.00
1.00
0.00
Mean CI
2013
2014
2015
2016
Year
Error Bars: 95% CI

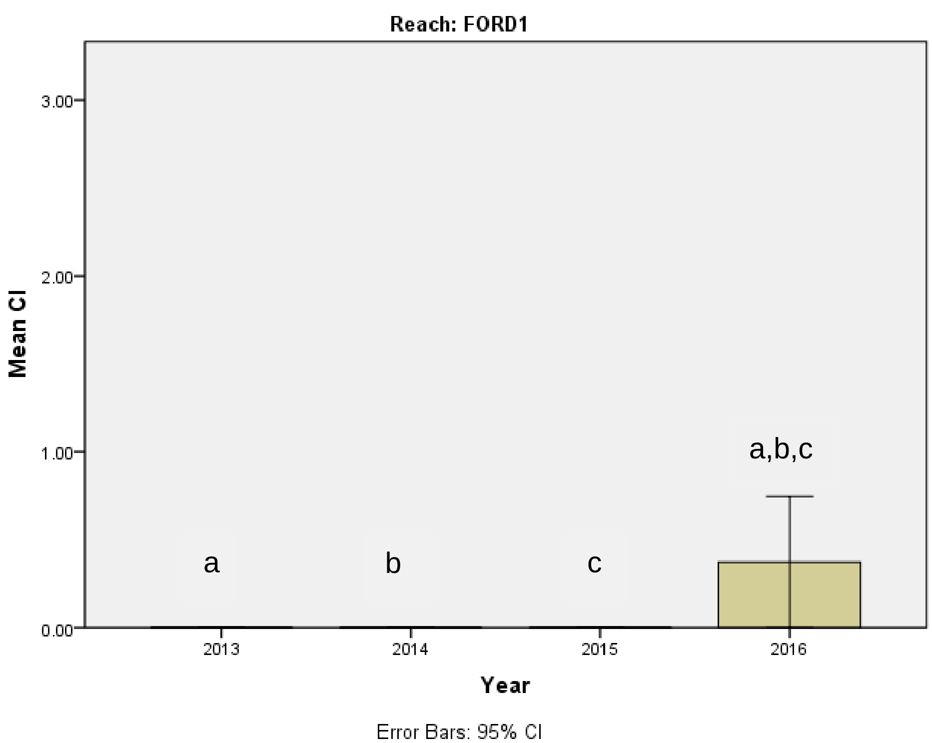

Reach: ELKR9
Mean CI
3.00
2.00
1.00
0.00
2013
2014
2015
2016
Year
Error Bars: 95% CI


Reach: EPOU1
Mean CI
3.00
2.00
1.00
0.00
2013
2014
2015
2016
Year
Error Bars: 95% CI

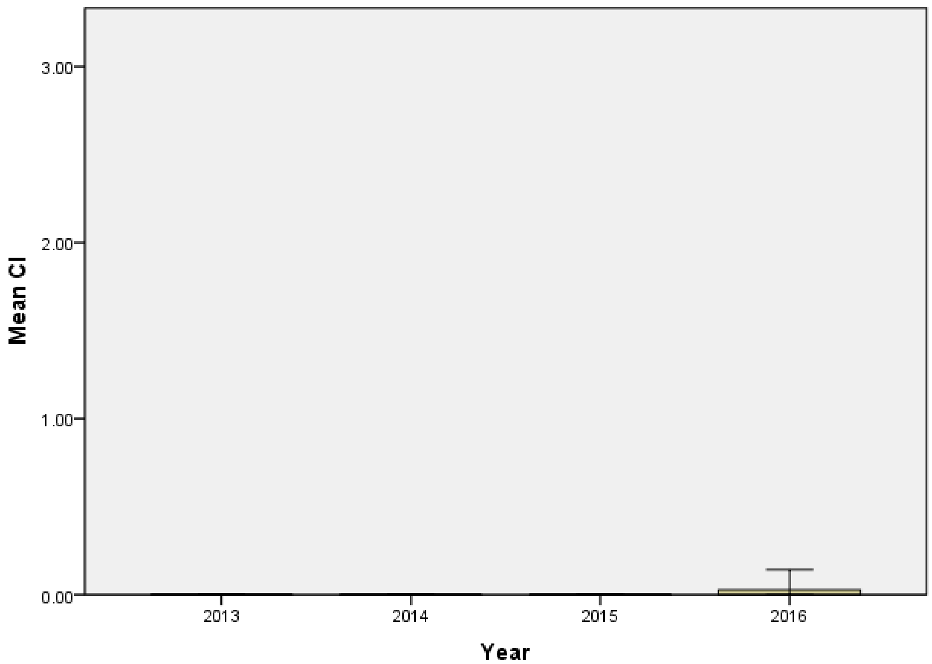

Reach: ERIC1
3.00
2.00
1.00
0.00
Mean CI
2013
2014
2015
2016
Year
Error Bars: 95% CI


Reach: FELT1
3.00
2.00
1.00
0.00
Mean CI
2013
2014
2015
2016
Year
Error Bars: 95% CI


Reach: FENN1
Mean CI
3.00
2.00
1.00
0.00
2013
2014
2015
2016
Year
Error Bars: 95% CI

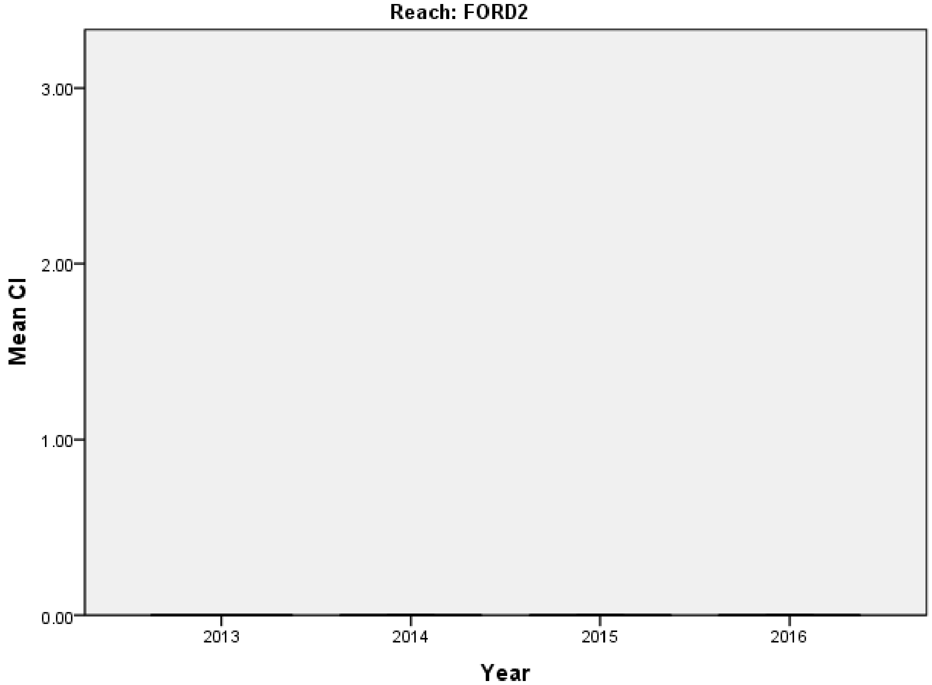

Reach: FORD1
Mean CI
3.00
2.00
1.00
0.00
a
b
c
a,b,c
2013
2014
2015
2016
Year
Error Bars: 95% CI

Reach: FORD12

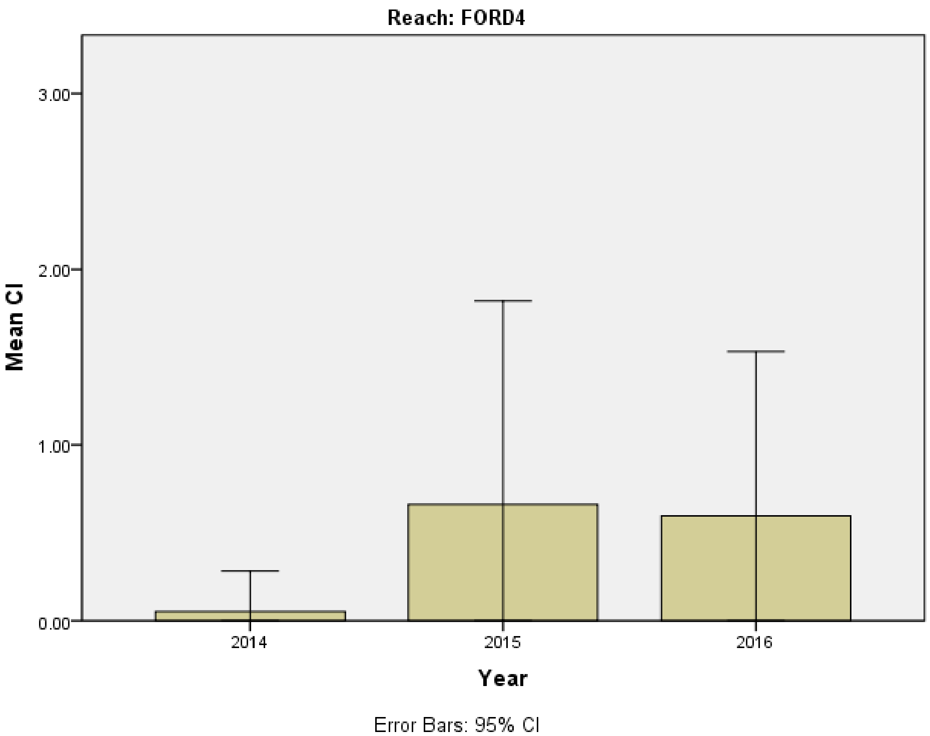


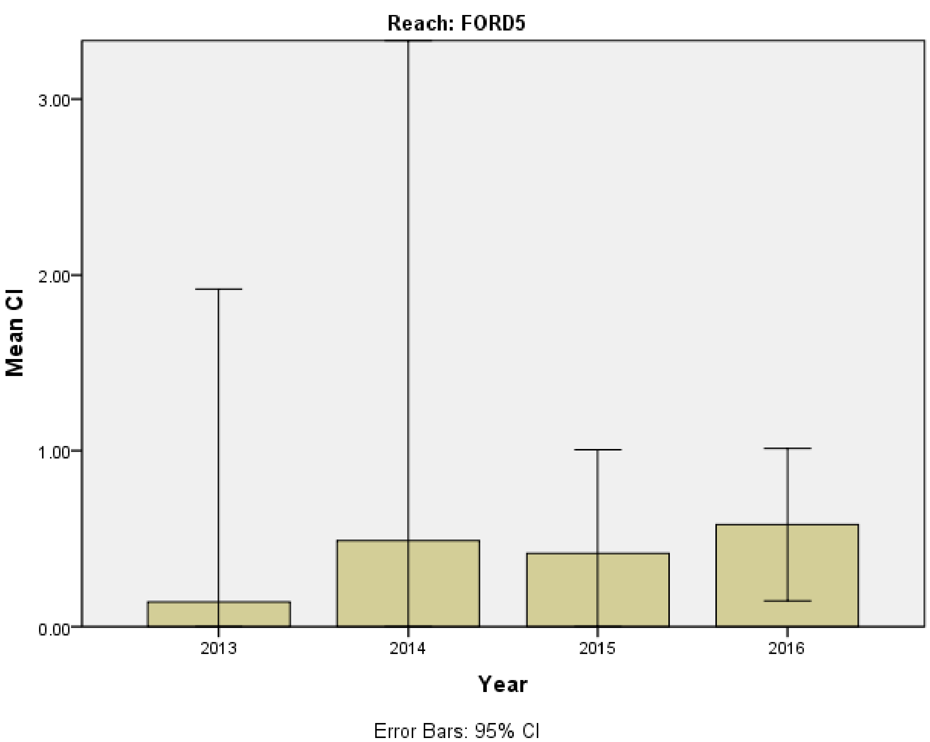
Error Bars: 95% CI

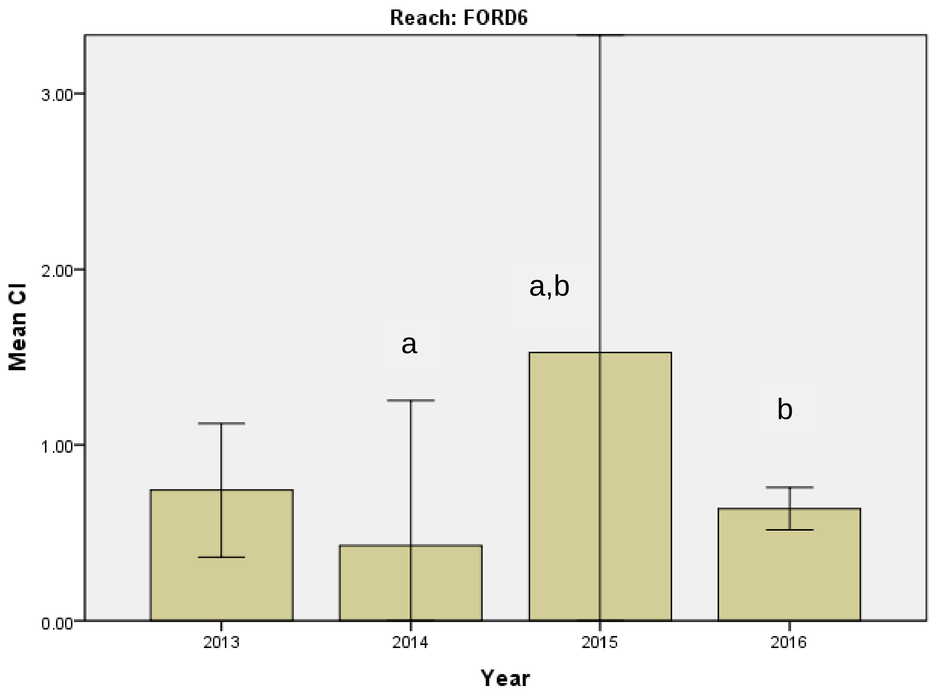
Reach: FORD2



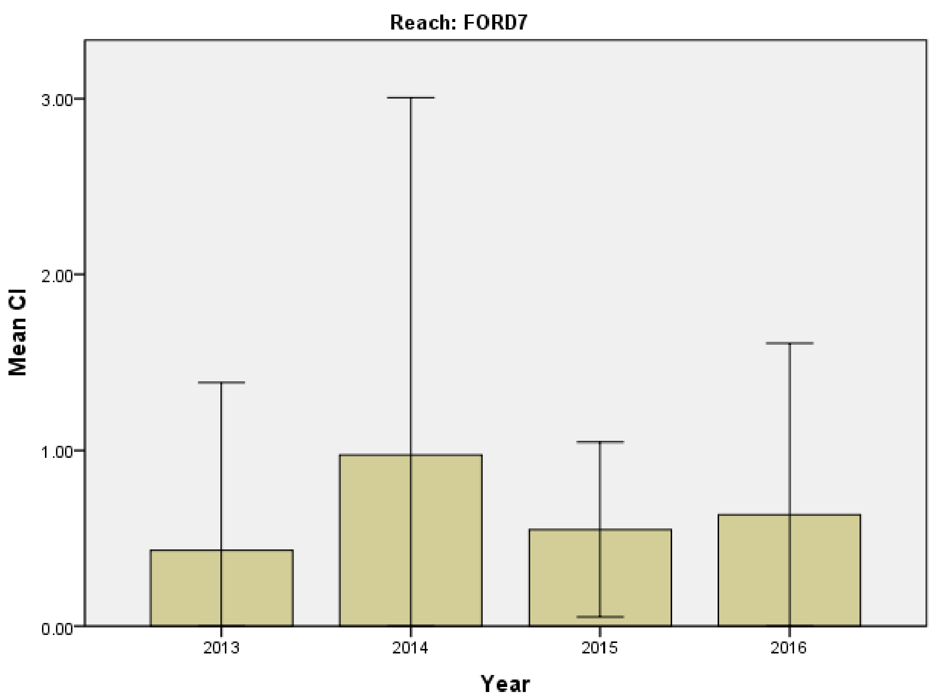
Error Bars: 95% CI


Reach: FORD4
3.00
2.00
1.00
0.00
Mean CI
2014
2015
2016
Year
Error Bars: 95% CI

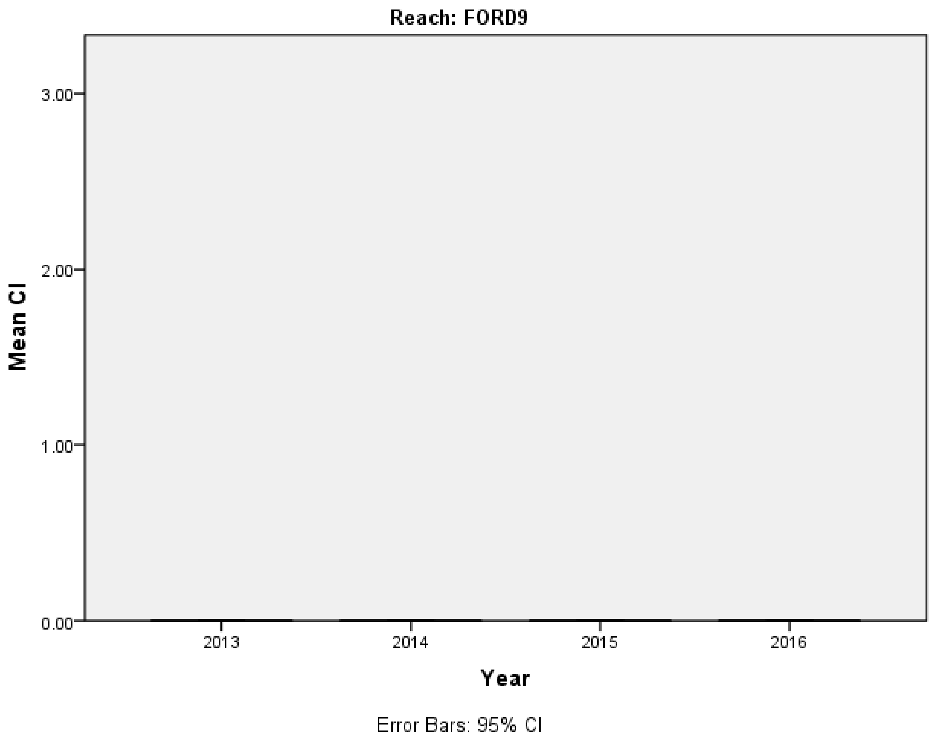

Reach: FORD5
3.00
2.00
1.00
0.00
Mean CI
2013
2014
2015
2016
Year
Error Bars: 95% CI

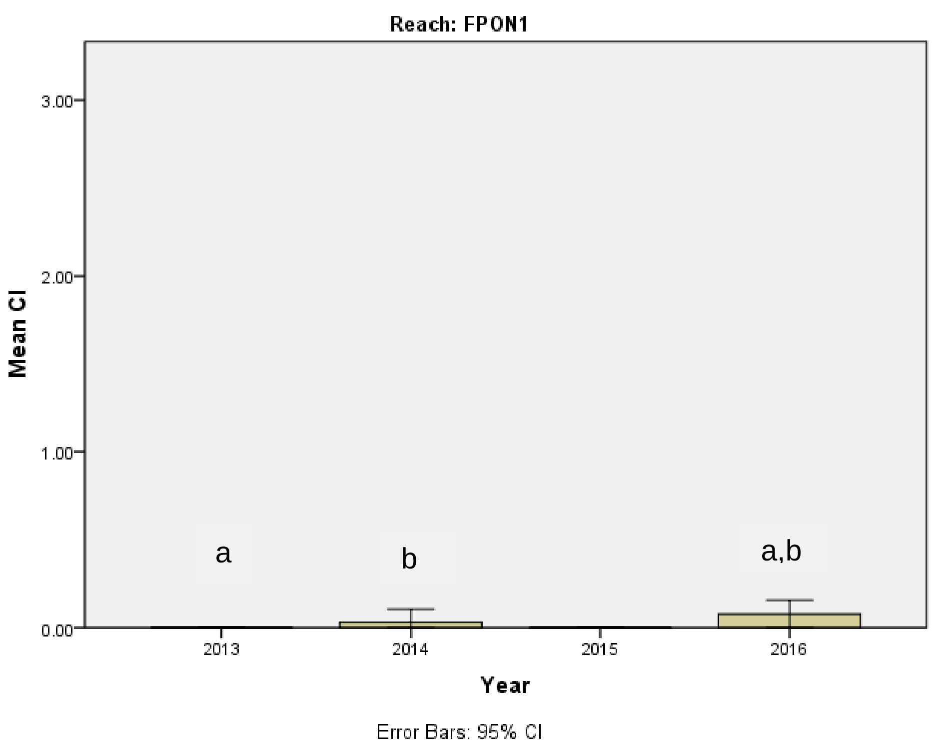


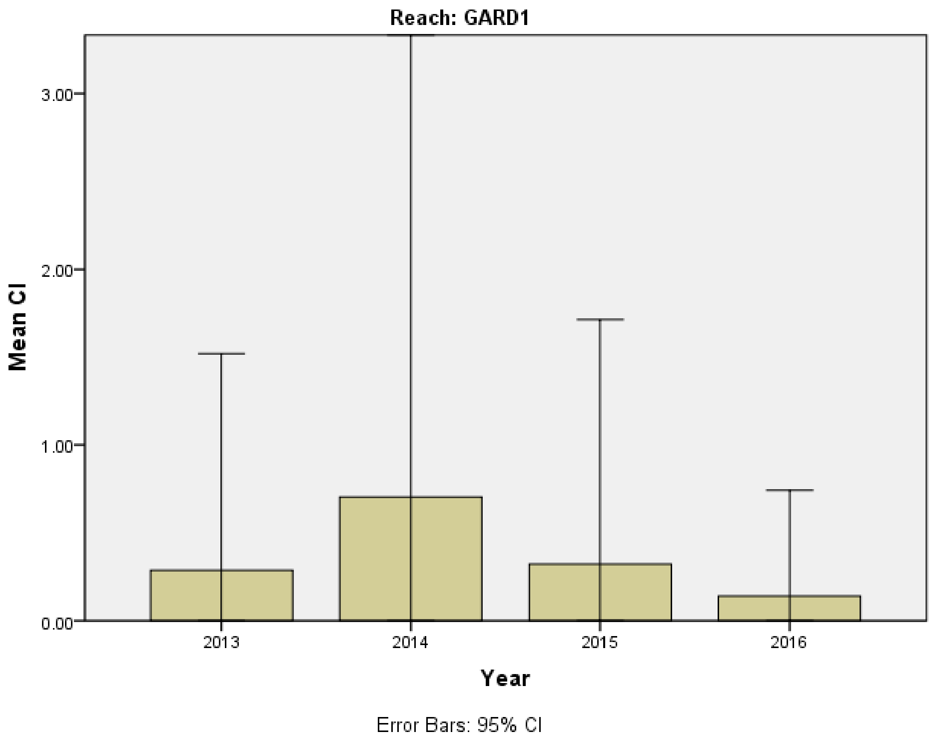
Error Bars: 95% CI

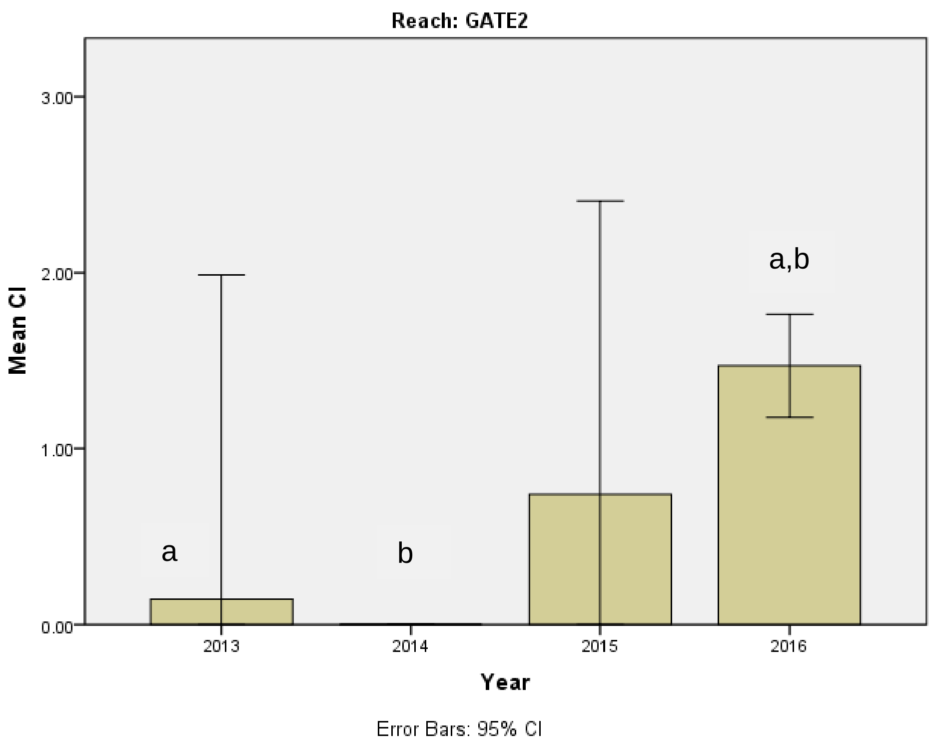


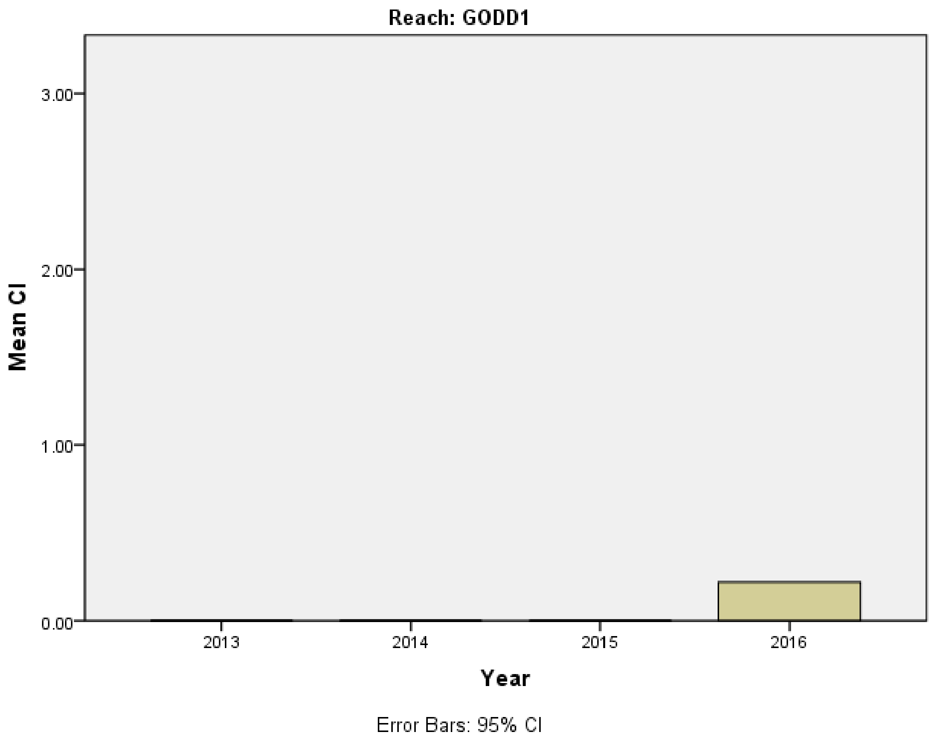
Error Bars: 95% CI

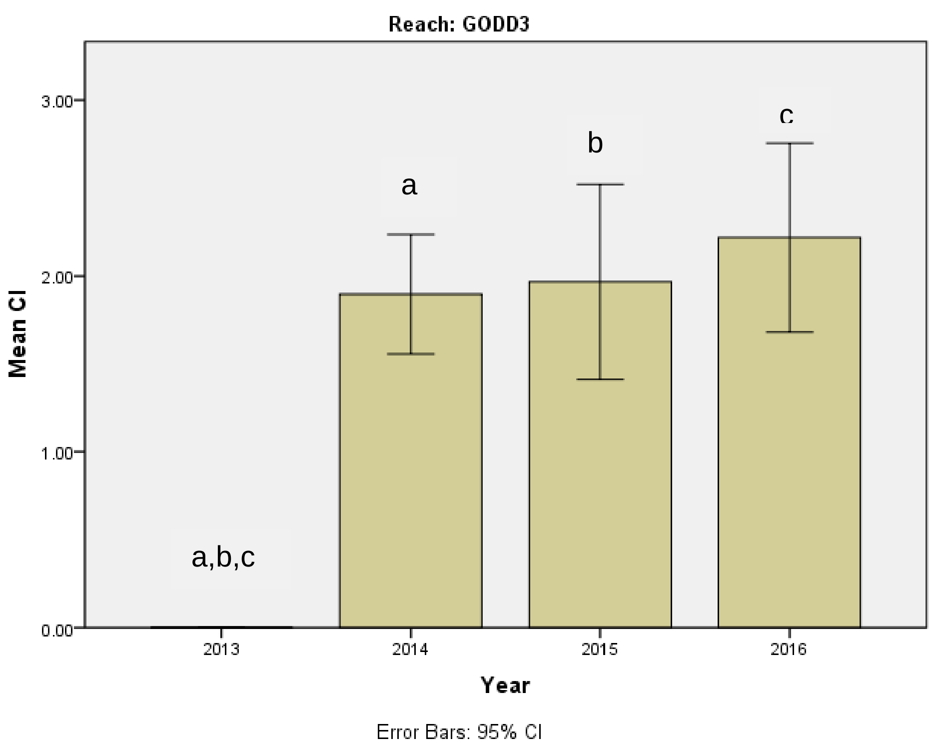

Reach: FORD9
Mean CI
3.00
2.00
1.00
0.00
2013
2014
2015
2016
Year
Error Bars: 95% CI

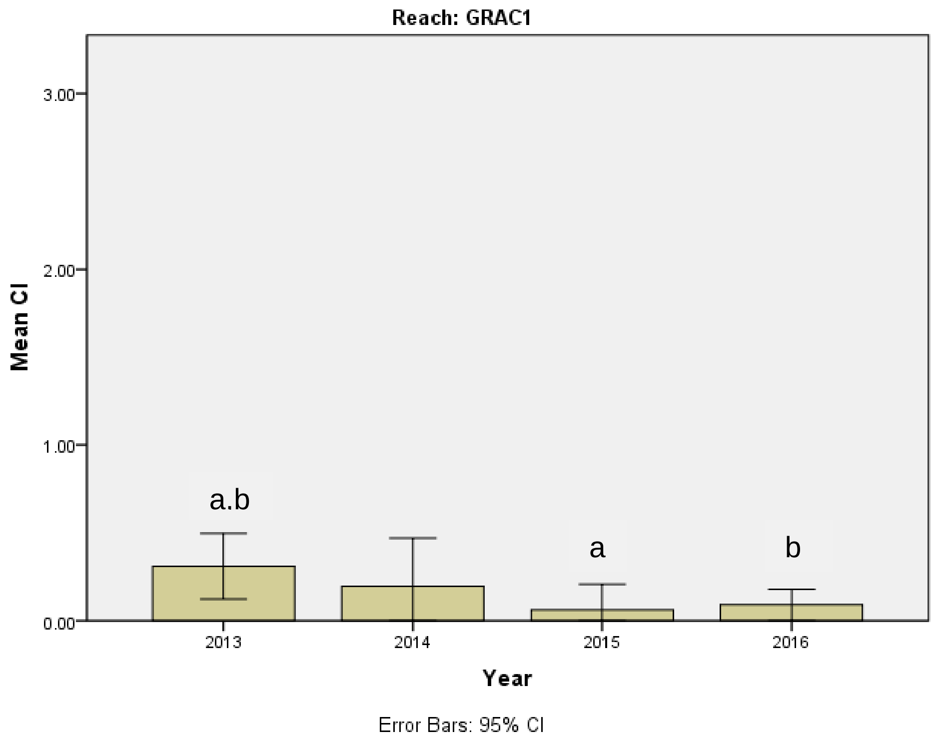

Reach: FPON1
Mean CI
3.00
2.00
1.00
0.00
a
b
a,b
2013
2014
2015
2016
Year
Error Bars: 95% CI

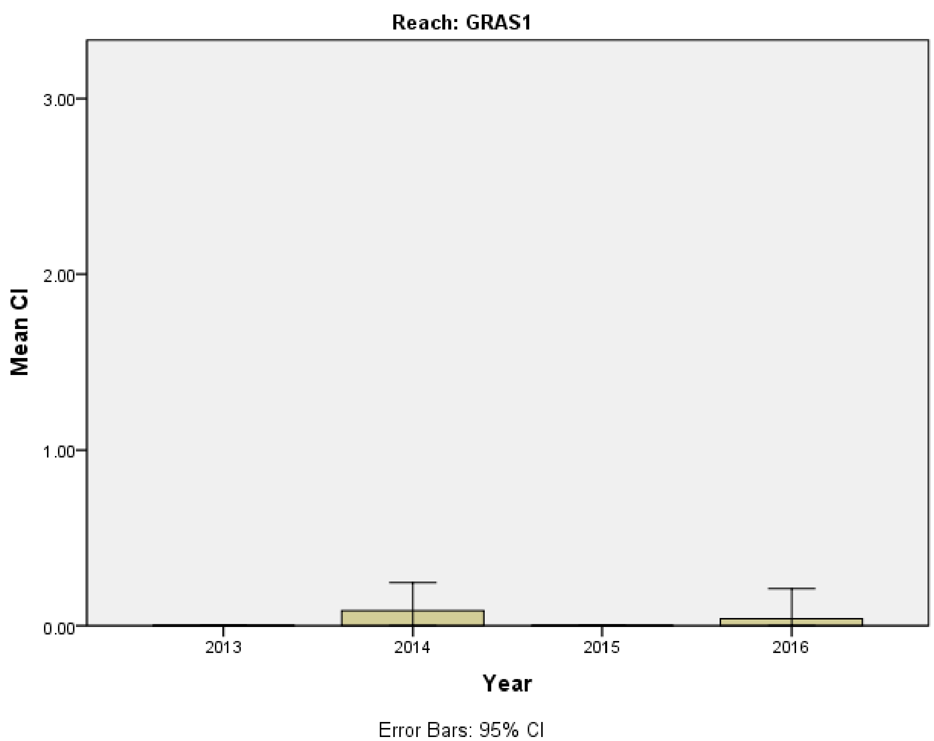

Reach: GARD1
Mean CI
3.00
2.00
1.00
0.00
2013
2014
2015
2016
Year
Error Bars: 95% CI

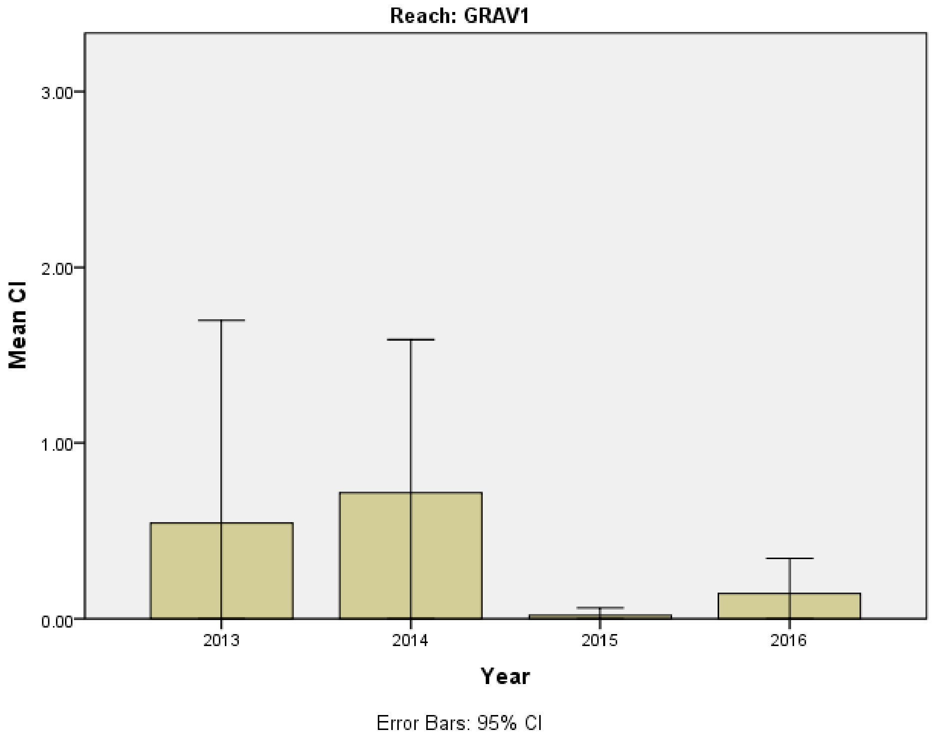

Reach: GATE2
Mean CI
3.00
2.00
1.00
0.00
a
b
a,b
2013
2014
2015
2016
Year
Error Bars: 95% CI

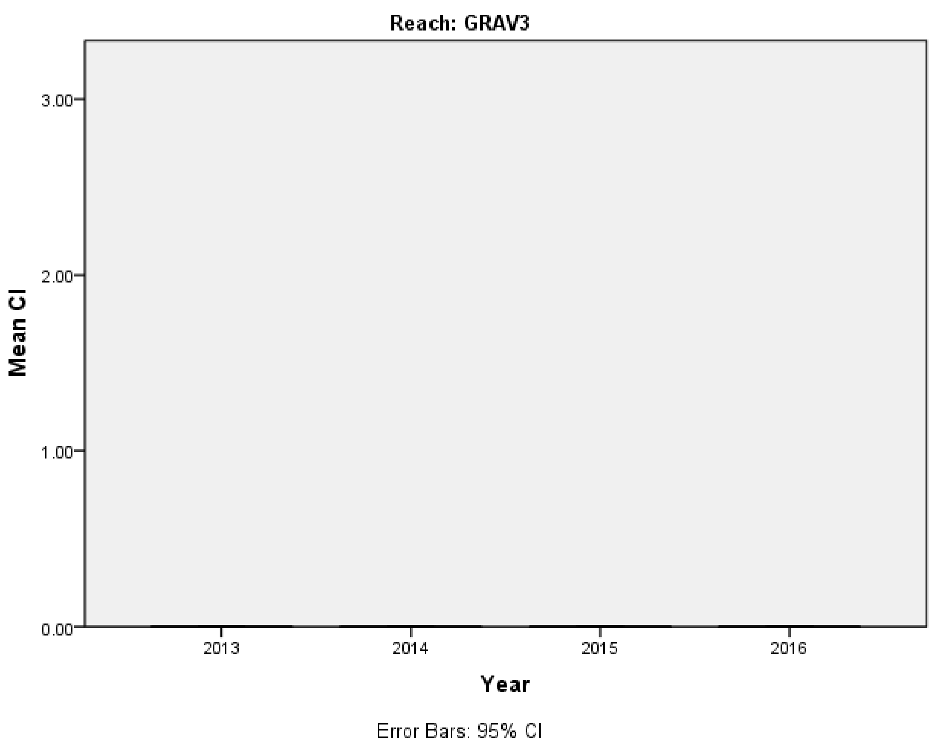

Reach: GODD1
Mean CI
3.00
2.00
1.00
0.00
2013
2014
2015
2016
Year
Error Bars: 95% CI

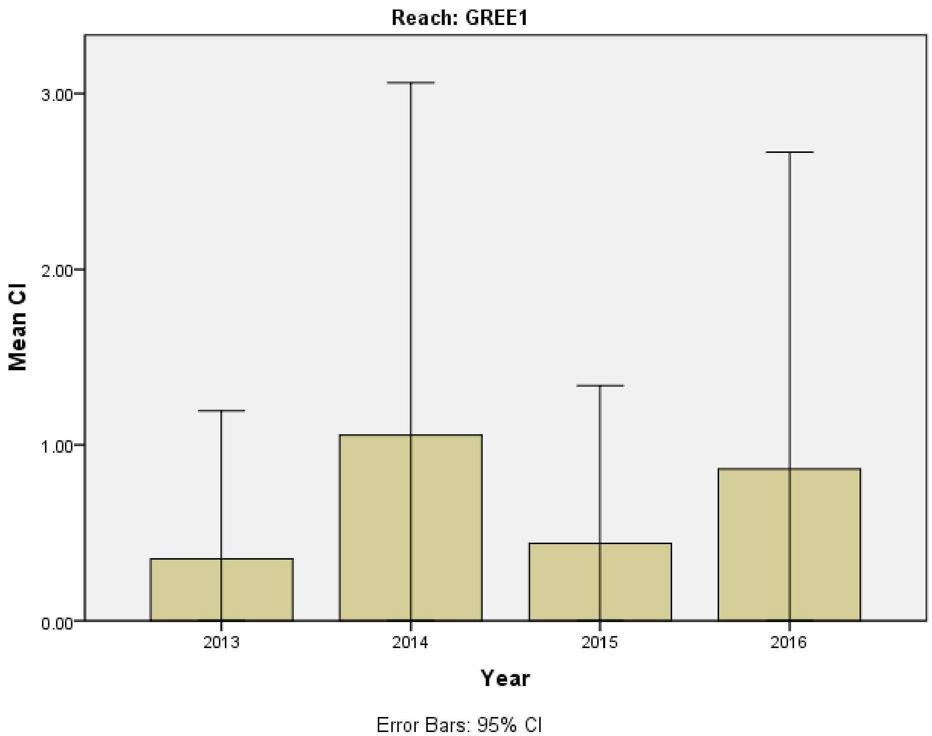

Reach: GODD3
Mean CI
3.00
2.00
1.00
0.00
a,b,c
a
b
c
2013
2014
2015
2016
Year
Error Bars: 95% CI

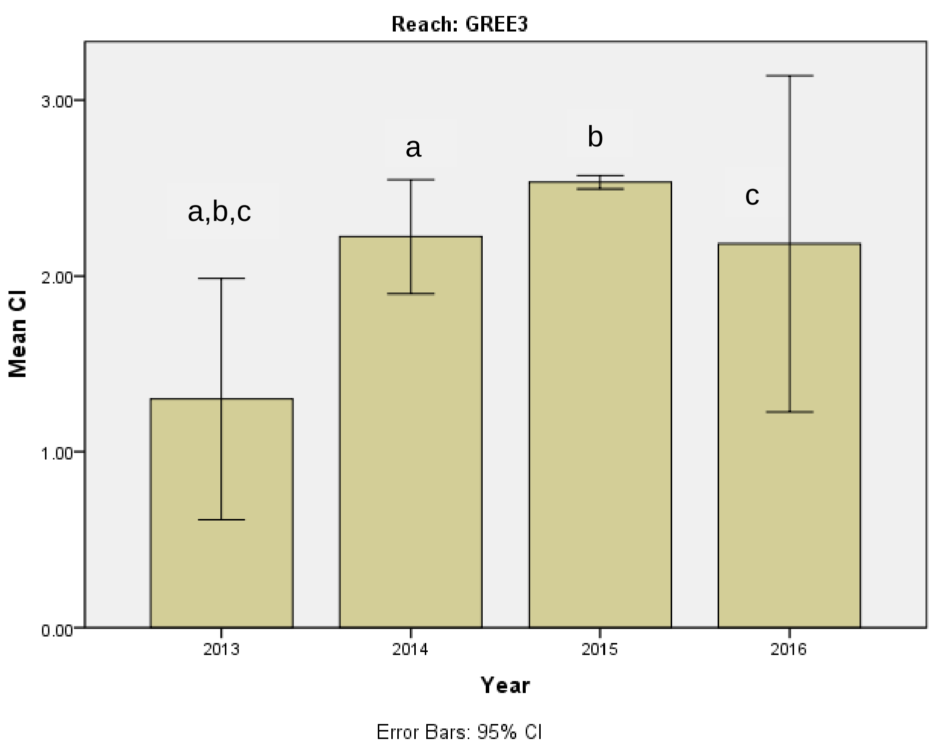

Reach: GRAC1
Mean CI
3.00
2.00
1.00
0.00
a.b
a
b
2013
2014
2015
2016
Year
Error Bars: 95% CI

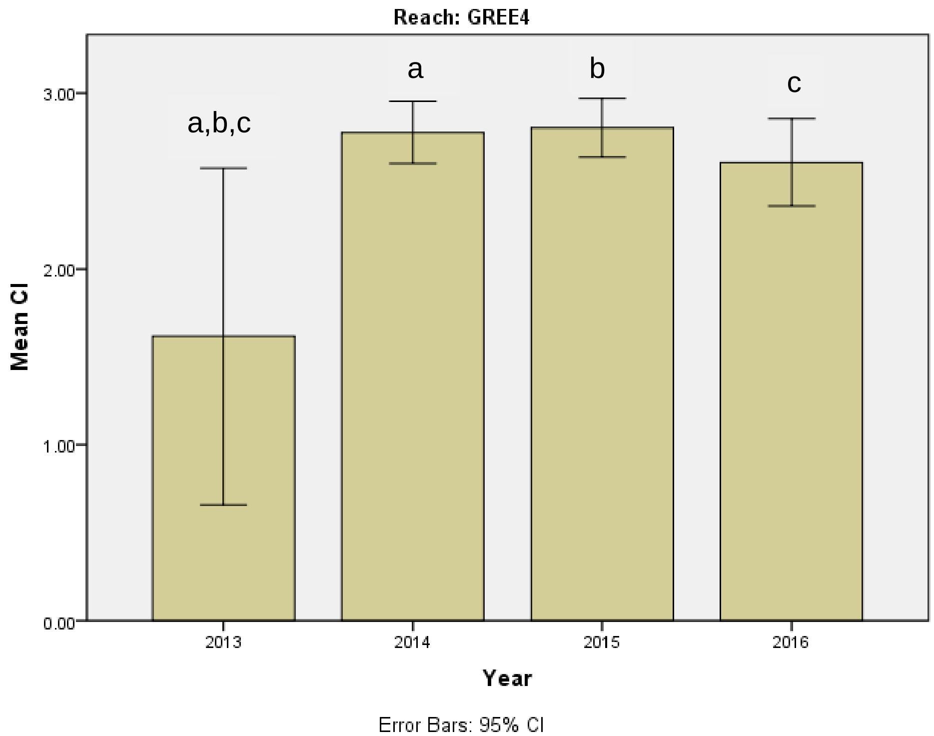

Reach: GRAS1
Mean CI
3.00
2.00
1.00
0.00
2013
2014
2015
2016
Year
Error Bars: 95% CI

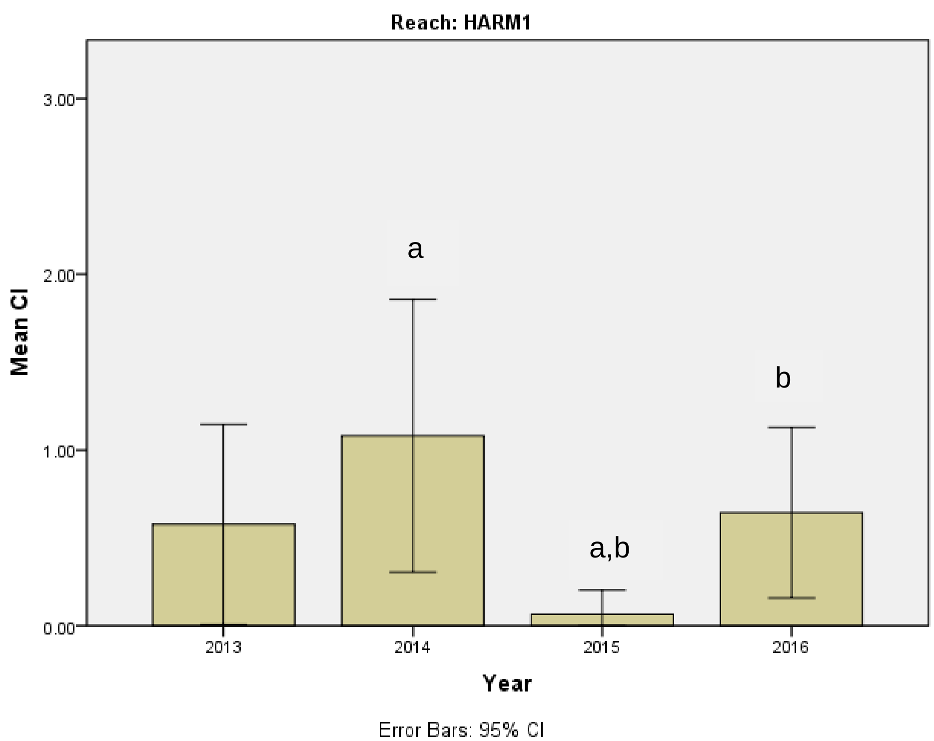

Reach: GRAV1
Mean CI
3.00
2.00
1.00
0.00
2013
2014
2015
2016
Year
Error Bars: 95% CI

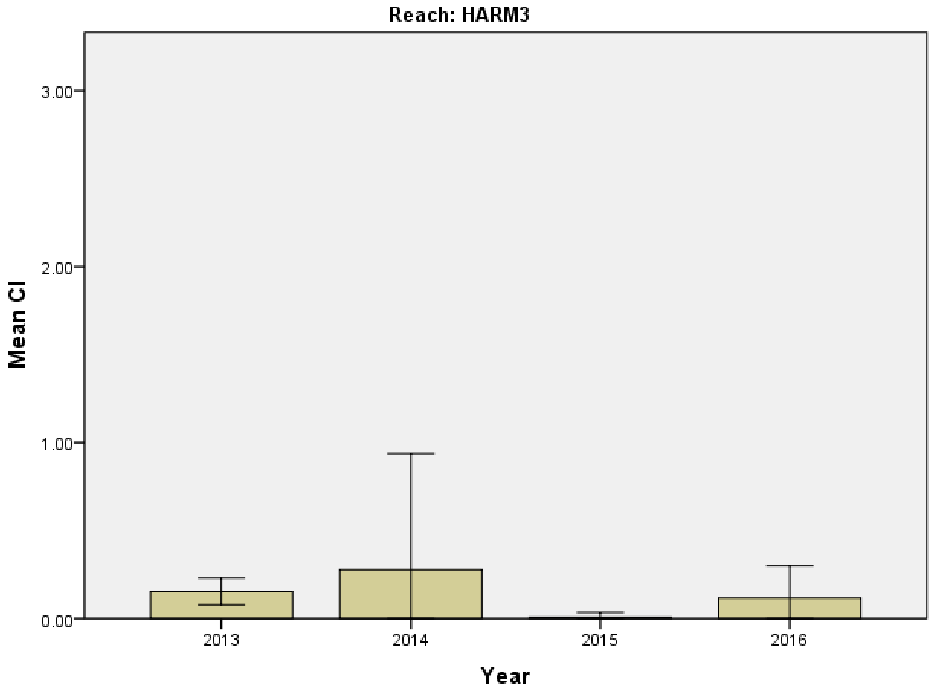

Reach: GRAV3
Mean CI
3.00
2.00
1.00
0.00
2013
2014
2015
2016
Year
Error Bars: 95% CI


Reach: GREE1
Mean CI
3.00
2.00
1.00
0.00
2013
2014
2015
2016
Year
Error Bars: 95% CI

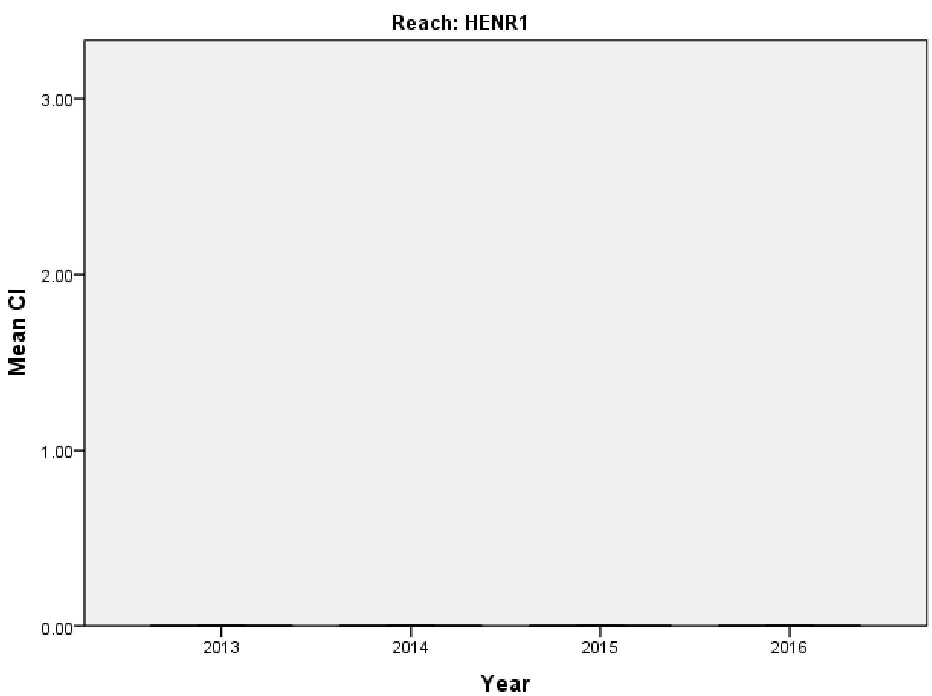

Reach: GREE3
Mean CI
3.00
2.00
1.00
0.00
a,b,c
a
b
c
2013
2014
2015
2016
Year
Error Bars: 95% CI


Reach: GREE4
a,b,c
a
b
c
Mean CI
3.00
2.00
1.00
0.00
2013
2014
2015
2016
Year
Error Bars: 95% CI

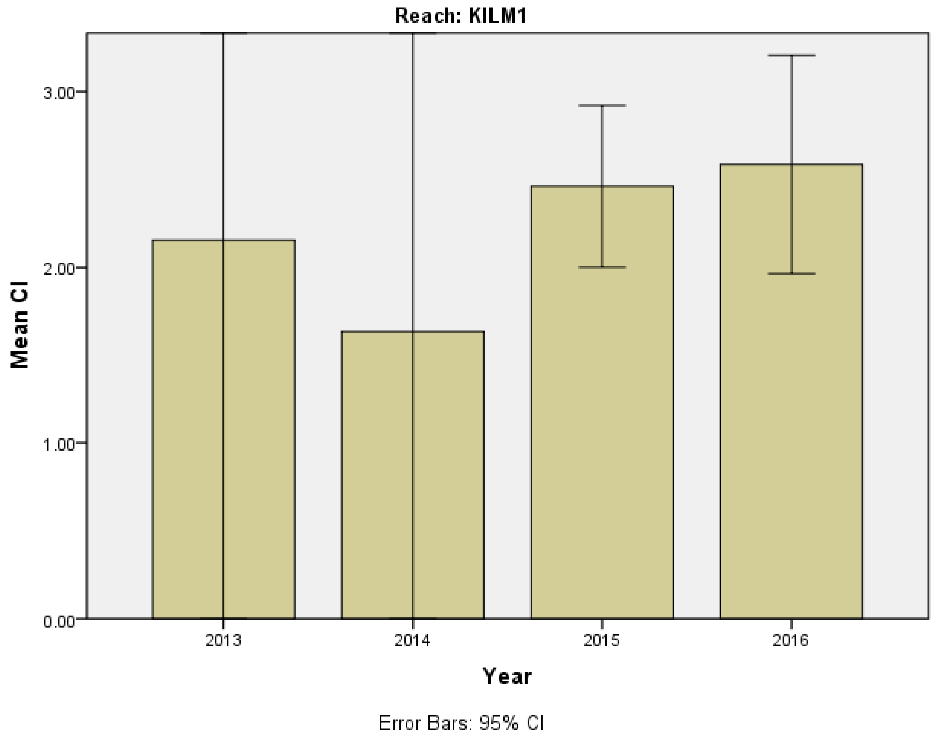

Reach: HARM1
a
b
a,b
Mean CI
3.00
2.00
1.00
0.00
2013
2014
2015
2016
Year
Error Bars: 95% CI

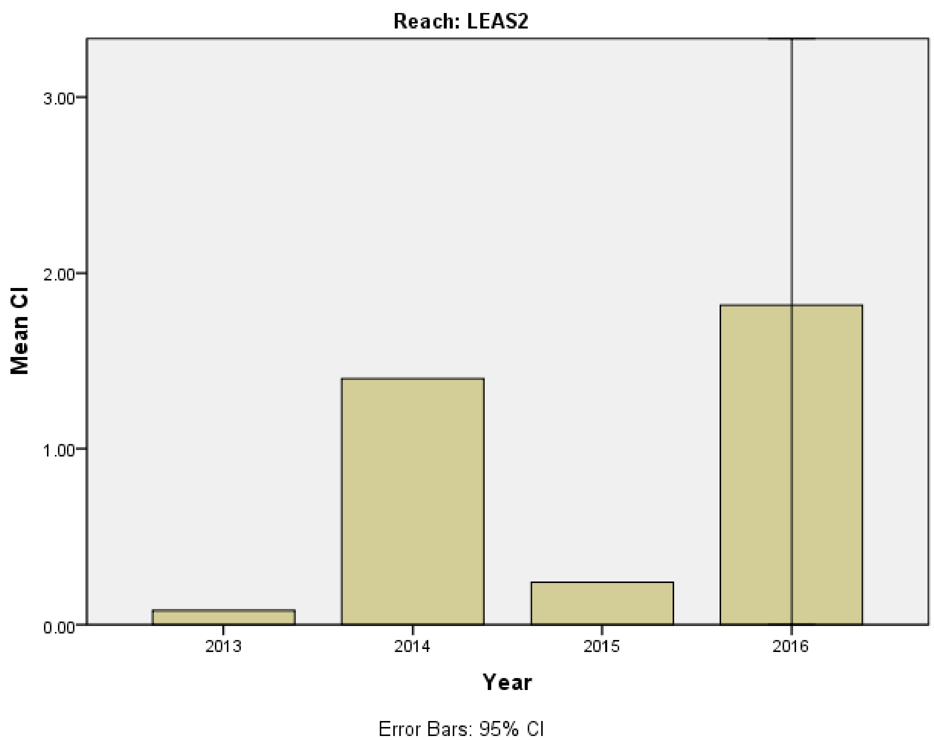


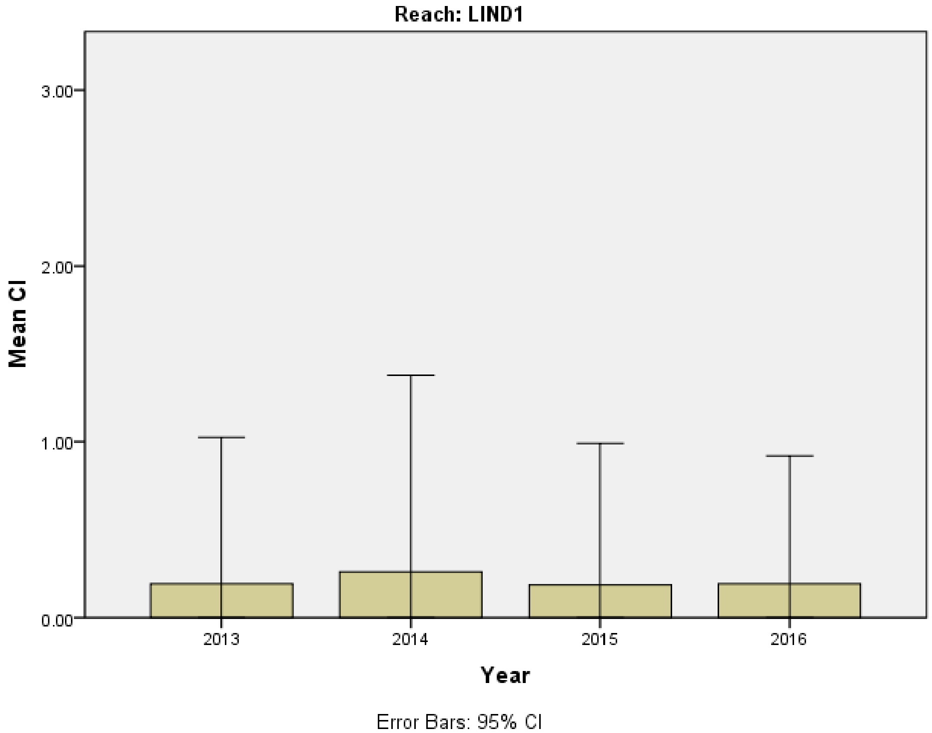
Error Bars: 95% CI

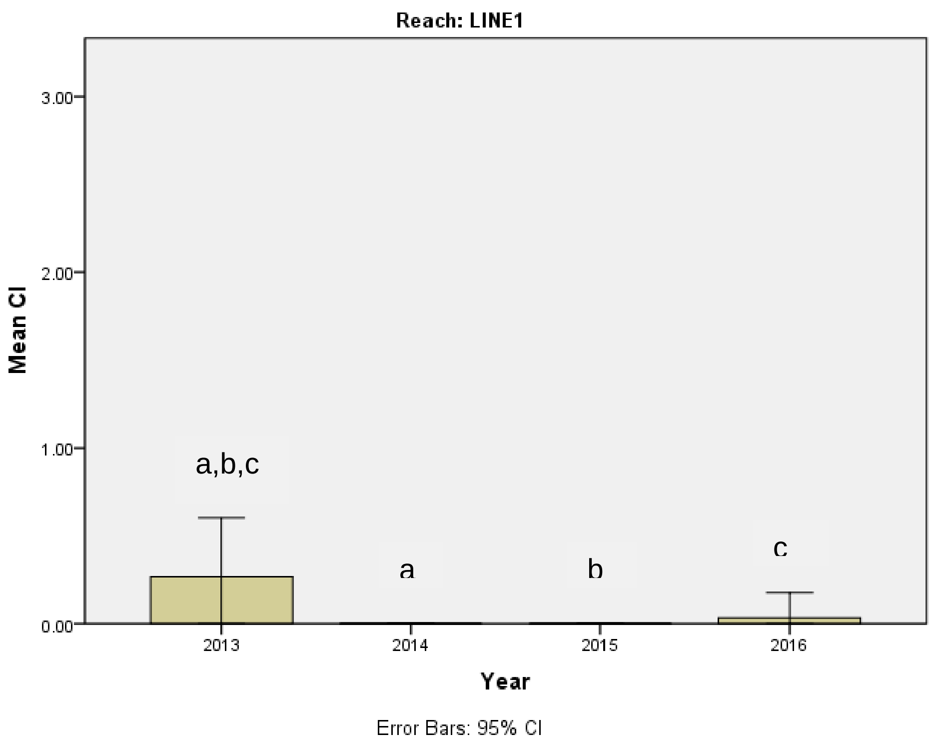


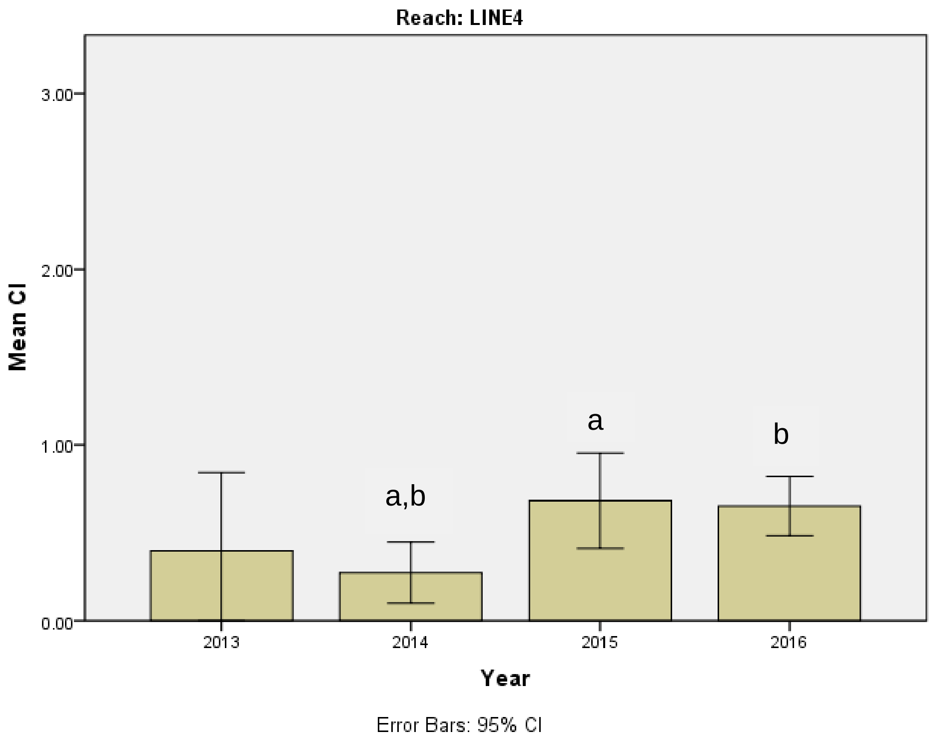
Error Bars: 95% CI

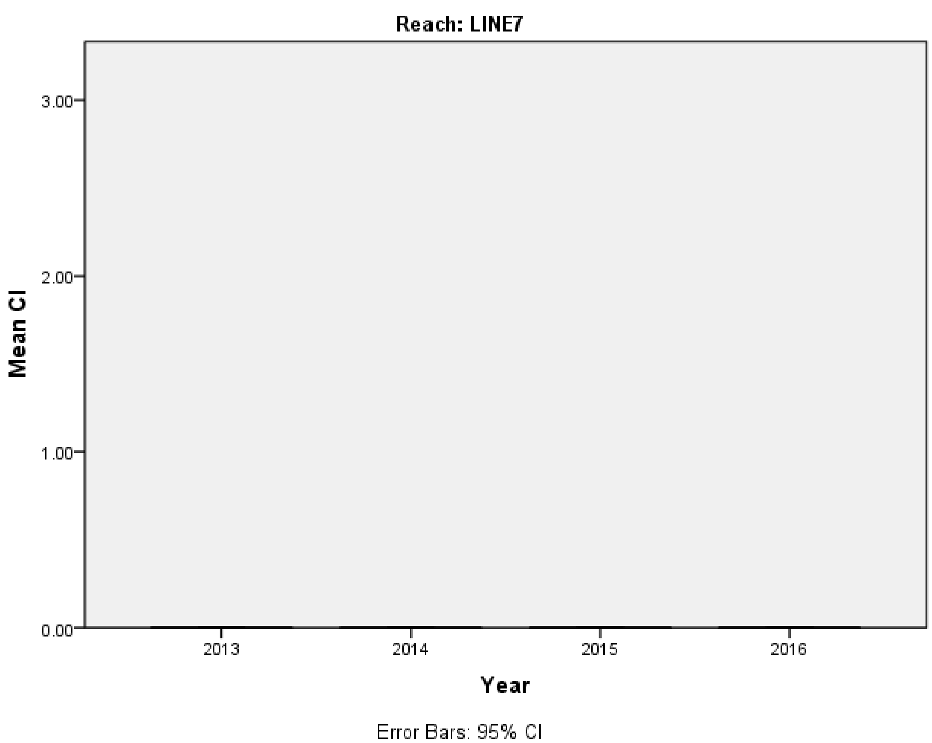

Reach: KILM1
Mean CI
3.00
2.00
1.00
0.00
2013
2014
2015
2016
Year
Error Bars: 95% CI

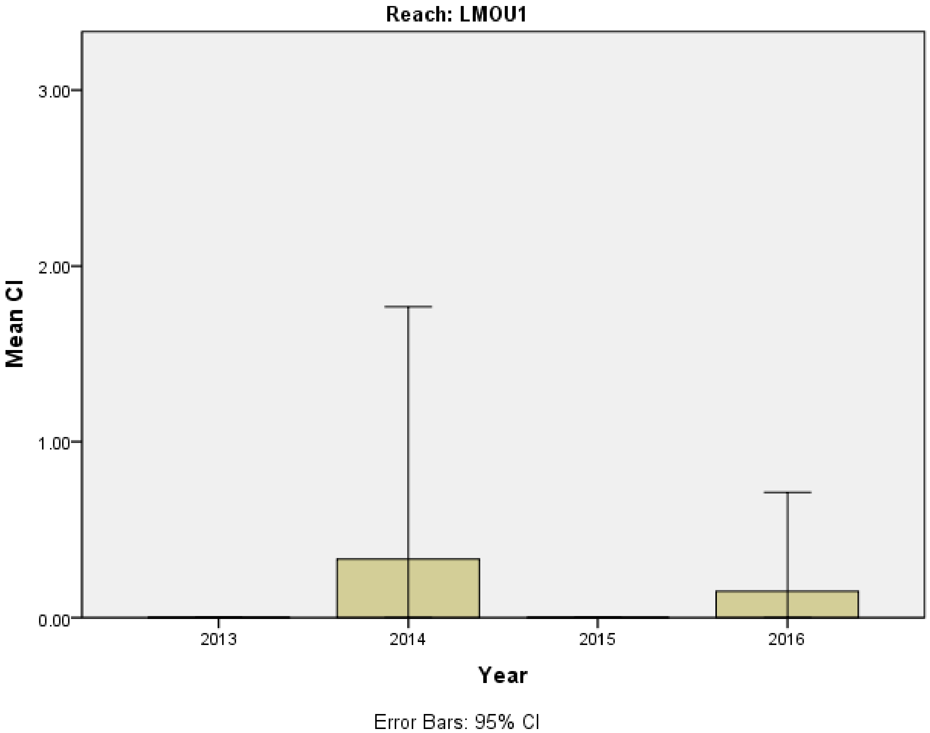

Reach: LEAS2
Mean CI
3.00
2.00
1.00
0.00
2013
2014
2015
2016
Year
Error Bars: 95% CI

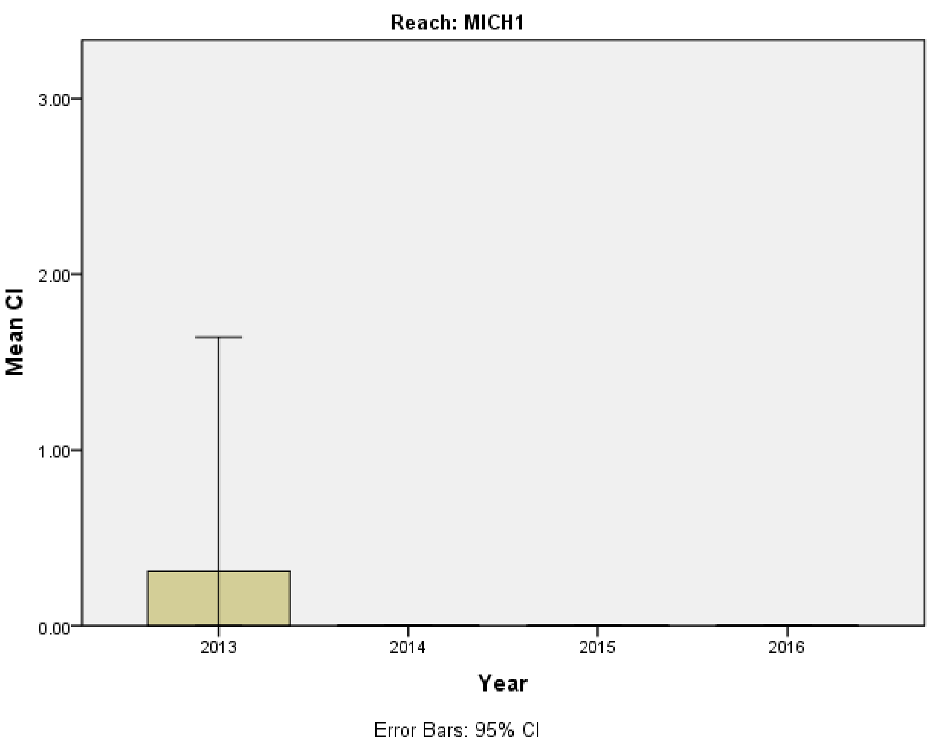

Reach: LIND1
3.00
2.00
1.00
0.00
Mean CI
2013
2014
2015
2016
Year
Error Bars: 95% CI

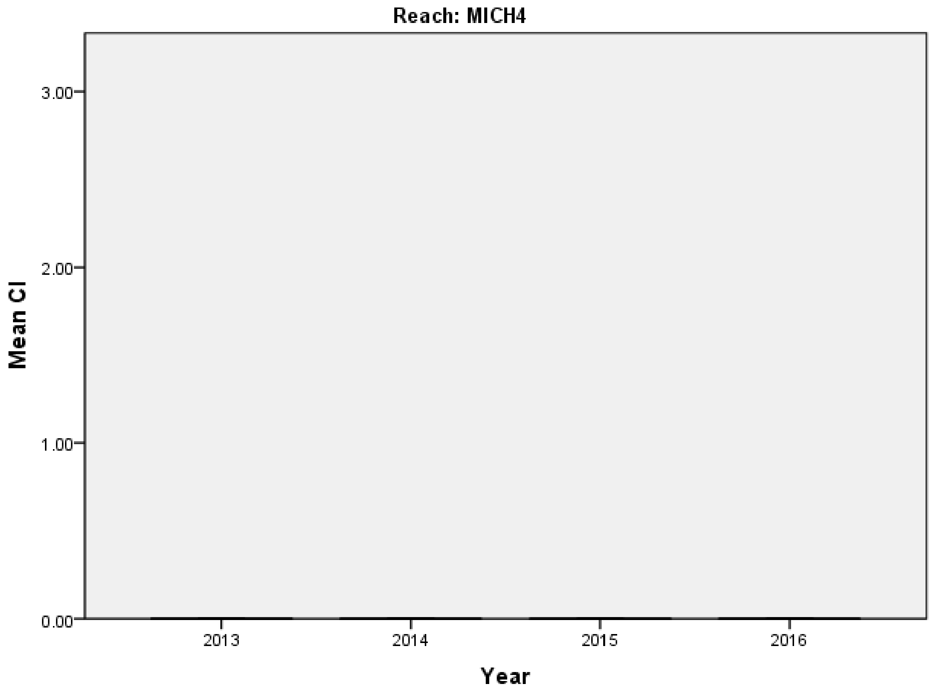

Reach: LINE1
3.00
2.00
1.00
0.00
Mean CI
a,b,c
a
b
c
2013
2014
2015
2016
Year
Error Bars: 95% CI


Reach: LINE4
Mean CI
3.00
2.00
1.00
0.00
a,b
a
b
2013
2014
2015
2016
Year
Error Bars: 95% CI

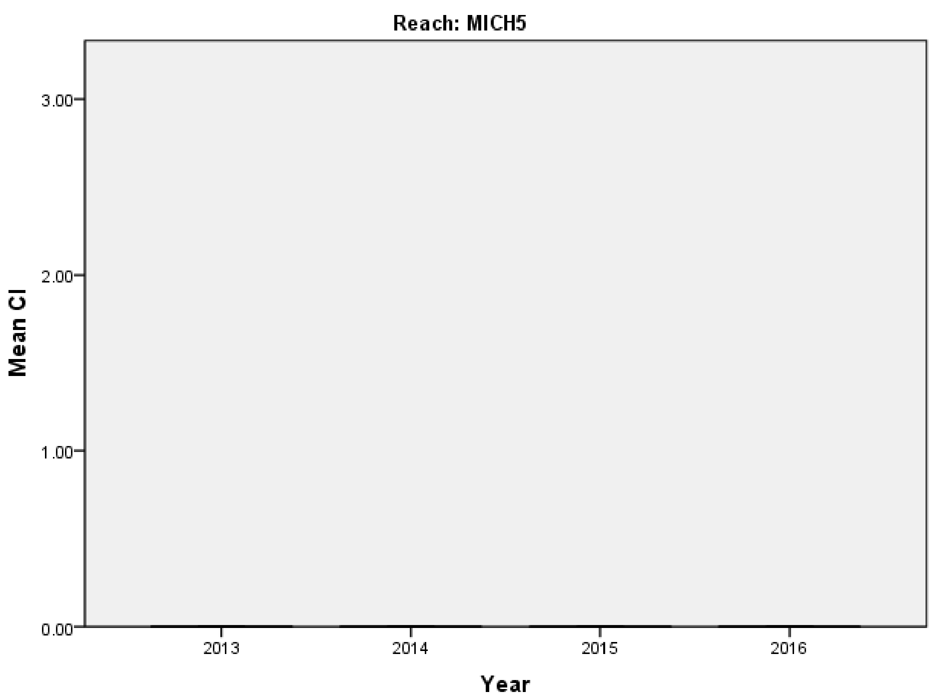

Reach: LINE7
Mean CI
3.00
2.00
1.00
0.00
2013
2014
2015
2016
Year
Error Bars: 95% CI


Reach: LMOU1
Mean CI
3.00
2.00
1.00
0.00
2013
2014
2015
2016
Year
Error Bars: 95% CI

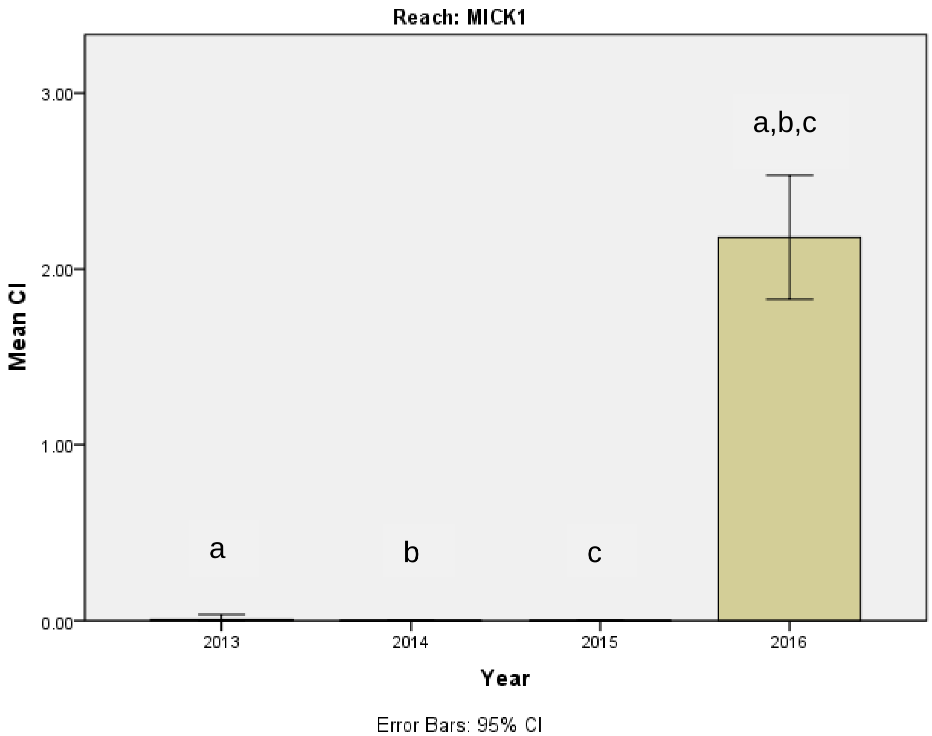

Reach: MICH1
Mean CI
3.00
2.00
1.00
0.00
2013
2014
2015
2016
Year
Error Bars: 95% CI

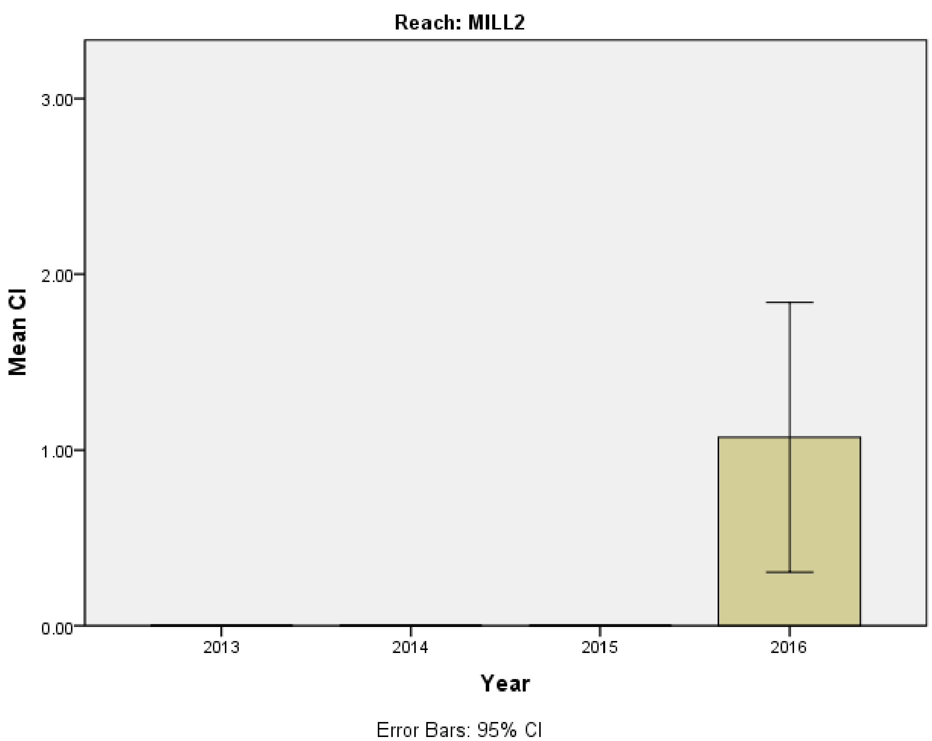


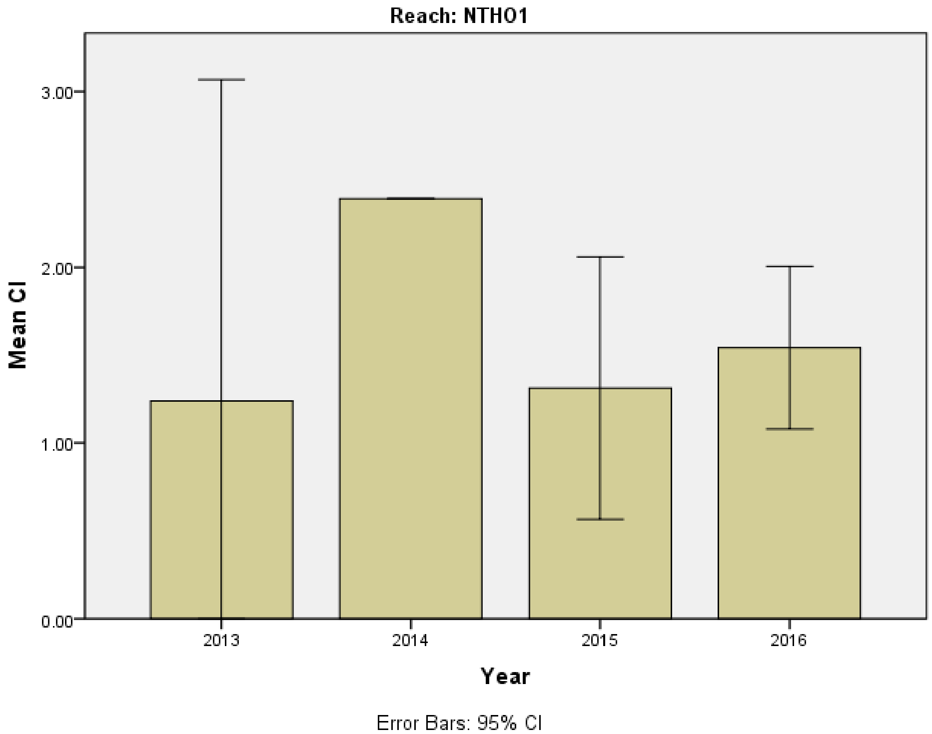
Error Bars: 95% CI

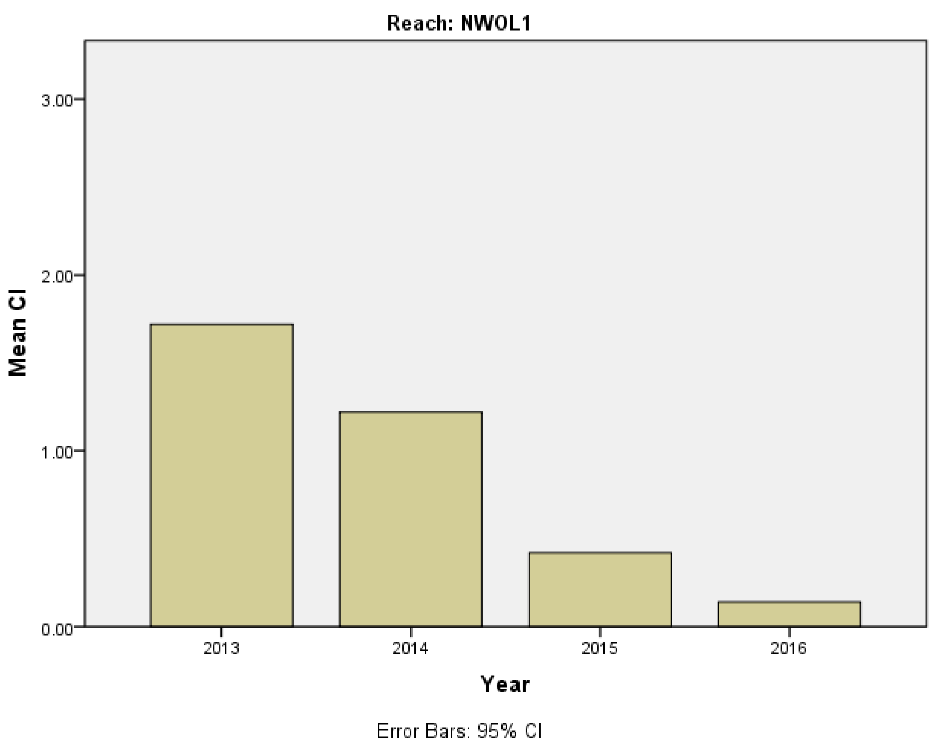


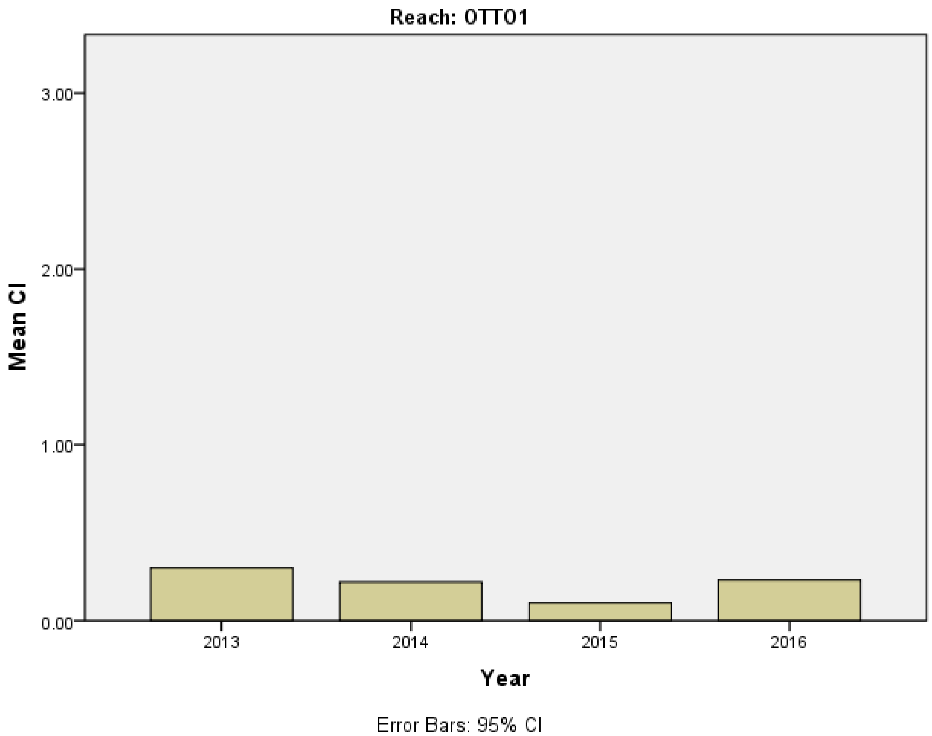
Error Bars: 95% CI

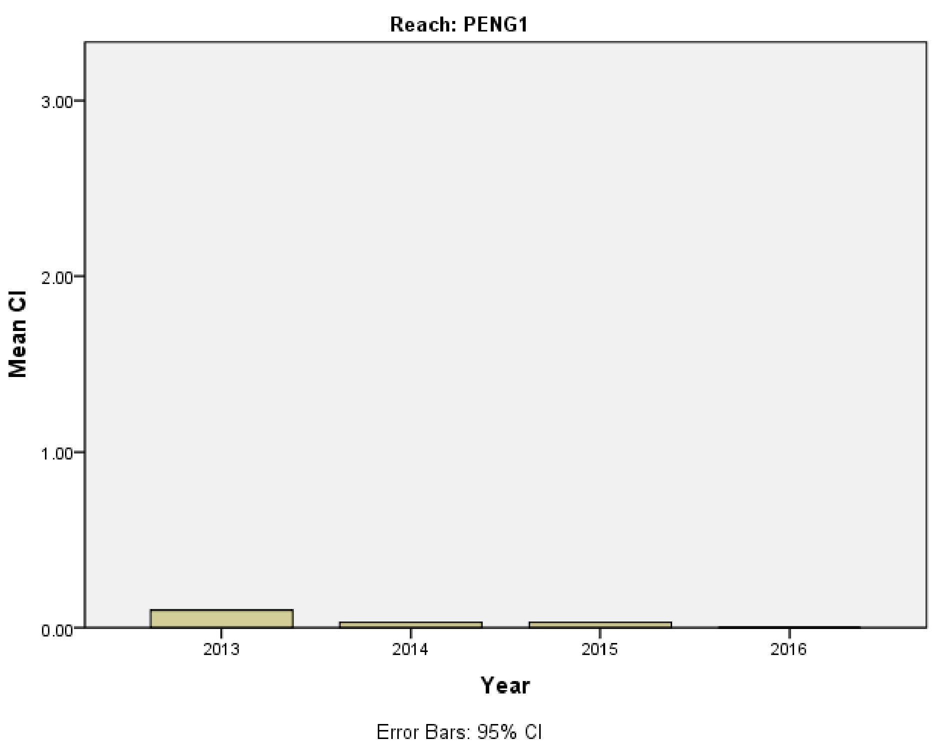

Reach: MICK1
a,b,c
a
b
c
3.00
2.00
1.00
0.00
Mean CI
2013
2014
2015
2016
Year
Error Bars: 95% CI

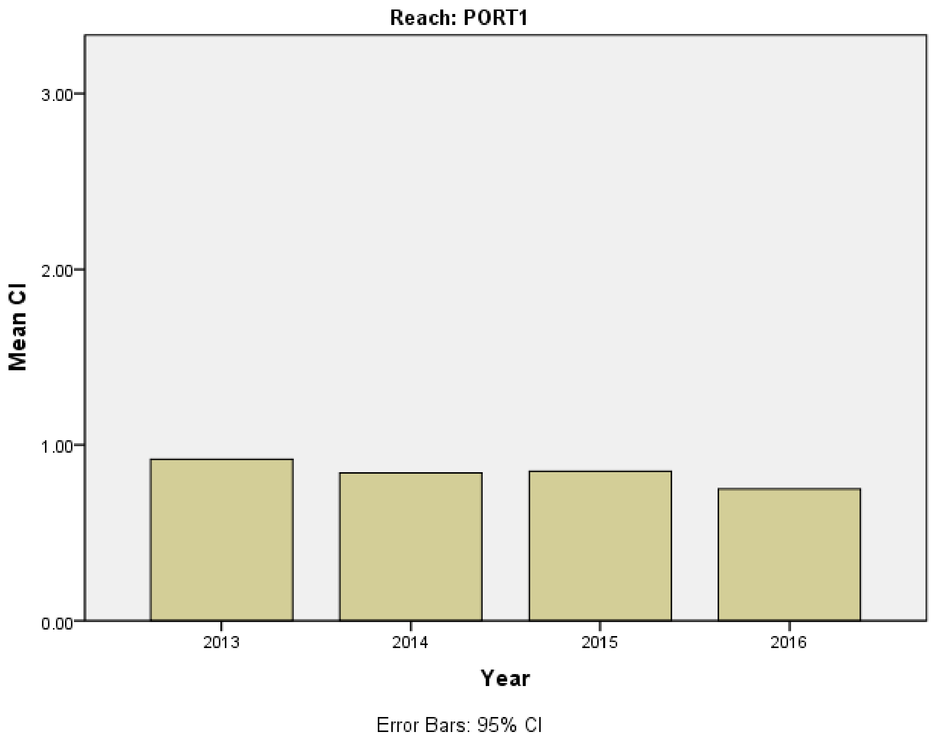

Reach: MILL2
3.00
2.00
1.00
0.00
Mean CI
2013
2014
2015
2016
Year
Error Bars: 95% CI

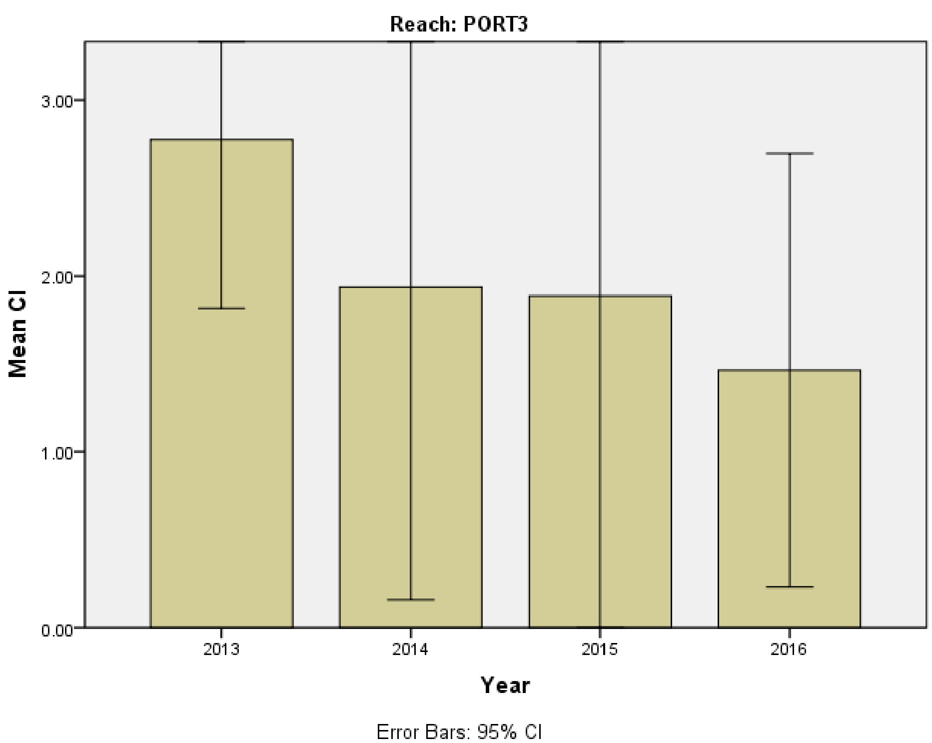

Reach: NTHO1
Mean CI
3.00
2.00
1.00
0.00
2013
2014
2015
2016
Year
Error Bars: 95% CI

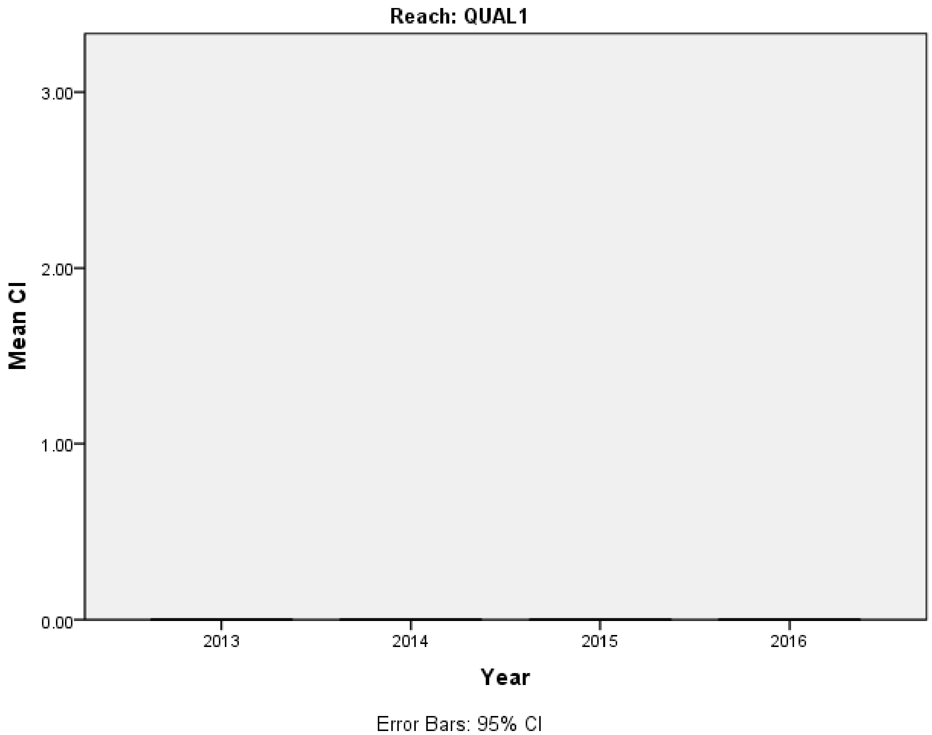

Reach: NWOL1
Mean CI
3.00
2.00
1.00
0.00
2013
2014
2015
2016
Year
Error Bars: 95% CI

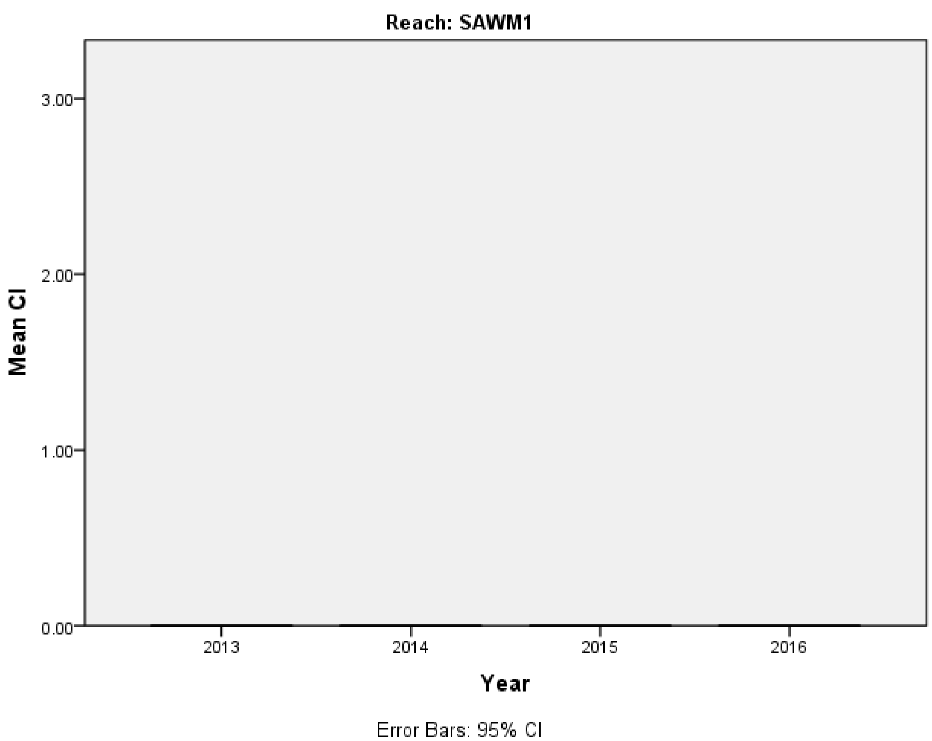

Reach: OTTO1
3.00
2.00
1.00
0.00
Mean CI
2013
2014
2015
2016
Year
Error Bars: 95% CI

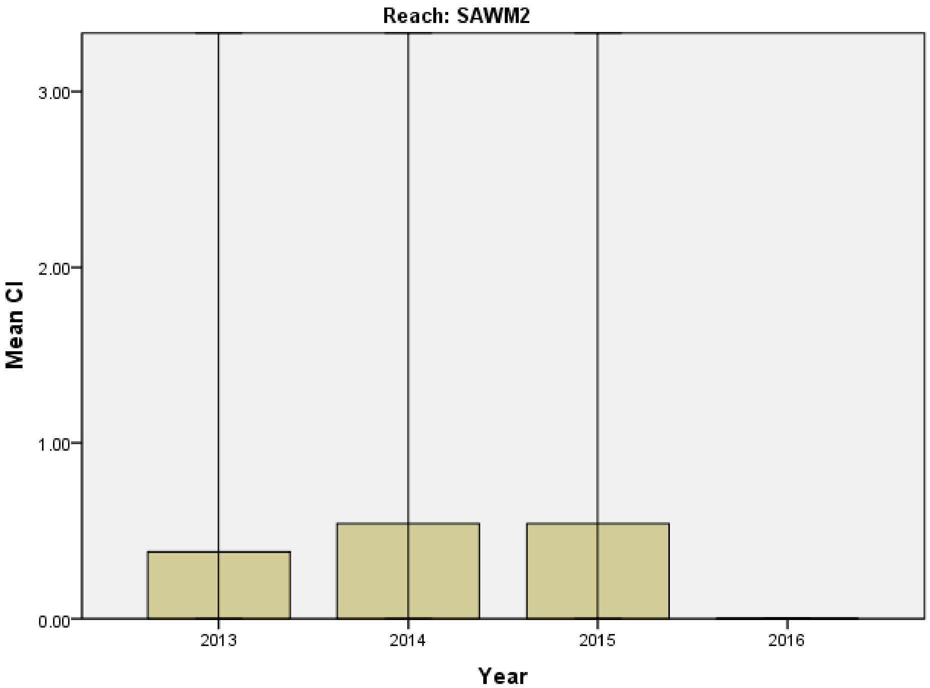

Reach: PENG1
3.00
2.00
1.00
0.00
Mean CI
2013
2014
2015
2016
Year
Error Bars: 95% CI


Reach: PORT1
Mean CI
3.00
2.00
1.00
0.00
2013
2014
2015
2016
Year
Error Bars: 95% CI

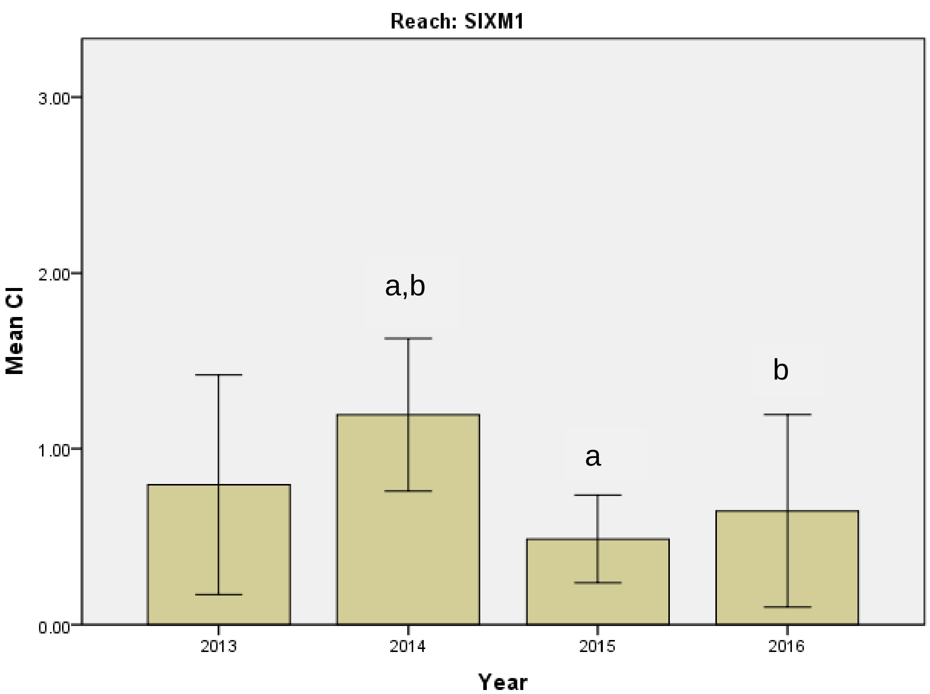

Reach: PORT3
Mean CI
3.00
2.00
1.00
0.00
2013
2014
2015
2016
Year
Error Bars: 95% CI


Reach: QUAL1
Mean CI
3.00
2.00
1.00
0.00
2013
2014
2015
2016
Year
Error Bars: 95% CI

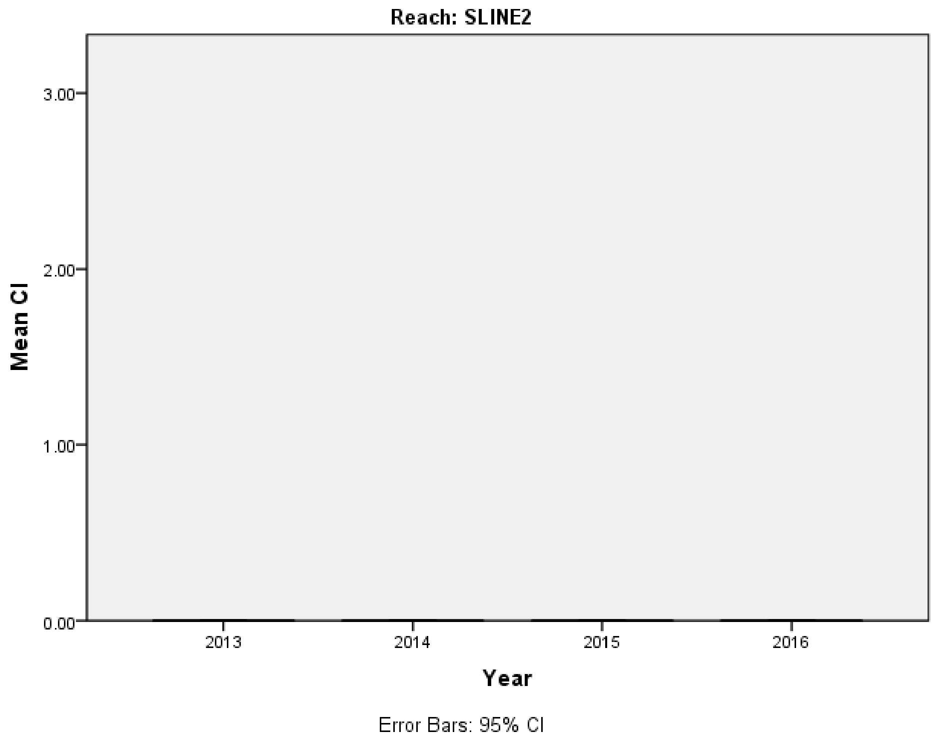

Reach: SAWM1
Mean CI
3.00
2.00
1.00
0.00
2013
2014
2015
2016
Year
Error Bars: 95% CI

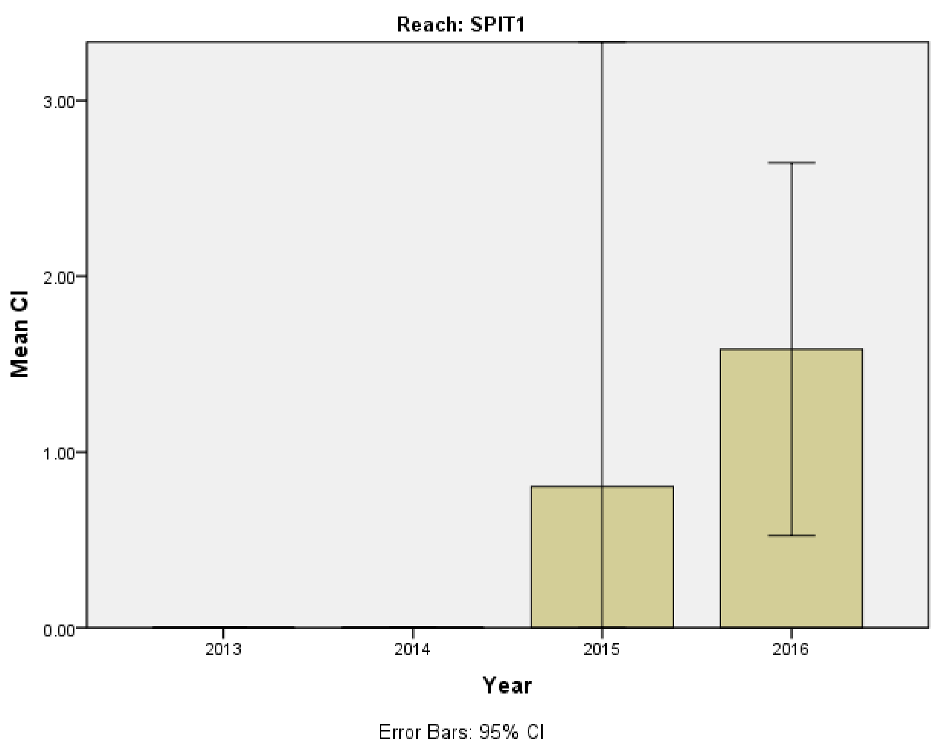


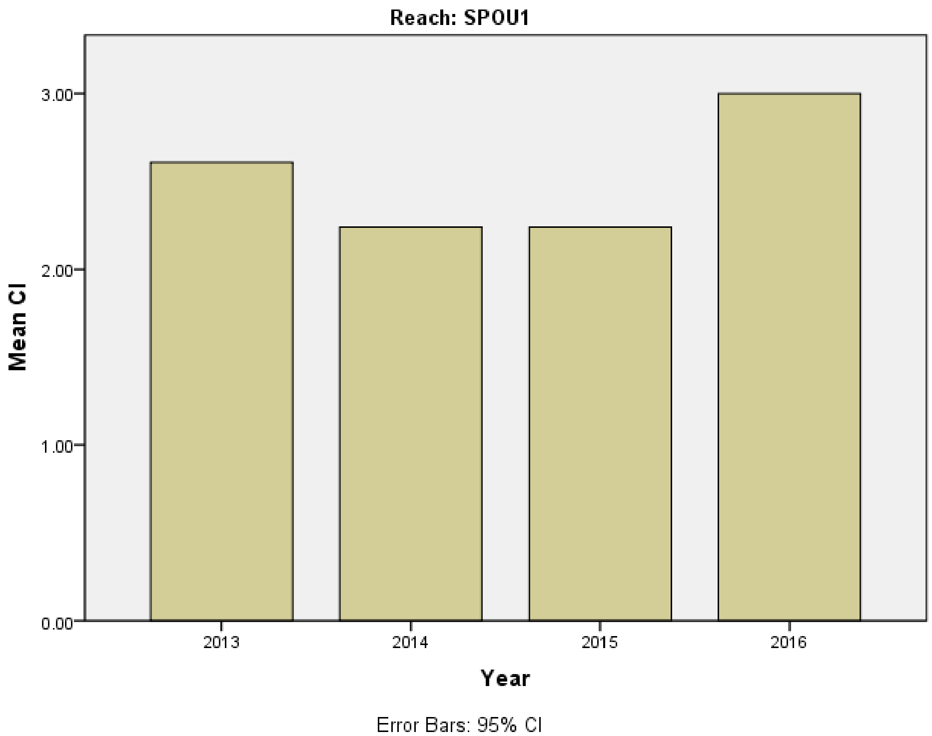
Error Bars: 95% CI

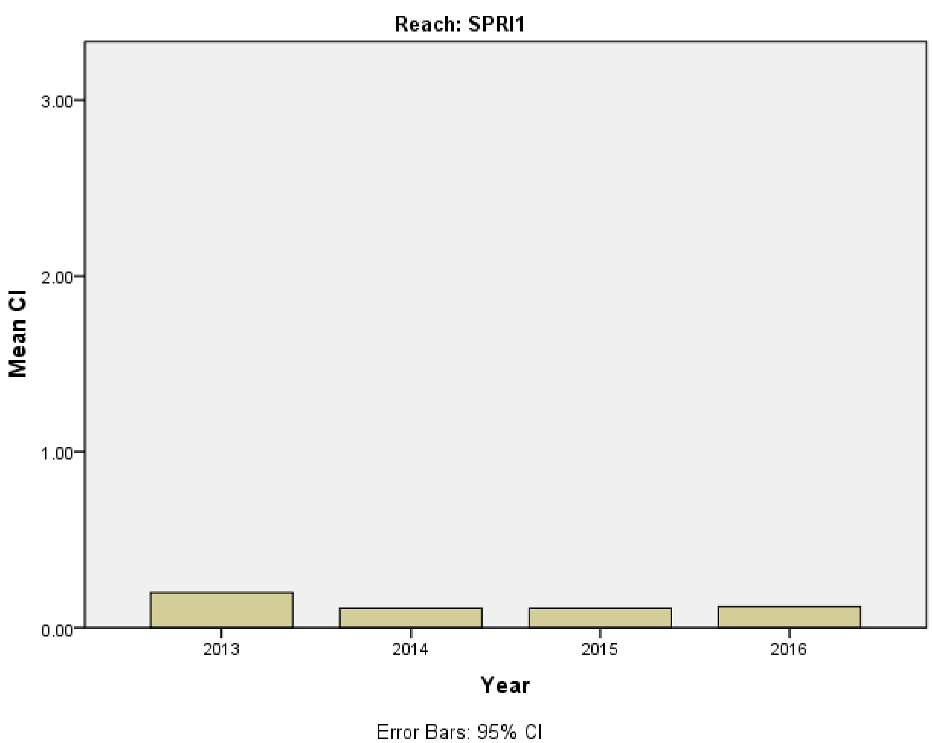


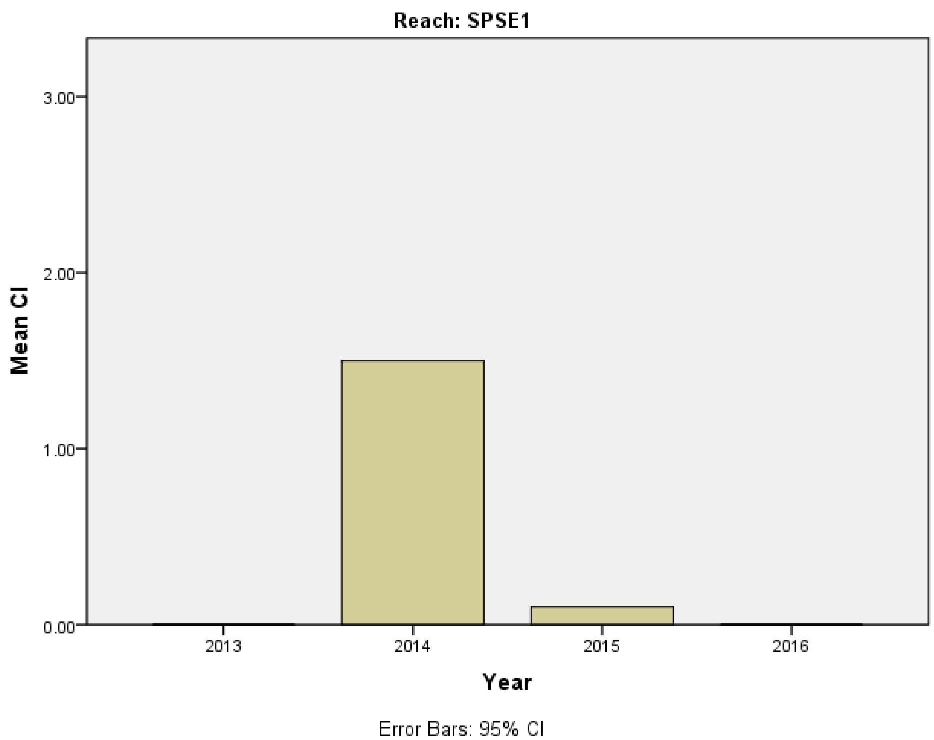
Error Bars: 95% CI

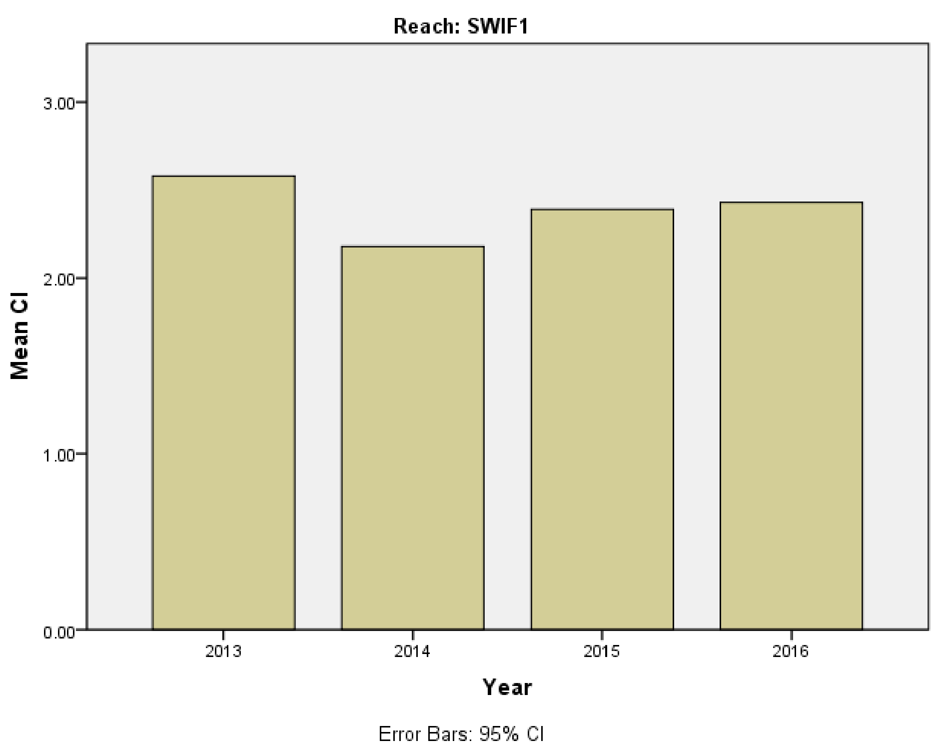

Reach: SLINE2
3.00
2.00
1.00
0.00
Mean CI
2013
2014
2015
2016
Year
Error Bars: 95% CI

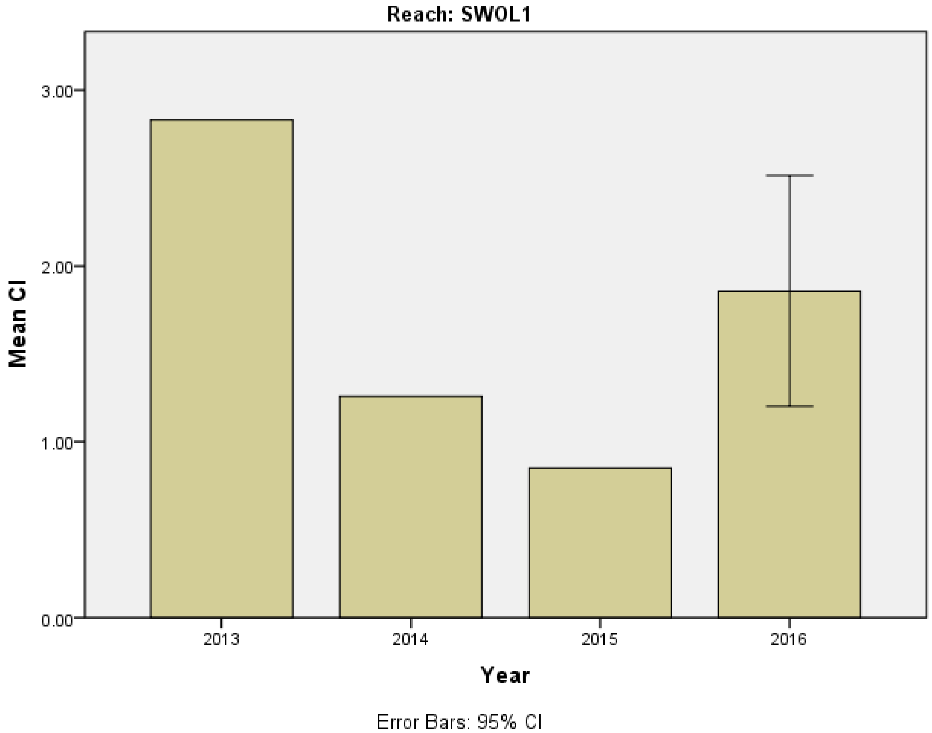

Reach: SPIT1
3.00
2.00
1.00
0.00
Mean CI
2013
2014
2015
2016
Year
Error Bars: 95% CI

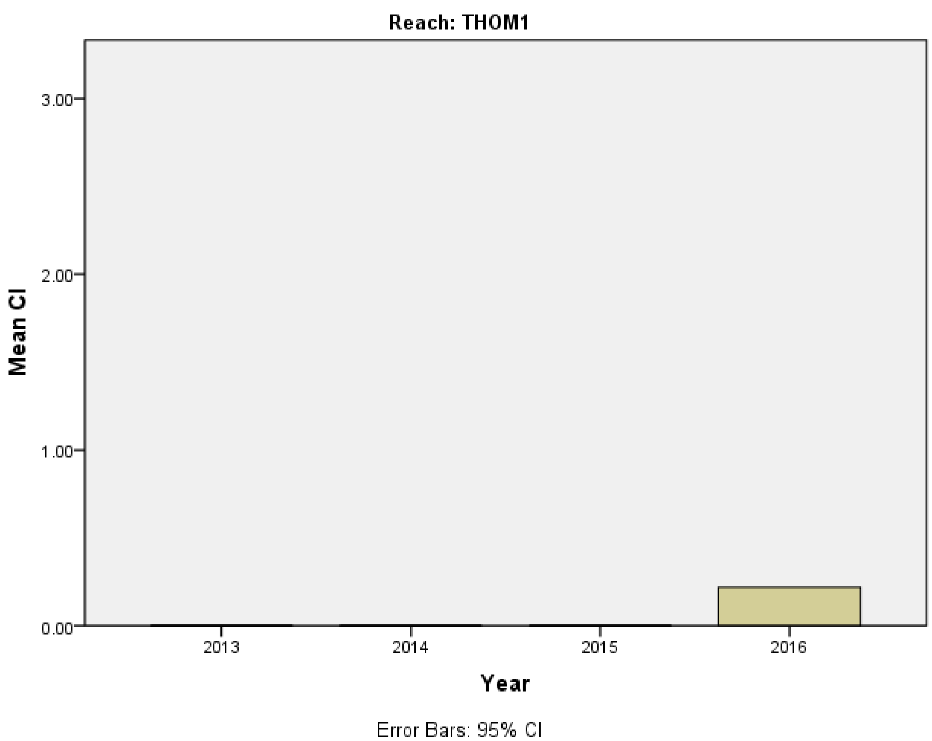

Reach: SPOU1
3.00
2.00
1.00
0.00
Mean CI
2013
2014
2015
2016
Year
Error Bars: 95% CI

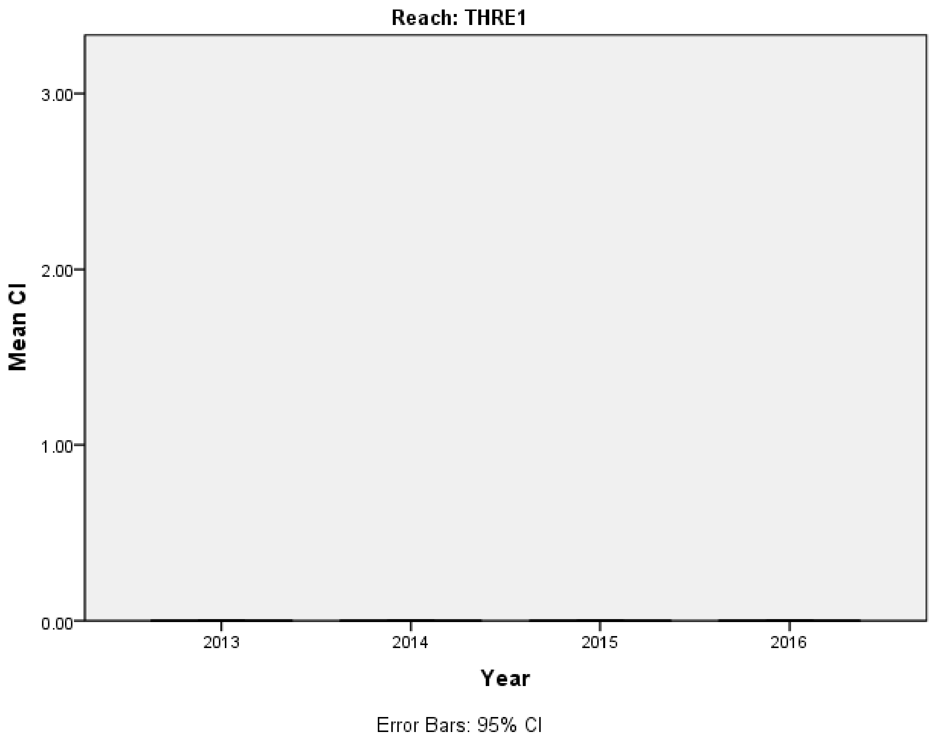

Reach: SPRI1
3.00
2.00
1.00
0.00
Mean CI
2013
2014
2015
2016
Year
Error Bars: 95% CI

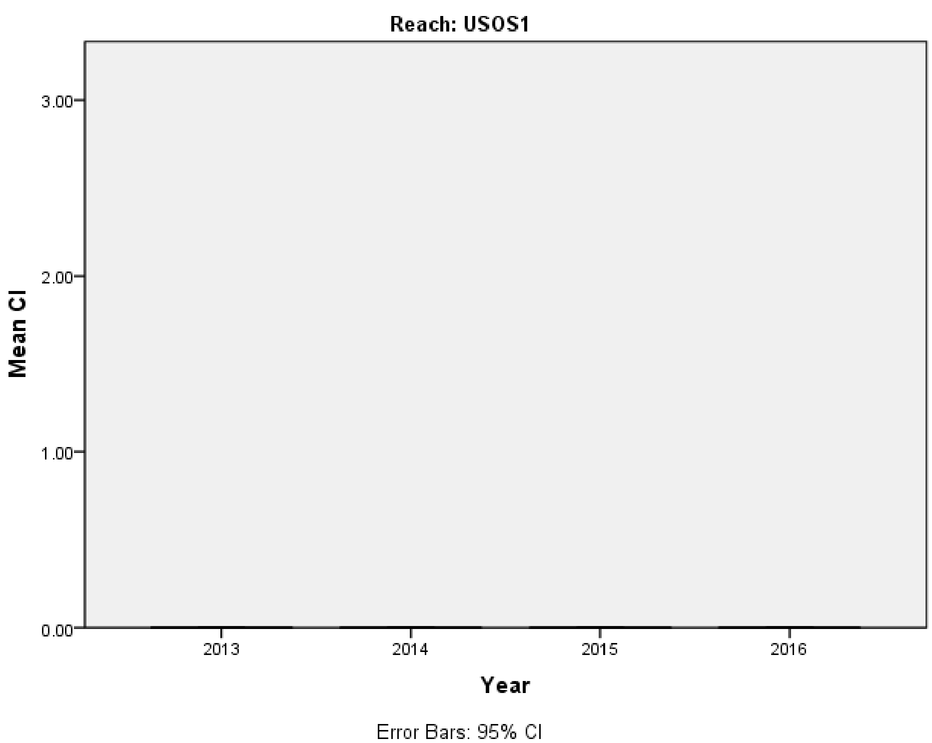

Reach: SPSE1
Mean CI
3.00
2.00
1.00
0.00
2013
2014
2015
2016
Year
Error Bars: 95% CI

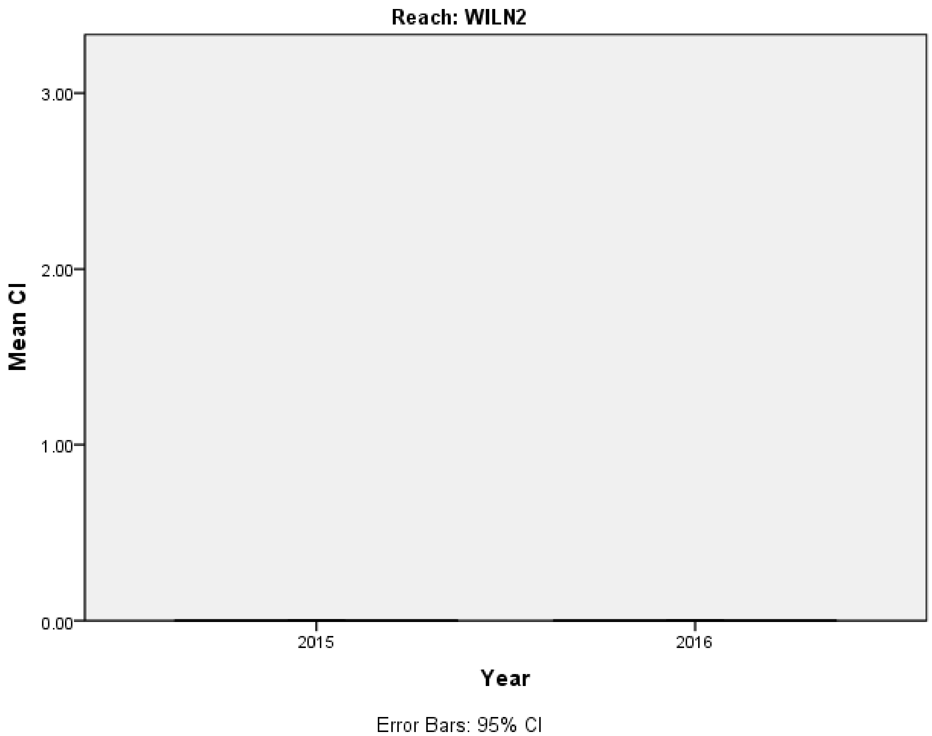

Reach: SWIF1
Mean CI
3.00
2.00
1.00
0.00
2013
2014
2015
2016
Year
Error Bars: 95% CI

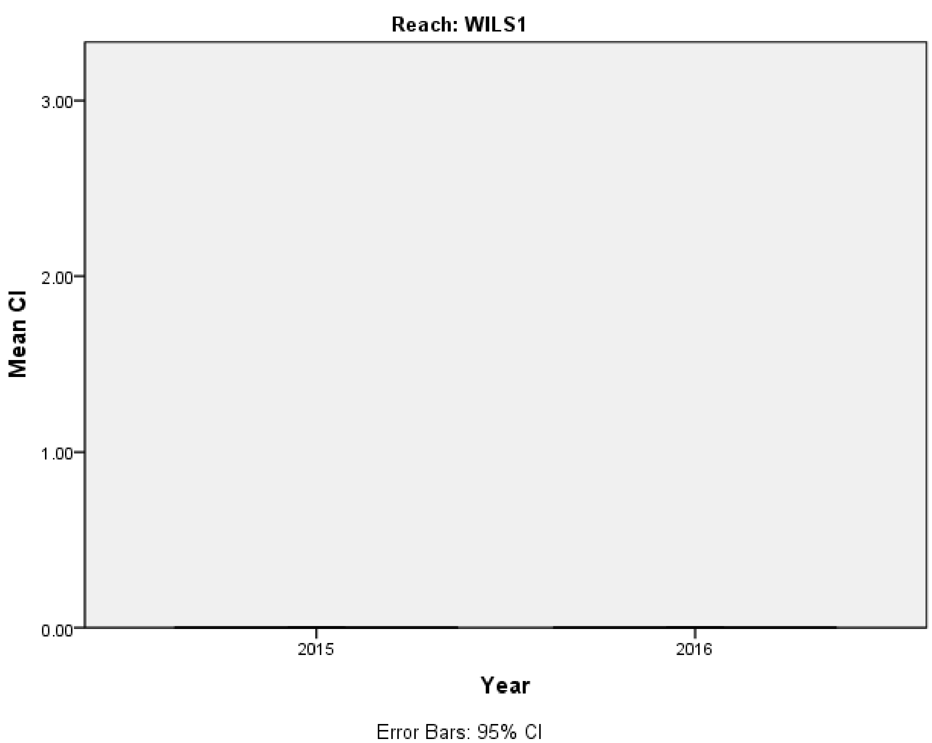

Reach: SWOL1
3.00
2.00
1.00
0.00
Mean CI
2013
2014
2015
2016
Year
Error Bars: 95% CI

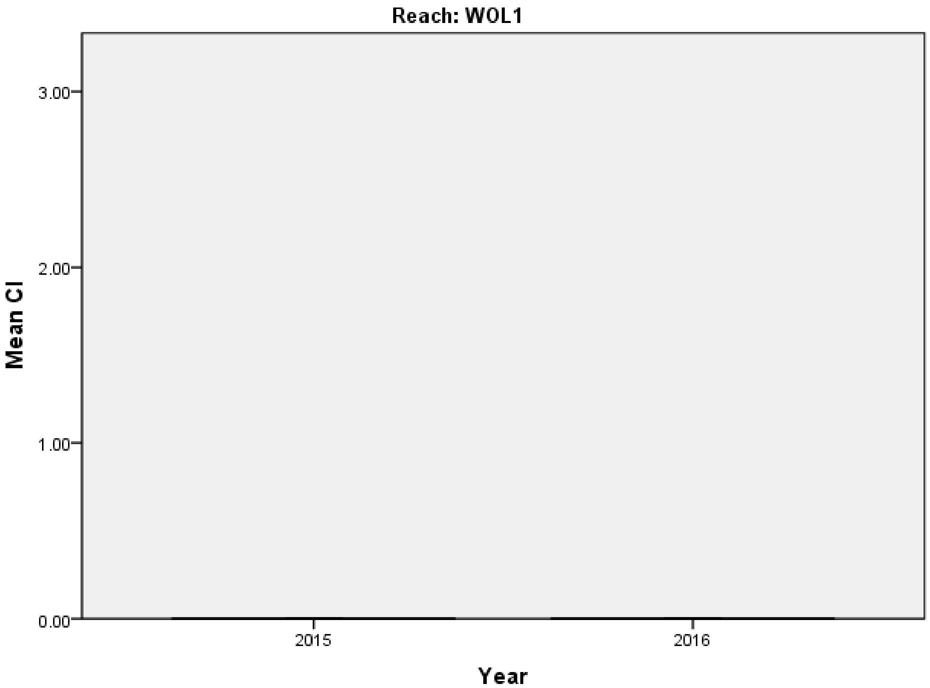

Reach: THOM1
3.00
2.00
1.00
0.00
Mean CI
2013
2014
2015
2016
Year
Error Bars: 95% CI


Reach: THRE1
Mean CI
3.00
2.00
1.00
0.00
2013
2014
2015
2016
Year
Error Bars: 95% CI

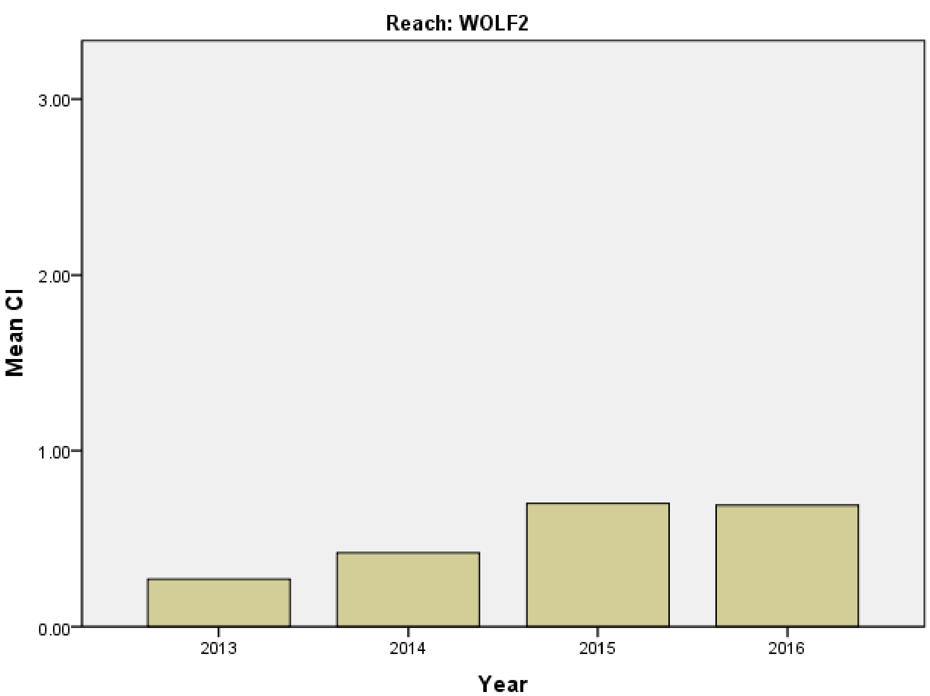

Reach: USOS1
Mean CI
3.00
2.00
1.00
0.00
2013
2014
2015
2016
Year
Error Bars: 95% CI


Reach: WILN2
Mean CI
3.00
2.00
1.00
0.00
2015
2016
Year
Error Bars: 95% CI

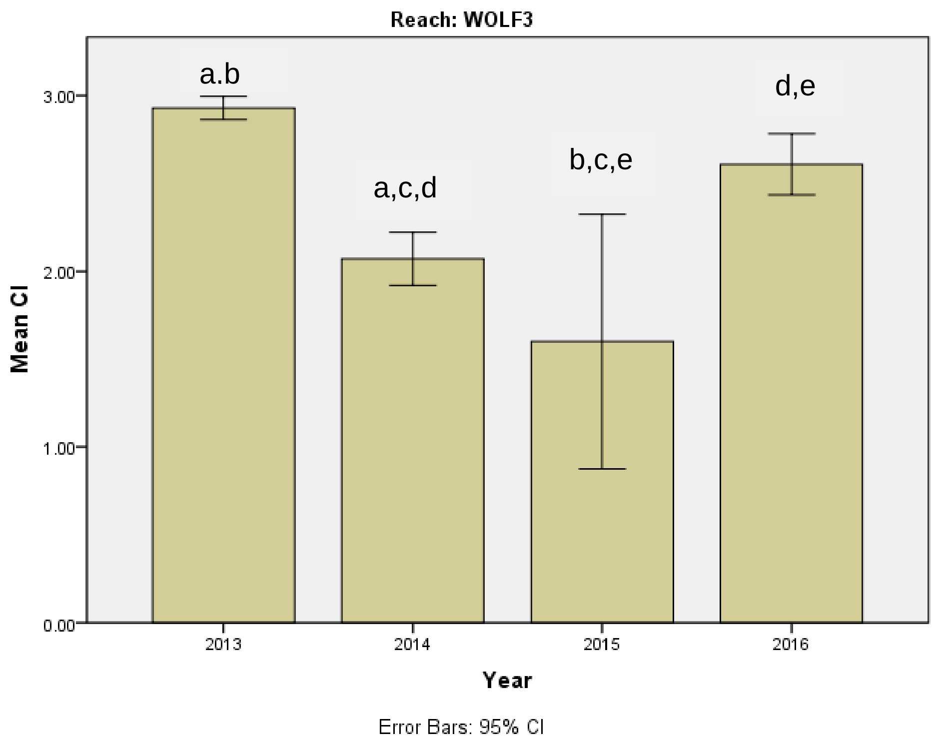

Reach: WILS1
Mean CI
3.00
2.00
1.00
0.00
2015
2016
Year
Error Bars: 95% CI



Error Bars: 95% CI



Error Bars: 95% CI


Reach: WOLF3
a.b
a,c,d
b,c,e
d,e
3.00
2.00
1.00
0.00
Mean CI
2013
2014
2015
2016
Year
Error Bars: 95% CI