Bridge River Power Development Water Use Plan

Lower Bridge River Spiritual and Cultural Value Monitoring

Implementation Year 1

Reference: BRGMON-16

Study Period: July 31, 2013 - June 30, 2014

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Executive Summary

The BRGMON-16 Water Use Plan (WUP) monitoring project was undertaken to measure and monitor a set of the cultural and spiritual attributes of different flow discharges in the Lower Bridge River below Terzhagi Dam. The information is needed to incorporate non-tangible inputs into a future long-term flow decision for the Lower Bridge River. Six St'át'imc elders participated as evaluators to score their perceptions of cultural and spiritual values at different water flow discharges ranging between 1.8 cubic meters per second (cms) in October and 15 cms in late-July/early August. The Yalakom River was adopted as an adjacent (unregulated) control river and four seasonal surveys were simultaneously conducted in the Lower Bridge River and the Yalakom. A total of 9 variables were evaluated at 10 sites with a scoring system that ranged between 0 (least favorable) and 4 (most favorable).

The data were analyzed by means of General Linear Model statistical approaches which yielded the following results:

1. There were significant temporal differences in all of the cultural and spiritual variables with the exception of shore access and movement which were non-significant. The effects of flow variation and seasonal variation were confounded and will need to be further tested during future surveys.

2. There were significant spatial differences between the 2 river systems in terms of water clarity, edge smell and smell. The 6 other variables did not vary between river systems.

3. There were significant interactions (time x river) for water clarity, edge smell, smell, movement and wadeability.

The results were further analyzed graphically by plotting the mean values of the elder scores. Results suggested that overall there were no differences in the measured parameters between river systems. However there was an apparent interaction such that most scores were higher in the Yalakom River during the first 2 surveys in late July and October when the Lower Bridge River discharge was 15 and 1.8 cms respectively. These differences did not persist in the April and May surveys when Lower Bridge River flows were 5 and 13.5 cms respectively. Comparison of elder scores suggested that there were no consistent variations between elders, nor were there differences observed between sampling sites along latitudinal gradients.

The program broke new ground in 2013-2014 by demonstrating that it is feasible to assess spiritual and cultural attributes in a quantitative fashion. Future surveys to be conducted quarterly between 2014-2017 will replicate the approach to provide input to a long-term flow discharge decision for the Lower Bridge River.

Contents

Introduction

This project was undertaken between July 31, 2013 and May 7, 2014 to monitor some of the intangible but culturally significant attributes of higher flows in the Lower Bridge River and their influence on peoples' perceptions of river health. This work is designed to assess the influence of flow changes associated with the Water Use Plan (WUP) on biological components and human perceptions of the ecosystem (present project).

The structured decision-making framework developed by Compass Resource Management Ltd. and the former Bridge River Technical Working Group (TWG) addressed 9 different objectives or endpoints. Eight of these -- salmon, river health, riparian health, riverine birds, species of concern, financial impacts, learning, and stewardship – were measurable via empirical data or through judgments from members of the TWG (e.g., assessments of learning associated with different flows). One objective, concerned with changes in the smell, sound, movement, and interaction associated with different flows of water in the Lower Bridge River, is expressed through scales for which input is obtained only from members of the St'át'imc community. This report describes the project that St'át'imc Eco Resources undertook to monitor the impact of changing Bridge River flows on spiritual and cultural values. Unlike the original project design which involved comparative observations under 0, 3 and 6 cms Lower Bridge River flows, the flow regime did not depart from 6 cms during the study period, rendering the original project design inapplicable. Instead, the project was modified to include comparative observations from the Yalakom River, a tributary of the Bridge River with similar flow characteristics.

Background

The Bridge-Seton Consultative Committee (BRG WUP CC) and more recent Bridge River Technical Working group recommended that as part of the Water Use Plan the current flow testing program now underway at Terzaghi Dam be continued and expanded to a second flow level (6 cms) to empirically document the response of the ecosystem to instream flow changes in Lower Bridge River. A long term test flow release program was recommended with monitoring programs to empirically measure the environmental benefits that could arise from two alternative instream flow release regimes considered by the Bridge River Technical working group. The flow regimes differ in the relative shape of the delivered hydrograph and the annual water budget delivered (referred to as: 3 cms/y, 6 cms/y treatments). The 3 cms/y treatment occurred from August 2000 to April 2011, and the 6 cms/y treatment started in May 2011.

St'át'imc elders speak of the "spirit" or "voice" of the Lower Bridge River. They have observed that in moving from a water budget of 0 to 3 cms/y there were noticeable improvements in conditions for tangible outcomes like fish, wildlife, and riparian vegetation.

But in addition, and distinct from these, there have been improvements in the “spirit” or “voice” of the river. Across the range of proposed flows (including a doubling of the average flows, from 3 cms/y to 6 cms/y), it was anticipated that there is potential for additional beneficial change to these important spiritual and cultural values

To obtain information to better define the spiritual and cultural objective, during the TWG review process, input was collected from interviews with St’át’imc TWG members, from discussions with other members of the St’át’imc community, and from a workshop held in Lillooet to hear the views of invited St’át’imc elders and other individuals familiar with the river. From these meetings, four key components of Cultural and Spiritual Quality were defined:

Sound:

- The voice of the water (a variable defined by the observers individually)
- Birdsong (an integration of songbird presence)

Smell:

- The smell of the river itself (as determined by the observers individually)
- The ambient smell at water’s edge (as determined by the observers individually)

Movement:

- Movement of water (seasonally appropriate)
- Diversity of movement (pools/riffles)

Interaction (of people and water):

- Shore access (ability to easily walk to the shoreline)
- “Wade-ability” (the ability to walk in and/or across the river at certain locations)

Prior to the initiation of the first session of field work, a 9th variable, **water clarity**, was added to the survey.

These nine components clearly do not provide a universal definition of cultural or spiritual quality. They define the aspects of cultural and spiritual quality believed to be relevant for the evaluation by St’át’imc of a suite of alternative flow regimes on the Lower Bridge River, within the (average annual) range of 0 to 6 cms/y.

This monitoring program documented these spiritual and cultural values under the 6 cms/y flow regime. For comparative purposes, the Yalakom River was adopted as an unregulated control river. The Yalakom is the only tributary of the Lower Bridge River available to study for comparative purposes. This information on spiritual and cultural values will provide an important measure that will be used along other social and environmental measures in an overall evaluation of the 6 cms/y flow regime.

The Yalakom River has been described by Komori (1997):

> "The Yalakom is 56 km in length and provides the majority of accessible stream length for salmonids within the Bridge River system....the stream gradient in the Yalakom is generally very steep, averaging 2.5% over the 15 km most commonly utilized by anadromous salmonids below the partial barrier. The typical annual hydrograph closely follows the cycle of highland snowmelt runoff causing water temperatures to be lower than the regional averages. Discharge in the Yalakom River varies from 1.4 to 28.1 cms. The torrential nature of this stream, low average temperatures and limited fish habitat reduces the production potential in the Yalakom River"

Objectives and Scope

The objective of this program is to collect the information needed on the smell, sound, movement and interaction of the Lower Bridge River under the 6 cms/y flow regime that is needed to help evaluate the overall benefits of this flow regime.

Management Questions

The primary management question that will be addressed by this monitoring program is:

> *How does the smell, sound, movement and interaction (of people and water) on the Lower Bridge River under the 6 cms/y flow regime compare with that in the Yalakom River, an adjacent unregulated tributary of the Lower Bridge River?*

Hypotheses Tested by the Monitoring

The primary management question will be tested using the following hypothesis:

> H_O: *The smell, sound, movement and interaction (of people and water) on the Lower Bridge River under the 6 cms/y flow regime does not differ from the Yalakom River.*

Key Water Use Decision Affected

The key water use decision affected by this monitoring program is the long term flow regime for the Lower Bridge River. Information from BRGMON 16 monitoring program will be used along with other performance measures to evaluate the 6 cms/y flow regime.

Study Area

The Study Area for this project extends between Terzhagi Dam and the Bridge River/Fraser River confluence. Consistent with the other WUP monitoring projects on the Lower Bridge River, the Study Area was divided into 4 reaches utilizing the existing reach boundaries. Reaches 2, 3 and 4 were analysed (Figure 1).

Reach boundaries of the Lower Bridge River and the locations of the sampling sites are shown in the maps below. There were 6 observation sites in the Lower Bridge River (B1 - B6) and 4 observation sites in the Yalakom River (Y1 - Y4).

The annual hydrographs for the 2 study rivers are shown below.

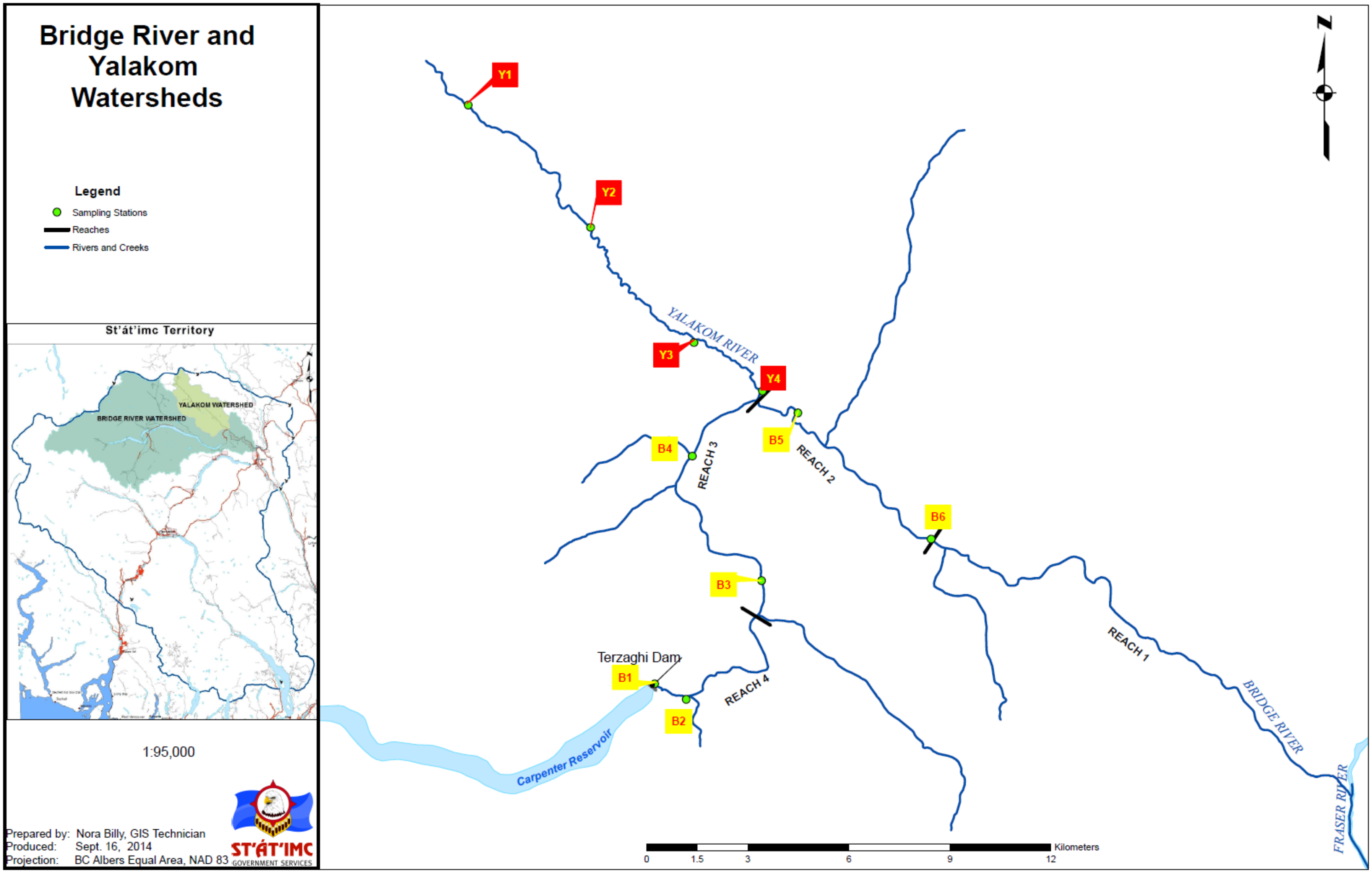


Figure 1. Location of sampling sites in the Yalakom and Lower Bridge Rivers.

The selection of the Yalakom River as an unregulated control river for conditions in the Lower Bridge River was predicated on the occurrence of similar hydrographs in the 2 systems (Figure 2).

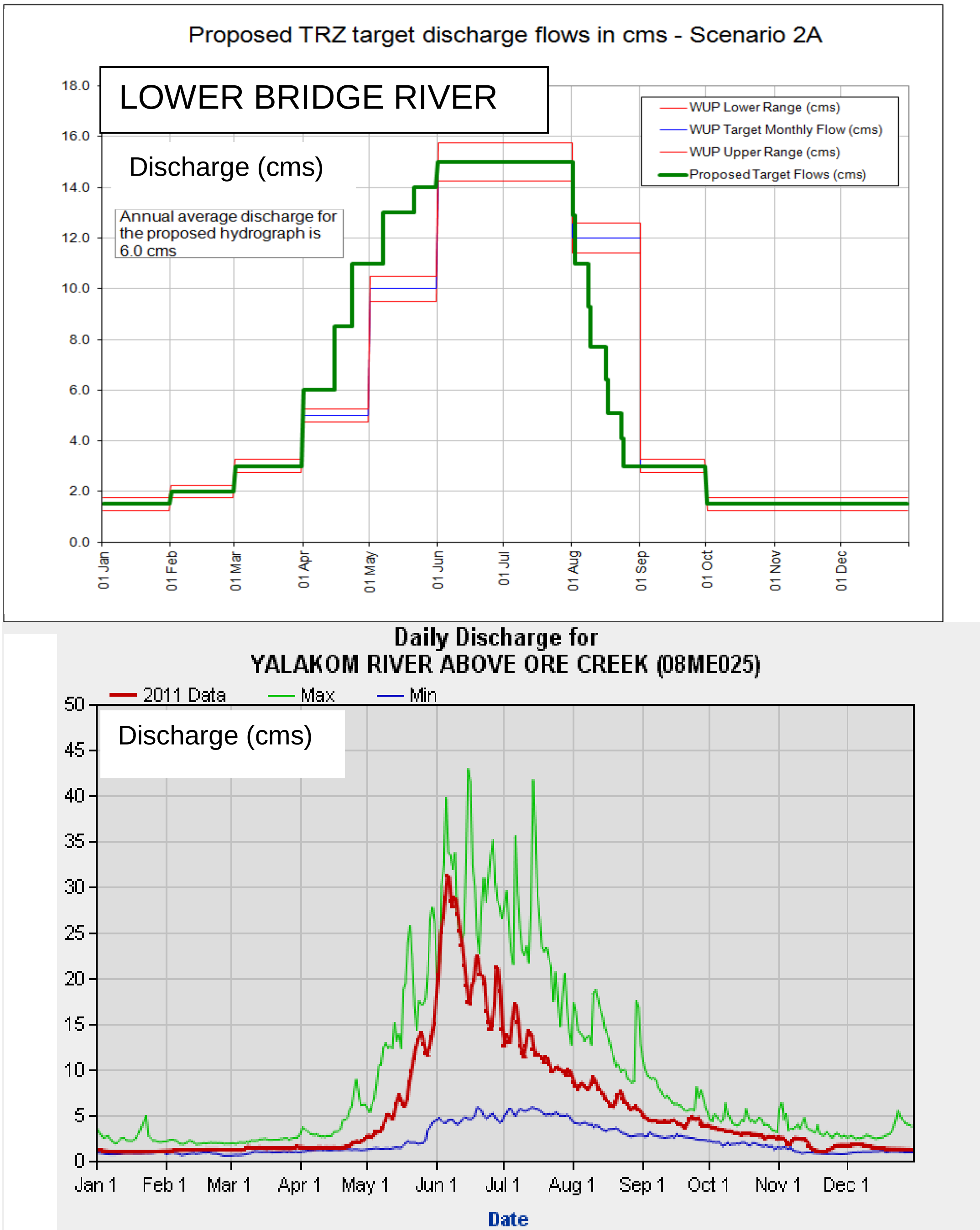


Figure 2. Comparison of the current flow hydrograph in the Lower Bridge River (upper - green line) with the flow discharge in the Yalakom during 2011 (lower; Source = Water Survey of Canada). The Lower Bridge River hydrograph results in an annual average flow of 6 cms, while the Yalakom flows at an annual average of around 4.11 cms covering 29 years spanning the years 1983-2011. The Yalakom discharge monitoring site is located at station Y2.

Approach and Methods

To maintain consistency and transparency in assessment, a ***Cultural and Spiritual Quality Scale*** and a protocol for measuring it was utilized. The approach involved:

- a committee of 6 St'át'imc elders to act as observers;
- observations to be taken four times per year under a range of test flows;
- observations to be taken at two Lower Bridge River sites per reach over reaches 4, 3 and 2;
- observations to be taken at four Yalakom sites;
- a simple and transparent scoring system for assigning scores to each component in each reach; and
- a plan for aggregating scores across observers, components, reaches and seasons.

Cultural and Spiritual Quality measures were evaluated at the conclusion of the monitoring program in terms of how measures change with respect to different flows. Results will be compared with those obtained from scales that address the other eight objectives utilized in the previous Structured Decision Making process for the Lower Bridge River[1]. Further, implementation of the program will be consistent over time, so as to enable the comparison of measures taken in different seasons or in different years.

A summary of the implementation plan is provided in the following table.

Who	6 members of the St'át'imc community. Continuity in membership is maintained so that consistency in the conduct of measurements is achieved.
When	Four times per year, at flows and seasons that represent a range of conditions: September (low flows, spawning fish present) February (low flows, winter conditions) April (moderate flows, spring conditions) June (peak flows, summer conditions, relatively low fish abundance/visibility). Sampling dates adopted in 2013-2014 will be replicated in successive surveys.
Where	Sampling sites are located on Figure 1. They include two sites per reach, for each of Lower Bridge River Reaches 4, 3 and 2 as well as 4 Yalakom River sites

[1] salmon, river health, riparian, riverine birds, species of concern, financial impacts, learning, and stewardship

Individual Reach Scoring	On the designated date and site, each observer will assign a score of 0 to 4 for each of the four components (sound, smell, movement, interaction as well as water clarity), where 0 = low quality, 1 = moderately low quality, 2 = moderate quality, 3 = moderately high quality and 4 = high quality.
Aggregating Across Observers	A simple average of scores across observers was used, assuming equal weighting of observers and components
Aggregating Across Reaches	This evaluation was analyzed statistically utilizing a General Linear Model
Aggregating Across Seasons and Years	This evaluation was analyzed statistically utilizing a General Linear Model
Supporting Documentation	Conditions at each site were recorded by video camera and still photography.

Scoring from this Cultural and Spiritual Quality scale will be used along with other social and environmental measures in an overall assessment of the 6 cms/y flow regime. These Cultural and Spiritual Quality results should not be interpreted as an overall or aggregate assessment of St'át'imc concerns. St'át'imc will be monitoring results for objectives relating to salmon, river health, riparian health, learning, and so forth in addition to monitoring results for cultural and spiritual quality. It is conceivable that there will be trade-offs among objectives – for example, one flow alternative may prove to be less beneficial for salmon but more beneficial from the perspective of cultural and spiritual quality, in which case choices will need to be made based on the preferred balance across objectives.

Schedule

The TORs indicate September (low flows, spawning fish present), February (low flows, winter conditions) April (moderate flows, spring conditions), and June (peak flows, summer conditions, relatively low fish abundance/visibility) as the preferred sampling schedule. The actual scheduled surveys during 2013-2014 were July 31-Aug.1'13, Oct. 7-8'13, April 7-8'14 and May 14-15'14. The timing of the surveys relative to the Lower Bridge River hydrograph, is shown on Figure 3.

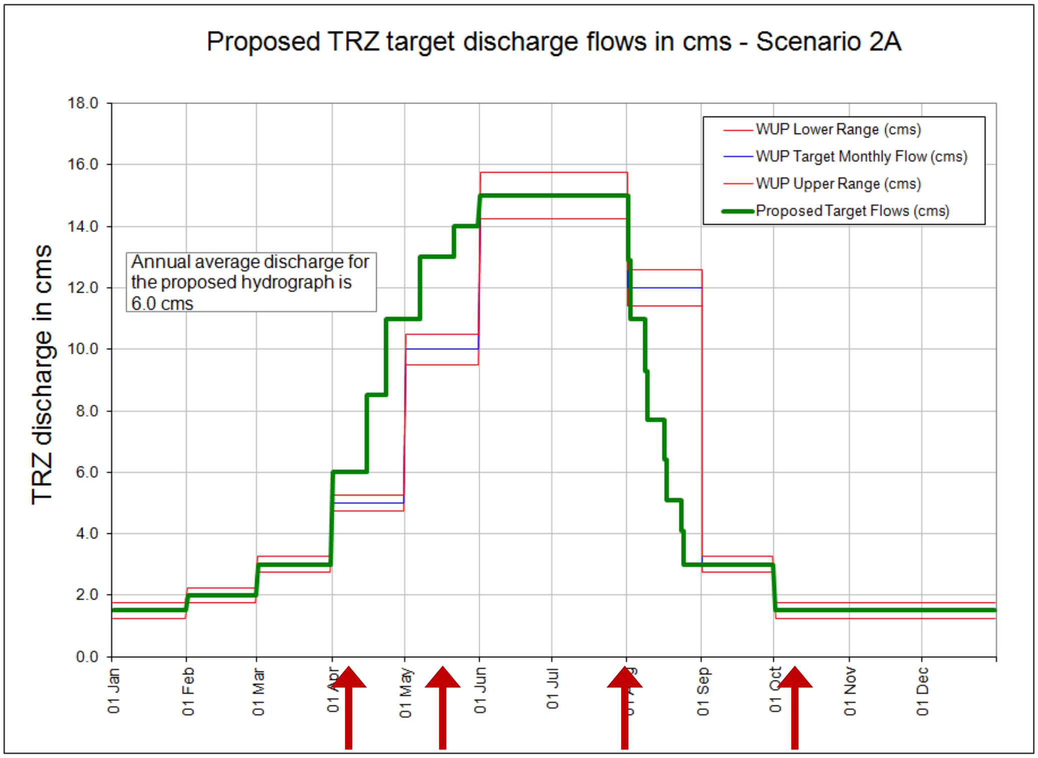


Figure 3. Timing of surveys (red arrows) in comparison with the Lower Bridge River hydrograph (green line).

The surveys bracketed the range of Lower Bridge River flows and included the following flow conditions:

	Lower Bridge River Flow	Approximate Yalakom Flow[2]
July 31-August 1	15 cms	10 cms
October 7-8	1.8 cms	3.5 cms
April 7-8	5 cms	2 cms
May 14-15	13.5 cms	7 cms

[2] extrapolated from Figure 2.

Results

Mean values for the different variable were plotted as histograms and analyzed statistically using a General Linear Model (GLM - Appendix 1). Comparisons of the different measurement variables obtained in the different rivers (aggregating across sampling sites) are shown in Figures 4a and 4b.

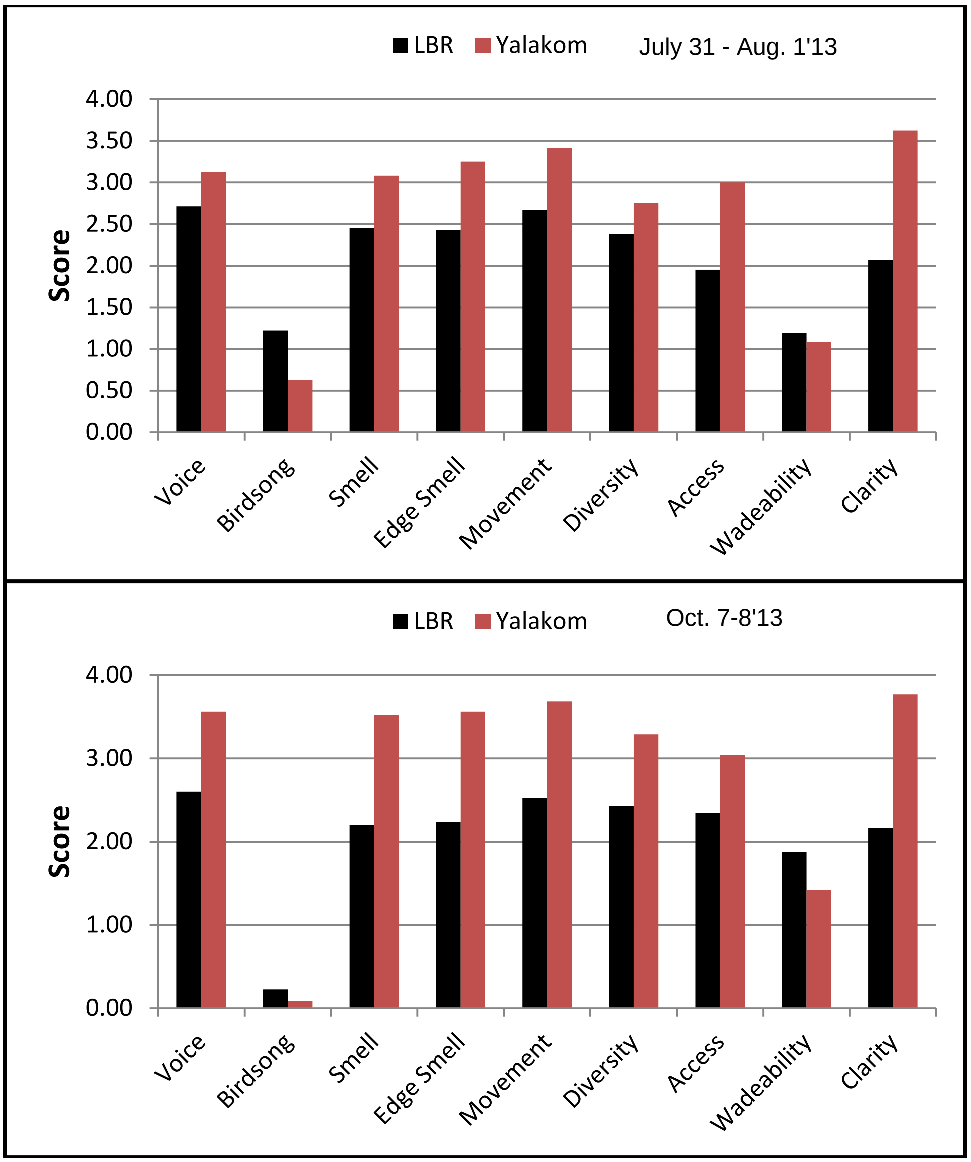


Figure 4a. Spiritual and cultural value scores in the Lower Bridge River and Yalakom River for July 31-Aug. 1'13 (upper) and Oct. 7-8'13 (lower).

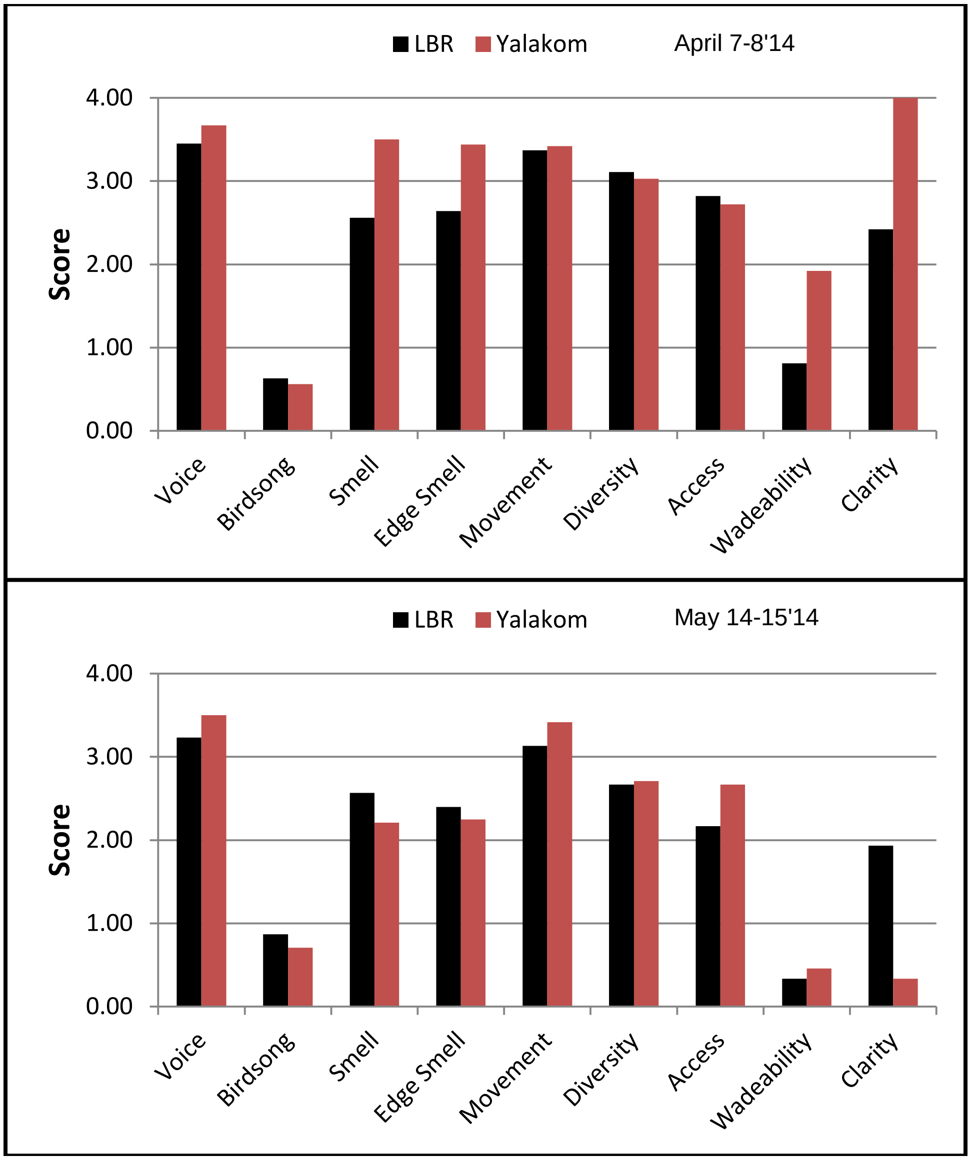


Figure 4b. Spiritual and cultural value scores in the Lower Bridge River and Yalakom River for April 7-8'14 (upper) and May 14-15'14 (lower).

Initially during the first 2 surveys most of the Yalakom scores were higher than those in the Lower Bridge River (Figure 4a). This trend wasn't evident during the latter 2 surveys and scores were generally similar with the exception of water clarity. There was high turbidity in the Yalakom during the final survey (Appendix 2) when the trend of higher water clarity in the Yalakom was reversed.

To obtain a qualitative evaluation of between observer variability in scoring trends, the different parameters were pooled and compared (Figures 5a and 5b).

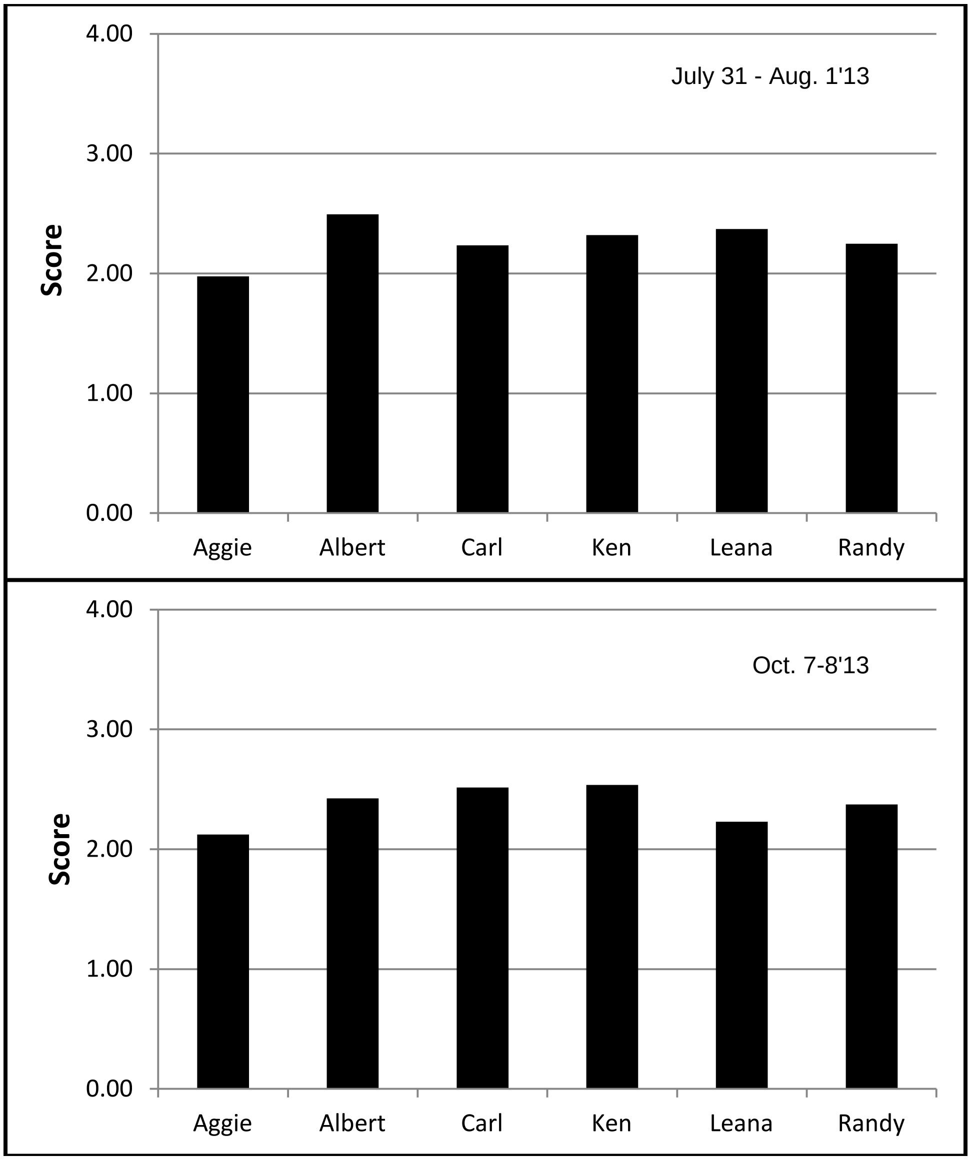


Figure 5a. Combined scores of cultural and spiritual value attributes obtained during July 31-Aug. 1'13 (upper) and Oct. 7-8'13 (lower).

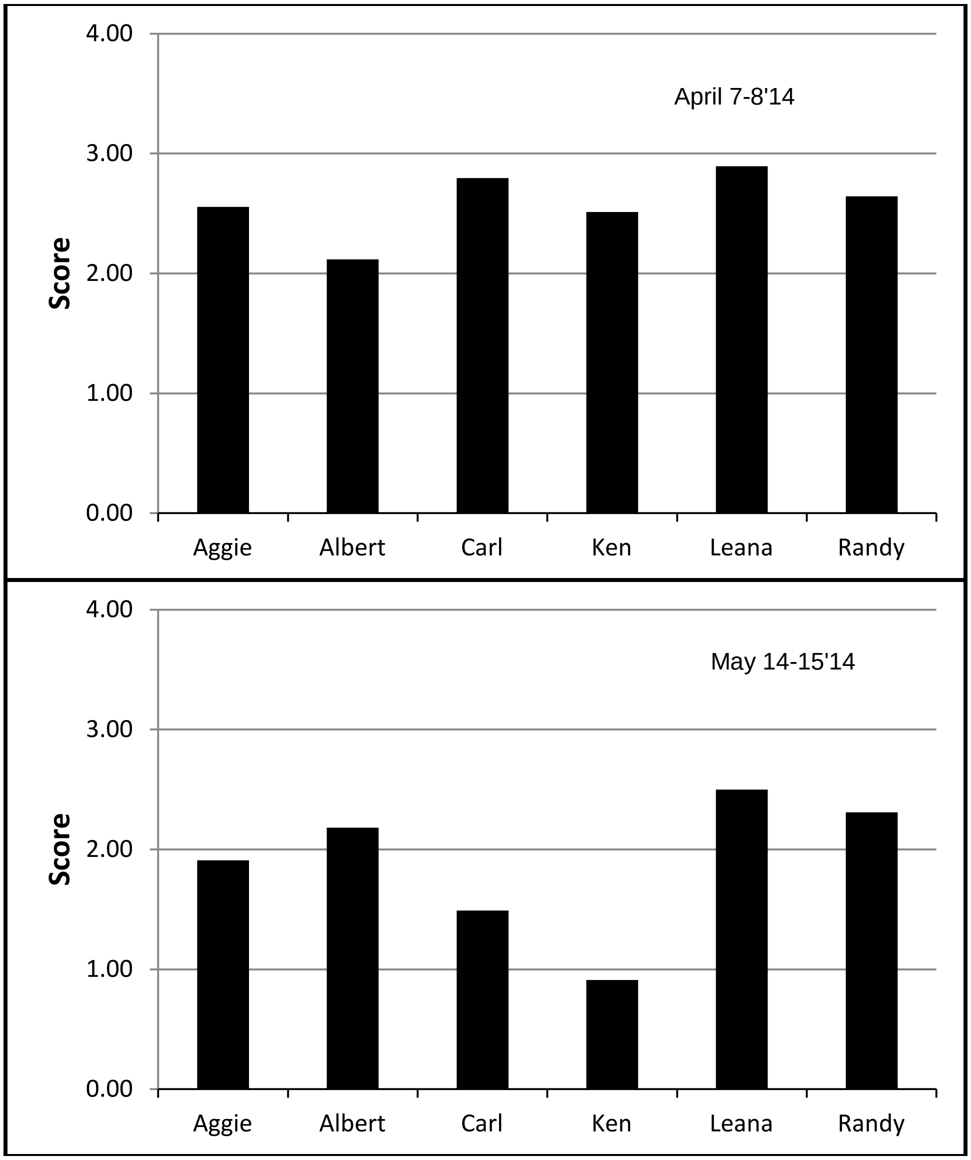


Figure 5b. Combined scores of cultural and spiritual value attributes obtained during April 7-8'14 (upper) and May 14-15'14 (lower).

During the first 2 surveys (Figure 5a), Aggie's scores were consistently lower than those of the other 5 observers. However, this trend didn't hold up in the latter 2 surveys when Aggie's scores were similar to those recorded by the other observers. During the final survey, Ken's scores were lower than the other observers. The inconsistency in observer scores suggests a high amount of intra-observer variability which masks any trends in inter-observer variability.

To evaluate whether there was a latitudinal gradient in observer scores extending from the uppermost through to the lowest positions in the surveys, site scores were combined and plotted in Figures 6a and 6b.

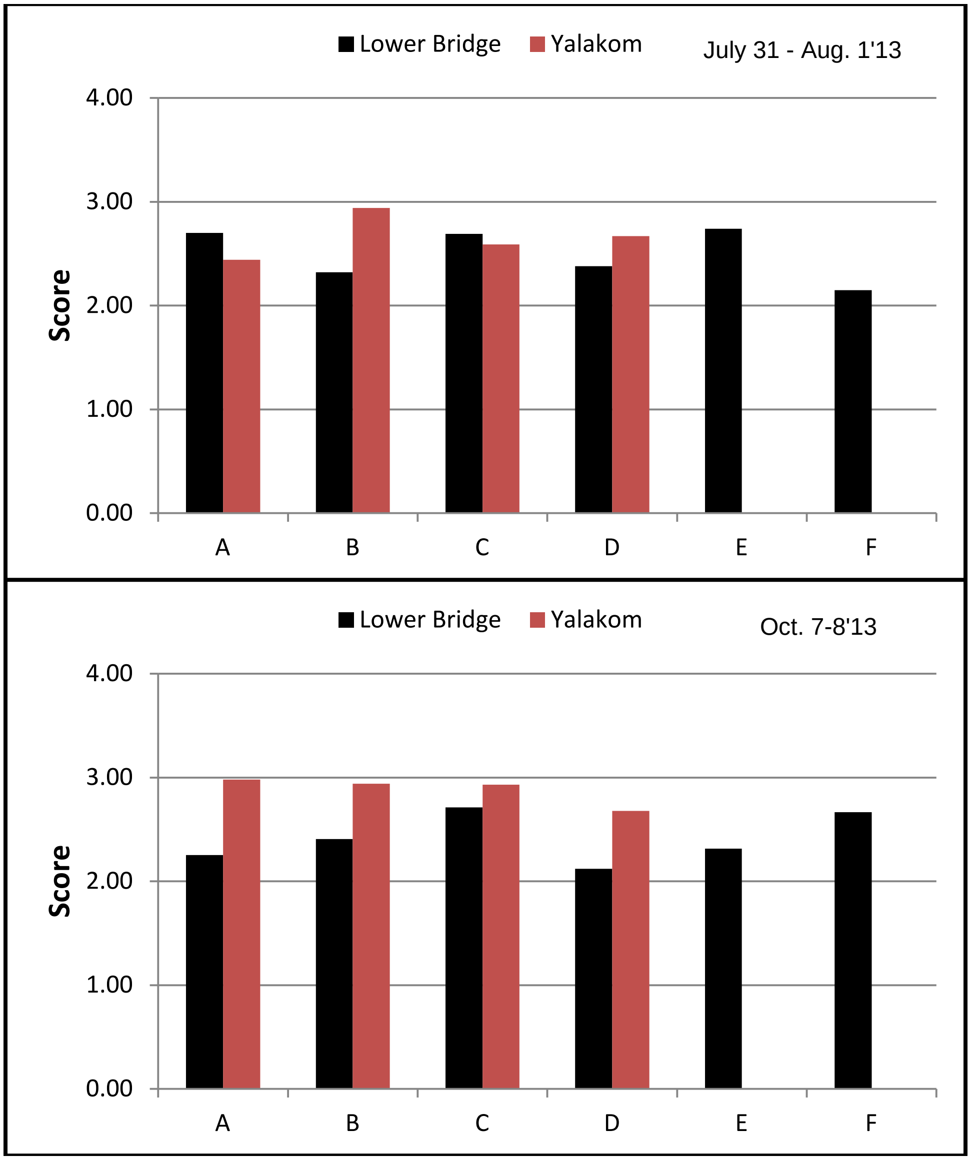


Figure 6a. Variation in observer scores at different positions in the Lower Bridge River and Yalakom River where A represents the upper most sites (B1 and Y1) and F represents the lowest site (B6). Upper chart shows July 31-Aug. 1'13 observations and lower chart depicts Oct. 7-8'13.

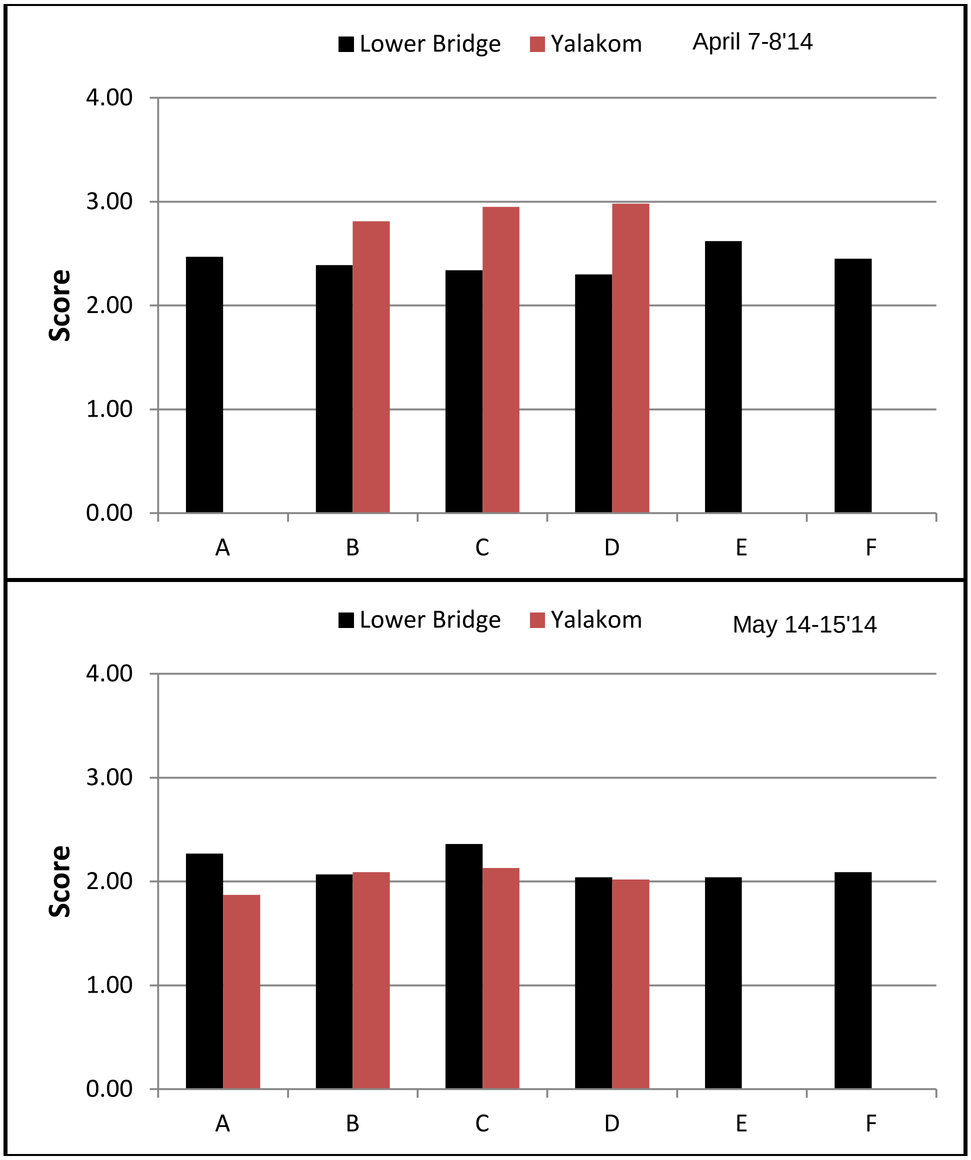


Figure 6b. Variation in observer scores at different positions in the Lower Bridge River and Yalakom River where A represents the upper most sites (B1 and Y1) and F represents the lowest site (B6). Upper chart shows April 7-8'14 observations and lower chart depicts May 14-15'14.

Comparing across the 4 surveys, there was no consistent difference in observer scores obtained during the different observations.

Statistical Analysis Results

Detailed results of the statistical analysis are provided in Appendix 1. The analysis was prepared by Dr. Eduardo Martins from the University of BC.

The challenge with the BRGMON 16 data analysis is the presence of a large number of factor variables (each with several levels) and research questions which relate to higher level interactions. In other words, there are too many parameters to estimate with the available data. In future years the collection of additional data will mitigate this challenge.

One way to substantially reduce the number of parameters to be estimated in the analyses is the adoption of a mixed model approach by treating elders and sites as random effects. That is, the analysis would assume the sampled elders and sites are a random sample of the "population" of elders and sites; this enables to variance parameters to be estimated that inform how much the intercept varies by elder and site. For BRGMON-16, 2 parameters (one variance for elders and another for sites) would be estimated, whereas if we treat elders and sites as fixed effects we would need to estimate 5 parameters for elders and 9 parameters for sites (i.e. n-1 parameters for each variable). Another advantage of the mixed model approach is that the inference is made for the full population of elders and potential sites, rather than to the specific elders and sites that were sampled.

The statistical models that were calculated are of the form:

Response ~ Intercept + River + Season + River*Season + (1|Elder) + (1|Site)

where (1|Elder) and (1|Site) are the random effects associated with Elder and Site, respectively.

During the analysis, the response variable (score 0-4) was treated as "continuous" and bounded between 0-4, making it relatively straightforward to fit a mixed model with a normal error distribution.

Appendix 1 provides the statistical outputs. Main results are summarized below:

Access: Interaction between Season and River is NOT significant at alpha = 0.05 and it was removed from the analysis. The main effects Season and River are NOT significant at alpha = 0.05. There was as much variation in scores among Elders as among Sites.

Bird Song: Interaction between Season and River is NOT significant at alpha = 0.05 and it was removed from the analysis. The main effect Season is significant at alpha = 0.05, but River is NOT. Multiple comparisons among Seasons showed that T1 differed significantly from T2 and T3, and T2 differed significantly from T4.

Clarity: Interaction between Season and River is significant at alpha = 0.05. Multiple comparisons among Seasons and River showed a number of differences AMONG sampling Seasons WITHIN a river. Differences BETWEEN rivers were always significant WITHIN a sampling Season -- scores were significantly higher for Yalakom

River at T1, T2, T3 and significantly higher for Bridge River at T4. There was as much variation in scores among Elders as among Sites.

Diversity: Interaction between Season and River is NOT significant at alpha = 0.05 and it was removed from the analysis. The main effect Season is significant at alpha = 0.05, but River is NOT. Multiple comparisons among sampling Seasons showed that T3 is only marginally significantly different from T4. Variability in scores among Elders is about nine times greater as among Sites.

Edge Smell: Interaction between Season and River is significant at alpha = 0.05. Multiple comparisons among sampling Seasons and River showed three significant differences AMONG sampling Times WITHIN the Yalakom River, but none WITHIN the Bridge River. Differences BETWEEN rivers were significant WITHIN sampling times T2 and T3 -- scores were significantly higher for Yalakom River during these two sampling seasons. There was negligible variation in scores due to Elders and Sites. This means that virtually no variability in scores is due to variation among Elders or Sites after accounting for Season, River and their interaction.

Movement: Interaction between Season and River is significant at alpha = 0.05. Multiple comparisons among sampling Season and River showed that the only significant difference is between the Bridge and Yalakom Rivers during sampling time T2. There was about as much variation in scores among Elders as among Sites.

Smell: Interaction between Season and River is significant at alpha = 0.05. Multiple comparisons among Season and River showed three significant differences AMONG sampling Seasons WITHIN the Yalakom River, but none WITHIN the Bridge River. Differences BETWEEN rivers were significant WITHIN sampling Times T2 and T3 -- scores were significantly higher for Yalakom River at these two sampling times. There was some variability in score related to Elders, but negligible variation in scores due to Sites. This means that virtually no variability in scores is due to variation among Sites after accounting for sampling Season, River and their interaction.

Voice: Interaction between Time and River is NOT significant at alpha = 0.05 and it was removed from the analysis. The main effect Time is significant at alpha = 0.05, but River is NOT. Multiple comparisons among Seasons showed that T1 differed significantly from T3. That is, scores were significantly higher at T3 than at T1. Variability in scores among Elders was about two times as great as among Sites.

Wadeability: Interaction between Season and River is significant at alpha = 0.05. Multiple comparisons among sampling Season and River showed a number of significant differences AMONG sampling Seasons WITHIN both rivers. No significant differences

BETWEEN rivers WITHIN Seasons were detected. There was about twice as much variation in scores among Sites as among Elders

Table 1 summarizes the main statistical results for the Year 1 data set.

Table 1. Summary of statistical results (✹ indicates significant at alpha = 0.05; ns = not significant)

Parameter	Season	River	Season x River	Interpretation
Access	ns	ns	ns	There was as much variation in scores among Elders as among Sites.
Birdsong	✹	ns	ns	There were temporal differences in birdsong observations such that T1 differed significantly from T2 and T3, and T2 differed significantly from T4.
Clarity	✹	✹	✹	Differences BETWEEN rivers were always significant WITHIN a sampling Season -- scores were significantly higher for Yalakom River at T1, T2, T3 and significantly higher for Bridge River at T4.
Diversity	✹	ns	ns	Comparisons among sampling Seasons showed that T3 is only marginally significantly different from T4. Variability in scores among Elders is about nine times greater as among Sites.
Edge Smell	✹	✹	✹	Comparisons among sampling Season and River showed three significant differences AMONG sampling Seasons WITHIN the Yalakom River, but none WITHIN the Bridge River. Differences BETWEEN rivers were significant WITHIN sampling seasons T2 and T3 -- scores were significantly higher for Yalakom River at these two sampling times.
Smell	✹	✹	✹	Comparisons among sampling Season and River showed three significant differences AMONG sampling Times WITHIN the Yalakom River, but none WITHIN the Bridge River. Differences BETWEEN rivers were significant WITHIN sampling Seasons T2 and T3 -- scores were significantly higher for Yalakom River during these two sampling seasons.
Movement	ns	ns	✹	Comparisons among sampling Season and River showed that the only significant difference is between the Bridge and Yalakom Rivers at sampling time T2.
Voice	✹	ns	ns	Comparisons among sampling Seasons showed that T1 differed significantly from T3. That is, scores were significantly higher at T3 than at T1.
Wadeability	✹	ns	✹	No significant differences BETWEEN rivers WITHIN sampling Seasons were detected.

Discussion

The main objective of the BRGMON-16 monitoring program is to evaluate whether there are differences in the spiritual and cultural values associated with different seasonal flow releases in 2 different river systems: the Lower Bridge River and the Yalakom. The program took a novel approach to evaluate the practicality of assessing cultural and spiritual attributes associated with different water flow discharge levels. St'át'imc elders participated as evaluators of nine different parameters related to spiritual and cultural attributes. The program has demonstrated that the approach can potentially yield valuable information for establishing a long-term flow level in the Lower Bridge River. A review of the available data to support a future flow decision will be undertaken in 2015 and will integrate the results of BRGMON-16 with the other Lower Bridge River monitoring programs that are presently underway.

Main results obtained in 2013-2014 are discussed below.

Histogram Plots

The following trends were evident in the histograms shown in Figures 4-6:

1. During the first 2 surveys, 7 out of 9 parameter scores were higher in the Yalakom than in the Lower Bridge River (Figure 4a). During the second 2 surveys, parameter scores were similar in the Yalakom and in the Lower Bridge River (Figure 4b). There was thus an interaction between the parameter scores and sampling dates.
2. There was no consistent trend in the relative scoring by the 6 observers (Figures 5a-5b).
3. There was no consistent trend in the scores between the different stations (Figure 6a-6b).

These preliminary results from Year 1 will be reevaluated in subsequent years to determine whether these trends are stable over time.

Summary of Statistical Results

The main results from the statistical analysis are shown in Table 1.

The results of the histogram analysis and the statistical analysis were consistent with each other, which is to be expected since the underlying data are the same.

For ACCESS, the absence of any effects may reflect that there was little impact of flow variations on the ability of the observers to approach the river banks. The flood plain of the Lower Bridge River was formed by the previously unimpounded flows of the river which averaged around 100 cms and reached peak flows of 700-800 cms. Given that present-day Lower Bridge River peak flows reach only 15 cms during summer periods, the existing river has a relatively broad flood plain adjacent to the sampling sites, making ACCESS relatively insensitive to observer perceptions and scores over the range of 1.5 - 15 cms.

BIRDSONG observations indicated no significant differences between the 2 rivers with a time effect such that higher values were recorded during T1 on Sep. 30-Oct. 1, 2013. These results likely reflect the seasonal distribution of songbirds in the Lower Bridge River and Yalakom watersheds.

CLARITY results (i.e. water clarity), were higher in the Yalakom than in the Lower Bridge River during T1-T3 but lower during T4 (May 14-15'14). This result accurately reflected the clarity conditions during the 4 surveys and for unknown reasons, water clarity was greatly reduced in the Yalakom during T4. Below are photos comparing the water clarity in the 2 rivers on May 14-15'14.

Lower Bridge River (B3)

Yalakom River (Y4)

DIVERSITY in flow movement was highest during T3 (April 7-8'14) when flows were at an intermediate level (5 cms). This may have reflected the river hydrodynamics which create a diversity of flow characteristics at intermediate flows in comparison with relatively high or low flows which may be more laminar and less heterogeneous. However the result should be interpreted with caution since it was only marginally significant and future observations and data collection are needed to clarify this observation.

EDGE SMELL and SMELL generated identical results varying between rivers and sampling time. There was also an interaction between rivers and sampling times. Differences among sampling times occurred in the Yalakom but not in the Lower Bridge River. Highest smell scores were obtained in the Yalakom during time periods T2 and T3 (Oct. 7-8'13 and April 7-8'14, respectively).

MOVEMENT did not vary by sampling date or river, however there was a significant interaction such that the Lower Bridge River and the Yalakom were significantly different at T2 (Oct. 7-8'13) under low flow conditions - 1.8 cms in the Lower Bridge River. This difference could be due to the underlying river bed differences generating seasonally different flow features under relatively low discharges.

VOICE of the river showed higher scores at T3 (April 7-8'14) than at T1 (July 31-Aug. 1'14) when flows were 5 cms and 15 cms, respectively. This result could reflect that medium flow levels (i.e. 5 cms) may have a stronger spiritual quality than higher flow levels. This hypothesis will be tested when the BRGMON 16 surveys are replicated.

WADEABILTY scores showed an interaction between time and river with the Yalakom River showing higher wadeability at T3 (April 7-8'14) when flows were the lowest (1.5 cms in the Lower Bridge River). Overall, wadeability didn't vary between rivers and significant differences were obtained at different sampling dates when flow levels varied between 1.5 cms and 15 cms. This result is consistent with an inverse relationship between wadeability and flow level.

There are a few examples of projects which have integrated spiritual and cultural values in water resource management, notably in Australia (Collings 2012). The latter study presents the results of 6 pilot projects involving spiritual and cultural value components (Table 2). The focus of these projects is integration, while the focus of BRGMON 16 is on the measurement of variables which were selected due to their close alignment with spiritual and cultural values. Overall Collings (2012) concluded:

> *"Integrating the cultural and spiritual values of Indigenous people into water quality management requires careful and considered planning and follow-up, as well as due respect for Indigenous law, custom and traditional knowledge."*

Novel results were obtained by the BRGMON 16 program during 2013-2014. Elders fully appreciated the significance of the project and understood the 0-4 scoring system that was adopted during the surveys. The project generated a unique data set that was amenable to standard methods of analysis and yielded interpretable results. While the data set was extensive, it is relatively modest from a statistical perspective and future surveys are needed to replicate and increase the statistical power of the data analysis.

Table 2. Key findings from Australian case studies undertaken to integrate spiritual and cultural values into water quality management. Source: Collings (2012)

Case Study	Key Findings
Adelaide Coastal Water Quality Improvement Plan, South Australia	During the development phase of the draft ACWQIP, the South Australia EPA reports that stakeholders have been generally satisfied with the consultation and engagement processes. A key lesson is to ensure early engagement with Kaurna People to help achieve effective outcomes. The correct people need to be identified from the outset of such processes.
Police Lagoons Conceptual Model, Queensland	The conceptual models for Police Lagoons integrate science with cultural, spiritual and ecological values in order to inform integrated natural resource management of the lagoons. The objective is to support community goals to maintain and improve the wetland's values.
Engaging with and incorporating the views of the Queensland Far South West Aboriginal Natural Resource Management Group in water quality management planning, Queensland	The Far South West Aboriginal Natural Resource Management Group's values for the waters within the region will be incorporated into the future statutory environmental values and water quality objectives for the waters of south west Queensland under the *Environmental Protection (Water) Policy 2009*. The establishment of water quality objectives to protect aquatic ecosystem values is considered to generally afford protection of the cultural and spiritual values for the waters of the region.
Prioritising rock-holes of aboriginal and ecological significance in the Gawler Ranges, South Australia	One of the lessons learnt is that for projects like this, with a range of stakeholders from diverse backgrounds, it is very important to develop, implement and maintain a comprehensive communication/stakeholder engagement strategy prior to project initiation that continues throughout the project including follow-up.
Recognising indigenous cultural and spiritual values in maintaining river health of the Daly River, Northern Territory	Indigenous people possess intimate knowledge of their local environment and have complex value systems in connection with water and biodiversity. This knowledge is integral to holistic management planning to maintain river and ecosystem health.
Kungun Ngarrindjeri Yunnan engagement with natural resource management	Protocols of engagement provide an important framework to recognise the values and status of Indigenous people in managing natural resources. The KNY Agreement provides a framework to assist and guide interactions with Ngarrindjeri people and for the most culturally appropriate and sensitive way of doing business on Ngarrindjeri traditional lands and waters.

References

Collings, N. 2012. Indigenous cultural and spiritual values in water quality planning. Australian Government. Dept. of Sustainability, Environment, Water, Population and Communities.

Komori, V. 1997. Strategic fisheries overview for the Bridge/Seton Habitat Management Area. Dept. of Fisheries and Oceans. Fraser River Action Plan. Vancouver, B.C. 88p.

Appendix 1. Statistical Analysis Results

SUMMARY for ACCESS

Interaction between Time and River is NOT significant at alpha = 0.05 and it was removed from the analysis. The main effects Time and River are NOT significant at alpha = 0.05 either (TABLE 1). Model estimates are shown in TABLES 2 and 3.

There was as much variation in scores among Elders as among Sites (see SD in TABLE 3)

An estimate of how much the Intercept (equivalent to mean score) changes with Elder and Site is provided in TABLE 4. Positive and negative values mean the score given by Elders and for different Sites are consistently above or below average (i.e. Intercept), respectively.

TABLE 1. TEST OF SIGNIFICANCE OF MAIN EFFECTS USING ANOVA (ALL P > 0.05)

	numDF	denDF	F-value	p-value
(Intercept)	1	223	98.73772	<.0001
Time	3	223	2.44646	0.0647
River	1	223	1.76513	0.1853

TABLE 2. SUMMARY OF COEFFICIENT ESTIMATES FOR FIXED EFFECTS

Fixed effects: Score ~ Time + River

	Value	Std.Error	DF	t-value	p-value
(Intercept)	2.4261629	0.3082899	223	7.869744	0.0000
TimeT2	0.2916667	0.1744374	223	1.672042	0.0959
TimeT3	0.2531135	0.1804624	223	1.402583	0.1621
TimeT4	-0.1258522	0.1799922	223	-0.699209	0.4851
RiverYalakom	0.3512594	0.2842848	223	1.235590	0.2179

TABLE 3. SUMMARY OF STANDARD DEVIATION ESTIMATES FOR RANDOM EFFECTS

Random effects:

Groups	Std. Dev
Elder(Int)	0.3723
Site(In)	0.3911
Residual	0.9554

TABLE 4. DEVIATION OF INTERCEPT BY ELDER AND SITE

ELDER	
Aggie	0.005671427
Albert	-0.433078054
Carl	-0.136922154
Ken	0.607829611
Leana	0.060515112
Randy	-0.104015943

SITE	
B1	0.42003539
B2	-0.27043374
B3	0.50634403
B4	-0.25317201
B5	-0.13233992
B6	-0.27043374
Y1	0.08393259
Y2	0.29461230
Y3	0.07769845
Y4	-0.45624334

SUMMARY for BIRD SONG

Interaction between Time and River is NOT significant at alpha = 0.05 and it was removed from the analysis. The main effect Time is significant at alpha = 0.05, but River is NOT. Model estimates are shown in TABLES 2 and 4.

Multiple comparisons among sampling Times showed that T1 differed significantly from T2 and T3, and T2 differed significantly from T4 (TABLE 3).

Variability in scores among Sites was about three times as greater as among Elders (see SD in TABLE 4).

An estimate of how much the Intercept (equivalent to mean score) changes with Elder and Site is provided in TABLE 5. Positive and negative values mean the score given by Elders and for different Sites are consistently above or below average (i.e. Intercept), respectively.

TABLE 1. TEST OF SIGNIFICANCE OF MAIN EFFECTS USING ANOVA (ONLY TIME IS SIGNIFICANT)

	numDF	denDF	F-value	p-value	
(Intercept)	1	222	32.48779	<.0001	
Time	3	222	11.27678	<.0001	*
River	1	222	1.34930	0.2466	

TABLE 2. SUMMARY OF COEFFICIENT ESTIMATES FOR FIXED EFFECTS

Fixed effects: Score ~ Time + River

	Value	Std.Error	DF	t-value	p-value	
(Intercept)	1.2346829	0.2789620	222	4.425990	0.0000	
TimeT2	-0.9107837	0.1616832	222	-5.633138	0.0000	*
TimeT3	-0.5433751	0.1673532	222	-3.246876	0.0013	*
TimeT4	-0.2853929	0.1665866	222	-1.713180	0.0881	
RiverYalakom	-0.3305812	0.3107505	222	-1.063816	0.2886	

Table 3. MULTIPLE COMPARISON AMONG TIMES USING TUKEY'S TEST

Linear Hypotheses:

	Estimate	Std. Error	z value	Pr(>|z|)	
T1 - T2 == 0	0.9108	0.1617	5.633	< 0.001	*
T1 - T3 == 0	0.5434	0.1674	3.247	0.00651	*
T1 - T4 == 0	0.2854	0.1666	1.713	0.31663	
T2 - T3 == 0	-0.3674	0.1666	-2.205	0.12173	
T2 - T4 == 0	-0.6254	0.1659	-3.770	< 0.001	*
T3 - T4 == 0	-0.2580	0.1717	-1.502	0.43589	

TABLE 4. SUMMARY OF STANDARD DEVIATION ESTIMATES FOR RANDOM EFFECTS

Random effects:

Groups	Std. Dev
Elder(Int)	0.1763
Site(Int)	0.4436
Residual	0.8817

TABLE 5. DEVIATION OF INTERCEPT BY ELDER AND SITE

ELDER

Aggie	-0.14109338
Albert	0.02529515
Carl	-0.03169945
Ken	0.05461952
Leana	-0.13327953
Randy	0.22615768

SITE

B1	0.88344201
B2	-0.11295506
B3	0.14132908
B4	-0.37814997
B5	-0.08130480
B6	-0.45236126
Y1	-0.18664036
Y2	-0.04512078
Y3	-0.11667693
Y4	0.34843807

SUMMARY for CLARITY

Interaction between Time and River is significant at alpha = 0.05. Model estimates are shown in TABLES 2 and 4.

Multiple comparisons among sampling Time and River showed a number of differences AMONG sampling Times WITHIN a river (TABLE 3).

Differences BETWEEN rivers were always significant WITHIN a sampling Time -- scores were significantly higher for Yalakom River at T1, T2, T3 and significantly higher for Bridge River at T4 (TABLE 3).

There was as much variation in scores among Elders as among Sites (see SD in TABLE 4)

An estimate of how much the Intercept (equivalent to mean score) changes with Elder and Site is provided in TABLE 5. Positive and negative values mean the score given by Elders and for different Sites are consistently above or below average (i.e. Intercept), respectively.

TABLE 1. TEST OF SIGNIFICANCE OF MAIN EFFECTS USING ANOVA (INTERACTION IS SIGNIFICANT)

	numDF	denDF	F-value	p-value	
(Intercept)	1	219	104.90069	<.0001	
Time	3	219	5.42982	0.0013	
River	1	219	22.16692	<.0001	*
Time:River	3	219	58.45586	<.0001	*

TABLE 2. SUMMARY OF COEFFICIENT ESTIMATES FOR FIXED EFFECTS

Fixed effects: Score ~ Time * River

	Value	Std.Error	DF	t-value	p-value	
(Intercept)	2.4166667	0.2359541	219	10.242104	0.0000	
TimeT2	0.1252756	0.1636798	219	0.765370	0.4449	
TimeT3	0.0000000	0.1624642	219	0.000000	1.0000	
TimeT4	-0.5257851	0.1715984	219	-3.064045	0.0025	*
RiverYalakom	1.2083333	0.2566458	219	4.708176	0.0000	*
TimeT2:RiverYalakom	0.0205577	0.2576490	219	0.079790	0.9365	
TimeT3:RiverYalakom	0.3697964	0.2724580	219	1.357260	0.1761	
TimeT4:RiverYalakom	-2.7658816	0.2627507	219	-10.526638	0.0000	*

TABLE 3. MULTIPLE COMPARISON AMONG TIMES AND RIVER USING TUKEY'S TEST

Linear Hypotheses:

	Estimate	Std. Error	z value	Pr(>|z|)	
T1.Bridge - T2.Bridge == 0	-1.253e-01	1.637e-01	-0.765	0.99221	
T1.Bridge - T3.Bridge == 0	1.656e-15	1.625e-01	0.000	1.00000	
T1.Bridge - T4.Bridge == 0	5.258e-01	1.716e-01	3.064	0.03030	*
T2.Bridge - T3.Bridge == 0	1.253e-01	1.637e-01	0.765	0.99221	
T2.Bridge - T4.Bridge == 0	6.511e-01	1.728e-01	3.767	0.00248	*
T3.Bridge - T4.Bridge == 0	5.258e-01	1.716e-01	3.064	0.03041	*

T1.Yalakom - T2.Yalakom == 0	-1.458e-01	1.990e-01	-0.733	0.99403
T1.Yalakom - T3.Yalakom == 0	-3.698e-01	2.187e-01	-1.691	0.62440
T1.Yalakom - T4.Yalakom == 0	3.292e+00	1.990e-01	16.543	< 0.001 *
T2.Yalakom - T3.Yalakom == 0	-2.240e-01	2.187e-01	-1.024	0.95869
T2.Yalakom - T4.Yalakom == 0	3.438e+00	1.990e-01	17.276	< 0.001 *
T3.Yalakom - T4.Yalakom == 0	3.661e+00	2.187e-01	16.740	< 0.001 *
T1.Bridge - T1.Yalakom == 0	-1.208e+00	2.566e-01	-4.708	< 0.001 *
T2.Bridge - T2.Yalakom == 0	-1.229e+00	2.574e-01	-4.774	< 0.001 *
T3.Bridge - T3.Yalakom == 0	-1.578e+00	2.722e-01	-5.797	< 0.001 *
T4.Bridge - T4.Yalakom == 0	1.558e+00	2.625e-01	5.933	< 0.001 *

TABLE 4. SUMMARY OF STANDARD DEVIATION ESTIMATES FOR RANDOM EFFECTS

Random effects:

Groups	Std. Dev
Elder(Int)	0.2944
Site(In)	0.2809
Residual	0.6893

TABLE 5. DEVIATION OF INTERCEPT BY ELDER AND SITE

ELDER	
Aggie	-0.42743537
Albert	0.16829773
Carl	0.19077822
Ken	-0.21225785
Leana	0.29216350
Randy	-0.01154623

SITE	
B1	-0.32418342
B2	-0.04887080
B3	0.36461097
B4	-0.37621054
B5	0.12341327
B6	0.26124053
Y1	-0.01561080
Y2	0.12178541
Y3	0.02185814
Y4	-0.12803276

SUMMARY for DIVERSITY

Interaction between Time and River is NOT significant at alpha = 0.05 and it was removed from the analysis. The main effect Time is significant at alpha = 0.05, but River is NOT. Model estimates are shown in TABLES 2 and 4.

Multiple comparisons among sampling Times showed that T3 is only marginally significantly different from T4 (TABLE 3).

Variability in scores among Elders is about nine times as greater as among Sites (see SD in TABLE 4).

An estimate of how much the Intercept (equivalent to mean score) changes with Elder and Site is provided in TABLE 5. Positive and negative values mean the score given by Elders and for different Sites are consistently above or below average (i.e. Intercept), respectively.

TABLE 1. TEST OF SIGNIFICANCE OF MAIN EFFECTS USING ANOVA (ONLY TIME IS SIGNIFICANT)

	numDF	denDF	F-value	p-value	
(Intercept)	1	223	325.2276	<.0001	
Time	3	223	3.2127	0.0238	*
River	1	223	0.8149	0.3676	

TABLE 2. SUMMARY OF COEFFICIENT ESTIMATES FOR FIXED EFFECTS

Fixed effects: Score ~ Time + River

	Value	Std.Error	DF	t-value	p-value	
(Intercept)	2.7288028	0.2103071	223	12.975327	0.0000	
TimeT2	0.2500000	0.1413259	223	1.768960	0.0783	
TimeT3	0.3226020	0.1454041	223	2.218657	0.0275	*
TimeT4	-0.0599467	0.1458143	223	-0.411117	0.6814	
RiverYalakom	0.0946596	0.1074533	223	0.880937	0.3793	

Table 3. MULTIPLE COMPARISON AMONG TIMES USING TUKEY'S TEST

Linear Hypotheses:

	Estimate	Std. Error	z value	Pr(>|z|)
T1 - T2 == 0	-0.25000	0.14133	-1.769	0.2883
T1 - T3 == 0	-0.32260	0.14540	-2.219	0.1181
T1 - T4 == 0	0.05995	0.14581	0.411	0.9766
T2 - T3 == 0	-0.07260	0.14540	-0.499	0.9592
T2 - T4 == 0	0.30995	0.14581	2.126	0.1448
T3 - T4 == 0	0.38255	0.15002	2.550	0.0525

TABLE 4. SUMMARY OF STANDARD DEVIATION ESTIMATES FOR RANDOM EFFECTS

Random effects:

Groups	Std. Dev
Elder(Int)	0.2843
Site(Int)	0.0326
Residual	0.7741

TABLE 5. DEVIATION OF INTERCEPT BY ELDER AND SITE

ELDER	
Aggie	-0.47725645
Albert	0.09371381
Carl	-0.10020062
Ken	0.23167751
Leana	0.17989800
Randy	0.07216776

SITE	
B1	-0.0105210903
B2	0.0022748303
B3	0.0056870758
B4	-0.0036965993
B5	0.0039809531
B6	0.0022748303
Y1	-0.0033773220
Y2	-0.0065387018
Y3	0.0002741656
Y4	0.0096418583

SUMMARY for EDGE SMELL

Interaction between Time and River is significant at alpha = 0.05. Model estimates are shown in TABLES 2 and 4.

Multiple comparisons among sampling Time and River showed three significant differences AMONG sampling Times WITHIN the Yalakom River, but none WITHIN the Bridge River (TABLE 3).

Differences BETWEEN rivers were significant WITHIN sampling Times T2 and T3 -- scores were significantly higher for Yalakom River at these two sampling times (TABLE 3).

There was negligible variation in scores due to Elders and Sites (note small SDs in TABLE 4). This means that virtually no variability in scores is due to variation among Elders or Sites after accounting for sampling Time, River and their interaction.

An estimate of how much the Intercept (equivalent to mean score) changes with Elder and Site is provided in TABLE 5. Positive and negative values mean the score given by Elders and for different Sites are consistently above or below average (i.e. Intercept), respectively. Again, note very small values.

TABLE 1. TEST OF SIGNIFICANCE OF MAIN EFFECTS USING ANOVA (INTERACTION IS SIGNIFICANT)

	numDF	denDF	F-value	p-value	
(Intercept)	1	219	373.3845	<.0001	
Time	3	219	1.3389	0.2626	
River	1	219	3.2300	0.0737	
Time:River	3	219	4.2620	0.0060	*

TABLE 2. SUMMARY OF COEFFICIENT ESTIMATES FOR FIXED EFFECTS

Fixed effects: Score ~ Time * River

	Value	Std.Error	DF	t-value	p-value	
(Intercept)	2.8333333	0.2136596	219	13.260971	0.0000	
TimeT2	-0.2333333	0.2088405	219	-1.117280	0.2651	
TimeT3	-0.1944444	0.2073646	219	-0.937694	0.3494	
TimeT4	-0.4333333	0.2174858	219	-1.992467	0.0476	*
RiverYalakom	0.4166667	0.2318406	219	1.797212	0.0737	
TimeT2:RiverYalakom	0.5458333	0.3288076	219	1.660039	0.0983	
TimeT3:RiverYalakom	0.3888889	0.3438752	219	1.130901	0.2593	
TimeT4:RiverYalakom	-0.5666667	0.3343653	219	-1.694753	0.0915	

TABLE 3. MULTIPLE COMPARISON AMONG TIMES AND RIVER USING TUKEY'S TEST

Linear Hypotheses:

	Estimate	Std. Error	z value	Pr(>|z|)
T1.Bridge - T2.Bridge == 0	0.23333	0.20884	1.117	0.92860
T1.Bridge - T3.Bridge == 0	0.19444	0.20736	0.938	0.97147
T1.Bridge - T4.Bridge == 0	0.43333	0.21749	1.992	0.39749
T2.Bridge - T3.Bridge == 0	-0.03889	0.20884	-0.186	1.00000
T2.Bridge - T4.Bridge == 0	0.20000	0.21889	0.914	0.97533

T3.Bridge - T4.Bridge == 0	0.23889	0.21749	1.098	0.93440
T1.Yalakom - T2.Yalakom == 0	-0.31250	0.25397	-1.230	0.88654
T1.Yalakom - T3.Yalakom == 0	-0.19444	0.27432	-0.709	0.99442
T1.Yalakom - T4.Yalakom == 0	1.00000	0.25397	3.937	0.00115 *
T2.Yalakom - T3.Yalakom == 0	0.11806	0.27432	0.430	0.99977
T2.Yalakom - T4.Yalakom == 0	1.31250	0.25397	5.168	< 0.001 *
T3.Yalakom - T4.Yalakom == 0	1.19444	0.27432	4.354	< 0.001 *
T1.Bridge - T1.Yalakom == 0	-0.41667	0.23184	-1.797	0.53310
T2.Bridge - T2.Yalakom == 0	-0.96250	0.23316	-4.128	< 0.001 *
T3.Bridge - T3.Yalakom == 0	-0.80556	0.25397	-3.172	0.02083 *
T4.Bridge - T4.Yalakom == 0	0.15000	0.24094	0.623	0.99750

TABLE 4. SUMMARY OF STANDARD DEVIATION ESTIMATES FOR RANDOM EFFECTS

Random effects:

Groups	Std. Dev
Elder(Int)	3.761896e-05
Site(Int)	5.195979e-06
Residual	0.8798

TABLE 5. DEVIATION OF INTERCEPT BY ELDER AND SITE

ELDER	
Aggie	2.894971e-09
Albert	-1.173225e-08
Carl	-8.989648e-09
Ken	7.283139e-09
Leana	3.992013e-09
Randy	6.551778e-09

SITE	
B1	1.278983e-10
B2	-1.197593e-10
B3	-6.743727e-11
B4	-1.89522e-10
B5	5.464744e-11
B6	1.941728e-10
Y1	-6.540252e-11
Y2	6.83093e-11
Y3	3.342796e-11
Y4	-3.633473e-11

SUMMARY for MOVEMENT

Interaction between Time and River is significant at alpha = 0.05. Model estimates are shown in TABLES 2 and 4.

Multiple comparisons among sampling Time and River showed that the only significant difference is between the Bridge and Yalakom Rivers at sampling time T2 (TABLE 3).

There was about as much variation in scores among Elders as among Sites (see SD in TABLE 4)

An estimate of how much the Intercept (equivalent to mean score) changes with Elder and Site is provided in TABLE 5. Positive and negative values mean the score given by Elders and for different Sites are consistently above or below average (i.e. Intercept), respectively.

TABLE 1. TEST OF SIGNIFICANCE OF MAIN EFFECTS USING ANOVA (INTERACTION IS SIGNIFICANT)

	numDF	denDF	F-value	p-value	
(Intercept)	1	220	252.16399	<.0001	
Time	3	220	2.29026	0.0792	
River	1	220	1.56042	0.2129	
Time:River	3	220	2.71119	0.0459	*

TABLE 2. SUMMARY OF COEFFICIENT ESTIMATES FOR FIXED EFFECTS

Fixed effects: Score ~ Time * River

	Value	Std.Error	DF	t-value	p-value
(Intercept)	3.1111111	0.2391987	220	13.006390	0.0000
TimeT2	-0.1666667	0.1651784	220	-1.009010	0.3141
TimeT3	0.2638889	0.1651784	220	1.597600	0.1116
TimeT4	0.0147748	0.1744780	220	0.084680	0.9326
RiverYalakom	0.3055556	0.2535182	220	1.205261	0.2294
TimeT2:RiverYalakom	0.4375000	0.2611699	220	1.675154	0.0953
TimeT3:RiverYalakom	-0.3462696	0.2769153	220	-1.250453	0.2125
TimeT4:RiverYalakom	-0.0147748	0.2671487	220	-0.055306	0.9559

TABLE 3. MULTIPLE COMPARISON AMONG TIMES AND RIVER USING TUKEY'S TEST

Linear Hypotheses:

	Estimate	Std. Error	z value	Pr(>|z|)
T1.Bridge - T2.Bridge == 0	1.667e-01	1.652e-01	1.009	0.9618
T1.Bridge - T3.Bridge == 0	-2.639e-01	1.652e-01	-1.598	0.6898
T1.Bridge - T4.Bridge == 0	-1.477e-02	1.745e-01	-0.085	1.0000
T2.Bridge - T3.Bridge == 0	-4.306e-01	1.652e-01	-2.607	0.1114
T2.Bridge - T4.Bridge == 0	-1.814e-01	1.745e-01	-1.040	0.9551
T3.Bridge - T4.Bridge == 0	2.491e-01	1.745e-01	1.428	0.7978
T1.Yalakom - T2.Yalakom == 0	-2.708e-01	2.023e-01	-1.339	0.8458
T1.Yalakom - T3.Yalakom == 0	8.238e-02	2.223e-01	0.371	0.9999
T1.Yalakom - T4.Yalakom == 0	-4.996e-16	2.023e-01	0.000	1.0000
T2.Yalakom - T3.Yalakom == 0	3.532e-01	2.223e-01	1.589	0.6950

T2.Yalakom - T4.Yalakom == 0	2.708e-01	2.023e-01	1.339	0.8459	
T3.Yalakom - T4.Yalakom == 0	-8.238e-02	2.223e-01	-0.371	0.9999	
T1.Bridge - T1.Yalakom == 0	-3.056e-01	2.535e-01	-1.205	0.9050	
T2.Bridge - T2.Yalakom == 0	-7.431e-01	2.535e-01	-2.931	0.0452	*
T3.Bridge - T3.Yalakom == 0	4.071e-02	2.697e-01	0.151	1.0000	
T4.Bridge - T4.Yalakom == 0	-2.908e-01	2.597e-01	-1.120	0.9341	

TABLE 4. SUMMARY OF STANDARD DEVIATION ESTIMATES FOR RANDOM EFFECTS

Random effects:

Groups	Std. Dev
Elder(Int)	0.3120
Site(In)	0.2691
Residual	0.7008

TABLE 5. DEVIATION OF INTERCEPT BY ELDER AND SITE

ELDER

Aggie	-0.367174024
Albert	0.075560418
Carl	-0.003904739
Ken	-0.037237133
Leana	0.506942695
Randy	-0.174187216

SITE

B1	-0.44488172
B2	0.09233394
B3	-0.17627389
B4	0.19306188
B5	0.05875796
B6	0.27700183
Y1	-0.24714325
Y2	0.01199637
Y3	0.14193739
Y4	0.09320950

SUMMARY for SMELL

Interaction between Time and River is significant at alpha = 0.05. Model estimates are shown in TABLES 2 and 4.

Multiple comparisons among sampling Time and River showed three significant differences AMONG sampling Times WITHIN the
Yalakom River, but none WITHIN the Bridge River (TABLE 3).

Differences BETWEEN rivers were significant WITHIN sampling Times T2 and T3 -- scores were significantly higher for Yalakom River at these two sampling times (TABLE 3).

There was some variability in score related to Elders, but negligible variation in scores due to Sites (note small SD for Site in TABLE 4). This means that virtually no variability in scores is due to variation among Sites after accounting for sampling Time, River and their interaction.

An estimate of how much the Intercept (equivalent to mean score) changes with Elder and Site is provided in TABLE 5. Positive and negative values mean the score given by Elders and for different Sites are consistently above or below average (i.e. Intercept), respectively. Again, note very small values for Sites.

TABLE 1. TEST OF SIGNIFICANCE OF MAIN EFFECTS USING ANOVA (INTERACTION IS SIGNIFICANT)

	numDF	denDF	F-value	p-value	
(Intercept)	1	220	296.52057	<.0001	
Time	3	220	0.91373	0.4351	
River	1	220	0.84287	0.3596	
Time:River	3	220	6.38209	0.0004	*

TABLE 2. SUMMARY OF COEFFICIENT ESTIMATES FOR FIXED EFFECTS

Fixed effects: Score ~ Time * River

	Value	Std.Error	DF	t-value	p-value	
(Intercept)	2.8611111	0.2345191	220	12.199905	0.0000	
TimeT2	-0.2916667	0.2161010	220	-1.349678	0.1785	
TimeT3	-0.3055556	0.2161010	220	-1.413948	0.1588	
TimeT4	-0.2831115	0.2276970	220	-1.243370	0.2151	
RiverYalakom	0.2222222	0.2416083	220	0.919763	0.3587	
TimeT2:RiverYalakom	0.7291667	0.3416857	220	2.134028	0.0339	*
TimeT3:RiverYalakom	0.7222222	0.3583630	220	2.015337	0.0451	*
TimeT4:RiverYalakom	-0.5918885	0.3491352	220	-1.695299	0.0914	

TABLE 3. MULTIPLE COMPARISON AMONG TIMES AND RIVER USING TUKEY'S TEST

Linear Hypotheses:

	Estimate	Std. Error	z value	Pr(>|z|)
T1.Bridge - T2.Bridge == 0	0.291667	0.216101	1.350	0.82911
T1.Bridge - T3.Bridge == 0	0.305556	0.216101	1.414	0.79343
T1.Bridge - T4.Bridge == 0	0.283112	0.227697	1.243	0.88101
T2.Bridge - T3.Bridge == 0	0.013889	0.216101	0.064	1.00000

T2.Bridge - T4.Bridge == 0	-0.008555	0.227697	-0.038	1.00000	
T3.Bridge - T4.Bridge == 0	-0.022444	0.227697	-0.099	1.00000	
T1.Yalakom - T2.Yalakom == 0	-0.437500	0.264669	-1.653	0.63603	
T1.Yalakom - T3.Yalakom == 0	-0.416667	0.285875	-1.458	0.76748	
T1.Yalakom - T4.Yalakom == 0	0.875000	0.264669	3.306	0.01326	*
T2.Yalakom - T3.Yalakom == 0	0.020833	0.285875	0.073	1.00000	
T2.Yalakom - T4.Yalakom == 0	1.312500	0.264669	4.959	< 0.001	*
T3.Yalakom - T4.Yalakom == 0	1.291667	0.285875	4.518	< 0.001	*
T1.Bridge - T1.Yalakom == 0	-0.222222	0.241608	-0.920	0.97439	
T2.Bridge - T2.Yalakom == 0	-0.951389	0.241608	-3.938	0.00130	*
T3.Bridge - T3.Yalakom == 0	-0.944444	0.264669	-3.568	0.00542	*
T4.Bridge - T4.Yalakom == 0	0.369666	0.252033	1.467	0.76170	

TABLE 4. SUMMARY OF STANDARD DEVIATION ESTIMATES FOR RANDOM EFFECTS

Random effects:

Groups	Std. Dev
Elder(Int)	0.1804
Site(In)	4.068533e-05
Residual	0.9168

TABLE 5. DEVIATION OF INTERCEPT BY ELDER AND SITE

ELDER	
Aggie	-0.11777428
Albert	-0.09463490
Carl	-0.10234803
Ken	0.05666568
Leana	0.24474267
Randy	0.01334887

SITE	
B1	-1.476899e-09
B2	-7.384497e-09
B3	-5.415298e-09
B4	-5.415298e-09
B5	2.461499e-09
B6	1.723049e-08
Y1	-7.384497e-10
Y2	-1.723049e-09
Y3	2.461499e-10
Y4	2.215349e-09

SUMMARY for VOICE

Interaction between Time and River is NOT significant at alpha = 0.05 and it was removed from the analysis. The main effect Time is significant at alpha = 0.05, but River is NOT. Model estimates are shown in TABLES 2 and 4.

Multiple comparisons among sampling Times showed that T1 differed significantly from T3 (TABLE 3). That is, scores were significantly higher at T3 than at T1.

Variability in scores among Elders was about two times as greater as among Sites (see SDs in TABLE 4).

An estimate of how much the Intercept (equivalent to mean score) changes with Elder and Site is provided in TABLE 5. Positive and negative values mean the score given by Elders and for different Sites are consistently above or below average (i.e. Intercept), respectively.

TABLE 1. TEST OF SIGNIFICANCE OF MAIN EFFECTS USING ANOVA (ONLY TIME IS SIGNIFICANT)

	numDF	denDF	F-value	p-value	
(Intercept)	1	222	269.78371	<.0001	
Time	3	222	2.76273	0.0429	*
River	1	222	2.77617	0.0971	

TABLE 2. SUMMARY OF COEFFICIENT ESTIMATES FOR FIXED EFFECTS

Fixed effects: Score ~ Time + River

	Value	Std.Error	DF	t-value	p-value	
(Intercept)	3.0540710	0.2313685	222	13.200030	0.0000	
TimeT2	0.1158605	0.1247837	222	0.928491	0.3542	
TimeT3	0.3633854	0.1283625	222	2.830931	0.0051	*
TimeT4	0.1494771	0.1282333	222	1.165666	0.2450	
RiverYalakom	0.2398224	0.1535240	222	1.562117	0.1197	

Table 3. MULTIPLE COMPARISON AMONG TIMES USING TUKEY'S TEST

Linear Hypotheses:

	Estimate	Std. Error	z value	Pr(>|z|)	
T1 - T2 == 0	-0.11586	0.12478	-0.928	0.7895	
T1 - T3 == 0	-0.36339	0.12836	-2.831	0.0238	*
T1 - T4 == 0	-0.14948	0.12823	-1.166	0.6485	
T2 - T3 == 0	-0.24752	0.12893	-1.920	0.2196	
T2 - T4 == 0	-0.03362	0.12878	-0.261	0.9938	
T3 - T4 == 0	0.21391	0.13250	1.614	0.3703	

TABLE 4. SUMMARY OF STANDARD DEVIATION ESTIMATES FOR RANDOM EFFECTS

Random effects:

Groups	Std. Dev
Elder(Int)	0.3792
Site(In)	0.1892
Residual	0.6805

TABLE 5. DEVIATION OF INTERCEPT BY ELDER AND SITE

ELDER	
Aggie	-0.44575591
Albert	0.19374364
Carl	-0.03126546
Ken	-0.37544346
Leana	0.51234789
Randy	0.14637330

SITE	
B1	-0.230644332
B2	0.076731937
B3	-0.131925365
B4	0.188015832
B5	0.048910964
B6	0.048910964
Y1	-0.190088243
Y2	-0.008818366
Y3	0.167123100
Y4	0.031783510

SUMMARY for WADEABILITY

Interaction between Time and River is significant at alpha = 0.05. Model estimates are shown in TABLES 2 and 4.

Multiple comparisons among sampling Time and River showed a number of significant differences AMONG sampling Times WITHIN both rivers (TABLE 3).

No significant differences BETWEEN rivers WITHIN sampling Times were detected (TABLE 3).

There was about twice as much variation in scores among Sites as among Elders (see SD in TABLE 4)

An estimate of how much the Intercept (equivalent to mean score) changes with Elder and Site is provided in TABLE 5. Positive and negative values mean the score given by Elders and for different Sites are consistently above or below average (i.e. Intercept), respectively.

TABLE 1. TEST OF SIGNIFICANCE OF MAIN EFFECTS USING ANOVA (INTERACTION IS SIGNIFICANT)

	numDF	denDF	F-value	p-value	
(Intercept)	1	220	25.894649	<.0001	
Time	3	220	19.132172	<.0001	*
River	1	220	0.614493	0.4339	
Time:River	3	220	7.879914	0.0001	*

TABLE 2. SUMMARY OF COEFFICIENT ESTIMATES FOR FIXED EFFECTS

Fixed effects: Score ~ Time * River

	Value	Std.Error	DF	t-value	p-value	
(Intercept)	1.3888889	0.3409030	220	4.074147	0.0001	
TimeT2	0.8055556	0.2479548	220	3.248800	0.0013	*
TimeT3	-0.5833333	0.2479548	220	-2.352579	0.0195	*
TimeT4	-1.0463662	0.2616167	220	-3.999615	0.0001	*
RiverYalakom	-0.3055556	0.4085201	220	-0.747957	0.4553	
TimeT2:RiverYalakom	-0.4722222	0.3920509	220	-1.204492	0.2297	
TimeT3:RiverYalakom	1.4923542	0.4160084	220	3.587318	0.0004	*
TimeT4:RiverYalakom	0.4213662	0.4008312	220	1.051231	0.2943	

TABLE 3. MULTIPLE COMPARISON AMONG TIMES AND RIVER USING TUKEY'S TEST

Linear Hypotheses:

	Estimate	Std. Error	z value	Pr(>|z|)	
T1.Bridge - T2.Bridge == 0	-0.8056	0.2480	-3.249	0.0167	*
T1.Bridge - T3.Bridge == 0	0.5833	0.2480	2.353	0.2043	
T1.Bridge - T4.Bridge == 0	1.0464	0.2616	4.000	<0.001	*
T2.Bridge - T3.Bridge == 0	1.3889	0.2480	5.601	<0.001	*
T2.Bridge - T4.Bridge == 0	1.8519	0.2616	7.079	<0.001	*
T3.Bridge - T4.Bridge == 0	0.4630	0.2616	1.770	0.5666	

T1.Yalakom - T2.Yalakom == 0	-0.3333	0.3037	-1.098	0.9405	
T1.Yalakom - T3.Yalakom == 0	-0.9090	0.3340	-2.721	0.0833	
T1.Yalakom - T4.Yalakom == 0	0.6250	0.3037	2.058	0.3664	
T2.Yalakom - T3.Yalakom == 0	-0.5757	0.3340	-1.723	0.6003	
T2.Yalakom - T4.Yalakom == 0	0.9583	0.3037	3.156	0.0222	*
T3.Yalakom - T4.Yalakom == 0	1.5340	0.3340	4.592	<0.001	*
T1.Bridge - T1.Yalakom == 0	0.3056	0.4085	0.748	0.9932	
T2.Bridge - T2.Yalakom == 0	0.7778	0.4085	1.904	0.4707	
T3.Bridge - T3.Yalakom == 0	-1.1868	0.4316	-2.750	0.0762	
T4.Bridge - T4.Yalakom == 0	-0.1158	0.4170	-0.278	1.0000	

TABLE 4. SUMMARY OF STANDARD DEVIATION ESTIMATES FOR RANDOM EFFECTS

Random effects:

Groups	Std. Dev
Elder(Int)	0.2994
Site(In)	0.4649
Residual	1.0520

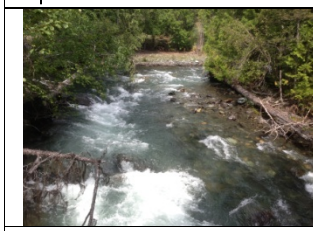
TABLE 5. DEVIATION OF INTERCEPT BY ELDER AND SITE

ELDER	
Aggie	0.12715151
Albert	0.24401519
Carl	0.04924239
Ken	0.04594723
Leana	-0.50586008
Randy	0.03950375

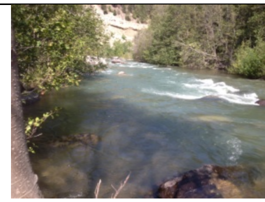
SITE	
B1	0.32004191
B2	-0.05334032
B3	0.53340319
B4	-0.48006287
B5	0.32004191
B6	-0.64008383
Y1	0.22706319
Y2	0.28487289
Y3	-0.17870505
Y4	-0.33323103

Appendix 2: Photos

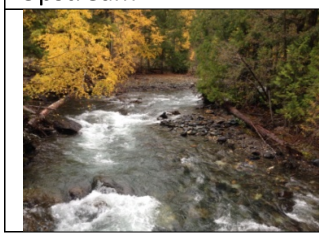
July 31 - August 1, 2013

B1	B2	B3	B4	B5	B6
Upstream					
					
Upstream					
					
Y1	Y2	Y3	Y4		

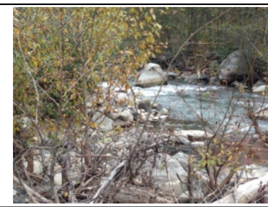
July 31 - August 1, 2013

B1	B2	B3	B4	B5	B6
Downstream					
					
Y1	Y2	Y3	Y4		
Downstream					
					

October 7-8, 2013

B1	B2	B3	B4	B5	B6
Upstream					
					
Y1	Y2	Y3	Y4		
Upstream					
					

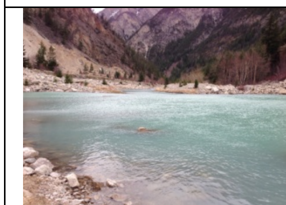
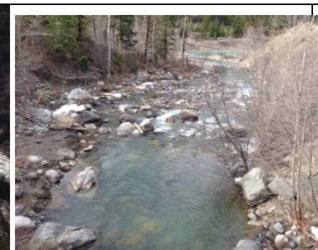
October 7-8, 2013

B1	B2	B3	B4	B5	B6
Downstream					
					
Y1	Y2	Y3	Y4		
Downstream					
					

April 7-8, 2014

B1	B2	B3	B4	B5	B6
Upstream					
					
Y1	Y2	Y3	Y4		
Upstream					
					

April 7-8, 2014

B1	B2	B3	B4	B5	B6
Downstream					
					
Y1	Y2	Y3	Y4		
Downstream					
					

May 14-15, 2014

B1	B2	B3	B4	B5	B6
Upstream					
					
Y1	Y2	Y3	Y4		
Upstream					
					

May 14-15, 2014

B1	B2	B3	B4	B5	B6
Downstream					
					
Y1	Y2	Y3	Y4		
Downstream