UNBC UNIVERSITY OF NORTHERN BRITISH COLUMBIA

# Kiskatinaw River surface water monitoring network: A summary of methodology and rating curve development

## GeoScience BC Report 2013-19

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# 1.0 Purpose

This report is serves to provide background information for the report titled "*Kiskatinaw River Watershed Monitoring Network – Research Outcomes of hydrologic modeling for West Headwater sub-basin, 2011 and East Confluence sub-basin 2012*", specifically: (a) provide methodology followed in designing, installing and maintaining the surface water monitoring network and (b) outline the process for data analysis and rating curve development. Further details, maps and history can be found in June & December 2011 progress reports.

# 2.0 Methodologies used to install and maintain surface water monitoring network

*2.1 Measuring water level: data logger and staff gauge installation*

To determine surface water levels, staff gauges along with Odyssey capacitance data loggers were calibrated and installed at each study site. Data loggers were suspended in ABS plastic casings. Holes were drilled in the ABS casings so that water could enter and the capacitance cable could intercept the river water level. The blue logger housing was protected by an ABS hardware housing that was fitted at the top of the water level casing. Staff gauges and the ABS housings were secured in the river bed by attaching them to 2 inch angle iron (Figure 1). At each site two lengths of 10 foot angle iron were driven into the river bed at a minimum of 4 feet. The staff gauge and ABS housing were attached to the angle iron using metal hose clamps. All staff gauges and water level recorders were surveyed in using 3 benchmarks.

Prior to installation data loggers were calibrated using a 6 point calibration method as outlined by Odyssey. At various sites, due to flood damage, the length of data logger capacitance cables needed to be adjusted to properly fit inside the water level housing. In such instances, the capacitance cable was cut, shortened and reattached to the logger (Figure 2). As recommended by Odyssey, data loggers were recalibrated after running approximately 12 months. All gauges were surveyed with three benchmarks.

Water levels were originally recorded at 10 minute intervals. However, after the first 6 months of data collection, the interval was changed to 15 minutes. After data review it was determined that peak water levels would be caught and recorded sufficiently at a 15 minute interval. During each site visit staff gauge readings were taken and correlated with logger capacitance values.

Figure 1. Staff gauge, ABS water gauge housing and angle iron.

Figure 2.  Example of shortening data logger.

*2.2 Cross Sections*

Cross sections were then completed in accordance with the BC Hydrometric Standards using Sontek's Acoustic Doppler Flow Tracker (Figure 3 & 4).  Sontek's flow tracker operates under the Doppler shift principal, measuring the velocity of passing sediment and air bubbles.  If the flow tracker indicated the signal to noise ratio (SNR) or boundary conditions were outside the quality control realm, vertical measurements were retaken.  Vertical measurements were always taken at intervals of 5 percent of the total discharge or less.  Cross sections were completed within 50 meters or less of each water level gauge at channel areas that were straight, relatively stable with little boulders.

Figure 3. Example of cross section at Sunderman Creek.

Figure 4. Sontek Acoustic Doppler Flow Tracker

Winter cross sections were also completed on reaches that had not frozen all the way to the river bed. To determine if a reach was frozen the entire water column depth gas powered ice augers were used to break through the ice and visually investigate the channel condition. If water was visibly flowing beneath the ice then auger holes were drilled to determine the wetted width of the channel. Upon determining the wetted width, the interval for measuring 5 percent of the total discharge was determined. Ice auger holes were then drilled at the pre-determined interval to allow for vertical flow tracker measurement (Figure 5, 6, 7). The winter cross sections were conducted in the same locations as the summer cross sections. It is important to have an understanding of the channel morphology from summer field visits prior to conducting winter cross sections.

Figure 5. Example of ice auger holes drilled for winter cross section.

Figure 6..Ice auger drilling

Figure 7. Example of winter cross section

Figure 8. Ice auger maintenance

For each reach an average of 30 to 40 ice auger holes had to be drilled in order to complete a cross section (Figure 5). The only way in which efficient winter hydrology can be completed is to always bring two ice augers into the field, back up blades and regularly conduct auger blade maintenance such as sharpening (Figure 8).

### *2.3 Logistics of field work*

Due to the remote nature of the sites, the monitoring network had to be designed such that all equipment could be transported on foot. The closest a vehicle can get to some sites is 1 kilometre. Trails were cut to all study sites for ease of access. All installation and maintenance equipment can be hiked in via pack back (Figure 9).


Figure 9. All installation and maintenance equipment must be transported by backpack due to remote distance of study sites.

During winter months snow shoeing to most field sites was difficult due to the depth of snow, and steep grade of access trail. Snowmobiles were used to access each site. Equipment was secured on a skimmer and study sites were accessed by sledding up each reach from the nearest confluence (Figure 10).

Figure 10. Winter field work

*2.4 Data management & Quality Control*

Whenever possible monthly visits were made to the field sites in order to download data and complete cross sections. Data was downloaded using a field tablet. The aspect of having a robust and waterproof field tablet for remote field work cannot be overlooked. A Yuma field tablet by Trimble was used for downloaded and storing data.

The water gauges were installed with the goal of achieving grade A data (table 1) as outlined in the BC Hydrometric Standards. Channel condition was a limiting factor at some sites due to the flashy nature of the local hydrology. At two sites, Oetata and East Headwater, beaver dams caused a drastic shift in the rating curve and a new cross section location needs to be explored (figure 11 & 12). In addition, no freshet discharge measurements were taken which reduced the overall accuracy of the rating curves. For correction of all water level and discharge data quality control and quality assurance guidelines were followed. Details of such guidelines can be found in Appendix A.

Table 1. Summary of current data grade achieved for surface monitoring network, in accordance with BC hydrometric standards.

| Data grade | Instrumentation | Surveyed benchmarks | No. verticals per cross sxn | Cross sxn per year | Accuracy of rating curve | Results compared with other stations | Channel condition |
|---|---|---|---|---|---|---|---|
| GRADE A | Automated water level gauge, 2 mm accuracy √ | 3 √ | 20 or more < 5 % of Q | 5 √ | < 7 percent | Yes √ | Stable, straight reach, minimal weeds & boulders |
| GRADE B | Automated water level gauge, 5 mm accuracy | 3 | 20 or more < 10 % of Q | 3 | < 15 percent | No | Minor instability, occasional weed & boulder |
| GRADE C | Manual gauge, 1 cm accuracy | 1 | 10 or more < 20 % of Q | 2 | < 25 percent | No | Unstable, erosion, turbulent, weed growth, boulder bed |


Figure 11. East Headwater beaver dam.


Figure 12. Oetata beaver dam blow out site occurred after spring freshet.

*2.5 Rating curve & hydrograph development*

Water level and discharge data for each site were correlated and rating curves along with annual hydrographs were developed. Annual hydrographs for all research sites can only be interpreted within the range of measured values. Beyond the peak measured values rating curves must be extrapolated. There are a number of methods in which rating curves can be extrapolated, some based upon channel physics while others are based upon graphical relationships. The Kiskatinaw rating curves have been extrapolated testing Manning's equation and the velocity-area method. For all rating curves the Manning's equation underestimated the measured discharge while the area-velocity method appeared to have a more realistic visual extrapolation. The area-velocity method was used for extrapolated discharge values; therefore discharge values above the peak measured value must always be considered as estimated values. In order to have a high level of confidence in rating curves discharge measurements must be taken for all levels of the hydrograph. The following graphs are the rating curves developed for each study site.

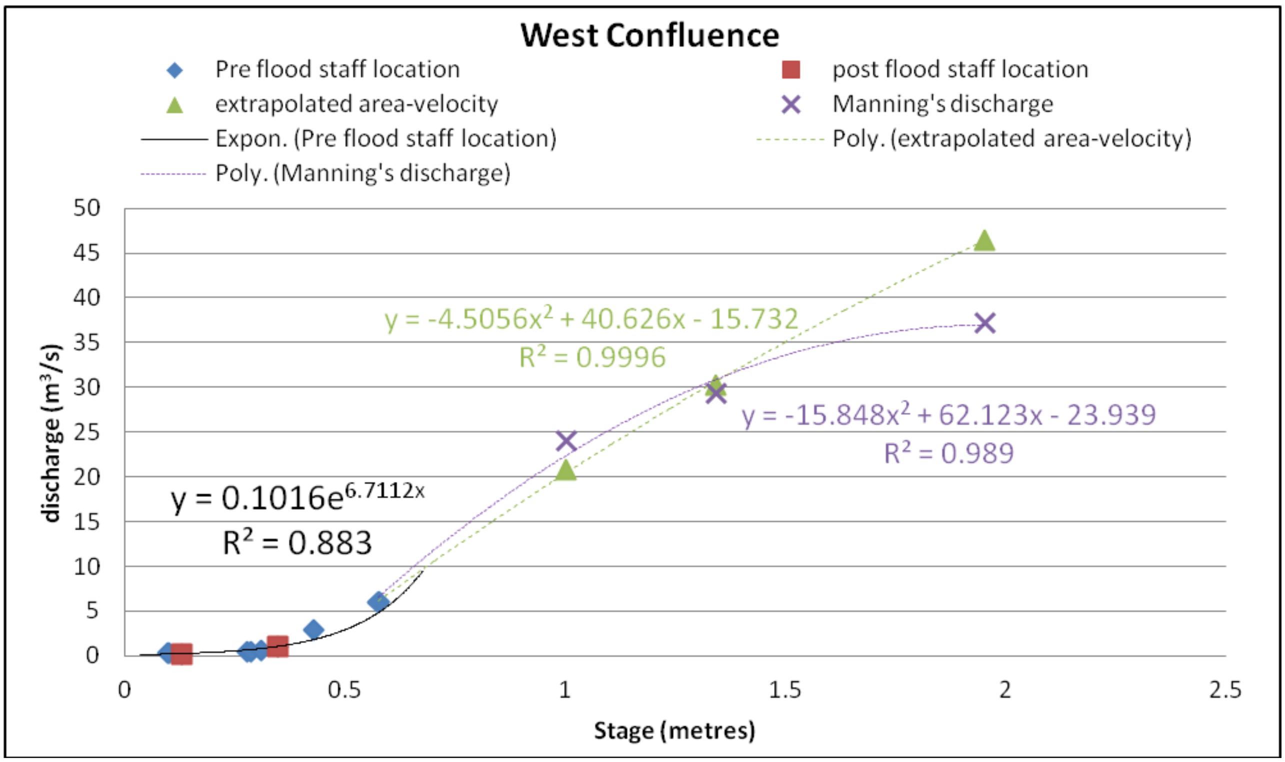


Figure 13. Rating curve and extrapolation for West Confluence study site. Exponential relationship is best fit for stage below 0.5759 metres. For stage above 0.5759 meters area-velocity extrapolation was used to estimate discharge for peak stages. Stage above 0.5759 meters polynomial relationship was used. Peak discharge based upon peak measured stage was also estimated using Manning's, however Manning's formula overestimated low flows and extrapolated curve appears to have a logarithmic pattern which does not necessarily represent the channel hydraulics.

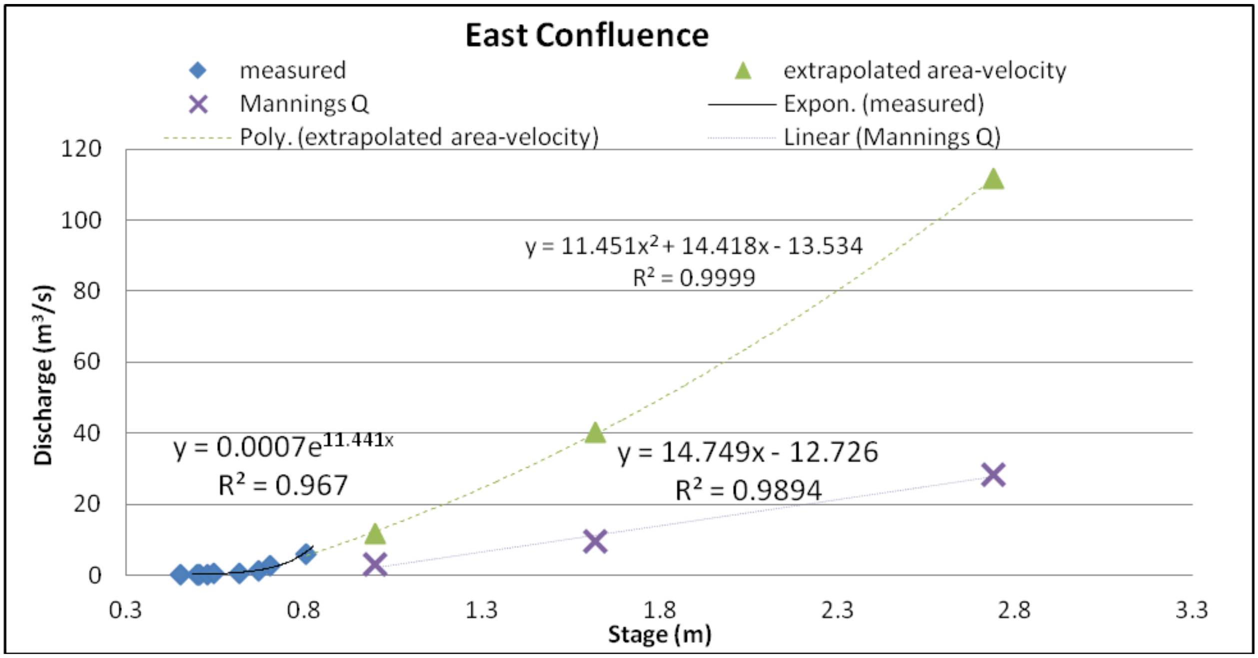


Figure 14. Rating curve and extrapolation for East Confluence study site. Exponential appear to be best relationship for stage below 0.8058 meters. Stage above 0.8 meters was Q estimated using area-velocity extrapolation. Stage above 0.8058 meters polynomial relationship used to calculate discharge. Peak Q based upon peak measurements was also estimated using Manning's, however Manning's formula underestimated low flows and extrapolated curve appears to also underestimate discharge.

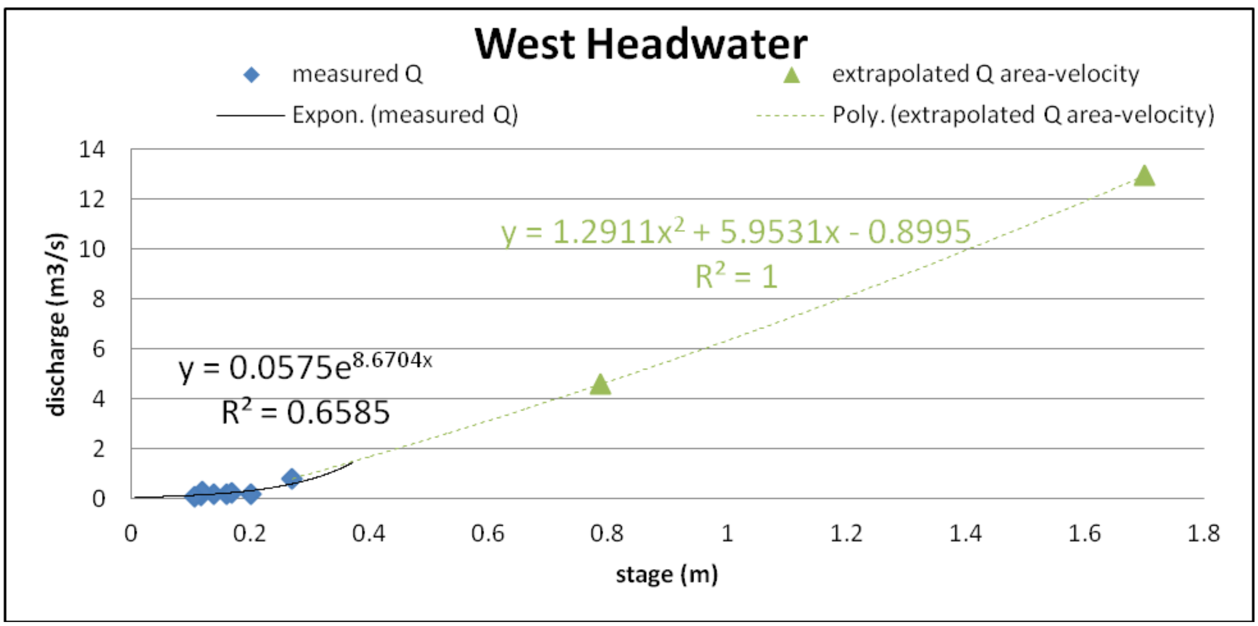


Figure 15. West Headwater rating curve. Exponential trend appears to be best relationship for stage below 0.271 meters. Stage above 0.271meters was estimated using area-velocity extrapolation to calculate discharge. Stage above 0.271 meters polynomial relationship used to calculate discharge.

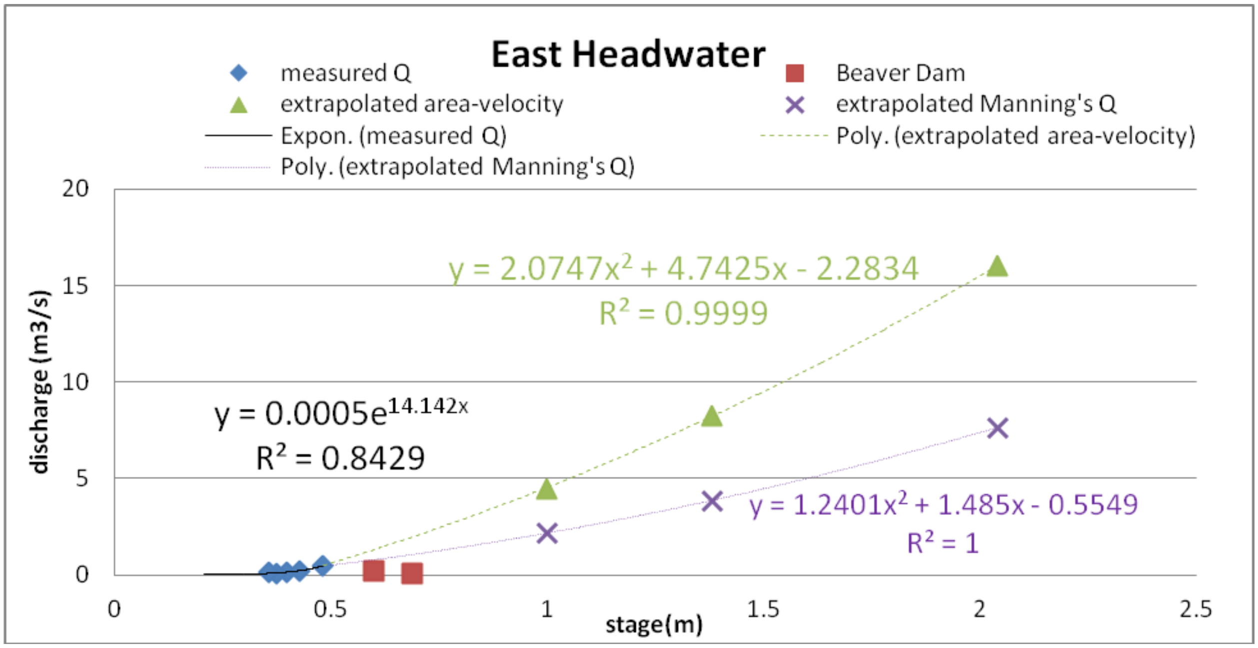


Figure 16. East Headwater rating curve. Exponential relationship appears to be best relationship for stage below 0.482meters. Stage above 0.482 meters discharge estimated using area-velocity extrapolation to calculate discharge. Stage above 0.482 meters power relationship used to calculate discharge. Discharge is only calculated up until 14August2011 as rating curve changes significantly due to beaver dam.

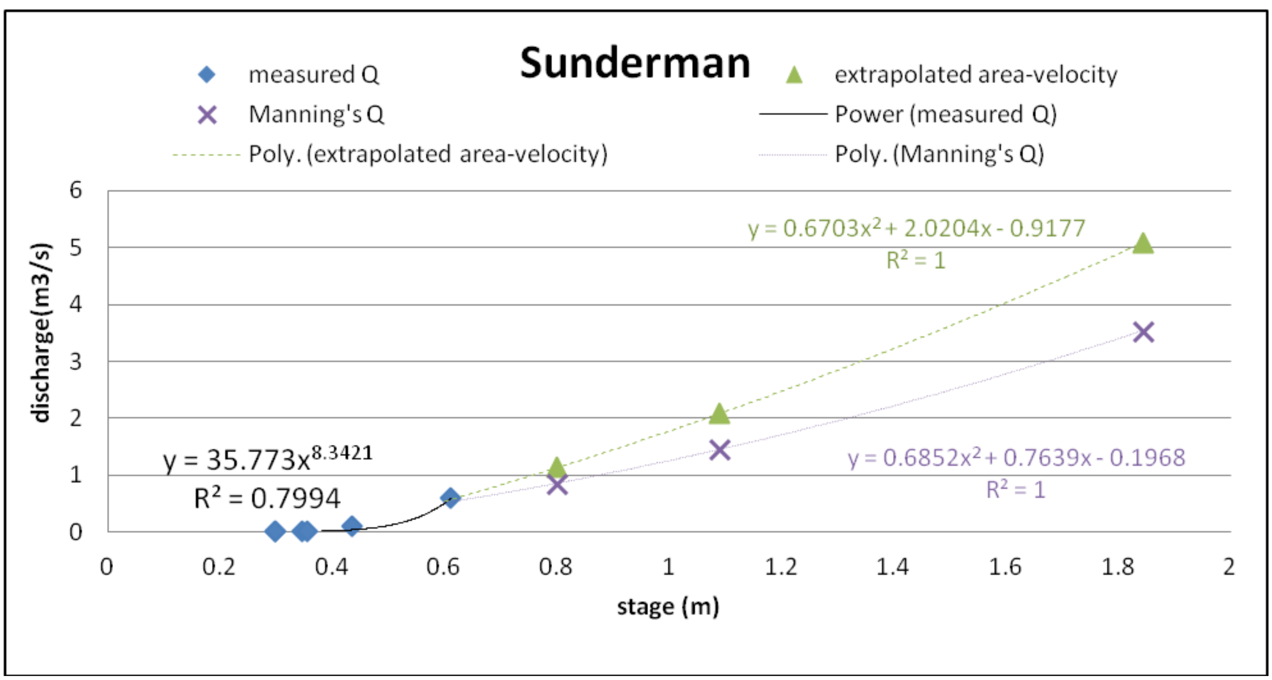


Figure 17. Sunderman rating curve. Power function appears to be best relationship for stage below 0.611meters. Stage above 0.611 meters polynomial relationship (area-velocity) used to calculate discharge. Peak Q based upon peak measurements was also estimated using Manning's, however Manning's formula overestimated low flows and extrapolated curve appears to also underestimate discharge. For measured Q, power function is based on open channel values only as winter hydrology discharge caused curve to go into negative Q values.

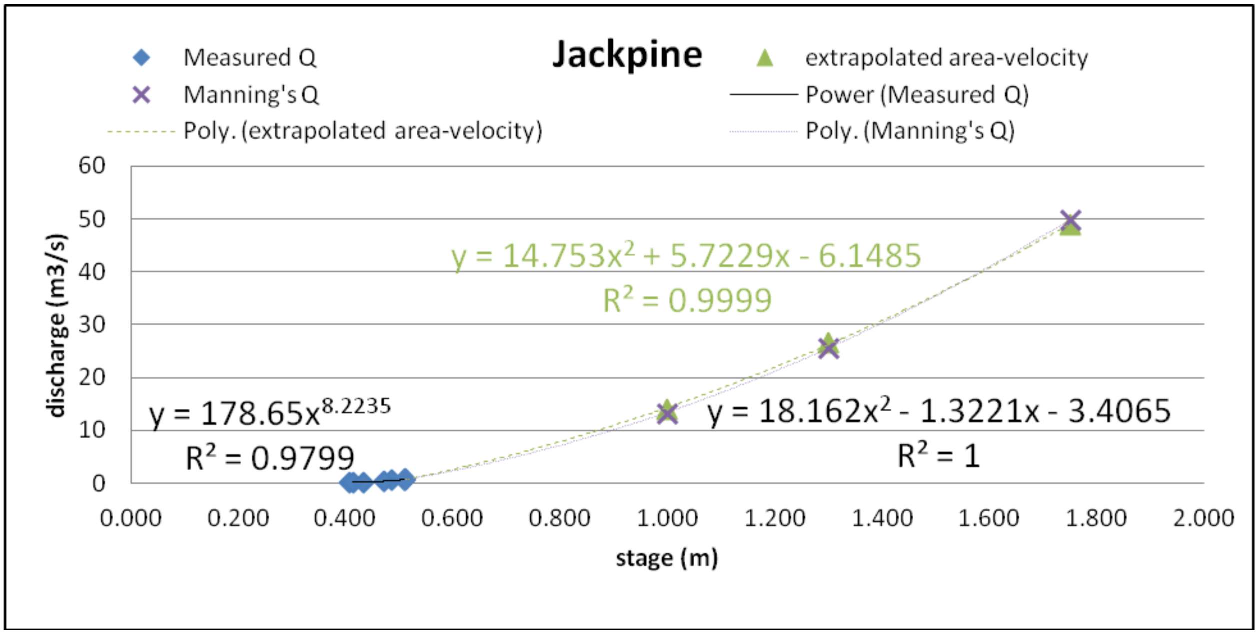


Figure 18. Jackpine rating curve. Power relationship is best fit for stage below 0.5103 metres. For stage above 0.5103 meters area-velocity extrapolation and Manning's formula used to estimate discharge for peak stages. Stage above 0.5103 meters Manning's formula was used.

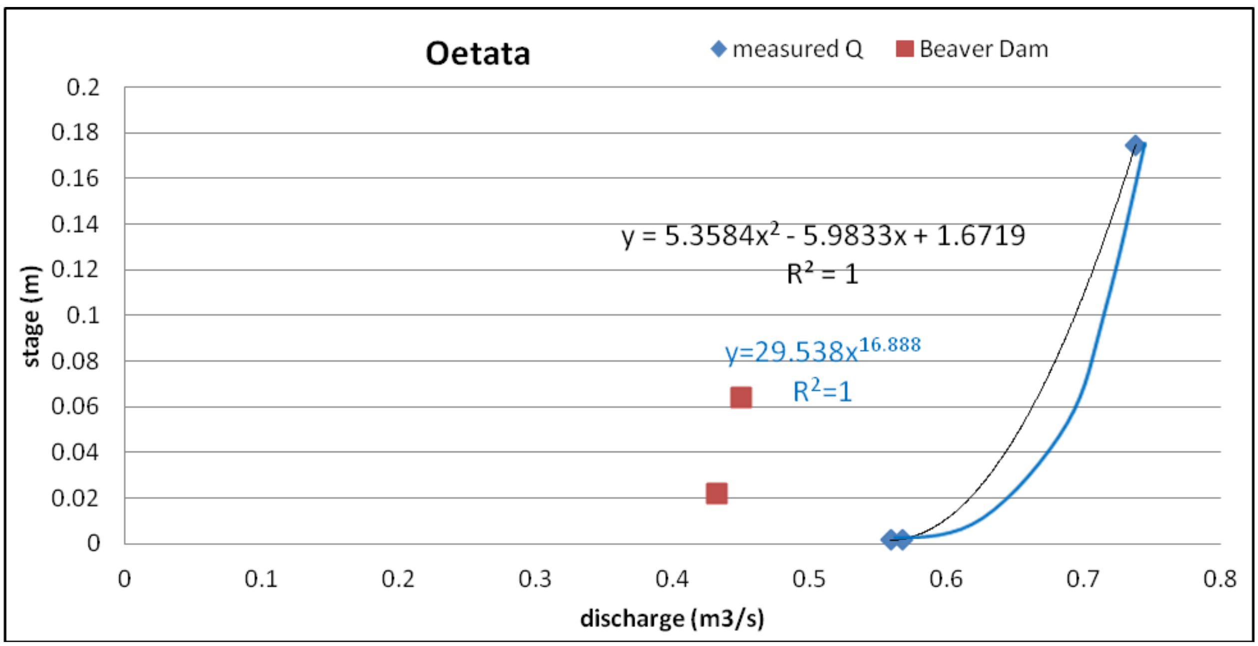


Figure 19. Oetata rating curve. Polynomial overestimates April 2011 low flows; however, remainder of hydrograph is acceptable. Power rating curve drastically overestimate freshet flows. CONCLUSION: neither rating curve is sufficient, based upon only 3 points. Beaver dam caused rating curve and channel morphology to change. For watershed balance purpose polynomial relationship used.

## 3.0 Monitoring Network Discharge Values & Farmington WSC 07FD001

Currently the 7 tributary sites where discharge measurements were collected represent the majority, but not all of the tributary streams connected to the Kiskatinaw mainstem (Table 2). As indicated in table 3, the surface water monitoring network only captures approximately 52 percent of the total volume that reaches the Farmington gauge. A total of 9 tributaries are not gauged (table 3) and may account for the additional volume. However inference can be made that groundwater may also contribute to the Kiskatinaw flow. A summary of total water licence withdrawals can be found in table 4.

Table 2. Summary of mean daily and mean annual discharge for monitoring network and comparison to WSC gauge at Farmington. Note: Jackpine and West Confluence values from June 16 2011-Sept 6 2011 were interpolated using individual linear correlation relationships with Farmington. Jackpine $R^2$ is 0.73 and West Confluence $R^2$ is 0.87. For all sites data is missing from Jan 29, 2011 – April 1, 2011. No interpolation was completed for this period.

| Station | Mean daily discharge (m3/s) for May 22, 2010 -Feb 13, 2012 | Total discharge (m3) for May 22, 2010 – Feb 13, 2012 (630 days) |
|---|---|---|
| Oetata | 0.53 | 26,101,229 |
| West Headwater | 1.16 | 55,691,277 |
| Jackpine | 1.00 | *interpolated values 47,306,574 |
| East Headwater | 1.17 | 36,994,168 |
| Sunderman | 0.28 | 12,205,628 |
| East Confluence | 3.99 | 216,644,262 |
| West Confluence | 4.03 | *interpolated values 218,818,828 |
| Farmington WSC 07FD001 | 16.19 | 847,801,259 |

Table 3. Summary of watershed volumes and licence withdrawals.

| | |
|---|---|
| Total licence withdrawal per day | 39,438 $m^3$/day |
| Total licence with per year | 14,394,925 $m^3$/year |
| Total licence withdrawal from May 22, 2010 – Feb 13, 2012 (630 days) | 24,846,035 $m^3$ |
| Total discharge for Kiskatinaw tributaries: East Confluence + West Confluence + Oetata | 461,564,319 $m^3$ |
| Measured tributary volume minus licence withdrawal as percent of measured Farmington volume | 52 % |
| Kiskatinaw tributaries not gauged:<br>Brassey, Tremblay, Sunset, Fox, Borden, Ministik, Sunset, Coal, Mica | |
| Additional volume over 630 days not captured in above measurements:<br>Farmington – gauged tributaries – licence withdrawals | 361,390,905 $m^3$ |

Table 4. Water licences currently granted to divert water from within the Kiskatinaw Watershed. Ponds, dugouts and springs were not included. Dust control licence withdrawals are valid for 180 days per year while irrigation is valid for 120 days per year.

| Licence No. | Pt. of Diversion | Source Name | Purpose | Quantity | Units | Annual Quantity ($m^3$/year) |
|---|---|---|---|---|---|---|
| C060532 | (PD75041) | Sloane Slough | Conserv.-Stored Water | 123348 | MY | 123348 |
| C060857 | (PD36352) | Wilde Creek | Conserv.-Stored Water | 302202.6 | MY | 302202.6 |
| C062752 | (PD36106) | Cutbank Creek | Conserv.-Stored Water | 626607.84 | MY | 626607.84 |
| C062753 | (PD36167) | Kiskatinaw River | Irrigation | 111013.2 | MY | 111013.2 |
| C062766 | (PD36353) | Wangler Creek | Conserv.-Stored Water | 204757.68 | MY | 204757.68 |
| C102248 | (PD63427) | Bosch Creek | Stockwatering | 4.546 | MD | 1659.29 |
| C102264 | (PD63538) | Little Brassey Creek | Domestic | 2.273 | MD | 829.645 |
| C102413 | (PD63790) | Kiskatinaw River | Dust Control | 45.461 | MD | 8182.98 |
| " | (PD63789) | Kiskatinaw River | Dust Control | 45.461 | MD | 8182.98 |
| C102464 | (PD63819) | Brassey Creek | Dust Control | 45.461 | MD | 8182.98 |
| C103920 | (PD61874) | Kiskatinaw River | Irrigation | 61674 | MY | 61674 |
| " | " | Kiskatinaw River | Stockwatering | 4.546 | MD | 1659.29 |
| C103921 | (PD61873) | Kiskatinaw River | Domestic | 2.273 | MD | 829.645 |
| " | " | Kiskatinaw River | Irrigation | 61674 | MY | 61674 |
| " | " | Kiskatinaw River | Stockwatering | 4.546 | MD | 1659.29 |
| C104190 | (PD36159) | Rimstad Creek | Domestic | 2.273 | MD | 829.645 |
| C104526 | (PD65596) | Kiskatinaw River | Irrigation | 8634.36 | MY | 8634.36 |
| C104905 | (PD69989) | Dew Creek | Stockwatering | 2.273 | MD | 829.645 |
| " | (PD65999) | Willow Creek | Stockwatering | 2.273 | MD | 829.645 |
| " | (PD66001) | Mist Creek | Stockwatering | 2.273 | MD | 829.645 |
| " | (PD66003) | Willow Creek | Stockwatering | 2.273 | MD | 829.645 |
| C104956 | (PD66069) | Reed Creek | Irrigation | 9004.404 | MY | 9004.404 |
| " | " | Reed Creek | Stockwatering | 4.546 | MD | 1659.29 |
| C105317 | (PD66547) | Willow Creek | Stockwatering | 4.546 | MD | 1659.29 |
| C105385 | (PD70372) | Brassey Creek | Stockwatering | 9.092 | MD | 3318.58 |
| " | (PD67010) | Brassey Creek | Stockwatering | 9.092 | MD | 3318.58 |
| C105702 | (PD67086) | Reamer Creek | Domestic | 4.546 | MD | 1659.29 |
| " | " | Reamer Creek | Stockwatering | 4.546 | MD | 1659.29 |
| " | (PD67087) | Reamer Creek | Stockwatering | 4.546 | MD | 1659.29 |
| C105762 | (PD67011) | Kiskatinaw River | Irrigation | 123348 | MY | 123348 |
| C107310 | (PD68420) | Kiskatinaw River | Dust Control | 27.277 | MD | 4909.86 |
| C107548 | (PD68730) | Brassey Creek | Dust Control | 13.638 | MD | 2454.84 |
| " | (PD68727) | Buffalo Creek | Dust Control | 13.638 | MD | 2454.84 |
| " | (PD68728) | Livingstone Creek | Dust Control | 13.638 | MD | 2454.84 |
| " | (PD68729) | Kiskatinaw River | Dust Control | 13.638 | MD | 2454.84 |
| " | (PD68732) | Five Mile Creek | Dust Control | 9.092 | MD | 1636.56 |
| " | (PD68733) | Five Mile Creek | Dust Control | 9.092 | MD | 1636.56 |
| " | (PD68735) | Five Mile Creek | Dust Control | 9.092 | MD | 1636.56 |
| " | (PD68736) | Brassey Creek | Dust Control | 13.638 | MD | 2454.84 |
| C108658 | (PD70435) | Mawson Creek | Stockwatering | 4.546 | MD | 1659.29 |
| C111413 | (PD72613) | Kiskatinaw River | Oil Field Injection | 0.014 | MS | 441504 |
| " | " | Kiskatinaw River | Storage-Non Power | 20969.16 | MY | 20969.16 |
| C118568 | (PD36164) | Kiskatinaw River | Irrigation | 86343.6 | MY | 86343.6 |
| C120406 | (PD68637) | Sunderman Creek | Dust Control | 13.638 | MD | 2454.84 |
| " | " | Sunderman Creek | Road Maintenance | 13.638 | MD | 2454.84 |
| " | (PD68598) | Borden Creek | Dust Control | 13.638 | MD | 2454.84 |
| " | " | Borden Creek | Road Maintenance | 13.638 | MD | 2454.84 |
| C120505 | (PD74883) | Norrie Creek | Stockwatering | 9.092 | MD | 3318.58 |
| " | " | Norrie Creek | Storage-Non Power | 3700.44 | MY | 3700.44 |
| C121908 | (PD79905) | Valleyview Creek | Conserv.-Stored Water | 376496.334 | MY | 376496.334 |
| C124416 | (PD82370) | Kiskatinaw River | Irrigation | 60933.912 | MY | 60933.912 |
| " | (PD82837) | Kits Creek | Storage-Non Power | 13691.628 | MY | 13691.628 |
| " | (PD82838) | Kits Creek | | | | |
| C124600 | (PD82494) | Hartnell creek | Conserv.-Stored Water | 742061.568 | MY | 742061.568 |
| C125120 | (PD67510) | Kiskatinaw River | Storage-Non Power | 2146255.2 | MY | 2146255.2 |
| " | " | Kiskatinaw River | Waterworks Local Auth | 3318645.7 | MY | 3318645.7 |
| " | (PD36165) | Kiskatinaw River | Storage-Non Power | 2146255.2 | MY | 2146255.2 |
| " | " | Kiskatinaw River | Waterworks Local Auth | 3318645.7 | MY | 3318645.7 |

# APPENDIX A

## Kiskatinaw River Watershed Monitoring Network: Standard operating guidelines (working document)

## Quality Assurance and Quality Control Guidelines

March 2012

Written by:
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*This document is to accompany all surface water and piezometer data sets produced by UNBC as part of the Kiskatinaw River Watershed Research Program.*

DISCLAIMER

This document is to accompany all Kiskatinaw River Monitoring Network data sets. It is advised that all data users read this document so to ensure proper data interpretation. Subsequent quality control and quality assurance procedures may result in differences between the current delivered data set and future data sets. It is the responsibility of all persons who use this data set to independently confirm the accuracy of the data, information, or results obtained through its use.

## INTRODUCTION

The purpose of this document is to outline the quality assurance and quality control procedures that were taken during data collection and analysis of surface water and piezometer data. Detailed methodology of equipment installation is not discussed here but rather in other chapters of the Kiskatinaw Monitoring Network standard operating procedures. The following definitions were used as guidelines in forming these QA-QC procedures:

*Quality Assurance*: set procedures concerning data review. Conducted by personnel not directly involved with the data development process.

*Quality Control:* a system of routine technical activities that check data integrity, correctness and completeness. This also includes procedures to detect and address data errors.

## QUALITY CONTROL: PRE-FIELD PROCEDURES

*Training Requirements*

Due to the complex nature of successful development of the monitoring network, specifically cross sections, subsequent rating curves and operation of capacitance water level recorders, all field personnel must be competent with the following material and associated field procedures: BC hydrometric standards, Sontek acoustic Doppler training video and user's manual, Sontek's software, Odyssey capacitance water level user's manual and software. Field personnel must also adhere to and be competent with all requirements listed under the Kiskatinaw Watershed Safety Plan.

*General*

- Ensure up-to-date software is installed on all primary and back up field computers.
- Original software installation disks should be copied and one copy should accompany staff into the field.
- All equipment is inspected prior to departure for damage and battery life.
- Extra capacitance data loggers, batteries and user manuals always accompany staff into the field.

## QUALITY CONTROL: FIELD PROCEDURES

| **General** |
|---|
| Detailed site notes recorded for each cross section indicating channel morphology, cross section location and other visual observations. All measurements taken and recorded within an instruments internal memory bank must also be recorded in field notebook. |
| Capacitance water probes are calibrated at least once per year. |
| All gauges and piezometers are surveyed in with 3 benchmarks. Survey to be verified at least once per year. |
| All capacitance probes are removed from casings and capacitance cables are cleaned from excess sediment/dirt buildup. |
| Silica gel moisture packets in Odyssey data logger housing must be changed during each site visit. |
| Grease sealant must be applied to threads of data logger housing during each site visit. |
| Data logger battery voltage must be checked during each site visit and battery replaced if voltage |

| |
|---|
| is below 6.8 volts. |
| Data logger trace mode should be run for each logger to ensure proper functioning. |
| Thought should be given to the channel characteristics and data logger time interval should be set such that peaks in water level are captured. |
| **Surface Water** |
| Sontek flow tracker<br>- always run qa/qc test on flow tracker prior to commencing cross section<br>- individual discharge measurements are repeated if large SNR variance, large velocity error or poor boundary conditions.<br>- upon completion of cross section, data review on flow tracker is necessary to ensure depths, velocities and discharges do not exceed the prescribed limits. |
| Evaluation of cross section location to examine change in morphology and representation of site. |
| **Piezometers** |
| Manual water level and inside casing depth is measured during each site visit. |
| Piezometers are only installed if hyporheic zone is reached. In case of East Headwater left bank and West Headwater right bank no piezometers were installed as groundwater was not reached. |

**QUALITY CONTROL: POST FIELD PROCEDURES**

| | |
|---|---|
| **General** | |
| At the end of each field day all recorded data and pictures must be downloaded and backed-up. | |
| | |
| **Data Management** | |
| Raw data files must be saved according to site file, date and time. | |
| Routine back up of data must be completed. | |
| **Data Rationalization for data loggers - general** | |
| All data logger calibration values will be entered and graphed against raw capacitance values. Calibrated water level values will be calculated (for verification of Odyssey software calibrated output). | |
| Calibrated data values are compared with manual field measurements for accuracy. | |
| Data is reviewed, graphed and inspected for spikes and suspect values. | |
| In the case of data spikes, capacitance values will be shifted down or up for the value and range of the spike. | |
| In the case of single spike values or obvious capacitance jumps for minimal time stamps, the average water level will be used in replacement of the spiked values. | |
| For instream piezometers and water gauges data spikes from wave action are smoothed. | |
| **Data Coding** | |
| f | Flood conditions |
| i | Ice conditions |
| e | Estimated data value: discharge exceeds that of measured value or spike in data and average value used. |
| m | Data missing: due to logger error or physical damage of logger from flood or animal |
| s | Data shift: shifted due to logger spike or data drift was greater than 5 units. |
| **Data Rationalization-Surface Water Rating Curve Development** | |
| Rating curve was only developed if a minimum of 5 cross sections were completed during stable | |

| |
|---|
| channel condition. Beaver dams at Oetata and East Headwater caused a shift in the rating curve and further data collection is required. |
| Discharge-stage relationship above the highest measured value must be estimated using an extrapolation method: the area-velocity method, Manning's formula and possible modeling using available software. |
| Discharge values calculated above the highest measured value are always considered and marked as estimated values. |
| Annual hydrographs must be verified by plotting against measured discharge values. |
| **Data Rationalization - Piezometers** |
| The water table must be calculated using the inside piezometer water depths. Water table is defined as the distance below the ground surface in which water is present. The ground surface is considered zero so water table values will be negative. |

**QUALITY ASSURANCE PROCEDURES**

| **General** |
|---|
| An external reviewer should go over data sets and data rationalization procedures to ensure accurate data compilation and rationalization |
| Data is checked for transcription errors |
| Data is compiled and graphed for visual observation of any spikes, outliers |
| |
| **Surface Water** |
| Review of discharge data and comparison of reaches and stream orders. Ensure that corresponding discharge aligns with associated stream order and overall hierarchy in watershed. |
| In case of sudden rise in water level, compare across all gauges in watershed to see if similar rise/spike was experienced. |
| Review precipitation data around times of water level spike. |