Environment

Assessment and Abandoned Mines

Mount Nansen 2010 Hydrology Monitoring

Prepared by:

AECOM
2251 2nd Avenue
Whitehorse, YT, Canada Y1A 5W1
www.aecom.com

867 633 6474 tel
867 633 6321 fax

Project Number:

60154930

Date:

March 2011

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AECOM
2251 2nd Avenue
Whitehorse, YT, Canada Y1A 5W1
www.aecom.com

867 633 6474 tel
867 633 6321 fax

March 22, 2011

Frank Patch
Senior Project Manager
Assessment and Abandoned Mines
Department of Energy Mines and Resources
Yukon Government
Royal Center
4144 4th Ave, Room 2C
Whitehorse, Yukon

Dear Mr. Patch:

Project No: 60154930

Regarding: Mount Nansen 2010 Hydrology Monitoring

AECOM is pleased to present our 2010 Hydrology Monitoring Report for the Mount Nansen Mine Site. If there are any questions or comments on this report, please contact the undersigned. Thank you for the opportunity to work on this project.

Sincerely,
AECOM Canada Ltd.

//original signed by//

Stephanie Whitehead, B. Eng., EIT
Water Resources Engineer-in-Training
stephanie.whitehead2@aecom.com

SLW:aj

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AECOM Signatures

Report Prepared By:

//original signed by//

Stephanie Whitehead, B.Eng., EIT
Water Resources Engineering-in-Training

Report Reviewed By:

//original signed by//

Eric Blais, B. Sc., MA
Manager, Water Resources

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Hydrology monitoring at the Mount Nansen Mine continued in 2010 as part of the Mine Closure Project. The 2010 program consisted of re-establishment of the hydrometric stations installed in 2009 and the addition of another station. The technical memo produced from the 2009 hydrology monitoring program is attached in Appendix A to give more background and context to the establishment of the hydrology monitoring network.

1. Field Program Summary

On April 26, 2010, a trip was conducted to measure low winter flows at Victoria Creek and inspect stations before spring freshet. Two freshet trips were then conducted during the spring freshet on May 12 and 31, 2010. A new station was installed in the upper portion of the Dome Creek drainage on the second freshet trip. The locations and drainages of each station can be seen on Figure 1. Three subsequent trips were conducted on June 30, July 28 and September 9 to collect stage and discharge measurements. Where possible, these measurements were added to the dataset from 2009 to improve on the rating curves developed for each site in 2009.

It was hoped after the extremely dry field season in 2009 that the 2010 field season would bring more rain events and a chance to gauge mid range flows. This did occur with three large rain events and many smaller rain events. The rain gauge on the weather station at site was operational for the duration of the field season, allowing for the hydrographs developed for each site to compare rain events with associated flows. As recommended after the 2009 field program, all dataloggers were protected in a latex sheath and glycol to protect the instrument from siltation and freezing. Siltation and freezing of the logger membrane was not a problem during the field season. Siltation did cause the datalogger at the Victoria Creek site to become completely encased resulting in erroneous data being recorded at that site.

2. Data Sources and Analysis

During the 2010 field season both hydrology and meterology data were collected at the Mount Nansen site. Hydrology data collected included a series of streamflow and water depth measurements taken periodically at each station throughout the open water season. Dataloggers measuring water depth every half hour were installed at each station. A barometric pressure logger was also installed to correct the submerged dataloggers. The manually collected stream flow and water depth measurements were used to create a stage discharge rating curve. This was then applied to the continuous stage measurements to create a continuous hydrograph (stream flow) for each site.

The manual stage measurements and datalogger readings were compared to ensure that any errors or shifts on the staff gauges or dataloggers were identified and corrected.

A weather station is operated by the Yukon Government at the Mount Nansen site. Among the various parameters collected by the on-site weather station, daily rainfall was presented on the hydrographs to allow for comment on various watersheds reactions to rainfall events.

A weather station is operated by Environment Canada at Carmacks. The temperature report at Carmacks during the 2010 field season showed a strong correlation with the daily temperature recorded at Mount Nansen. Unfortunately rainfall data at the Carmacks weather station is missing or not reported during the 2009 and 2010 field seasons. Monthly mean temperatures for the Carmacks CS station were reported by Environment Canada between October 1999 and December 2010. These means were used to create an average mean monthly temperature which was then compared with the means reported for 2010.

Yukon Governments Department of Water Resources operates a snow survey site at Mount Nansen. The results of the 2010 snow surveys can be used to give an indication of the freshet volumes that were observed.

3. Results

3.1 Upper Dome Creek

On May 31, 2010, an additional gauging station was added upstream of the Diversion Channel on Dome Creek. The creek channel at this location is braided with channels and marshy areas. A section of the creek with a single channel was chosen for the station. The channel is quite small at this location with a width of approximately 1.5 m and a drainage area of 1.8 km^2. The hydrograph developed for the Upper Dome Creek Site is seen on Figure 2 and shows the creek to be flashy, or reactive to rain events. The preliminary rating curve developed for Upper Dome Creek, shown on Figure 3 shows a linear relationship between stage and discharge, with a strong R^2 value of 0.91.

3.2 Dome Creek at Road

The station installed in 2009 was buried in silt from the 2010 freshet when crews returned to reinstall data loggers. A second station was installed on May 12, 2010 and an attempt was made to correlate the original and new staff gauges, although the original station appears to have shifted over the winter. The new station appears to have experienced significant shifts during the month of May indicating that the ground was probably frozen during installation and shifts were due to thawing. Further inspection of the half-hourly datalogger readings shows numerous small shifts at this site, not always correlated with rain events. This leads us to believe that the ground around this site is very soft. This is consistent with the observations of field staff.

Shifts were noted on June 30, August 28 and September 2, which corresponded with rain events and on May 31, June 30 and July 28, which corresponded to field measurements – likely occurring when the station cap was replaced putting pressure on the installation. To attempt to correct for thawing in May, any shifts over 2 cm in a half hour period between May 12 and May 30 were reset to the previous reading giving a better hydrograph over the month of May. These corrections did not result in an accurate enough datalogger reading at the end of May so the manual reading taken on May 31 was used to recalibrate the datalogger readings after the frost heaves. The manual measurements taken on May 31 and July 28 were used to calibrate the months of June and July respectively, given the heavy rain and shifts observed on June 30. Any shifts over 3 cm in a half hour period measured by the datalogger on August 18 or September 2 were reset to the previous reading.

Dome Creek at Road is still very reactive to rain events as seen on the resulting hydrograph shown on Figure 4. In using this data it should be noted that large shifts did occur and corrections were made using an estimate of the conditions from the continuous datalogger records.

The rating curve for this site was developed using only 2010 data as a strong correlation was not found when 2009 and 2010 data were compared. The level used for the June 31 data point is estimated from the corrected logger readings and the reading taken on May 12 was not included as the frost heaving may have caused the logger to move significantly. The stage discharge rating curve shows a logarithmic relationship with an R^2 value of 0.96 and can be seen on Figure 5.

3.3 Diversion Channel

The Diversion Channel station is located in a manmade structure that conveys water from Dome Creek around the tailings pond and back into Dome Creek below the tailings facility. Siltation was experienced in the channel during the 2009 field season due to dredging work upstream of the station. A rating curve for this station was developed using stage discharge measurements taken after the dredging occurred. The stage discharge rating curve developed for this site, shown on Figure 6, shows a logarithmic relationship with an R^2 value of 0.80.

Sudden large shifts in water depth were recorded by the datalogger during the June 30th and August 18th rain events. Levels recorded after the August 18th rain event were suddenly very low and did not correspond with the next manual reading taken on September 8th. The waterlevels were reset using the manual measurements taken on June 30th forward and from September 8th back to the August 18 rain event. While the two corrections – forward from June 30th and back from September 8th, did not match on August 18th, these corrections give a much more realistic representation of normal flows. In using this data it should be noted that large shifts did occur and corrections were made using an estimate of the conditions from the continous datalogger records. The resulting hydrograph can be seen on Figure 7.

3.4 Back Creek

The Back Creek station is located just above the confluence with Victoria Creek. Significant challenges were experienced at this site during the 2009 field season due to siltation from placer mining upstream. This caused changes in channel shape and siltation of the datalogger. These problems were not experienced during the 2010 field season, but given the changes to channel shape observed in the past, a rating curve was developed using only 2010 field data. The stage and discharge measurements rating curve from 2010 data shows a strong linear relationship with an R2 value of 0.99, and can be seen on Figure 8. This rating curve appears to estimate mid to high flows with good accuracy but does produce negative values below a stage of 13.2 cm. These flows were taken to be zero and considered low-flow conditions.

The hydrograph produced for this station can be seen on Figure 9. The hydrograph produced in 2010 shows Back Creek is very reactive to rainfall, the opposite of observations made in 2009. This may be due to the influence of placer mining during the 2009 field season. Siltation problems did not occur during the 2010 season, suggesting little to no placer mining activity upstream.

3.5 Victoria Creek

The station at Victoria Creek became encased in silt at some point during summer and was not detected until a high stage was measured in midsummer and the inconsistency was detected when the data was reduced. Attempts to remove the logger and clean out the silt from the station at the next trip were not possible, with field staff concerned that the aircraft cable would break, resulting in a loss of the logger. As such the data collected by the datalogger is not considered to be accurate.

The manual stage and discharge measurements collected during the 2010 field season were added to the 2009 data resulting in a better correlation of the rating curve developed for this station. The rating curve, seen on Figure 10, shows a logarithmic relationship and has an R^2 value of 0.92.

3.6 Upper Pony Creek

This station was located in the upper portion of the Pony Creek drainage basin, above the north wall of the mine pit. The station was installed as part of the hydrogeology investigations into seepage into the mine pit. The creek is small at this location with minimal flows. Earthworks were previously completed in this part of the drainage creating a series of berms causing the stream to pool and meander with some marshy areas. The creek appears reactive to rain events but the effect appears to be dampened by the pools and marsh, as seen on the hydrograph in Figure 11.

The stage discharge rating curve shows a linear relationship and can be seen on Figure 12. Two years of data collection allowed for a better correlation of the rating curve from that reported in 2009, with a R^2 value of 0.8 – an acceptable accuracy given the small channel and low flows.

3.7 Lower Pony Creek

This station is located in the lower portion of the Pony Creek drainage, below the culvert on the adit access road. Flows at this location can be influenced by the pooling seen upstream of the culvert, which can dampen the response to rain events. Overall this creek is very reactive to rain events as seen on the Hydrograph in Figure 13. The flows at the site are very low, challenging both stream gauging and datalogger capabilities. 2010 saw much more precipitation than 2009, resulting in a much stronger rating curve for this station when data from 2009 and 2010 were combined. The stage discharge rating curve shows a logarithmic relationship with an R^2 value of 0.91 and can be seen on Figure 14.

3.8 Meteorology

A comparison between the average monthly temperature for Carmacks CS and Mount Nansen shows strong correlation, as seen on figure 15. This allows for a comparison of temperatures recoded in 2010 with average monthly temperatures and also allows for comment on how this data compares to an average year, for the Carmacks & Mount Nansen region. A comparison of mean monthly temperatures for Carmacks (seen on Figure 16) shows that temperatures in the late winter and spring of 2010 were warmer than average with an average summer and fall , a warmer than average November and a colder than average December.

The 2010 snow surveys at Mount Nansen show a higher than average water content in the snowpack in March and April and no snowpack present in May when a portion of the snowpack would still remain on average. This indicates that a higher and earlier than average freshet occurred in the region. The snow survey data is summarized in Table 1 below.

Table 1 Mount Nansen 2010 Snow Survey Data

Month	Snow Depth (mm)	Water Content (mm)	Average Water Content (mm)
March 2010	51	76	66
April 2010	55	110	77
May 2010	0	0	17

Precipitation data for the Carmacks weather station is not available for 2009 and 2010, the period precipitation data has been collected at Mount Nansen. For this reason a correlation has not been developed between Carmacks and Mount Nansen. Also, as there is no 2010 precipitation data available for Carmacks, it is not possible to compare 2010 to an average.

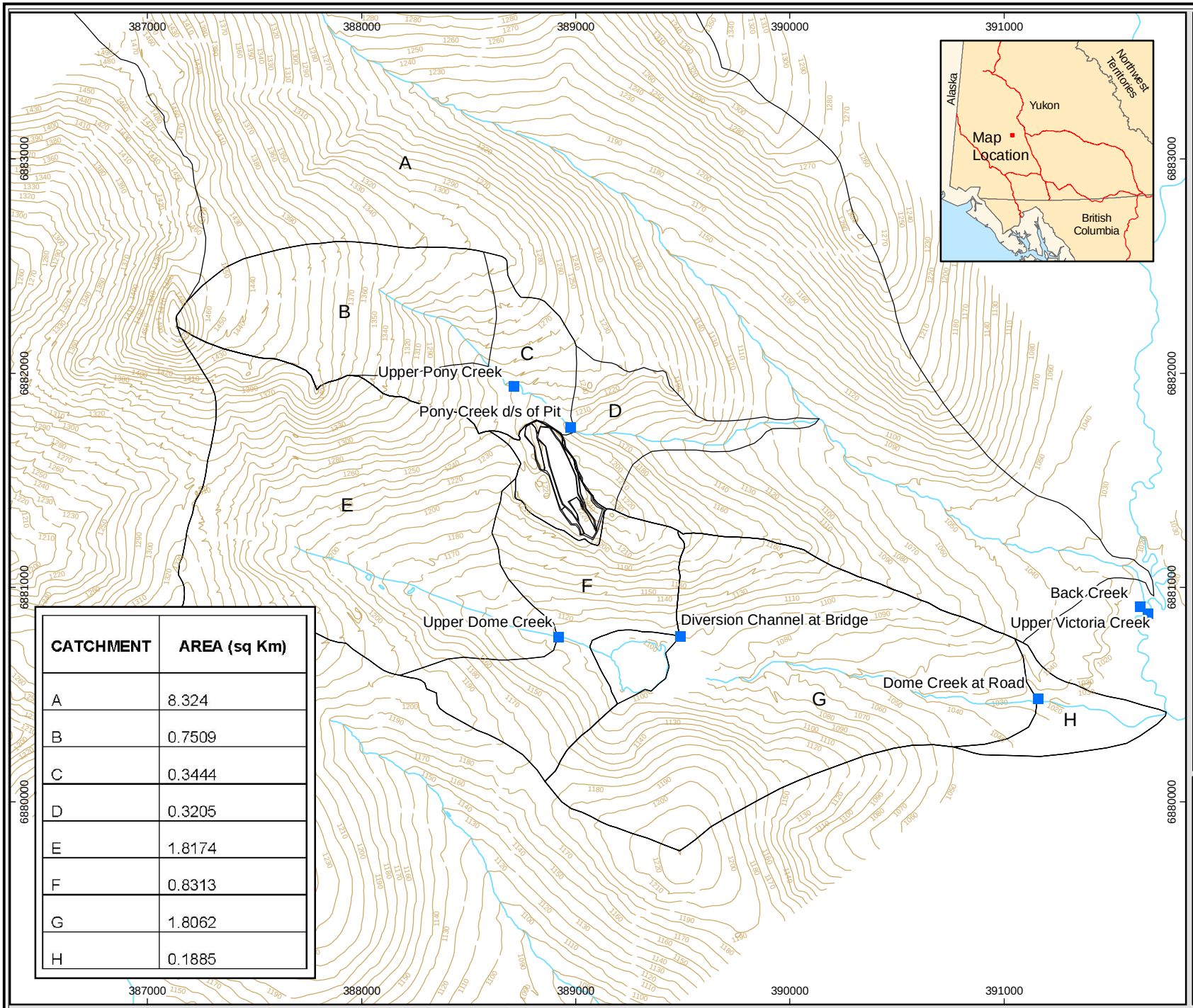
4. Conclusions and Recommendations

The moderate rainfall and midflow conditions hoped for after the 2009 field season did occur during the 2010 field season. The rating curves developed in 2009 were refined for most sites and a good general understanding of the flows experienced in the various water courses around the Mount Nansen Mine site was achieved.

Even with the rainfall and midflow conditions experienced during 2010, the small size of most of the streams around Mount Nansen Minesite challenged the capabilities of basic datalogger installations and stream flow gauging methods. If more accurate continuous flow data is required as the closure planning and implementation continues, alternative methods should be considered. These may include small weirs for streamflow gauging and buried stilling wells.

The absence of a long term precipitation record with data available for 2009 and 2010 has made discussion of the meteorological reasons for observed conditions challenging. There has been discussion around using Highways observations to recreate a long term precipitation record. This, or discussion with Environment Canada to try and locate missing precipitation records, could be perused for continued meteorology monitoring and modelling at this site.

Figures



CATCHMENT	AREA (sq Km)
A	8.324
B	0.7509
C	0.3444
D	0.3205
E	1.8174
F	0.8313
G	1.8062
H	0.1885

Legend

- Hydrology Stations
- Catchment Boundaries
- Intermediate contours (10m)
- Watercourses

N
W E
S

m
0 100 200 400 600

1:25,000

UTM Zone 8N, NAD 83

Map Sub-Title

Mount Nansen Catchment Map

November 2010
Project 60154930

AECOM

Figure 1

Map Document: W:\GIS\Small Projects\Y2010\60146995_Mount Nansen\MXD\Areas_Calculated_Catchments_sm_09Nov2010.mxd

Figure 2 - Upper Dome Creek Hydrograph

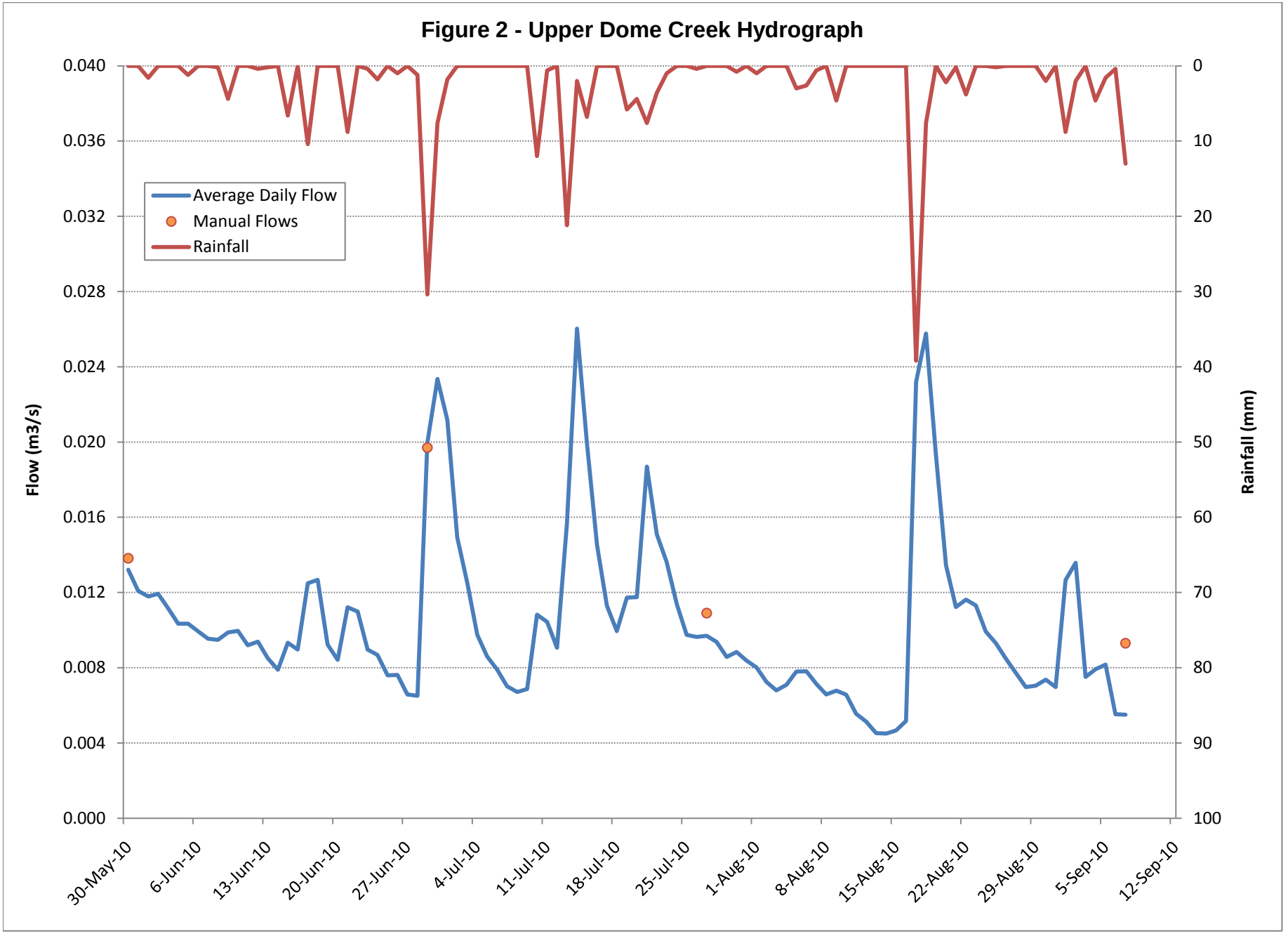


Figure 3: Upper Dome Creek Rating Curve

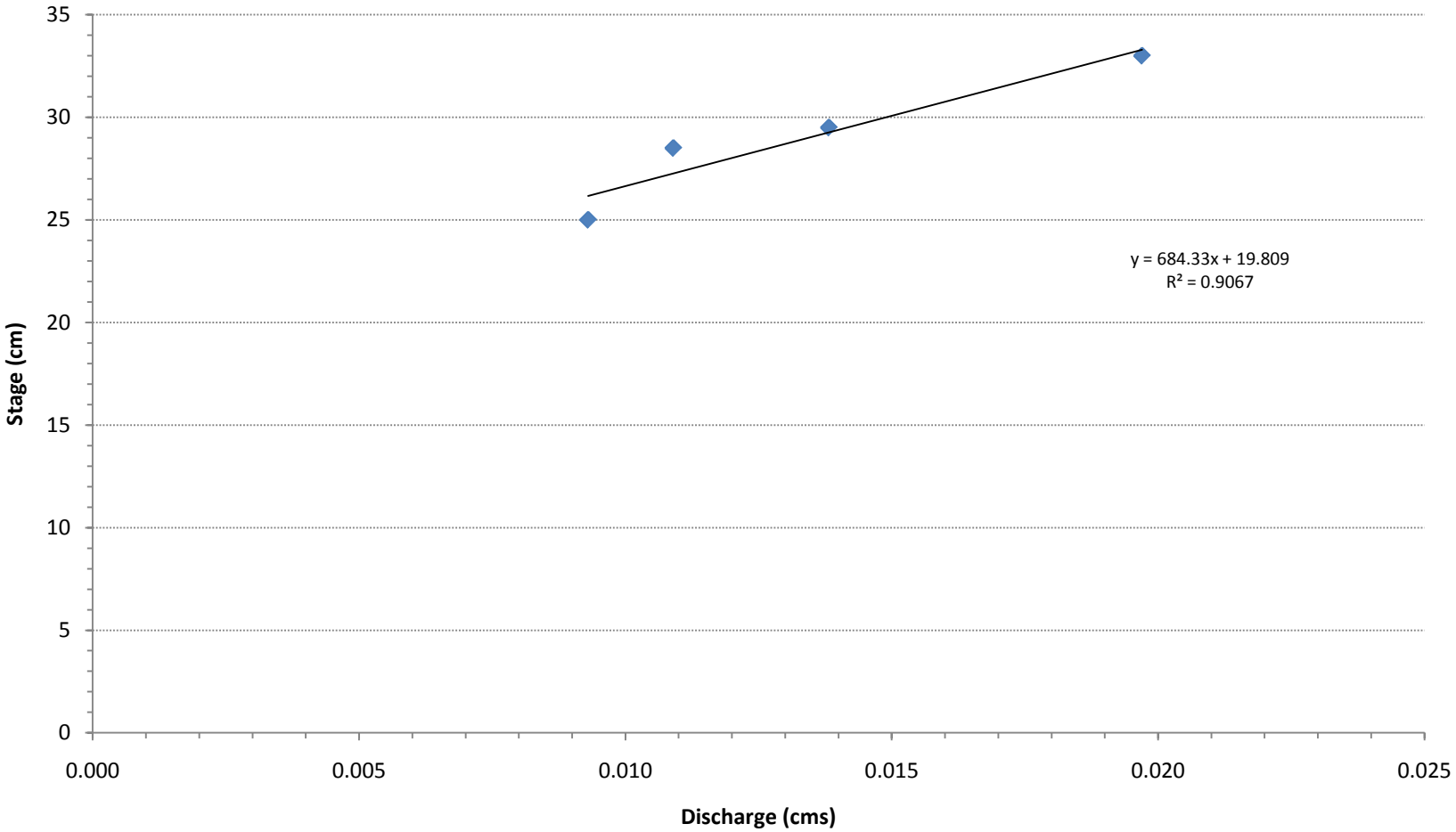


Figure 4 - Dome Creek at Road Hydrograph

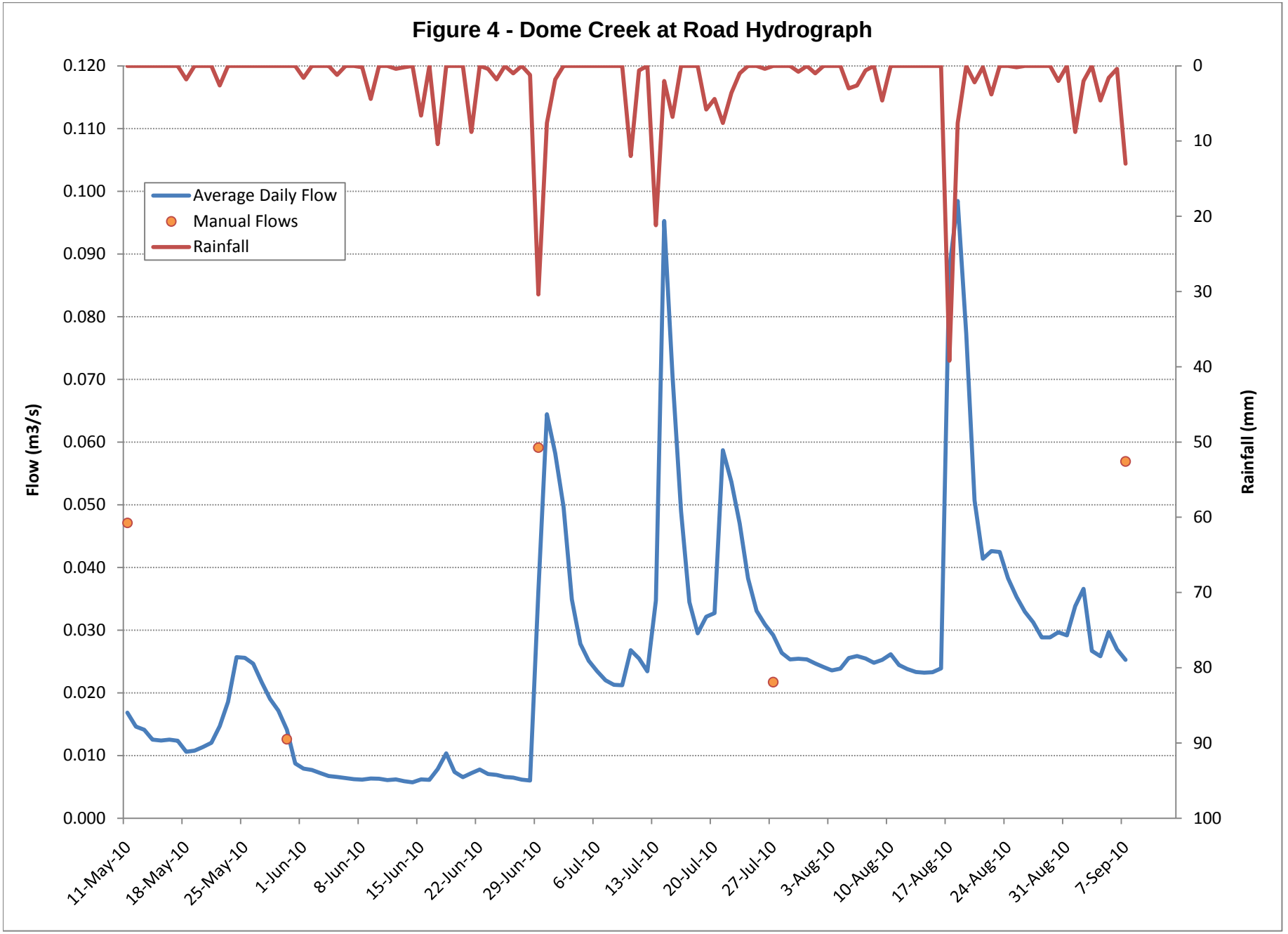


Figure 5: Dome Creek at Road Rating Curve - 2010

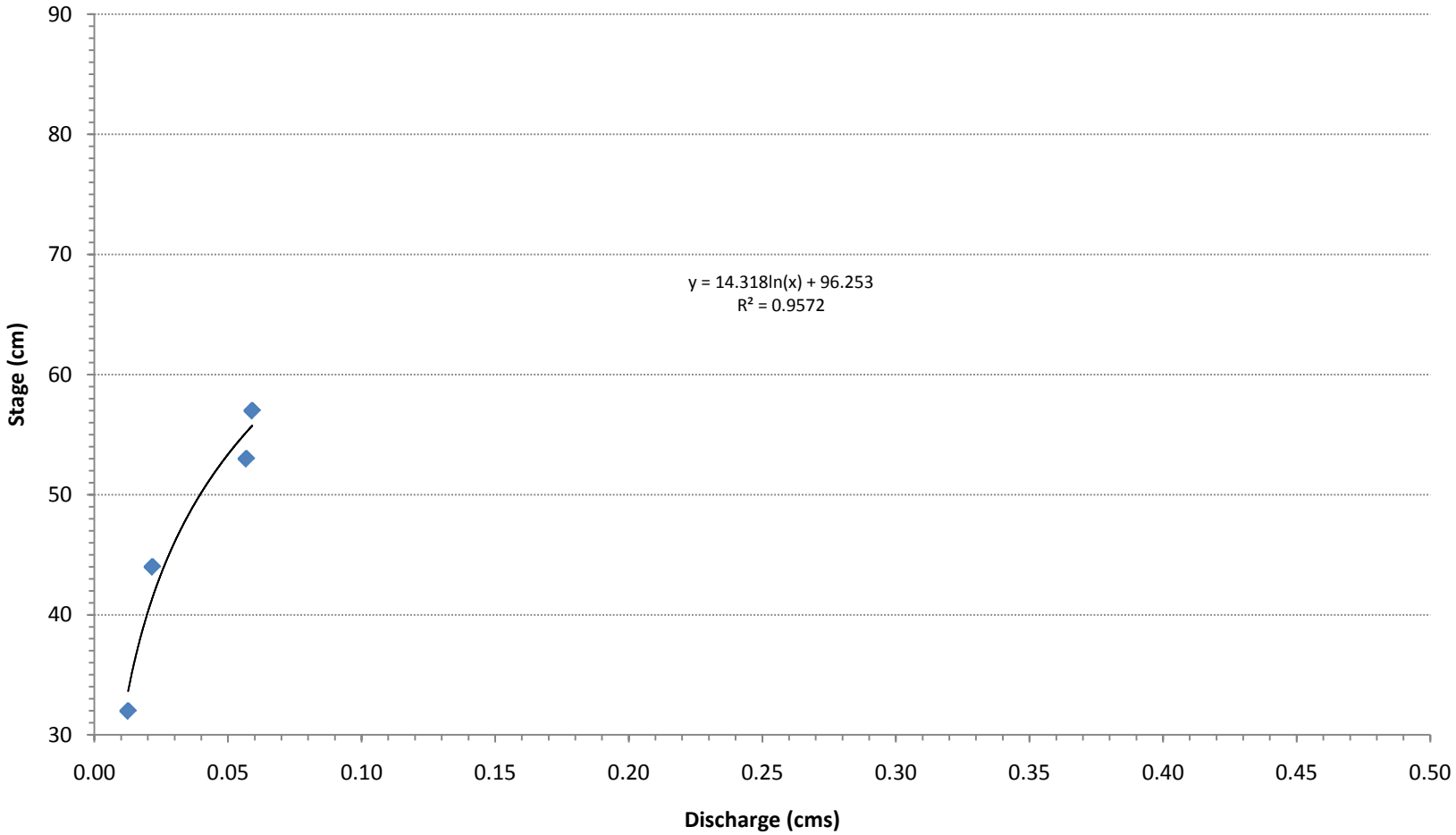


Figure 6: Diversion Channel Post-Dredging Stage Discharge Curve

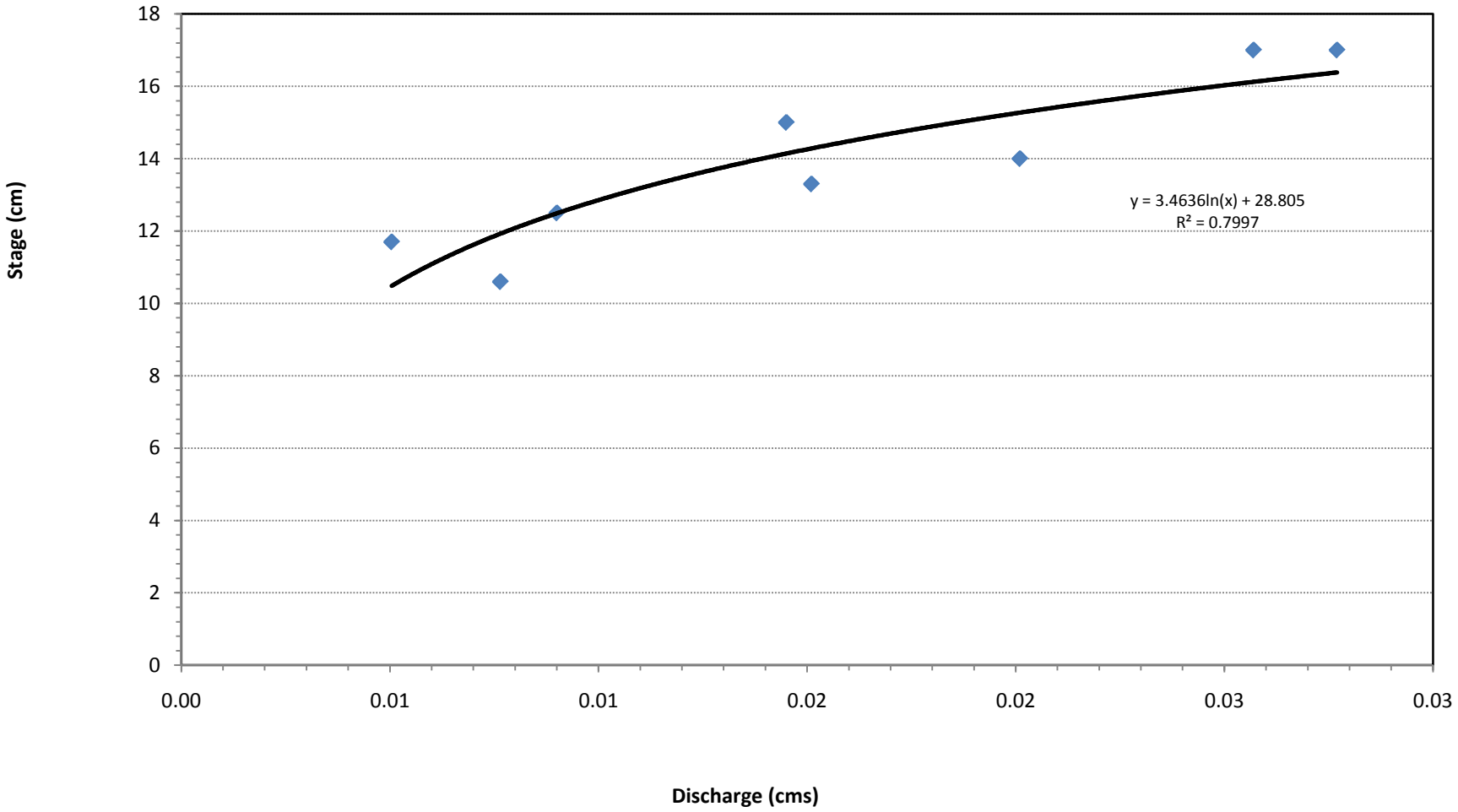


Figure 7 - Diversion Channel Hydrograph

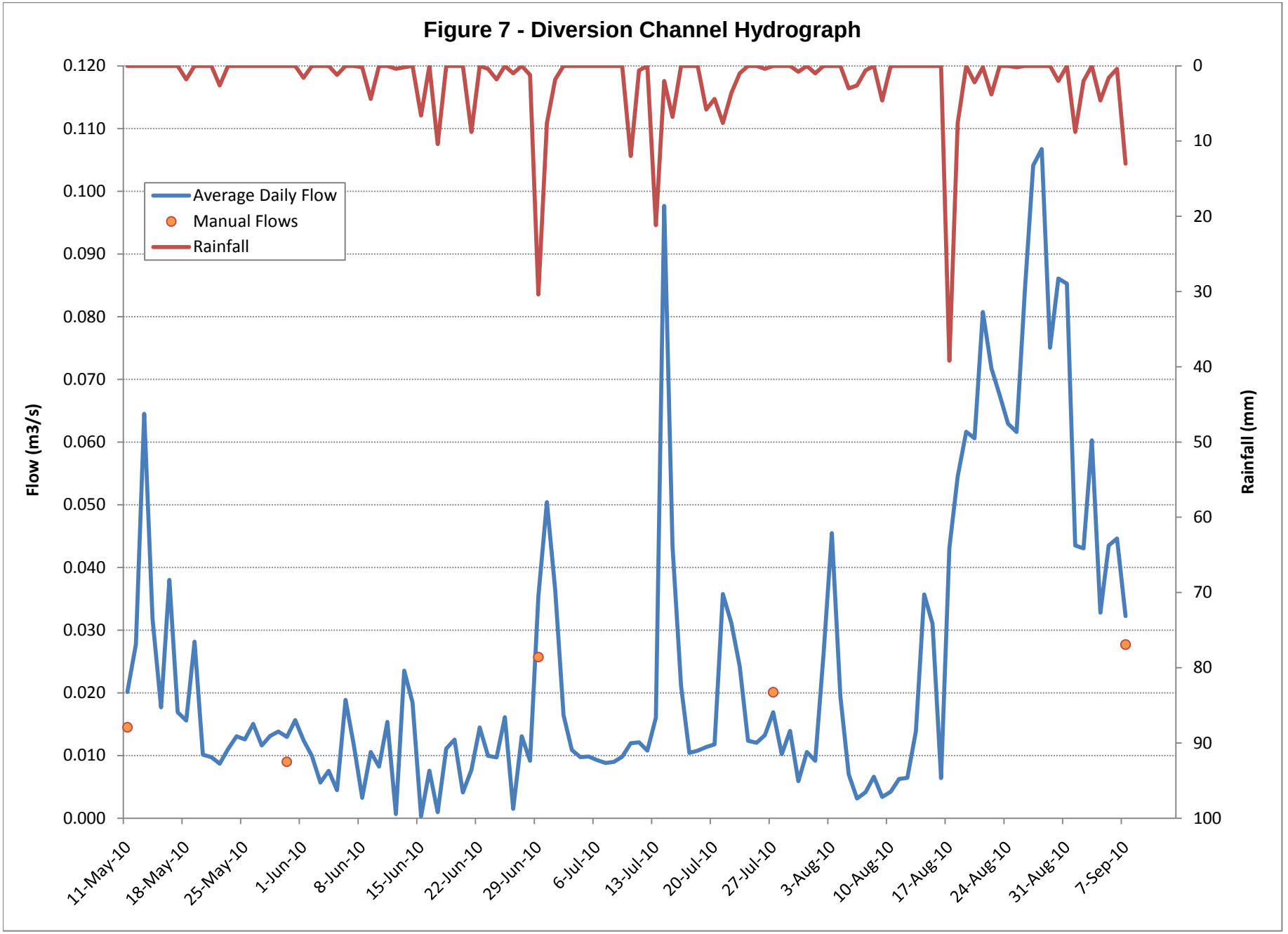


Figure 8: Back Creek Rating Curve 2010

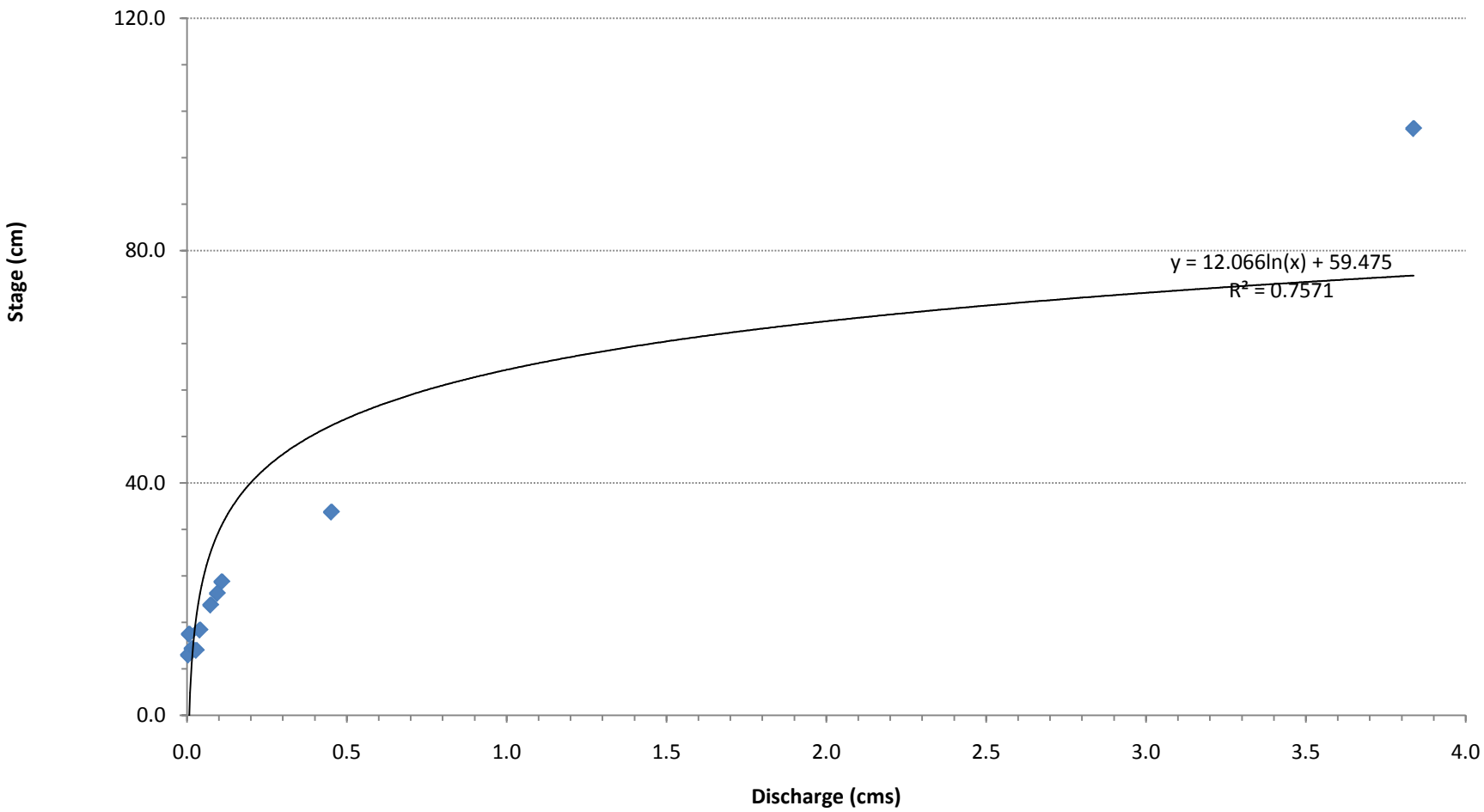


Figure 9 - Back Creek Hydrograph

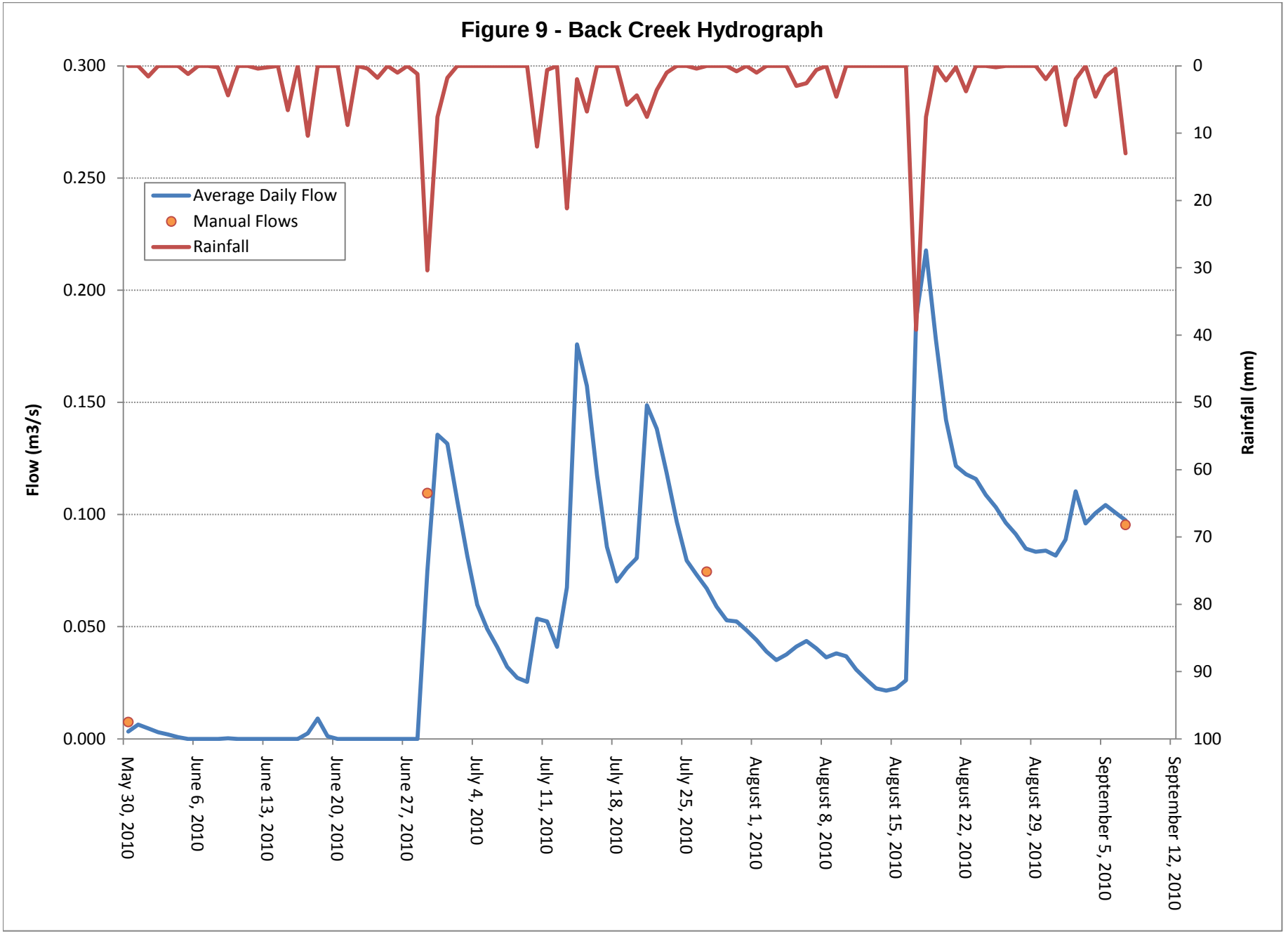


Figure 10: Upper Victoria Creek Rating Curve

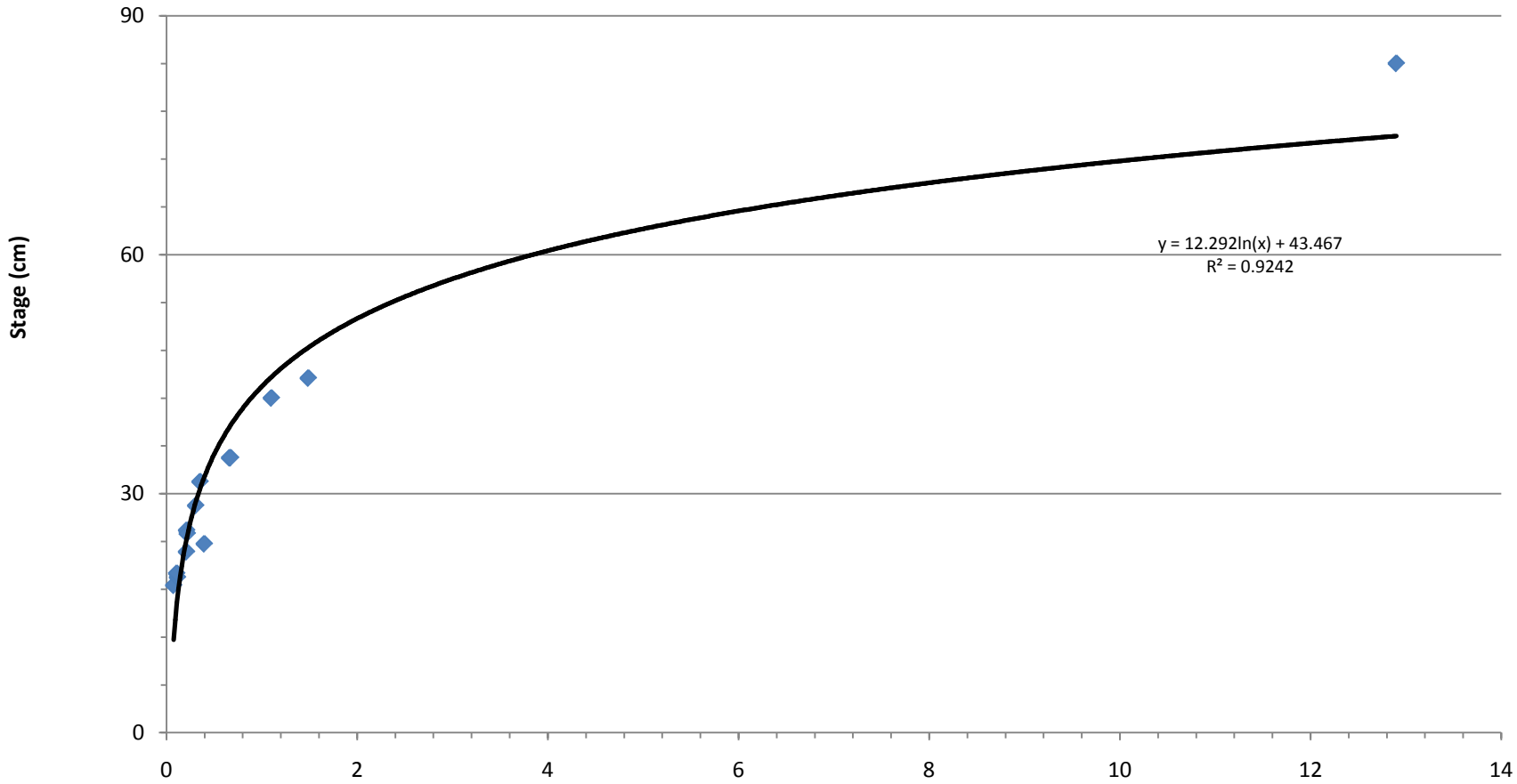


Figure 11 - Upper Pony Creek Hydrograph

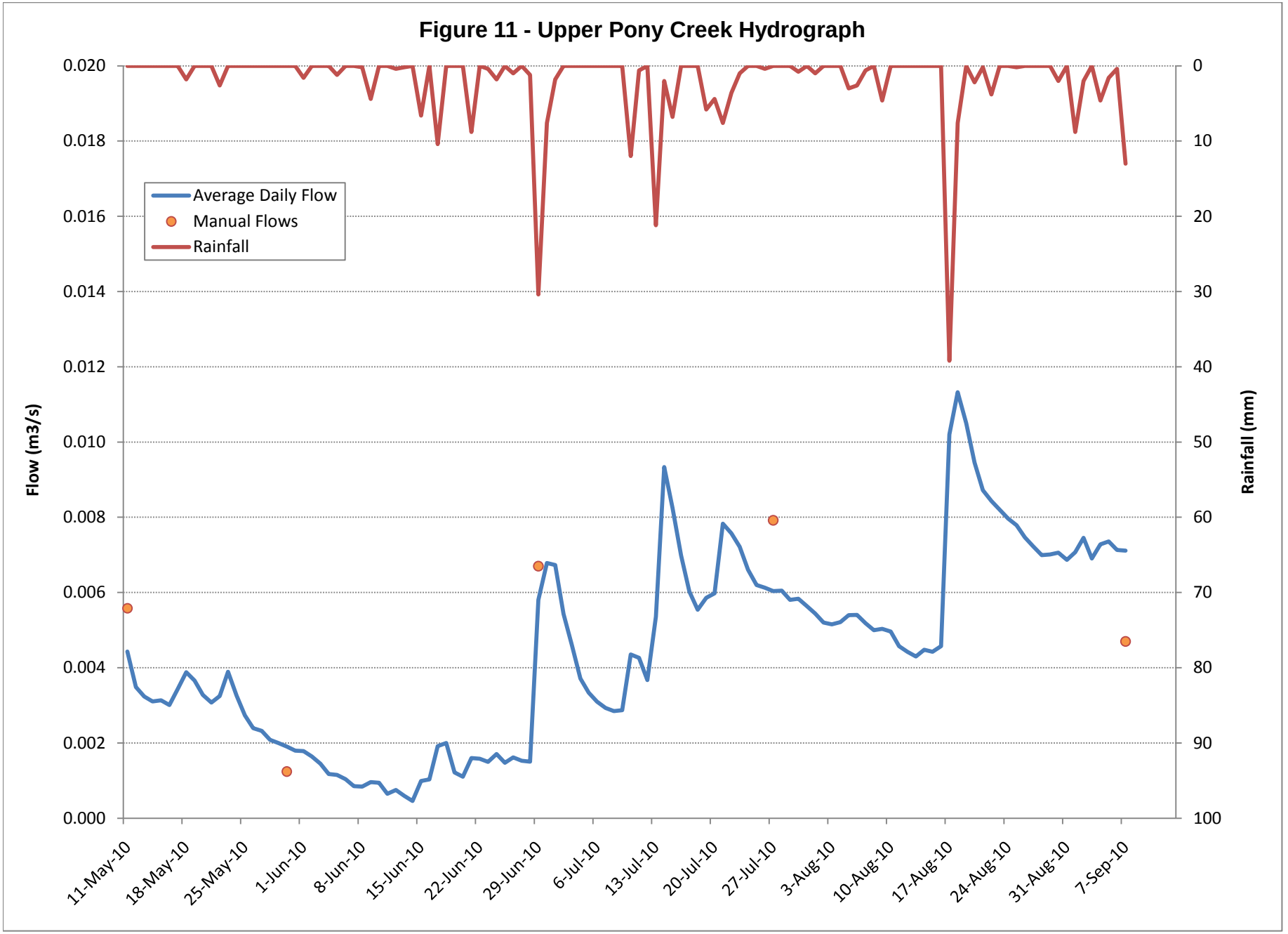


Figure 12: Upper Pony Creek Rating Curve

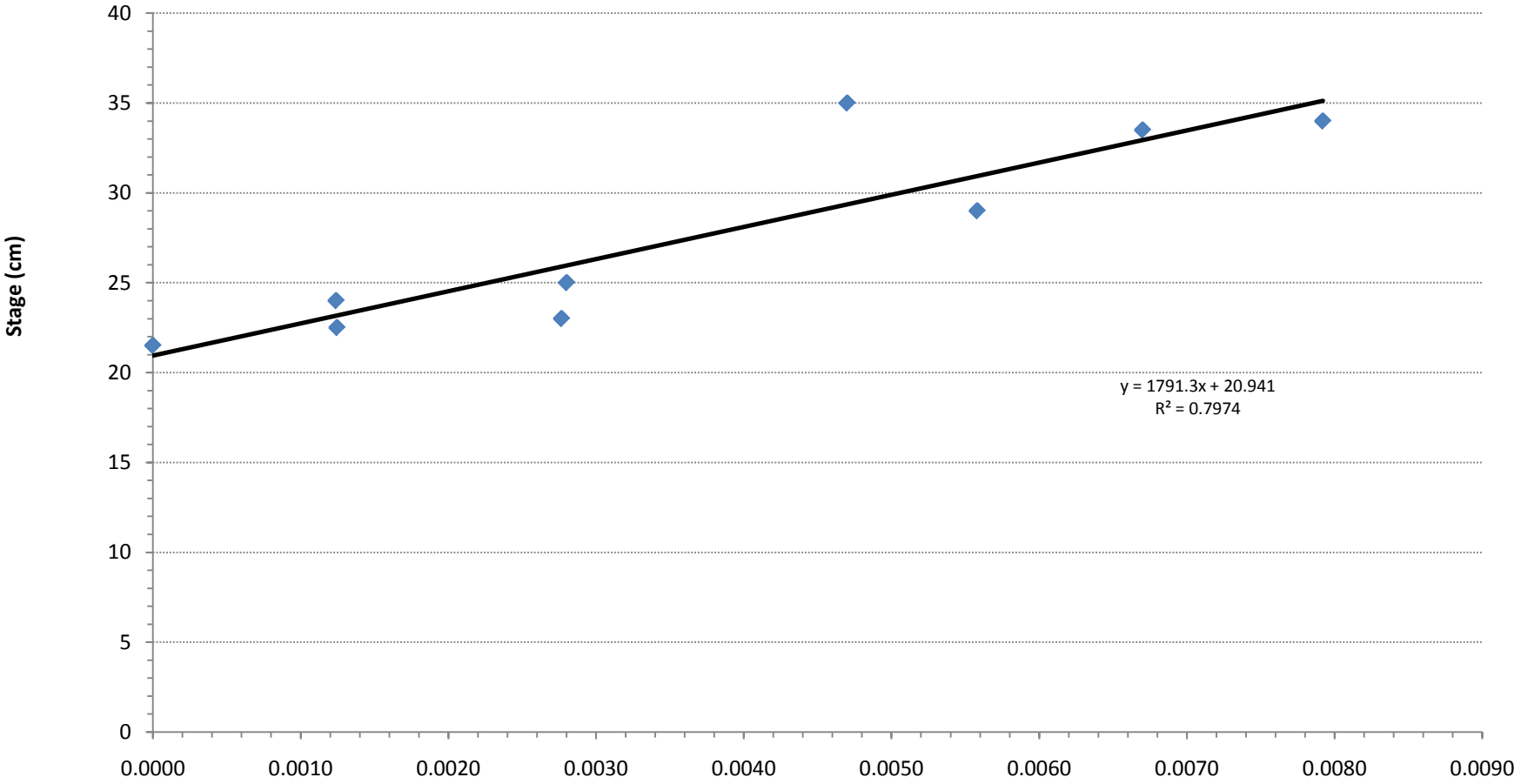


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Figure 13 - Lower Pony Creek Hydrograph

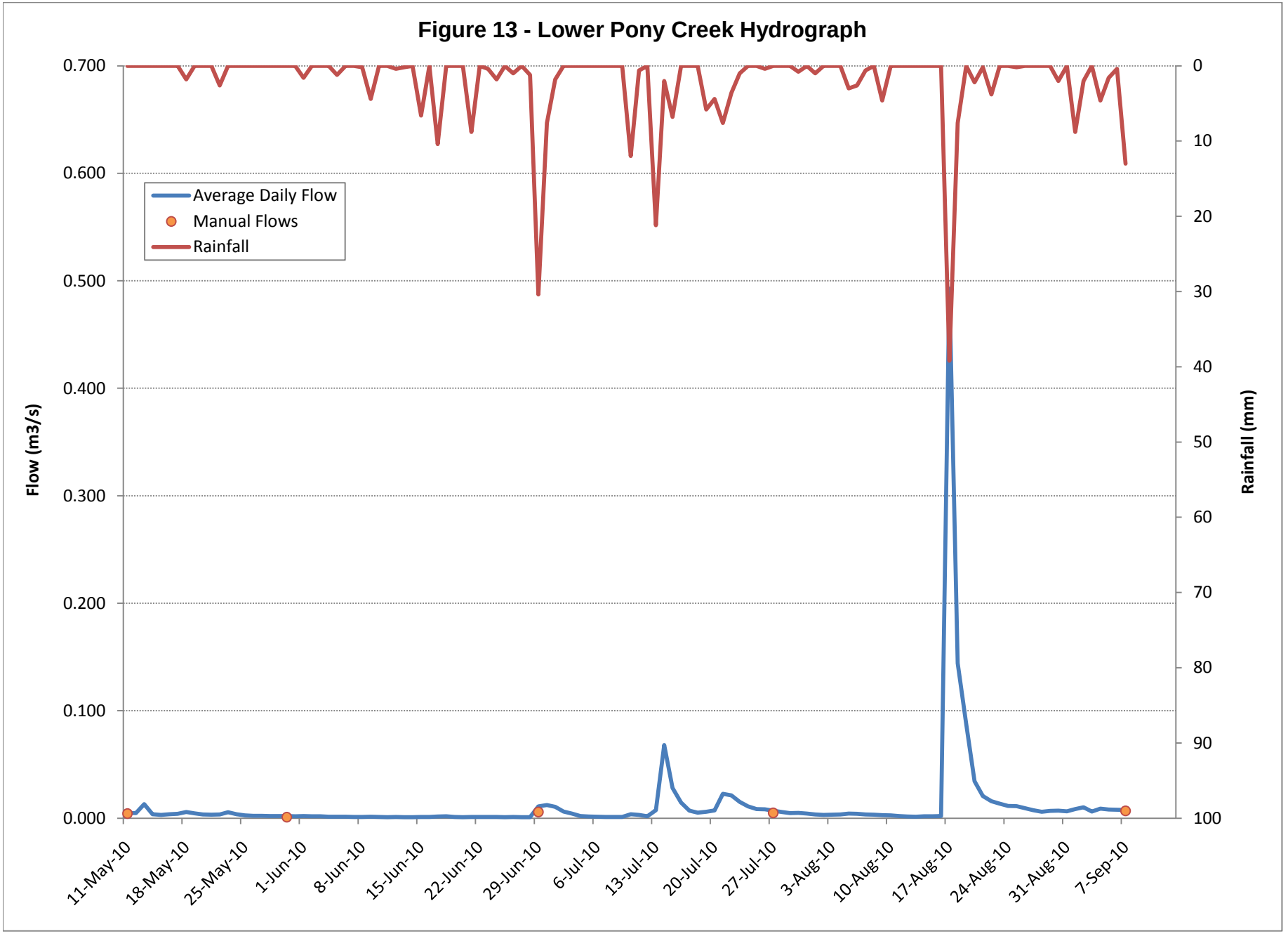


Figure 14: Lower Pony Creek Rating Curve

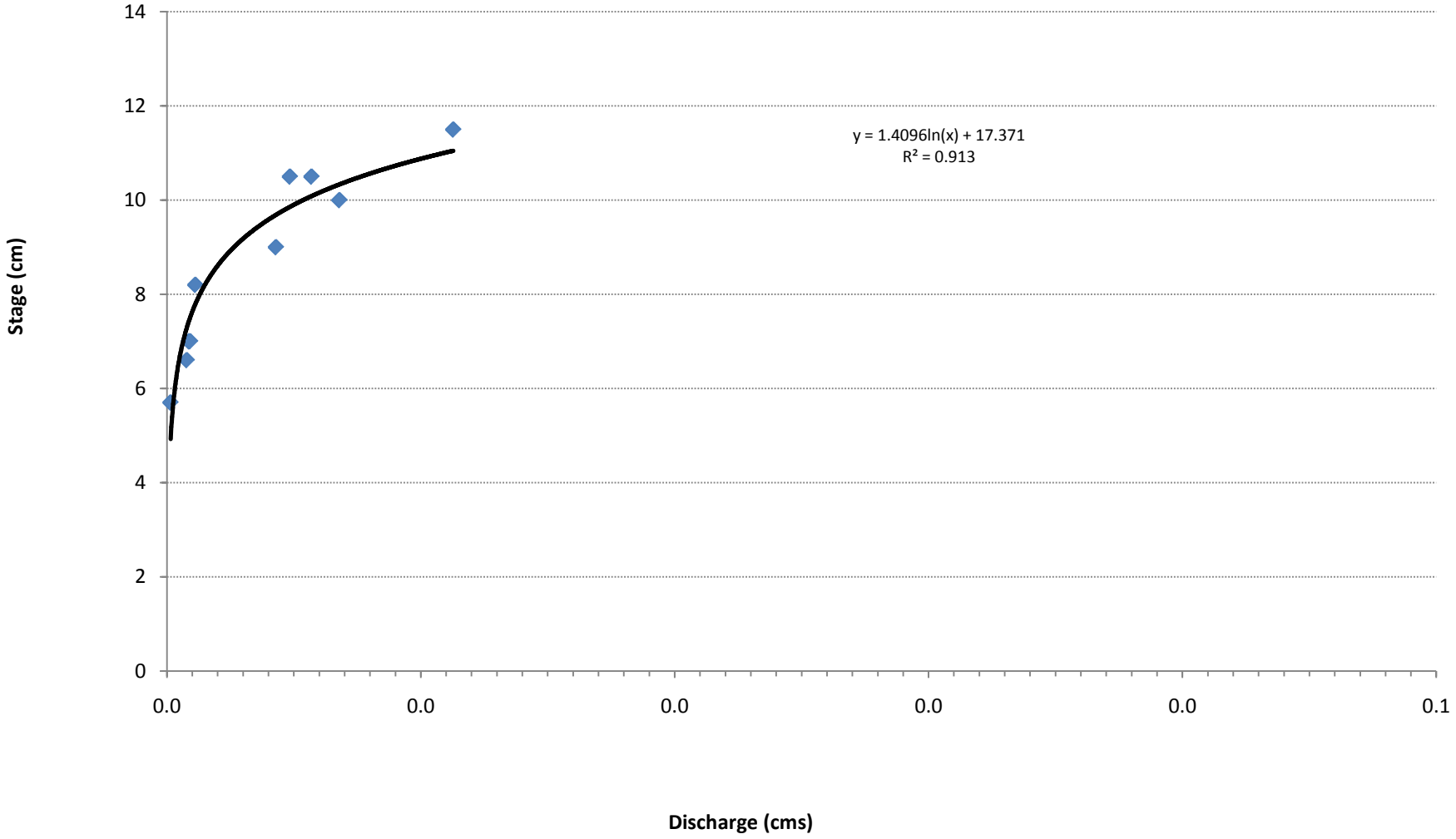


Figure 15: Mean Monthly Temperature at Carmacks vs Mt Nansen

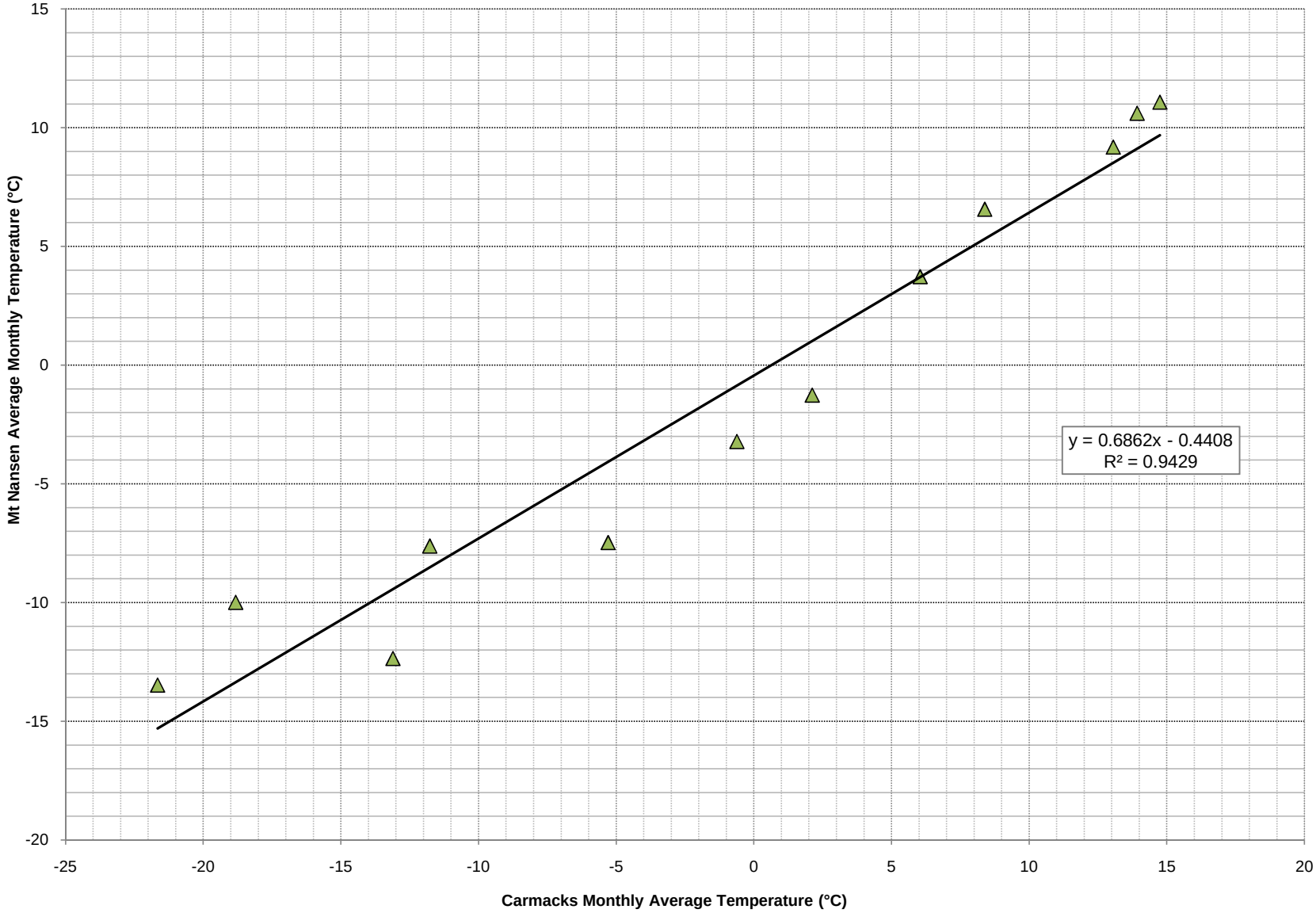


Figure 16: 2010 Carmacks Mean Monthly Temperature vs Mean Monthly Temperature

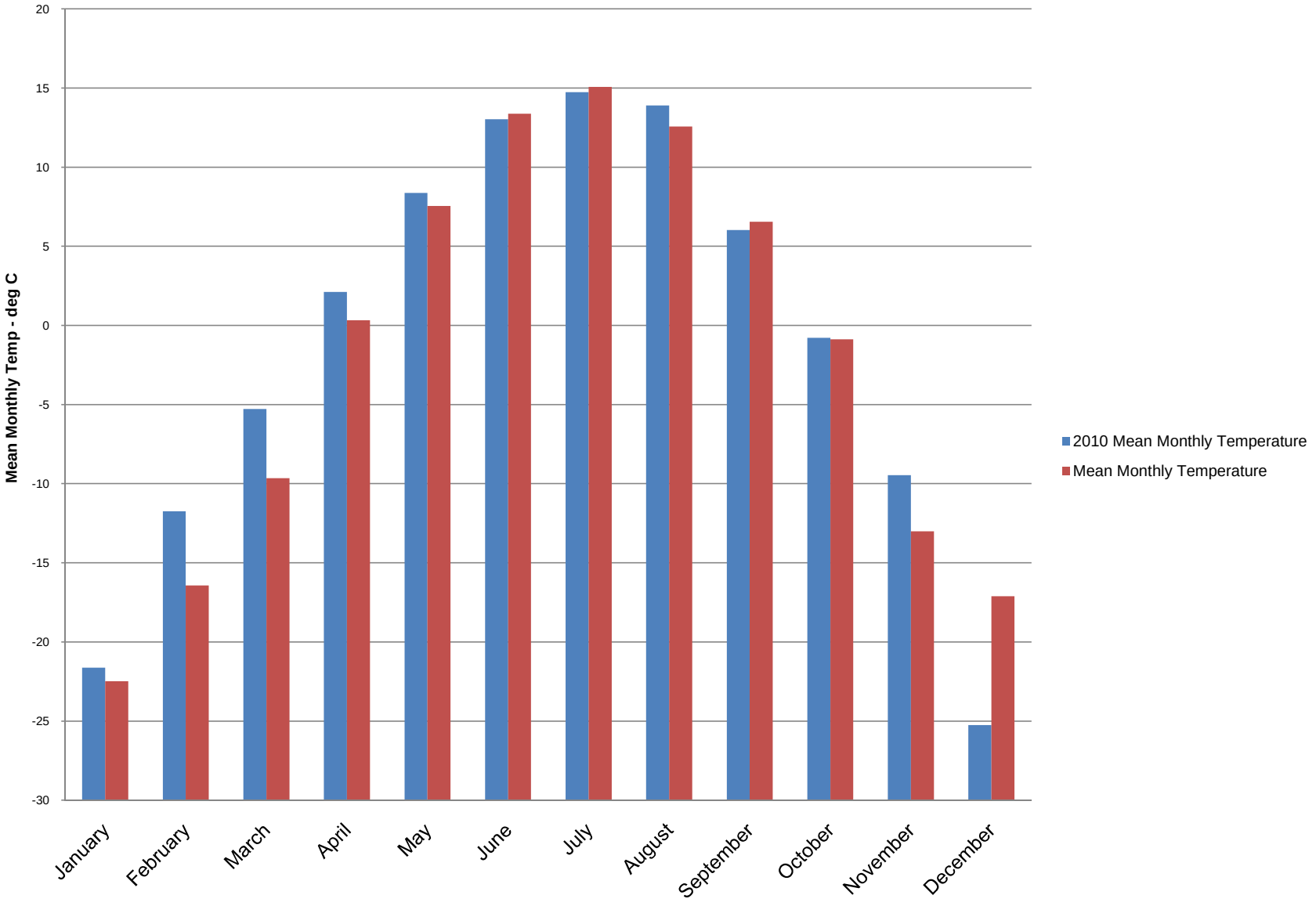


Fig 16 carmacks CS Monthly Averages.xlsx

Appendix A

Mount Nansen Hydrology Program Progress Summary

AECOM
2251 2nd Avenue
Whitehorse, YT, Canada Y1A 5W1
www.aecom.com

867 633 6474 tel
867 633 6321 fax

Memorandum

To	Rina Freed and Alastair Kent	Page	1
CC			
Subject	Mount Nansen Hydrology Program Progress Summary		
From	Stephanie Whitehead		
Date	February 4, 2010	Project Number	60119144

The 2009 Hydrology Program for the Mount Nansen Mine Closure Project has been completed and consisted of a field installation program and data analysis work. This includes the entry and analysis of additional field data collected in September and October and the winterizing of the existing Victoria Creek hydrometric station.

Field Program Summary

The hydrology field program was managed by AECOM while data collection was conducted by Environmental Dynamics Inc. (EDI) as part of their existing water quality monitoring program. The first step in the field program was a reconnaissance trip to the Mount Nansen site, along with EDI, to see their existing water quality sampling stations and choose locations for the hydrometric stations that compliment these water quality stations. This was conducted on April 29, 2009 by Stephanie Whitehead and Lyndsay Doetzel of EDI. Once these sites were chosen, an installation trip was planned as soon as the streams were free of ice and freshet flows could be captured. Due to an unusually high freshet flow, road access was cut off to the Nansen site. For this reason, a day trip to measure the freshet flow in the diversion channel was organized using a helicopter. This trip was conducted on May 7, 2009 by Chad Davey and Stephanie Whitehead. Other streams were gauged as soon as access was restored, however the high freshet flows had already started to recede at that time.

The hydrometric stations installation trip was completed as soon as road access was re-established on May 14th and 15th, 2009 by Chad Davey and Stephanie Whitehead. The stations were installed at five locations with each station consisting of a datalogger that continuously measured water depth and temperature and a staff gauge. At each site a cross-section and benchmark were established and surveyed in conjunction with the corresponding velocity measurements. The freshet gauging trip and installation trip were summarized in field memos.

Once the hydrometric stations were installed and functioning, an orientation trip was conducted with EDI to go over hydrometric station locations and sampling methods. During this trip one additional station was installed in Upper Pony Creek, at the request of the hydrogeology lead, Ryan Mills. A cross-section was also established in the upper diversion channel to determine if there is a loss or gain of groundwater into the diversion channel. This trip was conducted on June 10th by Stephanie Whitehead and Megan Marjonovic of EDI. Kai Woloshyn of AECOM also joined this trip to familiarize himself with the site and aid with his work on the water quality modelling being conducted.

From this point onwards the collection of field data was conducted by EDI staff who collected five sets of velocity and water level measurements throughout the field season. Dataloggers were downloaded by AECOM staff working on the hydrogeology program in August. At this time the hydrometric station on Back Creek was relocated as the water levels had dropped below the datalogger sensor.

Data Entry and Analysis

All field data collected throughout the field program was entered into MS Excel and any errors were identified and corrected if needed. The field measurements taken were used to calculate total discharge for each station. The calculated discharges were related to a water depth (or stage) resulting in a rating curve for each site. The data downloaded from the datalogger was corrected for barometric pressure and checked with manual water level measurements. The compensated data was examined and apparent errors were identified and corrected where necessary. The rating curves were then applied to the continuous water depth measurements collected by the logger and a continuous discharge record was generated.

The continuous discharge records were fed into a mine-wide water balance model and were intended to be used in conjunction with weather data being collected at site, as well as regional weather data. However, the weather station at site experienced technical problems that were corrected during the spring and the weather station was operational again in mid-summer. The mine site, like most of the Yukon, experienced an extremely dry summer and very few rain events were recorded, making site specific correlation between rainfall and streamflow very difficult.

Results

Preliminary rating curves were generated for each hydrometric station. Given the amount of data the overall trends between water level and discharge were strong with R^2 values between 0.7 and 0.94. As the program was started after freshet, the Chezy-Manning[1] equation was used to estimate a flow at bankfull. This was used in the preliminary rating curves to help remedy the trend towards overestimating flows at higher water levels. Bankfull stage estimates and the associated area and hydraulic radius were taken from the field surveys completed during the installation of the gauges and slopes estimated using field observations.

Using these preliminary rating curves, a hydrograph was generated for each site from the continuous stage data collected by the dataloggers.

Locations of the gauging sites can be seen on Figure 1.

Dome Creek

Dome Creek is a small creek, approximately 1 m wide at the gauge site; located just below the mine access road. Immediately below the gauge site and above the access road, the channel is braided and meandering. The hydrograph developed for Dome creek, seen on Figure 2, shows the creek to be flashy in response to rain events. The preliminary rating curve developed for Dome Creek, as shown on Figure 3, demonstrates a linear relationship between stage and discharge, with a strong correlation and R^2 value of 0.98. The flow appears to go to zero at 31.19cm, possibly because the datalogger was in a pool just downstream of the cross-section.

Upper Victoria Creek

Victoria Creek is the largest watercourse running through the site and, at the gauging site, appears to be groundwater fed due to open water year round at this particular location. The hydrograph developed for Victoria Creek, seen on Figure 4, shows high flows during freshet and lower flows throughout the rest of the year, with very little peaking during rain events. The logger in Victoria Creek was winterized and left in place to collect water level data over the winter. The preliminary rating curve for Victoria Creek, seen on Figure 5, shows a very strong correlation with an R^2 value of 0.94.

Back Creek

Back Creek is a smaller water course that flows into Victoria Creek just downstream of the Victoria Creek station. This creek was heavily influenced by placer mining during the summer of 2009, which attributed is to the heavy sedimentation and the spike in flows observed in late June during releases at the placer mine, as seen on the hydrograph developed for Back Creek (Figure 6). After the logger was moved, flows in Back Creek do not appear to react strongly to rain events.

Due to silt deposits around the datalogger, the station was moved in mid-July. For a period between mid-June to when the logger was moved on the 14th of July, the datalogger was completely buried in silt. The datalogger appears to be less accurate after being cleaned out and reset; however, it does provide a relatively good stage record when compared with the manual measurements. The preliminary rating curve for Back Creek, seen on Figure 7, shows an acceptable correlation with an R^2 value of 0.83. The rating curve appears to be under-estimating flows at the mid-level, as observed on both the hydrograph and the rating curve. This may be due to the change in channel shape from sedimentation during the placer mining activity.

Pony Creek

Pony Creek is a small creek affected by an access road crossing with a culvert and previously conducted earthworks at various points along the creek. The flow along the drainage conveying Pony Creek is suspected to influence the seepage into the north wall of the mine pit. This is being studied

as part of the hydrogeology investigations at site. Two dataloggers were placed at the site in order to help the hydrogeology investigations as well as the water balance modelling.

The first logger was placed high in the drainage, upstream of the pit. The earthworks in this part of the drainage are older and has only partially revegetated and have resulted in a series of berms, causing the stream to pool and meander. The logger was placed in a pool in order for it to remain submerged throughout the summer; however, it appears that there was no flow in the creek when stage levels went below 21.5 cm. For this reason elevations below this stage were not used in the rating curve. The second logger was placed downstream of the access road culvert, in order to correspond with the existing water quality sampling locations (Figure 1). The downstream site was also chosen as very low or no flow conditions occur in this stream during the summer and the culvert was used to conduct flow volume measurements by measuring the time required to fill a bucket.

Due to the extremely low-flow conditions over the summer, collecting flow and level data at the downstream Pony Creek site was challenging and likely also challenged the ability of the datalogger. For this reason, the levels and resulting flows estimated for the hydrograph do not exhibit the level of accuracy expected. The hydrograph for both stations can be seen on Figure 8. The downstream gauge is much more reactive to rain events than the upstream station. It can be seen however, that gauging generally occurred during low-flow periods. The rating curves for Pony Creek can be seen on Figures 9a and 9b. The rating curve for the downstream site shows a strong correlation with an R^2 value of 0.92 while the upstream site had a limited amount of data with an acceptable correlation and an R^2 value of 0.70. While all other rating curves at this site have been completed with a logarithmic formula, the rating curve for the upstream site appears to exhibit a linear trend. It should be noted that data available for the upstream site was limited due to a later installation and the flow going dry at points throughout the summer.

Diversion Channel

The Diversion channel is a man made structure bringing water from the top of the Dome Creek drainage around the tailing pond and back into Dome Creek, thus keeping water from coming in contact with the tailings. A logger was placed in the Diversion Channel, downstream of the bridge crossing the channel as this is an area of interest for future engineering design with regard to the tailings pond. In addition to the water from Dome Creek, the Diversion Channel conveys water pumped out of the tailings pond as part of dam safety maintenance, runoff from approximately 2/3 of the area surrounding the tailings pond and is suspected to be losing flow to groundwater seepage upstream of the bridge. A second cross-section was established just below the inflow of Dome Creek (upstream of the datalogger) to measure discharge and compare with the flows recorded at the gauge site. All measurements conducted showed the channel to be losing flow as suspected; however, this would need to be studied more to quantify the actual amount.

Due to the fine channel substrate upstream of the logger and dredging of the channel in early July, sedimentation occurred at the logger site, potentially changing the channel shape as well as the bed elevation. Again, sedimentation around the datalogger is suspected to have affected the readings. A hydrograph was not developed for the Diversion Channel, given the inconsistency between the datalogger and manual stage measurements. The preliminary rating curve developed for the Diversion Channel, seen on Figure 10, shows a strong correlation, despite the channel dredging, with the R^2 value of 0.86. Rating curves developed before and after the dredging activities, do not appear

to have substantively changed. These rating curves are also show on Figures 10a and 10b. Given the apparently strong rating curve, a gauge could be re-established at this site, with a new datalogger, protected from sediment and used to generate future flow estimates.

Recommendations

The summer of 2009, during which most of the field data collection for this project occurred, was unseasonably dry and resulted in the majority of the flows measured being in the low range. This may also be a characteristic of the region. The rating curve compiled from the data should be considered preliminary at this time and additional stage and flow data, especially at mid and high flows, should be collected and added to the rating curves in order to better estimate flows at all ranges.

The siltation of loggers in the Diversion Channel and Back Creek was also a challenge in data analysis and is thought to have damaged the loggers. Any datalogger used in these creek should be protected in a latex sheath filled with either water or, given the low temperatures at site, glycol. This would protect the logger from both siltation and freezing, if an unexpected cold snap occurs in spring or fall.

Temperature and Precipitation Correlations

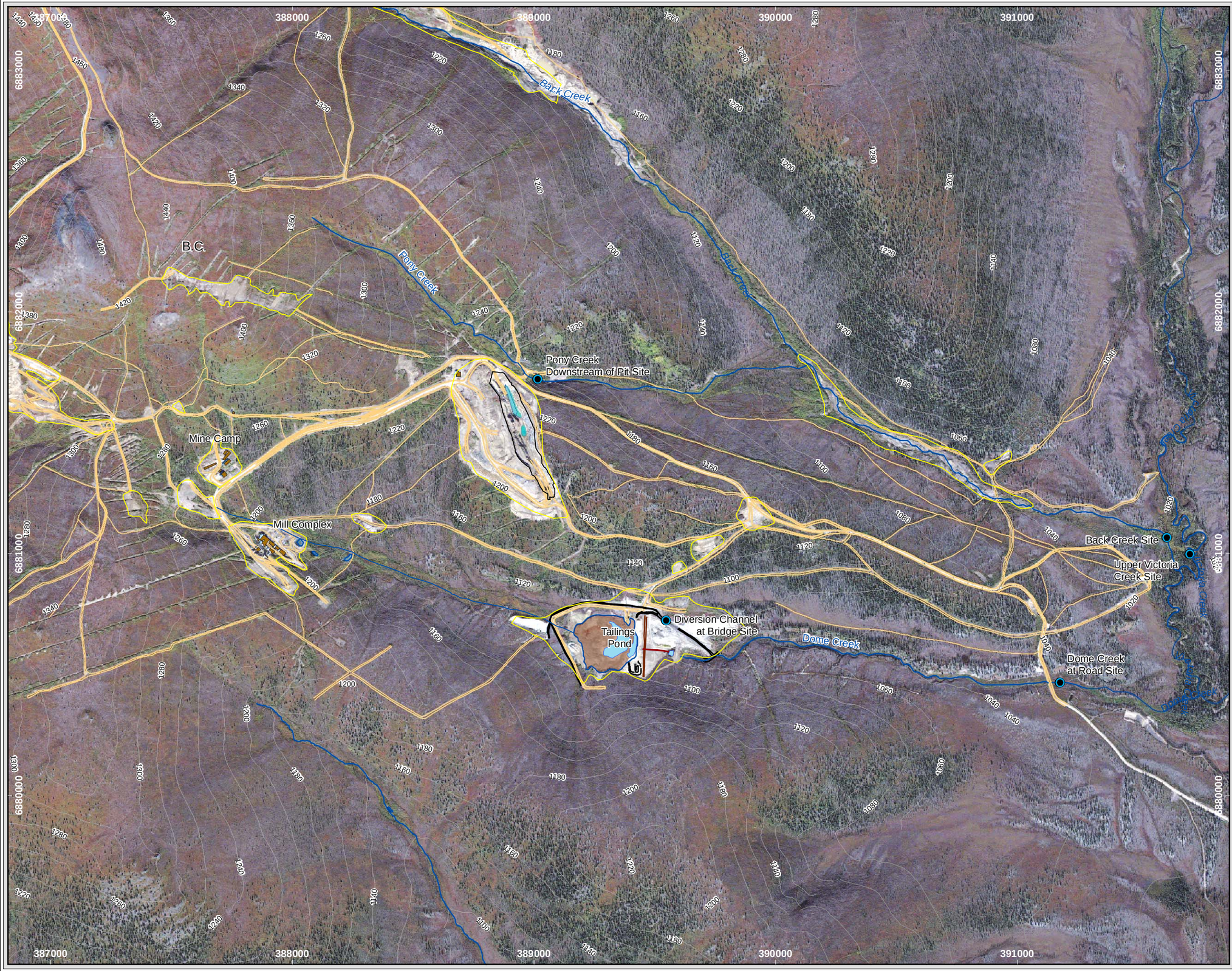
A statistical analysis was completed to determine whether a correlation exists between the temperature and precipitation data collected at the Mt Nansen Mine and the data obtained from the Environment Canada stations #2100300 and #2100301, located in the Village of Carmacks for both monthly precipitation and daily temperature. Monthly precipitation was chosen over daily precipitation due to the limited amount of data available at the Mt Nansen Mine. A linear regression was performed on both datasets using the Carmacks data as independent variable and the Mt Nansen data as dependant variable (Figures 11 and 12). A cross-validation was completed to assess whether the regression model could effectively predict the precipitation and temperature data at the Mt Nansen Mine. The main indicators used to evaluate the regression model are the mean error and the mean absolute error. For each parameter, a value close to 0 indicates that the model is representative of the conditions prevailing at the Mt Nansen Mine. The standard deviation is an indicator of the variability within the dataset.

Results for the daily temperature yield a very strong correlation, as suggested by the multiple correlation coefficient (R^2) of 96%, seen on Figure 11. The average of the predicted values is -1.1 °C with a standard deviation of 9.6 °C. The mean absolute error is 8.2 °C. The regression model for the temperature was deemed suitable to generate a more extensive temperature dataset to be integrated within the Water Balance Model.

Results for the monthly precipitation indicate a strong correlation between the two datasets, as suggested by the multiple correlation coefficient (R^2) of 78%, seen on Figure 12. The average of the predicted values is 0.6 mm/month with a standard deviation of 9 mm/month. The mean absolute error is 12.6 mm/month. This would indicate that the regression model for the temperature is suitable to to generate a more extensive precipitations dataset to be integrated within the Water Balance Model.

Following directions from Frank Patch, project manager for the Government of Yukon, a similar statistical analysis was carried out to assess the potential correlation between data recorded at Otter Falls and at the Mt Nansen Mine. Results from the statistical analysis suggest a weaker correlation between both variables when compared to the Carmacks-Mt Nansen Mine results. A weaker correlation reduces the level of confidence in the ability of the regression model to predict effectively meteorological conditions prevailing at the Mt Nansen Mine.

SW:dlt
Encl.



Legend

- Gauging Site
- Mining Disturbance
- Pond/Tailings Pond
- Mine Infrastructure
- Road/Trail
- Tailings
- Contour (Index 20m)

Imagery flown September, 2008.
Topographic data by The Orthoshop, based on 1998 aerial photography at 1:50,000 scale. Brown McDade Pit survey by Underhill Geomatics Ltd, Drawing 281-05B Dated March 18, 2003. Inferred fault by B.Y.G. Natural Resources, Inc. All other data, AECOM, 2009.

N
W E
S

0 250 500
Metres

1:15,000

UTM Zone 8N, NAD 83

Yukon Government

Mt. Nansen Mine Project
Location: West of Carmacks, Yukon Territory

Hydrometric Gauging Locations

May 2009

AECOM

Figure 1

File Location: E:\GIS\GIS_proj\Y2009\112359_MtNansen\ByB_Station\112359_ByB_Fig1_MtNan_Stations_11x17_09sMay27.mxd Date Revised: May 27, 2009 Prepared by: MM Project: 112359

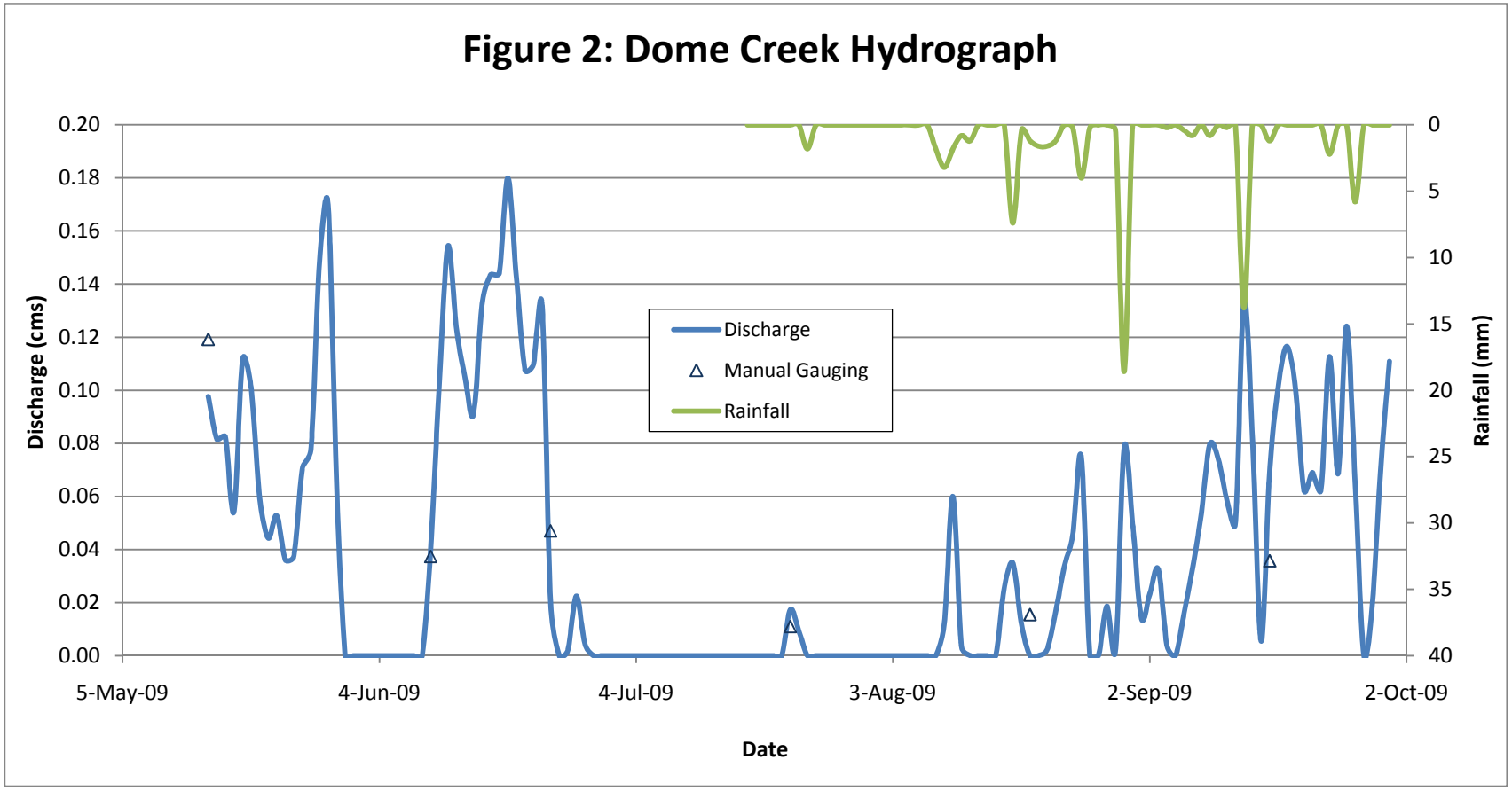


Figure 2: Dome Creek Hydrograph
Discharge (cms)
0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
Rainfall (mm)
0
5
10
15
20
25
30
35
40
5-May-09
4-Jun-09
4-Jul-09
3-Aug-09
2-Sep-09
2-Oct-09
Date
Discharge
Manual Gauging
Rainfall

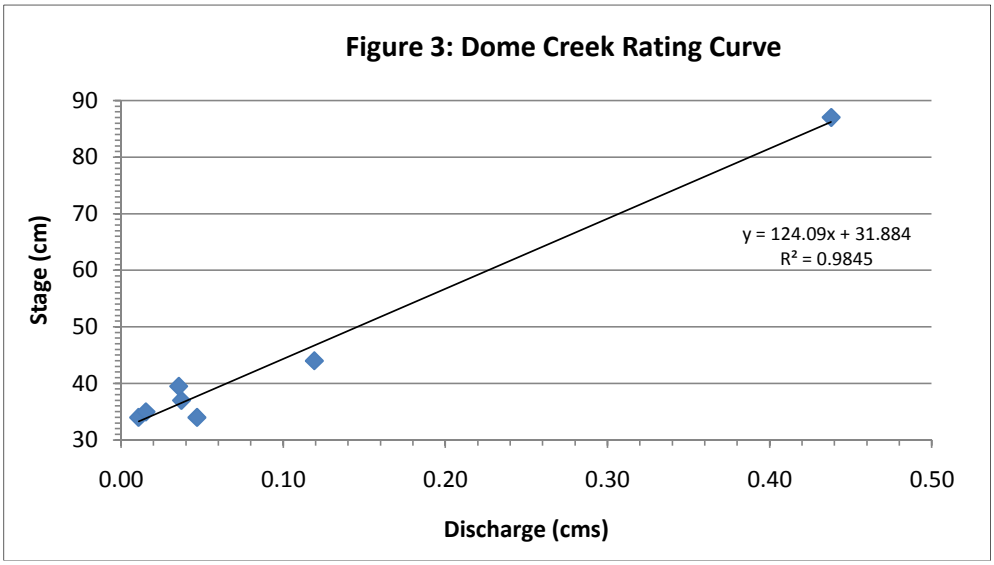
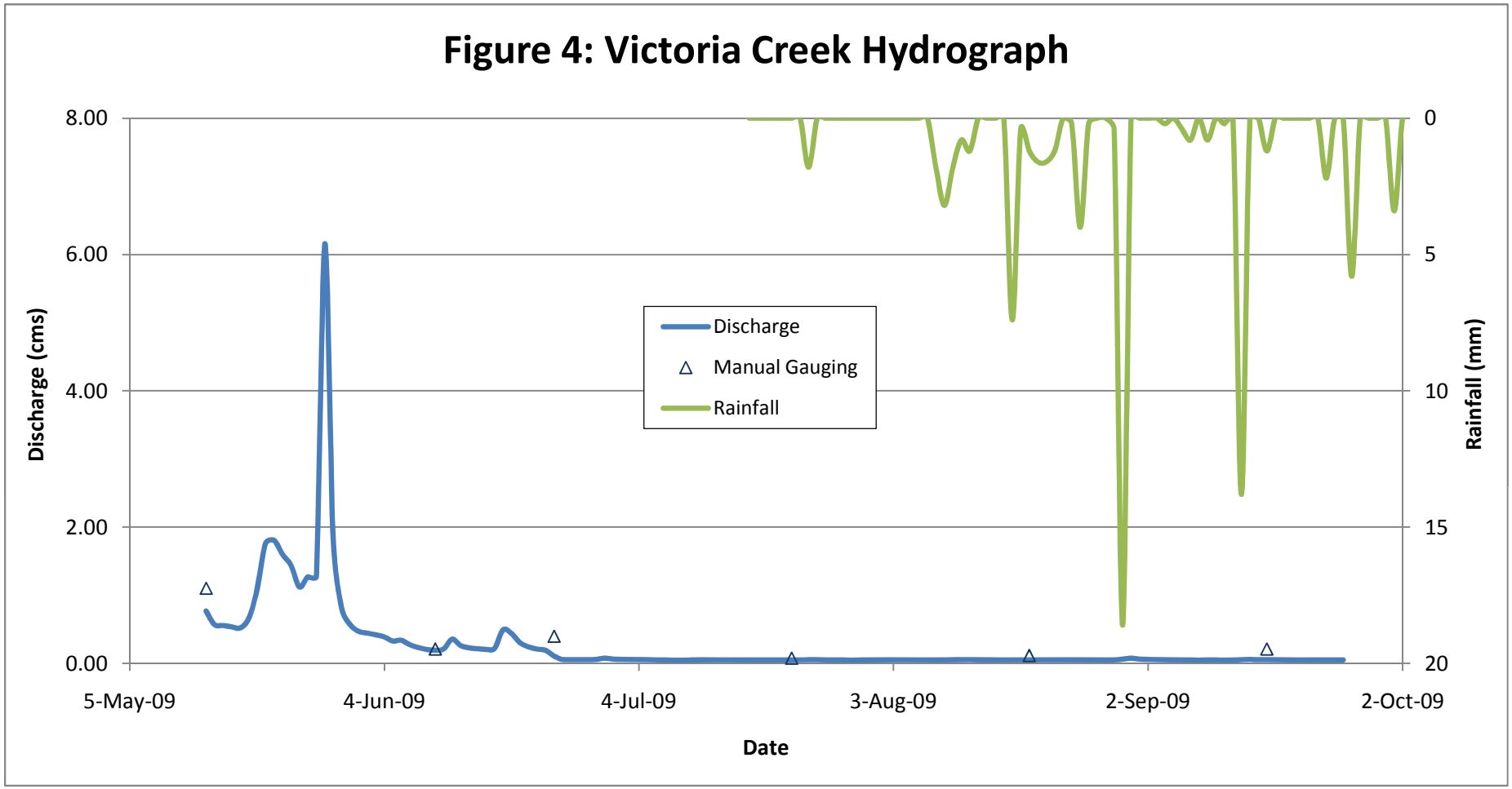


Figure 3: Dome Creek Rating Curve
Stage (cm)
90
80
70
60
50
40
30
0.00
0.10
0.20
0.30
0.40
0.50
Discharge (cms)
y = 124.09x + 31.884
R² = 0.9845

Figure 4: Victoria Creek Hydrograph



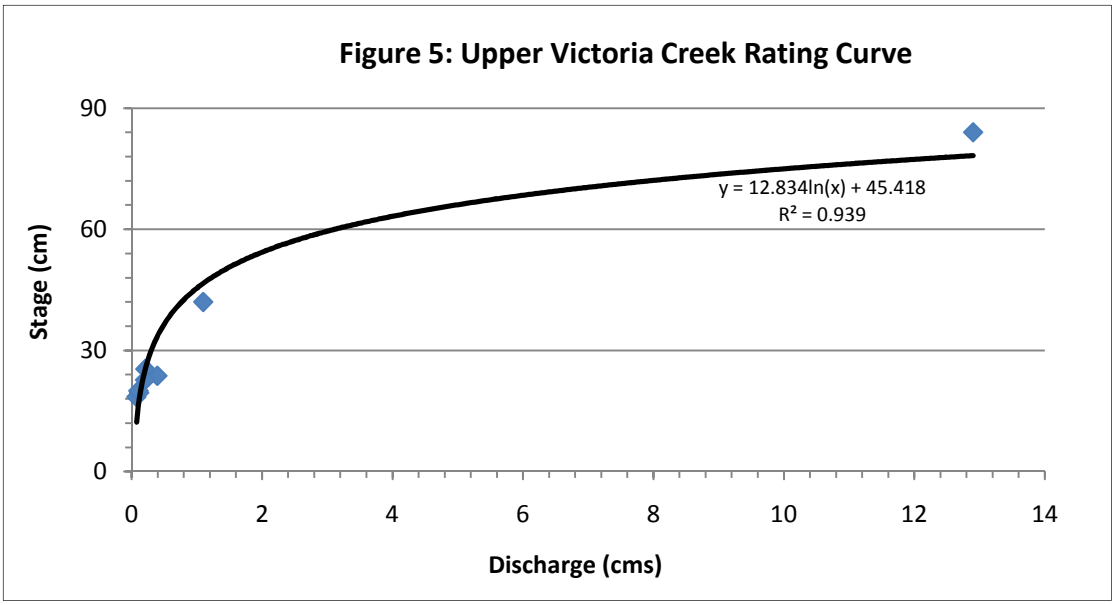
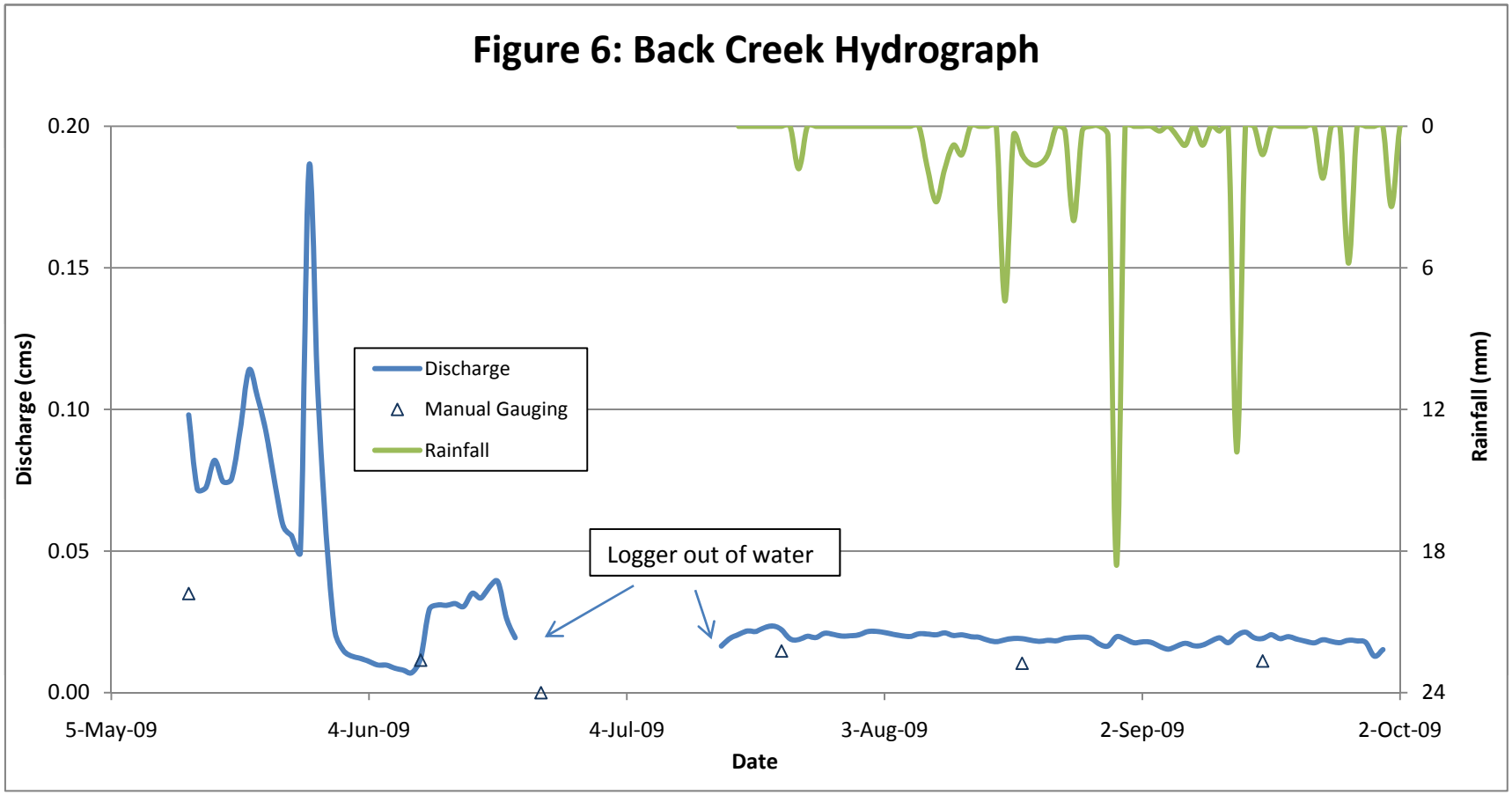


Figure 5: Upper Victoria Creek Rating Curve
Stage (cm)
90
60
30
0
0
2
4
6
8
10
12
14
Discharge (cms)
y = 12.834ln(x) + 45.418
R² = 0.939

Figure 6: Back Creek Hydrograph



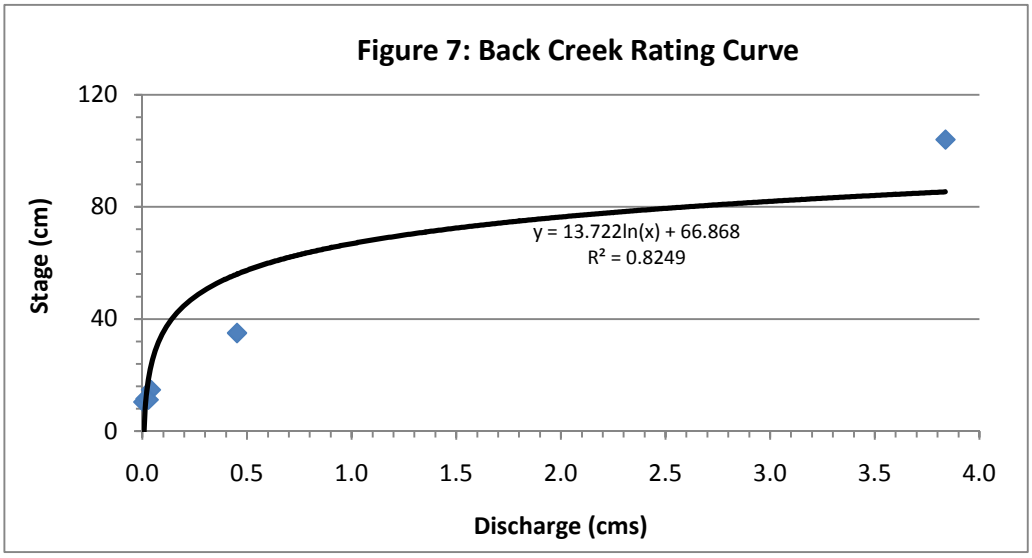


Figure 7: Back Creek Rating Curve
120
80
40
0
Stage (cm)
y = 13.722ln(x) + 66.868
R² = 0.8249
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
Discharge (cms)

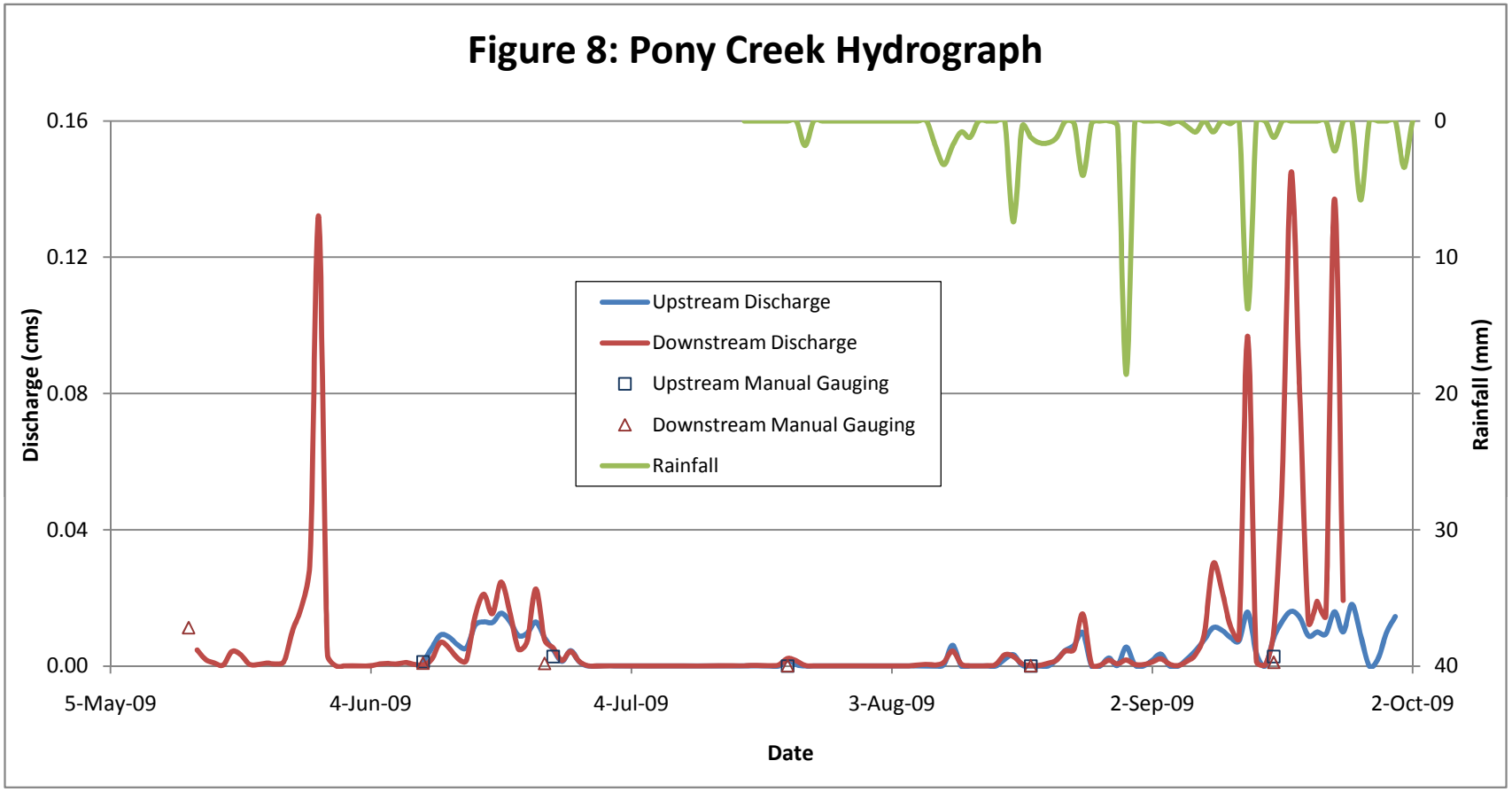


Figure 8: Pony Creek Hydrograph
0.16
0.12
0.08
0.04
0.00
Discharge (cms)
0
10
20
30
40
Rainfall (mm)
Upstream Discharge
Downstream Discharge
Upstream Manual Gauging
Downstream Manual Gauging
Rainfall
5-May-09
4-Jun-09
4-Jul-09
3-Aug-09
2-Sep-09
2-Oct-09
Date

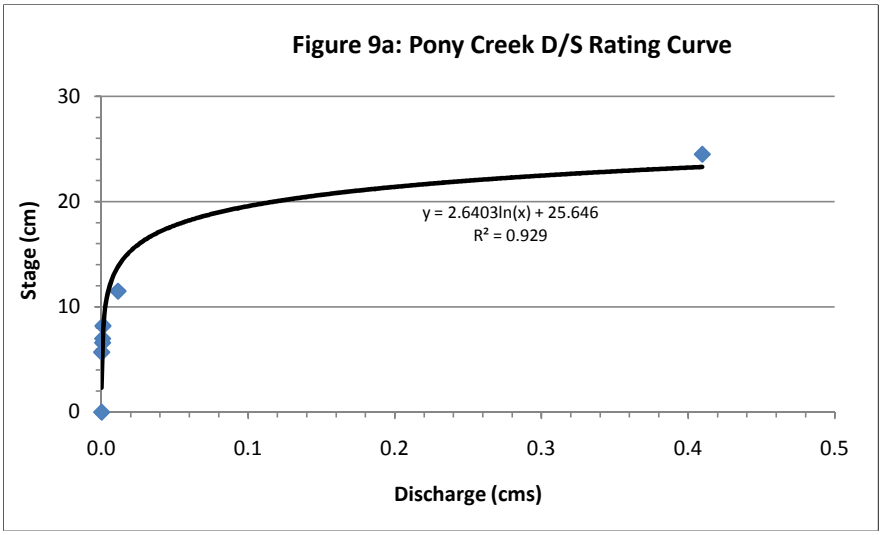


Figure 9a: Pony Creek D/S Rating Curve
30
20
10
0
Stage (cm)
y = 2.6403ln(x) + 25.646
R² = 0.929
0.0
0.1
0.2
0.3
0.4
0.5
Discharge (cms)

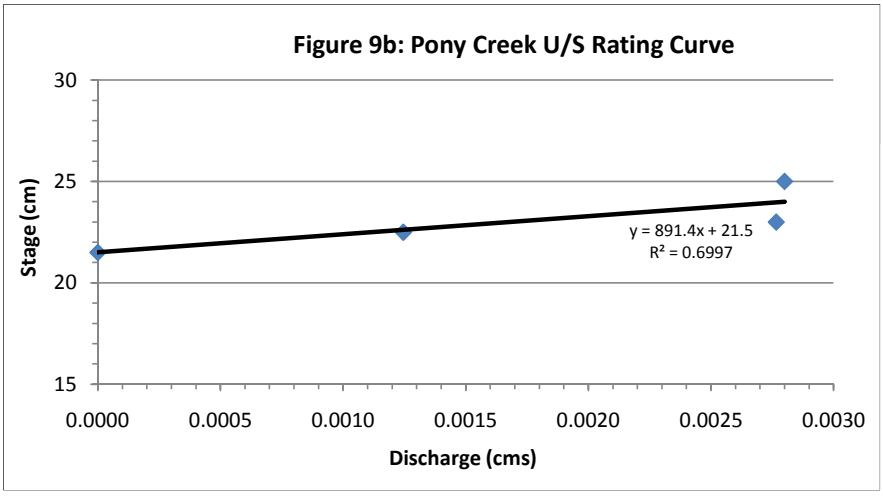


Figure 9b: Pony Creek U/S Rating Curve
30
25
20
15
Stage (cm)
y = 891.4x + 21.5
R² = 0.6997
0.0000
0.0005
0.0010
0.0015
0.0020
0.0025
0.0030
Discharge (cms)

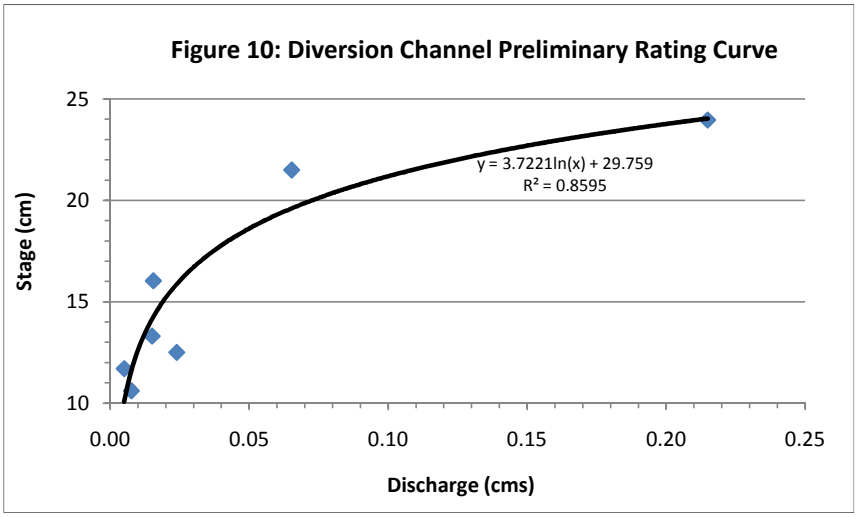


Figure 10: Diversion Channel Preliminary Rating Curve
y = 3.7221ln(x) + 29.759
R² = 0.8595
Stage (cm)
Discharge (cms)
25
20
15
10
0.00
0.05
0.10
0.15
0.20
0.25

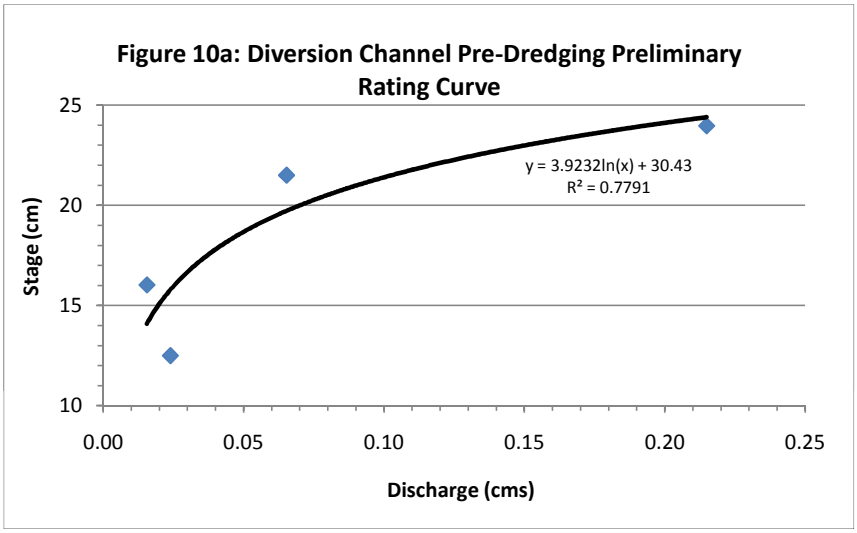


Figure 10a: Diversion Channel Pre-Dredging Preliminary Rating Curve
y = 3.9232ln(x) + 30.43
R² = 0.7791
Stage (cm)
Discharge (cms)
25
20
15
10
0.00
0.05
0.10
0.15
0.20
0.25

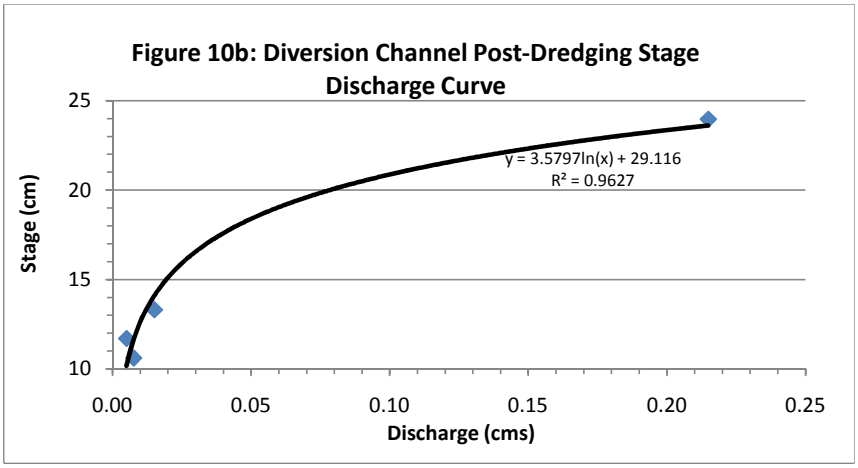


Figure 10b: Diversion Channel Post-Dredging Stage Discharge Curve
y = 3.5797ln(x) + 29.116
R² = 0.9627
Stage (cm)
Discharge (cms)
25
20
15
10
0.00
0.05
0.10
0.15
0.20
0.25

Figure 11. Correlation between Carmacks and Mt Nansen Temperature Data

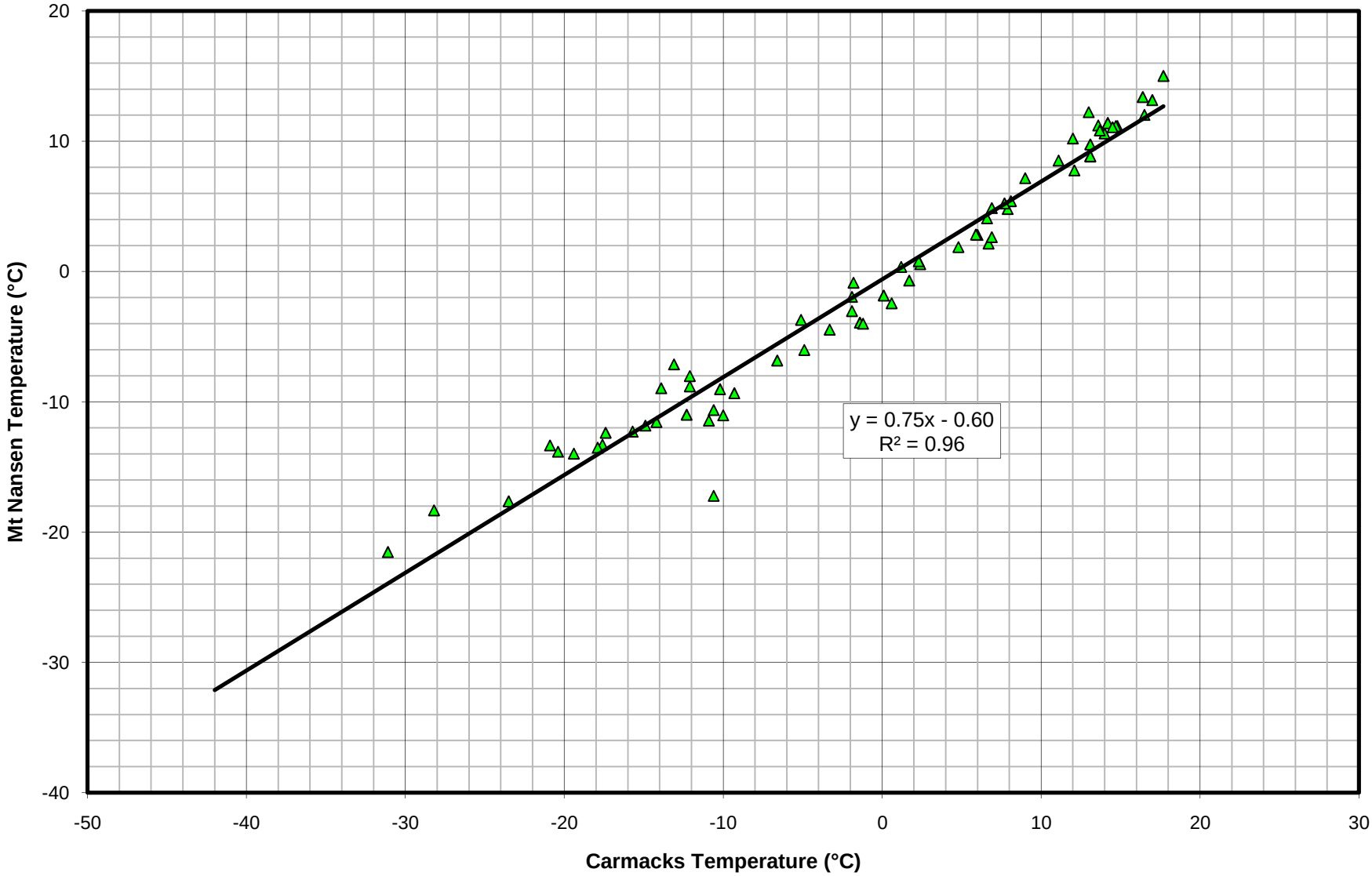


Figure 12. Correlation between Carmacks and Mt Nansen Precipitation Data