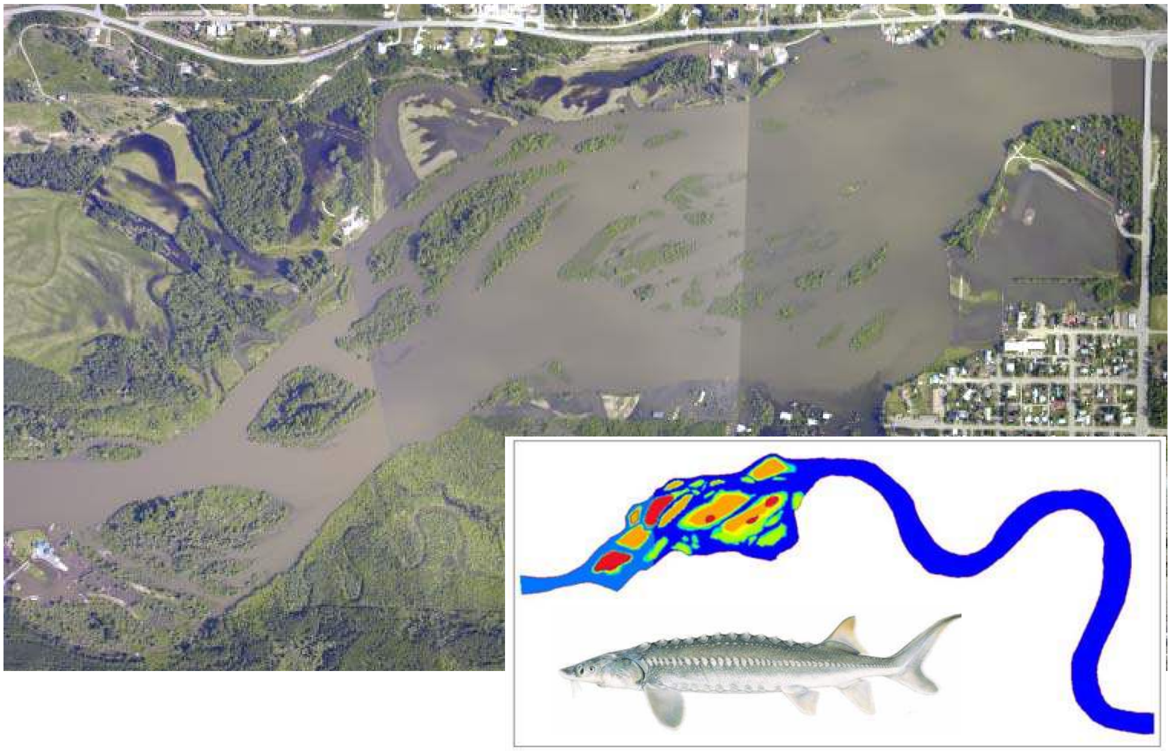

NECHAKO RIVER AT VANDERHOOF HYDRODYNAMIC MODEL UPGRADE

FINAL REPORT

3-4623

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nhc northwest hydraulic consultants

Leaders in water resource technology

NECHAKO RIVER AT VANDERHOOF HYDRODYNAMIC MODEL UPGRADE FINAL REPORT

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EXECUTIVE SUMMARY

In order to assess future habitat restoration works in a sturgeon spawning reach in the Nechako River at Vanderhoof, a depth-averaged flow model of the braided reach upstream from Burrard Avenue Bridge was developed in 2006 using limited low flow data. This model has been updated using additional bathymetric and flow data gathered during high flows in summer 2007. The updated model extends an additional 3 km downstream from the Burrard Bridge into the meandering reach of the Nechako River.

Flow data measured with an Acoustic Doppler Current Profiler (ADCP); as well as water level measurements was used to verify the model for high flows. The model provided good results for both water depth and velocity when compared with measured data, proving it can be a valuable tool to identify potential links between sturgeon spawning preference and flow hydraulics, as well as for assessing future potential habitat restoration measures.

CREDITS AND ACKNOWLEDGEMENTS

This report was prepared by Dr. Jose Vasquez, with contributions from Mr. Dale Muir, P.Eng., and reviewed by Mr. Barry Chilibeck, P.Eng.

The following individuals acted as representatives of the institutions involved in this project:

- Mr. Steve McAdam for BC Ministry of Environment
- Mr. Justus Benckhuysen for Rio Tinto Alcan.
- Mr Bill Shepert for Carrier Sekani Tribal Council

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1 INTRODUCTION

The Nechako River at Vanderhoof, British Columbia, is a known spawning and rearing area of white sturgeon. The sturgeon population has undergone a recruitment failure and is now recognized as endangered by the provincial and federal governments. Changes in the river morphology and substrate characteristics have been hypothesized as probable causes for the recruitment failure (McAdam *et al*. 2005).

The Nechako River has been regulated since 1952, with a portion of the river's flow diverted upstream for hydropower generation. Post-regulation reduction in flow discharges has reduced the normal extent of wetted areas in the braided reach upstream of Burrard Avenue Bridge, promoting the growth of vegetation in previously submerged bars. The additional flow resistance generated by vegetation reduces flow velocity and promotes sedimentation, further enhancing the growths of islands.

Figure 1.1 shows a comparison of pre- and post-regulation aerial photographs of the braided Nechako River. Despite the flow being higher in the 2007 airphoto (notice the larger over-bank flooded area), the area occupied by vegetated islands is much larger than the one shown in the 1951 airphoto. Not only existing islands have grown in size, but also old bars have been colonized by vegetation. The post-regulation emergence of new islands should have caused a concentration and realignment of flow in the channels of the braided reach.

Field observations of white sturgeon congregations during the spawning season in Nechako River at Vanderhoof exhibit inter annual variability (Figure 1.2). Changes in preference for congregation location might be linked to the bed substrate and water temperature, depth and velocity. In order to determine the hydraulic conditions (water depth and velocity) through the braided reach under different flow conditions, a two-dimensional (2D) depth-averaged hydrodynamic model was developed by **nhc** (2006) using the computer model River2D. Since this model was calibrated using limited low-flow data, there was considerable uncertainty of its prediction capabilities for high flows. To overcome these limitations, an additional field survey was conducted in summer 2007 to collect extra bathymetric data in the braided reach and new data on the meandering reach downstream from Burrard Avenue Bridge; as well as flow data using an Acoustic Doppler Current Profiler (ADCP). This new information was used to develop a new updated model, as described in this report.

2 MODEL SETUP AND DEVELOPMENT

2.1 RIVER2D MODEL

River2D is a computer model developed by the University of Alberta and intended for simulating river's flow in the 2D horizontal plane (Steffler and Blackburn 2002). The model assumes a zero vertical velocity, meaning that flow movements in the vertical plane are ignored, which is a reasonable assumption in most natural rivers. Within the 2D model domain, River2D computes at every point the water depth and the two depth-averaged velocity components in the Easting and Northing direction. Therefore, the model can compute the flow distribution across the channel width, which is particularly useful to model flow around islands in the braided reach.

Another relevant feature of River2D to model flow around bars and islands is its ability to trace the location of the moving boundary between dry and wet areas (water's edge) by applying a state-of-the art wetting and drying method. In dry areas, the model switches from a surface water model to a groundwater model, allowing a continuous computation of the water surface either above or below the ground.

The model setup requires: a topographic model of the riverbed surface; riverbed roughness; inflow discharge upstream and corresponding water level downstream. The topographic model is built from data points gathered using both ground and bathymetric surveys, and delineated with the aid of airphotos. Hydraulic information on water levels and discharges can be obtain from an existing hydrometric station (e.g. WSC Gauge 08JC001 at Burrard Bridge) or from direct field measurements (e.g. using ADCP and GPS). At present, riverbed roughness cannot be measured directly and must be determined by model calibration, i.e. by changing bed roughness until satisfactory agreement with observed water levels is achieved.

2.2 EXISTING MODEL

The existing 2006 River2D flow model covers about 3 km of the braided reach upstream from the Burrard Avenue Bridge. The model was developed and calibrated using low-flow surveys collected in August 2006, when the flow discharge was about 78 m^3/s (**nhc** 2006). The surveys included ground topography using GPS and bathymetric survey using a boat-mounted sounder. Giving the limited data available at the time, several model limitations and recommendations for further work were identified:

1. Need for updated colour aerial photographs to better identify vegetation units;
2. Additional topographic data on top of islands, where summer foliage prevented the collection of GPS data in the 2006 survey;

3. Installation of a temporary water-level gauging station at the upstream end of the reach during a freshet to compare with the predicted water levels of River2D;
4. Measure velocity profiles across different channel sections using an Acoustic Doppler Current Profiler (ADCP) to verify how accurately River2D is computing the flow distribution around the islands; and
5. Extend the model downstream by about 3 km to cover the spawning area observed in 2006.

Ground survey on island tops and the installation of a temporary gauge station upstream were not carried out. However, aerial photos taken on June 2007 during an unusually high freshet provide excellent information on vegetation coverage in the study area, as well as their relative elevation. Figure 1.1.b shows that certain islands remain dry even during extreme flows; therefore, the top elevation of those islands was assumed to be above the highest water level recorded in 2007 (El. 638 m).

Although a gauge was not installed upstream, high water marks believed to correspond to the peak discharge of the 2007 freshet were measured during the field survey, allowing the verification of the model for very high flows. Furthermore, 21 ADCP flow measurements were made at 10 transects in order to measure the flow distribution in the study reach. This unexpectedly rich additional information provides an excellent way to calibrate and verify the model, although at the expense of more demanding and laborious data post-processing.

2.3 NEW TOPOGRAPHIC MODEL

Figure 2.1.a shows the topographic data used to develop the new extended model. The 2006 ground and bathymetric survey covered only the main channels in the braided reach upstream from Burrard Avenue Bridge. This existing information was complemented by another bathymetric survey performed on August 20th, 2007, which in addition to the braided reach, also included several cross sections in the meandering reach downstream from the bridge, where spawning was observed in 2006 (Figure 1.2). That information was used to generate the topographic model shown in Figure 2.1.b. The surface of dry island tops in the 2007 aerial photograph (Figure 1.1.a) was assumed as El. 638 m to ensure that they will remain dry during the flow simulations.

3 CALIBRATION

3.1 WATER LEVELS

The 2007 bathymetric survey was carried out when the river discharge was about 460 m^3/s. To match the water levels measured for this flow, bed roughness heights were initially assumed as those of the existing 2006 model, which was calibrated for 78 m^3/s. However, after several trials it was decided to increase the roughness of the non-vegetated channels to 0.02 m from 0.01 m. The distribution of bed roughness including the extended reach downstream of the bridge is shown in Figure 3.1.

High water marks, believed to correspond to the peak 2007 freshet discharge around 800 m^3/s, were also measured at certain locations during the field survey. Figure 3.2 shows the comparison between measured and computed water levels for the 3 measured discharges of 78, 460 and 800 m^3/s using the roughness values shown in Figure 3.1. The agreement for 460 m^3/s is excellent, although for high and low flows the model slightly over predicts the observed water levels. Besides measurement errors, modeling errors, and uncertainty in the peak discharge, roughness might be indeed changing with discharge. For low flows, roughness is dominated by the bed sediment size. As flow increases and starts partially submerging the vegetation on top of low lying bars, roughness would increase. For very high flows, high velocities and water depths may bend tall slender grasses, reducing their resistance to the flow. The values adopted in Figure 3.1 seem as a good roughness estimate for intermediate flows and will be adopted herein.

3.2 ADCP AND FLOW SPLITS

Model calibration using only water levels does not guarantee that either discharges along the different channels of the braided reach or the velocity distribution across the channel are well predicted by the model. Velocity data gather by the ADCP provided additional data to verify the model.

The ADCP is an instrument intended to measure flow discharges across a channel. It is normally mounted in a boat that traverses the channel from bank to bank. While traversing the channel, the ADCP emits acoustic pulses through four downward looking beams (Figure 3.3.a). By applying the Doppler principle to the returning acoustic signal reflected off scatters moving with the flow (e.g. sediment, plankton), the ADCP can compute the three-dimensional (3D) flow velocity components at several points or bins both across the channel and through the water column. The typical bin size is 0.25 m, meaning that in a medium size river, the number of data points at a cross section can easily be in the order of several thousands.

In contrast with conventional current-meters that provide a smooth time-averaged velocity, the ADCP samples flow velocity at very high frequency not allowing time-averaging of random turbulence fluctuations, therefore generating noisy velocity data. Figure 3.3.b shows an example of the velocity measured by the ADCP at the upstream end of the model. If two passes of the boat-mounted ADCP are made at a given transect, flow discharges can be estimated with a relative error of 5% or lower (Muste *et al*. 2004).

Eighteen flow measurements at 9 transects (2 measurements per transect) were used to verify the flow splits computed by River2D, as shown in Table 3.1 and Figure 3.4 (the most downstream ADCP transect was too close to the model boundary and hence was not used). Total measured discharges (transects AA and H) varied between 450 and 480 m^3/s; while a constant inflow of 460 m^3/s was used in River2D. In general, River2D predicts flow splits around the islands of the braided reach in very good agreement with ADCP data; the discrepancies between computed and measured discharges are not very significant and probably in the range of the ADCP accuracy. These results are important because they demonstrate that River2D can reliably predict the main flow patterns in the braided reach, which could not be demonstrated in the 2006 model because of lack of suitable data.

3.3 ADCP VELOCITY

Although not considered in the original scope of work, additional effort was made to verify the model using ADCP velocity data. At each transect, the 3D ADCP velocity information was first depth-averaged over the water column, and later laterally averaged to produce smoother transverse velocity profiles (to filter out some of the noise). Velocity profiles at the same locations of the ADCP transects were extracted from the computed velocity field shown in Figure 3.5 for a discharge of 460 m^3/s. The comparison between computed and measured transverse velocity profiles is shown in Figure 3.6 (all cross sections are looking downstream). Considering the high complexity of the braided reach, with multiple channels, bars, islands, and different types of vegetation cover, the agreement between River2D and the ADCP data is fairly good, as the model follows the general trends of the velocity changes across the reach. Both the ADCP data and River2D results show velocity decreasing in the downstream direction. In the upstream portion of the channel (Transects AA, A and B, Figure 3.6.b) velocity reaches almost 2 m/s; while in the downstream portion (Transects F, G and H, Figure 3.6.a) velocity remains below 1.2 m/s.

Across the channel, the computed velocity profiles have similar shapes to those measured by the ADCP. Discrepancies near the banks can be probably explained by lack of adequate topographic resolution, as near bank topography is difficult to survey on the field; as well as roughness effects caused by riparian vegetation. However, near-bank flow is relatively small and does not have an important effect on the total flow conveyance of the channel.

Table 3.1 Flow discharges measured at ADCP transects and comparison with River2D

Transect	Time	Measured discharge (m^3/s)	ADCP average (m^3/s)	River2D discharge (m^3/s)
AA	13:43	465	458	455
AA	13:44	450		
B	13:53	165	163	149
B	13:55	160		
A	13:58	260	275	267
A	14:00	290		
C	14:07	102	111	85
C	14:09	120		
E	14:12	60	63	63
E	14:17	66		
D	14:26	397	405	387
D	14:29	413		
F	14:36	200	187	185
F	14:37	173		
G	14:43	196	202	174
G	14:43	208		
H	14:58	480	470	460
H	15:03	460		

Discrepancies on flow velocities within the channel, as those shown in Transect F (Figure 3.6.a) are harder to explain. Figure 3.7 shows the ADCP velocity measured at transect F along with the smoothed depth-averaged velocity compared with River2D results. River2D predicts across the left half of the channel velocity near 0.4 m/s, while the ADCP shows in the same region a central core of high velocity (~0.7 m/s) bounded by two low-velocity areas. This variability in velocity measured by the ADCP cannot be explained by topographic changes, as the water depth in the left half remains practically constant at 2 m. A likely explanation is that submerged vegetation at this location or immediately upstream is creating these low flow areas. However, these subtle differences do not unfavourably affect the total discharge computed at this transect (Table 3.1).

3.4 COMPARISON WITH PREVIOUS MODEL

Comparisons between the previous River2D model described in Section 2.2 and the new updated model for the calibration discharge of 460 m^3/s are shown in Figures 3.8 through 3.10, for water surface elevation, flow splits and velocity profiles. Both models provide good results of flow splits around islands (Figure 3.9); the major discrepancies are found in the small channels where transects C and E are located (Figures 3.9 and 3.10), because the island at the northwest of those channels was not well delineated in the old model (the recent 2007 airphoto was not available back then). The root mean square error (RMSE) of the predicted flow splits was 26 m^3/s for the old model and 16 m^3/s for the new model, proving that the flow distributions are better predicted by the new model.

Another important difference between the models is on water levels predicted upstream (Figure 3.8). The old model under-predicts water levels and hence water depths. Since water depth and velocity have an inverse relationship for a given discharge, underpredicting water depth means that velocity is overpredicted, as shown for transect AA in Figure 3.10.

Considering the limited data available at the time of the old 2006 model development, the results provided by this model seem reasonable. The main improvements of the new updated model in the braided reach are a better delineation of existing islands from airphotos and fine tuning of roughness values, leading to a better prediction of both water depth and velocity over the entire braided reach. In the meandering reach downstream, the new model provides flow information that was not available when the old model was developed.

The elevation datum used in this report is about 0.6 m lower than the one used in **nhc** (2006). The new datum was adopted to make it compatible with the water surface elevation used by Water Survey of Canada and supersedes the values reported previously.

4 FLOW SIMULATIONS

4.1 CURRENT CONDITIONS

A total of 6 discharges were simulated using the updated model. The computed velocity fields for a range of discharge, 78, 200, 300, 460, 600 and 800 m^3/s are shown in Figures 4.1 and 4.2. Besides the obvious increase in wetted area with discharge, another notable change is the flow concentration towards the northern side of the braided reach as flow increases. During low flows, most of the discharge is conveyed along the deeper meandering arm adjacent to the south (right) bank, where the channel thalweg is located. Most of the smaller and higher channels on the north (left) side are too shallow to convey a large portion of the incoming flow (some of them even remain unconnected).

However, as higher discharges cause an increase in water levels, it becomes possible for these higher elevation channels to convey more flow, as illustrated in Figure 4.3 for the lowest and highest flows simulated. Figure 4.4 shows the flow distributions (as percent of total incoming flow) computed by River2D for 78, 460 and 800 m^3/s, at the transect locations shown in Figure 3.4.a.

The results show that as flow increases, the percent of discharge conveyed along the south side of the reach (Transects A, D and F) decreases, while the opposite is true along the north side. The changes in flow velocity at both south and north sides are illustrated in Figure 4.5 for transects F and G. Across transect F, where the thalweg is located, there is a notable decrease in peak velocity between 78 and 460 m^3/s discharge, while peak velocity changes for discharges between 460 and 800 m^3/s are less dramatic. At transect G, velocity increases substantially between 78 and 460 m^3/s, while changes for higher flows are less remarkable. Since velocity does not seem to increase appreciably for discharges larger than 460 m^3/s; increases in flow discharge are accommodated mainly by increases in water depth.

The model predicts that the highest velocities in the braided reach for moderate to high flows occur at the upstream end of the braided reach, just before the channel splits around the first island (Figures 3.5.b, 4.1 and 4.2). Velocity in this region increases consistently with discharge from 1.5 m/s at 200 m^3/s to almost 2.8 m/s at 800 m^3/s. However, for low flows around 78 m^3/s, velocity in this region remains below 0.9 m/s and the highest velocity (up to 1.7 m/s) occurs farther downstream in the south channel between the mouth of Stoney Creek and Burrard Avenue Bridge (Figure 4.3). These two areas of high velocity, upstream of the braided reach and south of the large island-bar complex, are identified areas of sturgeon spawning (Figure 2.1), suggesting that there might be a link between spawning preference and flow velocity. If that were the case, then the model could be used to assess whether a proposed restoration measure indeed improves the spawning habit and to what extent. Additional data is required to verify if such link between spawning preference and flow velocity actually exists.

4.2 EXAMPLE SCENARIO

Figure 4.6 shows an example application for a hypothetical scenario where the top elevation of some islands in the central bar-island complex was lowered from 638 to 636 m. The islands that were lowered were those that do not appear in the 1951 airphoto (Figure 1.1.a); this scenario actually turns these islands into submerged bars for a discharge of 600 m^3/s. The bed roughness in the bar-island complex was also set as that of clean gravel (without vegetation cover). Compared with the existing conditions, flow across the central part of the channel increased; while a larger portion of the flow conveyed by the southern channel - where the thalweg is currently located - was transferred farther north. This example is intended to show the potential application of the model as predictive tool for future works in the river.

5 SUMMARY AND CONCLUSIONS

In order to assess future habitat restoration works in a sturgeon spawning reach in the Nechako River at Vanderhoof, a depth-averaged flow model of the braided reach upstream from Burrard Avenue Bridge was developed in 2006. This model was calibrated using low flow data (78 m^3/s) and its predictive capabilities for higher discharges remained unverified. Additional bathymetric and flow data was gathered during high flows in summer 2007 (460 m^3/s) making it possible to extend the model 3 km farther downstream into the meandering reach and also update and verify the flow computations in the braided reach.

Comparison of measured and computed results showed that both the previous and updated version of the River2D model produced good results in the braided reach. However, since the updated model has been calibrated using new additional information, it produces better results (lower errors) for both water depth and flow velocity, especially in the upstream portion of the modeled reach. Since the updated model also representatively predicts the observed water levels for very high flows (800 m^3/s), it should provide good results for the range of flows to be simulated in the future for different potential restoration scenarios.

Besides model uncertainty, some of the discrepancies between predicted and measured velocities can be attributed to lack of adequate topographic resolution (especially near channel banks and shallow areas where the boat has limited reach) and variability in channel roughness caused by submerged vegetation and changes in sediment size.

The model predicts that flow distribution across the braided reach will change with discharge because of the different bottom elevation of the different channels. The deeper channels along the south side of the reach convey a greater portion of the flow during low flows. As discharge and water levels increase, more flow starts to be conveyed along the north side of the reach.

The model predicts that the highest velocities in the braided reach for moderate to high flows occur at the upstream end of the braided reach, just before the main channel splits around the first island; while for low flows the highest velocity occurs farther downstream in the south channel between the mouth of Stoney Creek and Burrard Avenue Bridge. Coincidentally, these are two areas identified as sturgeon spawning sites in recent years, suggesting that there might be a link between spawning preference and flow velocity. Additional data is required to verify if that is indeed the case.

6 REFERENCES

McAdam, S.O., Walters, C.J., and Nistor, C. (2005) "Linkages between white sturgeon recruitment and altered bed substrates in the Nechako River, Canada". Trans. Amer. Fish. Soc., 134: 1448-1456.

Mueller, D.S., Wagner, C.R., and Winkler, M.F. (2007) "Best practices for measuring discharge with Acoustic Doppler Current Profilers". USGS Publications.

Muste, M., Yu, K., and Spasojevic, M. (2004) "Practical aspects of ADCP data use for quantification of mean river flow characteristics; Part I: moving-vessel measurements". Flow Measurements and Instrumentation, 15: 1-16.

nhc (2006) "2D Hydrodynamic Model Development – Nechako River at Vanderhoof". Final Report prepared by Northwest Hydraulic Consultants for The UBC Department of Zoology and Alcan Primary Metal BC. Nov. 2006 (nhc Project # 3-4354).

Steffler, P.M., and Blackburn, J. (2002) "River2D – Two-dimensional depth averaged model of river hydrodynamics and fish habitat, Introduction to depth averaged modeling and user's manual". University of Alberta.

Triton (2007) "Adult white sturgeon monitoring – Nechako River 2006". Prepared for Alcan Primary Metal by Triton Environmental Consultants Ltd.

FIGURES

a) Pre-regulation Q = 614 m^3/s (1951)

b) Post-regulation Q = 780 m^3/s (2007)

Figure 1.1 Pre- and post-regulation airphotos of the Nechako River at Vandehoof (upstream from Burrard Avenue Bridge) showing increased extent of vegetated islands.

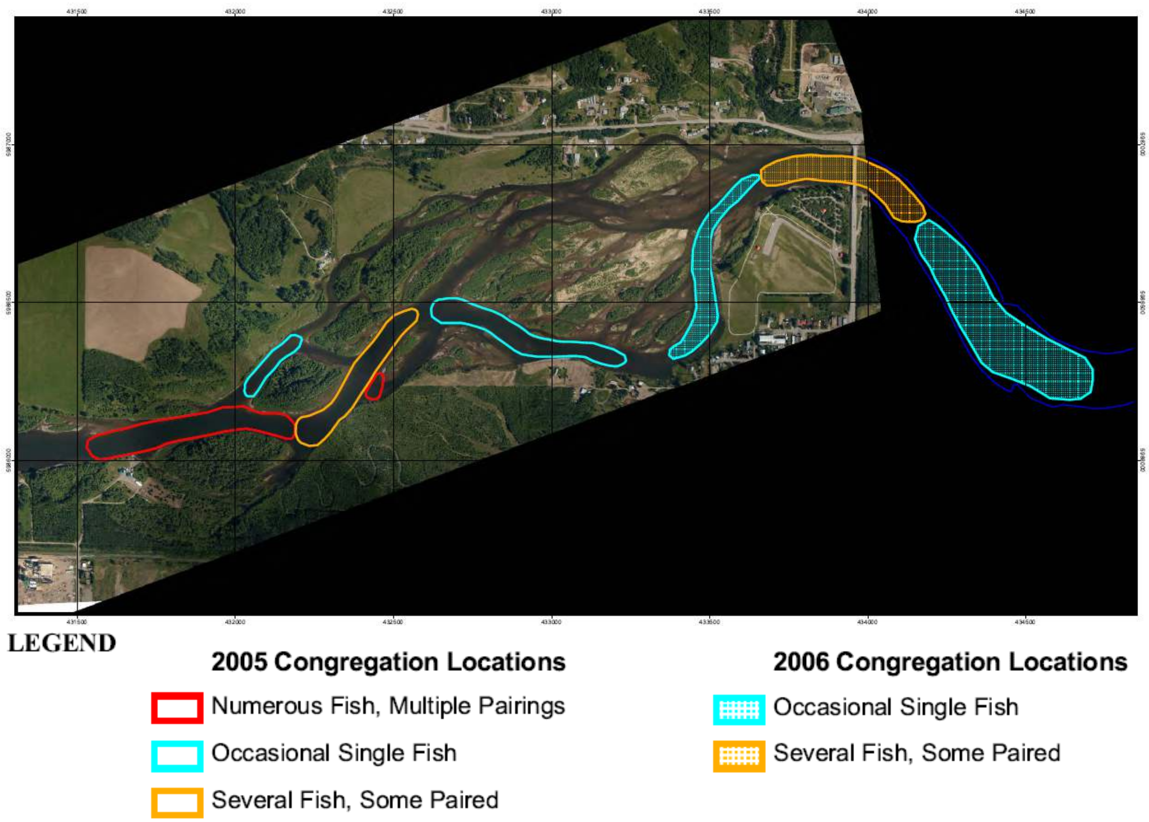
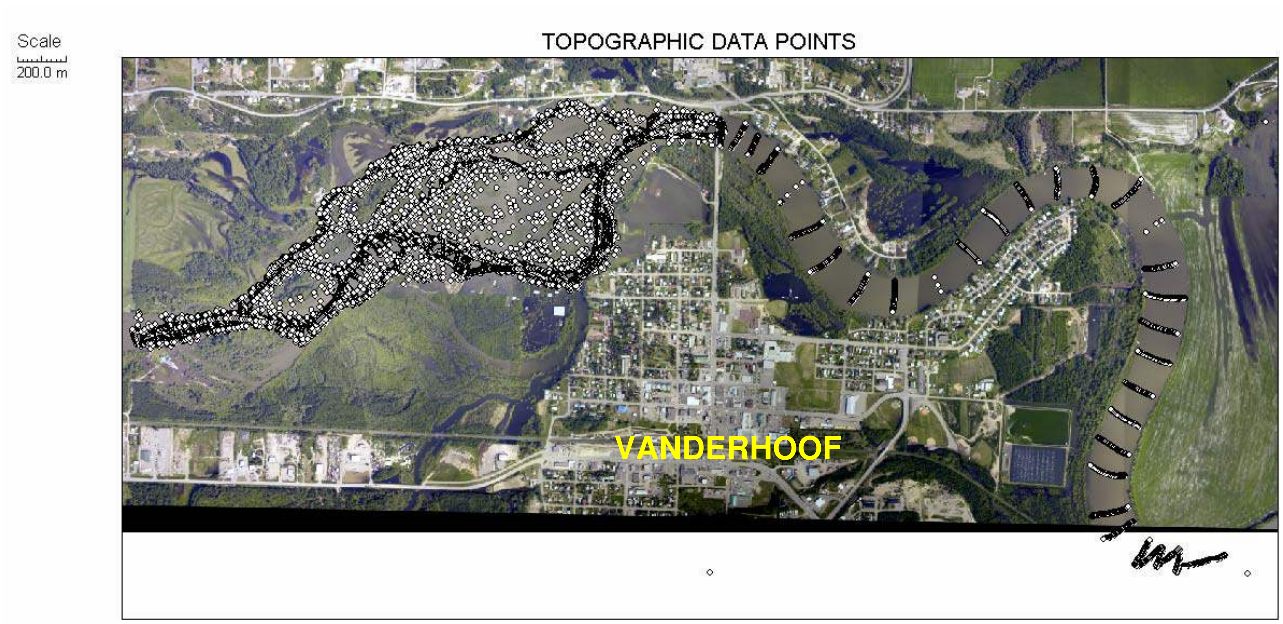


Figure 1.2 Recent observations of white sturgeon congregation locations in the Nechako River at Vanderhoof (Triton 2007).

a)



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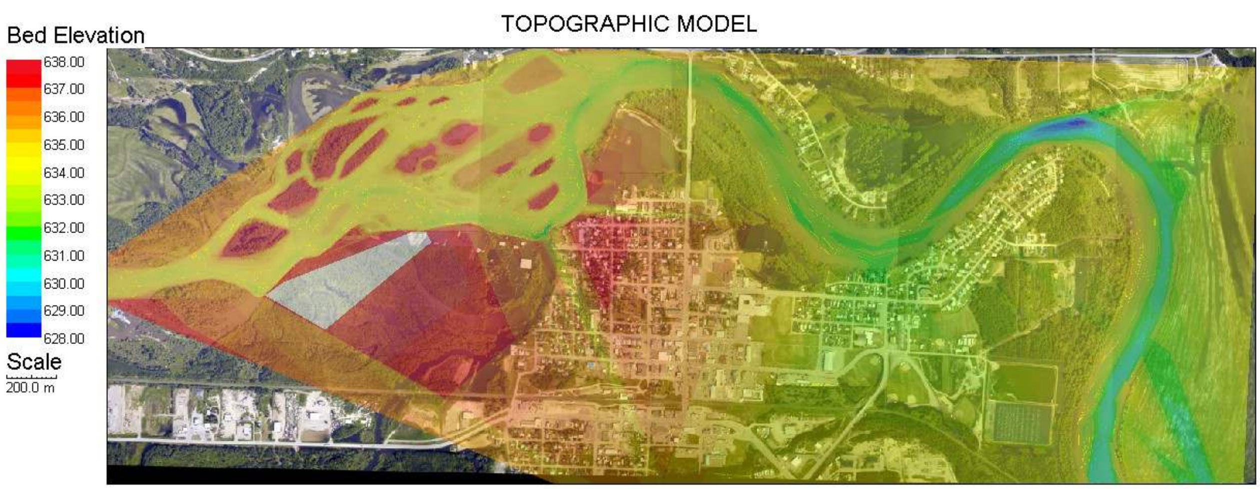


Figure 2.1 (a) Combined topographic data points from 2006 and 2007 surveys (b) topographic model generated from surveyed data points (elevation of islands assumed at El. 638 m).

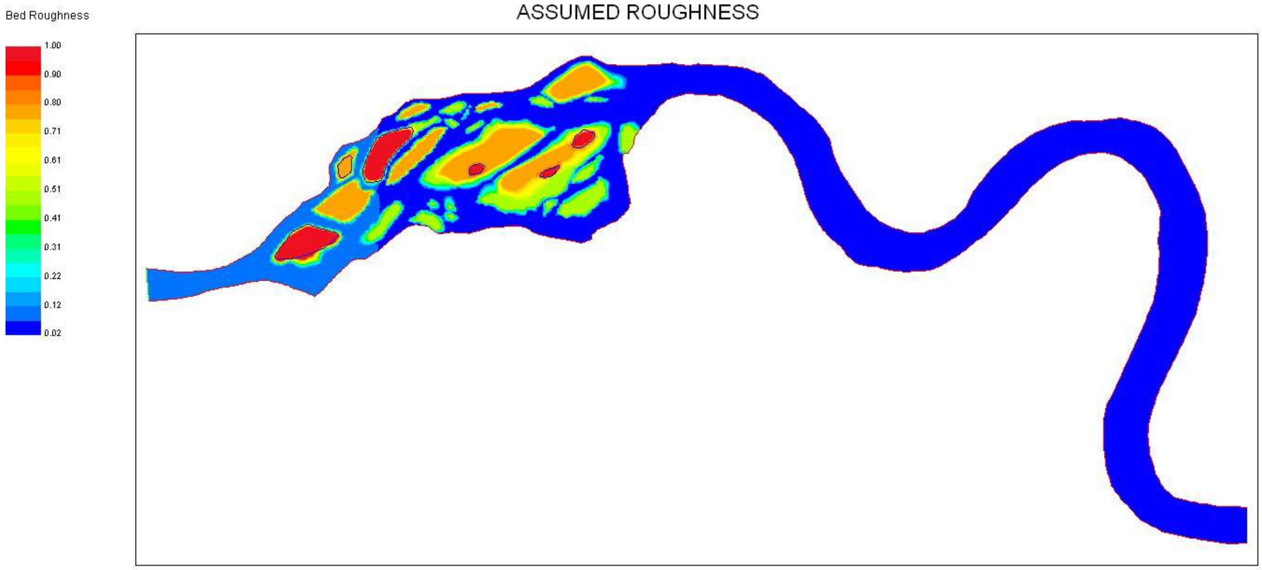


Figure 3.1 Assumed bed roughness heights (in meters).

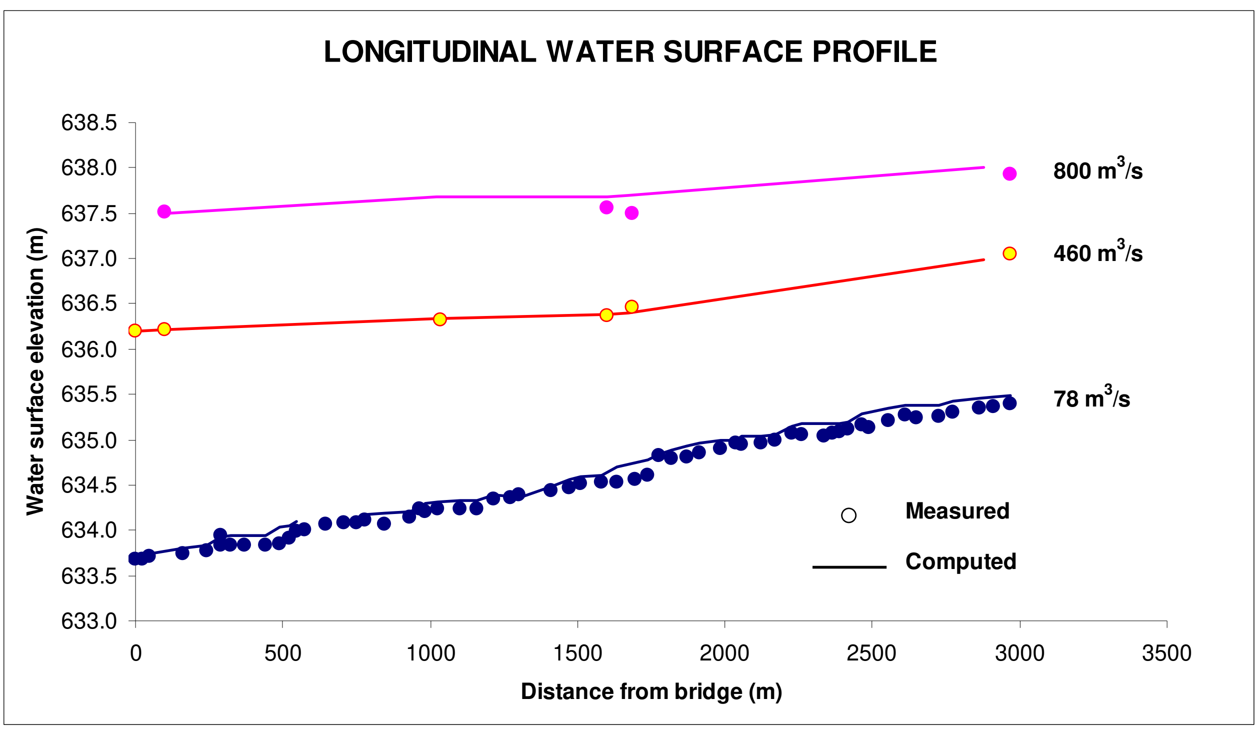
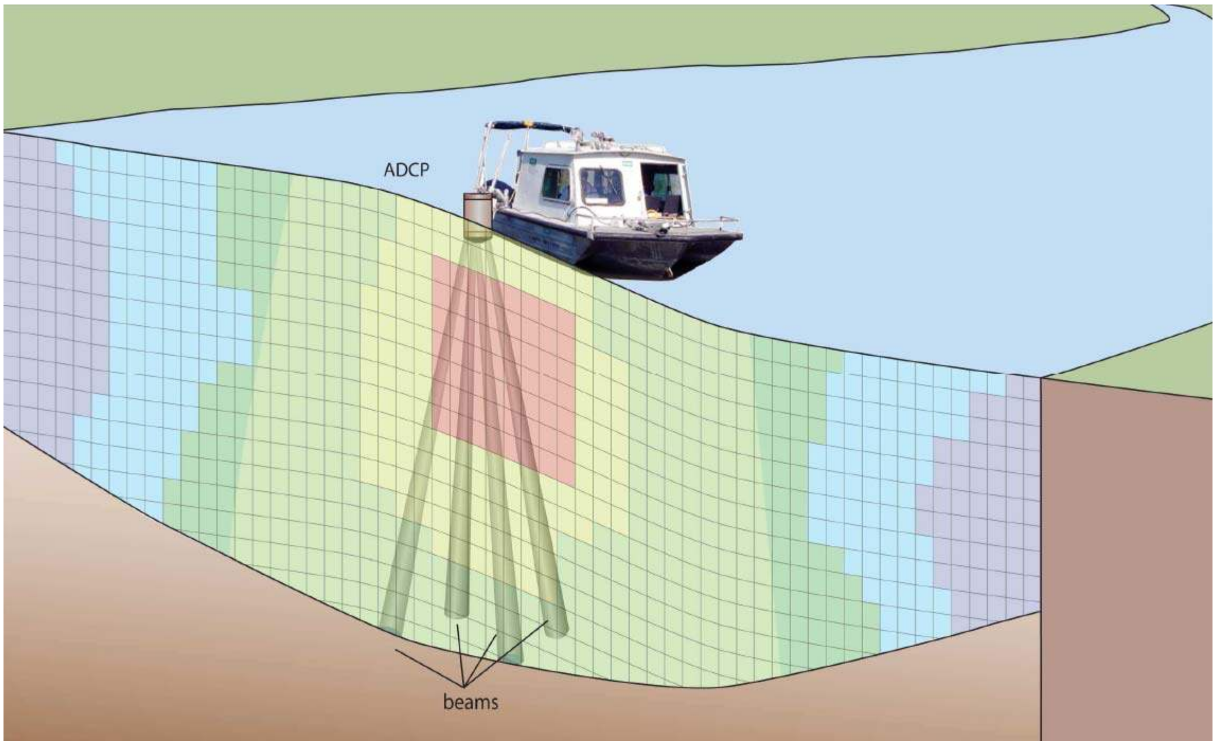


Figure 3.2 Computed and measured water levels upstream of Burrard Avenue Bridge for discharges: 78, 460 and 800 m^3/s.

a)



b)

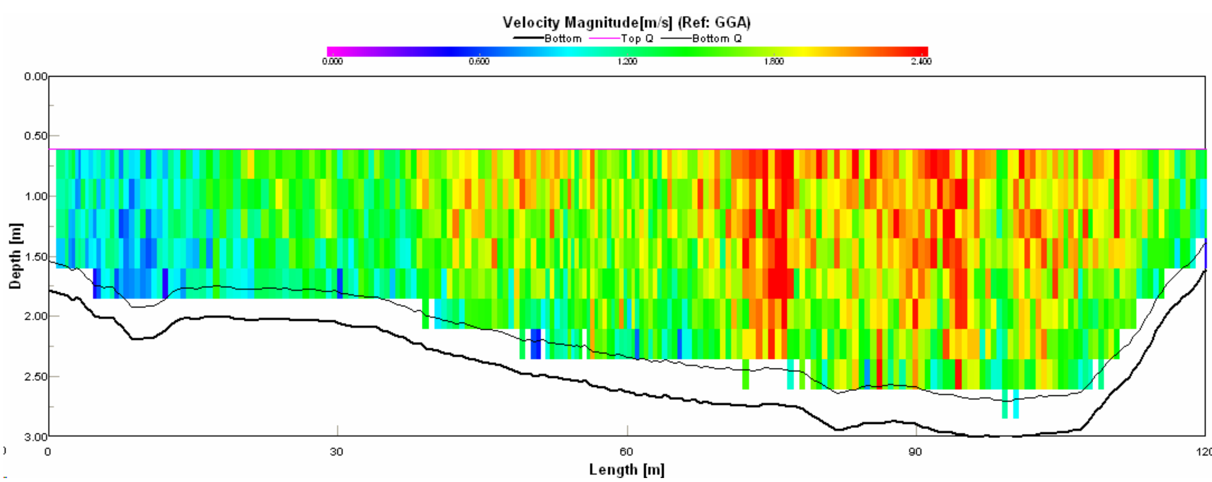
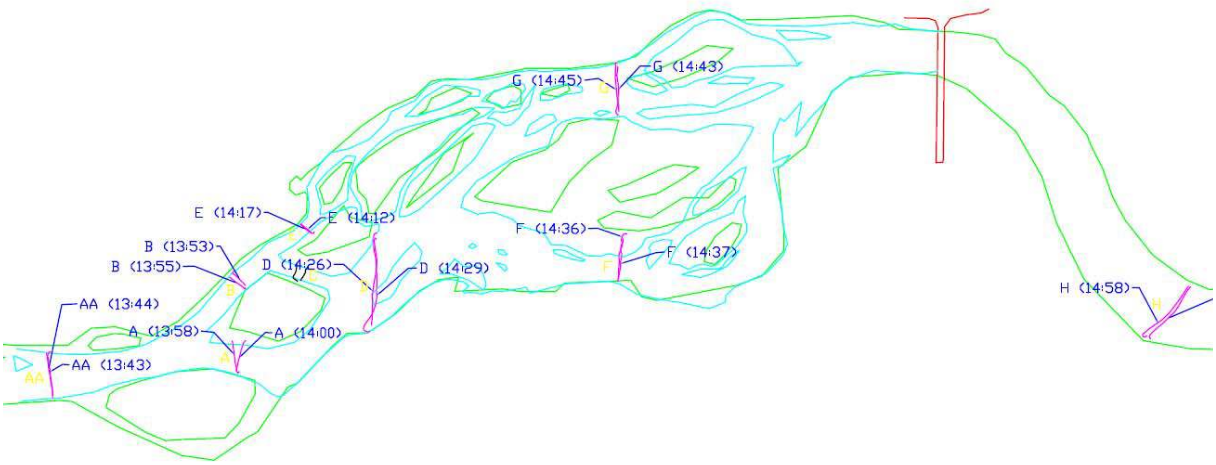


Figure 3.3 (a) Streamflow measurements from a boat-mounted ADCP (Muller et al. 2007). (b) ADCP Velocity measurement at upstream end of study reach (transect AA).

a)



b)

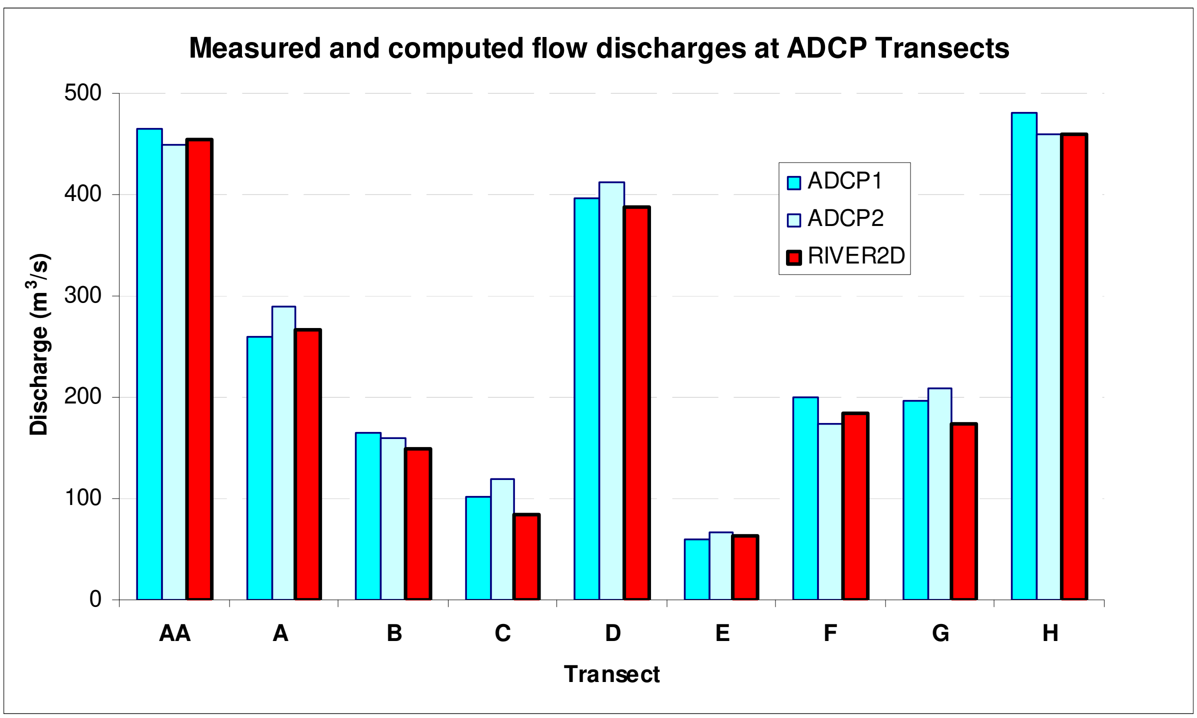
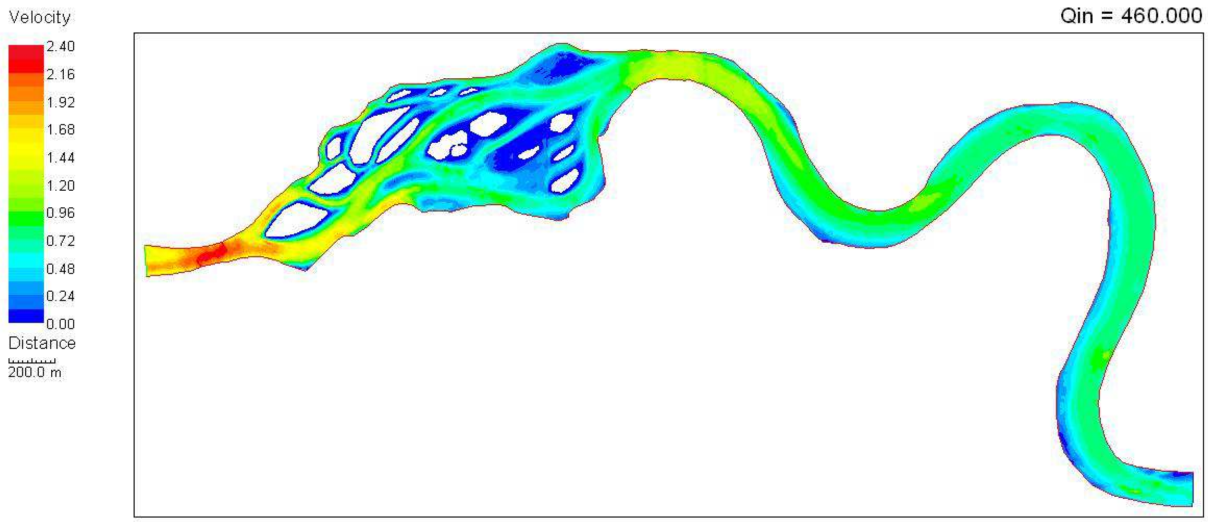


Figure 3.4 (a) Location of ADCP transects measured on August 20th, 2007; time is indicated in (hh:mm) format. (b) Measured and computed discharges at each transect (two measurements "ADCP1" and "ADCP2" were made at each transect).

a)



b)

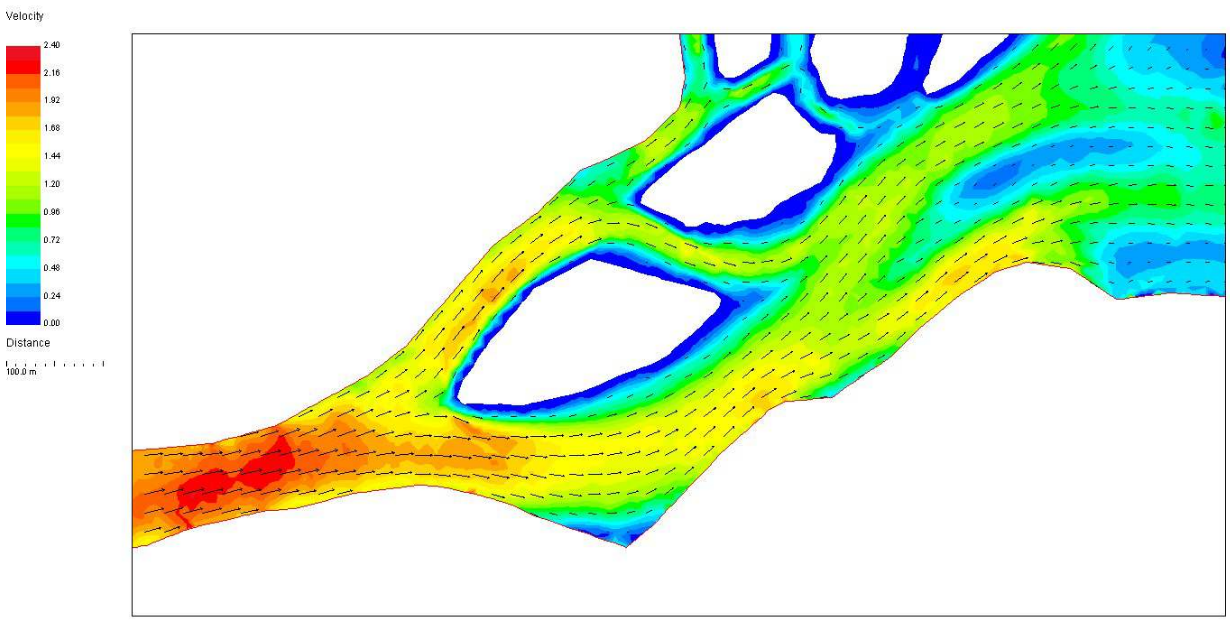


Figure 3.5 (a) Computed velocity field in the new extended model for a discharge of 460 m^3/s; (b) detail of flow around islands in upstream end of the model

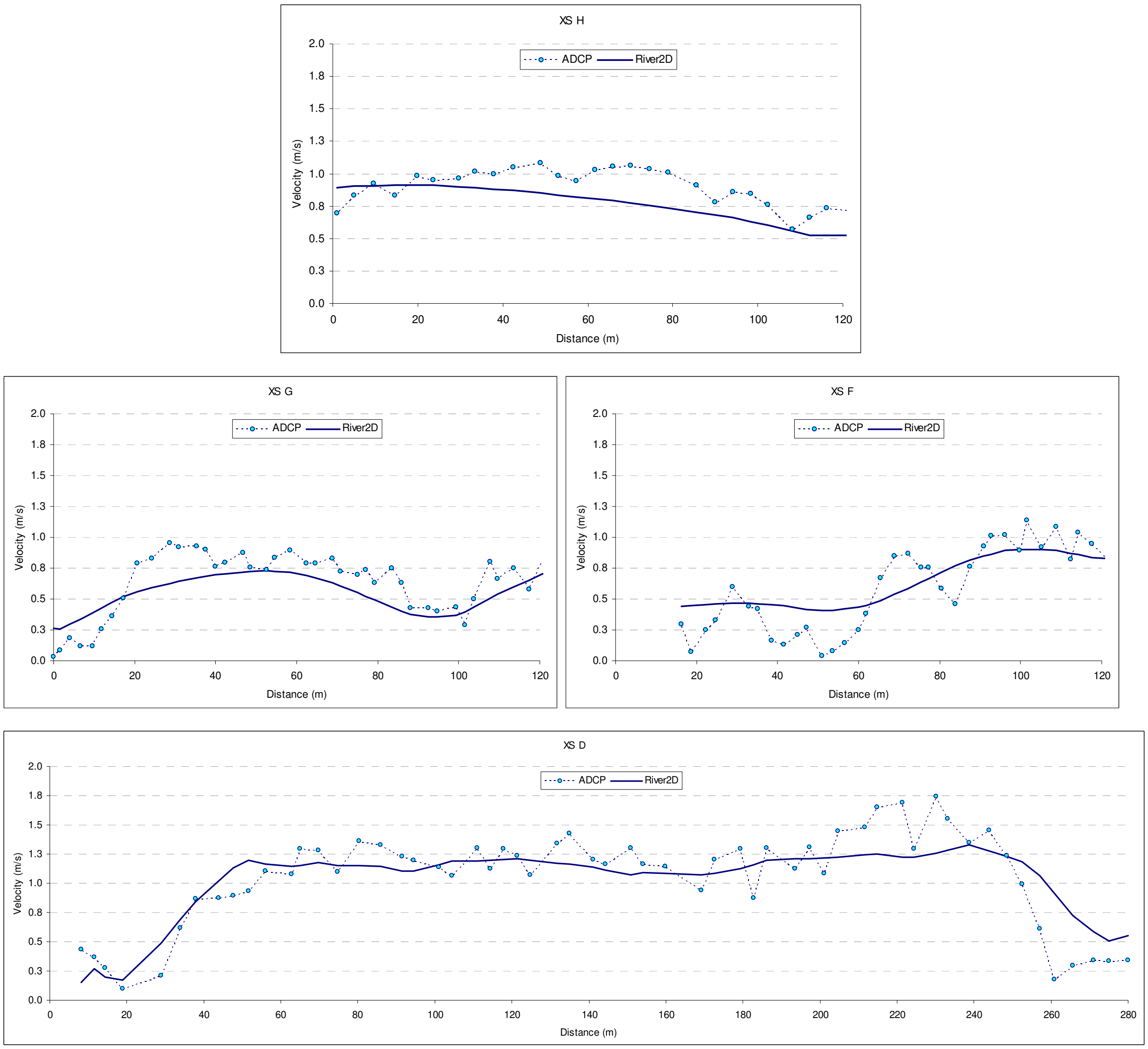


Figure 3.6.a Transverse profiles of velocity across ADCP transects showing also results computed by River2D (looking downstream).

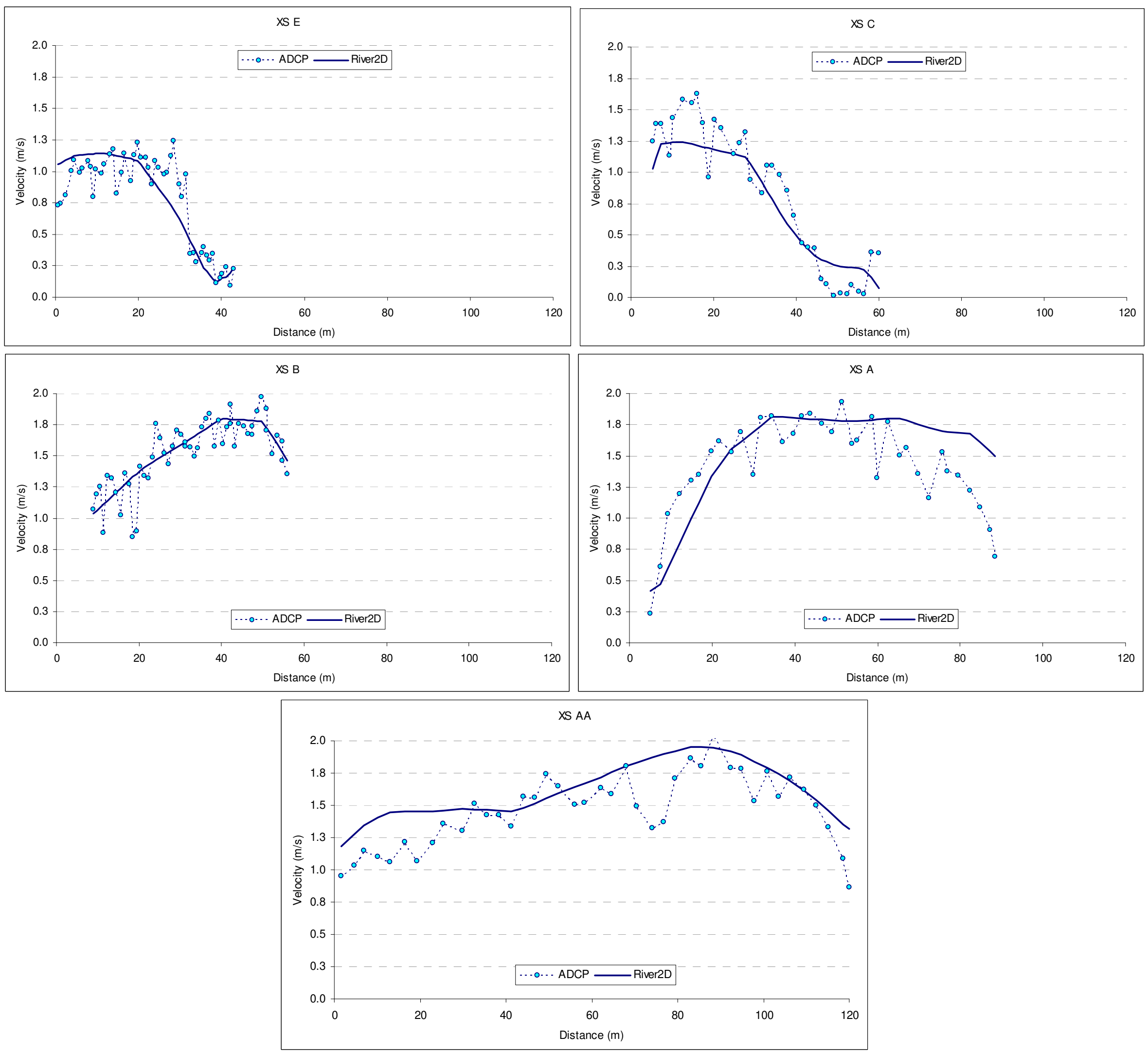
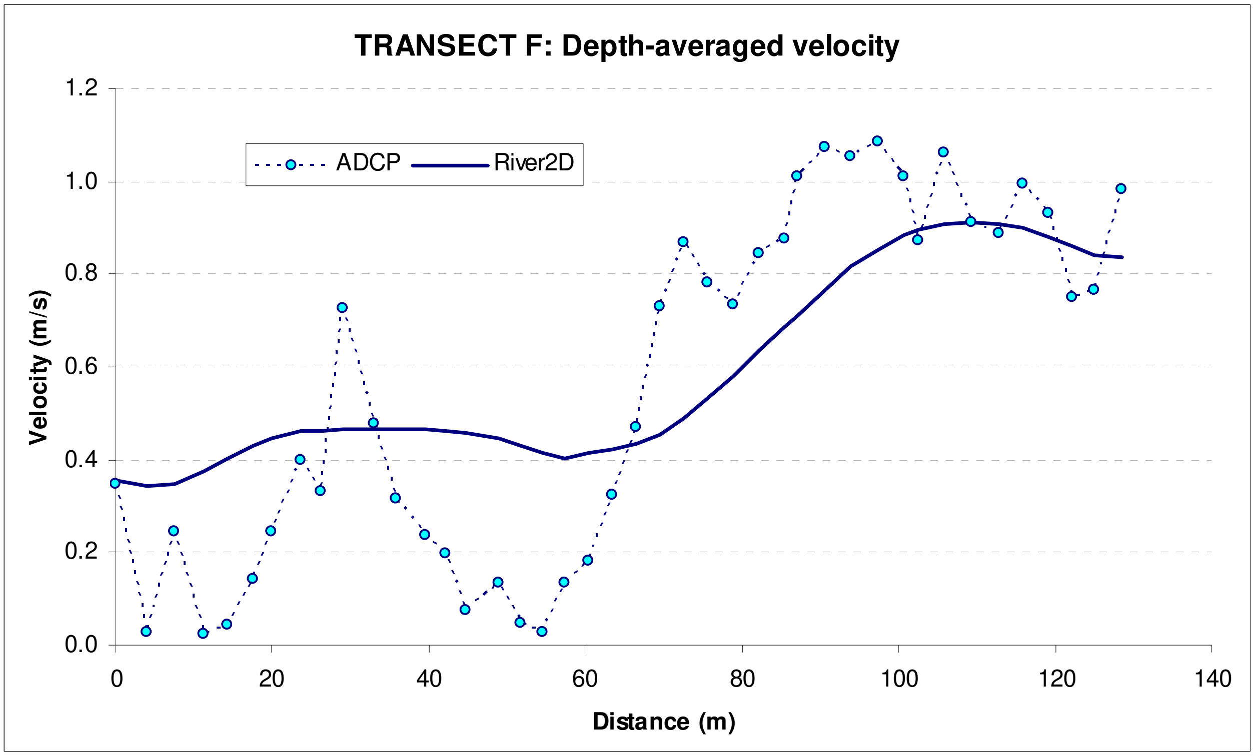


Figure 3.6.b Transverse profiles of velocity across ADCP transects showing also results computed by River2D (looking downstream).



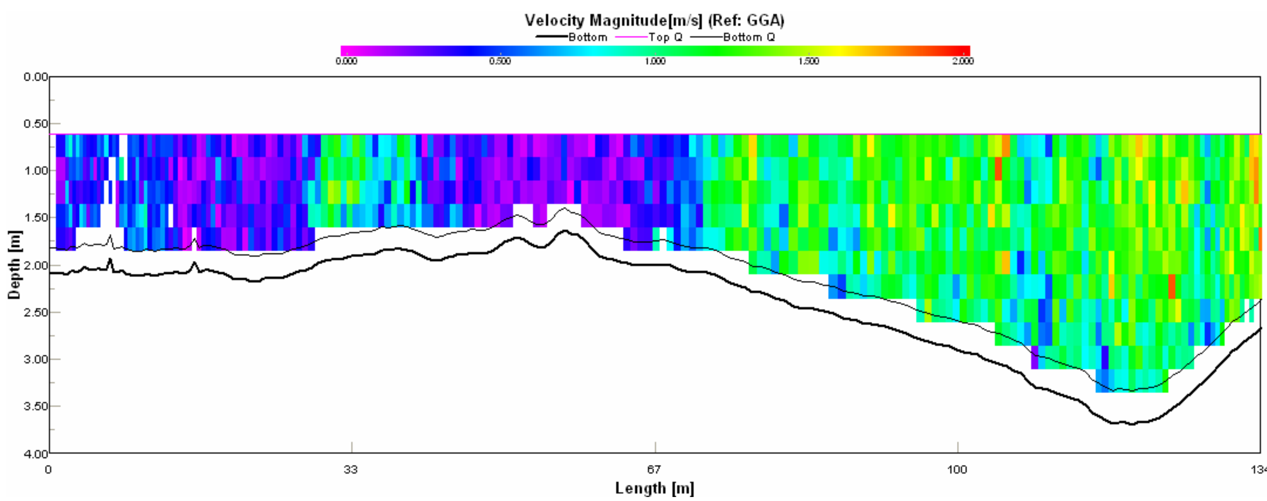


Figure 3.7 ADCP transect F showing areas of low flow velocity in the left half of the channel.

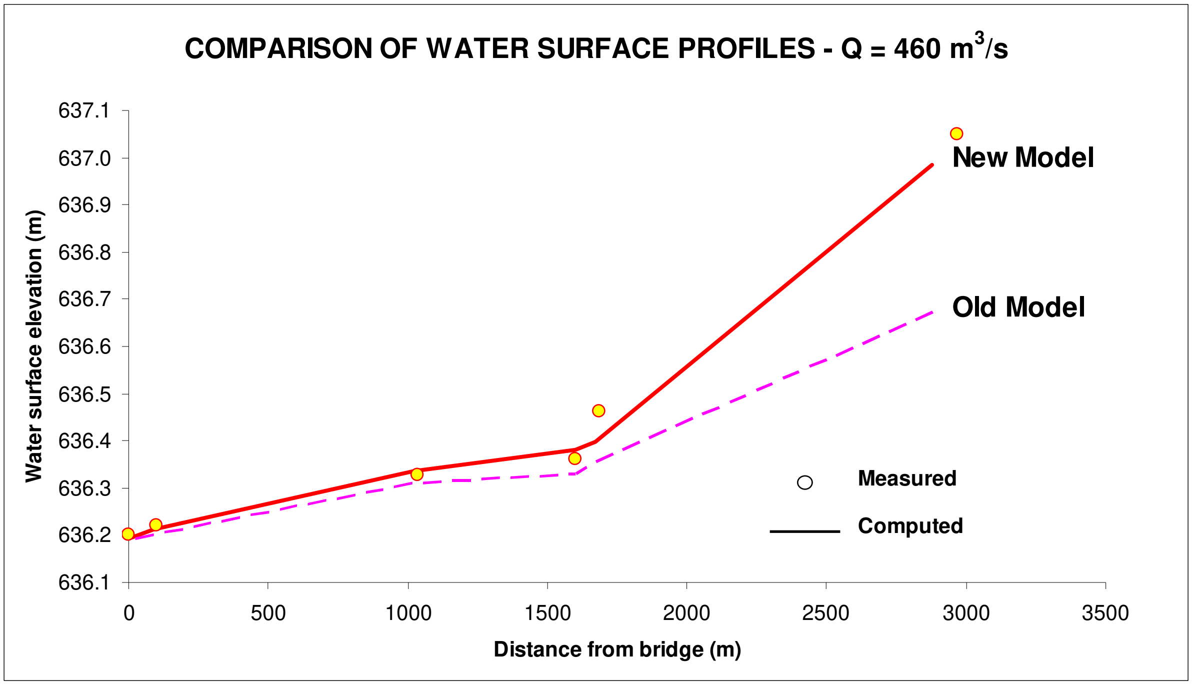


Figure 3.8 Comparison of water levels for 460 m^3/s computed by the old (**nhc** 2006) and new River2D models.

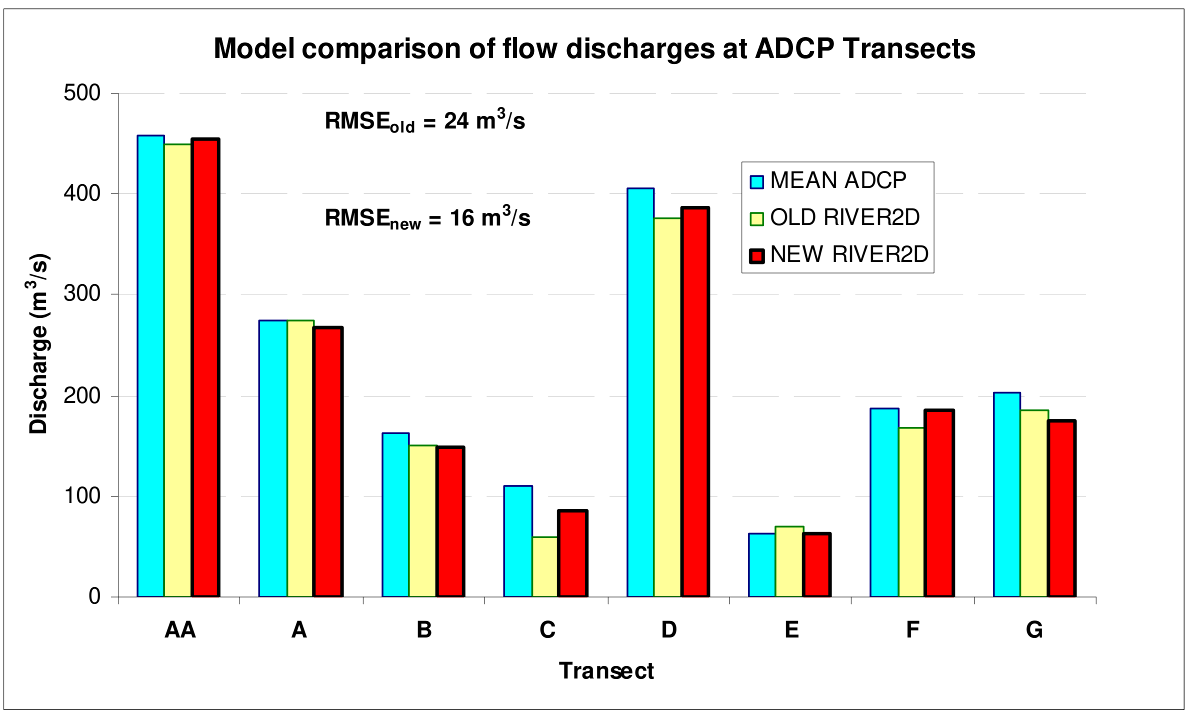


Figure 3.9 Comparison of flow splits for 460 m^3/s computed by the old (**nhc** 2006) and new River2D models.

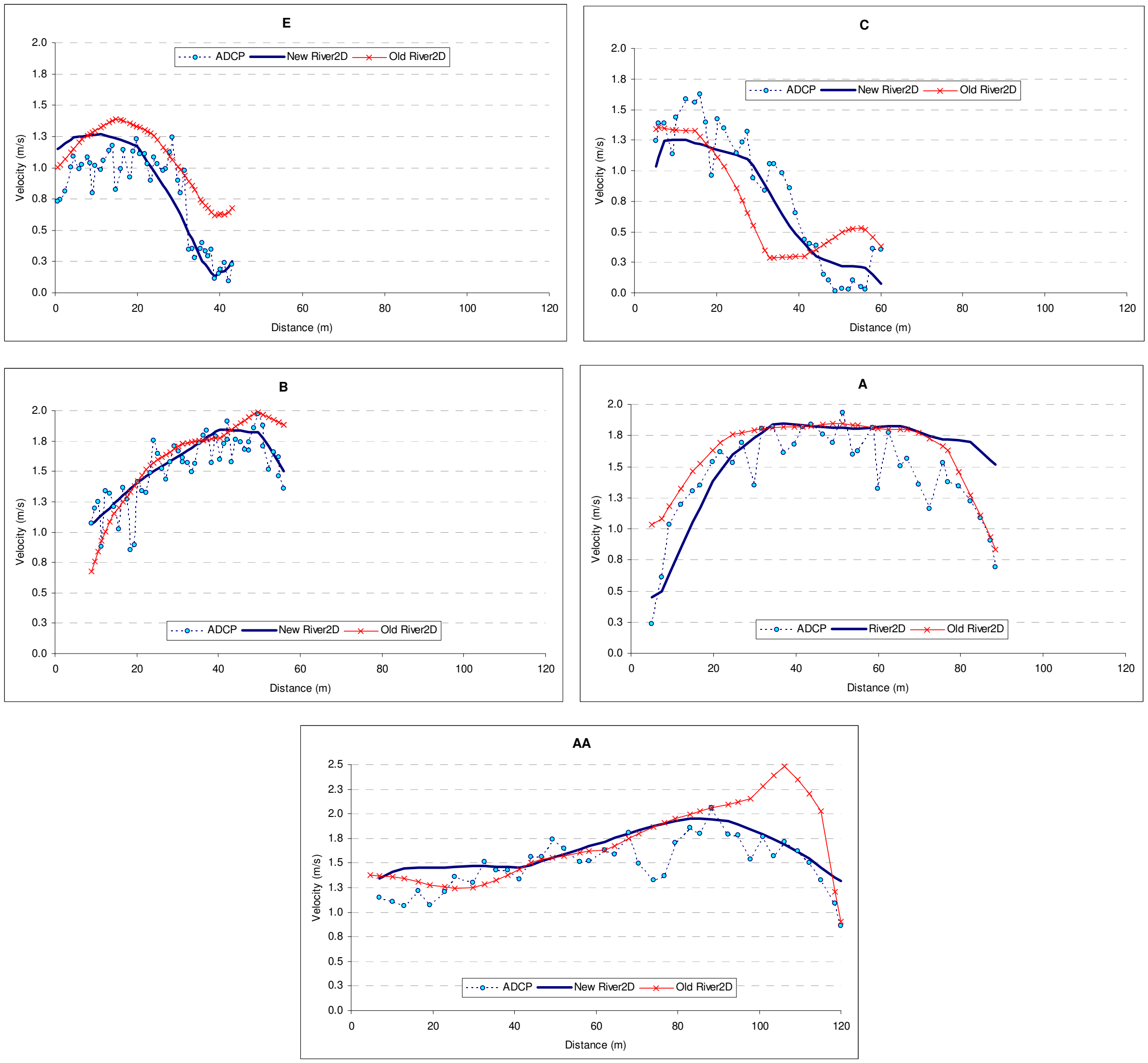


Figure 3.10 Comparison of transverse velocity profiles for 460 m^3/s computed by the old (**nhc** 2006) and new River2D models at the five most upstream transects.

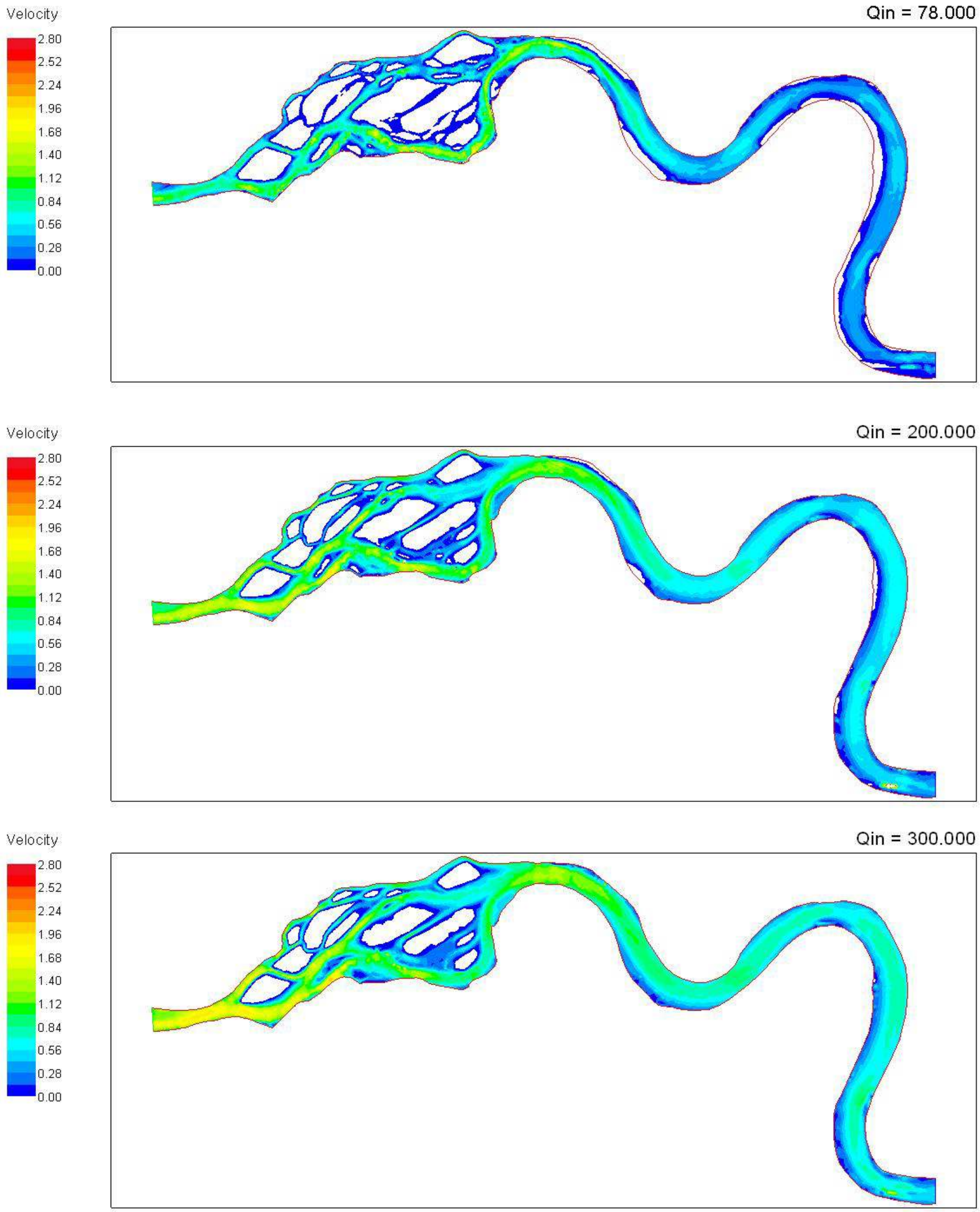


Figure 4.1 Velocity fields computed by River2D for low flows.

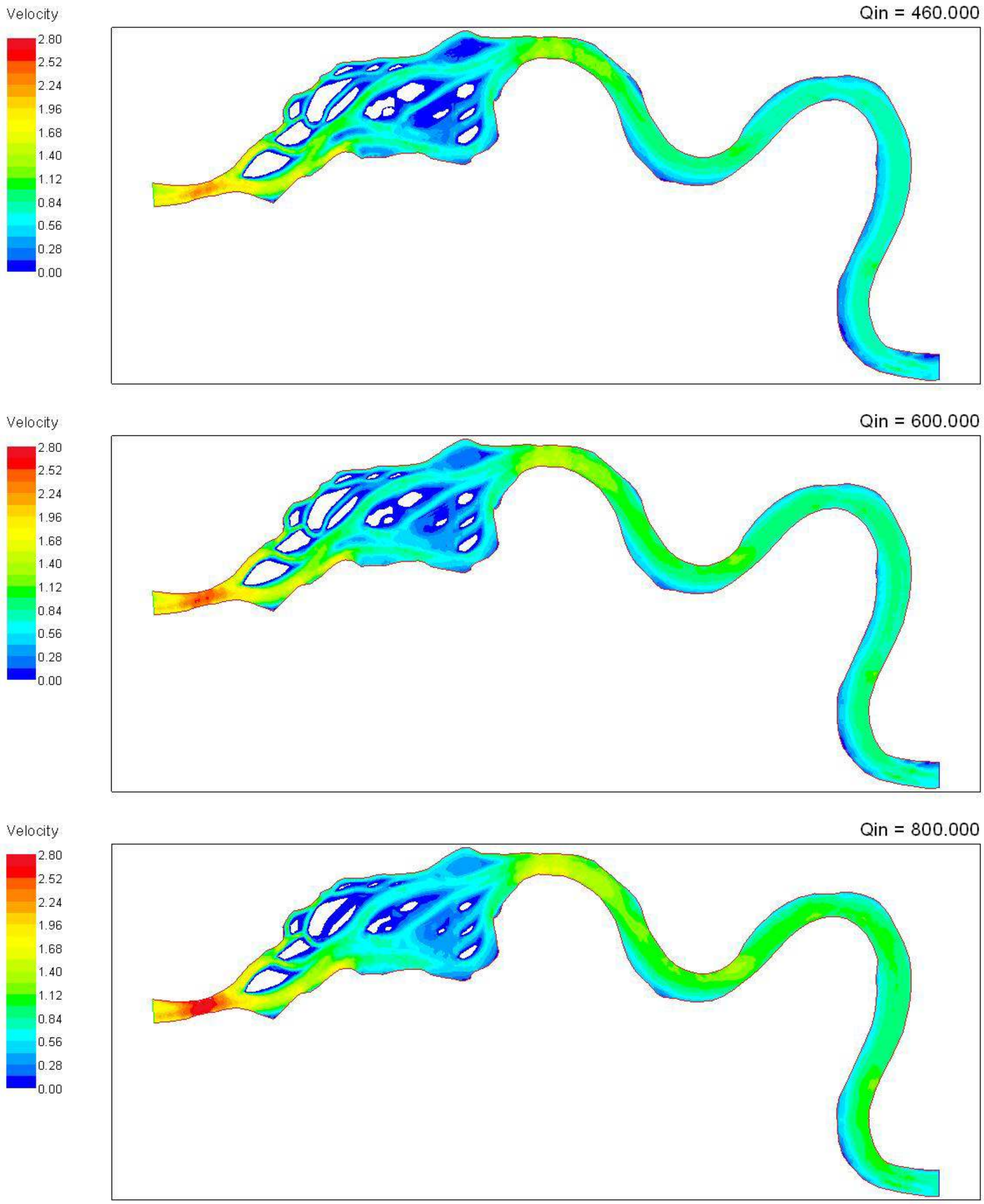


Figure 4.2 Velocity fields computed by River2D for high flows.

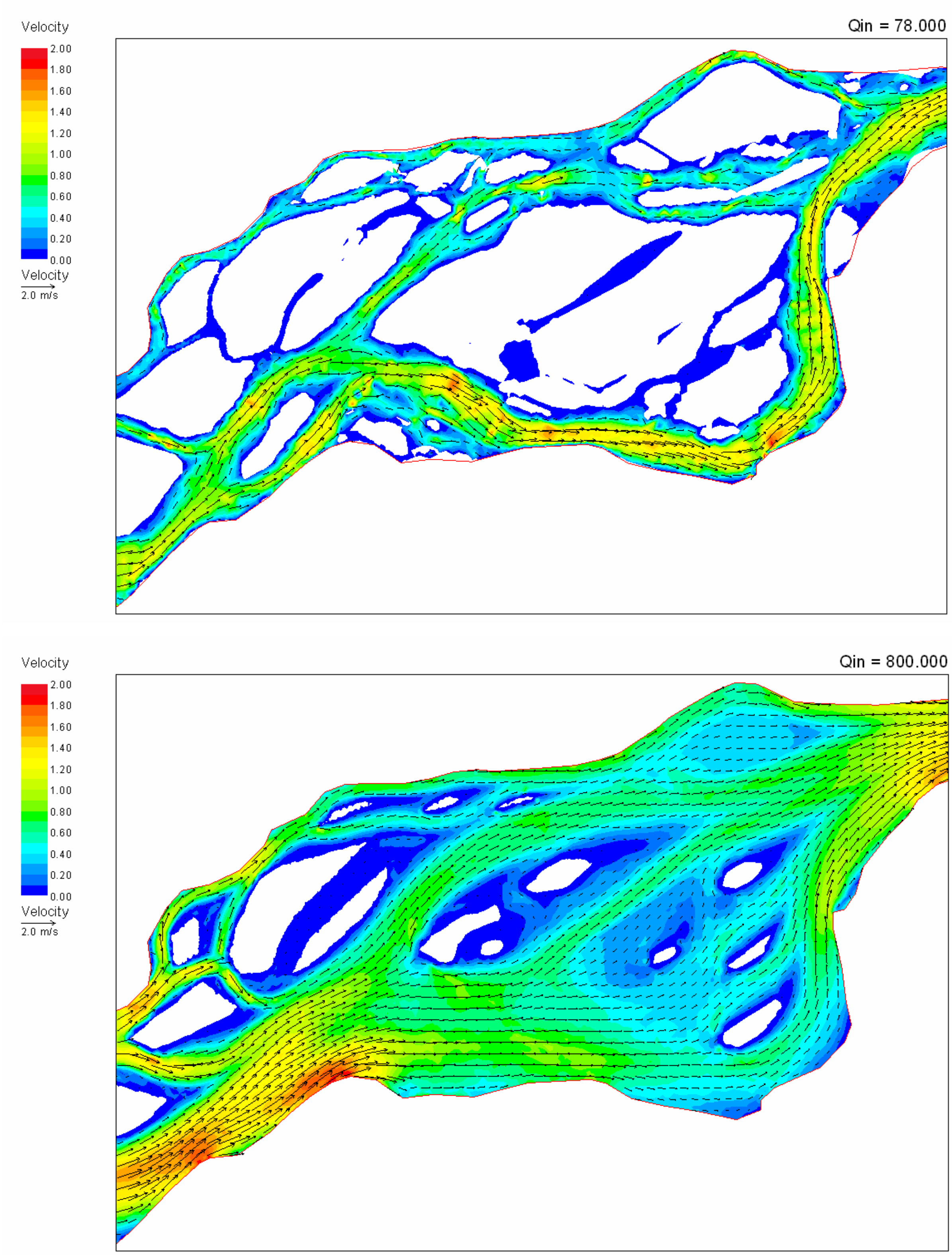


Figure 4.3 Vector velocity plots for 78 and 800 m^3/s.

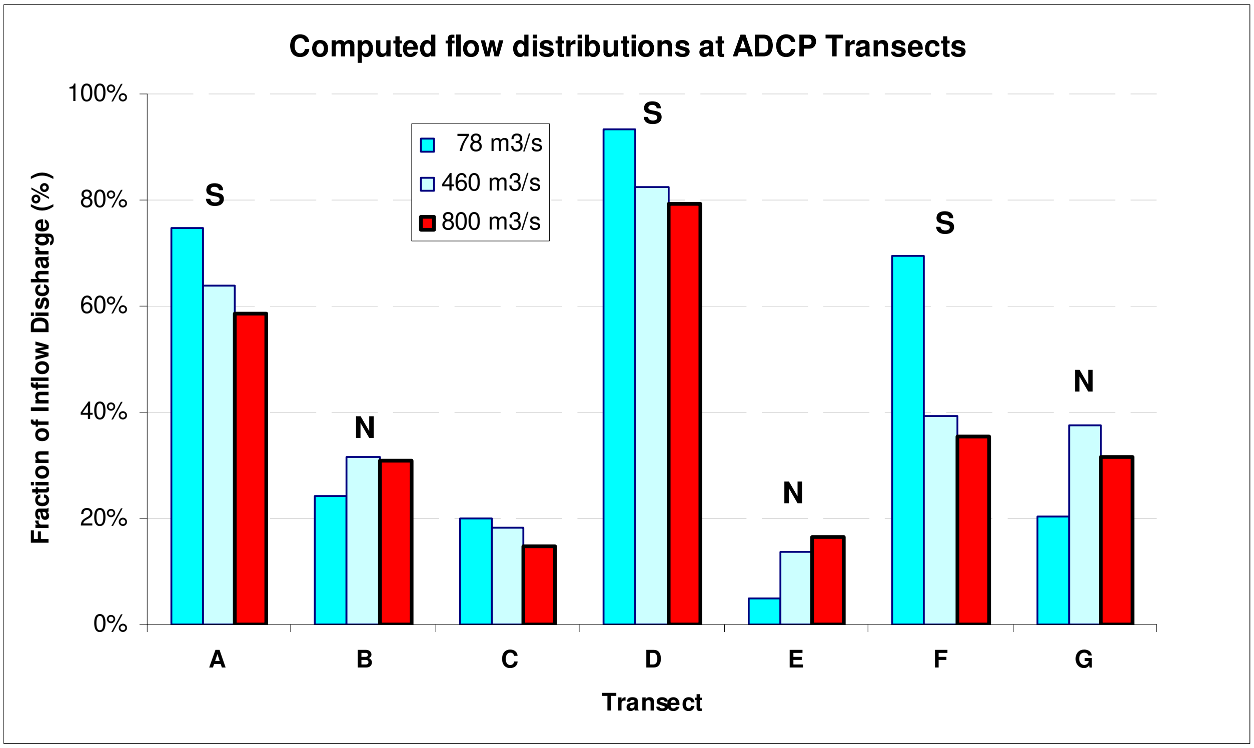
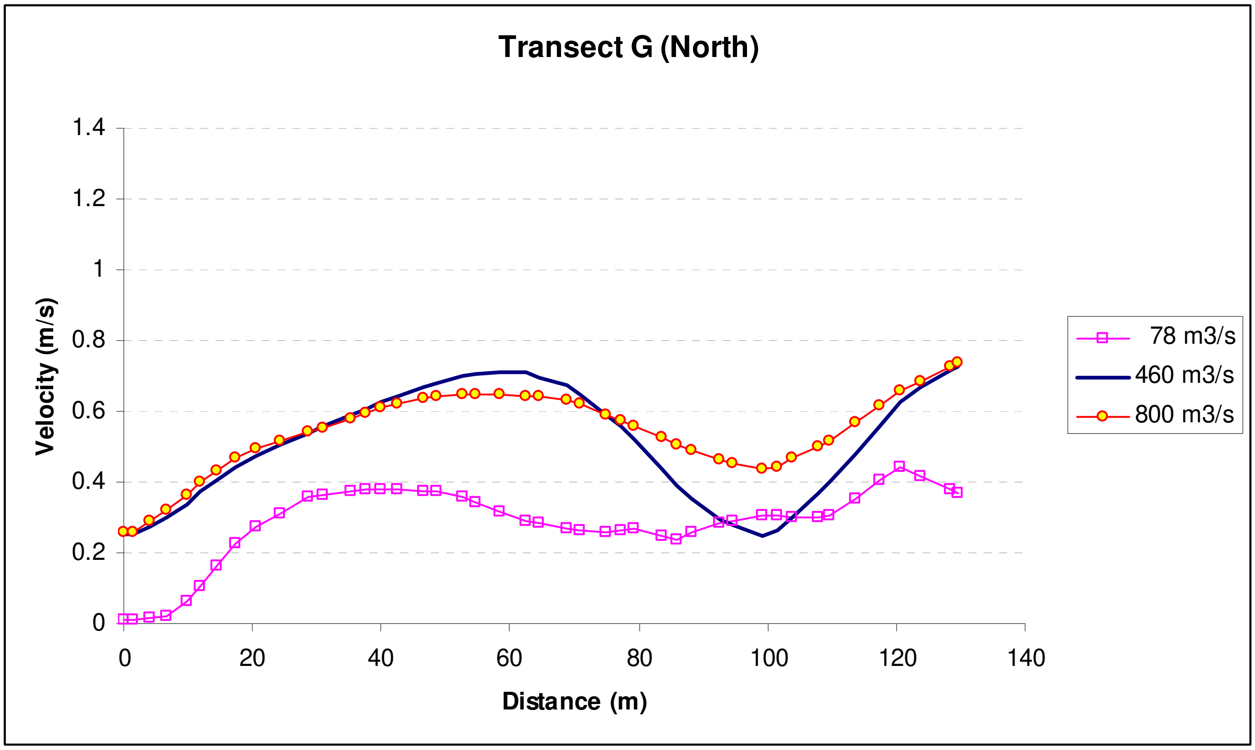


Figure 4.4 Flow distributions (as percent of incoming flow) computed by River2D for discharges 78, 460 and 800 m^3/s at ADCP transects (Figure 3.4.a). S and N refer to channels located in the south and north side of the braided reach respectively.



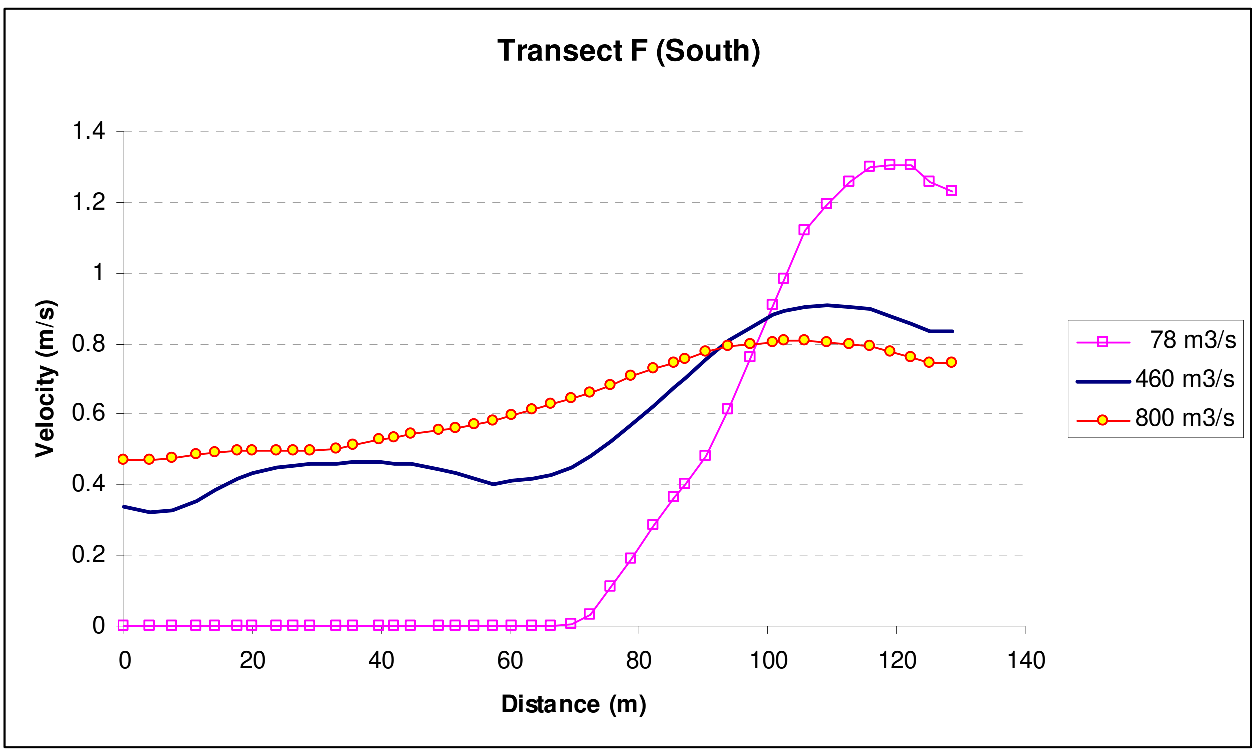


Figure 4.5 Examples of velocity changes with discharges across transect located at both south and north sides of the braided reach.

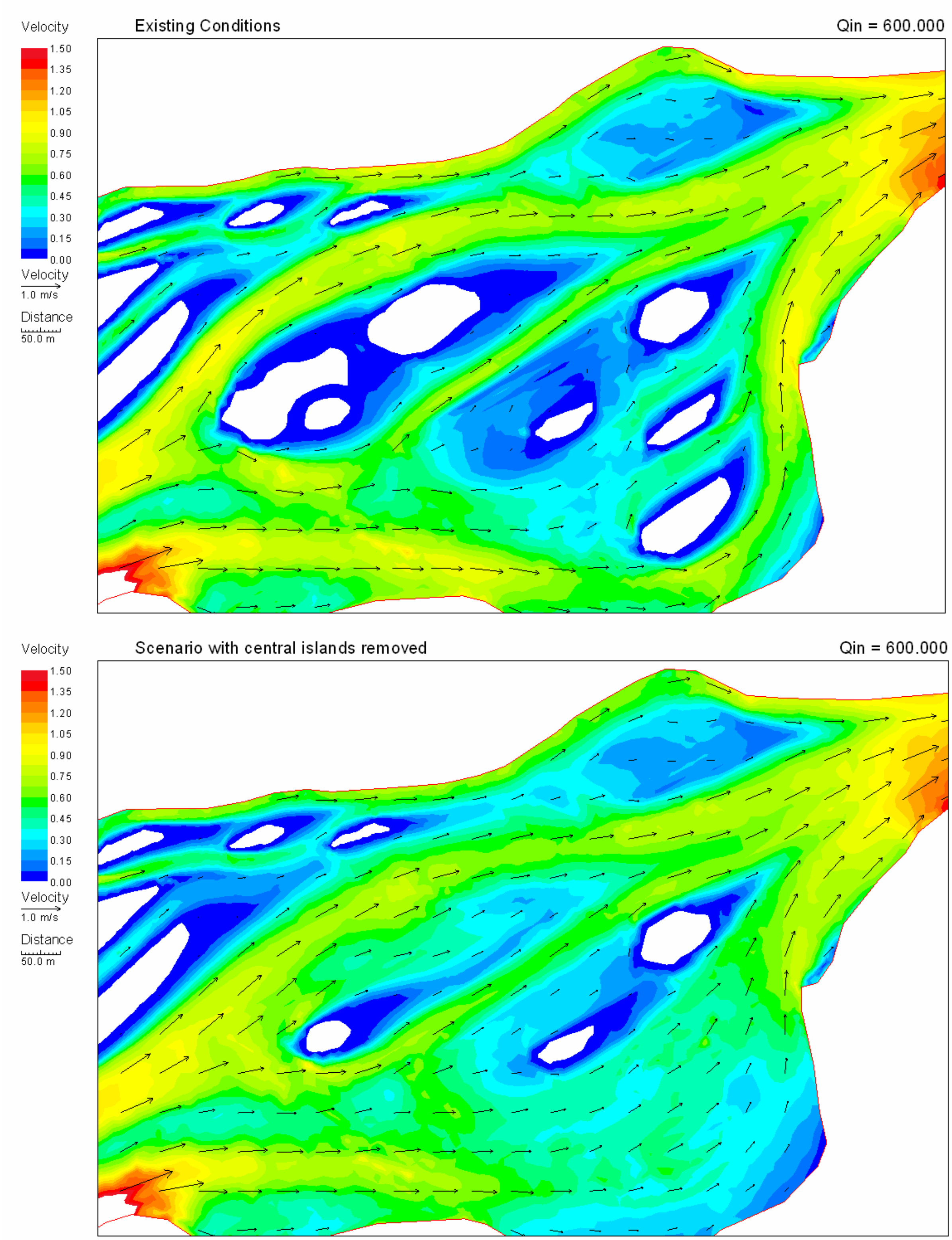


Figure 4.6 Comparison of existing conditions and scenario with elevation of central islands lowered from elevation 638 m to elevation 636 m.