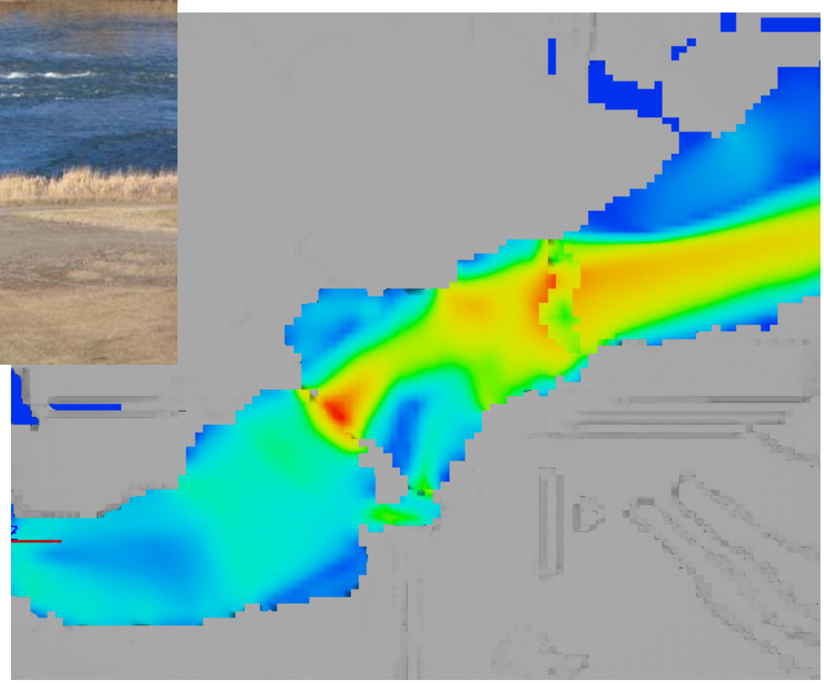
Manitoba Hydro

VELOCITIES AT THE BRANDON GENERATING STATION WEIR ON THE ASSINIBOINE RIVER



REPORT NO. PP&D – 06/07

WATER RESOURCE DEVELOPMENT & ENGINEERING DEPARTMENT
POWER PLANNING & DEVELOPMENT
August 2006

REPORT ON

VELOCITIES AT THE BRANDON GENERATING STATION WEIR ON THE ASSINIBOINE RIVER

PREPARED BY:

CHECKED BY:

APPROVED BY:

NOTED BY:

DATE: 2006 08 18

REPORT NO.: PP&D 06/07

FILE NO.: 00109-11400-0001-00

AUTHORIZED FOR IMPLEMENTATION

BY:

DATE:

PROVINCE OF MANITOBA
2006 09 15
M. P.
MORRIS
Member
22467
REGISTERED PROFESSIONAL ENGINEER

DISTRIBUTION:

N.G. Read
N.B. Szaura
Frederike Schneider-Vieira (North/South Consultants)

TABLE OF CONTENTS

LIST OF FIGURES — Page

LIST OF TABLES — Page

1. SUMMARY

At the request of the Generation Maintenance Engineering Department, the velocity distribution was determined at the Brandon Generating Station weir on the Assiniboine River shown in Figure 1. The velocity distribution was modelled with FLOW3D, a three dimension model, using bathymetry from surveys completed in 1956 and 2004. Results of the model will be used to assess the ability for fish passage under a variety of discharges.

2. DATA

2.1 Discharges

Discharge data used in this study was taken from Water Survey of Canada gauge 05MH013 from 1974-2004. The gauge is located approximately 24 km upstream of the Brandon G.S. weir. Figure 2 shows the discharge duration curve with the 5^{th}, 50^{th} and 95^{th} percentile discharges. Duration curves were developed for the entire record, the open water season (May 1 –Oct 31), the ice covered season (Nov 1- Apr 30) and the spring freshet (Apr 15 – Jun 15).

2.2 Water Levels

Water levels at the weir required for calibration were taken from surveys done in September 2004 and July 2006. The 2004 survey only collected water levels directly upstream and downstream of the weir while the 2006 survey captured a complete water surface profile from approximately 150m upstream of the weir to 250 m downstream.

2.3 Bathymetry

Bathymetric information was compiled from two surveys completed in 1956 and 2004. The 1956 survey shown in Figure 3 was commissioned before the weir was constructed and consisted of bathymetry and upbank elevations. The 2004 survey, shown in Figure 4, collected transects only across the weir.

In addition to the survey data collected in 1956 and 204, a number of cross sections were fabricated upstream of the weir to reduce the effects of the model boundary on the weir velocities. Information from both surveys and the fabricated points were incorporated into a single bathymetry file for use in the FLOW3D model.

3. MODELLING

3.1 Model Set-up

The model boundaries included 300 m upstream and 250 m downstream of the weir. This distance was deemed large enough to reduce the effects of the model boundaries on the velocities at the weir. The model was set up with 3 m horizontal modelling elements and 0.2 m vertical elements. Inputs for each modelled scenario included a discharge and its corresponding downstream water level.

3.2 Calibration and Sensitivity

The model was calibrated using the following two runs:

Date Collected	Discharge (m^3/s)	Downstream Water Level (m)
September 2004	20.2	353.8
July 2006	65	354.25

The modelled downstream water levels were calibrated to within 0.1 m while the upstream water levels were within 0.2 m. The only parameter used in the calibration was the bottom roughness. The sensitivity of the modelled water levels to the modelled bottom roughness was examined. The results indicate the bottom roughness used in the model had less than 0.03 m influence on the water levels.

3.3 Modelled Scenarios

The Generation Maintenance Engineering Department requested the modelling of the velocity distribution for the 5^{th}, 50^{th} and 95^{th} percentile discharges for both the open water season and the spring freshet. Since the 5^{th} percentile flows for both the open water and spring periods were very similar, only one of the flows was modelled. Coincidently, the two flows used to calibrate the model were very close to the 50^{th} percentile flows for the open water and freshet periods. As a result the calibration runs were used instead of rerunning the model precisely at the defined 50^{th} percentile discharges. The table below shows the five discharges that were modelled and the condition that they represent.

Table 1: Modelled Discharges

Modelled Discharge m^3/s	Open Water	Spring Freshet
4.8	5%ile (4.8 m^3/s)	5%ile (7.8 m^3/s)
20.2	50%ile (17.9 m^3/s)	-
65	-	50%ile (48.1 m^3/s)
136	95%ile (136 m^3/s)	-
294	-	95%ile (294 m^3/s)

An important parameter needed to model the velocities in the vicinity of the weir is the downstream water levels. Since this data was not available for most of the discharges that were used in the model, a variety of downstream water levels were modelled for each discharge. Comparing the model results to aerial photographs taken at similar discharges, a suitably downstream boundary condition was chosen. For example, the aerial photos shown in Figure 5 show that under high discharges, there does not appear to be any appreciable head loss across the weir. Therefore the downstream boundary condition was chosen to reflect the observations.

4. Results

4.1 Water Surface Profile

The water surface profile of each of the modelled discharge is shown in Figure 6. The 2006 surveyed water surface profile is also shown.

4.2 Model Velocity Distribution

The velocity distribution of each of the modelled discharge is shown in Figure 7.

4.3 Cross Sectional Velocity Distribution

The velocity distribution was plotted for each of the cross sections shown in Figure 8. The cross sectional velocities are shown in figures 9 to 13.

The maximum velocities at each cross section are shown in Table 2 and the maximum water depths at each cross section are shown in Table 3.

Table 2: Maximum Velocities (m/s)

	Discharge m^3/s				
Cross Section	4.8 m^3/s	20.2 m^3/s	65 m^3/s	136 m^3/s	294 m^3/s
A	0.3	0.7	1.3	1.7	2.1
B	0.9	1.6	2.0	2.2	2.6
C	1.3	2.1	2.2	2.3	2.8
D	0.5	0.9	1.4	1.7	2.4
E	0.7	1.6	2.1	2.6	2.7

Table 3: Maximum Flow Depth (m)

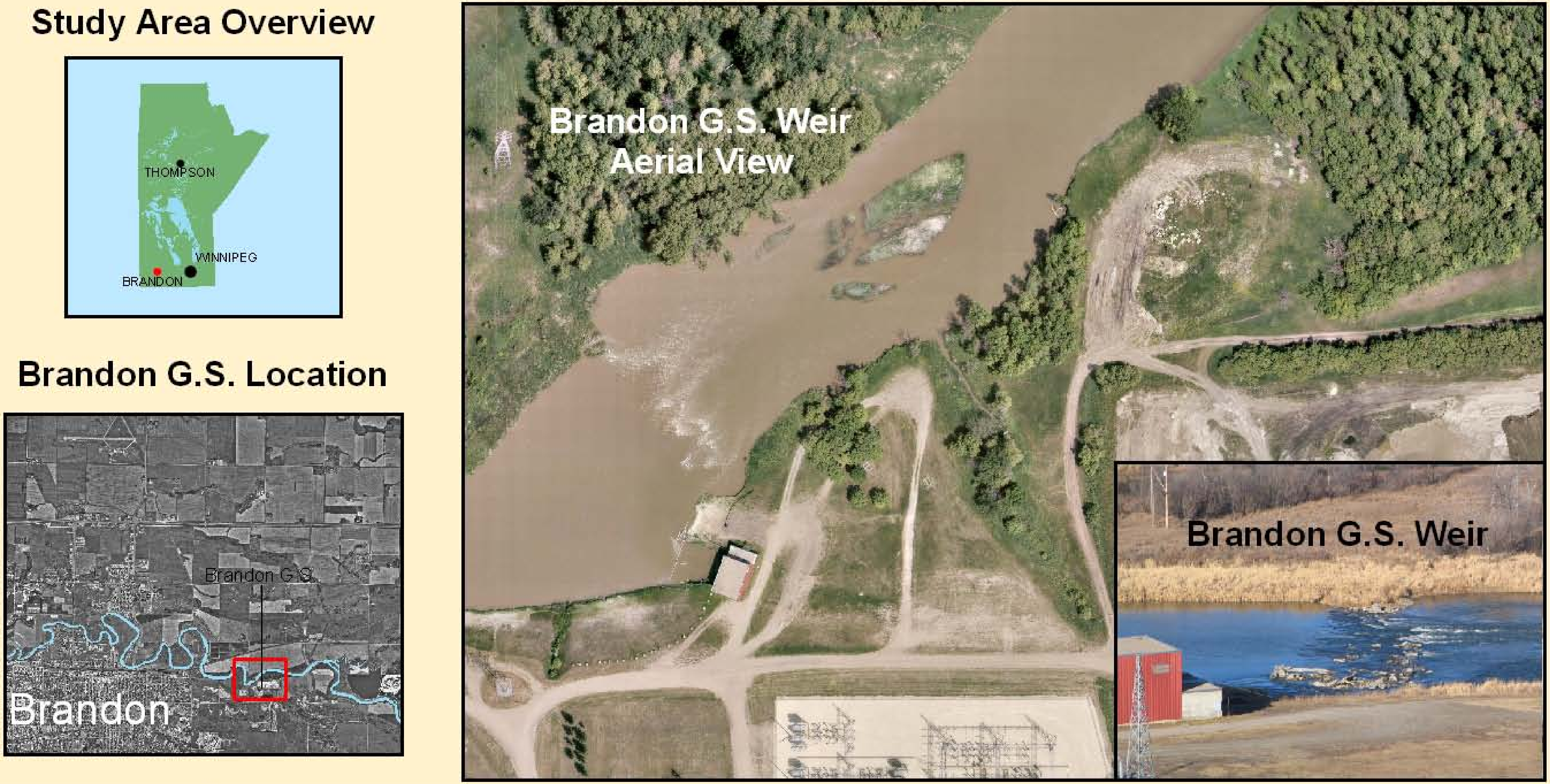
	Maximum Flow Depth (m)				
Cross Section	4.8 m^3/s	20.2 m^3/s	65 m^3/s	136 m^3/s	294 m^3/s
A	0.9	1.1	1.5	2.1	2.7
B	1.7	1.9	2.3	2.9	3.7
C	0.9	1.3	1.7	2.1	2.9
D	1.1	1.3	1.7	2.3	2.9
E	0.7	0.9	1.3	1.9	2.5

5. CONCLUSIONS

At high discharges, the water levels across the weir (and the rest of the study area) are controlled by backwater from downstream (outside the model). As a result of the backwater effect, the weir is flooded out and the velocities throughout the reach are relatively consistent. This effect was confirmed from the model as well as the aerial photographs.

At average discharges, the weir exhibits higher velocity zones than the surrounding area. Although the centre portion of the weir exhibits high velocity, the south section of the weir has a deeper, more tranquil zone. Depths across the weir range from minimal to almost 2 m.

At the extremely low discharges, flow across the weir appears to be limited to the centre portion and the south section. Velocities are extremely low and depths range from minimal to almost 1 m.

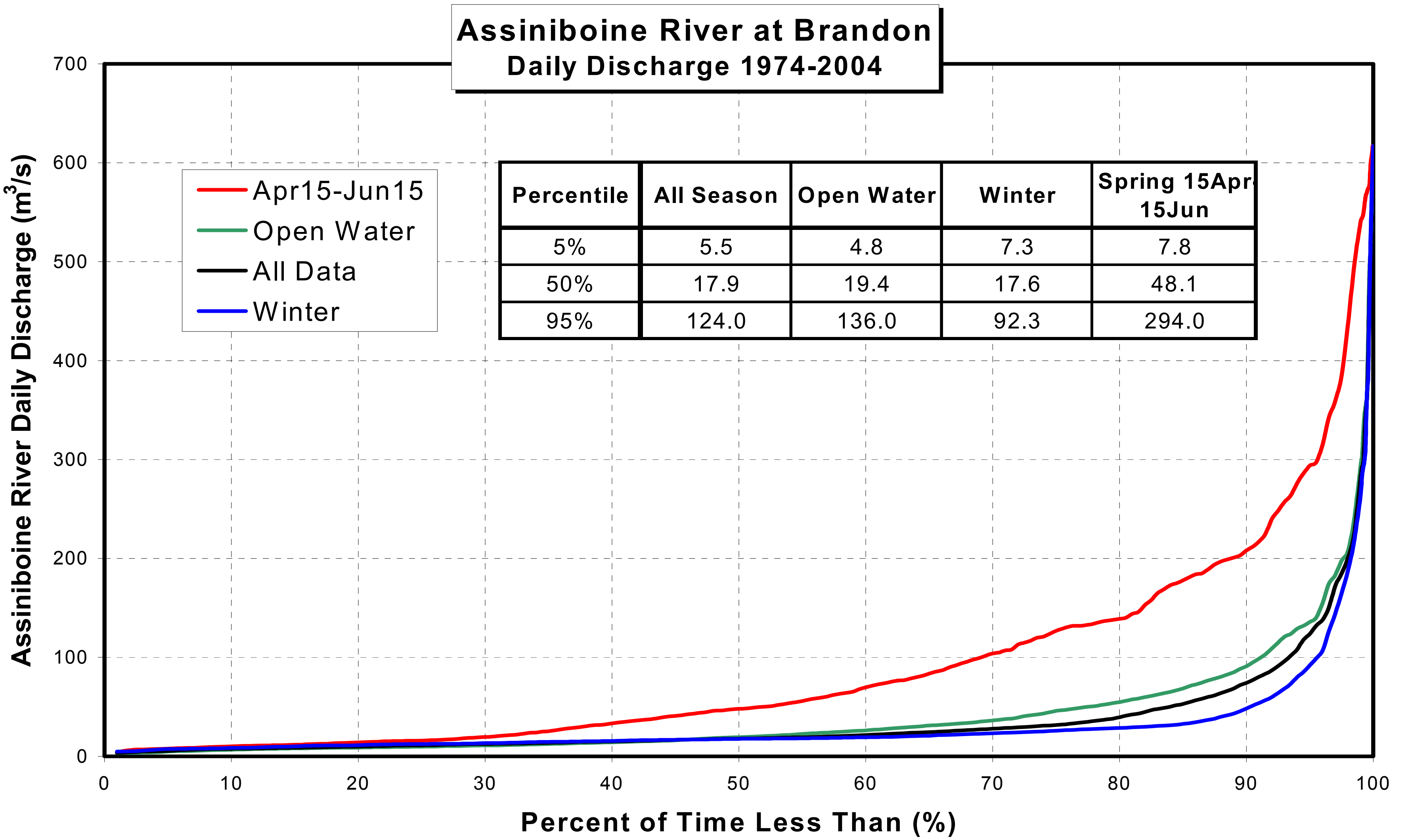


BRANDON GENERATING STATION WEIR SITE MAP

Date: August 11, 2006

Location: Hydraulic-Section-Data\Rivers\Assiniboine\Brandon Weir\Brandon Weir Site Map

Manitoba Hydro
Water Resource Dev. & Eng. Dept.
Brandon G.S. Weir Velocity Modelling
FIGURE 1

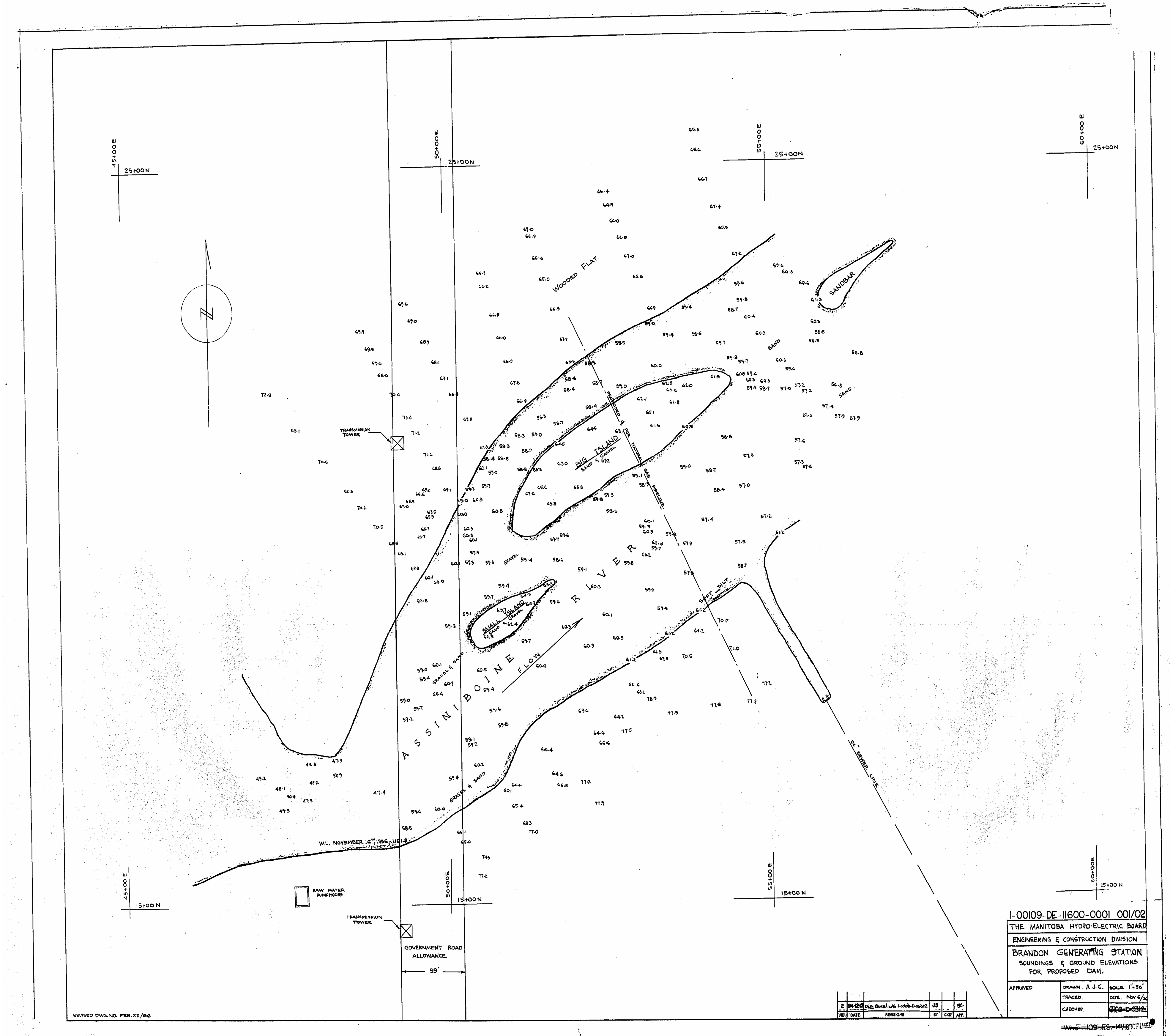


Percentile	All Season	Open Water	Winter	Spring 15Apr-15Jun
5%	5.5	4.8	7.3	7.8
50%	17.9	19.4	17.6	48.1
95%	124.0	136.0	92.3	294.0

Manitoba Hydro	MANITOBA HYDRO
	Water Resource Development & Engineering Dept.
	BRANDON GS WEIR MODELLING

Assiniboine River Discharge Duration Curves

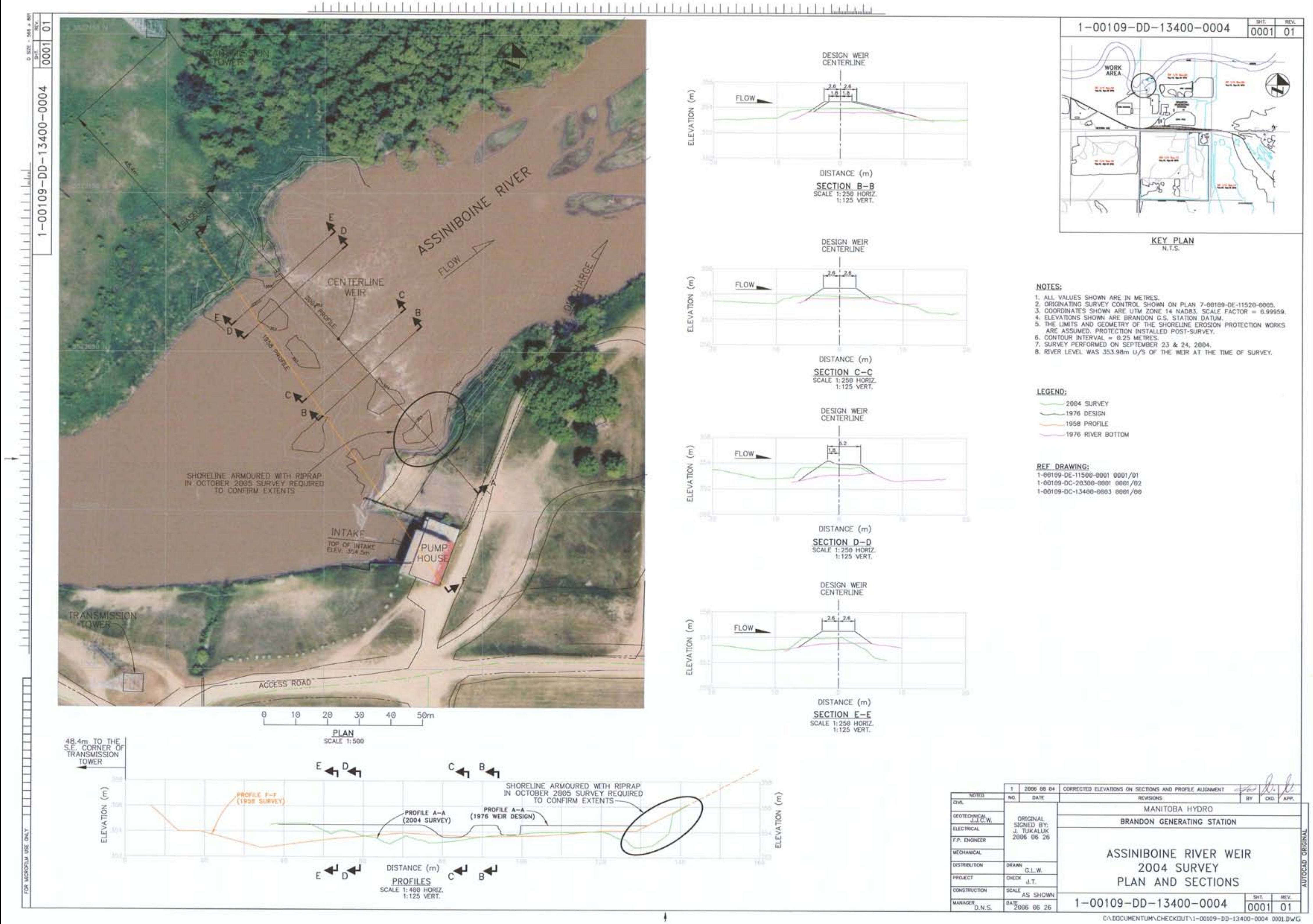
DATE	REFERENCE TO REPORT NO.	
2006-08-18	PP&D-06/07	FIGURE 2



	MANITOBA HYDRO
Manitoba Hydro	Water Resource Development & Engineering Dept.
	BRANDON GS WEIR MODELLING

Brandon GS Weir 1956 Bathymetric Survey

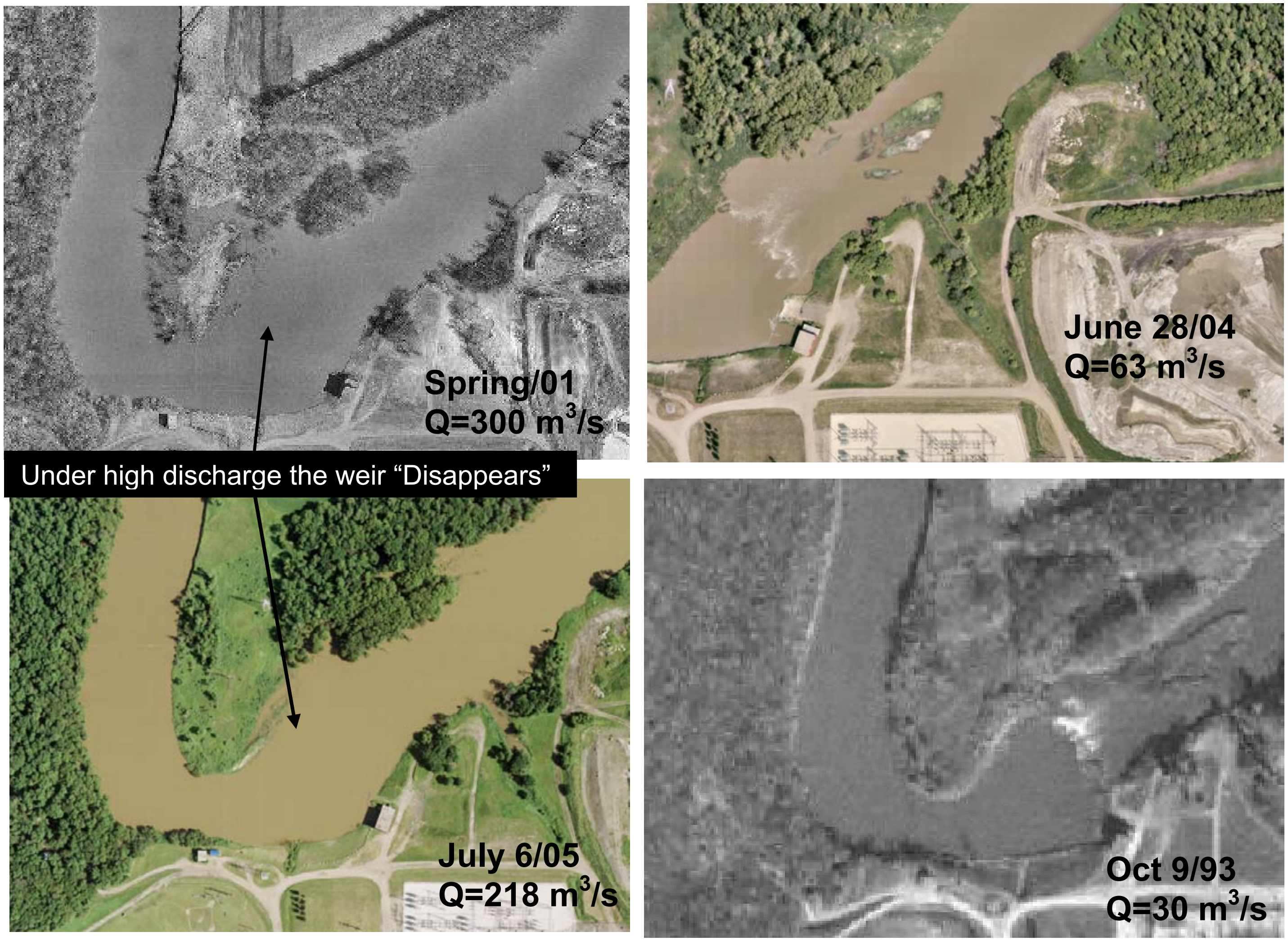
DATE	REFERENCE TO REPORT NO.	FIGURE 3
2006-08-18	PP&D-06/07	



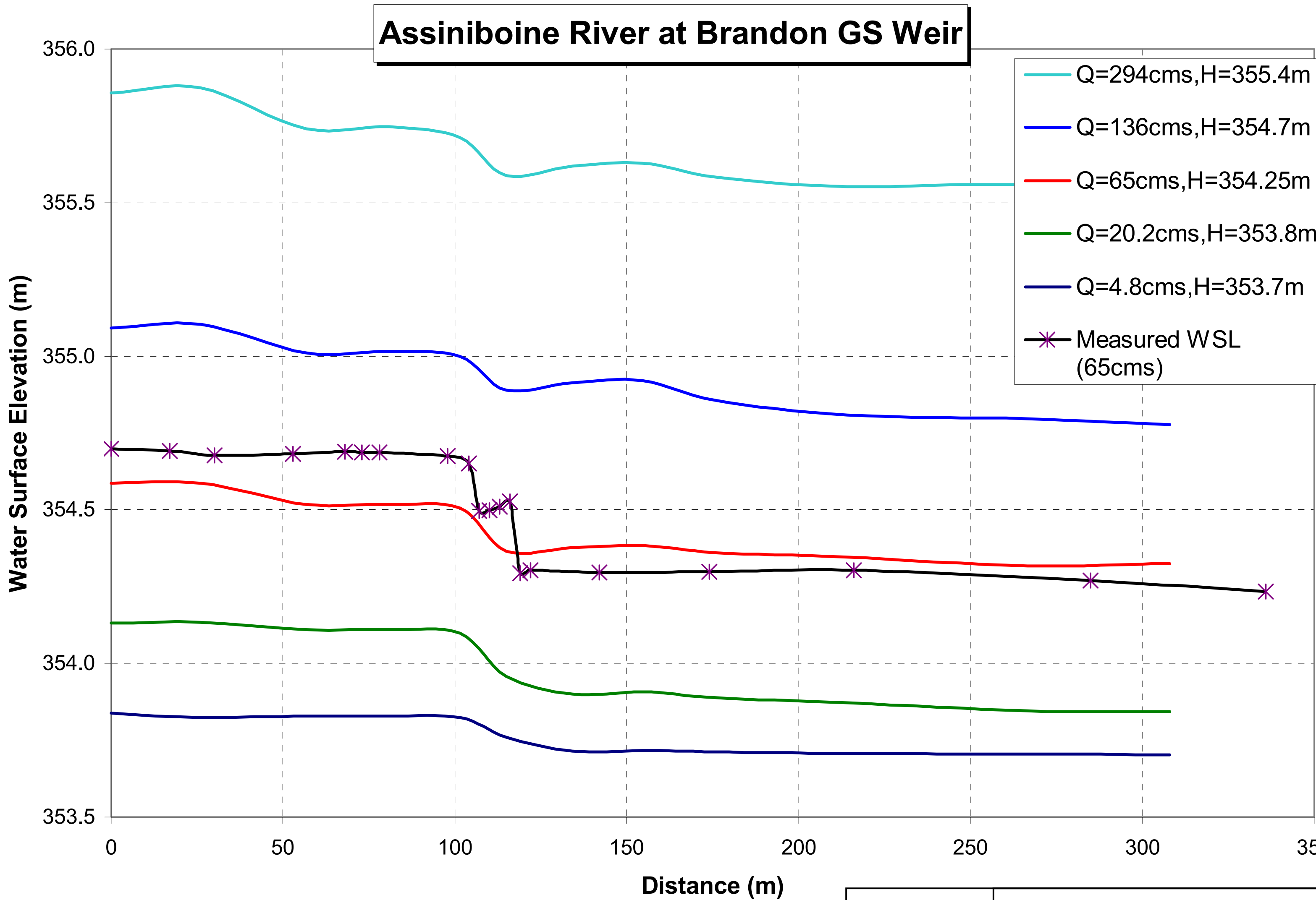
Manitoba Hydro	MANITOBA HYDRO
	Water Resource Development & Engineering Dept.
	BRANDON GS WEIR MODELLING

Brandon GS Weir 2004 Bathymetric Survey

DATE	REFERENCE TO REPORT NO.	
2006-08-18	PP&D-06/07	FIGURE 4



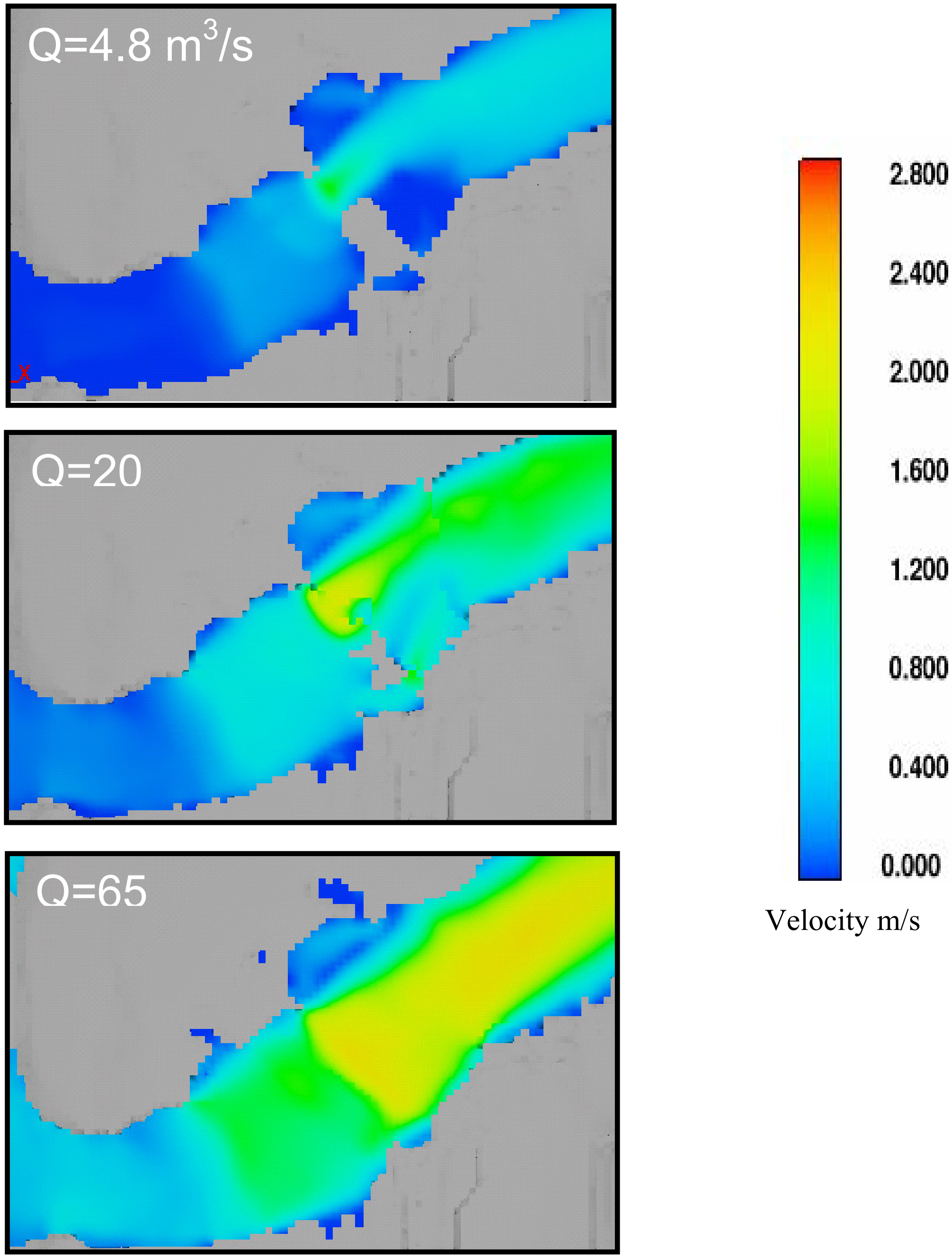
Manitoba Hydro	MANITOBA HYDRO	
	Water Resource Development & Engineering Dept.	
	BRANDON GS WEIR MODELLING	
Aerial Photographs of the Weir		
DATE 2006-08-18	REFERENCE TO REPORT NO. PP&D-06/07	FIGURE 5

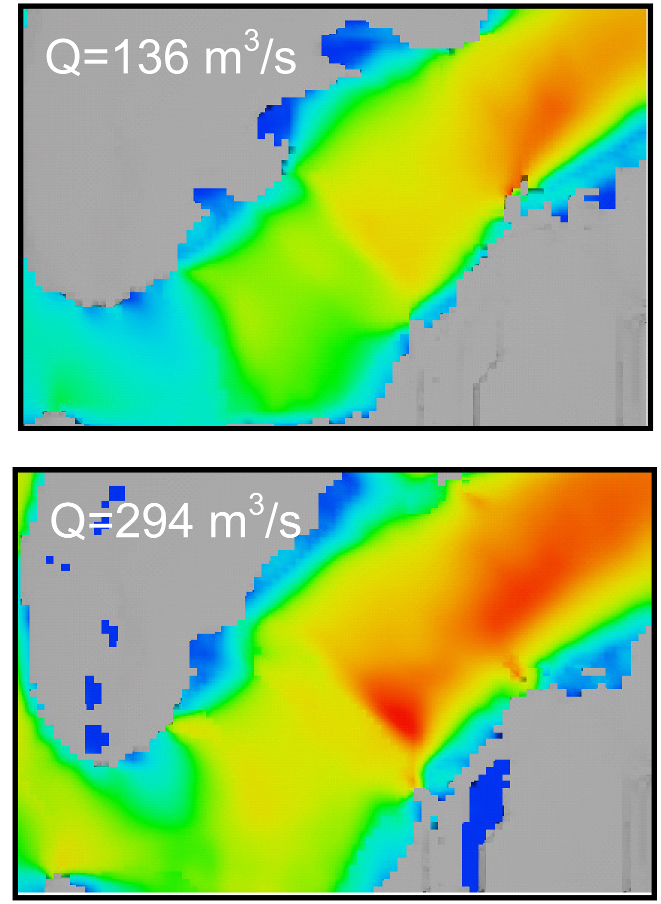


Manitoba Hydro	MANITOBA HYDRO
	Water Resource Development & Engineering Dept.
	BRANDON GS WEIR MODELLING

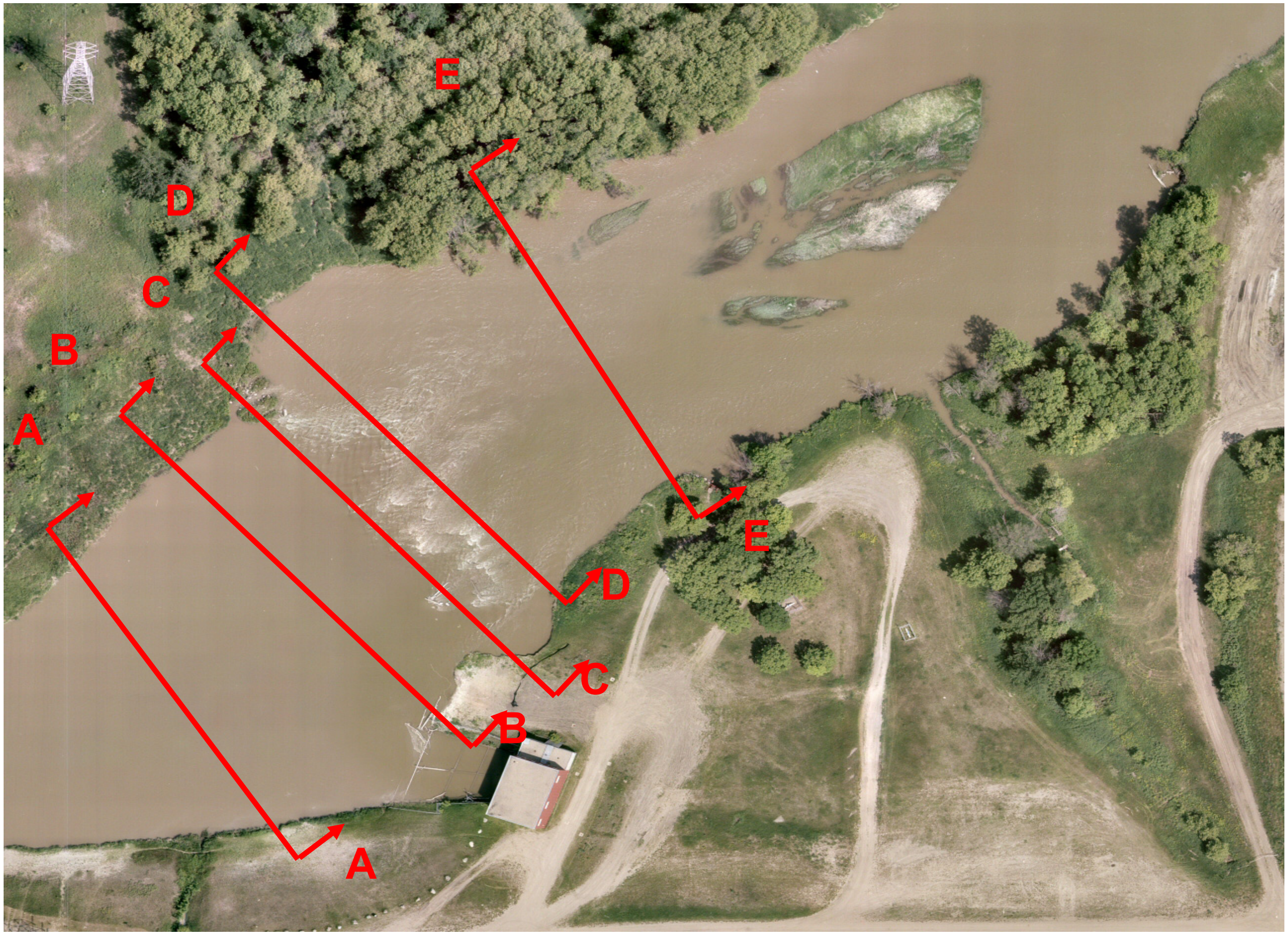
Brandon GS Weir Modelled Water Surface Profiles

DATE	REFERENCE TO REPORT NO.	
2006-08-18	PP&D-06/07	FIGURE 6





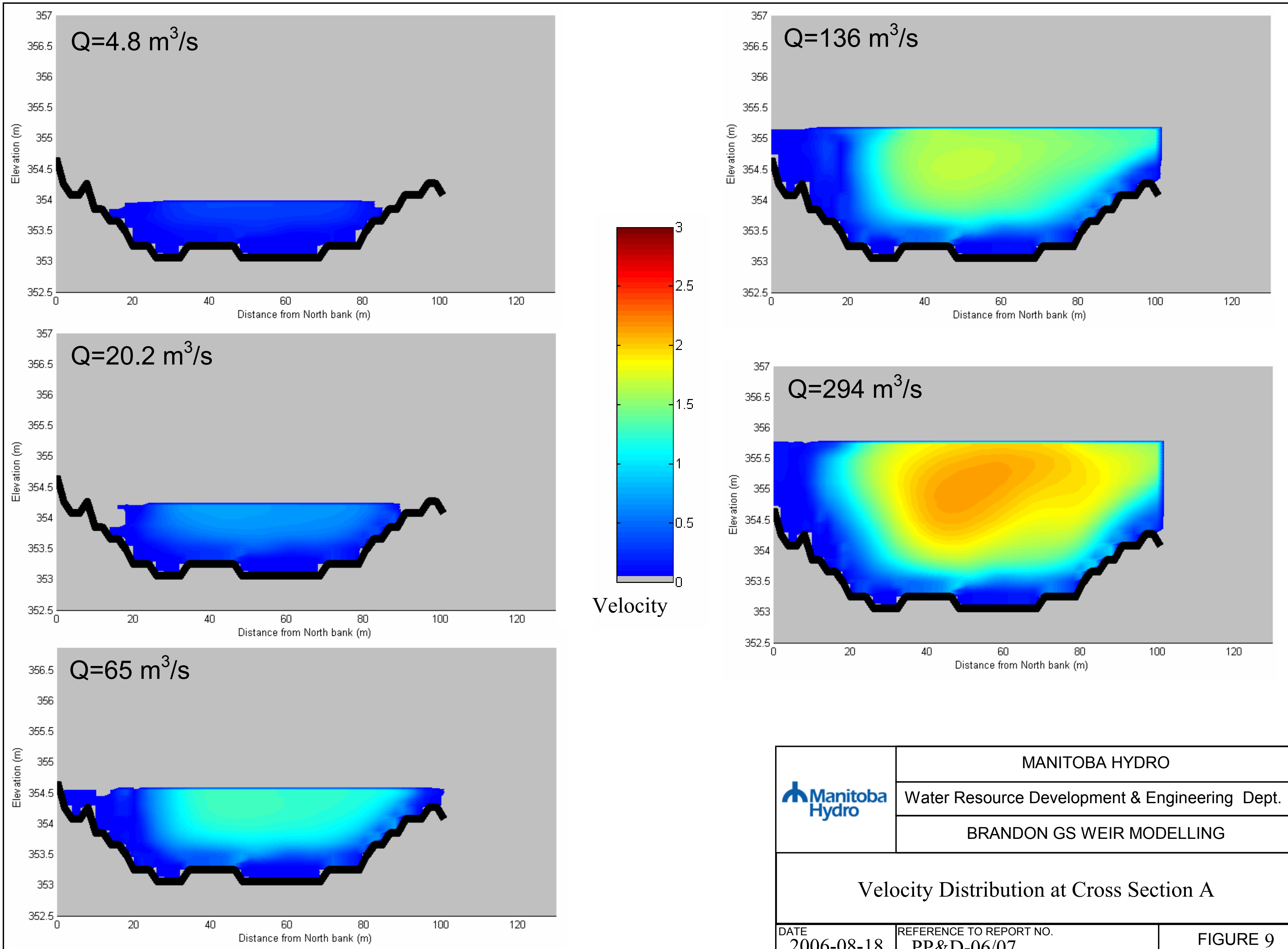
Manitoba Hydro	MANITOBA HYDRO	
	Water Resource Development & Engineering Dept.	
	BRANDON GS WEIR MODELLING	
Brandon GS Weir Velocity Profiles		
DATE 2006-08-18	REFERENCE TO REPORT NO. PP&D-06/07	FIGURE 7



Manitoba Hydro	MANITOBA HYDRO
	Water Resource Development & Engineering Dept.
	BRANDON GS WEIR MODELLING

Cross Section Locations

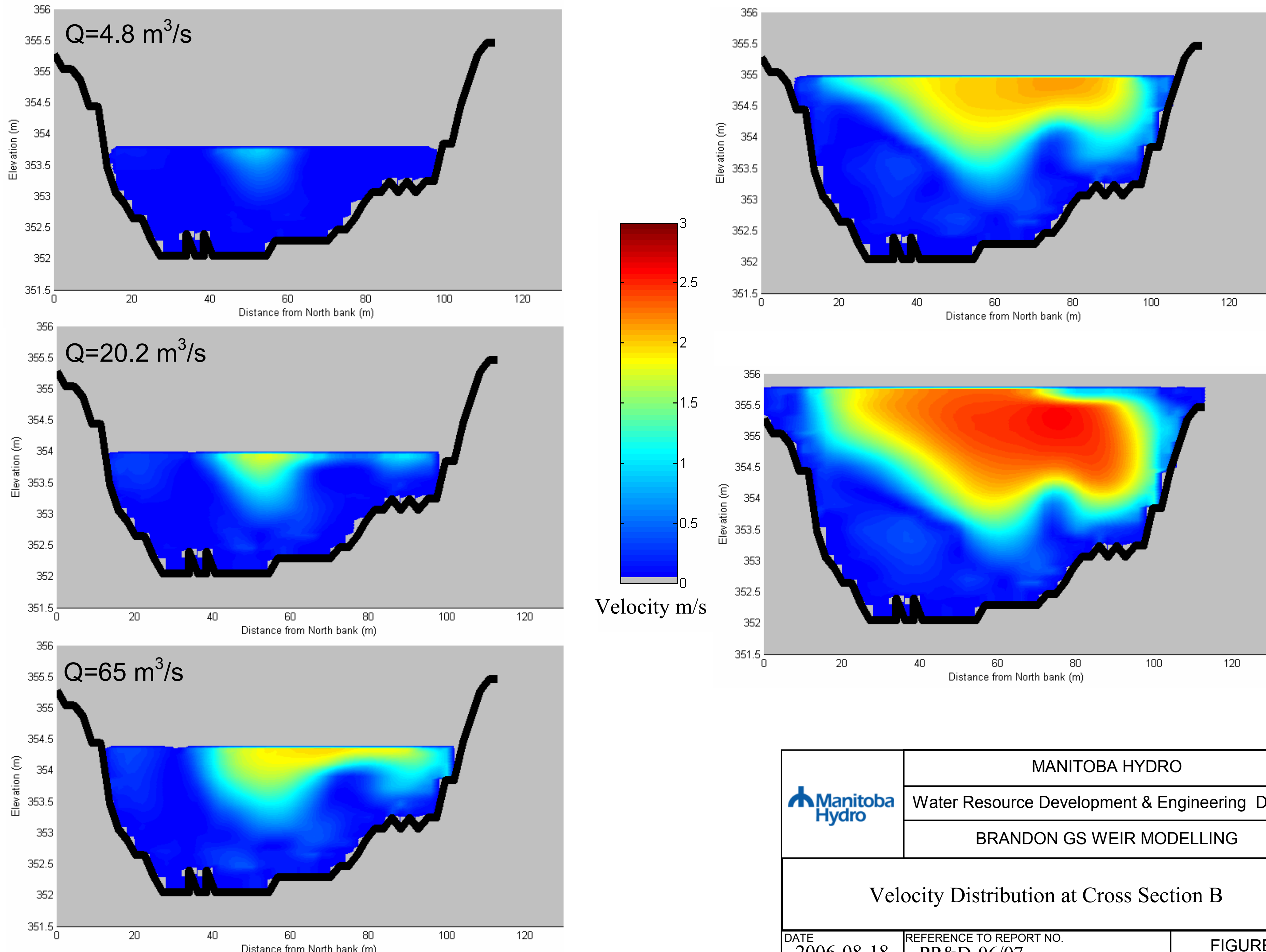
DATE	REFERENCE TO REPORT NO.	
2006-08-18	PP&D-06/07	FIGURE 8



Manitoba Hydro	MANITOBA HYDRO
	Water Resource Development & Engineering Dept.
	BRANDON GS WEIR MODELLING

Velocity Distribution at Cross Section A

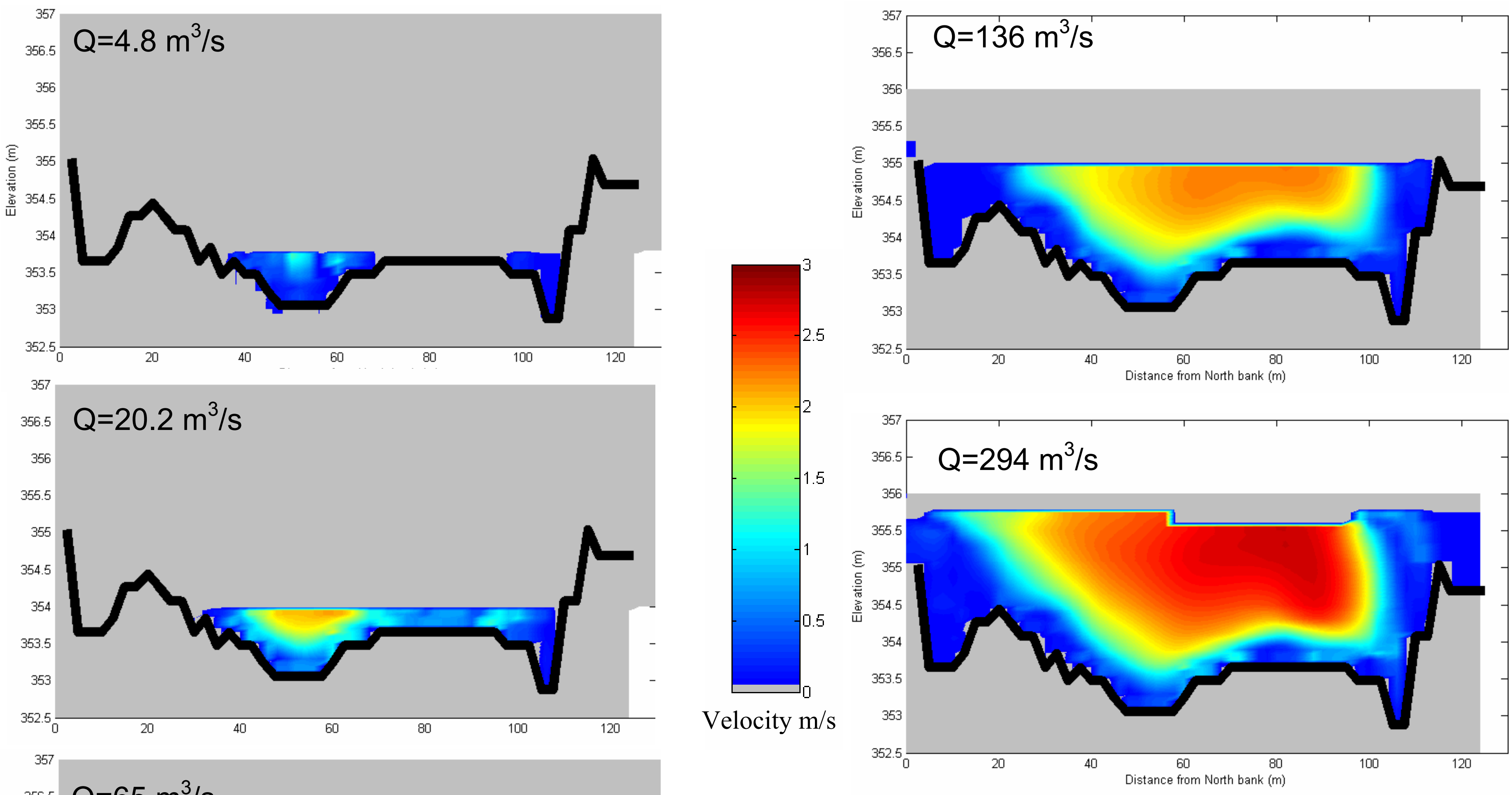
DATE	REFERENCE TO REPORT NO.	
2006-08-18	PP&D-06/07	FIGURE 9

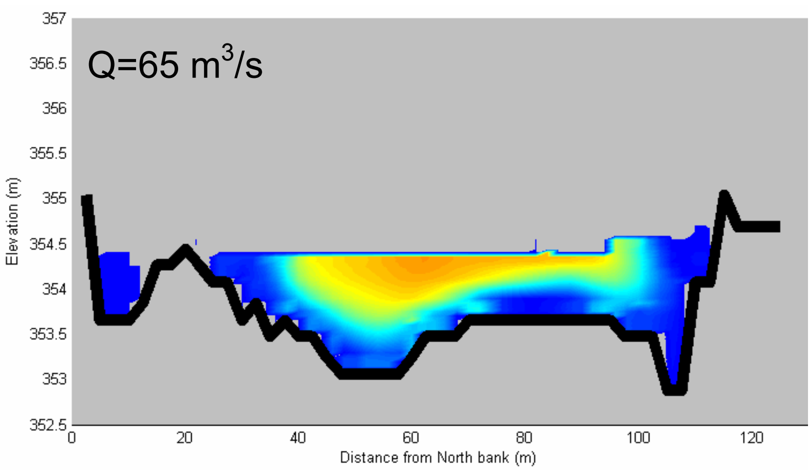


Manitoba Hydro	MANITOBA HYDRO
	Water Resource Development & Engineering Dept.
	BRANDON GS WEIR MODELLING

Velocity Distribution at Cross Section B

DATE	REFERENCE TO REPORT NO.	
2006-08-18	PP&D-06/07	FIGURE 10

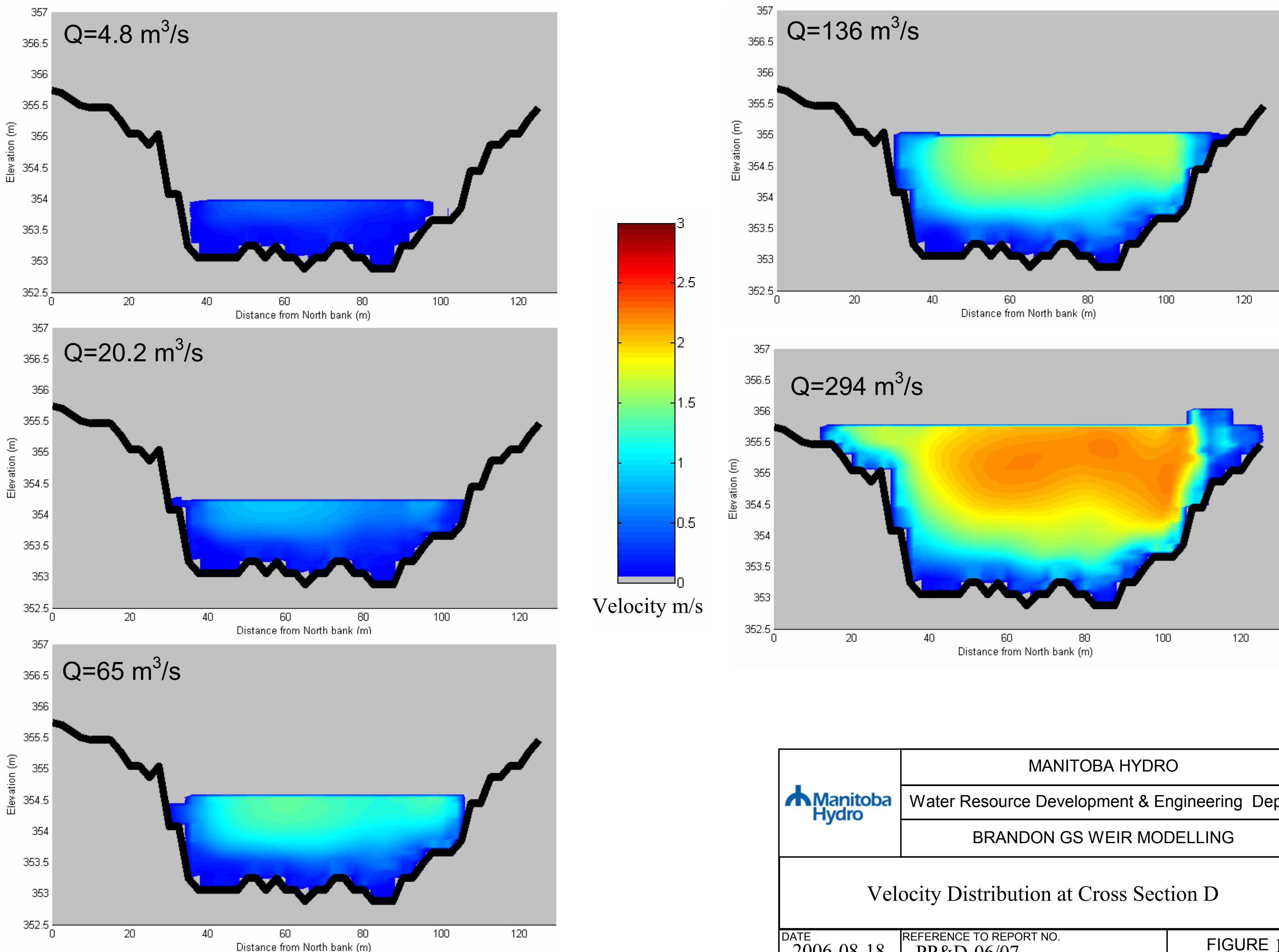




Manitoba Hydro	MANITOBA HYDRO
	Water Resource Development & Engineering Dept.
	BRANDON GS WEIR MODELLING

Velocity Distribution at Cross Section C

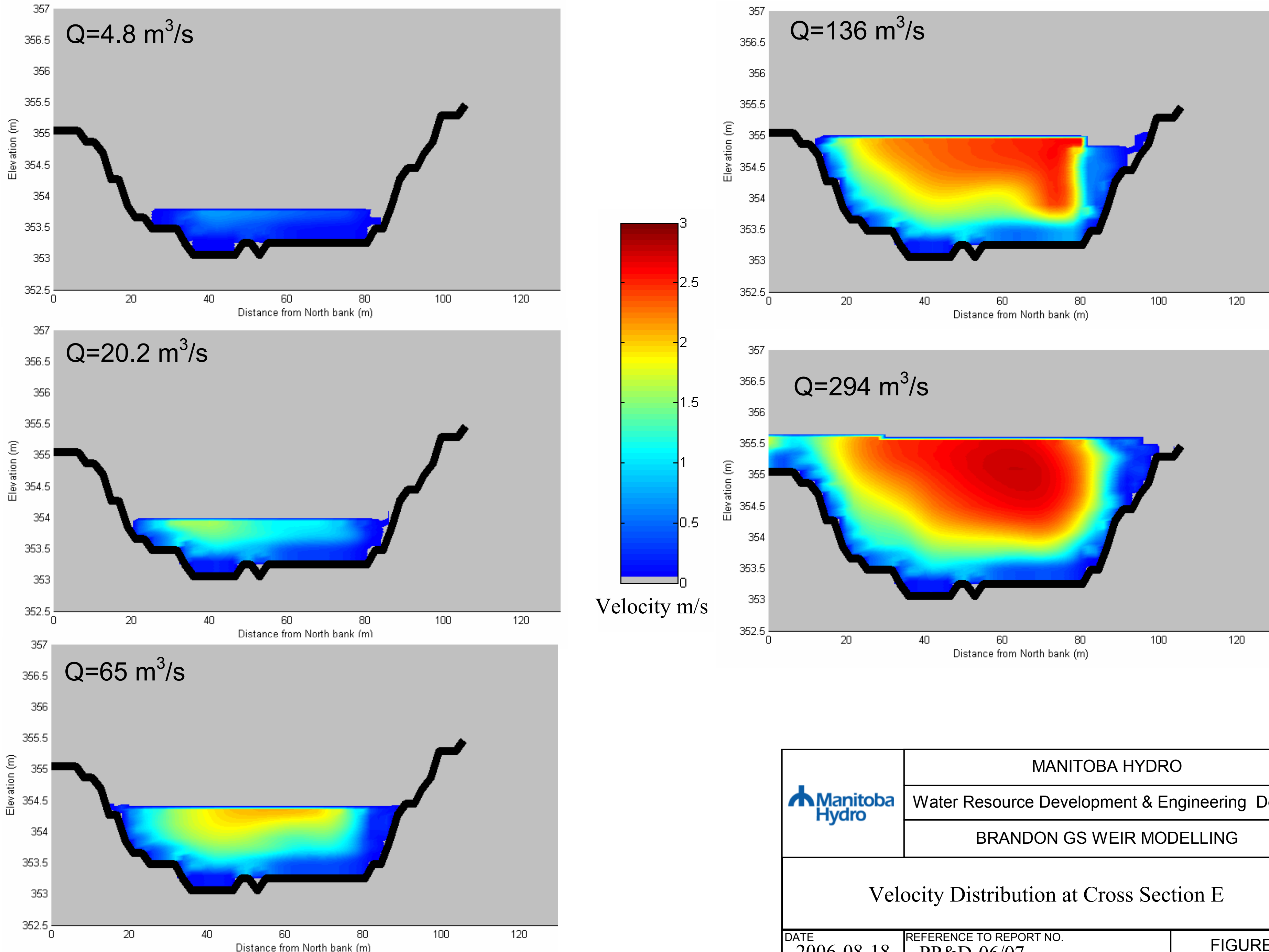
DATE	REFERENCE TO REPORT NO.	
2006-08-18	PP&D-06/07	FIGURE 11



Manitoba Hydro	MANITOBA HYDRO
	Water Resource Development & Engineering Dept.
	BRANDON GS WEIR MODELLING

Velocity Distribution at Cross Section D

DATE	REFERENCE TO REPORT NO.	
2006-08-18	PP&D-06/07	FIGURE 12



Manitoba Hydro	MANITOBA HYDRO
	Water Resource Development & Engineering Dept.
	BRANDON GS WEIR MODELLING

Velocity Distribution at Cross Section E

DATE	REFERENCE TO REPORT NO.	
2006-08-18	PP&D-06/07	FIGURE 13