



Rockwater
P R O P R I E T A R Y L I M I T E D

**CARINA
IRON ORE DEPOSIT**

**MINE FLOOD MANAGEMENT
AND
FLOOD PROTECTION REPORT**

OCTOBER 2009

**REPORT FOR
POLARIS METALS NL**

349.0/09/1

TABLE OF CONTENTS

	PAGE
1 INTRODUCTION	1
2 SCOPE	1
3 HYDROLOGY	1
3.1 Catchment Areas	2
3.2 Rainfall Analysis and Examination of Historical Records	2
3.3 Time of Concentration	3
3.4 Comments on Rainfall Analysis and Record Examination	3
3.5 Rational Method	4
3.6 Flood Index Method	4
3.7 Summary of the Estimated Peak Flows in Catchments C1, C2 and Cm	4
3.8 Adopted Design Flows	6
4 MAPS, CONTOUR PLANS AND ADDITIONAL SURVEY INFORMATION	6
5 SURFACE WATER HYDRAULIC ANALYSIS	6
5.1 Manning's and Continuity Equations	7
5.2 Preparation of Stage-Discharge and Velocity-Discharge Curves at Five Natural Cross-Sections	8
5.3 Hydraulicanalysis Results	8
5.4 Estimated Extent of Flow Paths from Catchment C2	8
5.5 Estimated Extent of Flow Paths from Catchment C1	8
5.6 Estimated Extent of Flow Paths from Catchments C1 and C2	8
5.7 Estimated Extent of Flow Paths from Catchment Cm	9
6 COMMENTS, RECOMMENDATIONS AND CONCLUSIONS	9
REFERENCES	10

Tables

Table 1:	Properties of catchments C1, C2 and Cm	2
Table 2:	Summary of significant recorded 24 hour rainfall	3
Table 3:	Summary of calculated peak flow estimates of Catchment C1	5
Table 4:	Summary of calculated peak flow estimates of Catchment C2	5
Table 5:	Summary of calculated peak flow estimates of Main Catchment Cm	5
Table 6:	Summary of adopted design peak flow estimates	6

Figures

1	Carina, Catchments and Drainage Lines
2	Carina, Extent of 1in 100 Year Flood Event



TABLE OF CONTENTS (Continued)

Appendices

- I HYDROLOGY
 - (A) Intensity Frequency Duration Curve Southern Cross
 - (B) Rational and Flood Index Method
 - (C) Historical Rainfall Records Southern Cross

- II HYDRAULICS
 - (A) Cross Sections
 - (B) *AFFLUX* Results Summary
 - (C) *AFFLUX* Input/Output
 - (D) Stage Discharge Curves



1 INTRODUCTION

Polaris Metals NL (Polaris) proposes to develop an open-cut iron ore mine at Carina, north-west of Koolyanobbing. The mine infrastructure includes an ore pad and a waste dump. A contour map of the area with the major drainage lines and catchments is shown in Figure 1.

Rockwater Pty Ltd was commissioned by Polaris to conduct a hydrological and hydraulic analysis in order to identify the surface water regime in the area of the proposed pit, ore pad and waste dump that would be produced by a 1 in 100 year Average Recurrence Interval (ARI) flood event, and to make recommendations for protection of the infrastructure, if warranted.

2 SCOPE

The scope of this report includes:

- An identification and description of the relevant catchment areas.
- Hydrological analysis to estimate peak flows up to the 1 in 100 year ARI.
- Hydraulic analyses to identify the natural flow paths, and to estimate the depths, widths and velocities of flood waters along the natural flow paths.
- Assessment on the impact and risk of the 1 in 100 years ARI flow on the mine pit, ore pad and waste dump.
- Recommendations of concept flood protection works, such as levees (bunds) and drains, in order to prevent flooding of the mine pit, ore pad and waste dump for the 1 in 100 year ARI peak flow, and ensure efficient drainage for the more frequent, lower flow events.
- Recommendation for scour protection works, if warranted.
- An investigation of the flow path from the main catchment (Cm) in order to assess whether the peak water level from the 1 in 100 year ARI flood event will impact on the proposed waste dump.

3 HYDROLOGY

Carina is located on the border of the Wheatbelt and Arid Interior climatic zones. Conservatively, the hydrological analysis techniques recommended for the Wheatbelt Region of WA in the 1987 Australian Rainfall and Runoff (AR&R) publication was used. Both, the Rational and the Flood Index methods were applied for different soil types. The results were then adjusted to allow for local terrain and soil-type conditions.

These techniques were developed with limited data in the mid 1980s. Generally, the peak flows derived by the techniques recommended by the AR&R (1987) are likely to be over-

estimates, particularly for the more regular flood events. Therefore, some adjustments were made to the computed peak flows for hydraulic design purposes. These adjustments were made from a combination of experience and anecdotal evidence with a conservative factor of safety.

3.1 CATCHMENT AREAS

An examination of 1:50,000 contour plan provided by Polaris, and Google Earth imagery, identified that the following sub-catchments could impact the site:

- Catchment C2, which could impact the mine pit
- Catchments C1 and C2, which together could impact the mine pit and proposed ore pad location.
- Cm was also examined in order to assess whether the 1 in 100 year could impact the proposed waste dump location.

The boundaries of catchments C1, C2 and Cm are shown in Figure 1, and their properties are summarised in Table 1.

Table 1: Properties of catchments C1, C2 and Cm

Catchment	Area	Length	Rainfall	Loss
	A (km ²)	L (km)	P (mm)	C _L %
C1	24	7	300	85
C2	20	5.5	300	85
Cm	180	15	300	85

3.2 RAINFALL ANALYSIS AND EXAMINATION OF HISTORICAL RECORDS

For the estimation of peak flows in the catchments, a set of rainfall Intensity Frequency Duration (IFD) curves for Southern Cross was prepared using the polynomials recommended by AR&R (1987). This IFD curve is presented in Appendix I.

To check the validity of the IFD curves in estimating the ARI of the rainfall events, the 24-hour rainfall records for Southern Cross (1907-2009) were examined. These records were obtained from the Bureau of Meteorology. Over the 102 years of recorded rainfall data, only those years with significant rainfalls were extracted and ranked, as presented in Appendix I. The maximum daily rainfall events is presented in Table 2.

Table 2: Summary of significant recorded 24 hour rainfall

Location	Years of Record	No of rainfall days 50mm < 24 Hr Rain < 100 mm	Highest 24 Hr Rain (mm)
Southern Cross	102	16	84.20

The rainfall records shown in Table 1 indicate that the IFD curves used in the hydrological analysis are of the right order. In addition, the return periods of the rainfall events which caused significant flooding were also assessed, when this rainfall data was input into the IFD tables.

3.3 TIME OF CONCENTRATION

The time of concentration is required in order to assess the critical storm duration for peak flow estimates. The equation for the Wheatbelt Region of WA was used. This equation was cautiously used, because the peak flows are very much affected by local terrain and the soil types and other unique catchment parameters.

Equation 1 was used to estimate the time of concentration, as it was the most conservative of those recommended in AR&R (1987).

$$t_c = 0.76 \cdot A^{0.38} \qquad \text{Equation 1}$$

Where:

- t_c is the time of concentration (hours), and
- A is the catchment area in (km²)

3.4 COMMENTS ON RAINFALL ANALYSIS AND RECORD EXAMINATION

In peak flood estimation techniques both the total rainfall and the duration of the storm events were considered. This is based on the catchment size (see Equation 1) and the assumption that rainfall is distributed uniformly throughout the catchment area.

The time of concentration for Catchment C1 is about 2.5 hours and for C2 it is about 2.4 hours.

Due to the coincidence of peak flows from catchments C1 and C2 at the mines site, the peaks were added in order to assess the magnitude of the flood at the critical location of the mine site.

For the main catchment Cm, the time of concentration is estimated to be about 5.5 hours for the peak flow at the mine site.

In comparison with the 24 hour rainfall records, the intensity used in the computation is very conservative. It is also important to note that in reality the return period of a rainfall event

cannot always be directly translated to the return period of the flood event. Joint probability of two successive storms that contributed to antecedent conditions of the catchment can significantly increase flood magnitude. This is the main reason for the adoption of conservative approach in the flood estimation in this report.

3.5 RATIONAL METHOD

The first technique used in peak flow estimation in this report is the Statistical Rational Method, as presented in Equation 2.

$$Q_y = 0.278 \cdot C_y \cdot I_{tcy} \cdot A \quad \text{Equation 2}$$

Where:

- Q_y is the peak flow for return period y years (m^3/s),
- 0.278 is a dimensionless metric conversion factor,
- C_y is the runoff coefficient for y years (dimensionless),
- I_{tcy} is rainfall intensity (mm/hr),
- A is catchment area (km^2).

3.6 FLOOD INDEX METHOD

The Flood Index Method presented as Equations 3 and 4 for different soil characteristics, was also used. Again, this generalised technique is based on very few statistical data for the Wheatbelt Region of WA and should be used with caution.

$$Q_5 = 2.77 \times 10^{-6} \cdot A^{0.52} \cdot P^{2.12} \quad \text{Equation 3}$$

(For loamy soil catchments 75-100% cleared)

$$Q_5 = 3.04 \times 10^{-1} \cdot A^{0.60} \cdot 10^{0.0052 \cdot C_L} \quad \text{Equation 4}$$

(For loamy and lateritic soil catchment and, sandy soil catchments)

Where:

- Q_5 is the peak discharge for the 5 year ARI flow
- A is the catchment area (km^2)
- P is the annual rainfall (mm)
- C_L is the clearing measured as a percentage of the catchment area. Summary of the Estimated Peak Flows in Catchments C1, C2 and Cm

Carina is located in an area of mixed rocky soil overlain in parts with dust and clay. The techniques of peak flow estimation for both lateritic and loamy and lateritic soil were used in the computation. The more conservative results were adopted. For computational purposes, a percentage clearing of 85% was adopted throughout. Detailed calculations are included in Appendix I and the results are summarised in Tables 3, 4 and 5.

Table 3: Summary of calculated peak flow estimates of Catchment C1

Soil Types	Method	ARI (Years)					
		2	5	10	20	50	100
<i>Loamy and lateritic soil catchments</i>	<i>Rational (m³/s)</i>	3	6	11	19	33	58
	<i>Index (m³/s)</i>	3	6	11	19	35	61
<i>Loamy soil catchments</i>	<i>Rational (m³/s)</i>	3	7	13	24	43	78
	<i>Index (m³/s)</i>	1	3	5	8	16	29
	<i>Design flows (m³/s)</i>						

Table 4: Summary of calculated peak flow estimates of Catchment C2

Soil Types	Method	ARI (Years)					
		2	5	10	20	50	100
<i>Loamy and lateritic soil catchments</i>	<i>Rational (m³/s)</i>	3	6	10	18	32	56
	<i>Index (m³/s)</i>	3	5	10	17	31	55
<i>Loamy soil catchments</i>	<i>Rational (m³/s)</i>	3	7	13	24	43	78
	<i>Index (m³/s)</i>	1	2	4	8	14	26
	<i>Design flows (m³/s)</i>						

Table 5: Summary of calculated peak flow estimates of Main Catchment Cm

Soil Types	Method	ARI (Years)					
		2	5	10	20	50	100
<i>Loamy and lateritic soil catchments</i>	<i>Rational (m³/s)</i>	10	21	38	67	118	209
	<i>Index (m³/s)</i>	10	21	36	63	116	204
<i>Loamy soil catchments</i>	<i>Rational (m³/s)</i>	10	23	42	78	143	261
	<i>Index (m³/s)</i>	4	7	14	24	45	82
	<i>Design flows (m³/s)</i>						

3.7 ADOPTED DESIGN FLOWS

Table 6 shows a summary of the calculated design flows.

Table 6: Summary of adopted design peak flow estimates

Catchment	ARI (Years) /Flow (m ³ /s)					
	2	5	10	20	50	100
C1	3	7	13	24	43	78
C2	3	7	13	24	43	78
Combined (C1+C2)	6	14	26	48	86	156
Cm	10	23	42	78	143	261

4 MAPS, CONTOUR PLANS AND ADDITIONAL SURVEY INFORMATION

Concept design layouts and contour plans with an interval of 5.0 m were provided by Polaris. Ideally, a contour plan of closer contour interval is required for hydraulic analysis. The 5.0 m contours were therefore interpolated to an interval of 2.0 m. The large event flow paths take the form of wide sheet flows in an area of relatively flat terrain. The hydraulic analyses were carried out based on an interpolation of the approximate ground levels.

Preferably, ground surveys of sections across existing and proposed flow paths, and the conceptual diversion levee and drainage system, are also required. However, due to time and cost constraints, the interpolated 2.0 m contour plan was used to estimate cross-section profiles.

5 SURFACE WATER HYDRAULIC ANALYSIS

After estimating the peak flows, hydraulic computations were carried out in order to analyse the natural and design flow characteristics. Specifically, the objectives of the hydraulic analyses were:

- To estimate the levels, velocities and extent of the peak flows for the 1 in 100 year ARI storm events along the undisturbed natural drainage paths in the vicinity of the proposed mine pit, ore pad and waste dump.
- To comment on the impact of the natural flow paths on the proposed mine pit, waste dump and ore pad.
- To carry out a concept design of the size and configuration of the perimeter drains and levees (bunds) in order to protect the infrastructure, if warranted.

- Use the velocities for the various flow events to assess their scouring hazard and recommend protective anti-scour measurements, if warranted.

The hydraulics analysis was carried out for the various ARI as shown in the hydrological analysis in Section 3. Stage discharge curves were prepared at the 5 relevant cross-section locations, as shown in Appendix II. Manning’s Equation 5 was adopted for this analysis.

At each cross-section, the roughness coefficients ‘n’ for the main natural wide sheet flows were estimated by examination of the aerial photos and Google Earth imagery. The hydraulic gradients were estimated from the 5.0 m contour plan. These parameters are included in Appendix II.

5.1 MANNING’S AND CONTINUITY EQUATIONS

Manning’s equation used to estimate flow velocity:

$$V = \frac{1}{n} \cdot \left(\frac{A}{P} \right)^{2/3} \cdot (S)^{1/2}$$

Equation 5

Where:

- V is the velocity (m/s)
- n is a dimensionless roughness coefficient
- A is the wetted waterway area (m²)
- P is the wetted perimeter (m)
- S is the hydraulic gradient (m/m)

The continuity equation was used to estimate the flow:

$$Q = A \cdot V$$

Equation 6

Where:

- A is the waterway area in (m²)
- V is the velocity (m/s)

From examination of the contour plan and Google Earth the following parameters values were used:

Manning’s “n”	0.045 throughout
Slope	0.0065 m/m for streams C1 and C2 0.0002 m/m for stream Cm

5.2 PREPARATION OF STAGE-DISCHARGE AND VELOCITY-DISCHARGE CURVES AT FIVE NATURAL CROSS-SECTIONS

The cross-section profiles, calculation tables and stage-discharge curves details are provided in Appendix II.

The Manning’s equation was solved for each discreet cross section using the software *AFFLUX* in order to obtain the stage discharge and velocity discharge relationships. All hydraulic computations have been included in Appendix II.

The flow paths and extent of the 1 in 100 year ARI flood waters along the natural streams were estimated from these hydraulic analyses (Figure 2).

5.3 HYDRAULIC ANALYSIS RESULTS

The results of the hydraulic analysis are as follows:

<u>Location</u>	<u>100 Year ARI Stage (m. AHD)</u>	<u>Velocity (m/s)</u>
X-Section 2	458.25	0.60
X-Section 1	457.40	0.61
X-Section 3	455.35	0.50
X-Section 4	452.90	0.62
X-Section 5	448.50	0.49

5.4 ESTIMATED EXTENT OF FLOW PATHS FROM CATCHMENT C2

The estimated extent of peak flow (78 m³/s) from catchment C2 at cross section 2-2 is 458.25 m AHD. Slightly further downstream at cross section 1-1 the peak level is at 457.40 m AHD. This flow path appears to impinge slightly on the corner of the pit (Figure 2).

5.5 ESTIMATED EXTENT OF FLOW PATHS FROM CATCHMENT C1

The estimated flow from catchment C1 (also 78 m³/s) does not impact the proposed mine pit and ore pad shown (Figure 2).

5.6 ESTIMATED EXTENT OF FLOW PATHS FROM CATCHMENTS C1 AND C2

The combined flows of catchments C1 and C2 (156 m³/s) extends to 455.35 m AHD. This flow path appears to impinge on the original proposed ore pad location as shown at cross-

section 3 (Figure 2). Further downstream, at cross section 4-4, the extent of the combined C1 and C2 1 in 100 year ARI peak flows is at 452.90 m AHD.

5.7 ESTIMATED EXTENT OF FLOW PATHS FROM CATCHMENT CM

The approximate extent of the flow path from the main catchment (Cm) is shown in Figure 2. The extent of the 1 in 100 year AR peak flows as shown at cross section 5-5 is 448.5 m AHD. It does not adversely impact the proposed waste dump site.

6 COMMENTS, RECOMMENDATIONS AND CONCLUSIONS

Based on the above analysis the following the comments and conclusions are made:

- The approximate extent of the 1 in 100 year ARI peak flows is shown in Figure 2.
- The estimated 1 in 100 year peak flow from sub-catchment C2 could impact the ground below 458.25 m AHD. It is therefore recommended that a perimeter levee of at least 458.35 m AHD, with added free board, be constructed to protect the southern margin of the mine pit.
- The combined 1 in 100 flows from sub-catchments C1 and C2 extends to ground level 455.35 mAHD at cross-section 3 and will impact the proposed ore pad. It is recommended that ore pad be relocated to the northern end of the pit. If this is not feasible, the ore pad should be reshaped in order to allow sufficient flow width to allow the 1 in 100 year ARI peak flow to pass.
- The maximum velocity for the 1 in 100 years ARI peak is in the order of 0.5 m/s and 0.60 m/s. Given the fact that the estimated duration of peak flow to be in the order of 2 to 3 hours, scour hazard to protective levees is not considered a serious issues and is not warranted.
- The peak flow from the main catchment Cm is estimated to be about 260 m³/s. The extent of the peak water level is 448.50 m AHD, which will not adversely impact the proposed waste dump location.
- If the combined peak flows from sub-catchment C1 and C2 peak coincide with the peak of the main catchment Cm at the mine site, the risk of backwater adversely impacting the ore pad or waste dump is not an issue.
- Local drainage issues have not been examined in this report. The local drainage design will be included in the detail design stage.

- If regulatory compliance required the protection of receiving waters, pollution traps may need to be included during the detail design phase.

Dated: 9 October 2009

Rockwater Pty Ltd

REFERENCES

Australian Rainfall and Runoff 1987 (Institute of Engineers Australia)

AustRoads Waterway Design Manual (1994)

5.0 m Contour Interval Map (Polaris Metals NL)

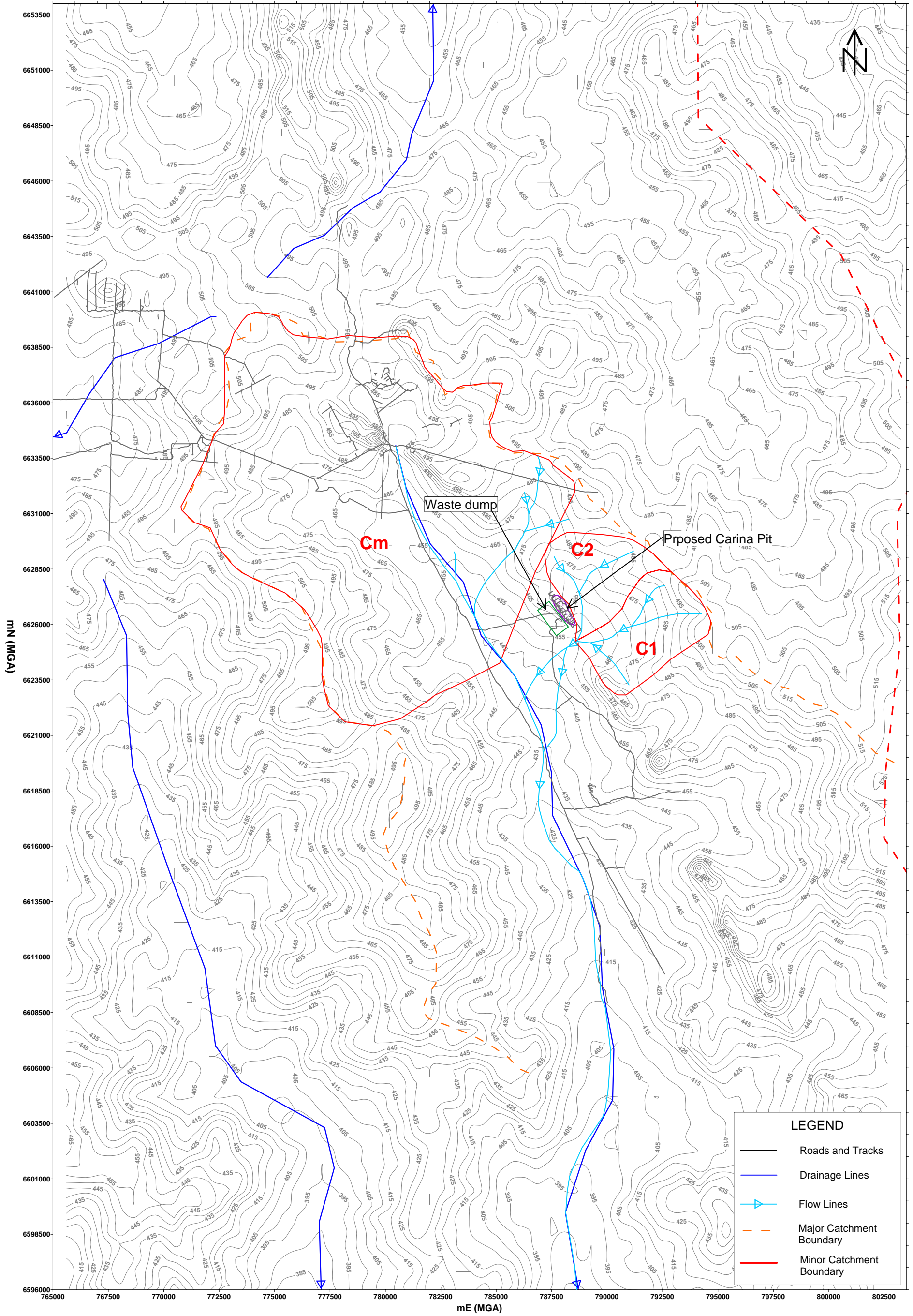
Rainfall Records for Southern Cross (Bureau of Meteorology)



FIGURES



Figure 1

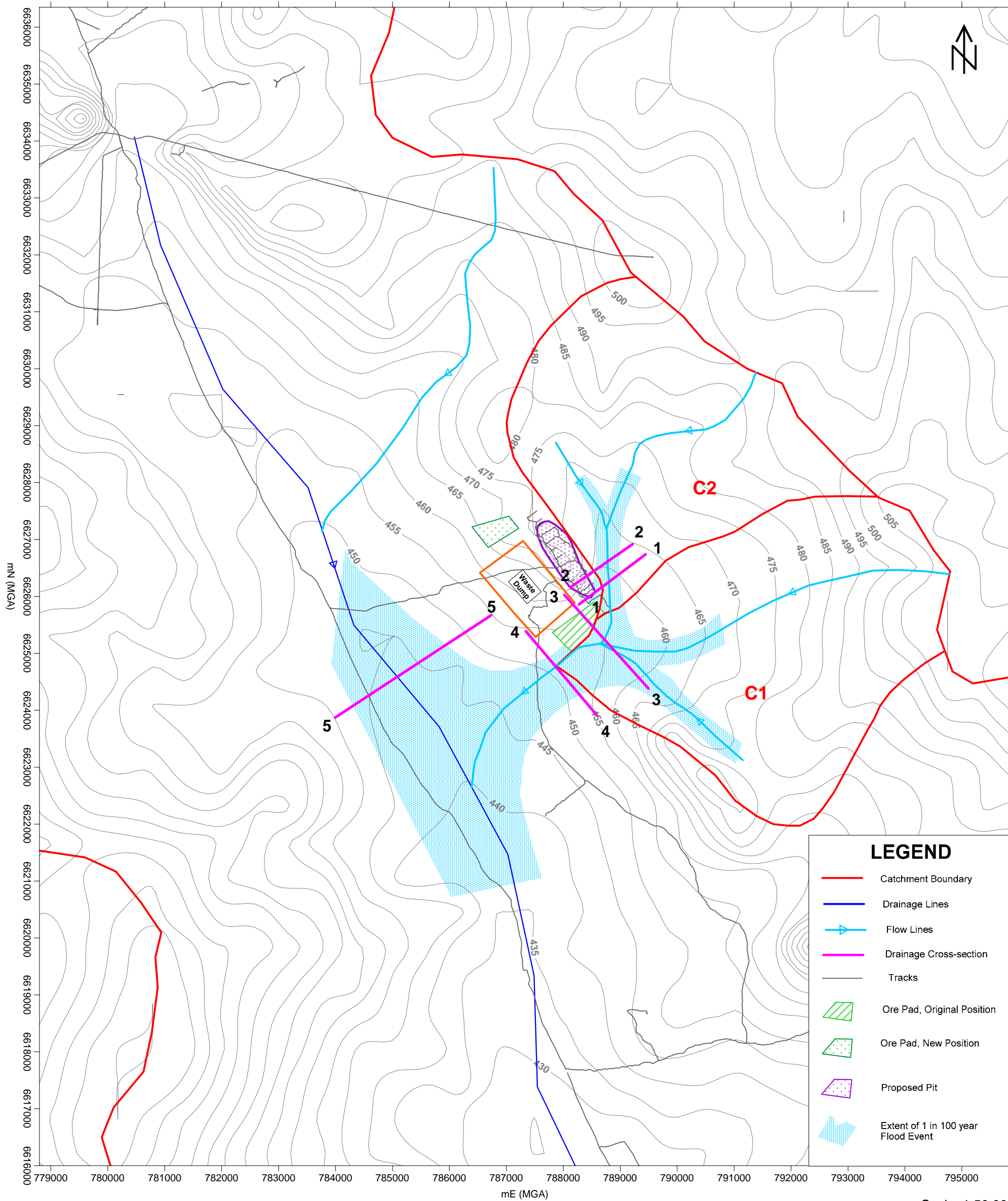


I:/349-0/surfer/Figure 1 - Location Plan + Catchment Areas

CLIENT: Polaris Metals NL
 PROJECT: Carina Hydrological Investigation
 DATE: October 2009
 Dwg. No: 349.0/09/1-1

CARINA, CATCHMENTS AND DRAINAGE LINES

Figure 2



LEGEND	
	Catchment Boundary
	Drainage Lines
	Flow Lines
	Drainage Cross-section
	Tracks
	Ore Pad, Original Position
	Ore Pad, New Position
	Proposed Pit
	Extent of 1 in 100 year Flood Event

I:/349-0/Surfer/Figure 2 - 1 in 100 Yr Flood.srf

Scale: 1:50,000

CLIENT: Polaris Metals NL
 PROJECT: Carina Hydrological Investigation
 DATE: October 2009
 Dwg. No: 349.0/09/1-2

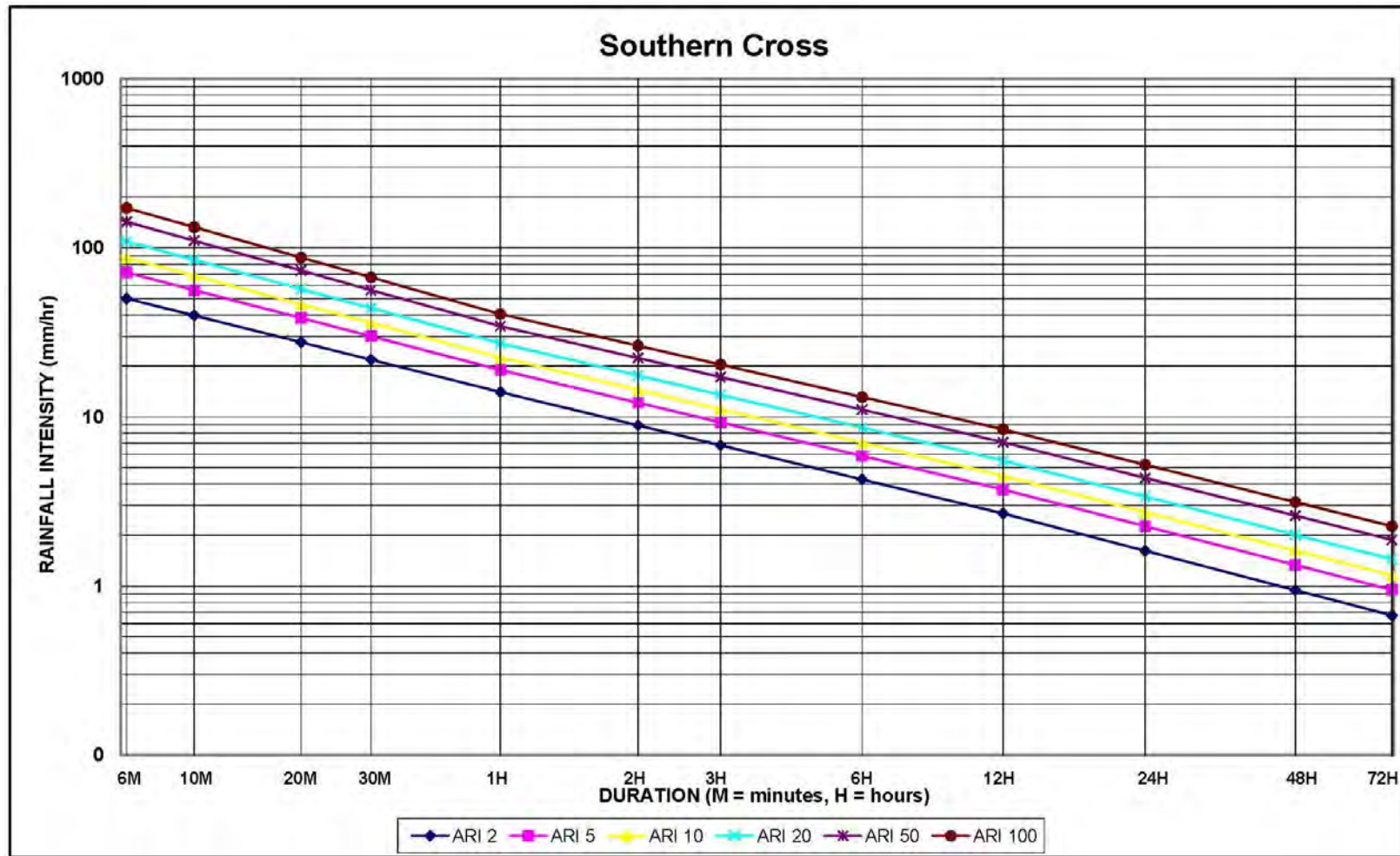
CARINA, EXTENT OF 1 IN 100 YEAR FLOOD EVENT

APPENDIX I

HYDROLOGY

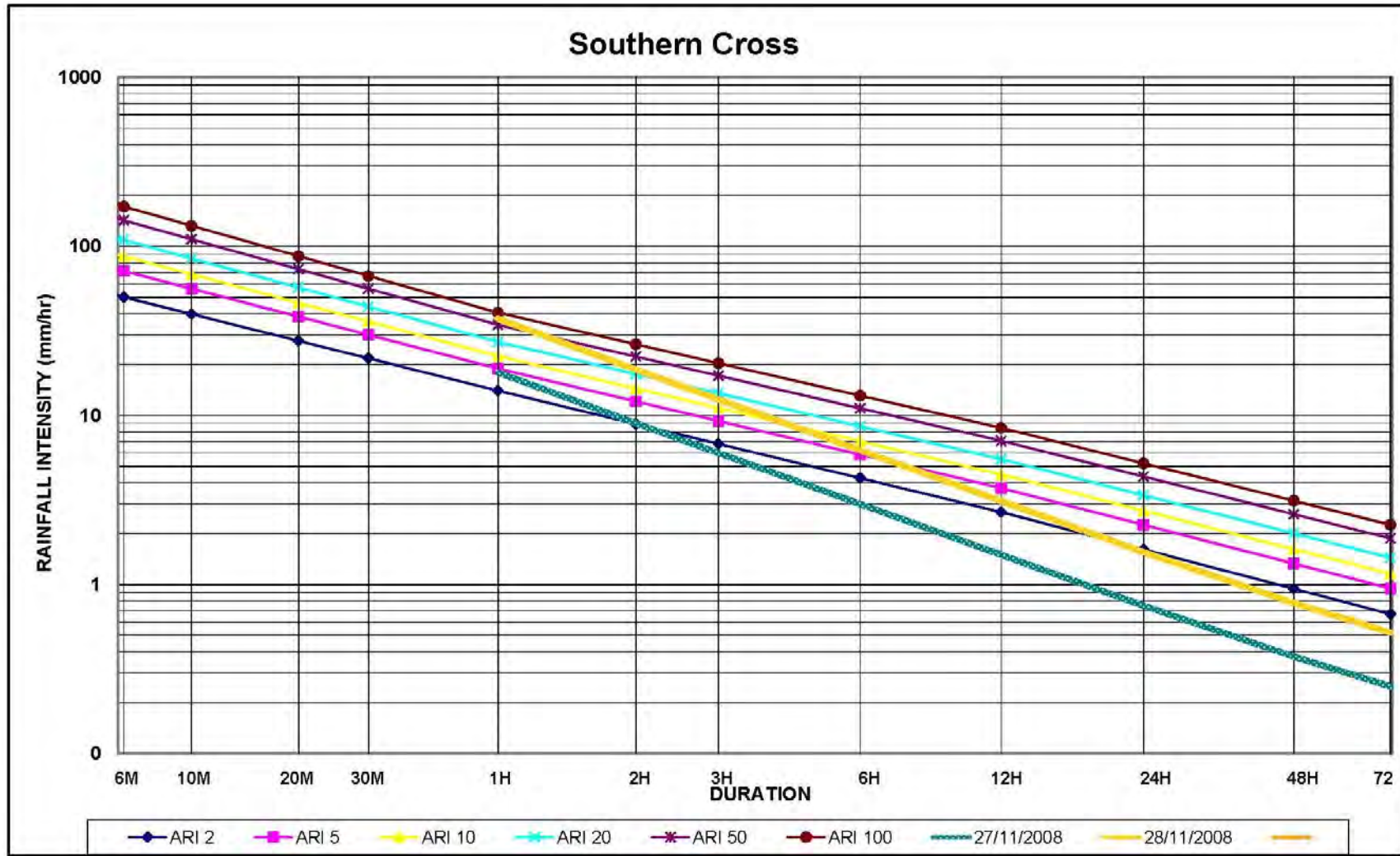
- (A) Intensity Frequency Duration Curve for Southern Cross**
- (B) Rational and Flood Index Method**
- C) Historical Rainfall Records for Southern Cross**





CLIENT: Polaris Metals NL
 PROJECT: Carina Hydrological Investigation
 DATE: October 2009
 Dwg. No: 349.0/09/1-APPI-1

INTENSITY FREQUENCY DURATION CURVE FOR SOUTHERN CROSS



CLIENT: Polaris Metals NL
 PROJECT: Carina Hydrological Investigation
 DATE: October 2009
 Dwg. No: 349.0/09/1-APPI-2

INTENSITY FREQUENCY DURATION CURVE FOR SOUTHERN CROSS WITH RAINFALL

**AUSTRALIAN RAINFALL AND RUNOFF VOLUME 1 & 2 (1987)
RATIONAL AND INDEX METHODS - WESTERN AUSTRALIA**

REGION: WHEATBELT REGION

LOCATION: Southern Cross

CATCHMENT: WHEATBELT RIVER

i. Wandoo Woodland (75-100% cleared) - Loamy Soils

Catchment	A (km ²)	L (km)	S _e (m/km)	P (mm)	C _L %
Characteristics	24	7		300	85

RATIONAL METHOD:

Care needs to be taken when catchment characteristics fall outside the following:

A =	0.034	-	20500	km ²
L =	0.492	-	440	km
S _e =	0.65	-	40.3	m/km
C _L =	75	-	100	%
P =	300	-	600	mm

$$Q_Y = 0.278C_Y \cdot I_{t_c, Y} \cdot A \quad \dots \quad (1.1)$$

$$t_c = 0.76A^{0.38} \quad \dots \quad (1.29)$$

$$t_c = \underline{2.543} \text{ hours}$$

$$C_{10} = 3.46 \times 10^{-1} L^{-0.42} \quad \dots \quad (1.30)$$

$$C_{10} = \underline{0.153}$$

Frequency Factors (C_Y/C₁₀)

	ARI (years)					
	2	5	10	20	50	100
C _Y /C ₁₀	0.41	0.65	1.00	1.54	2.20	3.38

100 year ARI extrapolated using the power trendline

Therefore:

	ARI (years)					
	2	5	10	20	50	100
C _Y	0.063	0.099	0.153	0.235	0.336	0.516

**AUSTRALIAN RAINFALL AND RUNOFF VOLUME 1 & 2 (1987)
RATIONAL AND INDEX METHODS - WESTERN AUSTRALIA**

REGION: WHEATBELT REGION

LOCATION: Southern Cross

CATCHMENT: WHEATBELT RIVER

**RATIONAL METHOD:
CONTINUES**

DETERMINE AVERAGE RAINFALL INTENSITY FOR DESIGN DURATION

$t_c =$ 2.543 hours

$P_D =$ 0.418 **A(3.8)**

$P_L =$ 0.000

$P_U =$ 1.126

$N =$ 0.371

Intensity upper and lower bound parameters

	ARI (Years)					
	2	5	10	20	50	100
I_L	14.029	18.931	22.447	27.253	34.401	40.540
I_U	2.683	3.719	4.479	5.515	7.079	8.441

Use Equation A(3.9)

Duration (hours)	ARI (Years) [mm/hr]					
	2	5	10	20	50	100
2.543	7.595	10.351	12.345	15.066	19.136	22.650

Calculate peak discharge using equation (1.1)

Discharge (m^3/s)	ARI (Years)					
	2	5	10	20	50	100
Q	3	7	13	24	43	78

**AUSTRALIAN RAINFALL AND RUNOFF VOLUME 1 & 2 (1987)
RATIONAL AND INDEX METHODS - WESTERN AUSTRALIA**

REGION: WHEATBELT REGION

LOCATION: Southern Cross

CATCHMENT: WHEATBELT RIVER

INDEX FLOOD METHOD:

Care needs to be taken when catchment characteristics fall outside the following:

A =	0.034	-	20500	km ²
L =	0.492	-	440	km
S _e =	0.65	-	40.3	m/km
C _L =	75	-	100	%
P =	300	-	600	mm

$Q_5 = 2.77 \times 10^{-6} A^{0.52} P^{2.12}$ **(1.31)**

$Q_5 = \underline{3} \text{ m}^3/\text{s}$

Frequency Factors (Q_Y/Q_5)

	ARI (years)					
	2	5	10	20	50	100
Q_Y/Q_5	0.48	1.00	1.84	3.23	6.10	11.13

100 year ARI extrapolated using the power trendline

Therefore the peak discharge

Discharge (m ³ /s)	ARI (Years)					
	2	5	10	20	50	100
Q	1	3	5	8	16	29

**AUSTRALIAN RAINFALL AND RUNOFF VOLUME 1 & 2 (1987)
RATIONAL AND INDEX METHODS - WESTERN AUSTRALIA**

REGION: WHEATBELT REGION

LOCATION: Southern Cross

CATCHMENT: WHEATBELT RIVER

ii. Loamy and lateritic soil catchments

Catchment	A (km ²)	L (km)	S _e (m/km)	P (mm)	C _L %
Characteristics	24	7	0	300	85

RATIONAL METHOD:

Care needs to be taken when catchment characteristics fall outside the following:

A =	0.034	-	20500	km ²
L =	0.492	-	440	km
S _e =	0.65	-	83.4	m/km
C _L =	0	-	100	%
P =	300	-	680	mm

$$Q_Y = 0.278C_Y \cdot I_{t_c, Y} \cdot A \quad \dots \quad (1.1)$$

$$t_c = 0.76A^{0.38} \quad \dots \quad (1.29)$$

$$t_c = \underline{2.543} \text{ hours}$$

$$C_{10} = 1.06 \times 10^{-1} L^{-0.32} 10^{0.0042C_L} \quad \dots \quad (1.30)$$

$$C_{10} = \underline{0.129}$$

Frequency Factors (C_Y/C₁₀)

	ARI (years)					
	2	5	10	20	50	100
C _Y /C ₁₀	0.43	0.67	1.00	1.45	1.98	2.96

100 year ARI extrapolated using the power trendline

Therefore:

	ARI (years)					
	2	5	10	20	50	100
C _Y	0.056	0.087	0.129	0.188	0.256	0.383

**AUSTRALIAN RAINFALL AND RUNOFF VOLUME 1 & 2 (1987)
RATIONAL AND INDEX METHODS - WESTERN AUSTRALIA**

REGION: WHEATBELT REGION

LOCATION: Southern Cross

CATCHMENT: WHEATBELT RIVER

**RATIONAL METHOD:
CONTINUES**

DETERMINE AVERAGE RAINFALL INTENSITY FOR DESIGN DURATION

$t_c =$ 2.543 hours

$P_D =$ 0.418 **A(3.8)**

$P_L =$ 0.000

$P_U =$ 1.126

$N =$ 0.371

Intensity upper and lower bound parameters

	ARI (Years)					
	2	5	10	20	50	100
I_L	14.029	18.931	22.447	27.253	34.401	40.540
I_U	2.683	3.719	4.479	5.515	7.079	8.441

Use Equation A(3.9)

Duration (hours)	ARI (Years) [mm/hr]					
	2	5	10	20	50	100
2.543	7.595	10.351	12.345	15.066	19.136	22.650

Calculate peak discharge using equation (1.1)

Discharge (m^3/s)	ARI (Years)					
	2	5	10	20	50	100
Q	3	6	11	19	33	58

**AUSTRALIAN RAINFALL AND RUNOFF VOLUME 1 & 2 (1987)
RATIONAL AND INDEX METHODS - WESTERN AUSTRALIA**

REGION: WHEATBELT REGION

LOCATION: Southern Cross

CATCHMENT: WHEATBELT RIVER

INDEX FLOOD METHOD:

Care needs to be taken when catchment characteristics fall outside the following:

A =	0.034	-	20500	km ²
L =	0.492	-	440	km
S _e =	0.65	-	83.4	m/km
C _L =	0	-	100	%
P =	300	-	680	mm

$Q_5 = 3.04 \times 10^{-1} A^{0.60} 10^{0.0052CL}$ **(1.31)**

$Q_5 = \underline{6} \text{ m}^3/\text{s}$

Frequency Factors (Q_Y/Q₅)

	ARI (years)					
	2	5	10	20	50	100
Q _Y /Q ₅	0.50	1.00	1.76	3.05	5.65	9.94

100 year ARI extrapolated using the power trendline

Therefore the peak discharge

Discharge (m ³ /s)	ARI (Years)					
	2	5	10	20	50	100
Q	3	6	11	19	35	61

AUSTRALIAN RAINFALL AND RUNOFF VOLUME 1 & 2 (1987) RATIONAL AND INDEX METHODS - WESTERN AUSTRALIA
--

REGION: WHEATBELT REGION

LOCATION: Southern Cross

CATCHMENT: WHEATBELT RIVER

iii. Sandy soil catchments

It is recommended that method (ii) be used for sandy soil catchments. However, it should be noted that generally there will be a tendency to overestimate design flows, especially for higher ARIs.

Discharge (m ³ /s)	ARI (Years)					
	2	5	10	20	50	100
Rat	3	6	11	19	33	58
Index	3	6	11	19	35	61

iv. Albany Region - sandy soils

It is recommended that method (ii) be used in this sub-region.

A =	7.33	-	2860	km ²
L =	3.6	-	109	km
S _e =	1.92	-	28.3	m/km
C _L =	0	-	100	%
P =	620	-	900	mm

Discharge (m ³ /s)	ARI (Years)					
	2	5	10	20	50	100
Rat	3	6	11	19	33	58
Index	3	6	11	19	35	61

AUSTRALIAN RAINFALL AND RUNOFF VOLUME 1 & 2 (1987) RATIONAL AND INDEX METHODS - WESTERN AUSTRALIA
--

REGION: WHEATBELT REGION

LOCATION: Southern Cross

CATCHMENT: WHEATBELT RIVER

SUMMARY OF RATIONAL AND INDEX METHODS:

i. Wandoo Woodland (75-100% cleared) - Loamy Soils

Discharge (m ³ /s)	ARI (Years)					
	2	5	10	20	50	100
Rat	3	7	13	24	43	78
Index	1	3	5	8	16	29

ii. Loamy and lateritic soil catchments

Discharge (m ³ /s)	ARI (Years)					
	2	5	10	20	50	100
Rat	3	6	11	19	33	58
Index	3	6	11	19	35	61

iii. Sandy soil catchments

Discharge (m ³ /s)	ARI (Years)					
	2	5	10	20	50	100
Rat	3	6	11	19	33	58
Index	3	6	11	19	35	61

iv. Albany Region - sandy soils

Discharge (m ³ /s)	ARI (Years)					
	2	5	10	20	50	100
Rat	3	6	11	19	33	58
Index	3	6	11	19	35	61

**AUSTRALIAN RAINFALL AND RUNOFF VOLUME 1 & 2 (1987)
RATIONAL AND INDEX METHODS - WESTERN AUSTRALIA**

REGION: WHEATBELT REGION

LOCATION: Southern Cross

CATCHMENT: WHEATBELT RIVER

i. Wandoo Woodland (75-100% cleared) - Loamy Soils

Catchment	A (km ²)	L (km)	S _e (m/km)	P (mm)	C _L %
Characteristics	20	5		300	85

RATIONAL METHOD:

Care needs to be taken when catchment characteristics fall outside the following:

A =	0.034	-	20500	km ²
L =	0.492	-	440	km
S _e =	0.65	-	40.3	m/km
C _L =	75	-	100	%
P =	300	-	600	mm

$$Q_Y = 0.278C_Y \cdot I_{t_c, Y} \cdot A \quad \dots \quad (1.1)$$

$$t_c = 0.76A^{0.38} \quad \dots \quad (1.29)$$

$$t_c = \underline{2.372} \text{ hours}$$

$$C_{10} = 3.46 \times 10^{-1} L^{-0.42} \quad \dots \quad (1.30)$$

$$C_{10} = \underline{0.176}$$

Frequency Factors (C_Y/C₁₀)

	ARI (years)					
	2	5	10	20	50	100
C _Y /C ₁₀	0.41	0.65	1.00	1.54	2.20	3.38

100 year ARI extrapolated using the power trendline

Therefore:

	ARI (years)					
	2	5	10	20	50	100
C _Y	0.072	0.114	0.176	0.271	0.387	0.595

**AUSTRALIAN RAINFALL AND RUNOFF VOLUME 1 & 2 (1987)
RATIONAL AND INDEX METHODS - WESTERN AUSTRALIA**

REGION: WHEATBELT REGION

LOCATION: Southern Cross

CATCHMENT: WHEATBELT RIVER

**RATIONAL METHOD:
CONTINUES**

DETERMINE AVERAGE RAINFALL INTENSITY FOR DESIGN DURATION

$t_c =$ 2.372 hours

$P_D =$ 0.386 **A(3.8)**

$P_L =$ 0.000

$P_U =$ 1.126

$N =$ 0.343

Intensity upper and lower bound parameters

	ARI (Years)					
	2	5	10	20	50	100
I_L	14.029	18.931	22.447	27.253	34.401	40.540
I_U	2.683	3.719	4.479	5.515	7.079	8.441

Use Equation A(3.9)

Duration (hours)	ARI (Years) [mm/hr]					
	2	5	10	20	50	100
2.372	7.955	10.834	12.916	15.757	20.004	23.669

Calculate peak discharge using equation (1.1)

Discharge (m^3/s)	ARI (Years)					
	2	5	10	20	50	100
Q	3	7	13	24	43	78

AUSTRALIAN RAINFALL AND RUNOFF VOLUME 1 & 2 (1987) RATIONAL AND INDEX METHODS - WESTERN AUSTRALIA
--

REGION: WHEATBELT REGION

LOCATION: Southern Cross

CATCHMENT: WHEATBELT RIVER

INDEX FLOOD METHOD:

Care needs to be taken when catchment characteristics fall outside the following:

A =	0.034	-	20500	km ²
L =	0.492	-	440	km
S _e =	0.65	-	40.3	m/km
C _L =	75	-	100	%
P =	300	-	600	mm

$Q_5 = 2.77 \times 10^{-6} A^{0.52} P^{2.12}$ **(1.31)**

$Q_5 = \underline{2} \text{ m}^3/\text{s}$

Frequency Factors (Q_Y/Q_5)

	ARI (years)					
	2	5	10	20	50	100
Q_Y/Q_5	0.48	1.00	1.84	3.23	6.10	11.13

100 year ARI extrapolated using the power trendline

Therefore the peak discharge

	ARI (Years)					
Discharge (m ³ /s)	2	5	10	20	50	100
Q	1	2	4	8	14	26

**AUSTRALIAN RAINFALL AND RUNOFF VOLUME 1 & 2 (1987)
RATIONAL AND INDEX METHODS - WESTERN AUSTRALIA**

REGION: WHEATBELT REGION

LOCATION: Southern Cross

CATCHMENT: WHEATBELT RIVER

ii. Loamy and lateritic soil catchments

Catchment	A (km ²)	L (km)	S _e (m/km)	P (mm)	C _L %
Characteristics	20	5	0	300	85

RATIONAL METHOD:

Care needs to be taken when catchment characteristics fall outside the following:

A =	0.034	-	20500	km ²
L =	0.492	-	440	km
S _e =	0.65	-	83.4	m/km
C _L =	0	-	100	%
P =	300	-	680	mm

$$Q_Y = 0.278C_Y \cdot I_{t_c, Y} \cdot A \quad \dots \quad (1.1)$$

$$t_c = 0.76A^{0.38} \quad \dots \quad (1.29)$$

$$t_c = \underline{2.372} \text{ hours}$$

$$C_{10} = 1.06 \times 10^{-1} L^{-0.32} 10^{0.0042C_L} \quad \dots \quad (1.30)$$

$$C_{10} = \underline{0.144}$$

Frequency Factors (C_Y/C₁₀)

	ARI (years)					
	2	5	10	20	50	100
C _Y /C ₁₀	0.43	0.67	1.00	1.45	1.98	2.96

100 year ARI extrapolated using the power trendline

Therefore:

	ARI (years)					
	2	5	10	20	50	100
C _Y	0.062	0.097	0.144	0.209	0.285	0.426

**AUSTRALIAN RAINFALL AND RUNOFF VOLUME 1 & 2 (1987)
RATIONAL AND INDEX METHODS - WESTERN AUSTRALIA**

REGION: WHEATBELT REGION

LOCATION: Southern Cross

CATCHMENT: WHEATBELT RIVER

**RATIONAL METHOD:
CONTINUES**

DETERMINE AVERAGE RAINFALL INTENSITY FOR DESIGN DURATION

$t_c =$ 2.372 hours

$P_D =$ 0.386 **A(3.8)**

$P_L =$ 0.000

$P_U =$ 1.126

$N =$ 0.343

Intensity upper and lower bound parameters

	ARI (Years)					
	2	5	10	20	50	100
I_L	14.029	18.931	22.447	27.253	34.401	40.540
I_U	2.683	3.719	4.479	5.515	7.079	8.441

Use Equation A(3.9)

Duration (hours)	ARI (Years) [mm/hr]					
	2	5	10	20	50	100
2.372	7.955	10.834	12.916	15.757	20.004	23.669

Calculate peak discharge using equation (1.1)

Discharge (m^3/s)	ARI (Years)					
	2	5	10	20	50	100
Q	3	6	10	18	32	56

**AUSTRALIAN RAINFALL AND RUNOFF VOLUME 1 & 2 (1987)
RATIONAL AND INDEX METHODS - WESTERN AUSTRALIA**

REGION: WHEATBELT REGION

LOCATION: Southern Cross

CATCHMENT: WHEATBELT RIVER

INDEX FLOOD METHOD:

Care needs to be taken when catchment characteristics fall outside the following:

A =	0.034	-	20500	km ²
L =	0.492	-	440	km
S _e =	0.65	-	83.4	m/km
C _L =	0	-	100	%
P =	300	-	680	mm

$Q_5 = 3.04 \times 10^{-1} A^{0.60} 10^{0.0052CL}$ **(1.31)**

$Q_5 = \underline{5} \text{ m}^3/\text{s}$

Frequency Factors (Q_Y/Q_5)

	ARI (years)					
	2	5	10	20	50	100
Q_Y/Q_5	0.50	1.00	1.76	3.05	5.65	9.94

100 year ARI extrapolated using the power trendline

Therefore the peak discharge

Discharge (m ³ /s)	ARI (Years)					
	2	5	10	20	50	100
Q	3	5	10	17	31	55

AUSTRALIAN RAINFALL AND RUNOFF VOLUME 1 & 2 (1987) RATIONAL AND INDEX METHODS - WESTERN AUSTRALIA
--

REGION: WHEATBELT REGION

LOCATION: Southern Cross

CATCHMENT: WHEATBELT RIVER

iii. Sandy soil catchments

It is recommended that method (ii) be used for sandy soil catchments. However, it should be noted that generally there will be a tendency to overestimate design flows, especially for higher ARIs.

Discharge (m ³ /s)	ARI (Years)					
	2	5	10	20	50	100
Rat	3	6	10	18	32	56
Index	3	5	10	17	31	55

iv. Albany Region - sandy soils

It is recommended that method (ii) be used in this sub-region.

A =	7.33	-	2860	km ²
L =	3.6	-	109	km
S _e =	1.92	-	28.3	m/km
C _L =	0	-	100	%
P =	620	-	900	mm

Discharge (m ³ /s)	ARI (Years)					
	2	5	10	20	50	100
Rat	3	6	10	18	32	56
Index	3	5	10	17	31	55

AUSTRALIAN RAINFALL AND RUNOFF VOLUME 1 & 2 (1987) RATIONAL AND INDEX METHODS - WESTERN AUSTRALIA
--

REGION: WHEATBELT REGION

LOCATION: Southern Cross

CATCHMENT: WHEATBELT RIVER

SUMMARY OF RATIONAL AND INDEX METHODS:

i. Wandoo Woodland (75-100% cleared) - Loamy Soils

Discharge (m ³ /s)	ARI (Years)					
	2	5	10	20	50	100
Rat	3	7	13	24	43	78
Index	1	2	4	8	14	26

ii. Loamy and lateritic soil catchments

Discharge (m ³ /s)	ARI (Years)					
	2	5	10	20	50	100
Rat	3	6	10	18	32	56
Index	3	5	10	17	31	55

iii. Sandy soil catchments

Discharge (m ³ /s)	ARI (Years)					
	2	5	10	20	50	100
Rat	3	6	10	18	32	56
Index	3	5	10	17	31	55

iv. Albany Region - sandy soils

Discharge (m ³ /s)	ARI (Years)					
	2	5	10	20	50	100
Rat	3	6	10	18	32	56
Index	3	5	10	17	31	55

**AUSTRALIAN RAINFALL AND RUNOFF VOLUME 1 & 2 (1987)
RATIONAL AND INDEX METHODS - WESTERN AUSTRALIA**

REGION: WHEATBELT REGION

LOCATION: Southern Cross

CATCHMENT: WHEATBELT RIVER

i. Wandoo Woodland (75-100% cleared) - Loamy Soils

Catchment	A (km ²)	L (km)	S _e (m/km)	P (mm)	C _L %
Characteristics	180	15		300	85

RATIONAL METHOD:

Care needs to be taken when catchment characteristics fall outside the following:

A =	0.034	-	20500	km ²
L =	0.492	-	440	km
S _e =	0.65	-	40.3	m/km
C _L =	75	-	100	%
P =	300	-	600	mm

$$Q_Y = 0.278C_Y \cdot I_{t_c, Y} \cdot A \quad \dots \quad (1.1)$$

$$t_c = 0.76A^{0.38} \quad \dots \quad (1.29)$$

$$t_c = \underline{5.468} \text{ hours}$$

$$C_{10} = 3.46 \times 10^{-1} L^{-0.42} \quad \dots \quad (1.30)$$

$$C_{10} = \underline{0.111}$$

Frequency Factors (C_Y/C₁₀)

	ARI (years)					
	2	5	10	20	50	100
C _Y /C ₁₀	0.41	0.65	1.00	1.54	2.20	3.38

100 year ARI extrapolated using the power trendline

Therefore:

	ARI (years)					
	2	5	10	20	50	100
C _Y	0.045	0.072	0.111	0.171	0.244	0.375

**AUSTRALIAN RAINFALL AND RUNOFF VOLUME 1 & 2 (1987)
RATIONAL AND INDEX METHODS - WESTERN AUSTRALIA**

REGION: WHEATBELT REGION

LOCATION: Southern Cross

CATCHMENT: WHEATBELT RIVER

**RATIONAL METHOD:
CONTINUES**

DETERMINE AVERAGE RAINFALL INTENSITY FOR DESIGN DURATION

$t_c =$ 5.468 hours

$P_D =$ 0.768 **A(3.8)**

$P_L =$ 0.000

$P_U =$ 1.126

$N =$ 0.682

Intensity upper and lower bound parameters

	ARI (Years)					
	2	5	10	20	50	100
I_L	14.029	18.931	22.447	27.253	34.401	40.540
I_U	2.683	3.719	4.479	5.515	7.079	8.441

Use Equation A(3.9)

Duration (hours)	ARI (Years) [mm/hr]					
	2	5	10	20	50	100
5.468	4.540	6.240	7.478	9.166	11.703	13.903

Calculate peak discharge using equation (1.1)

Discharge (m^3/s)	ARI (Years)					
	2	5	10	20	50	100
Q	10	23	42	78	143	261

**AUSTRALIAN RAINFALL AND RUNOFF VOLUME 1 & 2 (1987)
RATIONAL AND INDEX METHODS - WESTERN AUSTRALIA**

REGION: WHEATBELT REGION

LOCATION: Southern Cross

CATCHMENT: WHEATBELT RIVER

INDEX FLOOD METHOD:

Care needs to be taken when catchment characteristics fall outside the following:

A =	0.034	-	20500	km ²
L =	0.492	-	440	km
S _e =	0.65	-	40.3	m/km
C _L =	75	-	100	%
P =	300	-	600	mm

$Q_5 = 2.77 \times 10^{-6} A^{0.52} P^{2.12}$ **(1.31)**

$Q_5 = \underline{7} \text{ m}^3/\text{s}$

Frequency Factors (Q_Y/Q_5)

	ARI (years)					
	2	5	10	20	50	100
Q_Y/Q_5	0.48	1.00	1.84	3.23	6.10	11.13

100 year ARI extrapolated using the power trendline

Therefore the peak discharge

Discharge (m ³ /s)	ARI (Years)					
	2	5	10	20	50	100
Q	4	7	14	24	45	82

**AUSTRALIAN RAINFALL AND RUNOFF VOLUME 1 & 2 (1987)
RATIONAL AND INDEX METHODS - WESTERN AUSTRALIA**

REGION: WHEATBELT REGION

LOCATION: Southern Cross

CATCHMENT: WHEATBELT RIVER

ii. Loamy and lateritic soil catchments

Catchment	A (km ²)	L (km)	S _e (m/km)	P (mm)	C _L %
Characteristics	180	15	0	300	85

RATIONAL METHOD:

Care needs to be taken when catchment characteristics fall outside the following:

A =	0.034	-	20500	km ²
L =	0.492	-	440	km
S _e =	0.65	-	83.4	m/km
C _L =	0	-	100	%
P =	300	-	680	mm

$$Q_Y = 0.278C_Y \cdot I_{t_c, Y} \cdot A \quad \dots \quad (1.1)$$

$$t_c = 0.76A^{0.38} \quad \dots \quad (1.29)$$

$$t_c = \underline{5.468} \text{ hours}$$

$$C_{10} = 1.06 \times 10^{-1} L^{-0.32} 10^{0.0042C_L} \quad \dots \quad (1.30)$$

$$C_{10} = \underline{0.101}$$

Frequency Factors (C_Y/C₁₀)

	ARI (years)					
	2	5	10	20	50	100
C _Y /C ₁₀	0.43	0.67	1.00	1.45	1.98	2.96

100 year ARI extrapolated using the power trendline

Therefore:

	ARI (years)					
	2	5	10	20	50	100
C _Y	0.044	0.068	0.101	0.147	0.201	0.300

**AUSTRALIAN RAINFALL AND RUNOFF VOLUME 1 & 2 (1987)
RATIONAL AND INDEX METHODS - WESTERN AUSTRALIA**

REGION: WHEATBELT REGION

LOCATION: Southern Cross

CATCHMENT: WHEATBELT RIVER

**RATIONAL METHOD:
CONTINUES**

DETERMINE AVERAGE RAINFALL INTENSITY FOR DESIGN DURATION

$t_c =$ 5.468 hours

$P_D =$ 0.768 **A(3.8)**

$P_L =$ 0.000

$P_U =$ 1.126

$N =$ 0.682

Intensity upper and lower bound parameters

	ARI (Years)					
	2	5	10	20	50	100
I_L	14.029	18.931	22.447	27.253	34.401	40.540
I_U	2.683	3.719	4.479	5.515	7.079	8.441

Use Equation A(3.9)

Duration (hours)	ARI (Years) [mm/hr]					
	2	5	10	20	50	100
5.468	4.540	6.240	7.478	9.166	11.703	13.903

Calculate peak discharge using equation (1.1)

Discharge (m^3/s)	ARI (Years)					
	2	5	10	20	50	100
Q	10	21	38	67	118	209

**AUSTRALIAN RAINFALL AND RUNOFF VOLUME 1 & 2 (1987)
RATIONAL AND INDEX METHODS - WESTERN AUSTRALIA**

REGION: WHEATBELT REGION

LOCATION: Southern Cross

CATCHMENT: WHEATBELT RIVER

INDEX FLOOD METHOD:

Care needs to be taken when catchment characteristics fall outside the following:

A =	0.034	-	20500	km ²
L =	0.492	-	440	km
S _e =	0.65	-	83.4	m/km
C _L =	0	-	100	%
P =	300	-	680	mm

$Q_5 = 3.04 \times 10^{-1} A^{0.60} L^{0.0052 C_L}$ **(1.31)**

$Q_5 = \underline{21} \text{ m}^3/\text{s}$

Frequency Factors (Q_Y/Q_5)

	ARI (years)					
	2	5	10	20	50	100
Q_Y/Q_5	0.50	1.00	1.76	3.05	5.65	9.94

100 year ARI extrapolated using the power trendline

Therefore the peak discharge

Discharge (m ³ /s)	ARI (Years)					
	2	5	10	20	50	100
Q	10	21	36	63	116	204

AUSTRALIAN RAINFALL AND RUNOFF VOLUME 1 & 2 (1987) RATIONAL AND INDEX METHODS - WESTERN AUSTRALIA
--

REGION: WHEATBELT REGION

LOCATION: Southern Cross

CATCHMENT: WHEATBELT RIVER

iii. Sandy soil catchments

It is recommended that method (ii) be used for sandy soil catchments. However, it should be noted that generally there will be a tendency to overestimate design flows, especially for higher ARIs.

Discharge (m ³ /s)	ARI (Years)					
	2	5	10	20	50	100
Rat	10	21	38	67	118	209
Index	10	21	36	63	116	204

iv. Albany Region - sandy soils

It is recommended that method (ii) be used in this sub-region.

A =	7.33	-	2860	km ²
L =	3.6	-	109	km
S _e =	1.92	-	28.3	m/km
C _L =	0	-	100	%
P =	620	-	900	mm

Discharge (m ³ /s)	ARI (Years)					
	2	5	10	20	50	100
Rat	10	21	38	67	118	209
Index	10	21	36	63	116	204

AUSTRALIAN RAINFALL AND RUNOFF VOLUME 1 & 2 (1987) RATIONAL AND INDEX METHODS - WESTERN AUSTRALIA
--

REGION: WHEATBELT REGION

LOCATION: Southern Cross

CATCHMENT: WHEATBELT RIVER

SUMMARY OF RATIONAL AND INDEX METHODS:

i. Wandoo Woodland (75-100% cleared) - Loamy Soils

Discharge (m ³ /s)	ARI (Years)					
	2	5	10	20	50	100
Rat	10	23	42	78	143	261
Index	4	7	14	24	45	82

ii. Loamy and lateritic soil catchments

Discharge (m ³ /s)	ARI (Years)					
	2	5	10	20	50	100
Rat	10	21	38	67	118	209
Index	10	21	36	63	116	204

iii. Sandy soil catchments

Discharge (m ³ /s)	ARI (Years)					
	2	5	10	20	50	100
Rat	10	21	38	67	118	209
Index	10	21	36	63	116	204

iv. Albany Region - sandy soils

Discharge (m ³ /s)	ARI (Years)					
	2	5	10	20	50	100
Rat	10	21	38	67	118	209
Index	10	21	36	63	116	204

Bureau of Meteorology Rainfall Data - Data Extraction Spreadsheet Current to 2002 Data CD

district ID number : 12 eg. 1, 2, 3, 4, 5, 6, 7, 7a, 8, 9, 9a, 10, 10a, 11, 12, 13 Southern Cross
 gauging station number : 12074 eg. 8139, 1000, 5603, 10568, 13045
 letter of cd-rom drive : d eg. d, e, f, ...

note: cd must be in cdrom drive before pressing "get data" button
 only enter values into cells shaded yellow

gauging station	year	month	total monthly rainfall	no. rain days for month	highest daily rainfall	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	
12320	2009	1	29.6		15.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.2	0	0	0	0	0	0	0.8	15.4	11.2	0	0	
12320	2008	7	76.8		21	0.2	0.2	1.6	0.4	0.2	0.8	0	0	0	0	0.6	0.4	0	0	0.2	12.2	2.8	4	8.4	0	0.2	0	0	2.8	0.4	3.4	1.6	21	11.6	0.6	3.2	
12074	2007	1	42.2	4	27	0	0	0.4	27	13.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.4	0	0	0	0	0	0		
12074	2006	3	73.6	2	53	53	20.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
12074	2005	5	89.5	12	35	5.2	10	9	14	0	0.4	3.5	1.2	0	0	0	3	0	0	0	0	3.4	0	0.8	0	35	4	0	0	0	0	0	0	0	0		
12074	2004	2	84.6	7	41	0	0	0	0	0	0.2	0	0	0	0	0	0	41	4	0	0	0	0	0	31	0	0	0	0	0	0.2	0.2	0	0	0		
12074	2003	2	56.5	5	38.3	0	0.4	0	0	0	0	0	0	0	0	0	0	0	0	10.8	38.3	6.5	0	0	0	0.5	0	0	0	0	0	0	0	0	0		
12074	2002	1	27.4	6	18.2	0	0	0	0	0	0	0	0	0	0	0	0	0.2	18.2	0	3	1	0	0	0	0	0	0	0	0	0	0	0.4	4.6	0		
12074	2001	1	123.8	9	35.6	0	0	0	0	0	0	20.4	0	0	0.4	12	0	0	0	0	8.6	0	17.8	6.8	35.6	5	0	0	0	0	0	0	0	0	17.2	0	
12074	2000	3	107.3	8	72.1	11.4	0	0	0	0	0	0	0	0	6.2	72.1	0.6	0.8	0	0	0	0	0	0	0	2	0	0	0	0	10	4.2	0	0	0		
12074	1999	4	82.6	4	81.6	0	0	0	0	0	0	0	0	0	0.4	81.6	0.4	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
12074	1998	6	71.6	11	25.8	0.4	0	0	0	5.2	0	0	25.8	4.8	4.8	7.4	0.2	0	0	0	0	13	3.8	0	0	0	0	0	0	0	1	5.2	0	0	0		
12074	1997	3	69.4	5	53.8	0	0	0	0	0	0	0	0	0	9	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	2.6	0	53.8	1		
12074	1996	4	107.2	4	54.4	0	0	0	0	0	0	0	0	0	0	42	54.4	0	0	0	0	0	1.8	9	0	0	0	0	0	0	0	0	0	0	0	0	
12074	1995	2	81.4	8	33.4	15	0	0	0	0	0	0	0	0	0	0	0	7.8	1	0	0	0	0	0	0	0	15.8	3.4	0.8	33.4	4.2	0	0	0	0		
12074	1994	8	43.8	6	20.2	0	0	0	0.4	20.2	0	0	0	0	9	11.8	2.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2	0	0	0		
12074	1993	6	58.6	11	34.4	0	0	0	0	0	0	0	34.4	0	0.8	0.6	0	0	0	0	2	0.4	0	0	0	0	0.2	0	4.6	8.8	1.2	5.2	0.4	0	0		
12074	1992	8	136.8	18	33.8	2.6	13.2	12	0.8	4	0	0.6	0	7.2	7.6	0	3.8	0	0	0	11.4	0.2	0	0	0	0	0	33.8	4.4	22.6	0.8	3.4	7	0	1.4		
12074	1991	7	58	13	33	0	12.8	0.6	1.8	0	0.4	0	0	0	0.4	0	0	0	0	0	0.2	0.8	2.6	33	1	0.8	0	0.8	0	0	0	0	0	2.8	0		
12074	1990	3	58.2	8	41.4	0	0	0	0	0.6	0	0	0	4	0.6	0	9.4	41.4	0	0	0	0.8	0	1	0.4	0	0	0	0	0	0	0	0	0	0	0	
12074	1989	6	52.7	10	36.4	0.2	0	0	0	0	0.4	3.8	0.6	0	0	1.3	0	0	36.4	5.2	0.4	0	0	0	0	0	0	0	0	0	0	0	4	0.4	0		
12074	1988	5	97.1	13	26.7	11.5	7.2	3	3.6	1.9	0	0	0	0	0	0	18	4	1.7	1.4	0	2.3	0	1.6	26.7	14.2	0	0	0	0	0	0	0	0	0	0	
12074	1987	6	52.5	13	23.6	0	0	0	2	0.4	0	23.6	7.3	0	2.8	0	0	0	0	0	0	6.4	0.6	3.7	1	0	2.2	0	0	0	1.6	0	0.3	0.6	0		
12074	1986	5	53.4	10	24.6	0	0	0	0	0	0	0	0	5.6	0	0	0.4	24.6	2.2	4.9	0	0	0.4	1	0	11.2	0	0	0	2.6	0.5	0	0	0	0		
12074	1985	2	60.7	6	37.7	37.7	0	0	0	5	1.4	0	0	3.8	12.2	0	0	0	0	0.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
12074	1984	5	99.8	14	43.2	1.4	0	0	0	0	2.8	43.2	15.2	1.4	1	0	0	1.6	0	0	0	0	0	0	0	0	0	0	1.4	11.2	6.2	0	0	0	0.6	0	
12074	1983	11	58.2	6	38	0	0	0	0	0	0.6	0	0	0	0	0	7.6	6.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
12074	1982	5	56	7	42.6	0	8.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6	1.4	42.6	0	0.4	2.6	0	0.2	0	0	0	
12074	1981	1	46.4	4	27	15	0	0	0	0	0	0	0	0	0	0	2	27	0	0	0	0	0	0	2.4	0	0	0	0	0	0	0	0	0	0	0	
12074	1980	6	82.5	11	35.5	0	8	0	0	1.4	0	0	0.2	0	0	0	0	14.4	0	1.6	0	0	0	7.8	35.5	0.4	2.6	0	3.2	0	0	0	0	7.4	0	0	
12074	1979	6	46.6	8	19.6	0	11.6	0.4	3.2	0	0	0	0	0	0	5.2	0	0	0	0	5	0	0	0	0	0	0	19.6	1.2	0	0.4	0	0	0	0	0	
12074	1978	2	135	9	36.2	0	0	0.6	0	0	0	0	0	0	0	0	1.4	3.6	36.2	2.2	0	0	0	21	0	0	0	32.4	35.8	1.8	0	0	0	0	0	0	
12074	1977	10	59.4	7	36	6.4	0	0	0	0	0	0	0	0	0	0.4	0.8	0	0	0	0	0	0	0	0	0	0	0.2	0	0	0	0.2	15.4	36	0	0	
12074	1976	4	44.8	8	22	0	0	0	0	0	1.6	0	0	0	0.6	2.2	4.4	0	7	6	0	0	1	0	22	0	0	0	0	0	0	0	0	0	0	0	0
12074	1975	10	55.7	10	23.2	0	0	0	5.9	2.6	3	1.2	0	0	0	0	0	0	0	23.2	0.6	0.4	9.2	8	1.6	0	0	0	0	0	0	0	0	0	0	0	0
12074	1974	4	59.6	9	28.4	0.2	0	12.4	28.4	4.6	0	0	0	0	0	0	0	10.2	0.4	0.4	0	0	0	0	0	2	1	0	0	0	0	0	0	0	0	0	
12074	1973	4	82.8	8	28.4	0	0	0	0	0	0	5.8	19.8	28.4	16.3	0.8	0	0	0	0	4.8	0	0	0	0	0	0	2.8	4.1	0	0	0	0	0	0	0	
12074	1972	6	96.8	9	32.3	19.8	0	0	0	0	0	0	0	0	0	0	0	3.3	6.1	19.6	3	0	0.3	0	8.1	32.3	0	0	3.8	0	0.5	0	0	0	0	0	
12074	1971	2	39.5	7	32.8	0	1	0.8	0	3.3	32.8	0	0	0	0	0	0	0	0	0	0.5	0.8	0	0	0	0	0	0	0	0	0.3	0	0	0	0	0	
12074	1970	2	96.5	3	77.2	0	0	0	6.9	0	0	0	0	0	0	0	0	0	0	12.4	77.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12074	1969	6	44.2	7	26.7	0	0	0	0	0	0	0	0	0	0	0.5	0	12.4	0	26.7	0	0	0	0	2	0.3	0	0	0	0	0	1.3	1	0	0	0	
12074	1968	6	182.7	18	42.7	3.3	0	0	3.8	0	0	6.6	3	42.7	19.8	4.1	0	10.7	4.3	0	0	18.8	22.1	0	0	0	0	0.3	17.3	3.3	9.9	5.3	2.8	4.6	0	0	
12074	1967	1	65.3	3	61.7	0	0	0	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.3	61.7	0	0	0	0	0	0	0	0	0	0
12074	1966	1	112.8	2	63	0	63	49.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12074	1965	6	81	12	21.6	0	4.1	0	0	0	17	2.8	0	0	0	0	0	1.8	0	0	0	0	0	5.3	21.6	0	0	0.5	15	0	2.5	1	8.4	1	0	0	
12074	1964	1	24.2	3	18.8	0	18.8	0	0	0	0	0	0	0	0	1.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4.1	0	
12074	1963	7	97.6	19	28.7	3	5.3	1.5	1.5																												

gauging station	year	month	total monthly rainfall	no. rain days for month	highest daily rainfall	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31					
12074	1956	11	47.7	5	22.9	0	0	0	0	0	0	0	3.8	0	0	0	0	0	12.4	0	0	0	0	0	0	0	0	0	0	0	0.5	22.9	8.1	0							
12074	1955	2	58.9	8	16	0	0	0	0	5.6	2.3	0	0	0	0	1.8	3	0	0	11.9	16	4.3	14	0	0	0	0	0	0	0	0	0	0	0	0						
12074	1954	5	49.2	7	18.5	0	0	0	0	0	0	0	0	0	0	0	1.8	0	0	0	0	0	0	0	0.5	0	0	18.5	0	17.5	1.5	0	1	0	8.4						
12074	1953	3	87.5	5	61	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	14	61	0.8	0	11.4	0	0	0						
12074	1952	2	29.5	4	21.1	0	0	0	0	0	0	0	0	0	0	1.3	0	0	0	5.3	21.1	1.8	0	0	0	0	0	0	0	0	0	0	0	0							
12074	1951	6	81.8	15	30.7	5.8	8.6	0.5	0	0	6.6	8.1	30.7	1	5.8	2.8	0	0	2	0	0	0	0	0	0.5	0.5	8.1	0.3	0.5	0	0	0	0	0	0						
12074	1950	8	30.3	8	15.2	0	0	0.3	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	3.6	0	0	2	15.2	8.1	0.3						
12074	1949	2	66.8	4	59.7	0	0	0.5	59.7	0	0	0	0	0	0	0	2.5	0	0	0	0	4.1	0	0	0	0	0	0	0	0	0	0	0	0	0						
12074	1948	2	74.9	3	35.1	0	0	0	0	0	0	0	35.1	0	0	0	0	0	0	0	0	0	0	0	0	0	15.7	24.1	0	0	0	0	0	0	0						
12074	1947	11	36.1	2	35.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	35.1						
12074	1946	5	51.1	6	27.9	0	0	0	0	0	0	6.4	0	0	0	0	0	0	0	0	0	0	0	0	0	2.5	0	9.4	0.8	0	0	0	4.1	0	0	0					
12074	1945	5	34.7	6	26.7	0	0	0	1.5	0.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.3	4.1	0	0	0	0	0	0	0	0	0	0					
12074	1944	5	49.4	7	31.8	0	0	0	1.3	0	0	0	0	0	0	0	0	0	0	2.5	1.3	0	31.8	1	0	0	0	7.4	4.1	0	0	0	0	0	0	0	0				
12074	1943	2	136.7	5	63.5	0	0	0	0	0	0	0	7.9	0	0	0	18.8	63.5	38.9	0	0	0	0	0	0	0	0	0	0	0	0	0	7.6								
12074	1942	2	34.1	4	26.7	0	0.5	6.4	0.5	0	26.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
12074	1941	8	37.4	7	15.2	0	1.8	0	0	0	0	0	0	0	0	0	0	0	0	0	1.8	0	0	3.8	6.9	0	0	0	0	0	6.9	15.2	1	0	0	0					
12074	1940	7	36.9	9	20.6	0	0	0	0	0	0	0	0	2.3	0	0	0	0	0	0.8	0	0	1	0	0	1.3	5.6	2	0	0	1.3	20.6	2	0	0	0					
12074	1939	5	68.4	10	52.1	1.3	0	1.5	0	5.6	4.8	0	0.5	52.1	0.8	0	0	0	0	0.5	0	0.5	0	0	0	0	0	0	0	0	0.8	0	0	0	0	0	0				
12074	1938	11	25.7	4	15	0	5.3	4.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.8	15	0	0	0	0	0	0	0	0	0				
12074	1937	3	63.1	6	33.3	0	0	33.3	6.4	0	1.8	5.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5.1	0	0	0	0	0	0	0	0	0			
12074	1936	6	38.1	7	28.7	0	0	28.7	0	0	0	3.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1.8	1.5	0	0.5	1							
12074	1935	10	79.2	6	54.9	0	0	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0	0	0			
12074	1934	4	128	8	28.7	5.1	20.1	0	0	28.7	20.8	0	0	22.6	4.3	10.4	0	0	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
12074	1933	5	49.8	10	20.1	0	0	0	0	0	0	0	0	0	0	2.5	1.5	0	0	0	0	0	0	0	0	6.1	12.2	0.3	20.1	2.5	0.3	1.8	2.5	0	0	0	0				
12074	1932	5	44	6	32	0	0	1.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	32	1.5	6.4					
12074	1931	5	63.3	9	27.7	0	0	0	19.1	27.7	0.3	0	0	2.8	2.5	3.8	4.3	2.3	0	0	0	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0		
12074	1930	2	50.8	2	47	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
12074	1929	11	74.5	6	44.5	0	0	0	1.3	44.5	13.5	0	0	0	0	1.3	0	0	2.5	11.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
12074	1928	1	24.1	2	22.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	22.1	0	0	0	2	0	0	0	0			
12074	1927	3	169	10	55.1	3.6	0	0	0	0	0	4.3	0	0	0	0	11.7	8.9	55.1	0	0	0	0	0	24.4	47.8	4.6	2.5	6.1	0	0	0	0	0	0	0	0	0			
12074	1926	3	88.4	6	43.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
12074	1925	2	50.6	4	27.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
12074	1924	5	52.2	7	18.5	0	0	0	0	0	0	0	0	10.2	0	0	9.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3			
12074	1923	6	72	17	17	2.3	0	0	0	3.3	3.6	3.8	5.3	0.5	0	0	0	0	6.9	3.8	0.8	0	0	0	7.4	3.6	3.3	5.1	0	0	0	0	0	0	0	0	0	0	0	0	
12074	1922	3	62.5	3	30.5	0	30.5	29.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
12074	1921	5	119.3	14	55.1	0.8	0	0	0	0	2.3	5.8	55.1	4.1	0	0	0	4.1	24.1	0	0	0	0	0	0.8	0	0	3.6	0	5.6	1	10.7	0.8	0	0.5	0	0	0			
12074	1920	3	59	4	35.8	0	0	0	0	0	0	0	0	0	0	0	3.6	35.8	6.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12.7			
12074	1919	4	78.8	7	43.7	1.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	43.7	17.5	13.5	0	0	1.3	0	0	0	0	0	0	0	0.5	0	0	0	0		
12074	1918	2	122.9	9	84.1	0	0	0	84.1	9.1	0	0	0	0	0	10.7	0	0	2	1.3	2	0	0	0	1.3	0	0	0	0	3.3	0	9.1	0								
12074	1917	3	117.1	10	58.4	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
12074	1916	11	62.8	7	50.8	0	0	0	0	0	0	3.6	50.8	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	2.3	1.5	0.8	0	0	0	0	0	0	0	0	0	
12074	1915	1	98.8	10	51.8	0	0	0	7.6	51.8	0	1.8	0	0	0	0	0	0	0	2.8	10.9	1	0	4.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
12074	1914	10	57.3	7	20.3	0	0.5	0	0	0	0	0	0	0.8	0	3	15.2	0	0	0	0	0	0	0	0	0	6.6	10.9	20.3	0	0	0	0	0	0	0	0	0	0	0	
12074	1913	8	55.8	9	30.5	1	1.8	0	0	0	30.5	0	0	0	0	7.6	0	3	2.5	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
12074	1912	5	67.6	9	27.9	0	0	0	0	14	1.5	0.3	10.4	0	0	0	0	0	0	0.5	27.9	8.9	0	0	0	0	0	0.3	3.8	0	0	0	0	0	0	0	0	0	0	0	0
12074	1911	5	37.3	8	21.8	0	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0.5	3.8	21.8	6.4	1.8	0.5	0	0	0	0	0	0	0	0	0	
12074	1910	2	30.3																																						

APPENDIX II

HYDRAULICS

(A) Cross Sections 1–1 to 5–5

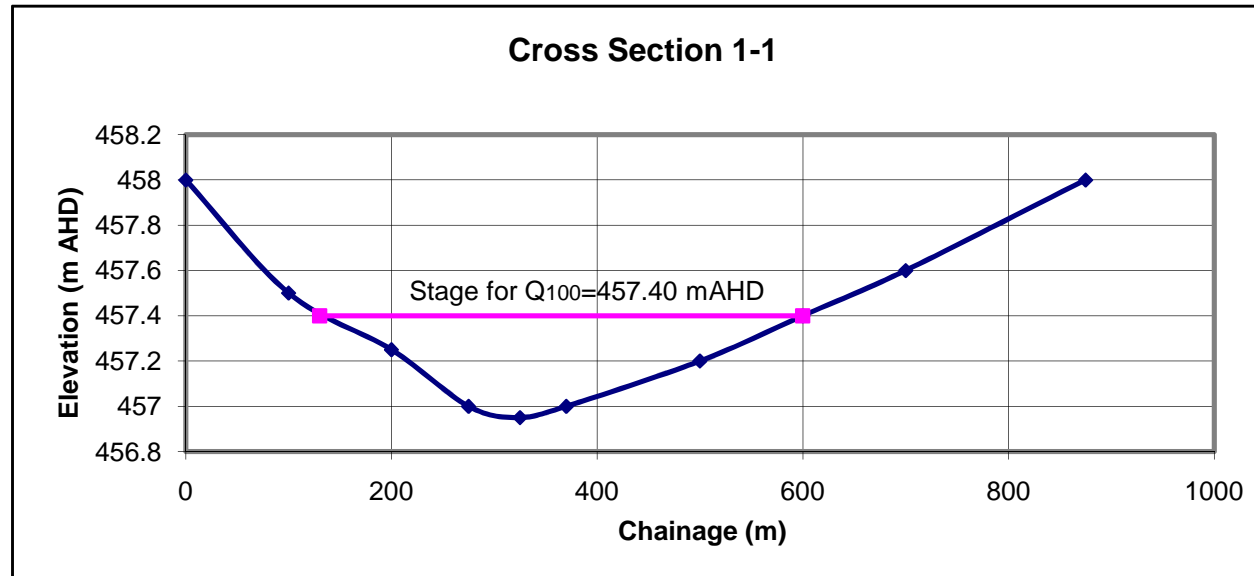
(B) AFFLUX Results Summary

(C) AFFLUX Stage & Discharge Curves for Sections 1–1 to 5–5



Cross Section 1-1

X	Y
0	458
100	457.5
200	457.25
275	457
325	456.95
370	457
500	457.2
600	457.4
700	457.6
875	458

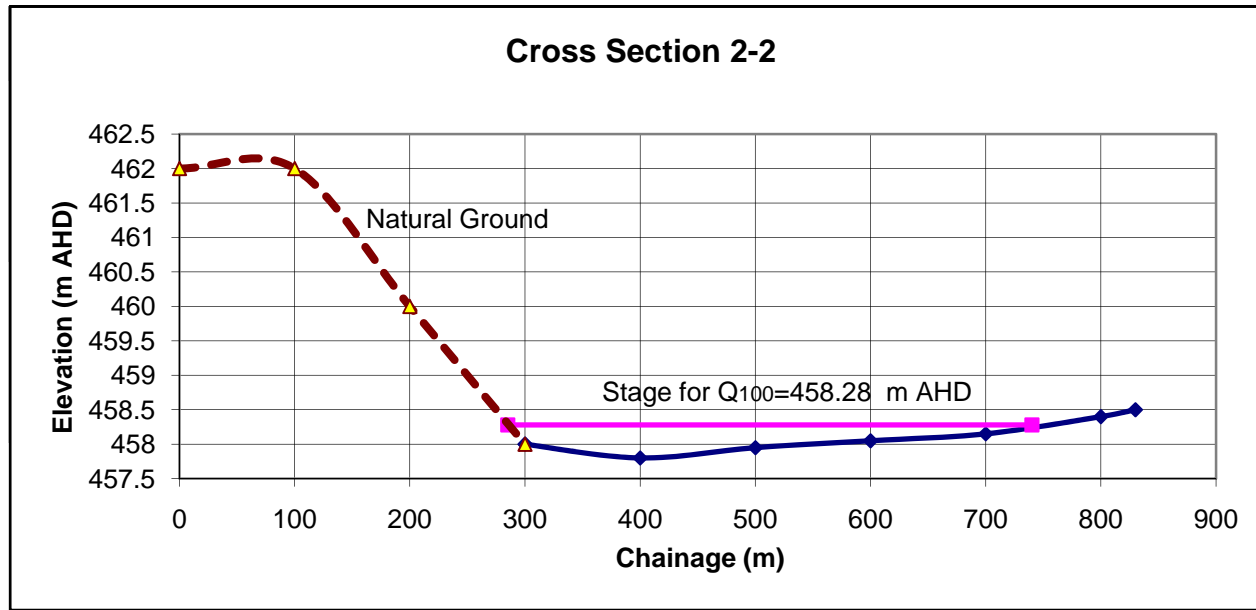


Stage for Q100

130	457.4
600	457.4

Cross Section 2-2

X	Y
0	462
100	462
200	460
300	458
300	458
400	457.8
500	457.95
600	458.05
700	458.15
800	458.4
830	458.5

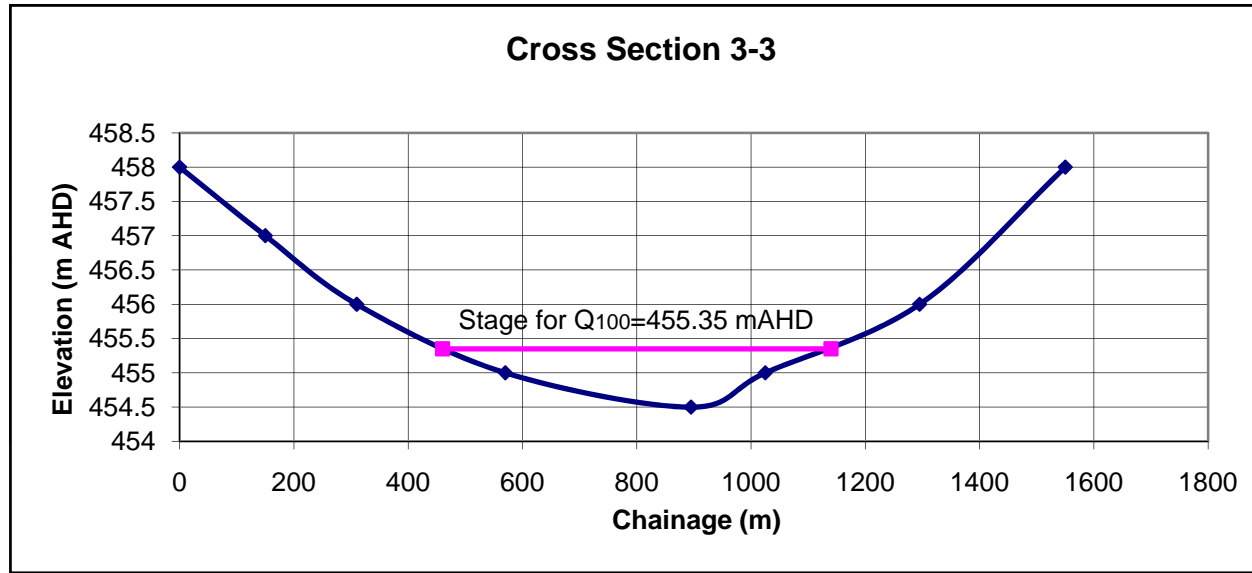


Stage for Q100

285	458.28
740	458.28

Cross Section 3-3

X	Y
0	458
150	457
310	456
570	455
895	454.5
1025	455
1295	456
1550	458

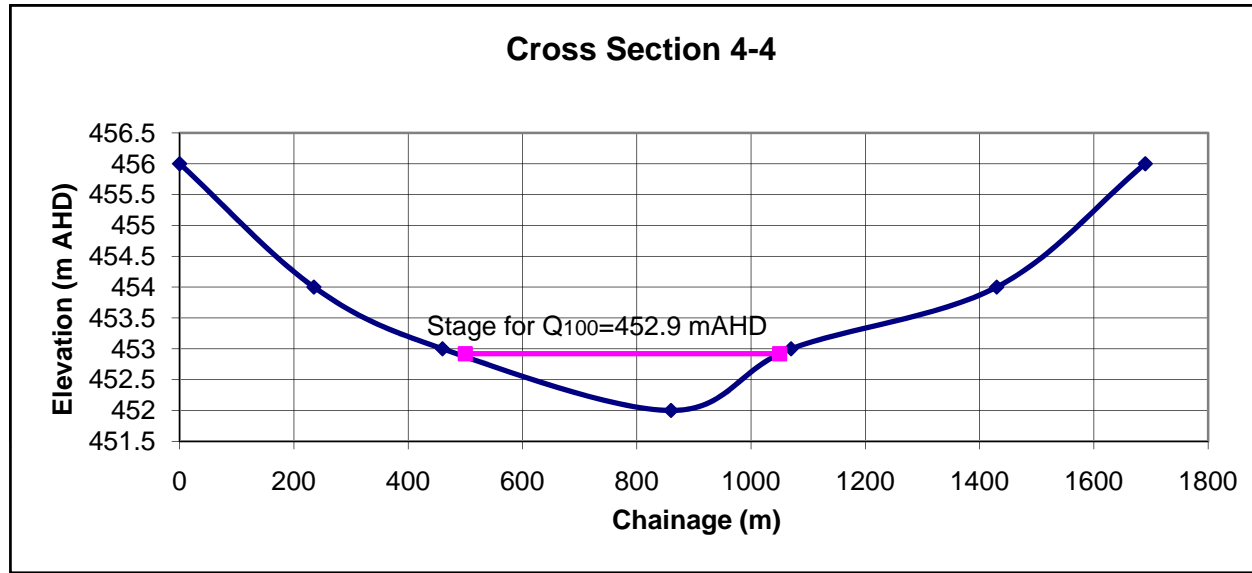


Stage for Q100

460	455.35
1140	455.35

Cross Section 4-4

X	Y
0	456
235	454
460	453
860	452
1070	453
1430	454
1690	456

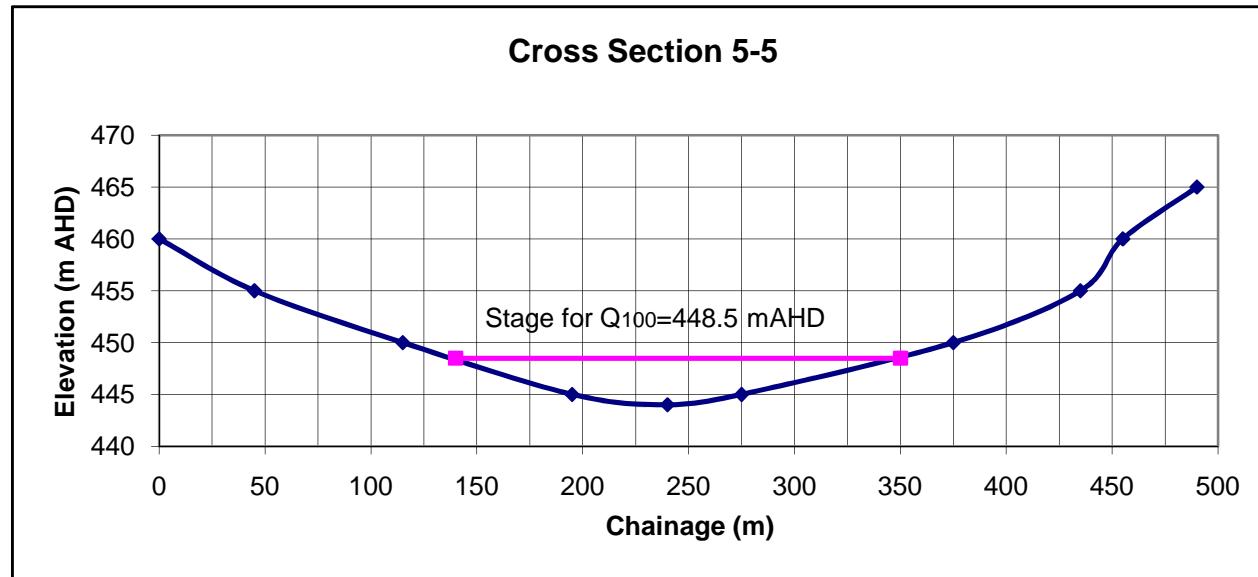


Stage for Q100

500	452.92
1050	452.92

Cross Section 5-5

X	Y
0	460
45	455
115	450
195	445
240	444
275	445
375	450
435	455
455	460
490	465



Stage for Q100

140	448.5
350	448.5

Summary Report

Cross-Section 1-1

AFFLUX Version 1.2.6.17987

Hydraulic Analysis Program for Bridges

File Information

File: CS 1-1 Model.txt
Date: Saturday, 26 September 2009
Comments: Cross-Section 1-1

Section Information

Stream Gradient	0.00650 m/m	Number of Piers:	0
Section Skew:	0.00°	Total Pier Width:	0.00 m
Minimum Bed Level:	456.950 m RL	Pier Type:	N/A
Bridge Skew:	NaN	Deck Level 1:	NaN
Bridge Length:	NaN	Deck Level 2:	NaN
Bridge Opening:	NaN	Abutment Type:	N/A
Deck Depth:	NaN		
No. Spans:	0		

Analysis Results

Stage	Natural Section			Bridge Analysis							Floodway		
	Q _T	A ₀	V ₀	Q _A	Q _B	Q _C	A _{n2}	V _{n2}	h ₁ *	USWL	Max depth over deck	Max depth at Floodway	Max D/H
m RL	m ³ /s	m ²	m/s	m ³ /s	m ³ /s	m ³ /s	m ²	m/s	m	m RL	m	m	m
457.000	0.3	2.4	0.11										
457.100	4.9	16.6	0.29										
457.200	16.1	40.4	0.40										
457.300	37.6	73.0	0.51										
457.400	69.8	114.5	0.61										
457.500	115.0	165.0	0.70										
457.600	174.8	223.5	0.78										
457.700	249.9	288.7	0.87										
457.800	340.0	360.3	0.94										

Notation:

- A_{n2} Flow area through bridge below water level
- A₀ Flow area below water level on natural section
- h₁* Backwater
- Q_A Flow to left of bridge opening
- Q_B Flow directly through bridge opening
- Q_C Flow to right of bridge opening
- Q_T Total Flow
- Stage Water level on natural section
- V_{n2} Average velocity through bridge
- V₀ Average velocity on natural section
- USWL Upstream water level (Stage + Backwater)
- D/H Measure of the level of submergence of the floodway

Summary Report

Cross-Section 2-2

AFFLUX Version 1.2.6.17987

Hydraulic Analysis Program for Bridges

File Information

File: CS 2-2 Model.txt
Date: Saturday, 26 September 2009
Comments: Cross-Section 2-2

Section Information

Stream Gradient	0.00650 m/m	Number of Piers:	0
Section Skew:	0.00°	Total Pier Width:	0.00 m
Minimum Bed Level:	457.800 m RL	Pier Type:	N/A
Bridge Skew:	NaN	Deck Level 1:	NaN
Bridge Length:	NaN	Deck Level 2:	NaN
Bridge Opening:	NaN	Abutment Type:	N/A
Deck Depth:	NaN		
No. Spans:	0		

Analysis Results

Stage	Natural Section			Bridge Analysis								Floodway	
	Q _T	A ₀	V ₀	Q _A	Q _B	Q _C	A _{n2}	V _{n2}	h ₁ *	USWL	Max depth over deck	Max depth at Floodway	Max D/H
m RL	m ³ /s	m ²	m/s	m ³ /s	m ³ /s	m ³ /s	m ²	m/s	m	m RL	m	m	m
458.000	7.2	23.7	0.30										
458.050	14.0	37.6	0.37										
458.100	23.5	54.0	0.43										
458.150	35.7	73.1	0.49										
458.200	51.1	94.0	0.54										
458.250	69.5	116.1	0.60										
458.300	90.6	139.3	0.65										
458.350	114.7	163.6	0.70										
458.400	141.5	189.0	0.75										
458.450	171.8	215.4	0.80										
458.500	205.0	242.8	0.84										

Notation:

- A_{n2} Flow area through bridge below water level
- A₀ Flow area below water level on natural section
- h₁* Backwater
- Q_A Flow to left of bridge opening
- Q_B Flow directly through bridge opening
- Q_C Flow to right of bridge opening
- Q_T Total Flow
- Stage Water level on natural section
- V_{n2} Average velocity through bridge
- V₀ Average velocity on natural section
- USWL Upstream water level (Stage + Backwater)
- D/H Measure of the level of submergence of the floodway

Summary Report

Cross Section 3-3

AFFLUX Version 1.2.6.17987

Hydraulic Analysis Program for Bridges

File Information

File: CS 3-3 Model.txt
Date: Saturday, 26 September 2009
Comments: Cross Section 3-3

Section Information

Stream Gradient	0.00200 m/m	Number of Piers:	0
Section Skew:	0.00°	Total Pier Width:	0.00 m
Minimum Bed Level:	454.500 m RL	Pier Type:	N/A
Bridge Skew:	NaN	Deck Level 1:	NaN
Bridge Length:	NaN	Deck Level 2:	NaN
Bridge Opening:	NaN	Abutment Type:	N/A
Deck Depth:	NaN		
No. Spans:	0		

Analysis Results

Stage	Natural Section			Bridge Analysis							Floodway		
	Q _T	A ₀	V ₀	Q _A	Q _B	Q _C	A _{n2}	V _{n2}	h ₁ *	USWL	Max depth over deck	Max depth at Floodway	Max D/H
m RL	m ³ /s	m ²	m/s	m ³ /s	m ³ /s	m ³ /s	m ²	m/s	m	m RL	m	m	
454.600	0.5	4.6	0.10										
454.850	13.0	55.7	0.23										
455.100	59.2	161.9	0.37										
455.350	152.3	305.5	0.50										
455.600	290.5	482.2	0.60										
455.850	478.2	692.0	0.69										
456.100	728.0	933.7	0.78										
456.350	1047.7	1196.1	0.88										
456.600	1425.8	1476.5	0.97										
456.850	1863.1	1774.9	1.05										
457.100	2362.9	2091.1	1.13										
457.350	2928.3	2424.9	1.21										
457.600	3556.9	2776.0	1.28										
457.850	4249.9	3144.4	1.35										

Notation:

A _{n2}	Flow area through bridge below water level
A ₀	Flow area below water level on natural section
h ₁ *	Backwater
Q _A	Flow to left of bridge opening
Q _B	Flow directly through bridge opening
Q _C	Flow to right of bridge opening
Q _T	Total Flow
Stage	Water level on natural section
V _{n2}	Average velocity through bridge
V ₀	Average velocity on natural section
USWL	Upstream water level (Stage + Backwater)
D/H	Measure of the level of submergence of the floodway

Summary Report

Cross Section 4-4

AFFLUX Version 1.2.6.17987

Hydraulic Analysis Program for Bridges

File Information

File: CS 4-4 Model.txt
Date: Saturday, 26 September 2009
Comments: Cross Section 4-4

Section Information

Stream Gradient	0.00370 m/m	Number of Piers:	0
Section Skew:	0.00°	Total Pier Width:	0.00 m
Minimum Bed Level:	452.000 m RL	Pier Type:	N/A
Bridge Skew:	NaN	Deck Level 1:	NaN
Bridge Length:	NaN	Deck Level 2:	NaN
Bridge Opening:	NaN	Abutment Type:	N/A
Deck Depth:	NaN		
No. Spans:	0		

Analysis Results

Stage	Natural Section			Bridge Analysis								Floodway	
	Q _T	A ₀	V ₀	Q _A	Q _B	Q _C	A _{n2}	V _{n2}	h ₁ *	USWL	Max depth over deck	Max depth at Floodway	Max D/H
m RL	m ³ /s	m ²	m/s	m ³ /s	m ³ /s	m ³ /s	m ²	m/s	m	m RL	m	m	m
452.200	2.7	12.2	0.22										
452.450	23.2	61.8	0.38										
452.700	75.2	149.4	0.50										
452.950	169.9	275.3	0.62										
453.200	343.8	438.7	0.78										
453.450	590.0	638.7	0.92										
453.700	910.2	875.3	1.04										
453.950	1311.7	1148.5	1.14										
454.200	1825.8	1451.4	1.26										
454.450	2436.1	1770.3	1.38										
454.700	3135.5	2104.6	1.49										
454.950	3924.1	2454.4	1.60										
455.200	4802.2	2819.7	1.70										
455.450	5770.4	3200.4	1.80										
455.700	6829.7	3596.6	1.90										
455.950	7981.0	4008.3	1.99										

Notation:

- A_{n2} Flow area through bridge below water level
- A₀ Flow area below water level on natural section
- h₁* Backwater
- Q_A Flow to left of bridge opening
- Q_B Flow directly through bridge opening
- Q_C Flow to right of bridge opening
- Q_T Total Flow
- Stage Water level on natural section
- V_{n2} Average velocity through bridge
- V₀ Average velocity on natural section
- USWL Upstream water level (Stage + Backwater)
- D/H Measure of the level of submergence of the floodway

Summary Report

Cross Section 5-5

AFFLUX Version 1.2.6.17987

Hydraulic Analysis Program for Bridges

File Information

File: CS 5-5 Model.txt
Date: Saturday, 26 September 2009
Comments: Cross Section 5-5

Section Information

Stream Gradient	0.00020 m/m	Number of Piers:	0
Section Skew:	0.00°	Total Pier Width:	0.00 m
Minimum Bed Level:	444.000 m RL	Pier Type:	N/A
Bridge Skew:	NaN	Deck Level 1:	NaN
Bridge Length:	NaN	Deck Level 2:	NaN
Bridge Opening:	NaN	Abutment Type:	N/A
Deck Depth:	NaN		
No. Spans:	0		

Analysis Results

Stage	Natural Section			Bridge Analysis							Floodway		
	Q _T	A ₀	V ₀	Q _A	Q _B	Q _C	A _{n2}	V _{n2}	h ₁ *	USWL	Max depth over deck	Max depth at Floodway	Max D/H
m RL	m ³ /s	m ²	m/s	m ³ /s	m ³ /s	m ³ /s	m ²	m/s	m	m RL	m	m	
444.200	0.1	1.6	0.05										
444.400	0.5	6.4	0.08										
444.600	1.5	14.4	0.11										
444.800	3.3	25.6	0.13										
445.000	5.9	40.0	0.15										
445.200	10.4	56.7	0.18										
445.400	16.0	74.9	0.21										
445.600	22.8	94.5	0.24										
445.800	30.7	115.5	0.27										
446.000	39.7	138.0	0.29										
446.200	50.0	161.9	0.31										
446.400	61.5	187.3	0.33										
446.600	74.3	214.1	0.35										
446.800	88.4	242.3	0.36										
447.000	103.8	272.0	0.38										
447.200	120.6	303.1	0.40										
447.400	138.7	335.7	0.41										
447.600	158.4	369.7	0.43										
447.800	179.5	405.1	0.44										
448.000	202.1	442.0	0.46										
448.200	226.2	480.3	0.47										
448.400	252.0	520.1	0.48										
448.500	265.4	540.5	0.49										
448.600	279.3	561.3	0.50										
448.800	308.2	603.9	0.51										
449.000	338.9	648.0	0.52										
449.200	371.2	693.5	0.54										
449.400	405.3	740.5	0.55										
449.600	441.1	788.9	0.56										
449.800	478.8	838.7	0.57										
450.000	518.2	890.0	0.58										
450.200	564.8	942.5	0.60										
450.400	613.3	996.1	0.62										
450.600	663.7	1050.7	0.63										
450.800	716.2	1106.3	0.65										
451.000	770.7	1163.0	0.66										
451.200	827.2	1220.7	0.68										
451.400	885.7	1279.5	0.69										
451.600	946.3	1339.3	0.71										
451.800	1009.0	1400.1	0.72										
452.000	1073.8	1462.0	0.73										
452.200	1140.7	1524.9	0.75										
452.400	1209.8	1588.9	0.76										
452.600	1280.9	1653.9	0.77										
452.800	1354.3	1719.9	0.79										
453.000	1429.8	1787.0	0.80										
453.200	1507.5	1855.1	0.81										
453.400	1587.4	1924.3	0.82										
453.600	1669.5	1994.5	0.84										
453.800	1753.9	2065.7	0.85										
454.000	1840.5	2138.0	0.86										
454.200	1929.4	2211.3	0.87										

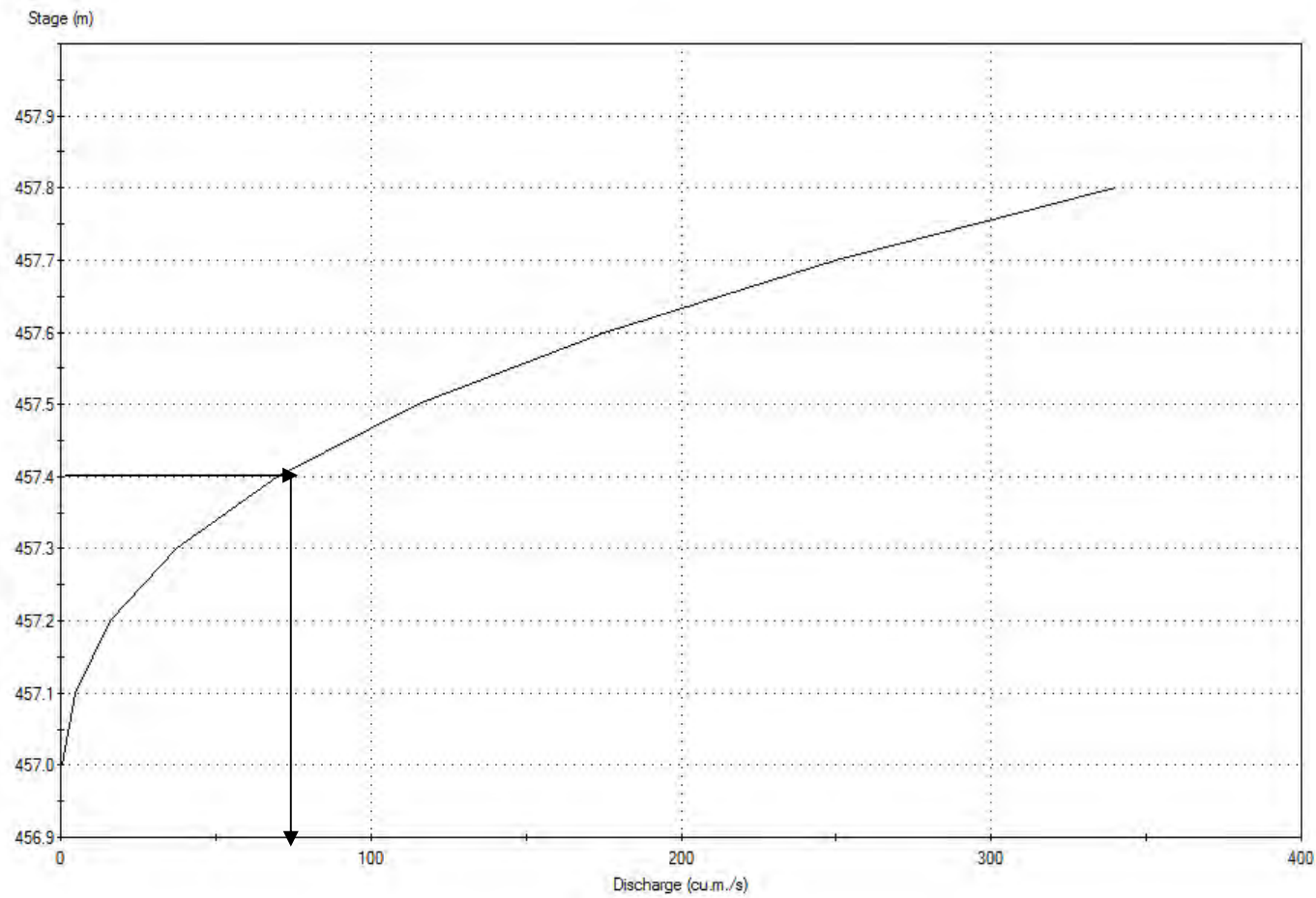
Cross Section 5-5

Stage	Natural Section			Bridge Analysis							Floodway		
	Q _T	A ₀	V ₀	Q _A	Q _B	Q _C	A _{n2}	V _{n2}	h ₁ *	USWL	Max depth over deck	Max depth at Floodway	Max D/H
m RL	m ³ /s	m ²	m/s	m ³ /s	m ³ /s	m ³ /s	m ²	m/s	m	m RL	m	m	m
454.400	2020.6	2285.7	0.88										
454.600	2114.0	2361.1	0.90										
454.800	2209.8	2437.5	0.91										
455.000	2307.9	2515.0	0.92										
455.200	2412.1	2593.3	0.93										
455.400	2518.7	2672.0	0.94										
455.600	2627.7	2751.3	0.96										
455.800	2739.0	2831.2	0.97										
456.000	2852.7	2911.5	0.98										
456.200	2968.7	2992.4	0.99										
456.400	3087.1	3073.7	1.00										
456.600	3207.9	3155.6	1.02										
456.800	3331.0	3238.1	1.03										
457.000	3456.4	3321.0	1.04										
457.200	3584.2	3404.5	1.05										
457.400	3714.4	3488.4	1.06										
457.600	3846.8	3572.9	1.08										
457.800	3981.6	3658.0	1.09										
458.000	4118.8	3743.5	1.10										
458.200	4258.3	3829.6	1.11										
458.400	4400.1	3916.1	1.12										
458.600	4544.2	4003.2	1.14										
458.800	4690.7	4090.9	1.15										
459.000	4839.5	4179.0	1.16										
459.200	4990.7	4267.7	1.17										
459.400	5144.2	4356.8	1.18										
459.600	5300.0	4446.5	1.19										
459.800	5458.2	4536.8	1.20										
460.000	5618.7	4627.5	1.21										

Notation:

- A_{n2} Flow area through bridge below water level
- A₀ Flow area below water level on natural section
- h₁* Backwater
- Q_A Flow to left of bridge opening
- Q_B Flow directly through bridge opening
- Q_C Flow to right of bridge opening
- Q_T Total Flow
- Stage Water level on natural section
- V_{n2} Average velocity through bridge
- V₀ Average velocity on natural section
- USWL Upstream water level (Stage + Backwater)
- D/H Measure of the level of submergence of the floodway

Stage vs. Discharge
Cross-Section 1-1



General settings

- Grid Lines (X)
- Grid Lines (Y)
- Boxed

Printer settings

Print to:

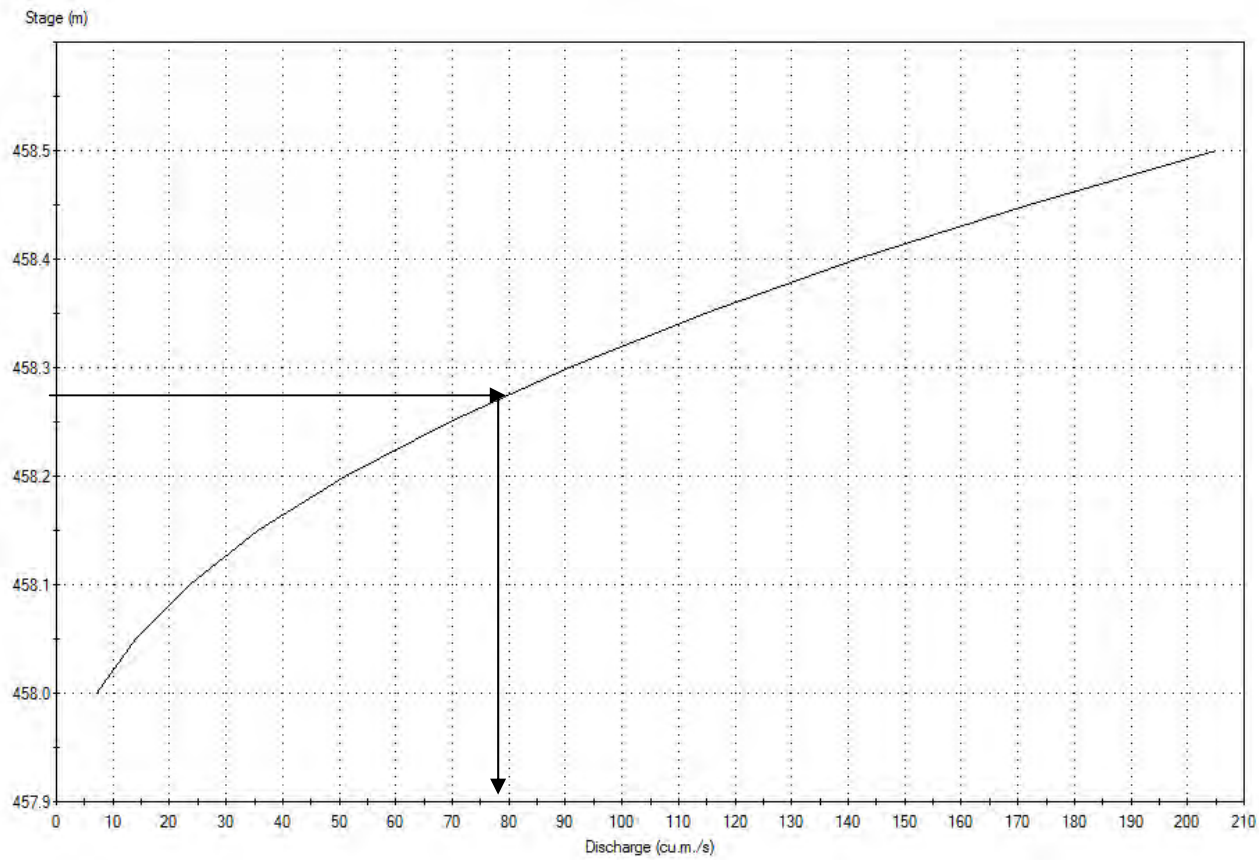
- Clipboard
- Printer

Top	0
Left	0
Width	4640
Height	4640

Set Key Point

Help Print Exit

Stage vs. Discharge
Cross-Section 2-2



General settings

- Grid Lines (X)
- Grid Lines (Y)
- Boxed

Printer settings

Print to:

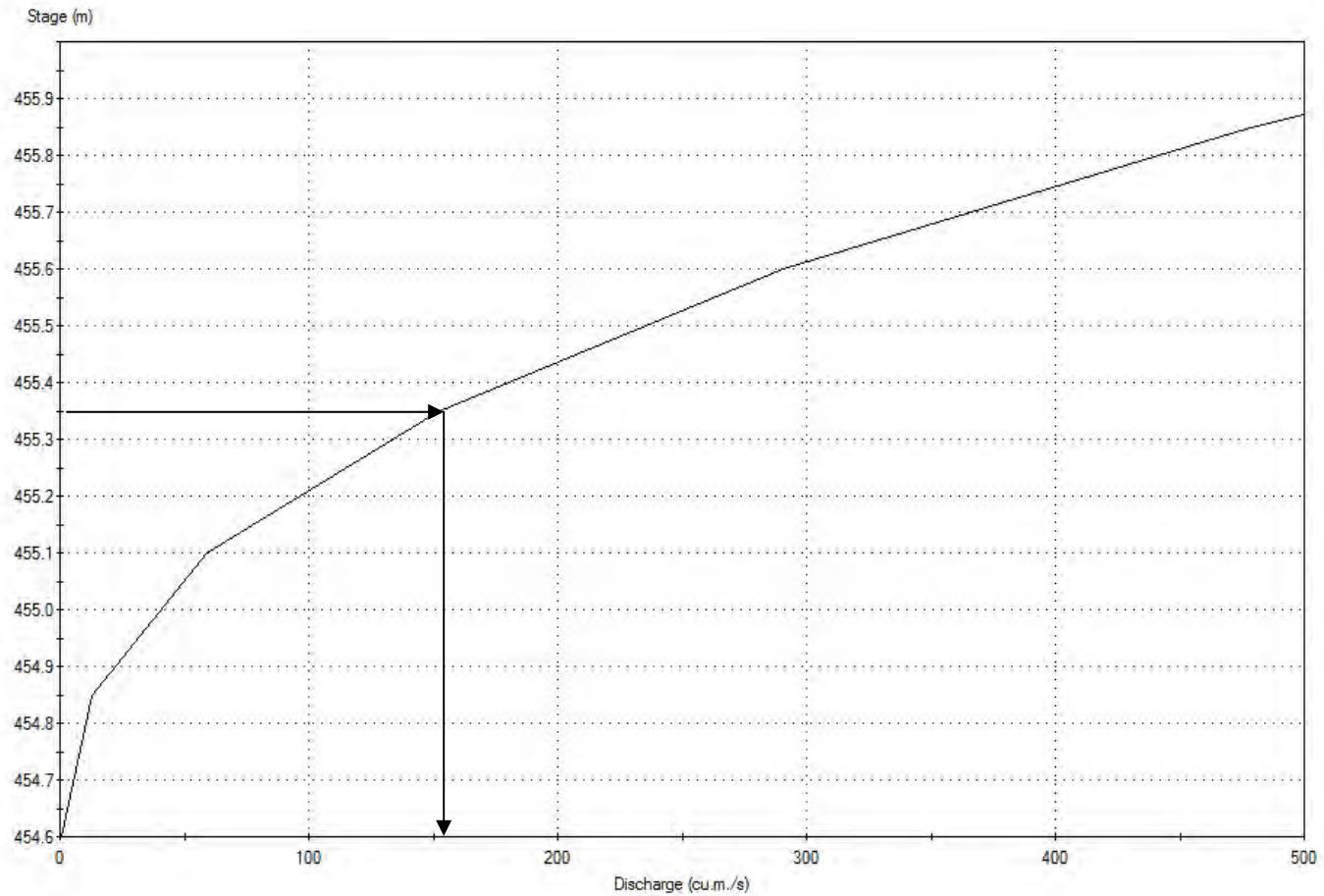
- Clipboard
- Printer

Top	0
Left	0
Width	4640
Height	4640

Set Key Point

Help Print Exit

Stage vs. Discharge
Cross Section 3-3



General settings

- Grid Lines (X)
- Grid Lines (Y)
- Boxed

Printer settings

Print to:

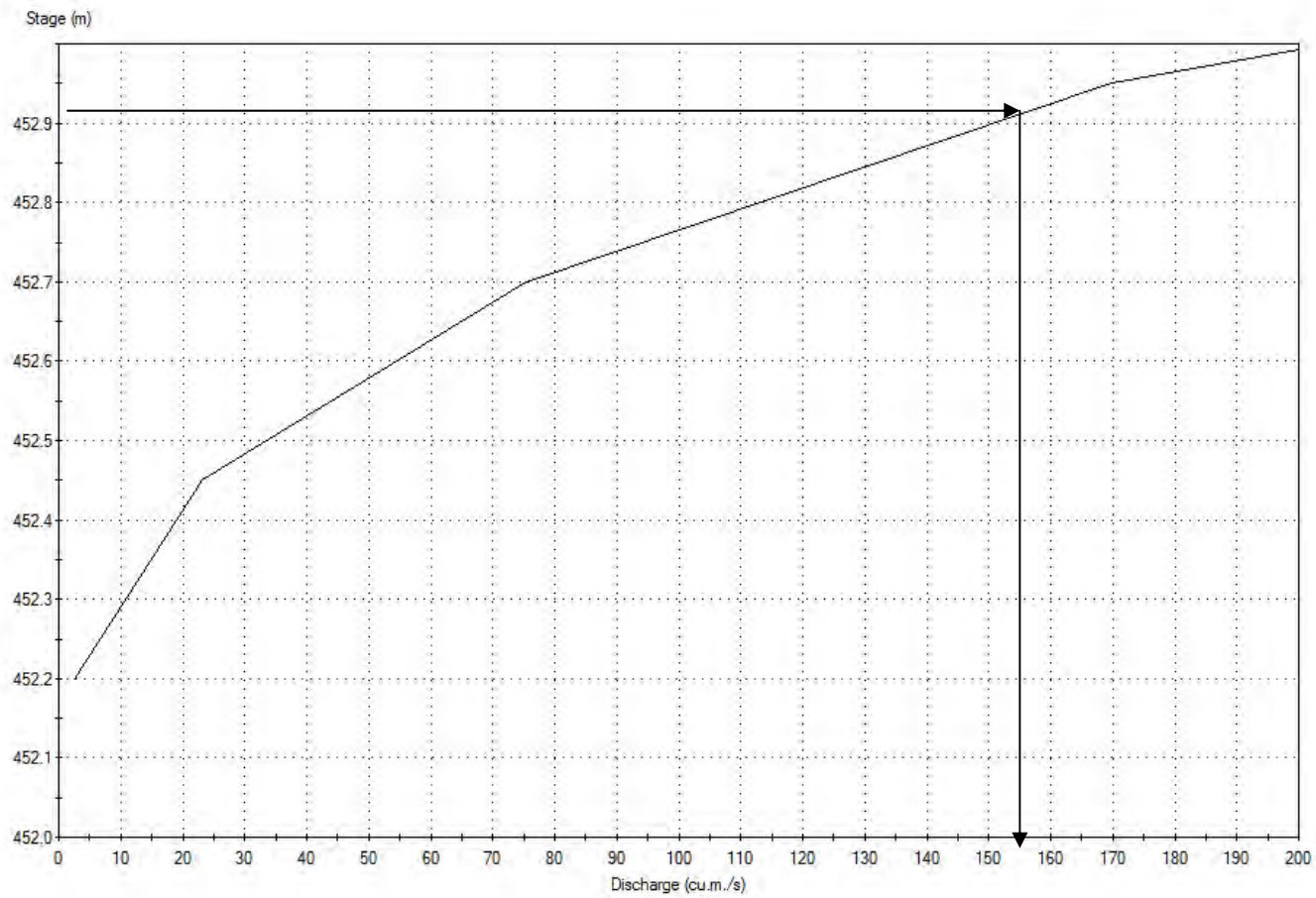
- Clipboard
- Printer

Top	0
Left	0
Width	4640
Height	4640

Set Key Point

Help Print Exit

Stage vs. Discharge
Cross Section 4-4



General settings

- Grid Lines (X)
- Grid Lines (Y)
- Boxed

Printer settings

Print to:

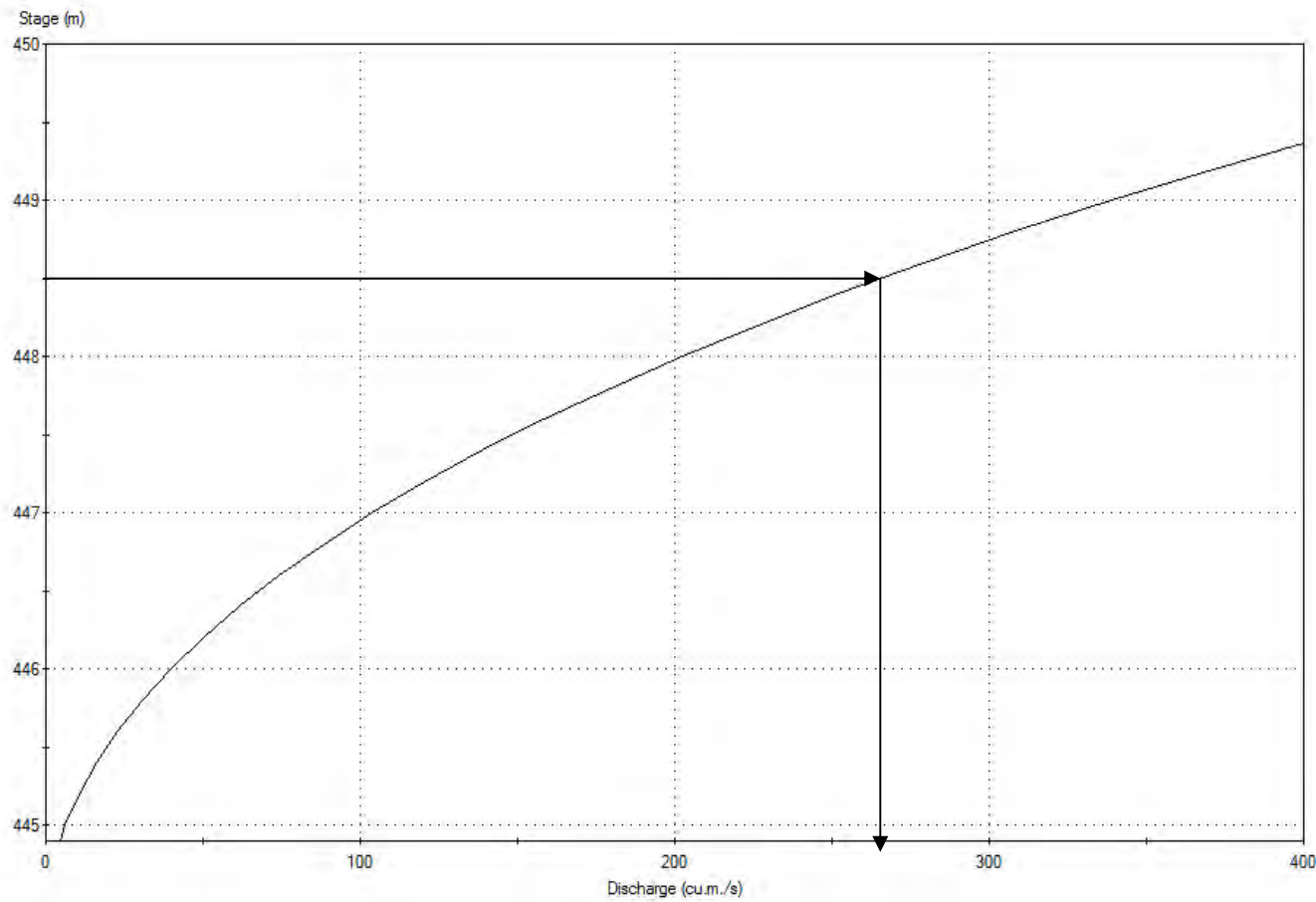
- Clipboard
- Printer

Top	0
Left	0
Width	4640
Height	4640

Set Key Point

Help Print Exit

Stage vs. Discharge
Cross Section 5-5



General settings

- Grid Lines (X)
- Grid Lines (Y)
- Boxed

Printer settings

Print to:

- Clipboard
- Printer

Top	0
Left	0
Width	4640
Height	4640

Set Key Point

Help Print Exit