Floods in South Australia's Arid Zone – Experiences and Challenges

David Kemp – DTEI, SA

Outline

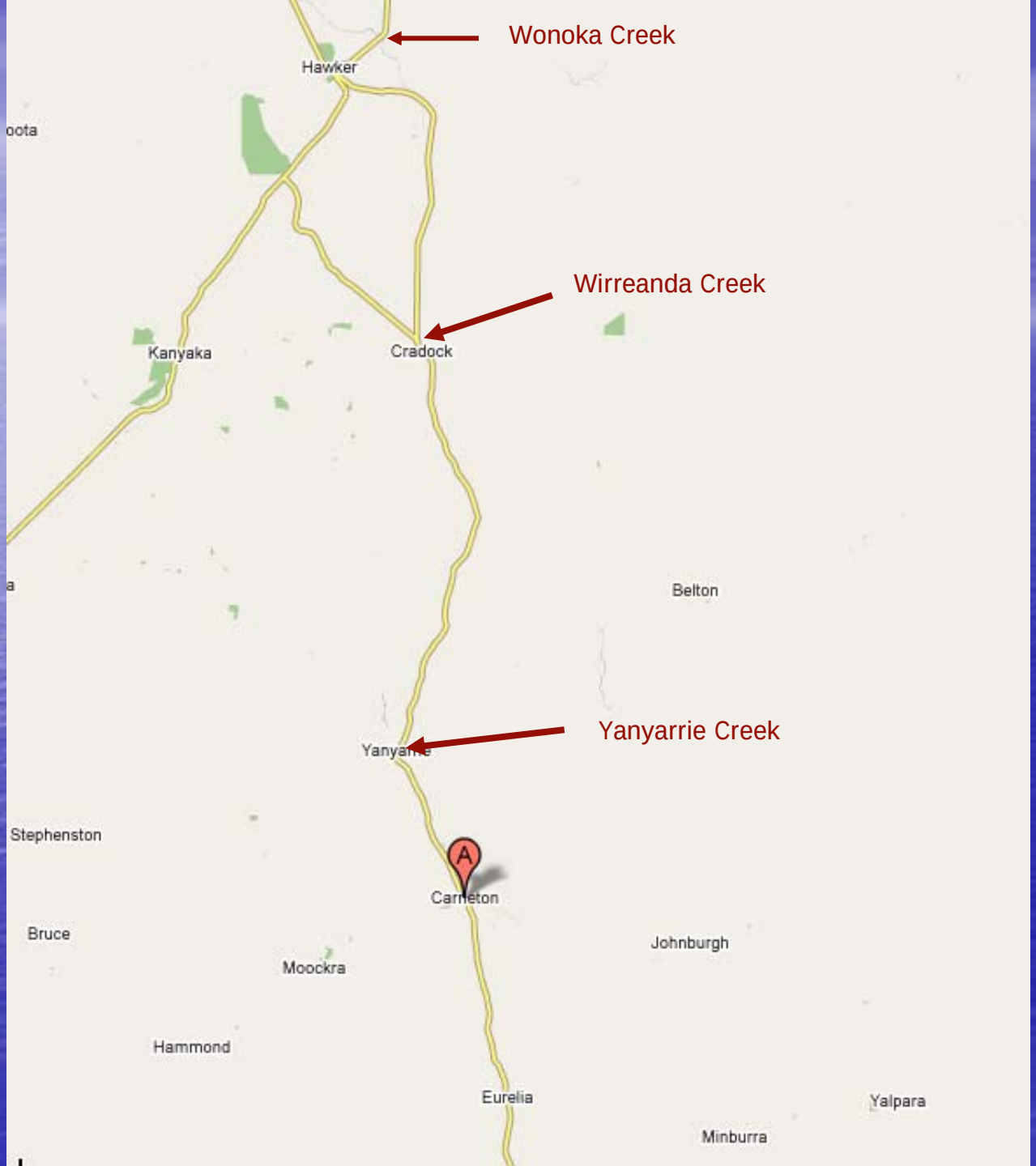
- The January 2007 floods
- Investigation of the flood
- Reconstruction of road asset
- The Gammon Ranges project
- The insights gained
- Challenges
- Summary

The January 2007 flood

- Peak intensities and damage near Hawker
- However had a widespread impact on roads in the far north
- Major damage to 3 floodways, and one other section of the Wilpena Road
- Minor damage to a number of other floodways
- Scouring of road shoulders

The January 2007 flood

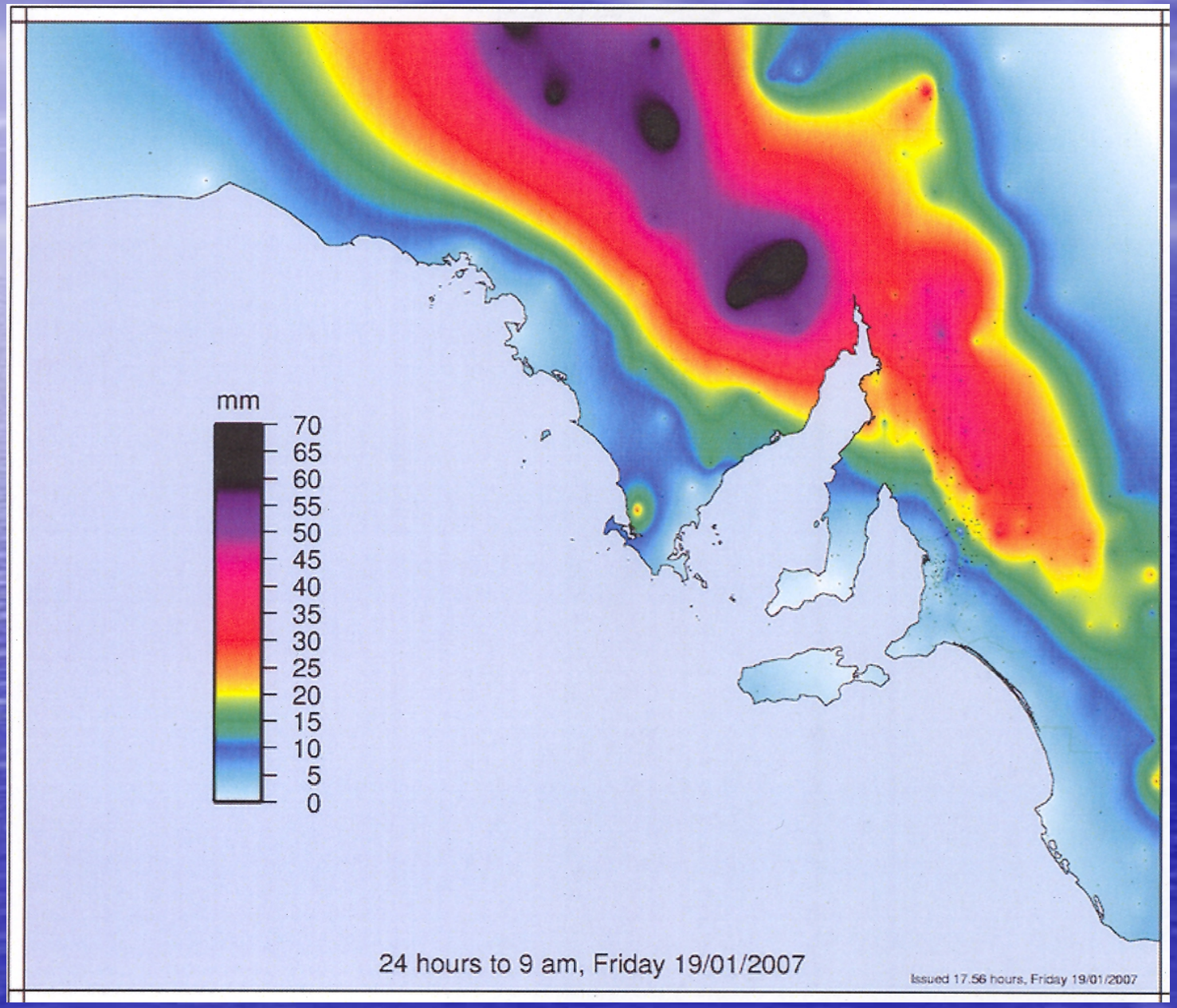
- Total damage across the road network $30m
- Other transport infrastructure costs:
  - Rail Industry – three operators impacted – total cost $3.7m.
  - Councils – approximately $7m.
  - DEH and PIRSA roads – approximately $0.4m.

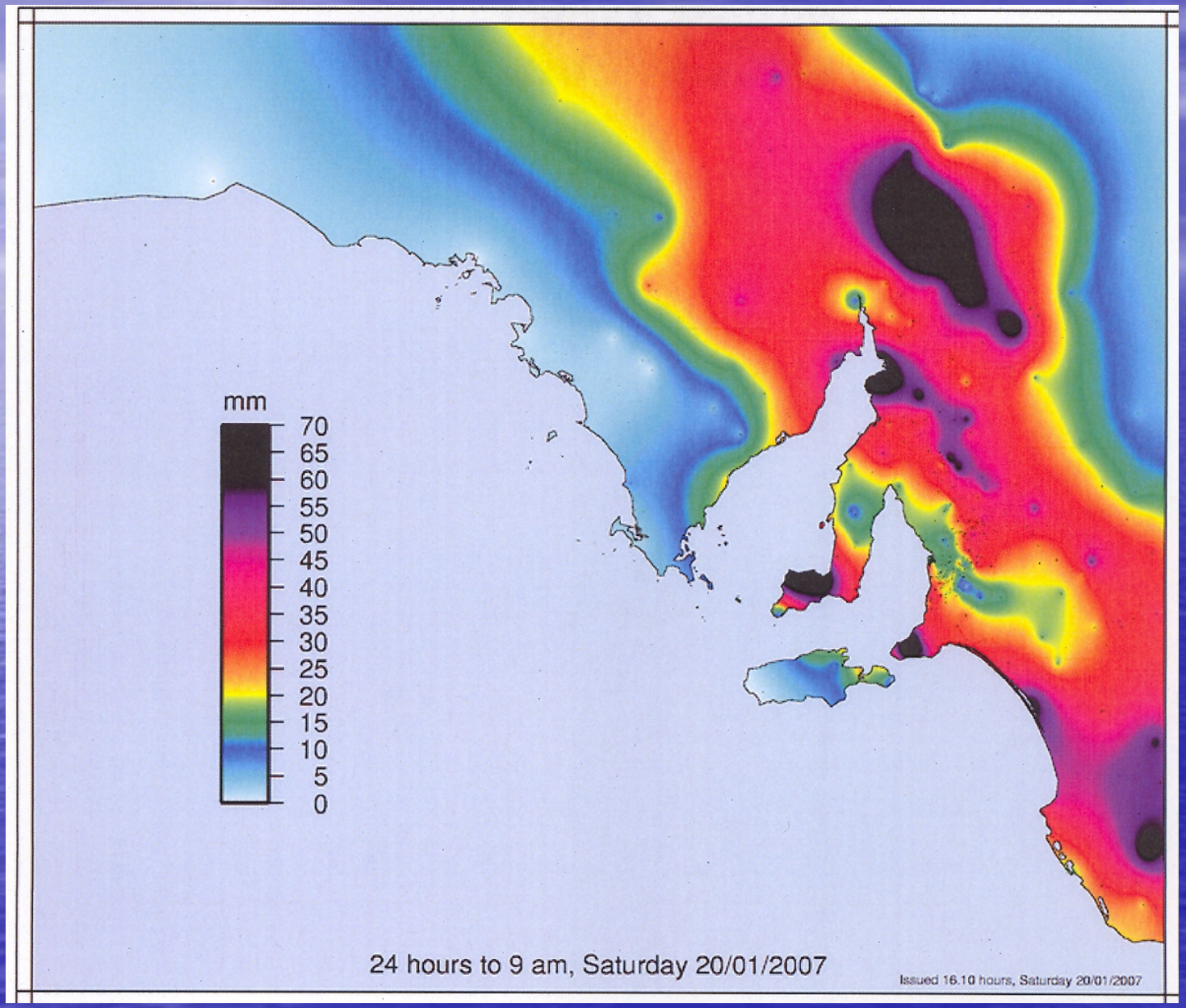

Wonoka Creek
Hawker
Wirreanda Creek
Kanyaka
Cradock
Belton
Yanyarrie Creek
Stephenston
Carrieton
Bruce
Johnburgh
Moockra
Hammond
Eurelia
Yalpara
Minburra


01/22/2007


23/01/2007


08/02/2007


mm
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
24 hours to 9 am, Friday 19/01/2007
Issued 17.56 hours, Friday 19/01/2007


mm
70
65
60
55
50
45
40
35
30
25
20
15
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5
0
24 hours to 9 am, Saturday 20/01/2007
Issued 16.10 hours, Saturday 20/01/2007

Rainfall

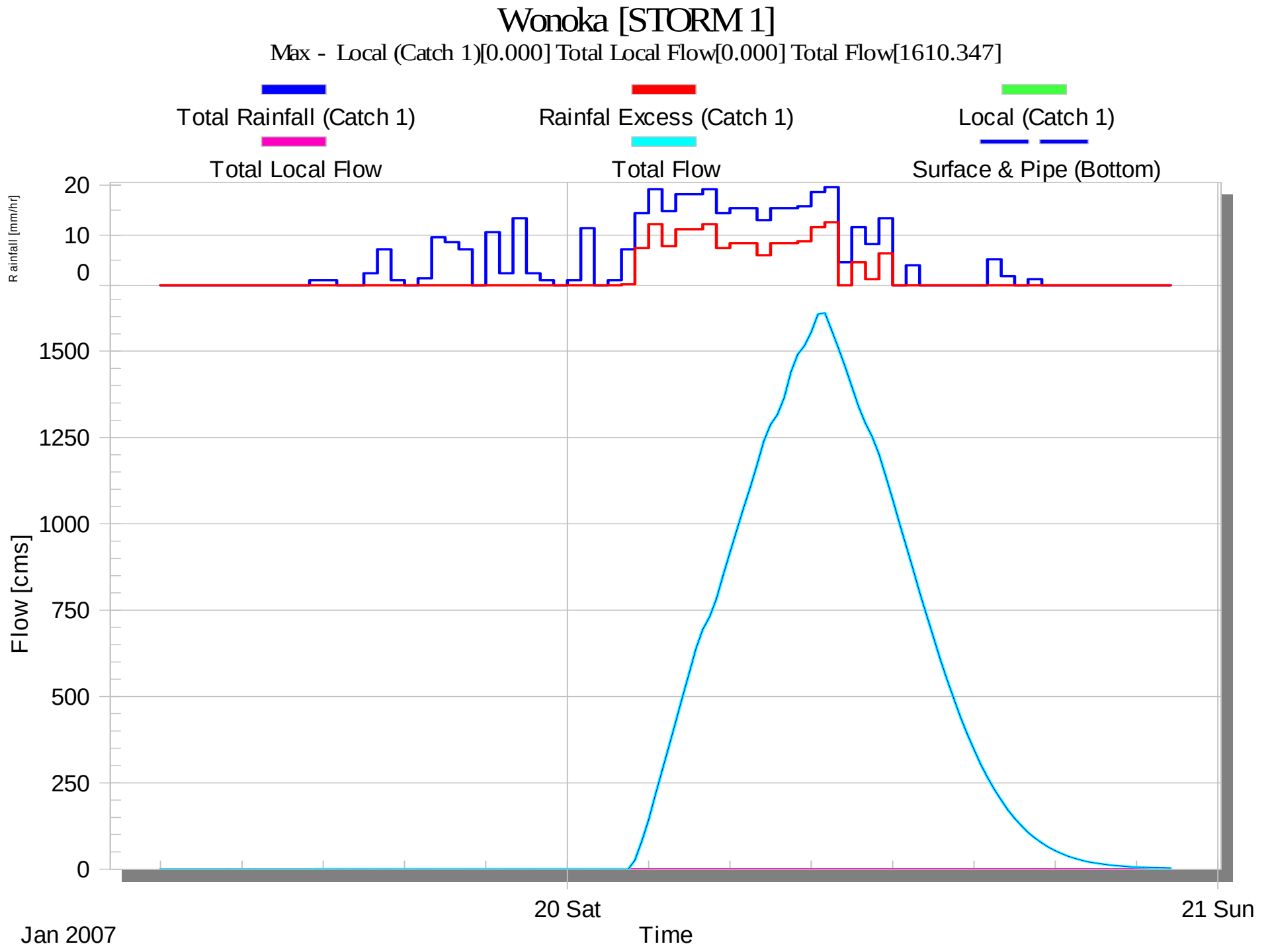
- Rainfall data around Hawker sourced from BOM, local residents
- Most of the rainfall occurring from early on Saturday morning (1am) until early afternoon (1pm), a period of 12 hours
- the maximum rainfall recorded is estimated to be 180mm at Yednalue, 15km east of Cradock. This is estimated to have an Average Recurrence Interval (ARI) of the order of 1 in 1000 years.

Rainfall

- The average rainfall on the Wonoka Creek catchment on the Hawker to Wilpena Road for the same period was probably of the order of 120mm to 140mm, which is between 200 and 500 years ARI

Model

- Hyetograph based on Radar images from Woomera
- The channel storage parameter was set so that the channel velocity was greater than would normally occur in humid areas
- An initial loss of 40mm, and continuing loss of 7mm/hr gave reasonable coincidence with the measured peak flows, and the time of the peak occurring in the creeks


Wonoka [STORM 1]
Max - Local (Catch 1)[0.000] Total Local Flow[0.000] Total Flow[1610.347]
Total Rainfall (Catch 1)
Rainfal Excess (Catch 1)
Local (Catch 1)
Total Local Flow
Total Flow
Surface & Pe (Bottom)
Rainfall [mm/hr]
20
10
0
1500
1250
1000
750
500
250
0
Flow [cms]
Jan 2007
20 Sat
21 Sun
Time

Location	Catchment Area (km^2)	Estimated Peak Flow (m^3/sec)
Wirreanda Creek 3.5km upstream of Cradock	231	500
Yanyarrie Creek at the Hawker – Orroroo Road	454	850
Wonoka Creek at Blinman – Hawker Road	712	1500

Response

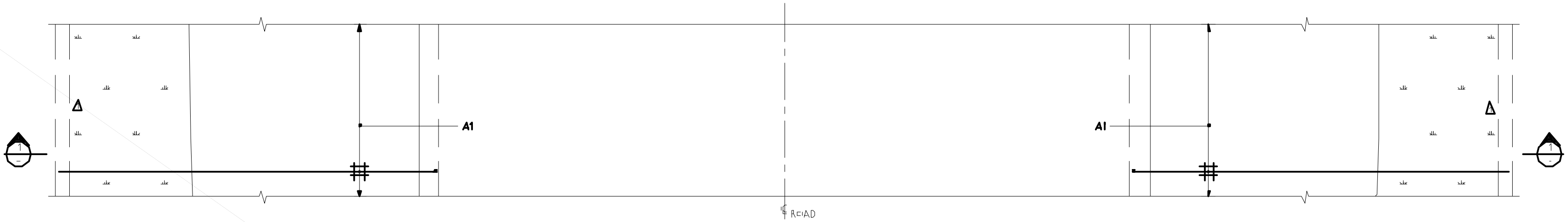
- Temporary works to reopen roads
- Assessment by geomorphologist
- Replacement of 3 floodways, creation of one other
- desilting culverts and removing debris
- Shoulder reinstatement, some stabilised
- Significant rock protection

Design principles - floodways

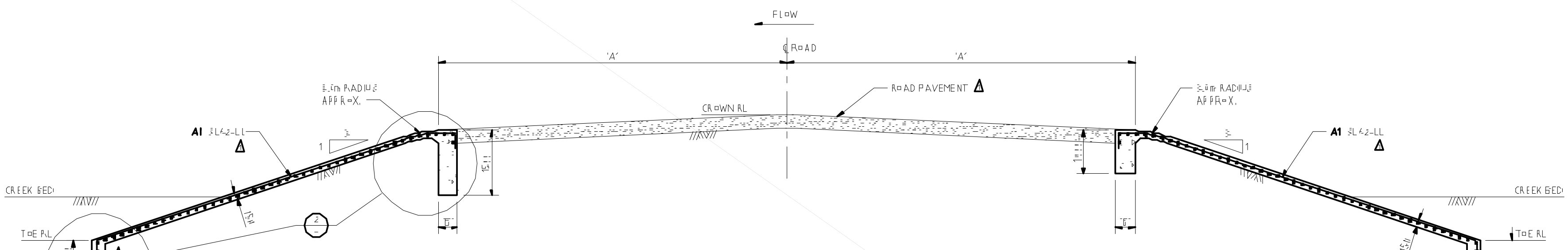
- Road pavement contained by cutoff walls
- Cement treated (low velocity) or concrete (high velocity) pavement
- Culverts for low flows – if possible. Be aware of debris
- Allow for changes in bed elevation

Design principles

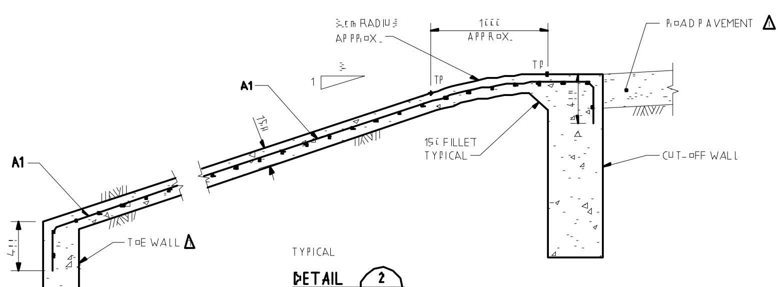
- Batter protection if floodway level above creek bed level
- Rounded at top of batter to reduce hydraulic uplift
- Use rock protection, but be aware of high velocities



PLAN
SCALE 1:50



SECTION 1
SCALE 1:50



TYPICAL
DETAIL 2
SCALE 1:20

NOTES

DESIGN
1. FOR DIMENSIONS 'A', 'B', 'C', RLs AND EXTENT OF PROTECTION REFER ROAD DRAWINGS.

CONCRETE
1. GRADE N32.
2. REINFORCED CONCRETE MAY BE SUBSTITUTED WITH A SUITABLE STRUCTURAL FIBRE REINFORCED CONCRETE, SUBJECT TO APPROVAL.

REINFORCEMENT
1. REINFORCEMENT MESH TO BE GRADE D500L IN ACCORDANCE WITH AS/NZS 4671.
2. REINFORCEMENT MESH TO BE PLACED CENTRALLY IN BATTER PROTECTION
3. STANDARD HOOKS AND BENDS SHALL BE IN ACCORDANCE WITH AS 3600.

COVER
1. COVER TO BE 45mm ALL ROUND.

DESCRIPTION	No	Date	Drafter	Examined	Approved for Executive Director	Date
TOE & ADDED. CEMENT TREATED REMOVED. DIM B ADDED TO NOTES	1	21/-/07	ER	F. MOLLOY	F. WILSON	21/10/07

AMENDMENTS

100 MILLIMETRES ON ORIGINAL DRAWING

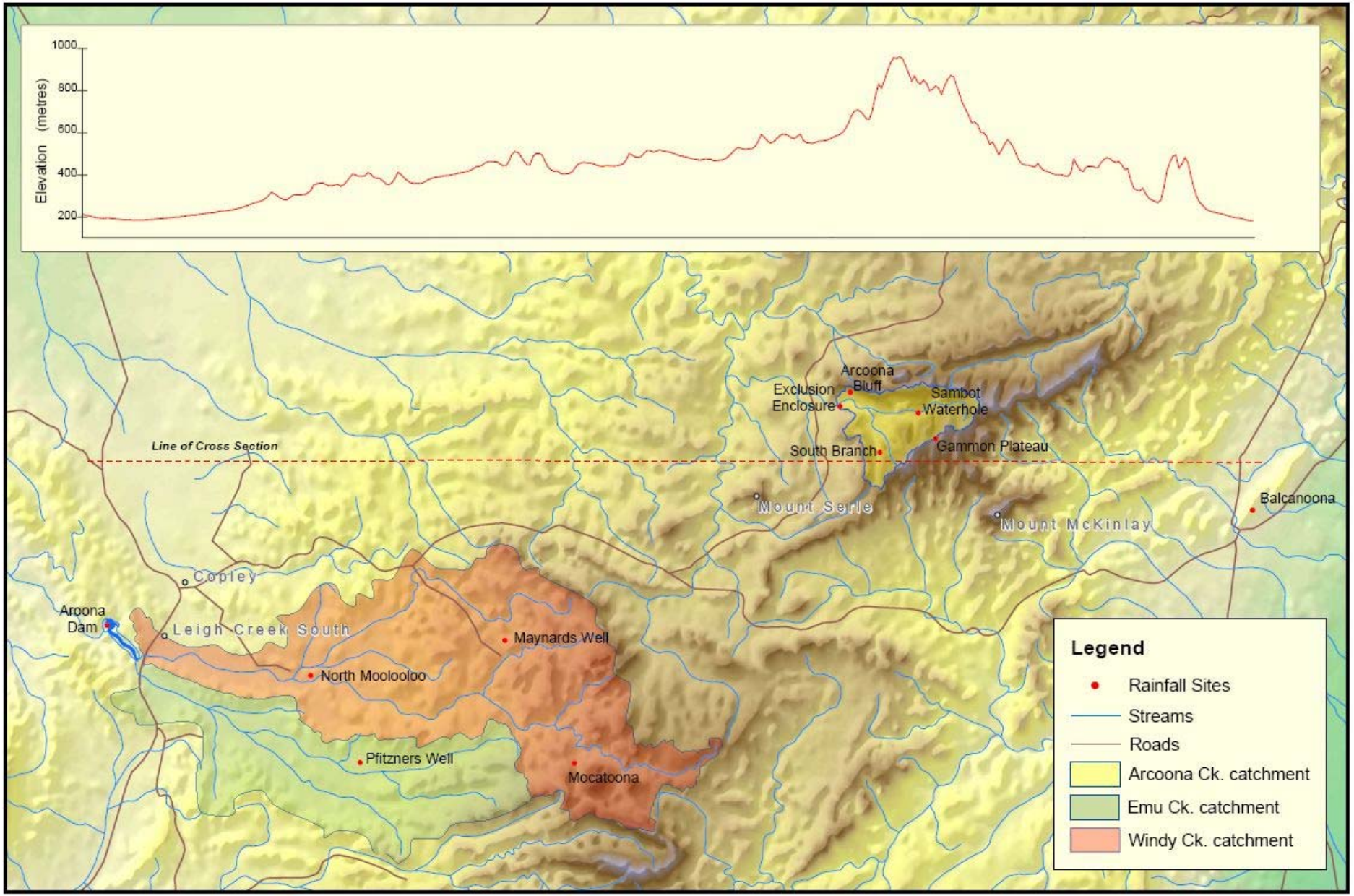
ALL DIMENSIONS ARE IN MILLIMETRES UNLESS SHOWN OTHERWISE

DESIGN DESIGN UNIT	ENDORSED D KEMPTER Principal Stormwater Engineer	STANDARD DRAWING	DEPARTMENT OF TRANSPORT, ENERGY AND INFRASTRUCTURE
DRAWN DESIGN UNIT		BATTER PROTECTION	
CHECKED F MOLLOY	APPROVED F WILSON For Executive Director Date 2006-2007	FLOODWAY ROAD CROSSING	
EXAMINED F MOLLOY Unit Head	CONSTRUCTED	AMEND 1	SHEET 25	DRG S-4112
ENDORSED F WILSON Manager, Structures	Title Date		PAVEMENTS STRUCTURES


E2

The Gammon Ranges Project

- Project managed by Scientific Expedition Group (SEG), a volunteer organisation.
- The aim of the group is to provide field experience, particularly to young people.
- Site approximately 600km north of Adelaide.
- Started in 1988, continually evolving.
- Main monitoring within a national park.


1000
800
600
400
200
Elevation (metres)
Line of Cross Section
Arcoona Bluff
Exclusion Enclosure
Sambot Waterhole
South Branch
Gammon Plateau
Mount Serle
Mount McKinlay
Balcanoona
Copley
Aroona Dam
Leigh Creek South
Maynards Well
North Mooloolloo
Pfitzners Well
Mocatoona
Legend
Rainfall Sites
Streams
Roads
Arcoona Ck. catchment
Emu Ck. catchment
Windy Ck. catchment

The Gammon Ranges Project

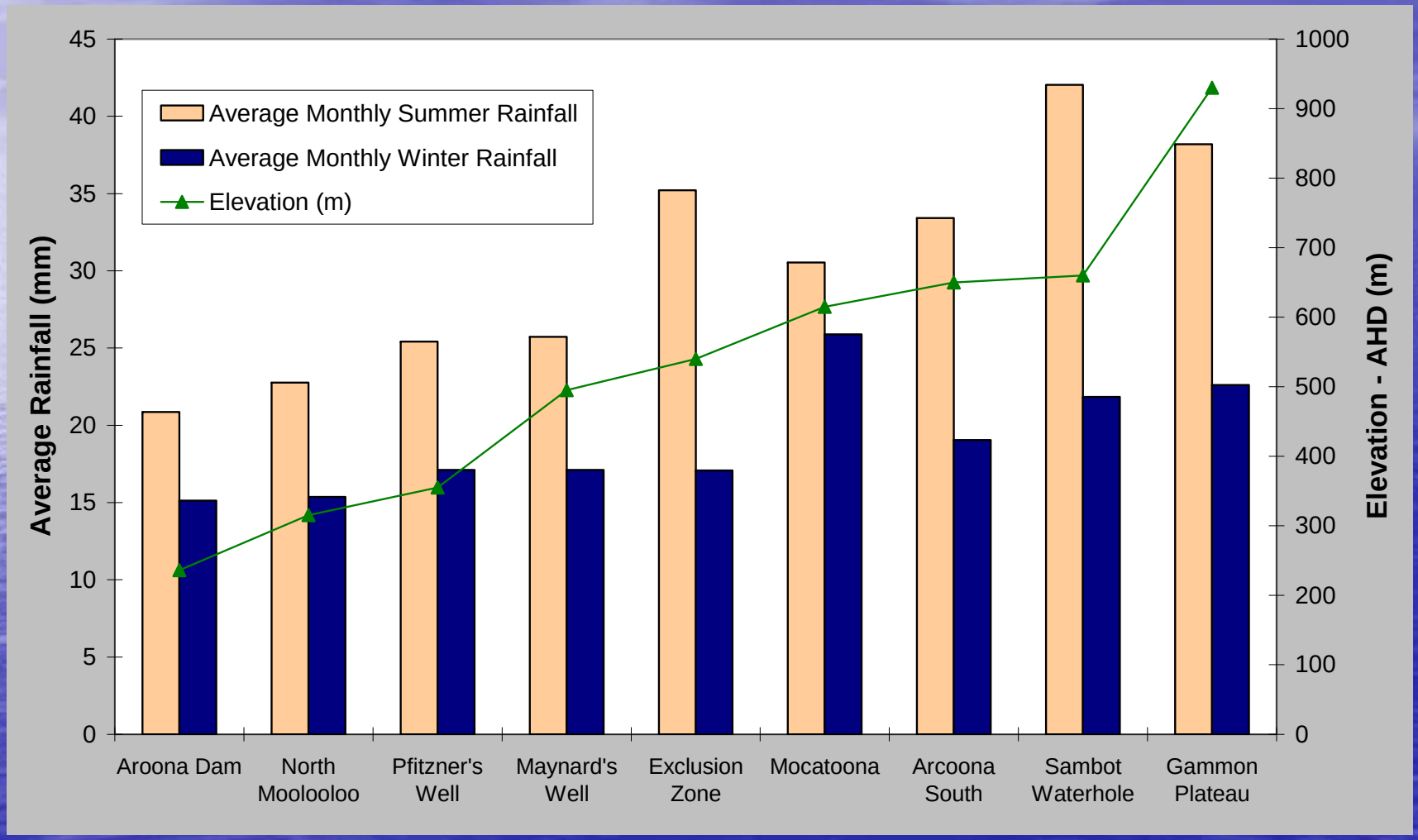
- Pluviometers at eight sites, in two catchments.
- Botanical monitoring at six sites within the national park,
- Aquatic biology monitoring at two sites within the park,
- Human impact monitoring at three sites associated with the monitoring activities.

The Gammon Ranges Project

- Stream flow monitoring and electrical conductivity recording at one site on Arcoona Creek,
- Yellow footed rock wallaby colony monitoring, and
- Feral animal counts and locations.

The Gammon Ranges Project

- Winter rainfall events are generally low intensity, with orographic effects.
- Summer rainfalls are either localised convective storms, or caused by slow moving tropical low pressure systems.
- There is very significant variability in rainfall, that masks any trends


Average Monthly Summer Rainfall
Average Monthly Winter Rainfall
Elevation (m)
Average Rainfall (mm)
Elevation - AHD (m)
0
5
10
15
20
25
30
35
40
45
0
100
200
300
400
500
600
700
800
900
1000
Aroona Dam
North Moolooloo
Pfitzner's Well
Maynard's Well
Exclusion Zone
Mocatoona
Arcoona South
Sambot Waterhole
Gammon Plateau

Stream Flow

- Arcoona Creek - 49.1km^2 catchment.
- Rating is theoretical only.
- Flow in the creek is rare (most years have no flow), but very large flows do occur.
- Flood frequency analysis has low confidence due to the number of no flow years, and the variability.
- A flow in 1989 of 150m^3/sec to 200m^3/sec

Stream Flows

Year	Peak Flow Date	Peak Flow (m^3/s)	Comment
1993	12 December	6.0	
1994	-	-	
1995	16 January	47.5	
1996	15 March	92.7	
1997	7 February	10	Gauge not operating – estimated flow from flood level
1998	-	-	
1999	-	-	
2000	20 February	2.7	
2001	-	-	
2002	-	-	
2003	-	-	
2004	-	-	
2005	-	-	

Flood Modelling

- For two events examined, flow went from zero to peak in about 10 minutes.
- Both events caused by short duration, intense rainfall bursts.
- Modelled using RRR model, can account for more than one runoff process.

Flood Modelling

- Large continuing loss, possibly due to large creek gravel deposits.
- Evidence of a “base flow”, probably from water stored in the gravel deposits.
- Rapid response once losses are taken up.
- Variability in modelled parameters probably due to limitations in rainfall data input.

Insights

- Flow in semi-arid areas very variable
- Floods can have a big impact on road infrastructure
- Main issues are associated with the mobility of watercourses, and debris
- Due to high flows (when they happen) and low road usage, it is best to design roads to resist flooding

Insights

- This involves the extensive use of cement treated or concrete pavements
- Monitoring has shown that creek systems have large losses, but rapid response times
- Flow monitoring is difficult, but necessary if design flows are required

Challenges

- It will always be difficult to construct and maintain fixed infrastructure in a movable environment
- Stream monitoring is difficult, and will remain so
- However long term monitoring is required to define design flows

Challenges

- Design flows are likely to become more important as more venerable infrastructure is placed in arid and semi-arid environments.
- Who is going to pay for and manage this monitoring?

Summary

- The January 2007 floods caused significant damage to road infrastructure.
- We are learning all the time how to build immovable structures in a very mobile environment.
- Arid zone hydrology is characterised by extreme variability, and this makes it difficult to predict flood flows.