POWER AND WATER AUTHORITY
WATER DIRECTORATE

NORTHERN TERRITORY
FLOOD WARNING SYSTEMS
OPERATION
DECEMBER 1986 TO JUNE 1987

REPORT 19/1987

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Water Resources Group
Darwin
November 1987
ABSTRACT

This report describes in detail the components of the flood warning systems for Katherine, the lower Daly River and Alice Springs. The performance of each component of these systems during the 1986/87 wet season, and the overall performance of the systems are discussed. On the basis of performance, equipment upgrades are recommended.
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1. INTRODUCTION

Prior to the 1986/87 wet season in the Northern Territory, a flood warning system was installed at four gauging stations on the Katherine and Daly Rivers; these being Katherine Bridge, Katherine Gorge, Daly River Police Station and Daly River Mount Nancar. A flood warning system has been in operation for Alice Springs since 1984.

This report describes in detail the components of each of these systems, the performance of each component and the overall performance of the flood warning systems.

An important point to note is that during the testing period, there were two occasions when the Northern Territory Emergency Service (NTES) utilised the information available from the Katherine/Daly system to assist in their handling of flood events (Reference 2). From the information gained by the system, Water Resources Group was able to provide the NTES with a 12 hour forecast of heights for the Katherine River, thus removing much of the uncertainty involved with flood forecasting. The Alice Springs system was also used during 1986/87; Childs (Reference 1) reported on this event.
2. DESCRIPTION OF THE FLOOD WARNING SYSTEMS

2.1 Katherine/Daly System

The equipment used in the flood warning system fits directly onto existing stream gauge stations. Figure 2.1(a) is a diagrammatic representation of the components of the system. The components of the system are listed in Table 2.1(a).

(Note: Pulse Generator fits directly onto shaft from water level sensor)

FIGURE 2.1(a)

DIAGRAMMATIC REPRESENTATION OF THE KATHERINE/DALY FLOOD WARNING SYSTEM
At present, the encoder/logger is examined either from the Darwin office, or from a portable unit which connects to any standard phone socket and is user activated. Information stored in the logger can be dumped and cleared directly from the office. At present dumped information goes onto a hard copy device (line printer). The amount of memory available depends on the recording interval (one hour intervals allows 33 days memory, 12 hour intervals allow 400 days memory).

The field processor is used to program or interrogate the logger/encoder on site.

Appendix A shows the cost of converting an existing stream gauge station into a flood warning site, and also the office costs to allow interrogation of such a site, in the Katherine/Daly system.

TABLE 2.1(a)

KATHERINE/DALY FLOOD WARNING SYSTEM COMPONENTS

<table>
<thead>
<tr>
<th>SITE</th>
<th>COMPONENT</th>
<th>TYPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field</td>
<td>Sensor</td>
<td>Pressure head sensing unit</td>
</tr>
<tr>
<td></td>
<td>Pulse Generator</td>
<td>Stevens</td>
</tr>
<tr>
<td></td>
<td>Encoder/Logger</td>
<td>Stevens Telemark</td>
</tr>
<tr>
<td></td>
<td>Modem</td>
<td>Volksmodem 12</td>
</tr>
<tr>
<td></td>
<td>Power Supply</td>
<td>Battery with solar charging</td>
</tr>
<tr>
<td></td>
<td>Field Processor</td>
<td>Cannon X-07</td>
</tr>
<tr>
<td>Field/Office/</td>
<td>Communications</td>
<td>Telecom phone line</td>
</tr>
<tr>
<td>Home Office</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Office</td>
<td>Modem</td>
<td>Volksmodem 12</td>
</tr>
<tr>
<td></td>
<td>Terminal/Monitor</td>
<td>DEC VT131</td>
</tr>
<tr>
<td>Home</td>
<td>Modem</td>
<td>Volksmodem 12</td>
</tr>
<tr>
<td></td>
<td>Computer</td>
<td>Cannon X-07</td>
</tr>
</tbody>
</table>

5a:BST
Table 2.1(b) lists those sites already installed, and those marked for installation before the next wet season. Figure 2.1(b) shows the locations of these sites.

<table>
<thead>
<tr>
<th>SITE</th>
<th>NAME &amp; LOCATION</th>
<th>PHONE NO.</th>
<th>INSTALLED</th>
</tr>
</thead>
<tbody>
<tr>
<td>GS 8140001</td>
<td>Katherine Railway Bridge</td>
<td>72 2270</td>
<td>Yes</td>
</tr>
<tr>
<td>GS 8140023</td>
<td>Katherine Gorge Caravan Pk</td>
<td>72 3922</td>
<td>Yes</td>
</tr>
<tr>
<td>GS 8140003</td>
<td>Daly River, Police Station</td>
<td>75 3415</td>
<td>Yes</td>
</tr>
<tr>
<td>GS 8140040</td>
<td>Daly River, Mount Nancar</td>
<td>75 3493</td>
<td>Yes</td>
</tr>
<tr>
<td>GS 8140067</td>
<td>Daly River, Claravale</td>
<td></td>
<td>No</td>
</tr>
<tr>
<td>GS 8140042</td>
<td>Daly River, Beeboom Crossing</td>
<td></td>
<td>No</td>
</tr>
</tbody>
</table>

The two Daly River sites utilise the new Telecom microwave radio service, as opposed to the land lines used for Katherine. The two new sites are expected to be installed in the next financial year, using the new radio system.

2.2 The Alice Springs System

As with the Katherine/Daly system, the equipment used fits directly onto an existing gauge or pluviometer station. With the short warning time (2-3 hours) however, the Alice Springs system requires more intelligent components in the field. These components allow the field installation to initiate warning of a flood event rather than rely on user instigated contact from the office or a portable unit.

5a:BST
KATHERINE/DALY RIVER FLOOD WARNING SYSTEM

The flood warning system is a network of recorders with communication links to Darwin. River levels can be predicted. When necessary flood warnings are issued by Emergency Services (Police).
A diagrammatic representation of the system is given in Figure 2.2(a). Components of the system are listed in Table 2.2(a).

![Diagram of the system](image)

**FIGURE 2.2(a)**

**DIAGRAMMATIC REPRESENTATION OF ALICE SPRINGS FLOOD WARNING SYSTEM**

At present, the encoder is interrogated by the data logger which in turn may be interrogated from a computer or portable unit via a modem from any standard telephone connection at user instigation. The data logger is an intelligent unit, which once a set alert flood level is reached, will via the modem ring a series of telephone numbers continuously until an answer is received. Thus, there is no need for continual interrogation and an early alert can be given in real time.
TABLE 2.2(a)

ALICE SPRINGS FLOOD WARNING SYSTEM COMPONENTS

<table>
<thead>
<tr>
<th>SITE</th>
<th>COMPONENT</th>
<th>TYPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field</td>
<td>Sensor</td>
<td>Float</td>
</tr>
<tr>
<td></td>
<td>Encoder</td>
<td>Stevens memomark</td>
</tr>
<tr>
<td></td>
<td>Data Loggers</td>
<td>Sharp Pocket PC/JED</td>
</tr>
<tr>
<td></td>
<td>Modem</td>
<td>Case</td>
</tr>
<tr>
<td></td>
<td>Communications</td>
<td>Telecom phone line</td>
</tr>
<tr>
<td>Office</td>
<td>Modem</td>
<td>Various</td>
</tr>
<tr>
<td></td>
<td>Computer</td>
<td>PRO</td>
</tr>
<tr>
<td>Home</td>
<td>Computer</td>
<td>NEC Personal Computer</td>
</tr>
</tbody>
</table>

Table 2.2(b) lists the sites at which flood warning equipment has been installed. The locations of these sites are given in Figure 2.2(b).

TABLE 2.2(b)

FLOOD WARNING SITES IN THE ALICE SPRINGS SYSTEM

<table>
<thead>
<tr>
<th>SITE</th>
<th>NAME AND LOCATION</th>
<th>PHONE NO.</th>
</tr>
</thead>
<tbody>
<tr>
<td>GS 0060046</td>
<td>Todd River Wigley Gorge</td>
<td>52 6814</td>
</tr>
<tr>
<td>GS 0060009</td>
<td>Todd River Wills Terrace</td>
<td>52 5435</td>
</tr>
<tr>
<td>R 0060009'B'</td>
<td>Bond Springs</td>
<td>52 6728</td>
</tr>
</tbody>
</table>

The Bond Springs and Wigley Gorge sites use Telecom VHF radio services and solar power supplies while a land line and main power are used at Wills Terrace.

5a:EST
LEGEND

- CATCHMENT BOUNDARY

△ GS0060046 GAUGE STATION

○ R0060046 RAIN GAUGE STATION

TODD RIVER CATCHMENT TELEMETRY STATIONS

Fig. 2.21b
3. PERFORMANCE OF THE FLOOD WARNING SYSTEMS

This chapter describes in more detail the components of the flood warning systems, and each unit's performance and reliability.

Appendix B is a tabulated and summarised form of the following information.

3.1 Katherine/Daly System

3.1.1 Components

Terminal Monitor

Description: Digital Equipment Corporation VT131 video terminal.

Special Features: Printer Port - allows for dumping data onto hard copy. RS232c Communication - easily modifiable for use with different devices.

Cost: $900.00

Number in Stock: 2 1 in Darwin office
1 in Katherine office

Performance: (To 30 June 1987)

Darwin Office - Uptime 100% since 23 Dec 1986
Katherine Office - Uptime 100% since 23 Jan 1987
Modem (Office and Field)

Description: Volksmodem 12 Intelligent Data Modem

Special Features: Auto Dial, Auto Answer, 1200 baud,
microprocessor provides limited command language.

Cost: $820 (local distributor, serviced in Victoria).

Number in Stock: 6
1 Darwin office
1 Katherine Bridge
1 Katherine Gorge
1 Daly River Police Station
1 Daly River Mount Nancar
1 Spare

Performance (23 Dec 1986 to 30 June 1987):

- Darwin office - 100% uptime
- Katherine Bridge - 100% uptime
- Katherine Gorge - 100% uptime
- Daly River Police Station - 91% uptime (replaced units twice through lightening strike)
- Daly River Mount Nancar - 100% uptime

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### Telecom Line

**Description:**
- Darwin Office - direct line
- Katherine Bridge - direct line
- Katherine Gorge - direct line
- Daly River Police Station - UHF radio line
- Daly River Mount Nancar - UHF radio line

**Cost:**
$1500 for UHF radio connection

**Performance (23 Dec 1986 to 30 June 1987):**
- Katherine Bridge - 100% uptime
- Katherine Gorge - 95% uptime (lines submerged in flood event caused failure)
- Daly River Police Station - 70% uptime (lightening strike/Telecom failure)
- Daly River Mount Nancar - 96% uptime (Telecom equipment failure)
Encoding Equipment

Description: Stevens Telemark II encoder

Special Features: Capable of storing 800 records if one input device, 500 records if two input device. Variable communication parameters. Water level range of 0-99.999 m

Cost: $1750 (available from Victoria distributor)

Number in Stock: 5
1 Katherine Bridge (memory)
1 Katherine Gorge (memory)
1 Daly River Police Station (no memory)
1 Daly River Mount Nancar (memory)
1 spare (no memory)

Performance (23 Dec 1986 to 30 June 1987):
All sites 100% uptime.
Reliability of data still to be examined.

Pulse Generator

Description: Stevens Pulse Generator

Special Features: Fits directly onto existing recorder of existing gauging station.

Cost: $1450 (available from Victoria distributor)
Number in Stock: 5 One each at each site + 1 spare

Performance: Katherine Bridge - Unit failed on 23 January 1986. Unit sent for repair. Uptime 96%.

Other sites: 100% uptime.

Power supply

Description: Power supply

Special Features: Battery supply constantly charged by solar panel. Power dissipators used to discharge excess power generated by cells.

Cost: Approx. $400 (all parts purchased and assembled locally).

Number in Stock: One at each site plus components at workshop for at least one spare unit.

Performance: 100% uptime.

Field Interrogation Unit

Description: Cannon X-07 hand held computer.

Special Features: Runs microsoft basic.
Simple but efficient communications to RS232c ports.
Easily programmable for field and office use.

5a:BST
Cost: Approx. $600 (includes level converter for RS232 comms).

Number in Stock: 2, both in office

Performance (since 23 Jan 1987): 100% uptime.

3.1.2 Overall performance of each site 23 Dec 1986 to 30 June 1987

Katherine Bridge: Accessible 96% of testing period. 4% failure of pulse generator. 1 week information lost in downtime period. Repair cost of faulty pulse generator not yet available.

Katherine Gorge: Accessible 95% of testing period. 5% failure by Telecom. No information lost in downtime period.

Daly River Police Station: Accessible 60% of testing period. 31% failure by Telecom, 9% failure of modem. No information lost in downtime period.

Daly River Mount Nancar: Accessible 96% of testing period. 4% failure by Telecom. No information lost in downtime period.

5a:BST
3.2 Alice Springs System

3.2.1 Performance of each site

(i) Bond Springs
   (advance warning rainfall station).

   One period of downtime to 30 June 1987. Six weeks April-May, suspected Telecom fault. Accessible 78% of testing period. 22% failure due to Telecom.

   Total down time is high because of low priority given to effecting repairs during dry season.

   Software has since been modified to give improved self monitoring and reporting of battery status.

(ii) Wigley Gorge
   (key river height prediction station)

   Three periods of downtime:
   (b) Approximately six weeks Dec-Jan 1987 due to second theft of Telecom equipment.
   (c) Two days, June 1987, due to battery failure.

   Accessible 80% of time. 19% of failure due to loss of Telecom equipment. 1% due to battery problems.
(iii) Wills Terrace 1 period of down time - February 1987 to June 1987. All equipment required replacement or repair. Lightning strike suspected. Re-installation was delayed due to lack of appropriate staff, also this gauge is less critical as it can be manually read if required.

3.2.2 Running costs of Alice Springs System

The Wills Terrace equipment was installed at the beginning of 1984; that at Wigley Gorge became operational at the beginning of 1985 and that at Bond Springs at the beginning of 1986.

- The Bond Springs installation has required no further expenditure, merely topping up batteries, and battery recharging on one occasion.

- Wigley Gorge required replacement of batteries after 2 years (a reasonable life for the application) costing approximately $200. A protective enclosure to prevent theft of Telecom equipment cost $400 (materials only), though this is properly viewed as part of the capital cost. Various other failures (corrosion of wiring, jamming of shaft encoder) were dealt with in-house and not costed.

- Wills Terrace has required replacement of one battery ($80) and repairs to modem (twice, $560), logger ($309), and power supply (in-house). Most of those repairs are related to a single major failure; the repairers describe the damage as being consistent with high voltage surge (i.e. lightning strike).
Average maintenance costs are therefore $109 per station per year. This does not however reflect the in-house effort required to keep all equipment running. In the most recent 12 month period, 9 man-days have been spent on maintaining the system. That is equivalent to $675 per station per annum costing officer time at $30 per hour. An integrated, properly engineered commercial system would be expected to require a fraction of this.
4. FUTURE ENHANCEMENTS

4.1 Katherine/Daly System

4.1.1 Microprocessor at flood warning site

The present Katherine/Daly system requires all interrogation to be performed from the office. This presents problems including high telephone costs and lag time in a flood event.

Efficiency could be improved by introducing some 'intelligence' at the flood warning site itself as in the case of Alice Springs. If a microprocessor were introduced into the system, then most of the flood warning control would be automated and taking place at each particular site. In the event of a flood, the processor would determine that the height has passed a designated watch point, and Water Resources Group staff could be alerted by means such as telephone beepers. The processor also provides advantages such as warning the office staff when the memory starts to become full so that a data dump can be performed.

4.1.2 Cheaper pulse generators

Hydrological Services have informed Water Resources Group of the availability of an equivalent pulse generator to the Steven's version, but at a cost of approximately $700. One of these units has been purchased and is to be installed at our test site on Darwin Wharf. If it proves successful, it represents a $700 saving to the cost of each flood warning site.
4.1.3 Replace monitor with personal computer (P.C.)

At present the data recorded by the encoder/pulse generator is printed out in the office, and compared against LSF charts to test reliability. This and future data will have to be stored directly into computer data files or on mass storage devices. This involves the use of an intelligent monitor or P.C.

Because of the standard of current networking software, it is not important which brand of P.C. is utilised. The only pre-requisite it must have is the ability to link into an Ethernet network system.

4.2 Future Enhancements To The Alice Springs System

4.2.1 Status of flood warning equipment

All stations are now in excess of the two year design life envisaged for the Stage 1 interim system. Components are essentially what was available within the organisation in 1983/84 and are not in the main designed for field use.

Of the two Memomark shaft encoders one is expected to last only one more summer period (1987/88). Custom-built interfaces between encoders and loggers are all different, and in the case of Wills Terrace, rather delicately constructed.

The risk of system failure is therefore relatively higher than that of a commercial hydrologic product, and is likely to occur at times of system stress, viz. during a flood event. A major difficulty when responding to failures is that up to six items are connected together (at Wills Terrace), with the order
of power-up critical to operation of the system. Identification of a problem causing non-performance is rendered difficult by the non-integrated nature of the components and the lack of any engineered self-testing and self-monitoring abilities. The software is the best aspect of the system, containing some features not included in general purpose data loggers.

Specification and selection of commercial data recorder/warning equipment has been held up pending the finalisation of an overall electronic instrumentation strategy for the Water Resources Group. Current organisational developments have rendered an early finalisation unlikely. It is therefore recommended that equipment for flood warning be selected in advance of the overall strategy with the ability to integrate with future electronic data recording systems being one of the selection criteria.

4.2.2 Status of flood forecasting techniques

Computer programs for flood forecasting are still embryonic; the only current program is a prototype for routing flows in the 8 km above town. (From Wigley Gorge GS to Wills Terrace GS; see Reference 3). Officers have gained experience in the interpretation of rainfall and predictions of likely streamflow responses in a range of small flow events; the use of the RORB model with Bond Springs rainfall as a forecast tool should be investigated, particularly for larger events.

One apparent weakness in forecasting flood levels in Alice Springs is the lack of telemetry on the Charles River which joins the Todd River just above Wills Terrace gauging station. Historically the Charles

5a:B8T
River is reported to have broken its banks and flooded parts of the central town area at times when flow in the Todd River was low. It is recommended that the potential effects of flood flows in the Charles River be investigated; if significant, the Charles River gauging station (GS0060047) should be equipped as a floodwarning site.
5. A CHANGE IN DIRECTION?

It has been shown that a flood warning system can be utilised to effect during a flood event. The systems are desirable for the Northern Territory, being established and operated by Water Resources Group for NTES.

Although successfully operated, the present flood warning systems have shortcomings. These systems were designed using the philosophy that it is better to design a system in-house, since expertise is then located within the Water Resources Group, and a system which serves the precise needs of the Northern Territory can be developed.

With hindsight, this philosophy has left the Group with problems. Realistically, internal staff are not permanent fixtures of the Group. The particular staff with that developed expertise can leave, thus placing the Group back to almost square one (both Alice Springs and Darwin offices are facing this problem).

Also, those staff involved in the project can usually only devote part of their time to that project. In Darwin, the flood warning project effectively received only a few weeks preparation time and then less than one day per week during the trial period.

As only a relatively small amount (less than $20,000) has been spent on the current equipment, it may be a good time to examine our original philosophy and possibly alter the strategy for future years. There are a number of companies which now provide electronic data collection equipment for hydrological and
meteorological services. Of these, a number also provide flood warning systems. The easiest and most cost efficient solution to providing an automated and reliable flood warning system may be to utilise this already developed technology.

The advantages are:

1. These systems have already been through a development and testing period. The system we purchase will need only limited testing.

2. Expertise and advice is always available through the supplying company.

3. All maintenance and repairs to the system would be provided by the one company.

4. Such a system would then be integrated and compatible with other non-flood warning electronic instrumentation.

It is recommended that Water Resources Group develop specifications for Territory flood warning systems, and that expressions of interest for supplying the equipment be sought. The Group can then make a value judgement as to whether to continue the current strategy, or to adopt a system from a single supplier.
6. REFERENCES

1. CHILDS, J. (1986); Alice Springs Flood Forecasting System Performance During Flow Event June/July 1986; Department of Mines and Energy; Water Resources Report No. 15/1986


3. SANANIKONE, V. (1985); Flood Forecasting Model for the Todd River, Alice Springs; Department of Mines and Energy, Water Resources Division.
APPENDIX A

COSTING BREAKDOWN FOR KATHERINE/DALY FLOOD WARNING SYSTEM

Office Cost:

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Terminal/Monitor</td>
<td>$900</td>
</tr>
<tr>
<td>1 Modem</td>
<td>$820</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$1720</strong></td>
</tr>
</tbody>
</table>

The cost to place a field unit into an existing stream gauge station is:

**Field Cost (each site)**

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Encoder/Logger</td>
<td>$2150 (1750+400)</td>
</tr>
<tr>
<td>1 Pulse Generator</td>
<td>$1450</td>
</tr>
<tr>
<td>1 Telecom Line</td>
<td>$1500</td>
</tr>
<tr>
<td>1 Modem</td>
<td>$820</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$5920</strong></td>
</tr>
</tbody>
</table>
## APPENDIX B

### TABULATED PERFORMANCE OF KATHERINE/DALY FLOOD WARNING SYSTEM

Note: All figures are percentages of accessibility time for period 23 December 1986 to 30 June 1987 (189 days)

<table>
<thead>
<tr>
<th>EQUIPMENT</th>
<th>OFFICE</th>
<th>KATHERINE BRIDGE</th>
<th>KATHERINE GORGE</th>
<th>DAILY RIVER POLICE STN</th>
<th>DAILY RIVER MT NANCAR</th>
<th>EQUIPMENT AVERAGE UPTIME (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Office Monitor</td>
<td>100%</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>100%</td>
</tr>
<tr>
<td>Office Modem</td>
<td>100%</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>100%</td>
</tr>
<tr>
<td>Telecom Line</td>
<td>N/A</td>
<td>100%</td>
<td>95% (179 days)</td>
<td>70% (132 days)</td>
<td>96% (181 days)</td>
<td>90% (170 days)</td>
</tr>
<tr>
<td>Field Modem</td>
<td>N/A</td>
<td>100%</td>
<td>100% (172 days)</td>
<td>91% (184 days)</td>
<td>100% (187 days)</td>
<td>98% (184 days)</td>
</tr>
<tr>
<td>Encoding Equipment</td>
<td>N/A</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>Pulse Generator</td>
<td>N/A</td>
<td>96% (181 days)</td>
<td>100%</td>
<td>100%</td>
<td>98% (187 days)</td>
<td>98% (187 days)</td>
</tr>
<tr>
<td>Complete System</td>
<td>100%</td>
<td>96% (181 days)</td>
<td>95% (179 days)</td>
<td>60% (113 days)</td>
<td>96% (181 days)</td>
<td>87% (164 days)</td>
</tr>
</tbody>
</table>
APPENDIX C

PUBLIC EDUCATION INFORMATION ALICE SPRINGS

A3 size colour brochure produced (in conjunction with Emergency Service) and released July 1987.

Talks on flooding given to classes at Anzac Hill High School and Sadadeen Secondary College.

Briefing to Joint Geophysical and Geographic Research Station re hazard to their installation.

Expert witness to arbitration proceedings on flood damage.

Report to insurance company on the flood hazard and damage to a construction project.

Numerous advices to developers and public on flood risks.

Department of Lands and Housing (Southern) finally accepted responsibility for disseminating information from most up-to-date mapping.

Briefed Emergency Service volunteer group on all flooding issues, particularly the operation of the forecasting system.