

2018

Rockfall Risk Management Plan



Emergency Management Committee
Christmas Island

Adoption by the EMC

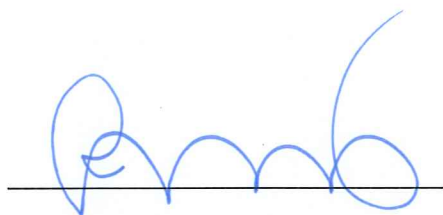
The Christmas Island Rockfall Risk Management Plan (RRMP) is a result of the 1997 Parliamentary Standing Committee on Public Works report on the Implementation of Rockfall Risk Reduction Strategies on Christmas Island. The RRMP recognises the Commonwealth's commitment to reducing rockfall risk across Flying Fish Cove.

The Murray Road section of this plan was introduced by Council resolution by the Shire of Christmas Island in 2009. This section recognises the Shire's responsibility to minimise the risk to road users in this area.

The RRMP is maintained by the Indian Ocean Territories Administration (IOTA) Emergency Management Officer as secretariat to the EMC.

The Rockfall Risk Management Plan is adopted by the Emergency Management Committee to ensure a coordinated response to rockfall risk on Christmas Island. As Chair of the EMC, the Administrator signs on behalf of the Committee recognising their commitment to the strategies within the RRMP.

The Christmas Island Rockfall Risk Management Plan is hereby adopted by the Christmas Island Emergency Management Committee

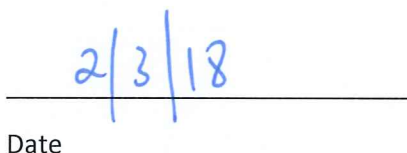


Natasha Griggs

Administrator

Chair

Christmas Island Emergency Management Committee



Date

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Amendments

Proposals for amendment or addition to the contents of the Plan are to be forwarded to:

Emergency Management Officer

Indian Ocean Territories Administration

Department of Infrastructure Regional Development and Cities

PO Box 868

Christmas Island 6798

Or via email to operations@infrastructure.gov.au

Document history and status

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Original	GHD			2001
Review	DOTARS -			2004
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Full	DOTARS - Karenn Singer	Administrator Neil Lucas	16 June 2006	2006
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Review Rainfall Triggers	IOTA – Mark Slattery	Administrator Jon Stanhope		2013
Review of Actions	IOTA – Chantelle Powell	Administrator Barry Haase		2016
Updated Level 1 Action Table	IOTA – Jessica Sullivan	EMC Executive		2016
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Australian Government

**Department of Infrastructure,
Regional Development and Cities**

Rockfall Risk Management Plan

Flying Fish Cove and Road to Smith Point

Christmas Island

Part 1 – Flying Fish Cove and Road to Smith Point

Summary

A Rockfall Risk Management Plan was developed for the Flying Fish Cove area of Christmas Island in March 1997 and was revised by GHD at the request of the Department of Transport and Regional Services in August 2001. It has since been updated to incorporate information from annual inspections, exercises and any incidents.

The Plan details the strategies and actions to:

- reduce the risk of rockfall impacting upon the individuals, community and facilities;
- increase the community awareness of the rockfall hazard, its causes, mitigation efforts and methods.

A series of consultations with the community and authorities were held between 5 and 12 November 1996 and reference was made to the past studies and reports about the rockfall risk at Flying Fish Cove.

The March 1997 Management Plan included requirements for the construction of fencing and warning signs and the erection of rockfall barriers to the areas at higher levels of risk. These were completed.

A further review of landslide risks was undertaken in July 2000.

The rockfall barriers were extended to the length of the Kampong and a secondary barrier comprising an earth berm was constructed in the areas subject to a greater risk of rockfall.

In 2006 a review was undertaken to assess the landslide risk and recommend risk reduction measures along Jalan Pantai where it extends from Flying Fish Cove to Smith Point.

In 2012/13, a review was undertaken using records and data to assess the accuracy of the Level 1 and Level 2 triggers.

It was recommended that the Rockfall Risk Management Plan be updated to reflect the possibility of a catastrophic tank failure due to an identified issue of the water tank foundations at Drumsite and George Fam. This measure is no longer required as the foundations of the water tanks have been strengthened.

The Management Plan has therefore been structured around the following:

- Control of Population Exposure to Hazard** by land use planning and reductions in activity on the foreshore, either permanently or during periods of high risk.
- Warning Mechanisms** leading to appropriate responses at times of greater risk. Monitoring of rainfall, seismic activity and rockfall incidents are the factors with potential for warning of rockfall. These factors have been grouped under two levels of warning conditions:
 - Level 1 condition – possible indicators of a potential event.
 - Level 2 condition – probable indicators of a likely event.
- Community Awareness** and Education Programs to inform, involve and educate the community to increase the perception of the hazard, its causes, mitigation efforts and methods. Develop a broader awareness of the Level 1 and Level 2 warning conditions and the expected response to them by the community.

- iv. **Research** to collect data over time to improve the understanding of the slope processes and refine the risk analysis.
- v. **Review** of the plan to ensure that recommendations made by specialist personnel and those involved with the plan are updated, and improvements to the plan are made.

Each of these strategies is developed by the plan to provide a series of actions with responsibilities.

It should, however, be realised by all concerned that a risk management plan can reduce but never entirely remove the risk of injury/fatality due to a rockfall event.

The main stakeholders and participants in the implementation of this management plan are:

- Administrator
- Department of Infrastructure Regional Development and Cities
- Indian Ocean Territories Administration
- Shire of Christmas Island
- Australian Federal Police
- Kampong Residents
- Harbour Master
- Indian Ocean Stevedores

Other stakeholders include:

- Emergency Management Australia
- The Bureau of Meteorology
- Water Corporation
- Indian Ocean Oil Company
- Indian Ocean Power Service
- Radio Station 6 RCI
- Australian Border Force
- Royal Australian Navy

1. Introductory Provisions

1.1 Background

By resolution on 17 June 1996, the House of Representatives referred the proposed implementation of rockfall risk reduction strategies on Christmas Island (Reference 1) to the Parliamentary Standing Committee on Public Works for consideration and report to parliament. Included in the strategies was a requirement to have in place a rockfall risk management plan before December 1996. Accordingly the following rockfall risk management plan was commissioned by the Department responsible for the Indian Ocean Territories on 31 October 1996 and prepared by Works Australia during November-December 1996. Advice on the plan was provided by Consulting Engineering Geologist Dr Fred Baynes. The Plan was revised in 2001, updated in October 2004, September 2005, June 2006 and March 2013.

The plan is administered by the Department responsible for the Indian Ocean Territories (the Department) through the Indian Ocean Territories Administration.

1.2 Title and Purpose

This management plan shall be referred to as the Rockfall Risk Management Plan – Flying Fish Cove and Road to Smith Point (RRMP). The purpose of the RRMP is to reduce the risk of injury or death to individuals and the risk of damage to property, from rockfall in the Flying Fish Cove and road to Smith Point area of Christmas Island.

1.3 Objectives of the Plan

The objectives of the Rockfall Risk Management Plan – Flying Fish Cove and Road to Smith Point are:

- To detail those strategies and actions that should be implemented to reduce the risk of rockfall impacting upon the individuals, community and facilities.
- To increase the community awareness about the rockfall hazard, its causes and mitigation efforts.

The Plan does not address actions required in the event of a significant rockfall. If this were to occur the Territory Controller would assume responsibility, under the Christmas Island Emergency Management Plan.

1.4 Scope

The Plan relates to the Flying Fish Cove and Road to Smith Point area of Christmas Island, Indian Ocean, and seeks to involve the community as well as those authorities that use and have responsibility for the control of land, buildings, infrastructure, services and activities at Flying Fish Cove and Smith Point.

1.5 Activation & Termination of the Plan

This Rockfall Risk Management Plan commenced in December 1996 in accordance with the recommendations of the Parliamentary Standing Committee on Public Works. The plan shall be continuously maintained and can only be deactivated by the Commonwealth Minister for Home Affairs.

1.6 Authority

As provided in the *Christmas Island Act 1958*, it is the function of the Commonwealth Minister for Home Affairs to provide a legislative basis for the administrative and judicial systems for Christmas Island.

The Administrator of Christmas Island is appointed by the Governor-General under the *Administration Ordinance 1968*, and subject to the direction of the Commonwealth Minister for Home Affairs, is responsible for the law, order and good government of the Territory.

The Plan is authorised and executed by the Administrator of the Territory of Christmas Island.

1.7 Technical Review

The Technical Review of the plan shall be carried out by the Emergency Management Committee.

The Committee shall discuss rockfall risk twice a year, specifically addressing the following:

- to consider each prescribed management action and determine whether or not it is being carried out;
- to evaluate the performance of each prescribed management action in relation to the objective or objectives it is intended to serve;
- to determine the cause of any prescribed action not achieving its objective/s;
- to report to the Administrator the results of the review; and
- to identify and recommend any amendments to the Plan.

Meetings should be held prior to the wet season (approx. October) and subsequent to the wet season (approx. April).

1.8 Related Documents

The plan is to be considered in conjunction with the Christmas Island Emergency Management Plan.

1.9 Interpretation

“Administrator” means the Commonwealth Official appointed to administer the Territory of Christmas Island on behalf of the Commonwealth of Australia under the *Administration Ordinance 1968*.

“Administration” means the Indian Ocean Territories Administration which is the on-island branch of the Department of Infrastructure Regional Development and Cities

“AFP” means the Australian Federal Police

“BoM” means the Bureau of Meteorology

“Department” means the Department responsible for the Indian Ocean Territories

“PWC” means the Parliamentary Standing Committee for Public Works, which conducted the hearing on Implementation of Rockfall Risk Reduction Strategies on Christmas Island in July 1996.

“RRMP” means the Rockfall Risk Management Plan, Flying Fish Cove and Road to Smith Point

“SOCl” means Shire of Christmas Island.

“Stevedores” means the Indian Ocean Stevedoring Company.

“Territory Controller” means the Officer in Charge, Australian Federal Police, who is responsible to the Administrator for the conduct of counter disaster operations.

“6RCI” means Christmas Island Community Radio Station.

2. Risk Identification

2.1 Background

At Flying Fish Cove a series of thickly vegetated cliffs and steep intervening slopes form an amphitheatre about 200 metres high above the Cove. The residential locality of the Kampong, and various other buildings and facilities, have been developed at or close to sea level on the relatively even ground at the base of the slope. The extent of this land, between the base of the cliffs and the shore, is limited and relocating the facilities is not considered viable.

Rockfalls and movements of boulders of various sizes down the slope are a natural process of the slopes of Flying Fish Cove and have been occurring throughout the recorded history of the area.

Whilst many of the boulders stop before they reach the lower slopes, occasionally boulders weighing several tonnes roll down onto the lower slopes and onto the base of the slope. Though there is no evidence of fatality or injury during the last 100 years, there is a risk that residents and facilities could be hit by boulders.

Rockfall risks at Flying Fish Cove were investigated and assessed in 1995 by Golder Associates (Reference 2). That report contains a summary of all of the various previous rockfall risk studies, and includes detailed observations of conditions on the slopes of Flying Fish Cove, analyses of rockfall risks, and quantitative assessment of the risk of fatality. The risks were summarised in the submission to the PWC dated July 1996 (Reference 4) and that summary formed the basis for the PWC deliberations dated 19 September 1996.

Rockfall risks between Flying Fish Cove and the Kampong were investigated in 2006 by GHD Geotechnics (Reference 8). That report found the slopes around Flying Fish Cove, which include the road to Smith Point, are subject to ongoing slope instability and landslide events, particularly during periods of rainfall or seismic activity. The results of the investigation and previous work confirm the active nature of the slopes and the hazard due to rockfalls and debris slides along the road alignment. Complete and effective mitigation of the risks would not be practical or economical, due largely to the extent of the very steep slopes and cliffs above the road. However, implementation of a number of treatment measures and controls, as an extension to the Rockfall Risk Management Plan, will assist to reduce the risk from landslides. The greatest risk to life and property is likely to occur as a result of large rockfalls, while the risk due to debris slides and undercutting of the toe of the slope by wave action is considered to be relatively low.

2.2 The Risks

The area considered to be at risk in Flying Fish Cove is indicated in Figure 1 (Reference 1 and 4). It should be noted that a rockfall could conceivably extend beyond the probable limit of rockfall defined in the figure, but that the risk of this happening is considered to be negligible. The red zones on the map indicate areas where the slope process is currently more active and possible sources of rockfall.

The assessed individual risk of a fatality is the Commonwealth's primary concern. The risk of property damage has therefore not been systematically assessed separately from the risk of fatality.

Level of Risk from Rockfall

The potential type of rockfall event and the assessed likelihood of occurrence giving rise to a level of risk may be summarised as follows:

- Individual boulders, or groups of boulders, each weighing several tonnes, that might roll down the slopes but not reach the lower slopes and thus do not impact upon the community or facilities. Such events can be expected to happen several times every year.
- Individual boulders, or groups of boulders, each weighing several tonnes, that might roll down onto the lower slopes and potentially endangering the community, possibly causing damage to facilities and/or injury or death to individuals. Such events may occur once every few years.
- Compound events, where numerous boulders originating from several different sources around the Cove simultaneously roll down to the lower slopes, due to some factor that could trigger extensive rockfall, such as a major seismic event or a major rainfall event. Each boulder that rolls down onto the lower slopes could then possibly cause damage to facilities and/or injury or death to individuals. Such events might occur once every several decades or every few centuries.

The most obvious risk is that individual boulders, or groups of boulders, might roll down onto the lower slopes and impact upon the community, possibly causing injury or death to individuals and/or damage to facilities including buildings and services.

Compound events, where numerous boulders originating from several different sources around the Cove simultaneously roll down to the lower slopes, are quite conceivable but very much less likely than single events.

2.3 *Potential for Warning of Rockfall*

Loose boulders and potentially unstable parts of cliffs are widespread on the slopes above Flying Fish Cove and to Smith Point, and any one of them might source rockfalls in the future. It is not feasible to physically monitor the stability of each of the boulders or all parts of each cliff, or to remotely sense their condition. However, some warning of rockfall might be provided by monitoring those factors which are known to trigger rockfall events or are observed to be associated with them in some way.

Rockfalls may be triggered by unusually heavy rain or by seismic activity, but they also occur without any identifiable trigger. Large rockfalls may be preceded by smaller rockfalls. Seismic events themselves occur without warning but several seconds might elapse between a seismic event and any rockfall impact on the lower slopes, and minor seismic events may precede more significant events.

It is proposed that the factors that might precede a rockfall incident be grouped into two levels of warning conditions.

- Level 1 condition – possible indicators of a potential event.
- Level 2 condition – probable indicators of a likely event.

Level 2 indicators are therefore considered as being more likely to be followed by a rockfall event than the Level 1 indicators. However, it should be noted that there are no indicators which can be reliably used as absolute warning of a rockfall.

Level 1 Condition – Possible indicators of Rockfall Event

Possible indicators of a rockfall incident include:

- Any rockfall incident greater than 1m³ in aggregate may be a precursor to further rockfall.
- Minor seismic events, typically – earthquake of an intensity of MM4/MM5 or greater on the Modified Mercalli Scale (ref Appendix B).
- Any seismic activity that may result in the failure of the Drumsite Water tank
- Intense rainfall, (for example, a one in five year event), resulting in
 - **52 mm in any hour; or**
 - **163 mm in any 24 hour period.**

Level 2 Condition – Probable indicators of Rockfall Events

Probable indicators of a rockfall incident include:

- Progressive increase of occurrence and intensity of rockfalls, typically greater than 10m³ in aggregate.
- Major seismic events, typically – earthquake of intensity of MM6 or greater on the Modified Mercalli Scale (ref Appendix B).
- Unusually intense rainfall, (for example, a one in fifty year event) resulting in:
 - **113 mm in any hour; or**
 - **356 mm in any 24 hour period.**

Note: These levels are based on advice provided by Dr Tim Mote, Certified Engineering Geologist, ARUP Consulting Engineers January 2013.

2.4 Risks to Utilities

Power

The risk to electrical supplies to the Kampong has been mitigated by the replacement of all overhead power lines with underground cables in 1997. The network has been designed to allow for a ring feed to the area. In the event of a direct hit on a substation it could be isolated and the remaining network restored. This work would require access by electrical staff of the Indian Ocean Power Service (IOTPS) to equipment located in the area.

The power supply to the Kampong is divided across three transformers. In the event of a loss of one substation from a rockfall event it would leave approximately a third of the customers without power until the fault is rectified. If this is not possible for an extended period of time placement of a portable genset for emergency power to the area would be provided. A genset for events of this nature is maintained on Island by IOTPS.

The power cable section along the roadway to Smith Point is vulnerable to damage from impact by a rockfall and would result in loss of the ring capacity to the Kampong and Settlement areas until the fault could be repaired. The cable construction and protection by its location beneath the other pipelines were considered at its time of installation. Any impact on the cable should not result in an exposed live cable as it would automatically be disconnected.

Water and Waste Water

Waste Water Treatment Plant (WWTP)

The Waste Water Treatment Plant (WWTP) on Christmas Island is located at Smith Point. The plant is manned during the week and the operator may visit it on a number of occasions during the weekend.

In the event of a rock fall alarm or incident, the WWTP may not be accessible and/or be evacuated. The WWTP can operate automatically for a period of 24 to 48 hours if there is power supply, but after this time a manual sludge decanting and a visual check of all equipment is required. As a rule, the maximum interval between checking the plant would be 24 hour intervals.

If the power supply was cut at the WWTP due to rock fall, then the WWTP will continue to receive waste water, but it could not be treated. The aeration tank would continue to fill, but decanting could not occur, and eventually the WWTP would overflow. Auxiliary power is not available at the site.

There are no facilities available on Christmas Island to clean up a waste water spill in the marine environment. The spill would mix with the seawater and eventually be dispersed. If access to the WWTP was permitted, action could be taken to prevent further spillage and to avoid contamination into the environment, both terrestrial and marine. The Water Corporation would inform the relevant Health and Environment authorities who will advise which precautions need to be taken.

Waste Water Pump 1

The No. 1 Waste Water Pump Station (PS1) is located along Jalan Pantai behind the Kampong units. PS1 is always heavily loaded during periods of heavy rainfall.

Equipment failure will result in an almost immediate overflow of waste water into the Cove. In the event of a breakdown of the PS1 and or genset, the Water Corporation would require, if possible, access to the site to carry out repairs.

The Water Corporation is currently in the process of designing (and subject to funding) installing overflow storage tanks at PS1. These tanks, when installed, will give approximately three (3) hours of waste water storage before the waste water overflows into the Cove. The major concern of a fall occurring in this area would be the loss of power. A genset has been installed at PS1 which would automatically start should this occur. If the rockfall hit the pump station building, it would need to damage the electrical wiring, the switchboard or the genset before the pump station would fail to work. There is no contingency in place if the pump station failed due to a rockfall.

Pipelines

There are two pipelines that are located along the side section of the concrete road to Smith Point.

Water

The water main has approximately 166m of exposed, above ground, ductile iron pipe. Should this pipe be ruptured due to a rockfall, then it could be isolated at the old boat club and outside the Gaseng fuel tanks. It could then be fed back to the other fuel tanks and refuelling jetty from the water pipe on the pipe rack. Services off the main between the closed valves (ie Tai Jin house and the WWTP) would not have any water supply.

Waste water

The wastewater pipe is also approximately 166m of exposed, above ground, ductile iron pipe. This pipe is used for pumping wastewater from PS1 to the WWTP. With the exception of the southern end of Drumsite and the new IRPC, all waste water collection from Christmas Island is pumped through this pipe. A rupture of this pipeline would result in immediate waste water overflow into the bay, either direct or by flowing down the concrete section of the road and then into the bay. Ruptures to the waste water pipe would not be identified until such time the pipe is inspected. At this time there is no contingency plan in place to repair this section of the pipe. The length of time it would take to repair the pipe would depend on the extent of damage and how quickly Water Corporation can gain access to the pipe. The repair timeframe would be measured in days rather than hours.

Telecommunications

There are no active services in the area and as such there is no danger to telecommunication services from a rockfall.

3. Risk Management Policy

The conclusions and recommendations from the July 1996 hearing of the PWC are attached at Appendix A.

The PWC report details those actions that the Golder Associates report of 1995 (Reference 2) recommended should form part of the risk management plan, which may be summarised as follows:

- Long term land use planning aimed at restricting access to those areas at greater risk of rockfall.
- Establishment of a response to extreme rainfalls.
- Establishment of a response to minor rockfalls and seismic events.
- Education of the community and visitors on the impact of rockfall events.
- A research program.

4. Prescribed Management Actions

The Prescribed Management actions required by the Plan are within the four following basic strategies:

- i) Monitoring of Rainfall, Rockfall and Seismic Activities leading to appropriate responses at times of greater risk.
- ii) Control of Population Exposure to Hazard by land use planning and restricting access to areas at risk, either permanently or during periods of high risk.
- iii) Community Education programs to increase the awareness of the hazard, the nature of the Level 1 and 2 warnings and expected response from the community.
- iv) Research to collect further information on rockfall mitigation, the slope processes and rockfall risks etc.
- v) Review of the RRMP and prescribed actions to ensure effectiveness and currency.

4.1 *Monitoring of Rainfall, Rockfall and Seismic Activities*

Background

Rockfalls have been associated with events of heavy rainfall and major seismic activity (earthquakes). It is also widely recognised that the occurrence of foreshocks is the most reliably established precursor to large earthquakes. Rockfall events are themselves precursor events to further rockfall. Monitoring these three factors and using them as warning indicators forms an important strategy in the RRMP.

Objectives

- To set in place a mechanism to collect data about rockfall events.
- To set the threshold intensities to determine warning conditions for rainfall.
- To set in place a warning – response mechanism for heavy rainfall events.

Prescribed Actions

No.	Proposed Action	Responsibility
i	<p>Monthly Inspections</p> <p>Carry out monthly inspections and clear any rockfall debris at the engineered rockfall barrier behind the Kampong and the slopes to the traffic lights at Smith Point. This is to be undertaken by two persons, one with a technical background, preferably somebody with environmental experience.</p> <p>Inspections are not to take place during periods of heavy rainfall nor for at least 24 hours after the cessation of level 1 and level 2 alarms.</p>	IOTA

	<p>Record the location and size of all significant rockfall activity. Examine the cliff immediately above the barrier and note any unusual geological activity or events.</p> <p>Document all events, including photographic records, to maintain a detailed record that will be useful to predict future behaviour.</p> <p>Inspections and clearing are to be undertaken with great care by two persons, one with a technical background, typically an Environment Officer or equivalent. One person is to approach the rockfall from undisturbed ground and the other remaining to warn of any further movement of rocks or soil in the vicinity. Do not approach any major rockfalls or areas that appear unstable. Inspections are not to take place during periods of heavy rainfall.</p> <p>Arrange for consultation with an experienced Engineering Geologist to discuss any significant events or geological activity and determine if any immediate, short term or long term action is required.</p>	
ii	<p>Barrier Maintenance</p> <p>In conjunction with 4.1.i, inspect the fence, anchorages, posts and base plate, wire ropes and nets and report any changes or obvious wear and tear.</p> <p>Arrange for maintenance of the fence in accordance with manufacturers specifications.</p>	IOTA
iii	<p>Maintenance of Alarm Warning System</p> <p>Maintain and check monthly the rain gauge warning system for correct operation and setting for level 1 and level 2 rainfall conditions.</p> <p>The person/s testing and maintaining the electronic computer and telemetry systems must be appropriately experienced / qualified, preferably a telecommunications technician.</p> <p>IOTA are to inform the AFP and SOCI of any problems with the alarm warning system.</p> <p>Test the Emergency Telephone installed at Flying Fish cove. This phone may only be used to contact the AFP and Hospital.</p>	<p>Prime:</p> <p>IOTA</p> <p>Support:</p> <p>BOM to undertake annual calibration check of rain gauge.</p> <p>Support:</p> <p>IOTA to change data loggers and clean filters of rain gauge bimonthly.</p>
iv	<p>Each time an alarm is triggered, check equipment and confirm that it is not a false trigger and record</p>	Prime:

	<p>details accordingly.</p> <p>The AFP is to notify IOTA and SOCI of false alarms. IOTA / DIRD to arrange rectification of alarm system.</p>	<p>AFP</p> <p>Support:</p> <p>SOCI and DORA</p>
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4.2 *Control of Population Exposure to Hazard*

Background

The area covered by the Plan is being used for a diverse range of activities. Apart from the Kampong residential and other community buildings, the area includes the boat trailer parking area and the beach. The Marine Building and the building next to it are workplaces. The Golder Associates Report of 1995 recommended long term land usage planning aimed at restricting access to these areas.

Objectives

- To limit exposure of the residents, workers and visitors to risk.
- To define actions to reduce risk in specific circumstances.

Prescribed Actions

No.	Proposed Action	Responsibility
i	Continue the general planning principles of not increasing the residential population in the areas of the Kampong at greater risk from rockfall.	SOCI
ii	Activities at the Cove resulting in an increase of people in the area, are to be minimised in the event of heavy and sustained rainfall.	SOCI
iii	In the event of an alarm follow procedures outlined under section 5.	AFP

4.3 *Community Awareness Program*

Background

The perception of the risk by the community in relation to damage, injury or loss of life from a major rockfall is relatively low. To ensure an appropriate response to an emergency, the community level of understanding of the implications of a major rockfall needs to be improved.

Objectives

- To increase the community perceptions of the rockfall hazard and the potential causes.
- To involve and encourage the community to informally monitor the rockfall conditions in the Kampong and report events as they occur.
- To advise on the reason for and nature of the warning conditions and the reasons for the required action.
- To advise on the actions to be undertaken subsequent to a warning condition being issued.

Prescribed Action

No.	Proposed Action	Responsibility
i	At the commencement of each wet season, prepare and circulate information in local languages advising the community of the rockfall hazards, the impact of seismic activity and rainfall, the importance of vegetation to stabilise the rock face and the safety and emergency procedures to be undertaken in the event of Level 1 and Level 2 warning conditions.	IOTA
ii	Using community communication systems eg. the Islander and actions under i, raise the importance of the community reporting rockfall events, seismic activity and any unusual geological activity on the cliff face.	IOTA

4.4 Research

Background

The Public Works Committee lists in its conclusions and recommendations that the risk management plan should “require continuous research”. Accordingly the research should be related to the data gathered over time in the regular inspections of the cliff face and rockfall barriers as part of the monitoring and maintenance regimes.

Objectives

The objective of the research activity is to increase the current understanding of natural methods of stabilising and controlling the movement of cliffs and arresting the motion of those rocks which are dislodged in a rockfall event. The research will also provide a database to better characterise the rockfall hazard and thus improve the assessment of rockfall risk. The research process will also provide a feedback mechanism for the evaluation of the Rockfall Risk Management Plan.

Prescribed Action

No.	Proposed Action	Responsibility
i	Annual Inspection: Arrange for an experienced Engineering Geologist to inspect the cliff face annually, review the collected data and provide a written report on the geological state of the cliff face with any recommendations on modifications to the Rockfall Risk Management Plan.	IOTA / DIRD
ii	Five Yearly Inspection: Arrange for a review of the research program at the end of the five year period by an experienced Engineering Geologist, including the preparation of a report which comments on the nature of the rockfall activity, the existing slope processes, any evidence of changes in conditions, any discernible trends in the changes and an assessment of any major rockfall events that might occur during the 5 year period. The report should also include an evaluation of the costs and benefits of the research, a review of future strategy and any changes required to the Rockfall Risk Management Plan.	IOTA / DIRD

4.5 Review

Background

Following from the research program, the Advisory Committee should assess and update technical points in the plan, and to ensure management actions are being carried out.

Objectives

The objectives of the review are:

- To draw together recommendations received from specialists and those involved in the plan, to ensure the plan is current and improvements are made.
- To undertake an exercise to ensure the effectiveness of the plan in the event of a rockfall warning.

Prescribed Action

No.	Proposed Action	Responsibility
i	Annual Exercise: An exercise to examine the effectiveness of the actions and response for a rockfall event is to be conducted annually. The exercise is to be based on a Level 1 rockfall event and is to involve all	Prime: IOTA

	personnel specified in the RRMP for that event. The exercise should occur prior to the wet season (around October) each year.	Support: All with responsibilities under the Plan.
ii	Annual Review: The EMC is to discuss and review the RRMP every six months. This should take into account outcomes of the annual exercise, inspections by the Engineering Geologist and any rockfall alarms and events.	Prime: IOTA Support: All with responsibilities under the RRMP.

5. Actions in the Event of a Rockfall Warning

5.1 Level 1 Rockfall Warning

Rockfall Events: In the order of 1m³ aggregate or greater seen to occur.

Earthquake: Intensity of MM4/M5 on the Modified Mercalli Scale

Water Tanks: Any seismic activity

Rainfall: >52 mm/hr or 163 mm/24 hrs.

This condition lasts for 24 hours from last initiation, unless it relates to the Water Tanks where the condition will cease once Water Corporation have inspected the tank and certified that there is no risk of catastrophic failure.

<ol style="list-style-type: none"> 1. Turn on the yellow warning lights, and place the ROCKFALL sign on the post 2. Restrict access to Flying Fish Cove for a period of 24 hours using barrier chain installed at the Marine building. This also closes the road to Smith Point. 3. Evacuate the Cove from the Marine Building to Smith Point. 4. Inform the Harbour Master of the risk 5. Evacuate the AFP boat shed 6. Broadcast Level 1 warning from a suitable location in the Kampong. 7. Advise users of Smith Point (Water Corporation, Indian Ocean Oil Company and Tai Jin House) and inform them that should access be required during the alert period, approval from AFP must be sought before entering the restricted area. 8. Place rockfall alert signs at the roundabout 9. Inform Community Emergency Management Officer of actions undertaken 	AFP
<ol style="list-style-type: none"> 1. Contact 6RCI and request the broadcast warning is broadcast as per Appendix C. 2. Inform Works and Services Manager, Shire of Christmas Island, to implement temporary speed reductions and notification of increased rockfall risk condition on Murray Road, if applicable. 3. Following advice from AFP, inform Administrator of commencement of Level 1 alert and actions undertaken. 	EMO/ IOTA
<p>After 24 hours from last initiation, inspect the rockfall fence for signs of rockfall or subsidence. Provide a report to the AFP regarding the condition of the barrier fencing and findings of the inspection.</p>	EMO/ IOTA
<p>Territory Controller to determine if it is safe for the alarm to cease, taking into account the outcome of the inspection of the rockfall fence.</p> <p>If so determined, AFP to remove barrier, deactivate warning lights and broadcast cessation of Level 1 warning from a suitable location in the Kampong. Remove signs from the roundabout.</p>	Territory Controller AFP
<p>Contact 6RCI and request all clear broadcast.</p> <p>Inform Works and Services Manager, Shire of Christmas Island to remove temporary speed reductions on Murray Road.</p> <p>Inform Administrator cessation of Level 1 rockfall alarm.</p>	EMO/ IOTA

In the event of a rockfall the Territory Controller (AFP) may assume responsibility under the Christmas Island Emergency Management Plan.

5.2 Level 2 Rockfall Warning

Rockfall Events: In the order of 10m³ aggregate or greater seen to occur.

Earthquake: Intensity of MM6 on the Modified Mercalli Scale

Rainfall: >113 mm/hr or 356 mm/24 hrs.

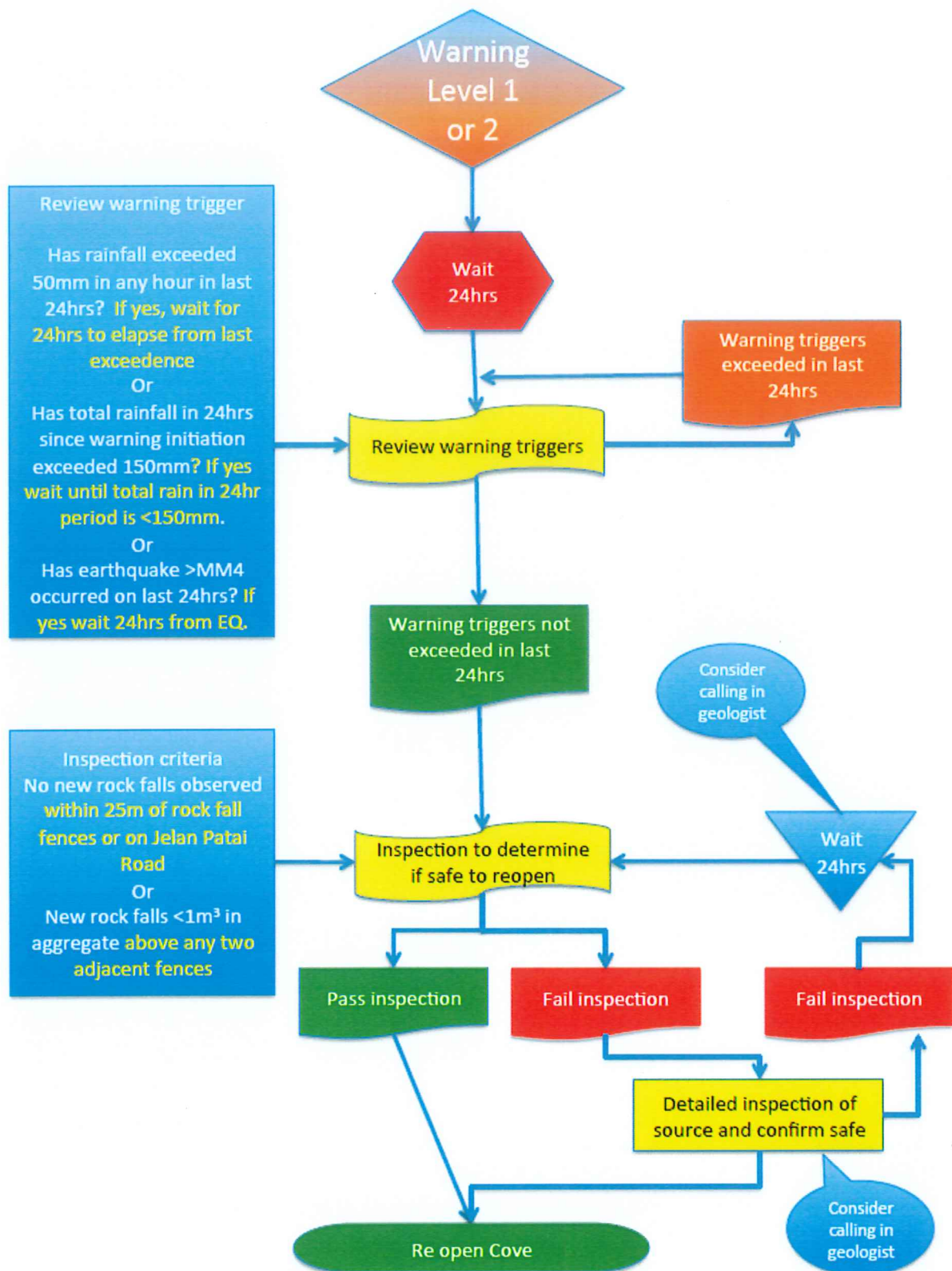
This condition lasts for 24 hours from last initiation.

Turn on the yellow warning lights, and place the ROCKFALL sign on the post	AFP
Broadcast warning on 6RCI, PA system at Mosque and Blackboard. Generic words are at Appendix C	AFP
Restrict access to fence line.	AFP
Inform Administrator of commencement of Level 2 Rockfall warning.	AFP
Access to the Cove area should be closed down and maintained as such for 24 hours by using barrier chain installed at the Marine building. The Cove should be evacuated. Essential services may require access but will need to be authorised by the AFP.	Prime: AFP Support: SOCI
The shut down at the Cove will also close the road to Smith Point. Users of facilities at Smith Point must be advised of the closure. If personnel are at the facilities (Gaseng, Water Corporation, Indian Ocean Oil Company and Tai Jin House) they may need to move from the area by car, foot or boat or remain at the facility.	AFP
Inform Harbour Master and Vacate Marine building and Custom/AFP shed.	AFP
Check populated area every 3 hours.	AFP
At 24 hours from last initiation meet to determine if it is safe for the alarm to cease. If so determined, remove barrier, deactivate alarm (may require to be manually turned off, although programmed to cease after 24 hours) and advise people through 6RCI, PA system at Mosque and Blackboard.	Prime: AFP Support: SOCI and IOTA
Inspect for rockfall after 24 hours and within 48 hours of alert completion. This will allow at least 24 hours from last heavy rainfall.	IOTA

In the event of a Rockfall the Territory Controller (AFP) will assume responsibility under the Christmas Island Disaster Management Plan.

5.3 Cancelling Level 1 or 2 Restrictions Following an Activation

The below flowchart, produced by Bowden Geological in 2015, demonstrates the process to reopen Flying Fish Cove and/ or cancel Level 1 or 2 restrictions following an activation



General procedure for reopening Flying Fish Cove after warning NOTES

- This procedure is based on the directions set out in the RRMP.
- Text in yellow has been added to provide greater definitions of actions
- Stage 2 check is included to provide better definition of what the Department should do to “determine that it is safe for the alarm to cease” (as stated in the tables in 5.1 and 5.1.2 of the RRMP).

5.4 Auto-Dialler Warning System

When triggered, the Drumsite rain gauge will auto-dial pre-set numbers to advise that a rockfall alarm has been activated, notifying the recipients through a recorded message. The following actions are to be taken on receipt of this warning:

1. The Auto Dialler will call all numbers in the system in order and will continue until a number on the telephone key pad is pressed. The current programming includes the Community Police, Territory Controller, EMO and IOTA Senior Ops Manager.
2. When you receive the first message, **hang up** (press the red button, NO, or stop on your telephone key pad) so that the call will go on to the next person.
3. The computer will continually call phone numbers until someone acknowledges the call by pressing any number key on the telephone key pad. When you hear the call for the second time press a number on the key pad. **Do not press the keypad on the first call**, otherwise the chain will cease and not all parties will be alerted. You need to make sure that all parties have been alerted and action commences under the Rockfall Risk Management Plan for the level of alert.
4. Transition from Level 1 to Level 2 alarm will initiate a new auto-dialler sequence for evacuation. This should be acknowledged as above.

6. Closure

It should be noted that extensive use of earlier studies on rockfall risk at Flying Fish Cove has been made in the preparation of the RRMP. These earlier studies were based on limited site investigations. It is thus essential to review the RRMP at regular intervals as more and more knowledge is acquired and risk levels reassessed.

It should also be noted that the risk levels summarised in the submission to PWC in July 1996 were put forward by a consultant commissioned for that purpose. The results of any particular risk assessment will be dependent upon the assumptions underlying the particular method used. There are examples in the technical research literature of how several independent risk assessments on the same problem differed widely in assumptions, presentation, and resulting conclusions. Thus, the risk assessment previously stated may by itself only provide a partial view, and any decisions solely based on that assessment could be erroneous when viewed in the light of future actual events. Therefore everyone concerned should realise that any risk prediction should always be complemented by sound strategies for ongoing management of risk mitigation in the area. This has been the underlying philosophy in the preparation of this manual.

Initiated in 2012, a review of records and rainfall data by Arup Consulting Engineers determined new Level 1 and Level 2 conditions.

The Level 1 trigger was altered from 45mm of rainfall per hour to 52mm per hour and 100mm of rainfall in a 24 hour period to 163mm.

The Level 2 trigger was altered from 56mm of rainfall per hour to 113mm per hour and 165mm of rainfall in a 24 hour period to 356mm.

7. References

1. **Parliamentary Standing Committee on Public Works** (September 1996), *Implementation of Rockfall Risk Reduction Strategies on Christmas Island*, a report.
2. **Golder Associates Pty Ltd** (October 1995), *Landslide Risk Assessment Flying Fish Cove, Christmas Island, Indian Ocean*, a report submitted to Australian construction Services, Perth
3. **Golder Associates Pty Ltd** (May 1992), *Landslide Risk Assessment Flying Fish Cove, Christmas Island, Indian Ocean*, a report.
4. **Works Australia**, (July 1996), *Christmas Island – Rockfall Risk Reduction Strategies*, Statement of Evidence and Supporting Drawing for presentation to the Parliamentary Standing Committee on Public Works.
5. **Guria Consulting** (March 1996), *Seismic Hazard Report on Christmas Island*, a report submitted to Works Australia
6. **GHD** (June 2004), *Christmas Island Administration Flying Fish Cove Rockfall Risk Management Plan Annual Inspection 2004*, a report.
7. **SKM** (September 2005) *Flying Fish Cove, Christmas Island Rockfall Risk Management Plan Annual Slope Stability Inspection 2005*
8. **GHD** (February 2006) *Road Between Flying Fish Cove and Tai Jin House, Christmas Island. Report on Engineering Geological Inspection of slopes February 2006*
9. **ARUP** (December 2008) *Annual Rockfall Inspection 2008*.



Shire of Christmas Island

Murray Road

Rockfall Risk Management Plan

Document history and status

Revision	Prepared by	Approved by	Date approved	Date Issued
Original 2009	SOCI	Council	24 Mar 2009	24 Mar 2009

Part 2 – Murray Road

Summary

This Rockfall Risk Management Plan has been developed for Murray Road, Christmas Island. The Plan details strategies and actions aimed to:

- reduce the risk of rockfall impacting upon individuals, community and facilities;
- increase the community awareness of the rockfall hazard, its causes, mitigation efforts and methods; and
- coordination of the plan with the existing rockfall risk management plan for Flying Fish Cove.

The plan was developed after inspections of two sections of Murray Road were carried out by geotechnical engineers in September 2008. This inspection concluded:

1. Ongoing rock falls can be expected almost on an annual basis at both sites.
2. The risk from rock falls has been assessed as ARL 3 on a scale of 1 to 5, with ARL 1 being the highest risk.
3. That the most cost effective options for significantly reducing risk is works that reduce the likelihood of accidental rock falls occurring.
4. Likelihood reducing options include scaling, drainage, wire mesh protection and barrier fences.
5. Options for reducing the consequences of a rock fall include reducing posted speeds and increasing warning signs.
6. Whatever the Shire determine as a course of action for the two sites, including the do nothing approach, that a management plan be documented and implemented.

This Management Plan is structured around the following strategies:

- i. **Programmed Inspections** of Murray Road rockfall risk areas to assess changes in the risk of occurrence of rockfall events.
- ii. **Maintenance** of Murray Road rockfall risk areas to reduce the likelihood of a rockfall event occurring.
- iii. **Coordination with Existing Warning Mechanisms** already in place on Christmas Island leading to appropriate responses at times of greater rockfall risk.
- iv. **Community Notification** to inform the community of any increase in the risk of a rockfall event impacting on vehicular movement on Murray Road.
- v. **Review** of the plan to ensure that recommendations made by specialist personnel and those involved with the plan are updated and improvements to the plan are made.

These measures can reduce the risk of a rockfall causing damage or injury, however they will not completely remove the risk. It is important that the general island community remain vigilant to the possibility of a serious rockfall event

1. Introductory Provisions

1.1 *Title and Purpose*

This management plan shall be referred to as the Murray Road Rockfall Risk Management Plan. The purpose of the plan is to reduce the risk of injury or death to individuals and the risk of damage to property, from rockfall on Murray Road, Christmas Island.

1.2 *Objectives of the Plan*

The objectives of the Risk Management Plan are:

- To detail those strategies and actions to reduce the risk of rockfall impacting upon individuals, community and facilities.
- To increase the community awareness about the rockfall hazard, its causes and mitigation efforts.

1.3 *Scope*

The Plan relates to a section of Murray Road from its intersection with Gaze Road to its intersection with Silver City Road, Christmas Island. The plan focuses on two specific sites within this area considered to be at the greatest risk of rockfall.

1.4 *Activation & Termination of the Plan*

This Rockfall Risk Management Plan commenced in March 2009 by resolution of the Shire of Christmas Island. The plan shall be continuously maintained and can only be deactivated by the Shire of Christmas Island.

1.5 *Review*

Review of the plan shall be carried out by a Review Committee of the Shire of Christmas Island appointed by the Chief Executive Officer. The Committee, chaired by the Chief Executive Officer or his/her nominee shall meet twice a year with the following terms of reference:

- to consider each prescribed management action and determine whether or not it is being carried out;
- to evaluate the performance of each prescribed management action in relation to the objective or objectives it is intended to serve;
- to determine the cause of any prescribed action not achieving its objective/s;
- to report to the Shire of Christmas Island the results of the review; and
- to identify and recommend any amendments to the Plan.

Meetings should be held prior to the wet season (approx. October) and subsequent to the wet season (approx. April) and should occur after receipt of an annual report from a Geotechnical Engineer.

1.6 *Related Documents*

The plan is to be considered in conjunction with:

- The Christmas Island Disaster Management Plan as amended from time to time and
- The Rockfall Risk Management Plan – Flying Fish Cove and Road to Smith Point as amended from time to time.

2. Risk Identification

2.1 *Background*

Murray Road is a major road on Christmas Island and connects Flying Fish Cove and Settlement to the urban areas of Poon Saan, Silver City and Drumsite. Currently it is the only open vehicle access route between these areas. The road is strategically critical to the Island because it provides connection between facilities such as the Police Station, Federal Government Offices, Marine Facilities on the lower part of the Island and the hospital and airport on the upper part of the Island.

2.2 *The Risks*

Rockfalls and movements of boulders of various sizes have been occurring throughout the recorded history of the Island. There is a risk that users of Murray Road could be hit directly by boulders, swerve into oncoming traffic to avoid boulders or that access along Murray Road could be blocked by a rockfall event.

2.3 *Site Investigations*

In September 2008, inspections of rockfall risk areas on Murray Road were arranged by the Commonwealth and carried out by geotechnical engineering consultants from ARUP. Two sites on Murray Road were specifically investigated and these are shown in Figure 1 below.

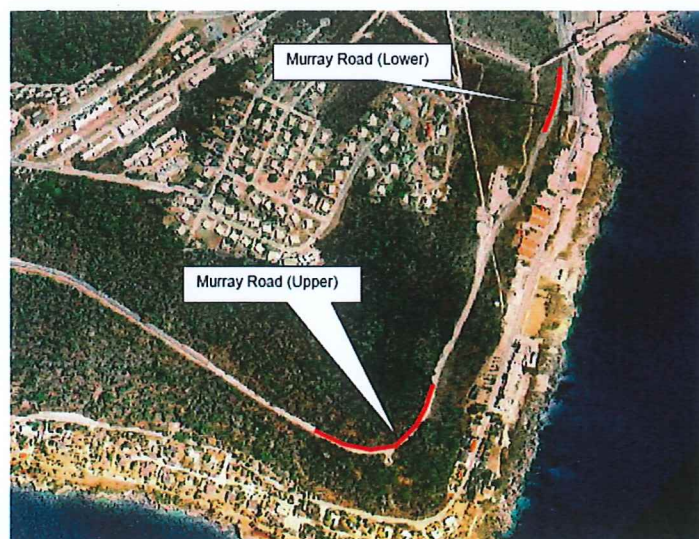


Figure 1 – Murray Road Rockfall risk investigation sites.

2.4 Descriptions of Rockfall Risk Sites

The first site - Murray Road Upper is shown in Figure 2. It consists of a “box cut” with slopes on both sides of the road within a ninety degree bend. Specific site details are as follows:

- The length of this site is approximately 200m;
- The cuttings on both sides of the road are up to about 4m high and vary in angle from near vertical to approximately 60°;
- The cuttings are formed in very thin soil and rock. The material surface is very rough and there is evidence of both erosion and small rock falls;
- The posted speed limit is 60km/h and sight distance on the bend is generally less than the required 60m;
- Two signs warning of falling rocks and slippery road surface are posted uphill of the site;
- A crash barrier exists on the down slope (northern side) of the road below the site.



Figure 2 – Murray Road upper site.

The second site - Murray Road Lower is shown in Figure 3. It consists of a single cutting on the left hand (western) side of the road. Specific site details are as follows:

- The cut exists on a slight bend in the road and extends for about 120m;
- The cutting is formed in limestone rock;
- There is evidence of small rock falls and erosion;
- The posted speed limit is 50km/h and the sight distances are generally greater than 45m;
- A crash barrier exists on the down slope (eastern side) opposite the cut slope.

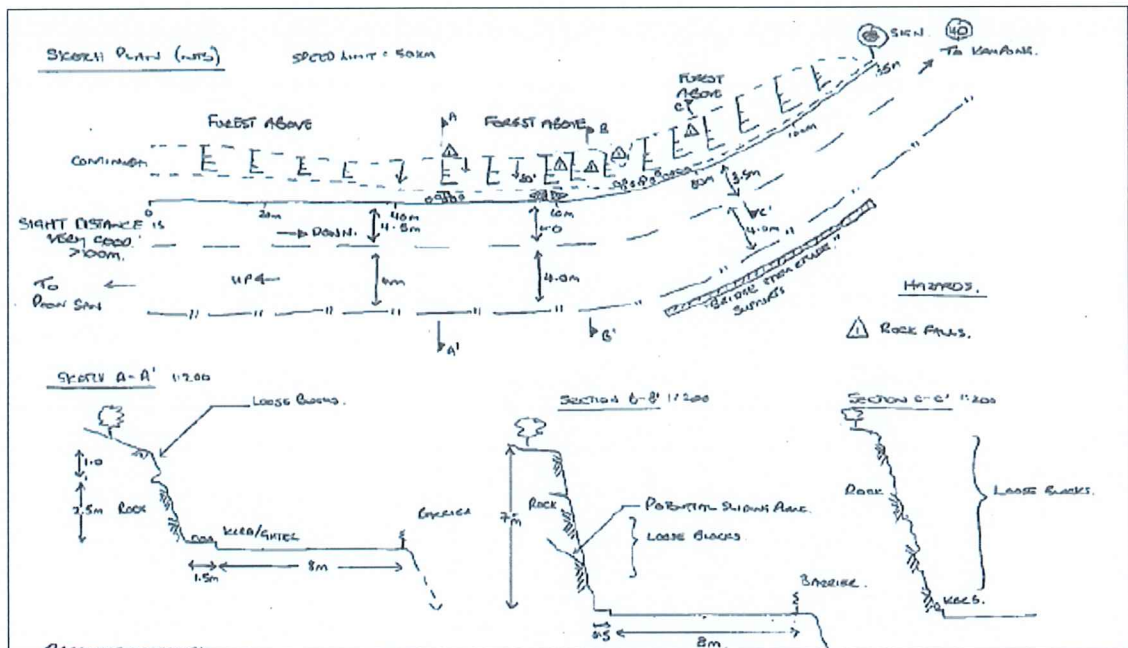


Figure 3 – Murray Road lower site

2.5 Risk Assessment

A preliminary rock fall risk assessment was carried out using the methodology developed by the Roads and Traffic Authority of NSW (RTA). This procedure takes into account the magnitude and likelihood of hazard and the consequence to road users. The RTA define five levels of risk Assessed Risk Levels (ARL) 1 to ARL5, where ARL 1 is the highest risk and ARL 5 the lowest.

While acceptable risk levels are not explicitly defined this plan accepts that new slopes or slopes being remediated to reduce risk must achieve a risk level of at worst ARL 3 or better.

The risks from the two most likely hazards at the sites on Murray Road were assessed. These hazards were from two different magnitude rock falls:

- Small rock falls, not exceeding 200mm maximum dimension and
- Medium rock falls not exceeding 500mm maximum dimension

The likelihood of these events were assessed as being:

- Small rock falls were assessed to be likely to occur within a short period under average conditions. A short period could be from days to no more than three years. (indicative annual probability of around 0.9)
- Medium rock falls were assessed to be likely to occur within a moderate period from a few years to no more than 30 years under slightly adverse circumstances (indicative annual probability of 10^{-1}).

For the purposes of assessing the consequences of a rock fall, traffic volumes along Murray Road were estimated to be greater than 150 cars per lane per day. The vulnerability of vehicles was assessed using the rock fall size and posted speed limit.

The highest risk level for both sites on Murray Road was assessed to be equivalent to an ARL 3. This risk level was for both small and medium rock falls.

2.6 Risk Reduction

Options for reducing risks fall into two categories:

- measures that reduce the likelihood of a rock fall occurring or affecting traffic and
- measures that reduce the consequences to individuals or property if a rock fall does occur.

Likelihood Reduction

In the report prepared by Arup it is recommended that measures that reduce the likelihood of a rockfall provide greater risk reduction at reasonable cost.

Options considered by the Shire to be practical for reducing the likelihood of rockfall events occurring or affecting traffic include:

- Removing (scaling) loose rocks with an excavator as part of a regular maintenance regime to reduce the occurrence of accidental rock falls
- Covering the slope with wire mesh to prevent rock falls reaching the carriageway

Consequence Reduction

Options available for reducing the consequences of rockfall events include:

- Reducing speed limits below those currently posted so that stopping distance is reduced. This relies on the public to obey posted speed limits.
- Posting more rock fall hazard signs at the lower site (signs already exist at the upper site).

Regarding reductions in speed limits, at the upper site, sight distances are low and a reduction in speed from the posted 60km/h to say 50km/h is likely to have only a marginal beneficial impact on risk. However an assessment of the horizontal alignment of this site indicates that the posted 60km/hr speed is too high for the curve and should be reduced to 50km/hr.

At the lower site, sight distances are good and posted speeds are already low (50km/h) and this option is likely to have only a marginal beneficial impact on risk.

Actions under this plan however further reduce speed limits through the use of variable signage during periods of increased rockfall risk.

2.7 Warning of Rockfall

It is not feasible to physically monitor the stability of the risk areas or to remotely sense their condition. However some warning of rockfall may be provided by monitoring those factors which are known to trigger or be associated with rockfall events

Rockfalls may be triggered by unusually heavy rain or by seismic activity but can also occur without any identifiable trigger. Large rockfalls may be preceded by smaller rockfalls. Seismic events themselves occur without warning but several seconds might elapse between a seismic event and any rockfall impact and minor seismic events may precede more significant events.

The existing Rockfall Risk Management Plan for Flying Fish Cove utilises two levels of warning conditions and this plan adopts this warning system as a basis for management strategies and actions.

- Level 1 condition – possible indicators of a potential event.
- Level 2 condition – probable indicators of a likely event.

Level 2 indicators are therefore more likely to be followed by a rockfall event than the Level 1 indicators. However, it should be noted that there are no indicators which can be reliably used as absolute warning of a rockfall.

Level 1 Condition – Possible indicators of Rockfall Event

Possible indicators of a rockfall incident include:

- Any rockfall incident greater than 1m³ in aggregate may be a precursor to further rockfall.
- Minor seismic events, typically – earthquake of an intensity of MM4/MM5 or greater on the Modified Mercalli Scale;
- Intense rainfall like a one in five year event such as:
 - 45mm in any hour; or
 - 100mm in any 24 hour period.
- On a broader scale, unusually wet periods, which would typically be:
 - 450mm rainfall in a month.

Level 2 Condition – Probable indicators of Rockfall Events

Probable indicators of a rockfall incident include:

- Progressive increase of occurrence and intensity of rockfalls, typically greater than 10m³ in aggregate.
- Major seismic events, typically – earthquake of intensity of MM6 or greater on the Modified Mercalli Scale.
- Unusually intense rainfall like a one in fifty year event such as:
 - 56mm in any hour; or
 - 165mm in any 24 hour period.
- On a broader scale, extremely unusual wet periods, which would typically be:
 - 750mm rainfall in a month.

3. Risk Management Strategies

This plan recommends the following strategies be implemented to reduce the risks and consequences of rockfall events on Murray Road;

- Monitoring** of Murray Road rockfall risk areas to assess changes in the risk of occurrence of rockfall events.
- Hazard Reduction** at Murray Road rockfall risk areas to reduce the likelihood and consequences of a rockfall event.
- Coordination with Existing Warning Mechanisms** already in place on Christmas Island leading to appropriate responses at times of greater rockfall risk.

- iv. **Community Awareness** actions to inform the community of any increase in the risk of a rockfall event impacting on vehicular movement on Murray Road.
- v. **Review** of the plan to ensure that recommendations made by specialist personnel and those involved with the plan are updated and improvements to the plan are made.

4. Risk Management Actions

The risk management actions required under this Plan are intended to implement the five strategies outlined in Section 3. These actions are detailed as follows:

4.1 Monitoring of Risk Areas

Objectives

- To set in place mechanisms to monitor the identified rockfall risk areas
- To set in place mechanisms to collect data about rockfall events.

Prescribed Actions

No.	Proposed Action	Responsibility
i	Programmed Inspections: Carry out two inspections in each year of the identified risk areas. Inspections are to occur prior to the commencement of the wet season (approx October) and after the wet season (approx April). Inspections are to identify and document any areas with conditions which may affect the stability of the rock slopes such as erosion and scouring, fractured rocks and minor rockfalls. Inspections are to identify any areas where hazard reduction works must be carried out to reduce rockfall risk.	SOCI – Manager Works and Services
ii	Rockfall Event Inspections: In the event of a rockfall occurring, an inspection of the event site shall be made. The location and size of the event shall be recorded and documented (including photographs). Examine the slope immediately above the rockfall and note any unusual geological activity or events. Inspections and any work are to be undertaken with great care by a minimum of two persons, one with a technical background. One person is to approach the rockfall from undisturbed ground and the other remaining to warn of any further movement of rocks or soil in the vicinity. Do not approach any major rockfalls or areas that appear unstable. If possible, inspections are not to take place during periods of heavy rainfall nor for at least 24 hours after the cessation of level 1 and level 2 alarms. This may not be possible however if an immediate hazard to road users exists and needs to be removed from the road. Arrange for consultation with an experienced	SOCI – Manager Works and Services

	Engineering Geologist to discuss any significant events or geological activity and determine if any immediate, short term or long term action is required.	
iii	<p>Geotechnical Expert Inspections: An inspection of the risk areas by an experienced Engineering Geologist shall be carried out annually.</p> <p>A report of the inspection shall be prepared which comments on the nature of any rockfall activity, the existing slope processes, any evidence of changes in conditions, any discernible trends in the changes and an assessment of any major rockfall event.</p> <p>The report should also include a review of future strategy and any changes required to the Rockfall Risk Management Plan.</p> <p>Where possible, this inspection shall be coordinated with the inspection and research program developed in the Flying Fish Cove Rockfall Risk Management Plan.</p>	SOCI and IOTA / DIRD

4.2 Risk Reduction

Objectives

- To set in place a mechanism to reduce the risk of rockfalls in the identified rockfall risk areas by reducing the *likelihood* of the risk.
- To set in place a mechanism to reduce the risk of rockfalls in the identified rockfall risk areas by reducing the *consequences* of the risk.

Prescribed Actions

No.	Proposed Action	Responsibility
i	<p>Rockfall Likelihood Risk Reduction: Scaling of rockfaces with an excavator or similar machinery shall only be carried out when recommended from the inspections program.</p> <p>Scaling works shall be limited to areas where immediate hazards are apparent such fractured or precarious rocks are apparent or there is evidence of erosion or scouring affecting the stability of rocks.</p> <p>Scaling must be undertaken with care as disturbance by scaling works in itself may contribute to the disturbance of adjacent areas and may place at risk those carrying out the</p>	SOCI – Manager Works and Services

	scaling works.	
ii	Rockfall Likelihood Risk Reduction: Further investigation of physical barriers such as mesh covering and fencing shall be carried out and implemented where feasible.	SOCI – Manager Works and Services
iii	<p>Rockfall Consequence Risk Reduction: Normal speed limits within the identified risk areas shall be reduced to 50km/hr.</p> <p>Signage warning of the risk of rockfall shall be reviewed to incorporate variable messaging which further reduces speeds during level 1 and level 2 alert conditions and alerts drivers to the increased risk condition.</p> <p>If possible, this signage shall include a warning lights system remotely linked to the existing rockfall warning system.</p>	SOCI – Manager Works and Services

4.3 *Coordination with the Existing Rockfall Warning Mechanisms*

Objectives

- To coordinate actions from risks associated with rockfall in the identified Murray Road risk area with existing warning mechanisms under the Rockfall Risk Management Plan for Flying Fish Cove.
- To advise on the actions to be undertaken subsequent to a warning condition being issued.

Prescribed Action

No.	Proposed Action	Responsibility
i	Implement this Murray Road Rockfall Risk Management plan as a subplan of the Rockfall Risk Management for Flying Fish Cove.	SOCI CEO Support – IOTA / DIRD
ii	In the event of a Level 1 Rockfall warning, actions shall be in accordance with Section 5.1.	Refer Section 5.1
iii	In the event of a Level 2 Rockfall warning, actions shall be in accordance with Section 5.2.	Refer Section 5.2

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4.4 *Community Awareness*

Objectives

- To involve and encourage the community to informally monitor the rockfall conditions and report events as they occur.
- To advise on the actions to be undertaken subsequent to a warning condition being issued.

Prescribed Action

No.	Proposed Action	Responsibility
i	At the commencement of each wet season prepare and circulate information in local languages advising the community of the rockfall hazards on Murray Road and the safety and emergency procedures to be undertaken in the event of Level 1 and Level 2 warning conditions.	SOCI – Chief Executive Officer
ii	Using community communication systems eg. the Islander and actions under i, raise the importance of the community reporting rockfall events, seismic activity and any unusual geological activity on the Murray Road risk areas.	SOCI – Chief Executive Officer
iii	Items i and ii shall be coordinated with existing community rockfall awareness programs developed under the Rockfall risk Management Plan for Flying Fish Cove.	

4.5 *Review*

Objectives

- To draw together information received from inspections, specialists and those involved in the plan to ensure the plan is current and improvements are made.
- To undertake an exercise to ensure the effectiveness of the plan in the event of a rockfall warning.

Prescribed Actions

No.	Proposed Action	Responsibility
i	<p>Review Committee: The Chief Executive Officer shall appoint a Murray Road Rockfall Risk Management Plan review committee to oversee the implementation of the Plan.</p> <p>The Committee, chaired by the Chief Executive Officer or his/her nominee shall meet twice a year with the terms of reference in accordance with Clause 1.5.</p>	SOCI CEO
ii	<p>Annual Exercise: An exercise to examine the effectiveness of the actions and responses to a rockfall event is conducted annually under the Flying Fish Cove Rockfall Risk Management Plan.</p> <p>The Shire shall participate in this exercise and coordinate the actions associated with risks associated with rockfalls on Murray Road .</p>	<p>Prime:</p> <p>IOTA / DIRD</p> <p>Support:</p> <p>All with responsibilities under the Plan.</p>

5. Actions in the event of a Rockfall Warning

5.1 Level 1 Rockfall Warning

A level 1 Rockfall Warning is generated by one of the following events:

Rockfall Events: In the order of 1m³ aggregate or greater seen to occur.

Earthquake: Intensity of MM4/M5 on the Modified Mercalli Scale

Rainfall: >52mm/hr or 163mm/24 hrs.

This condition lasts for 24 hours from last initiation.

Confirm valid activation of Level 1 Rockfall warning with AFP.	SOCI and AFP
Implement temporary speed reductions and notification of increased rockfall risk condition on Murray Road by changing variable sign.	SOCI – Works Manager
Inform AFP of reductions in speed for Murray Road for inclusion in public broadcasts.	SOCI – Works Manager
At 24 hours from last initiation meet to determine if it is safe for the alarm to cease. If so determined, remove speed restrictions and advise people through 6RCI, PA system at Mosque and Blackboard.	Prime AFP Support SOCI and IOTA / DIRD
Inspect after 24 hours and within 48 hours of alert completion.	IOTA / DIRD

5.2 Level 2 Rockfall Warning

A Level 2 Rockfall Warning is generated by one of the following events:

Rockfall Events: In the order of 10m³ aggregate or greater seen to occur.

Earthquake: Intensity of MM6 on the Modified Mercalli Scale

Rainfall: >113mm/hr or 365mm/24 hrs.

This condition lasts for 24 hours from last initiation.

Confirm valid activation of Level 2 Rockfall warning with AFP.	SOCI and AFP
Implement temporary speed reductions and notification of increased rockfall risk condition on Murray Road by changing variable sign.	SOCI – Works Manager
Inform AFP of reductions in speed for Murray Road for inclusion in public broadcasts.	SOCI – Works Manager
Inspect Murray Road every three hours in conjunction with inspections of Flying Fish Point.	AFP
At 24 hours from last initiation meet to determine if it is safe for the alarm to cease. If so determined, remove speed restrictions and advise people through 6RCI, PA system at Mosque and Blackboard.	Prime AFP Support SOCI and AGD
Inspect after 24 hours and within 48 hours of alert completion.	SOCI

6. References

Rockfall Risk Management Plan - Flying Fish Cove and Road to Smith Point -
(November 2007) Department of Transport and Regional Services.

Murray Road Rockfall Hazard Inspection – (November 2008) Arup Pty Ltd

Appendix A

Modified Mercalli Scale of Seismic Intensities (from AS2121-1979 Earthquake Code)

Mercalli Scale

- MM 1** Not felt by humans, except in especially favourable circumstances, but birds and animals may be disturbed.
Reported mainly from the upper floors of buildings more than 10 storeys high.
Dizziness or nausea may be experienced.
Branches of trees, chandeliers, doors and other suspended systems of long natural period may be seen to move slowly.
Water in ponds, lakes, reservoirs, etc may be set into seiche oscillation.
- MM 2** Felt by a few persons at rest indoors, especially by those on upper floors or otherwise favourably placed.
The long-period effects listed under MM1 may be more noticeable.
- MM 3** Felt indoors, but not identified as an earthquake by everyone.
Vibration may be likened to the passing of light traffic.
It may be possible to estimate the duration, but not the direction.
Hanging objects may swing slightly.
Standing motorcars may rock slightly.
- MM 4** Generally noticed indoors, but not outside.
Very light sleepers may be awakened.
Vibration may be likened to the passing of heavy traffic, or to the jolt of a heavy object falling or striking the building. Walls and frame of buildings are heard to creak. Doors and window rattle.
Glassware and crockery rattles.
Liquids in open vessels may be slightly disturbed.
Standing motorcars may rock, and the shock can be felt by their occupants.
- MM 5** Generally felt outside, and by almost everyone indoors.
Most sleepers awakened.
A few people frightened.
Direction of motion can be estimated.
Small unstable objects are displaced or upset. Some glassware and crockery may be broken. Some windows cracked.
A few earthenware toilet fixtures cracked. Hanging pictures move.
Doors and shutters swing.
Pendulum clocks stop, start, or change rate.
- MM 6** Felt by all.
People and animals alarmed.
Many run outside.
Difficulty experienced in walking steadily.
Slight damage to Masonry D. Some plaster cracks or falls. Isolated cases of chimney damage. Windows, glassware, and crockery broken.
Objects fall from shelves and pictures from walls.
Heavy furniture moved. Unstable furniture overturned.
Small church and school bells ring.
Trees and buses shake, or are heard to rustle.
Loose material may be dislodged from existing slips, talus slopes, or shingle slides.

- MM 7** General alarm
Difficulty experienced in standing
Noticed by drivers of motorcars.
Trees and bushes strongly shaken.
Large bells ring.
Masonry D cracked and damaged.
A few instances of damage to Masonry C.
Loose brickwork and tiles dislodged.
Unbraced parapets and architectural ornaments may fall.
Stone walls cracked.
Weak, chimneys broken, usually at the roof-line.
Domestic water tanks burst.
Concrete irrigation ditches damaged.
Waves seen on ponds and lakes.
Water made turbid by stirred-up mud.
Small slips, and caving-in of sand and gravel banks.
- MM 8** Alarm may approach panic.
Steering of motorcars affected.
Masonry C damaged, with partial collapse.
Masonry B damaged in some cases.
Masonry A undamaged.
Chimneys, factory stacks, monuments, towers, and elevated tanks twisted or brought down.
Panel walls thrown out of frame structures.
Some brick veneers damaged.
Decayed wooden piles broken.
Frame houses not secured to the foundation may move.
Cracks appear on steep slopes and in wet ground.
Landslips in roadside cuttings and unsupported excavations.
Some tree branches may be broken off.
Changes in the flow or temperature of springs and wells may occur.
Small earthquake fountains.
- MM 9** General Panic.
Masonry D destroyed.
Masonry C heavily damaged, sometimes collapsing completely.
Masonry B seriously damaged.
Frame structures racked and distorted. Damage to foundations general. Frame houses not secured to the foundations shifted off. Brick veneers fall and expose frames.
Cracking of the ground – conspicuous.
Minor damage to paths and roadways.
Sand and mud ejected in alleviated areas, with the formation of earthquake fountains and sand craters.
Underground pipes broken.
Serious damage to reservoirs.
- MM 10** Most masonry structures destroyed, together with their foundations. Some well built wooden buildings and bridges seriously damaged.
Dams, dykes and embankments seriously damaged.
Railway lines slightly bent.
Cement and asphalt roads and pavements badly cracked or thrown into waves.
Large landslides on river banks and steep coasts.
Sand and mud on beaches and flat land moved horizontally.
Large and spectacular sand and mud fountains.

Water from rivers, lakes, and canals thrown up on the banks.

MM 11 Wooden frame structures destroyed.
Great damage to railway lines.
Great damage to underground pipes.

MM12 Damage virtually total.
Practically all works of construction destroyed or greatly damaged.
Large rock masses displaced.
Lines of sight and level distorted.
Visible wave-motion of the ground surface reported.
Objects thrown upwards into the air.

Appendix B

Broadcast Warnings

Introduction

Standard words are to be used in the event of a rockfall warning due to high rainfall or seismic activity.

The AFP will advise 6RCI when to broadcast and whether the alarm is due to high rainfall or seismic activity.

These are to be broadcast by radio 6RCI every hour between 7:00 hours and 21:00 hours for a 24 hour period in English, Chinese and Malay, unless otherwise instructed by the AFP. It is envisaged that these words will be held in a pre- recorded format in English, Chinese and Malay by 6RCI enabling early broadcasting

Words in the event of a rockfall warning due to high rainfall

Rockfall Warning

A high rockfall risk currently exists in the area of Flying Fish Cove towards Smith Point due to high rainfall. A high rockfall risk also exists on Murray Road from Gaze Road to Silver City Road.

Flying Fish Cove and beyond has been closed. This area must not be accessed. The closure will remain in force for at least 24 hours from the start of the alarm.

Speed limits on Murray Road between Gaze Road and Silver City Road have been reduced and drivers are requested to follow all posted speed limits. Drivers are advised to avoid using this section of Murray Road unless absolutely necessary.

Please listen to Radio 6RCI for updates and if you have any urgent enquiries contact the Police on 9164 8444.

Words in the event of a rockfall warning due to seismic activity

Rockfall Warning

A high rockfall risk currently exists in the area of Flying Fish Cove towards Smith Point due to seismic activity. A high rockfall risk also exists on Murray Road from Gaze Road to Silver City Road.

Flying Fish Cove and beyond has been closed. This area must not be accessed. The closure will remain in force for at least 24 hours from the start of the alarm.

Speed limits on Murray Road between Gaze Road and Silver City Road have been reduced and drivers are requested to follow all posted speed limits. Drivers are advised to avoid using this section of Murray Road unless absolutely necessary.

Please listen to Radio 6RCI for updates and if you have any urgent enquiries contact the Police on 9164 8444.

Appendix C

Conclusions and Recommendations of the Parliamentary Standing Committee for Public Works in July 1996

1. The Commonwealth has a responsibility to implement measures designed to reduce the risk of fatality at various locations in Flying Fish Cove.
2. Before December 1996, the Department of Environment, Sport and Territories should have ready a rockfall risk management plan for Flying Fish Cove which identifies events, documents responses, assigns responsibilities, requires continuous research and monitoring, and increases community awareness of risks and dangers. Simulated exercises should be undertaken.
3. *Ficus microcarpa* trees should be planted upslope from the rockfall barrier to provide extra protection in the longer term.
4. As is evident from the major rockfall in 1972, the Committee believes that the Boat Club should be demolished and a new safe site, proximate to water frontage, and consistent with the Town Plan, be found. *[Boat club has been demolished prior to 2005]*
5. The Department of the Environment, Sport and Territories and Christmas Island Shire Council should give favourable consideration to construction costs of a new club building being wholly or partially funded from the community Benefit Fund.
6. Land for private development is the most pressing need on Christmas Island. *[Land has been released for private development prior to 2005]*
7. Block 408 in the Kampong should be demolished at the end of its economic life, expected to be in three to five years time. *[Demolished prior to 2005]*
8. Following the construction of the rockfall barrier and the implementation of a general rockfall risk reduction management plan, the future of Block 412 should be re-evaluated at the end of the same period. However, the Committee favours the eventual removal of Block 412. *[Demolished prior to 2005]*
9. Dwelling units at the south-west corners of both blocks, considered to be at greatest risk, should be progressively and permanently vacated. *[Blocks 408 and 412 have been demolished prior to 2005]*
10. The Department of the Environment, Sport and Territories, in conjunction with Christmas Island Shire Council, should identify parcels of land for residential and other developments that comply with the Draft Town Plan. *[Land has been released for private residential development]*
11. Land for private housing development should be offered without delay. *[Land has been released for private residential development prior to 2005]*
12. The future use of the site of Block 408, post demolition, should not preclude its use as a revegetated area to provide nesting sites for the Christmas Island Frigate bird. If Block 412 is demolished, the same uses could apply. *[incorporated into Kampong residential area]*
13. Potential trade-offs between the use of the sites as recommended and the use of land containing vestiges of primary rainforest, at present not favoured for development by the Australian Nature Conservation Agency, should be investigated.

Figure 1 – Kampong Rockfall Barriers

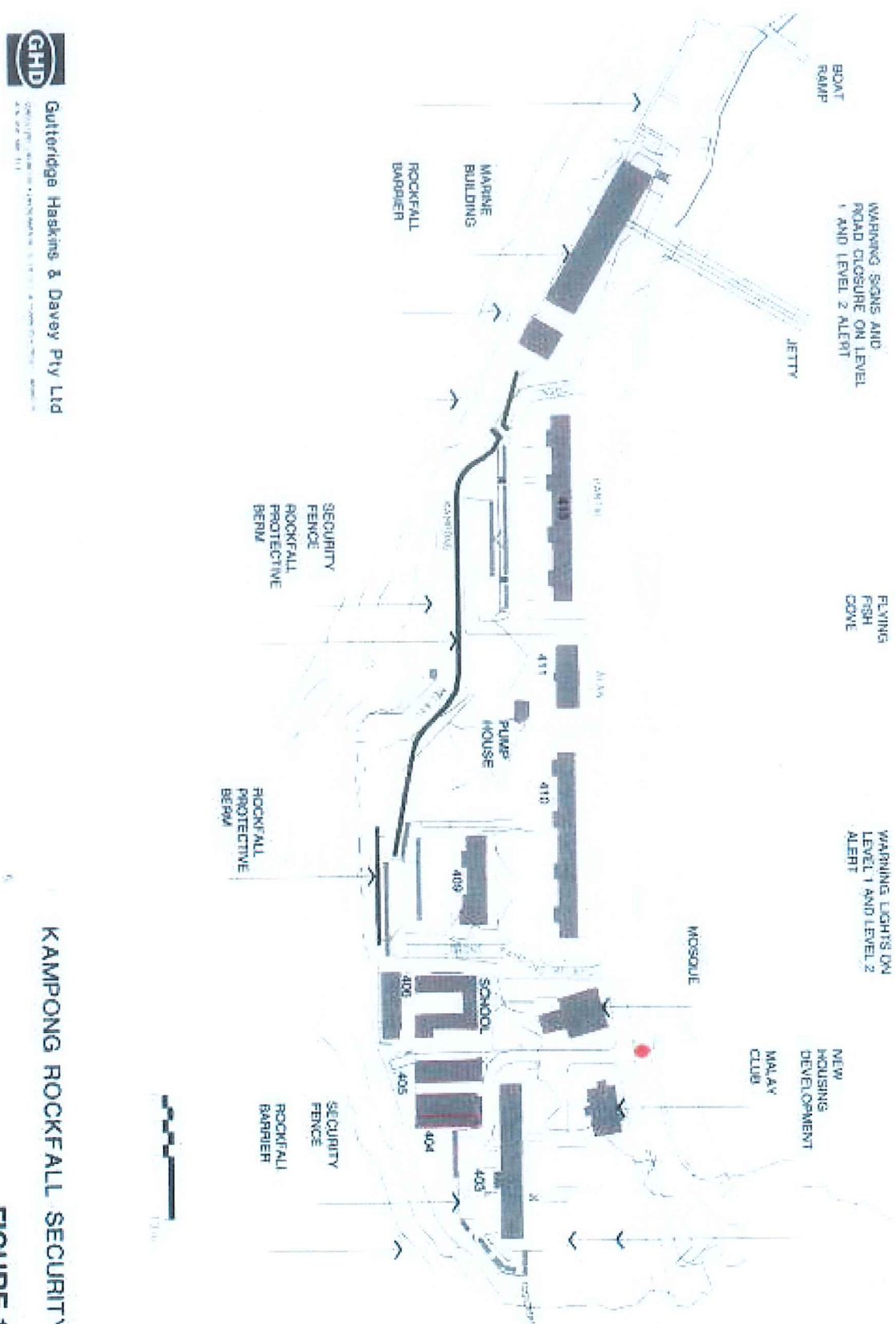


FIGURE 1

Figure 2 – Plan of FFC & Tai Jin House

