



Northern  
Territory  
Government

DEPARTMENT OF LANDS, PLANNING AND THE ENVIRONMENT

# DARWIN REGION

A photograph of a flooded street at night. Several cars with their headlights on are driving through the water. A person is standing in the middle of the road. The scene is dimly lit by streetlights and car headlights.

FLOOD  
MITIGATION  
ADVISORY  
COMMITTEE



## **DEPARTMENT OF LANDS, PLANNING AND THE ENVIRONMENT**

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# DARWIN REGION

## Committee Membership



- **PETER STYLES** (Chair)
- **JAMES DUNLEVIE**
- **TIM MOORE**
- **FRANK MAY**
- **ROBERT (Bob) WHITE**
- **PHIL BRESLIN**
- **PAUL KERNAGHAN**  
(represented by Jeff Wright)  
Insurance Council of Australia
- **GREG BICKNELL**  
Chamber of Commerce  
representative
- **PETER McLINDEN**  
Local Government Association  
NT representative



## FOREWORD

**Greater Darwin, with its tropical weather and relaxed lifestyle is a great region to live. During the wet season, Darwin's storms are unique to our location and a part of our tropical climate. Unfortunately, with heavy rainfall, flooding becomes a real risk to safety and property in certain areas of the Darwin Region.**

On the 28 January 2015, the Darwin Region Flood Mitigation Advisory Committee was formed and tasked with developing a strategy for flood mitigation

to improve community safety, as well as reducing the damage, disruption and costs associated with major flood events in the Darwin Region.

This report provides a policy framework for managing the flood risk in the Darwin Region and is committed to reducing this risk through specific recommendations and measures.

The Darwin Region Flood Mitigation Advisory Committee recognises the need for an integrated approach, whereby Government, working with the community, local council and other stakeholders, is crucial to achieve a sustainable approach to flood mitigation for now and into the future.

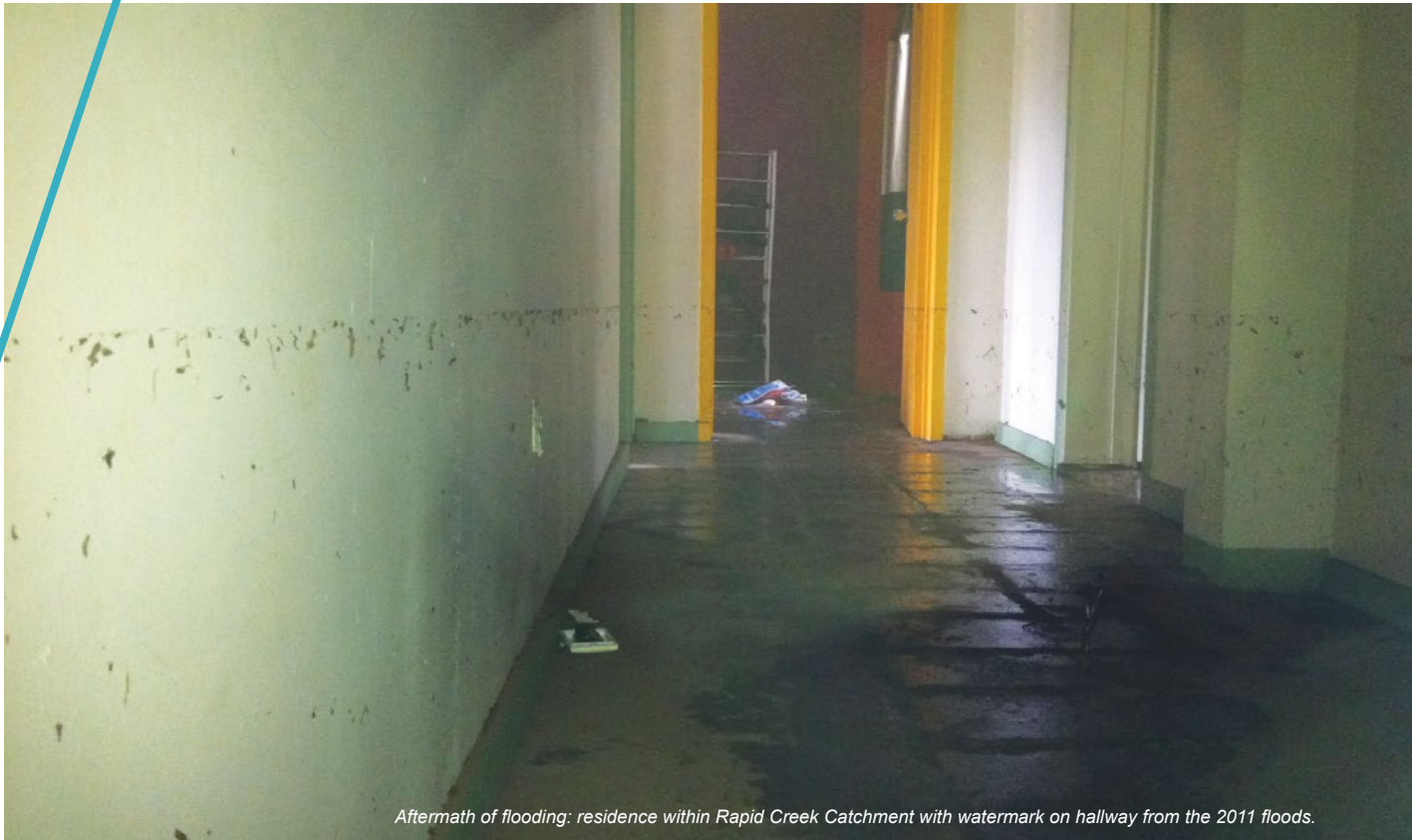
**Peter Styles**

CHAIR

Darwin Region Flood Mitigation Advisory Committee

# DEFINITIONS

TERM / ACRONYM	MEANING
<b>Annual Exceedance Probability (AEP)</b>	The chance of a flood of a given size occurring in any one year, usually expressed as a percentage. 1% AEP flood is a term used to define a flood event that has a 1% chance to occur in a given year and is a flood of a larger magnitude.
<b>Average Recurrence Interval (ARI)</b>	The statistical estimate of the average period in years between the occurrence of a flood of a given size. For example, a 100 year ARI event will occur on average once every 100 years and will have a 1 % chance (1% AEP) of occurring in any given year.
<b>Flood</b>	A natural phenomenon that occurs when water covers land that is usually dry. Sources of flooding include rivers and other watercourses, local overland flow paths and groundwater systems.
<b>Floodplain</b>	The area adjacent to a river or creek that is inundated by flood waters and which covers an extent related to the magnitude of the flood.
<b>Property Modification Measures</b>	Covers planning and building control measures and flood proofing.
<b>Q100 Level</b>	The design level provided to structural mitigation measures that equates to the 1% AEP. A structural measure that has a Q100 level is generally built to withstand a 1% AEP flood.
<b>Response Modification Measures</b>	Covers flood warnings, flood education and preparation for floods.
<b>Telemetric System</b>	The technology that involves the automatic measurement and transmission of data from remote sources.
<b>DLRM</b>	Department of Land Resource Management
<b>DLPE</b>	Department of Lands, Planning and the Environment
<b>DoI</b>	Department of Infrastructure
<b>DCA</b>	Development Consent Authority



*Aftermath of flooding: residence within Rapid Creek Catchment with watermark on hallway from the 2011 floods.*

## OVERVIEW

**This report provides the strategic direction and policy framework with respect to flood mitigation in the Darwin urban and rural areas. Relevant expert advice was provided through the Department of Lands, Planning and the Environment (DLPE), the Department of Land Resource Management (DLRM), the Northern Territory Emergency Service (NTES) and the Insurance Council of Australia (ICA) to assist the Committee in the formulation of this report.**

A number of recommendations have been made within the context of a flood risk management policy framework, and are listed in the summary of recommendations section. These recommendations address improving the quality of planning decisions in relation to stormwater management and recommend specific structural, property modifications and resilience measures to mitigate flood risks associated

with riverine flooding and stormwater flooding. Some urban areas within Darwin are also recognised as defined storm surge zones. The Committee recognises that storm surge issues may require consideration by Government in the future however the mitigation of storm surge flooding is not within the scope of this report.

In formulating these recommendations, the Committee has also given consideration to the impact these works will have on reducing insurance premiums, in particular those properties under a risk pricing model where the risk of riverine floods attracts higher premiums.

## SUMMARY OF RECOMMENDATIONS

The following is a summary of recommended mitigation measures taken from the body of this report. These recommended mitigation measures should be read in conjunction with the body of the report and the Works Plans.

### POLICY FRAMEWORK:

#### RECOMMENDATION 1

That the definition of flooding within the *NT Planning Scheme* is amended to include stormwater flooding to the effect that the owner or occupier of land maintains the pre-development peak flow rates within a catchment.

In conjunction with this, best practice policy for stormwater management in the Northern Territory is addressed; including the objective to reduce the risk of stormwater flooding. To support this objective, a single agency is resourced for the responsibility to hydraulically model trunk drainage systems to mitigate the impact of development on trunk drainage systems. This also includes the preparation of jointly funded maintenance agreements for the ongoing management (by relevant asset owners) of trunk drainage to maintain hydraulic efficiency.

### SPECIFIC MEASURES:

#### RECOMMENDATION 2

The Department of Defence transfer tenure of the Marrara Swamp Flood Control Weir to the Northern Territory Government to secure ongoing existence of this structure within the Rapid Creek catchment.

#### RECOMMENDATION 3

NT Airports investigate and implement mitigation solutions to manage stormwater runoff resulting from the total cumulative impacts of all development on NT Airport land since privatisation.

#### RECOMMENDATION 4

Power and Water Corporation fund and install back-flow prevention devices to all properties at risk of sewerage inundation in the Rapid Creek catchment as identified in the Jacobs report.

#### RECOMMENDATION 5

The Department of Land Resource Management delay submission of the Rapid Creek catchment flood map to the National Flood Insurance Database, until it is remodelled to include revised ground surveys and the impact of all mitigation measures detailed in the Works Plan – Rapid Creek, including detention basins. The Department of Land Resource Management are to commit to updating NTG websites with the most up to date mapping upon completion.

#### RECOMMENDATION 6

Mitigation works for the Rapid Creek catchment to the estimated value of \$11.8 million to be funded from the Flood Mitigation Fund in accordance with the Works Plan – Rapid Creek.

#### RECOMMENDATION 7

The Northern Territory Government and the Department of Defence develop a joint stormwater management plan for the Ludmilla Creek Catchment and implement appropriate mitigation measures including the construction of storm water detention basins on land owned by the Commonwealth and the Territory.

#### RECOMMENDATION 8

Mitigation works for the Ludmilla catchment to the estimated value of \$7.5 million to be funded from the Flood Mitigation Fund in accordance with the Works Plan – Ludmilla Creek Catchment.

#### RECOMMENDATION 9

Mitigation works for the Wadham Lagoon catchment to the value of \$300,000 to be granted to the Litchfield Council from the Flood Mitigation Fund in accordance with the Works Plan – Wadham Lagoon.

#### RECOMMENDATION 10

Mitigation works for the Yarrowonga catchment to the value of \$3,230,000 to be funded from the Flood Mitigation Fund in accordance with the Works Plan – Yarrowonga Catchment.

#### RECOMMENDATION 11

Mitigation works for the Pinelands catchment to the value of \$900,000 to be granted to the City of Palmerston from the Flood Mitigation Fund in accordance with the Works Plan – Pinelands.

## COST ESTIMATES

	RECOMMENDATIONS	FLOOD MITIGATION FUND
<b>POLICY FRAMEWORK:</b>		
1	To support the activities of the agency responsible for stormwater management	\$1,270,000
<b>SPECIFIC MEASURES:</b>		
2 - 6	Rapid Creek catchment	\$11,800,000
7-8	Ludmilla Creek catchment	\$7,500,000
9	Wadham Lagoon catchment	\$300,000
10	Yarrowonga catchment	\$3,230,000
11	Pinelands catchment	\$900,000
	<b>TOTAL</b>	<b>\$25,000,000</b>



## INTRODUCTION

**The Darwin Region Flood Mitigation strategy incorporates a holistic approach to reducing the impact of flood events for residents, industry and the community. The strategy recognises that not every flood situation is the same and a mix of solutions is needed to mitigate the risks.**

*The National Strategy for Disaster Resilience* objectives for a disaster resilient community is acknowledged, where disaster resilience is a shared responsibility of all sectors of society, including governments, councils, business, non-government organisations and individuals. An integrated approach is essential towards ensuring effective flood mitigation.

Depending on locality and the nature of the flooding, different structural (infrastructure) and non-structural (property and response modification) mitigation measures have been considered.

Flood studies, flood mapping and the analysis of flood risks for key areas have been undertaken by suitably qualified professionals and their findings are included in this report. Structural mitigation options have been considered with the key consideration that the overall benefit of any solution is to be received by those most at risk by flood waters.

### BACKGROUND

On 20 November 2014 the Chief Minister announced funding of \$50 million for flood mitigation for the Darwin Region and Katherine as part of the sale of the Territory Insurance Office (TIO).

On 28 January 2015 the Chief Minister established a Flood Mitigation Advisory Committee in Darwin, which met for the first time in February 2015 to review the draft Terms of Reference and the work program to June 2015.

The Darwin Region Flood Mitigation Advisory Committee has been tasked with providing a Report to Government by the end of June 2015 with recommendations on how \$25 million of the funding can best be spent to mitigate the impact of flooding while providing value for money for taxpayers.

### TERMS OF REFERENCE

The Committee has been tasked to assess and make recommendations on effective measures to reduce risks of flood events, including risks to public safety, and the economic and social impacts of major flood events in the Darwin Region. The key role of the Committee includes the following:

- Development of an overarching Flood Mitigation Strategy for the Darwin Region, including a policy framework for the mitigation of the flood risk and the impact of flood events;
- Provision of advice on specific policies, strategies, measures and actions necessary to support the achievement of the policy objectives of the Flood Mitigation Strategy;
- Provide advice on the estimated costs of the specific measures and initiatives to be implemented under the Darwin Region Flood Mitigation Strategy;
- Provide advice on an appropriate implementation framework for the Darwin Region Flood Mitigation Strategy; and
- Identify any Commonwealth Government funding that may be available to supplement NTG funding.



## FLOODING IN THE DARWIN REGION

**Flooding occurs when water covers land that is usually dry. Sources of flooding include rivers and other watercourses, inadequate stormwater drainage systems, local overland flow paths and groundwater systems.**

The Committee has considered major flooding associated with rivers and stormwater drainage. Minor nuisance flooding, such as trapping of surface water runoff on driveways, against a building, or in a road shoulder is not considered within the scope of work included in this report.

Riverine flooding is defined as flooding that occurs when heavy rainfall causes relatively high water levels in rivers or creeks to overtop the banks. The magnitude of a flood is determined by the amount of rainfall that has fallen in the catchment, its duration and its spatial distribution.

Extensive flooding can also occur as a result of stormwater flows during an intense rainfall event.

Surface water can surcharge from piped drainage systems or overflow from man-made stormwater channels which contribute to stormwater flooding.

The Rapid Creek catchment has been identified as the priority focus area for flood risk management as a result of riverine flooding in the Darwin Region, where there is a high and present risk to personal safety and property in the event of a flood.

There is also a history of extensive flooding occurring each wet season as a result of stormwater in the Ludmilla, Wadham Lagoon, Yarrowonga and Pinelands catchments. Stormwater flooding is particularly present in older subdivisions where inadequate drainage design exists or insufficient maintenance is undertaken.

## OVERARCHING FLOOD MITIGATION STRATEGY

The flood risk management framework is outlined in Figure 1 and incorporates the measures to be undertaken which work in conjunction and in parallel with one another to facilitate effective understanding and management of flood risks.

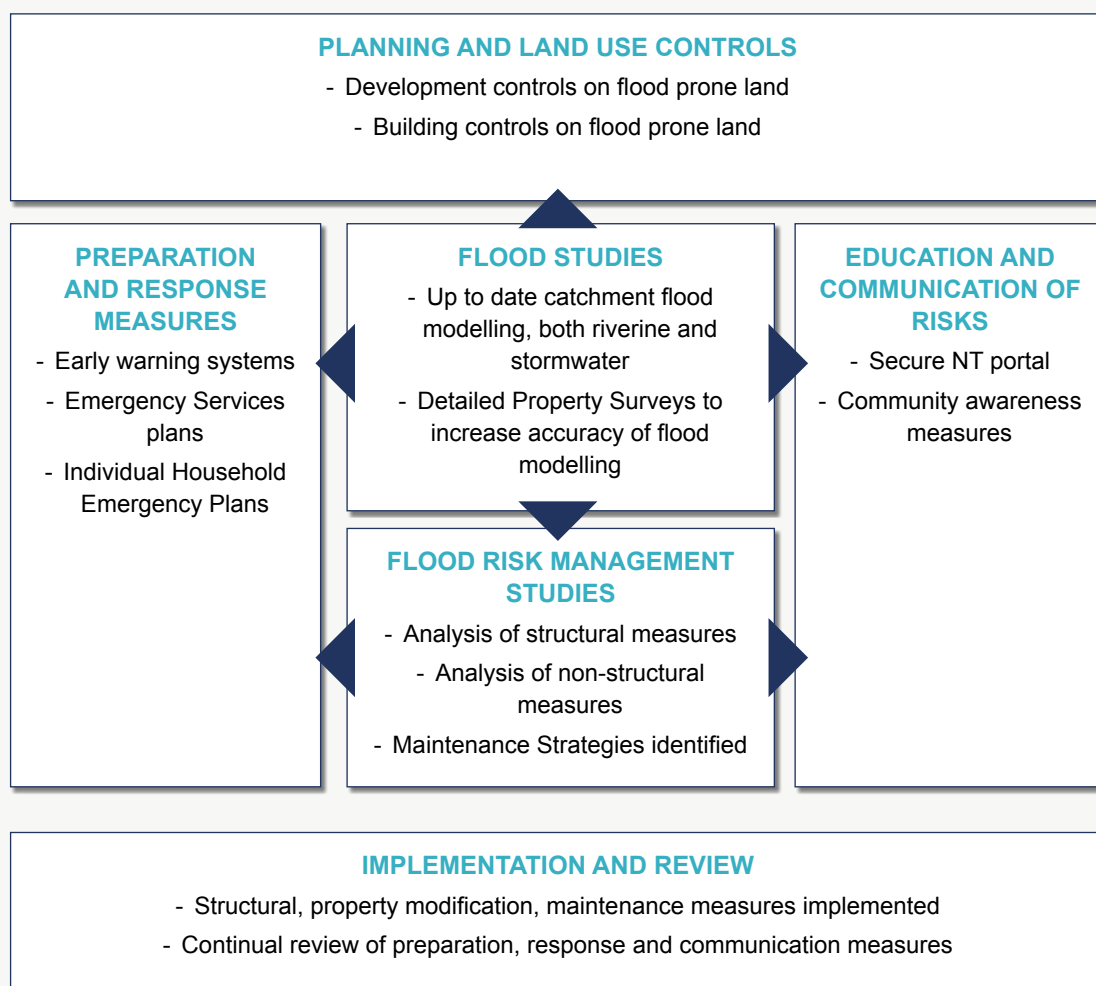
The policy framework builds upon existing floodplain management measures undertaken across the Northern Territory Government, particularly those that exist within the Department of Land Resource Management, Northern Territory Emergency Services and the Department of Lands, Planning and the Environment.

### The framework has the following key objectives;

- Understanding the exposure to flood risk;
- Understanding the planning and building controls in place;
- Making informed decisions on development within flood areas;
- Having the most accurate and relevant information available;
- Consultation with community and key stakeholders on the flood risk; and
- Recognise individual responsibilities to protect own property;

To achieve these outcomes requires a shared responsibility across all levels of governments (local, state and federal), non-government organisations, business and individuals.

Figure 1: The Flood Risk Management Framework





## PLANNING AND LAND USE CONTROLS

**Planning and land use controls address flood mitigation at the planning level by regulating land use activities in areas that may be prone to flooding.**

To ensure the flood risk is considered as early as possible in the planning and development process, planning decisions affecting flood prone land should take into account the best available flood information.

Maintaining up to date flood models of catchments assists the Development Consent Authority (DCA) to understand the impact of new development on existing residents in the catchment.

The Department of Land Resource Management (DLRM) is responsible for the modelling and mapping of riverine flooding in the Northern Territory but there is no government department that is responsible for mapping stormwater runoff.

Stormwater runoff is a result of rain that flows off roads, roofs and other sealed surfaces which results in water flowing at a different velocity and direction than what it would in the natural landscape.

There is currently a lack of information on the capacity and efficiency of existing stormwater drainage systems within catchments to inform future development and/or upgrades to prevent flooding.

The availability of stormwater modelling and mapping from the one source would allow for greater transparency across governments, council and developers, providing the information required to understand the cumulative impact on existing catchments and plan for upgrades to minimise flooding.

The cost of such an activity would need to be adequately resourced and stormwater flood maps would require continual review and updating as new knowledge comes to hand.

Specific areas in the Darwin region have been identified as immediately requiring catchment modelling and mapping of stormwater runoff and drainage where stormwater flooding issues are present. These are the areas of Virginia, Elizabeth Valley, Larrakeyah and areas of Darwin that may see increase development such as Parap and Stuart Park. These areas should be the first modelled as any new body of work.

Under the NT Planning Scheme, there is a requirement to avoid development of land affected by flooding. Development of land in any zone within a defined flood area requires the prior approval of the DCA. Existing building controls under the NT Planning Scheme also address flood risk by requiring new homes or substantial renovations to construct habitable rooms at the minimum 300mm above the 1%AEP flood level for the site

However, as there is no underlying legislation that deals directly with stormwater management, planning decisions requiring stormwater assessment are fragmented and responsibilities are ambiguous. There is no overarching understanding at the planning level of the principles and objectives of stormwater management to be followed in the Northern Territory.

A holistic approach to stormwater management is an increasing focus in other Australian jurisdictions and generally takes a total water cycle and natural resource management approach, addressing flooding as well as other factors such as quality of water. Whilst a total water cycle approach is above and beyond the scope of this report, it is recognised that some form of best practice management is required in the Northern Territory to minimise the adverse impacts of development on stormwater flows.

It is necessary, for flood mitigation, that a land suitability assessment addresses not only the singular impact but the cumulative impacts of post-development flows within a catchment. This is considered imperative at the planning level so that flood mapping is not done in a piece meal approach where the full impacts within a catchment are not fully understood.

The general principle that is adopted under a land suitability assessment and stormwater management plan is that the peak flow rate as a result of development must not exceed the pre-development peak flow rate.

In practice, the DCA notifies all councils of new development applications and various councils have primary responsibility for stormwater drainage assessment. Various government departments may also be sought to provide advice to the DCA on an ad-hoc basis.

## MAINTENANCE OF EXISTING INFRASTRUCTURE

**It is critical to ensure ongoing maintenance of existing infrastructure to maintain hydraulic performance and/or structural integrity of infrastructure such as trunk drainage. Developing and reviewing a regular maintenance schedule for flood prone areas is essential.**

A properly scheduled drainage maintenance plan can not only reduce the impact of smaller floods in flood affected areas, but can ensure that areas not usually subjected to flooding remain so.

The majority of stormwater trunk infrastructure and drains are assets owned by local councils who are responsible for their maintenance. There are also drainage systems associated with roads that are maintained by the Department of Transport and trunk infrastructure on defence land that are maintained by the Department of Defence.

The difficulty of ensuring a properly scheduled maintenance strategy becomes evident where a drainage system in a catchment has a number of asset owners. This is the case for the Rapid Creek and Ludmilla catchments, where local government, various government departments and the Department of Defence all have asset ownership along the length of the system. This requires a coordinated effort to obtain agreement and commitment between different levels of government on an ongoing maintenance strategy.

## RECOMMENDATION 1

**That the definition of *flooding* within the *NT Planning Scheme* is amended to include stormwater flooding to the effect that the owner or occupier of land maintains the pre-development peak flow rates within a catchment.**

**In conjunction with this, best practice policy for stormwater management in the Northern Territory is addressed; including the objective to reduce the risk of stormwater flooding. To support this objective, a single agency is resourced for the responsibility to hydraulically model trunk drainage systems to mitigate the impact of development on trunk drainage systems. This also includes the preparation of jointly funded maintenance agreements for the ongoing management (by relevant asset owners) of trunk drainage to maintain hydraulic efficiency.**

## FLOOD RESILIENCE MEASURES

**Flood modelling provides for predictions of flood events and those properties most likely to be impacted and by how much in the event of a flood. This information is essential to educate emergency services and the community on the need to prepare for a possible flood event. Detailed property surveys of flood affected residences can increase the accuracy of flood modelling so that homeowners, insurers and buyers can understand the actual impact of flooding on each property.**

Individual flood proofing measures where the inundation of flood water is relatively low (nominally less than 700mm) may be possible to keep flood waters out of homes by installing solid fences, raising windows, sealing doors with 'stop boards' and limiting sewerage contamination through reflux valves.

Surveying of properties in the Rapid Creek and Ludmilla catchments can identify the possible property modifications available and these measures are covered in their respective Works Plans on pages 17 and 20.

As many floods occur at night, early warning systems are extremely important in flooding events to provide residents with the ability to respond to impending flood waters. This may include moving vehicles, collecting pets and valuables and implementing personal emergency plans.

In conjunction with a Household Emergency Kit, a Household Emergency Plan is essential for all Territorians. Regardless of any other mitigation measures, every household must be prepared for extreme weather, including flooding.

The Northern Territory Government's Secure NT website gives advice on planning for emergencies and provides up-to-date information during and after emergencies including major flooding, extreme weather and cyclones.

Governments play an important role in promoting education and awareness to improve a community's resilience. In addition to the Secure NT website, NT Emergency Services have committed to continuing the promotion of education and awareness of flooding in the community through an annual education campaign.

## STRUCTURAL MEASURES

**Depending on locality and the nature of the flooding, a number of structural mitigation measures have been considered for key flood risk areas.**

Flood mapping and subsequent modelling has been analysed by suitably qualified professionals to provide the most cost effective structural mitigation measures that can address the risks of flooding for key risk areas.

When considering structural solutions, the analysis includes the impact of the infrastructure to reduce the flood risk profile. For example, some structural works which were not recommended only reduced the flooding by centimetres, providing little benefit to homeowners as the worst affected would still flood.

It must be noted that structural solutions have their limitations. No amount of intervention can stop flooding altogether for all rainfall events. It is extremely difficult to totally eliminate all risk.

## COMMONWEALTH FUNDING ARRANGEMENTS

**There is currently no Commonwealth funding available for flood mitigation. The existing Natural Disaster Resilience Program (NDRP) funding under the National Partnership Agreement expired on 30 June 2015 and is administered by the Northern Territory Emergency Service. The NDRP is a grant funding program that encourages governments to work together with volunteers, the private sector and non-government sectors in an effort to enhance Australian communities' resilience to natural disasters.**

A new funding arrangement is anticipated to be announced by the Federal Government. The Productivity Commission has produced a paper for consideration by the Federal Government that recommends a focus on disaster mitigation as opposed to recovery. Any federal funding would be distributed on a per capita basis, meaning that the Territory would likely receive limited funding.

The recommendations in this report do not consider any additional Commonwealth funding allocation at this time. Any future measures identified within the scope of the Darwin Region Flood Mitigation Strategy should be considered within the context of a potential matched funding arrangement with the Commonwealth to maximise the benefit to the Territory.

## INSURANCE

**Updated flood maps that take into account all available information, including ground surveys and mitigation measures provide for the most accurate data on risk profiles. This allows insurers to have more certainty of their risk exposure and to price premiums on this basis. Knowing the risk exposure is likely to reduce the cost of cover for the consumer as insurers can price with more certainty rather than inflating prices to cover an unknown risk.**

Under a risk price model, a property exposed to riverine flooding would be subject to higher premiums. Of the areas identified within this report, only the Rapid Creek catchment area is subject to riverine flooding. The works in this area are considered a priority not only in terms of mitigating the danger to personal safety and property, but also in reducing insurance premiums under a risk price model.

This report provides mitigation measures for other urban and rural areas in the Darwin Region with a known history of damage and disruption as a result of stormwater flooding. Although the works in these areas are not expected to impact insurance premiums under a risk pricing model, there is a general understanding that any reduction in the cost of damages will benefit an overall reduction in insurance premiums in the future. These areas include Ludmilla/ the Narrows, Wadham Lagoon, Yarrowonga and the Pinelands.



# SPECIFIC MITIGATION MEASURES

## RAPID CREEK CATCHMENT



## BACKGROUND

**Rapid Creek rises in the Marrara Swamp at the eastern end of the Darwin Airport, and flows for 9.8 km discharging into the Beagle Gulf at the southern end of Casuarina Beach. The Rapid creek catchment covers an area of 28 km<sup>2</sup>.**

The catchment area, in particular within the suburb of Milner, experiences flash flooding with little time to respond. Rapid Creek can flood across Rapid Creek Road and areas in Milner within 1.5 hours of the onset of heavy monsoonal rainfall. McMillans Road and Trower Road are also subject to flooding.

Major floods also occurred in 1974 (associated with Cyclone Tracy), 1977, and 1991. Minor floods have also occurred in other years, impacting mainly on Kimmorley Bridge.

Unprecedented flooding occurred during Cyclone Carlos in February 2011. A rainfall of 340 mm was recorded at Darwin Airport on 15 February 2011 and the stream gauge on Rapid Creek downstream of McMillans Road recorded a peak height of 3.74 m (SKM, 2013).

The updated Rapid Creek flood map publicly released on 17 January 2014 by Department of Land Resource Management identifies 67 residential properties located (wholly or partially) within the area inundated in 1% AEP (Q100) with depths of flooding up to 0.8m.

## RISK TO SAFETY AND PROPERTY

Parts of McMillans Road, Rapid Creek Road and Trower Road are in the floodway during a 1% AEP flood event. Hospital access via Trower Road is impeded during a flood event for both residents and emergency services.

The extent of properties within the current Rapid Creek flood map is summarised below:

Millner lots within extent of inundation for 1% AEP	Wholly	Partially	Total
Current	48	19	67

The net present value of potential damages as a result of rapid creek floods in a worst case scenario (without any prior warning) was estimated to be \$10.8 million to \$13.7 million (SKM, 2013).

In addition to the impact of flooding on property damage, the 2013 Sinclair Knight Merz (SKM) report identified the following;

The floodplain community of Rapid Creek, particularly in the Millner area, experience flooding that allows little time to respond. In a major storm event, Rapid Creek can inundate Rapid Creek Road and areas in the suburb of Millner within 1.0 to 1.5 hours of the onset of heavy rainfall.

A number of residents, whose properties mainly front Rapid Creek Road, experience difficulties evacuating to higher ground due to the restricted time to react and the early loss of access to Rapid Creek Road.

Large areas of the catchment have also been identified as 'high hazard' during Q100 flood events.

A high hazard rating indicates that there is:

- Possible danger to personal safety
- Evacuation by trucks difficult
- Able-bodied adults would have difficulty in wading to safety
- Potential for significant structural damage to buildings

## COMPLETED TO DATE

A number of flood investigations have been undertaken, including:

- The Rapid Creek Flood Study (Connell Wagner, 1999)
- Identifying Flood Risk For Rapid Creek (Saunders, Ruscheinsky, Rajaratnam, 2012)
- Rapid Creek Flood Study updated (Sinclair Knight Merz, 2013)

The study by SKM (now Jacobs) in 2013, confirmed that structural measures alone were not effective in mitigating the impact of flooding and identified a range of non-structural mitigation measures to reduce the risk of damages and increase public safety as a result of rapid creek floods.

In January 2014 the Department of Lands Planning and the Environment (DLPE) commenced extensive consultation with the residents of flood impacted properties regarding the range of mitigation options presented in the latest study by Jacobs.

There are still key flood investigations currently underway, including:

- Individual audits on all 67 properties within the current Rapid Creek flood map;
- Rapid Creek Maintenance Strategy with consultation led by Jacobs; and
- A joint investigation into the construction of detention basins.

These studies, funded by DLPE, will provide the information required to finalise the proposed mitigation measures for Rapid Creek.

## FLOOD MITIGATION

DLPE developed a Rapid Creek Flood Mitigation Action Plan to implement measures that would be effective in managing the impact of flooding on residents in Millner.

The key items on the Action Plan that directly assist affected residents with flood resilience are:

1. The flood awareness brochure prompting residents to prepare a personal flood action plan, currently being developed by DLPE and consultant Michels Warren Munday;
2. The NTES early warning system that provides residents with up to 45 minutes warning of an impending flood event (centred on interpretation of data from the flood gauge); and
3. Design and construction of detention basins that will reduce the peak of the flood event. The 2013 Jacobs Report identified that detention basins were one of the most effective measures in structural flood mitigation, demonstrated below:

Millner lots within extent of inundation for 1% AEP	Wholly	Partially	Total
Detention basins	22	17	39
Mitigation Measure	Benefit (damage reduction)	Indicative Cost	Ration Benefit/Cost
Detention basins	\$6.6 million	\$7.2 million	0.92

4. Undertake detailed survey of each property to ground truth the current flood model to update and remove all properties that are not affected by inundation.
5. The structural and hydrological assessment of all remaining affected properties to design and construction of specific flood proofing measures that will allow those residents to protect the interior of their homes during a flood event (e.g. raising windows, installing sewer reflux valves and installing 'stop-boards' on door openings).
6. Rezone all properties where flood proofing measures are not effective to support the redevelopment (with appropriate building controls) of these properties with habitable floors above the flood zone. Investigations by the Department indicate that a suitable zoning with a density of 6 units per 1,000m<sup>2</sup> lot will be incentive for both buyers and sellers.
7. Maintenance of Rapid Creek as a natural trunk drain to ensure that flood water flows through the Creek with an appropriate hydraulic efficiency, including maintenance of the existing flood control weir located on Defence land.

### RECOMMENDATION 2:

**The Department of Defence transfer tenure of the Marrara Swamp Flood Control Weir to the Northern Territory Government to secure ongoing existence of this structure, within the Rapid Creek catchment.**

These measures, acting together will improve the flood resilience of the affected residents and limit the extent of damages to external features such as landscaping and assist with a quick recovery from a flood event than if the floodwaters were to enter the houses.

An underlying factor in the success of these mitigation measures also relies on action by NT Airport. Jacobs (2012/13) identified that the urbanisation of the Darwin International Airport has already had an impact on floods within the Rapid Creek catchment with the potential of further development increasing the downstream impact.

### RECOMMENDATION 3

NT Airports investigate and implement mitigation solutions to manage stormwater runoff resulting from the total cumulative impacts of all development on NT Airport land since privatisation.

Jacobs report also identified health risks of sewerage inundation during flood events, with storm water inflow overloading the sewerage infrastructure and up to half of flood affected residents experiencing sewerage backflow. This resulted in a number of properties with raw sewerage through their homes.

Power and Water Corporation (PWC) have identified the sewerage overload issue is due to non-compliant overflow relief gully's (ORG) within the suburbs of Milner and Rapid Creek.

PWC have committed to funding and installing up to 20 back-flow prevention devices to properties identified in the Jacobs report at being at risk of sewerage inundation as a short term measure as they work through the rectification of non-compliant ORG's.

### RECOMMENDATION 4

Power and Water Corporation fund and install back-flow prevention devices to all properties at risk of sewerage inundation in the Rapid Creek catchment as identified in the Jacobs report.

It is anticipated that on completion of property upgrades to implement the flood mitigation measures, each property owner will receive certification from Jacobs that, in conjunction with the other key tenements of the Flood Resilience Implementation Plan, will have a lower risk of flood damage.

Properties that are not affected by flood inundation will also receive confirmation of this from Jacobs. This documentation will support the resident's efforts with reducing insurance premiums and in the future sale of their properties.

An updated flood map will be produced and take into account the finer survey detail and ground truthing data for the Rapid Creek catchment, providing a more accurate flood map for insurance pricing.

### RECOMMENDATION 5

The Department of Land Resource Management delay submission of the Rapid Creek catchment flood map to the National Flood Insurance Database, until it is remodelled to include revised ground surveys and the impact of all mitigation measures detailed in the Works Plan – Rapid Creek, including detention basins. The Department of Land Resource Management are to commit to updating NTG websites with the most up to date mapping upon completion.

## WORKS PLAN – RAPID CREEK

Action	Impact	Description	Re-sponsi-bility	Time-frame	Nature of Cost	Estimated Cost from Mitigation Fund
Flood awareness brochure	Increased public awareness to improve response to flooding.	Brochure similar to that produced for Katherine that includes information support the development of personal response plans.	DLPE	By June 2015	DLPE Operational budget	\$0
Early Warning System	Improved individual response to flood event.	Warning of impending flood via mobile or landline.	NTES/ DLRM	Complete	NT Govern-ment	\$0
Improved telemetric devices	Improved individual response to flood event.	Improved telemetric rainfall gauge to warn of rising creek height.	DLRM	2015-16	DLRM Operational budget	\$0
Improved display of river height mapping for hand-held devices	Improved individual response to flood event.	Provision of near real-time river height data on mobile-friendly website.	DLRM	2015-16	Flood Mitigation Funding	\$100,000
Detention Basin	Reduce flood impacts	Structural mitigation measure to reduce the impact of flooding to flood affected properties. This requires construction of a detention basin on Crown Land, (Lot 4294) which is in the optimal position to catch water from Marrara, Anula and Moil. The total estimated cost includes design and a contingency factor to accommodate additional basins and storm water management works, should they be required following detailed design.	DLPE / DoI	2015-16	Flood Mitigation Funding	\$7.2 million
Ground truthing survey	Improve accuracy of the Flood Map	Survey of all 67 lots to update the flood model and remove inaccuracies in the map.	DLPE	2015-16	DLPE Operational budget	\$0
Flood Proofing Assessment	Reduce damages to individual properties	Non-structural mitigation to reduce the potential for flood water to enter houses and sewerage contamination.	DLPE / DoI	2015-16	Flood Mitigation Funding	\$4.5 million (estimate only)

Action	Impact	Description	Re-sponsi-bility	Time-frame	Nature of Cost	Estimated Cost from Mitigation Fund
Rezoning of significantly impacted lots	Facilitate the redevelopment of lots above the flood level	Rezoning to facilitate willing buyer/ willing seller to redevelop the lots. Potentially 6 units per 1000m <sup>2</sup> lot.	DLPE	July 2015	DLPE Operational budget	\$0
Maintenance Strategy	Maintain hydraulic efficiency of the Creek	Identify maintenance requirements to maintain the Creek in its current natural state, with an emphasis on maintaining hydraulic efficiency of the entire channel, following detailed design and advice from geomorphological experts. This includes the formal hand-over of land surrounding the Marrara Swamp Flood Control Weir from Department of Defence to the NTG to facilitate the maintenance of the structural efficiency of the weir.	DLPE	July 2015	DLPE Operational budget	\$0
					<b>Total</b>	<b>\$11.8 million</b>

## RECOMMENDATION 6

Mitigation works for the Rapid Creek catchment to the estimated value of \$11.8 million to be funded from the Flood Mitigation Fund in accordance with the Works Plan – Rapid Creek.

# LUDMILLA CREEK CATCHMENT



## BACKGROUND

The Ludmilla creek catchment mainly consists of housing for RAAF Base Darwin and the suburb of the Narrows. The catchment area is identified above.

The contributing catchment into Ludmilla creek is approximately 2.1 square kilometres measured from Bagot road to the runway in RAAF Base Darwin. The catchment runoff ultimately flows towards the low

point on Bagot Road then into Ludmilla Creek. For major rainfall events the airport runway (shown in the image above with a dotted line) also contributes to catchment runoff and ultimately flooding at Bagot Road.

## RISK TO SAFETY AND PROPERTY

There are a number of properties that experience flooding on a regular basis each wet season at the Bagot Road low point. These properties recently experienced flooding up to 1 metre during heavy rainfall on the morning of Saturday 28 February 2015. Lot 3619 is situated in the primary storm surge zone and subject to flooding as a result of the storm surge tides flowing up Ludmilla Creek. Bagot Road also floods during heavy rainfall events.

Properties on Wilmot Street and Narrows Road are also prone to flooding each wet season. On the 28 February rainfall event, these properties were contaminated with sewerage outfall from toilets, waste drains and sink drains. The Department of Education advised it had flood level debris at Ludmilla School approximately 400-600 mm deep on the outside walls, and 100-150 mm deep on the inside of up to 18 rooms, on the same event. Winnellie Shopping Centre also experienced flooding through the entry and into individual tenancies of approximately 100 mm.

	<b>The Narrows/Ludmilla lots within extent of inundation for 1% AEP</b>
<b>Lots</b>	31
<b>Damage<sup>1</sup> \$</b>	\$1,640,000

<sup>1</sup> Damage Estimate for a 1 in 100 event. This is not an annual average damage estimate which would also take into account probabilities of 1 in 5, 1 in 10, 1 in 20 and 1 in 50 events.

## COMPLETED TO DATE

A number of flood investigations have been undertaken, including:

- Drainage of Stuart Highway Adjacent RAAF Base Darwin (Connell Wagner, 1998)
- Ludmilla Creek Hydrology/Flood Mitigation Study (SMEC, May 2013)
- RAAF Base Darwin Flood Remediation Project (Wood & Grieve Engineers, June 2013)
- Draft Ludmilla Creek Catchment Flood Mitigation Study (Aurecon, March 2015)

The study by SMEC in 2013 proposed a concrete lined drain through Ludmilla Creek, 35m in width and 1.5m in depth, at a cost of \$3.1M (excluding a contingency for acid sulphate soils). It will only mitigate the flooding on Bagot Rd to a 5 year ARI event. No assessment has been made in the SMEC study on the properties that experience flooding.

In December 2014 the Department of Lands Planning and the Environment (DLPE) commenced a flood

study on the Ludmilla Creek Catchment and the impacted properties. A draft report has been completed by Aurecon in March 2015 which proposed a range of mitigation measures.

The flood study suggested that flooding on three properties and Bagot Rd at its low point will not be effectively mitigated without significant earthwork and road reforming. Non-structural mitigation measures such as rezoning to facilitate development above the flood (and storm surge) level are being considered for these properties. A strategy is being developed with Department of Transport (DoT) to address the safety issue with Bagot Rd flooding.

Further investigation is required to understand the flooding impact on the downstream developments (Winnellie Industrial Area), and incorporate the proposed mitigation measures with the downstream drainage system.

## FLOOD MITIGATION

DLPE has developed a Ludmilla Creek Flood Mitigation Action Plan to implement measures that would be effective in managing the impact of flooding on residents in the Narrows.

The catchment area includes land under the control of the Department of Defence and requires a joint approach between the Department of Defence and the Northern Territory Government to implement these measures.

## RECOMMENDATION 7

**The Northern Territory Government and the Department of Defence develop a joint stormwater management plan for the Ludmilla Creek Catchment and implement appropriate mitigation measures including the construction of storm water detention basins on land owned by the Commonwealth and the Territory.**

The key items on the Action Plan that directly assist affected residents with flood resilience are:

1. Maintenance of the culverts under Stuart Hwy and the drainage system in RAAF Base Darwin, as well as Ludmilla Creek as a natural trunk drain to ensure optimum functionality.
2. Design and construction of detention basins that will reduce the peak of the flood event.
3. The requirement for a joint stormwater management plan with the Department of Defence.
4. Detailed design of drainage infrastructure that drains the eastern catchment of RAAF Darwin south to Sadgroves Creek. Note: further investigations on the impact of flooding along the proposed drain on the downstream catchment (Winnellie Industrial Area), and incorporate the proposed mitigating measures with the downstream drainage system.
5. Undertake detailed survey to ground truth the current flood model to update and remove all properties that are not affected by inundation.

The above measures will achieve a mitigated result where all properties except for 5, will have no or minimal flooding below 20mm;

	The Narrows/Ludmilla lots within extent of inundation for 1% AEP	
	Before Mitigation	After Mitigation
<b>Lots</b>	31	5
<b>Damage<sup>1</sup> \$</b>	\$1,640,000	\$299,000

<sup>1</sup> Damage Estimate for a 1 in 100 event. This is not an annual average damage estimate which would also take into account probabilities of 1 in 5, 1 in 10, 1 in 20 and 1 in 50 events.

6. Investigate non-structural mitigation measures for properties where the proposed flood mitigation measures are not effective, including flood proofing measures and / or rezoning to facilitate redevelopment.
7. Development of a maintenance plan for the Ludmilla Creek catchment that includes NTG, Department of Defence and Darwin City Council.
8. Develop a strategy with Department of Transport to address the safety issue with Bagot Road flooding.

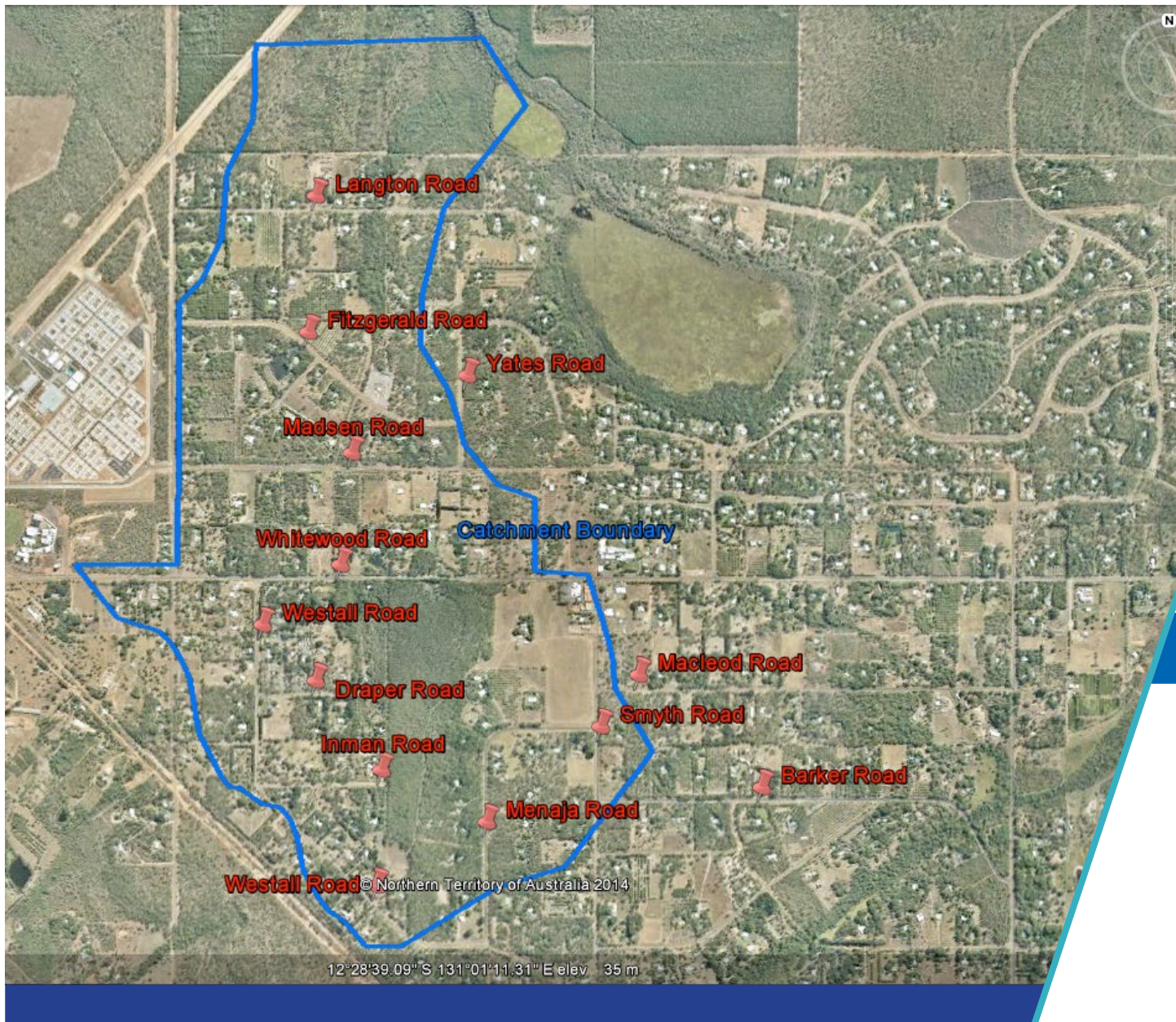
## WORKS PLAN – LUDMILLA CREEK CATCHMENT

Action	Impact	Description	Re-sponsi-bility	Time-frame	Nature of Cost	Estimated Cost from Mitigation Fund
Maintenance Strategy	Maintain hydraulic efficiency of the built drainage system and the creek	Identify maintenance requirements to maintain the built drainage system in RAAF Base Darwin, the Narrows and Stuart Hwy, as well as Ludmilla Creek in its current natural state.	DLPE / DoT/ Defence	July 2015	DLPE / DoT / Defence Operational budget	\$0
Stormwater Management Plan	Manage stormwater runoff to mitigate flooding	Identify and implement structural mitigation options to manage stormwater runoff from Defence land.	Defence	2015-16	Defence budget	\$0
Augment Winnellie West trunk drain including minor works to redirect flows through to Sadgroves Creek.	Reduce flood impacts	Structural mitigation measure to reduce the impact of flooding to flood affected properties. Includes estimate cost of design and a contingency factor to accommodate additional basins and storm water management works, should they be required following detailed design	DLPE / DoI	2015-16	Flood Mitigation Funding	\$7.5 million
Ground truthing survey	Improve accuracy of the Flood Map	Survey of lots to update the flood model and remove inaccuracies in the map.	DLPE	2015-16	DLPE Operational budget	\$0
Flood Proofing Assessment (Bagot Road)	Reduce damages to individual properties	Non-structural mitigation to reduce the potential for flood water to enter houses and sewerage contamination.	DLPE / DoI	2015-16	DLPE Operational budget	\$0
Rezoning of significantly impacted lots	Facilitate the redevelopment of lots above the flood level	Rezoning to facilitate willing buyer/willing seller to redevelop the lots.	DLPE	July 2015	DLPE Operational budget	\$0
Bagot Rd Safety Alert Strategy	Increased awareness to improve response to flooding	Warning of impending flood to inform decision of road closure.	DLPE / DoT	July 2015	DoT Operational budget	\$0
					<b>Total</b>	<b>\$7.5 million</b>

### RECOMMENDATION 8

Mitigation works for the Ludmilla catchment to the estimated value of \$7.5 million to be funded from the Flood Mitigation Fund in accordance with the Works Plan – Ludmilla Catchment.

# WADHAM LAGOON CATCHMENT



## BACKGROUND

The Wadham Lagoon catchment area is in the suburb of Howard Springs.

Water flows out of the lagoon through culverts and overtops Whitewood Road in larger storm events. Downstream of Whitewood Road, the water flows through open channels and crosses a series of roads through culverts before flowing into Dutchies Lagoon.

Flooding has occurred in and downstream of Wadham Lagoon in 1997 and 2011 (associated with Cyclone Carlos). Land use in the area is mostly rural residential and horticulture.

### RISK TO SAFETY AND PROPERTY

Approximately 79 lots have been identified from flood mapping to be impacted by a Q100 event. Of these, 12 properties would be the most affected with a Q100 flood level exceeding 0.5 metres. The worse impacted area is the upstream of Whitewood Road at the western fringes of Wadham Lagoon.

Studies identified the potential of large 4WD cars to float in a Q100 event at Madsen Road and the potential of small passenger cars to lose stability when crossing Langton Road.

### COMPLETED TO DATE

- Wadham Lagoon Drainage Study (Sinclair Knight Merz, 1997)
- Wadham Lagoon Flood Impact Assessment Report (Peter Saunders, Bijoy Joseph, 2014)
- Design Drawing of Culverts under Whitewood Road (Jacobs, 2014)

In August 2014, Jacobs developed a flood study to identify flood mitigation measures in Wadham Lagoon.

### FLOOD MITIGATION

The study recommended additional culverts to be underneath numerous roads and regrade the Wadham Lagoon outfall drain. The cost estimation for these improvements has been prepared, and the design for culverts underneath Whitewood Road has been completed.

In October 2014, the Litchfield Council (LC) has commenced consultation with impacted residents regarding the proposed mitigation recommendations, the location of culverts and the timing of work.

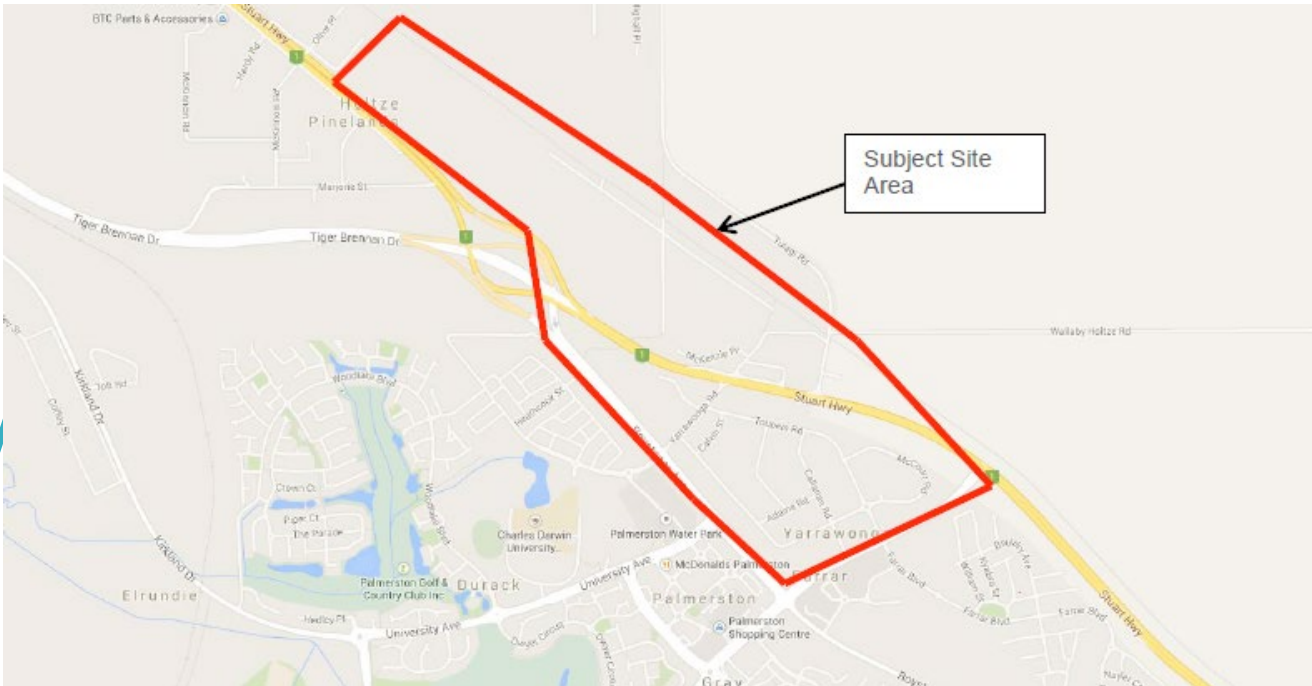
## WORKS PLAN – WADHAM LAGOON

Action	Description	Responsibility	Timeframe	Nature of Cost	Estimated Cost from Mitigation Fund
Detailed Design of mitigation option	Design of mitigation works on Whitewood Road, Madsen Road, Fitzgerald Road	Litchfield Council	Dec 2014 – Aug 2015	\$150,000 funded by existing DLPE budget to be granted to Litchfield Council	\$0
Consultation	Consultation with public regarding mitigation works	Litchfield Council	Ongoing	\$50,000 funded by existing DLPE budget to be granted to Litchfield Council	\$0
Whitewood Road and Sec 5986 driveway culvert upgrades	Detailed design and construction	Litchfield Council	May 2015	\$350,000 funded by existing DLPE budget to be granted to Litchfield Council	\$0
Raise Madsen Road, lower water main and regrade the drain on Sec A.	Detailed design and construction	Litchfield Council	Mar -Apr 2015	\$350,000 funded by existing DLPE budget to be granted to Litchfield Council	\$0
Upgrade Fitzgerald Road culverts, regrade and widen drain Madsen to Fitzgerald.	Detailed design and construction	Litchfield Council	Jun-Jul 2015	\$350,000 funded by existing DLPE budget to be granted to Litchfield Council	\$0
Upgrade of Langton Road culverts, regrade drain Fitzgerald to Langton and Langton to Pine Forest.	Structural mitigation option to reduce flood risk	DLPE	Jul-Aug 2015	\$300,000 (To be granted to Litchfield Council funded from Flood Mitigation Funding)	\$300 000
<b>Total</b>					<b>\$300 000</b>

### RECOMMENDATION 9

Mitigation works for the Wadham Lagoon catchment to the value of \$300,000 to be granted to the Litchfield Council from the Flood Mitigation Fund in accordance with the Works Plan – Wadham Lagoon.

# YARRAWONGA CATCHMENT



## BACKGROUND

Significant flooding has been present in the Yarrawonga catchment associated predominantly with stormwater drainage issues. The affected area is located north of the Stuart Highway, Yarrawonga within the City of Palmerston local government area.

The site is predominantly developed comprising of industrial and commercial properties. Flooding of properties occurs regularly in relatively small rainfall events. The current flooding issues include;

- Flooding in commercial buildings along Tulagi Road
- Road Reserve capacity issues along Wallaby Holtze Road

- Insufficient capacity and ponding in the swale at the rear of properties along McKenzie Place
- Additional flows from the Stuart Highway discharging through industrial area north of the Stuart Highway.

Flooding within these areas is largely due to inadequate drainage within subdivision roads and inadequate provision for trunk drainage. The drainage in the affected area is not considered to be at the standard condition required for new developments.

### RISK TO SAFETY AND PROPERTY

A number of buildings within the affected area are subject to flooding in a Q100 storm event (39 buildings have been identified). Flood modelling shows variations from 50mm to 600mm.

## COMPLETED TO DATE

Numerous investigations into addressing flooding in Yarrowonga Road North and Tulagi Road have been undertaken in the past.

Recent studies by DLPE include:

- Yarrowonga and Wallaby Holtze Flood Study - Draft (ADG, 2015)

ADG Engineering undertook additional detailed surveys in March 2015 to provide a higher level of detail about the stormwater conveyance and flood mitigation. The survey determined finer elevations over the catchment, established levels of existing building pads and confirmed levels along the Stuart Highway

This additional survey was undertaken to verify the assumptions made in the Draft Flood Study and allow the Flood Model to comprise of finer details. Using this information Q100 flood levels and flood immunity levels can be set for each lot in the area of interest.

DLPE have facilitated consultation with business owners in the affected areas.

## FLOOD MITIGATION

ADG have assessed flood mitigation options and have proposed new drains and culverts in addition to improving existing

infrastructure. This will alleviate flooding to insignificant levels below 50mm to those properties previously flooding up to 600mm.

The key flood mitigation measures are;

- Upgrade of existing culverts along Stuart Highway, Wallaby Holtze Rd;
- Shaping and grading of drains along Wallaby Holtze Rd to bikeway culvert;
- Upgrade of Yarrowonga Road to include a crest point as a stormwater control point; and
- New cross road culverts along Wallaby Holtze Rd.

## RECOMMENDATION 10

**Mitigation works for the Yarrowonga catchment to the value of \$3,230,000 to be funded from the Mitigation Fund in accordance with the Works Plan – Yarrowonga Catchment.**

## WORKS PLAN – YARRAWONGA CATCHMENT

Action	Impact	Description	Responsibility	Timeframe	Nature of Cost	Estimated Cost from Mitigation Fund
Tulagi Road – retaining wall and new drain	Mitigate flood impact	Structural diversion structure, a drain within an easement in favour of City of Palmerston and a new culvert under Wallaby Holtze Road.	DLPE/ DoI/City of Palmerston	2015-16	Flood Mitigation Funding	\$1,000,000
Yarrowonga Road upgrade of existing culverts and include crest point	Mitigate flood impact	Upgrade of Wallaby Holtze Road to act as a control point for stormwater on this road and channel stormwater into the new road drainage.	DLPE/ DoI/City of Palmerston	2015-16	Total cost of \$500,000 with City of Palmerston contributing \$470,000 and balance from Flood Mitigation Funding.	\$30,000
Wallaby Holtze Road Drainage upgrades	Mitigate flood impact	Construction of new road drainage on Wallaby Holtze Road from Tulagi Road to control stormwater within the road reserve.	DLPE/ DoI/City of Palmerston	2015-16	Flood Mitigation Funding	\$1,000,000
McKenzie Place Cul de Sac swale works	Mitigate flood impact	Drain in an easement on Lot 4223 to collect stormwater from the control point on Yarrowonga Road North.	DLPE/ DoI/City of Palmerston	2015-16	Flood Mitigation Funding	\$200,000
Stuart Highway drainage culvert upgrade	Mitigate flood impact	Upgrade of culverts along the northern side of Stuart Highway to keep the stormwater in the road reserve.	DLPE/ DoI/City of Palmerston	2015-16	Flood Mitigation Funding	\$700,000
Contingency for site issues	Mitigate flood impact	Structural mitigation measure	DLPE/ DoI/City of Palmerston	2015-16	Flood Mitigation Funding	\$300,000
Professional fees	Mitigate flood impact	Additional surveys to confirm ground levels and contingency for site issues	DLPE/ DoI/City of Palmerston	2015-16	Included above (6%)	\$0
<b>Total</b>						<b>\$3,230,000</b>

# PINELANDS CATCHMENT

## BACKGROUND

Significant flooding has been occurring in the subdivision of Baban Place, Pinelands since it was constructed by the Territory Government in the 1970s.

The site is predominantly developed comprised of industrial and commercial properties. Flooding of properties occurs regularly in relatively small rainfall events. The current flooding issues are caused by insufficient and inadequate drainage.

The drainage in the affected area is not considered to be at the standard condition required for new developments.

### RISK TO SAFETY AND PROPERTY

A number of buildings within the affected area are subject to flooding.

No assessment on potential damages is currently available.

### COMPLETED TO DATE

The City of Palmerston has undertaken significant consultation with business owners and a detailed design has been completed by Byrne Design that mitigates the risk of flooding entirely.

### FLOOD MITIGATION

The key flood mitigation measure is the construction of a drain from Baban Place in Pinelands to the Stuart Highway though easements acquired from private landholders.

The City of Palmerston is currently acquiring the last remaining easements along the proposed drain.

The City of Palmerston have commenced construction of the drain in the dry season of 2015.

## WORKS PLAN – PINELANDS

Action	Impact	Description	Responsibility	Timeframe	Nature of Cost	Estimated Cost from Mitigation Fund
Acquiring of easements on private property	Mitigate flood impact	Structural mitigation measure	City of Palmerston	2015-16	To be funded by the City of Palmerston	\$0
Construction of drainage	Mitigate flood impact	Structural mitigation measure	City of Palmerston	2015-16	\$900,000 (To be granted to City of Palmerston from Flood Mitigation Funding)	\$900 000
<b>Total</b>						<b>\$900 000</b>

## RECOMMENDATION 11

Mitigation works for the Pinelands catchment to the value of \$900,000 to be granted to the City of Palmerston from the Mitigation Fund in accordance with the Works Plan – Pinelands Catchment.

## PUBLIC FEEDBACK

The Draft Report was released for public feedback on the 14 May 2015 for a period of four weeks.

During this period, nineteen submissions were received. Eight submissions were received from local residents and eleven submissions from organisations.

The Committee carefully considered all submissions and feedback received. A summary of the submissions received associated with the recommendations of the Draft Report are detailed in Table 1: Summary of Submissions / Feedback. This summary includes the key points of the submissions received and the committee's responses.

The Committee agreed no amendments were required to the existing recommendations of the Draft Report.

**TABLE 1: SUMMARY OF SUBMISSIONS / FEEDBACK**

<b>RECOMMENDATION 1:</b>	
<p>That the definition of flooding within the NT Planning Scheme is amended to include stormwater flooding to the effect that the owner or occupier of land maintains the pre-development peak flow rates within a catchment.</p> <p>In conjunction with this, best practice policy for stormwater management in the Northern Territory is addressed; including the objective to reduce the risk of stormwater flooding. To support this objective, a single agency is resourced for the responsibility to hydraulically model trunk drainage systems to mitigate the impact of development on trunk drainage systems. This also includes the preparation of jointly funded maintenance agreements for the ongoing management (by relevant asset owners) of trunk drainage to maintain hydraulic efficiency.</p>	
<p><b>Resident Knuckey’s Lagoon:</b></p> <ul style="list-style-type: none"> <li>- Supports recommendation 1.</li> <li>- Relates very closely to own flooding problems in Knuckey’s Lagoon.</li> </ul>	<p>The Committee recommends DLPE investigate flooding in Knuckey’s Lagoon.</p> <p>Note: Berrimah North Area Plan limits further drainage to Knuckey’s Lagoon.</p>
<p><b>Resident Wells Creek Road:</b></p> <ul style="list-style-type: none"> <li>- Supports recommendation 1.</li> <li>- Questions why there are no funds allocated towards Wells Creek Road stormwater issues which has been a long standing problem with history of polluted stormwater through resident’s properties.</li> </ul>	<p>The Committee recommends DLPE investigate flooding on Wells Creek Road.</p>
<p><b>Residents Howard Springs:</b></p> <ul style="list-style-type: none"> <li>- Concerned that they will be liable for maintenance costs associated with a drain on their property.</li> </ul>	<p>The Committee recommends that the drain is vested with Council.</p>
<p><b>City of Palmerston:</b></p> <ul style="list-style-type: none"> <li>- Believes it is unlikely that trunk drainage networks are extensive enough that coordination of a mutually acceptable solution needs an independent body.</li> <li>- Suggests NTG and Councils agree on maintenance standards and enter into memorandums of understandings.</li> <li>- Would require political will and appropriate funding.</li> <li>- See more value in funding being directed towards development of drainage inspection procedures and activities rather than modelling flow.</li> <li>- Support the establishment of formalised infrastructure condition assessment processes, costed cyclic maintenance programs and the establishment of agreements of understanding and mutual commitment between parties that have drainage responsibilities that overlap.</li> </ul>	<p>The Committee agrees with these comments, with the exception of:</p> <ul style="list-style-type: none"> <li>- coordination is required to be done by a single agency (not necessarily an independent body).</li> <li>- modelling is essential for those areas known to have flooding issues (for existing and new development).</li> </ul>

<p><b>Department of Land Resource Management:</b></p> <ul style="list-style-type: none"> <li>- Incorporating storm water inundation criteria for development into the NT Planning Scheme may not be practicable as it differs from council to council. LGANT has developed guidelines for development in shires and councils which should incorporate stormwater design criteria.</li> <li>- Should be legislated at the local government level.</li> <li>- Trunk drainage should sit with the NTG.</li> <li>- Development criteria for riverine flood impacts should be separate from storm water flood impacts. Storm water flood impacts cover local areas whereas riverine flooding covers a town comprising of several storm water catchments. The differences between the two types of inundation are yet to be explored and this gives that opportunity. A stormwater management policy guided by LGANT should define the criteria and its assessment.</li> <li>- A stormwater management committee comprising of the LGANT, DoI, DLPE and DLRM should be formed to discuss this recommendation further. The discussion at this forum should lead to developing a policy.</li> </ul>	<p>The Committee supports an overarching body in Government to be responsible for stormwater management and to set best practice policy to work in hand with the proposed legislation change.</p>
<p><b>NT EPA:</b></p> <ul style="list-style-type: none"> <li>- NT EPA supports the proposed enhanced rigour in the provision of adequate stormwater infrastructure in future urban and industrial developments, and in the maintenance of stormwater infrastructure.</li> <li>- Maintenance of stormwater systems can be expensive, and often greater than need be the case. It might be helpful to include the need for improved application of regulation limiting sediment flows from building and construction sites to stormwater.</li> </ul>	<p>The Committee endorses this.</p>
<p><b>City of Darwin:</b></p> <ul style="list-style-type: none"> <li>- Seeks clarification on trunk drainage for the purpose of identifying ownership and maintenance responsibility.</li> <li>- Looks forward to working with other stakeholders in preparing a scheduled maintenance plan for existing assets.</li> <li>- Requests that the Sandy Creek catchment (including the suburb of Tiwi) also be included within the scope of the study, as it also experiences flooding issues. The City of Darwin has recently undertaken major stormwater drainage remedial works in response to flooding of private property within the suburb of Tiwi.</li> <li>- The City of Darwin has undertaken stormwater drainage study for the suburb of Stuart Park and is in the process of undertaking a stormwater drainage study for Parap / Fannie Bay.</li> </ul>	<p>The Committee recommends that ownership and maintenance responsibility should be included in the scope of works as part of identifying trunk drainage systems.</p>

<p><b>Ludmilla Creek Landcare:</b></p> <ul style="list-style-type: none"> <li>- Supports the concept of an identified single agency and single point of contact with regard to flood mitigation and stormwater flooding, particularly in the Ludmilla Creek area.</li> <li>- Supports an active coordination of maintenance of infrastructure, and that owner/occupiers should be responsible to control storm water flows to pre-development levels within a catchment.</li> </ul>	<p>Acknowledged by the Committee</p>
<p><b>Plan: The Planning Action Network Inc</b></p> <ul style="list-style-type: none"> <li>- The most single most effective direct action is to clean out existing long neglected concrete drains, and to keep them regularly maintained. This should be done sensitively.</li> </ul>	<p>Agreed by the Committee</p>
<p><b>RECOMMENDATION 2:</b></p> <p>The Department of Defence transfer tenure of the Marrara Swamp Flood Control Weir to the Northern Territory Government to secure ongoing existence of this structure within the Rapid Creek catchment.</p>	
<p><b>NT Airports:</b></p> <ul style="list-style-type: none"> <li>- Strongly support this recommendation</li> </ul>	<p>Acknowledged by the Committee</p>
<p><b>Defence:</b></p> <ul style="list-style-type: none"> <li>- Defence Support Central &amp; West is liaising with the Defence Property Management Branch to establish a suitable licence with the NT Government for the Marrara Swamp Flood Control Weir. This will ensure the protection of the Weir and the use of the land in its locality remains extant.</li> </ul>	<p>Acknowledged by the Committee</p>
<p><b>RECOMMENDATION 3:</b></p> <p>NT Airports investigate and implement mitigation solutions to manage stormwater runoff resulting from the total cumulative impacts of all development on NT Airport land since privatisation.</p>	
<p><b>NT Airports:</b></p> <p>Have commenced;</p> <ul style="list-style-type: none"> <li>- design work on a channel pond in the conservation reserve which runs up to Charles Eaton Drive;</li> <li>- design work on diversion of a drain to divert run-off of 8.76 ha of land behind the existing flood control weir; and</li> <li>- development of guidelines for containment of stormwater flows for new developments to pre-development levels.</li> </ul>	<p>The Committee supports these works and proposes the NTG and NT Airports sign an agreement to commit to mitigation measures within the Rapid Creek catchment, so that post-development flows will not exceed pre-development flows.</p>
<p><b>Plan: the Planning Action Network, Inc</b></p> <ul style="list-style-type: none"> <li>- The new Darwin International Airport Management Plan should address run-off, including polluted run-off from operational areas, and minimize clearing / building in sensitive locations.</li> </ul>	<p>The Committee supports the Darwin International Airport Management Plan addressing management of stormwater runoff.</p>
<p><b>RECOMMENDATION 4:</b></p> <p>Power and Water Corporation fund and install back-flow prevention devices to all properties at risk of sewerage inundation in the Rapid Creek catchment as identified in the Jacobs report.</p>	

<p><b>Power and Water Corporation:</b></p> <ul style="list-style-type: none"> <li>- 2 back flow prevention devices as a result of consultation with residents during the ORG survey have been installed. Waiting on final advice from Jacobs on what other residences require back flow devices installed. As soon as this information is provided this work will be completed.</li> </ul>	<p>Acknowledged by the Committee</p>
<p><b>RECOMMENDATION 5:</b></p> <p>The Department of Land Resource Management delay submission of the Rapid Creek catchment flood map to the National Flood Insurance Database, until it is remodelled to include revised ground surveys and the impact of all mitigation measures detailed in the Works Plan – Rapid Creek, including detention basins. The Department of Land Resource Management are to commit to updating NTG websites with the most up to date mapping upon completion.</p>	
<p><b>DLRM:</b></p> <ul style="list-style-type: none"> <li>- Supports not lodging current flood map and data into the National Flood Risk Information Portal (NFRIP) and supports revision of the flood mapping following proposed detailed ground survey and review of the underlying modelling.</li> </ul>	<p>Acknowledged by the Committee</p>
<p><b>RECOMMENDATION 6:</b></p> <ul style="list-style-type: none"> <li>- Mitigation works for the Rapid Creek catchment to the estimated value of \$11.8 million to be funded from the Flood Mitigation Fund in accordance with the Works Plan – Rapid Creek.</li> </ul>	
<p><b>NT Airports:</b></p> <ul style="list-style-type: none"> <li>- From the jointly funded hydrology studies (DLPE/ NT Airport) the single most effective measure to mitigate flooding for Rapid Creek residents is a retention structure on the 'triangle block' (Lot 4294). The 'triangle block' retention structure should be the first project to be funded out of the \$11.8m. Additional to the retention structure the area should be designed and planted so that it is available to the public and a real community amenity. This is consistent with most of the Rapid Creek riparian corridor.</li> </ul>	<p>Acknowledged by the Committee</p>
<p><b>Rapid Creek Landcare Group:</b></p> <ul style="list-style-type: none"> <li>- Has decided not to provide a formal comment on Draft Report at this stage. Will provide feedback when the geomorphologist report is available which is seen as crucial in relation to the comments made in the Draft Report about maintenance of hydraulic efficiency of the creek.</li> <li>- Noted that there is concern in the community regarding a proposed detention pond but cannot comment without information about its size, location and operating processes and the modelling results that led to the process.</li> <li>- Also requesting an economic rationale for building a detention basin for \$7.2m as per the Works Plan, given the 2013 SKM report indicated that it was uneconomical to build detention basins as the costs exceed the benefit.</li> </ul>	<p>The Committee recommends the geomorphologist report commissioned by DLPE to be made available to the Rapid Creek Landcare Group.</p> <p>Additional Information: The recommendations in the report cover a range of measures which work in unison to address flooding in the Rapid Creek catchment. The cost benefit ratio is 0.92 for the building of detention basins as per the 2013 SKM report and was identified as marginally cost effective. Subsequent modelling has identified the construction of a detention basin in the 'Marrara triangle' (Lot 4294) would reduce the peak flow at Millner by 27% and is the recommended option, in conjunction with other measures that address flood proofing and redevelopment in those areas that are worst affected (properties with frontage on Rapid Creek Road in lowest point).</p>

<p><b>City of Darwin:</b></p> <ul style="list-style-type: none"> <li>- Supports work plan in Report.</li> <li>- Although part of the channel runs through Council land, Council is responsible for the maintenance of land above the high water mark of the stream flow, either side of the creek. Responsibility for the maintenance of the creek itself and any flooding of the creek falls with the NT Government.</li> </ul>	<p>The Committee recommends that responsibility associated with maintenance is clearly identified in the maintenance plan.</p>
<p><b>Plan: the Planning Action Network, Inc</b></p> <ul style="list-style-type: none"> <li>- Support a detention basin in the upper Defence Airport land to provide better control of flows, and also heightening the nearby weir.</li> <li>- The Marrara Swamp, acting as a natural seasonal retention basin, should be protected.</li> <li>- Does not support rezoning and rebuilding as two storey dwellings on the same lots. This would create a precedent, with insurance issues, at present unresolved.</li> </ul>	<p>Acknowledged by the Committee</p> <p>Additional Information: The Committee recommends that any rezoning to higher density would have strict conditions on building requirements, at the minimum 300mm above the Q100 flood level for habitable rooms. Emergency egress points will needed to be determined to allow for additional evacuation access.</p>
<p><b>Resident Rapid Creek:</b></p> <ul style="list-style-type: none"> <li>- Would prefer that vegetation is not removed from creek channel or banks.</li> <li>- Does not support rezoning to higher density as it would mean more people are subjected to flooding. Rezoning would be against the issues raised in the report whereby floods occur at night and there is already difficulties evacuating to higher ground due to restricted time and early loss of access to Rapid Creek Road.</li> <li>- Supports the funds be available for redevelopment of ground level dwellings into elevated houses or the buy-back of dwellings.</li> <li>- Supports funding towards property buy-backs rather than spending funds on proposed detention basin.</li> </ul>	<p>The Committee recommends the geomorphologist report will provide the expert advice of where any silt and/or debris should be removed from the creek to ensure hydraulic efficiency, which will inform the maintenance plan.</p> <p>The Committee recommends that any rezoning to higher density would have strict conditions on building requirements, at the minimum 300mm above the Q100 flood level for habitable rooms. Emergency egress points will needed to be determined to allow for additional evacuation access.</p> <p>Additional information:  Redevelopment of ground level dwellings to elevated is not feasible for brick on ground slab construction, which is the majority of the most flood-affected houses on the Rapid Creek floodplain.</p> <p>In some jurisdictions, buy backs have been contemplated where flooding is frequent, the risk to life or property is high and there are no other viable options. Buy backs have a high economic cost and also a high social cost as not all residents would accept voluntary purchase. A conservative figure for the buy-back of the most flood-affected houses in the Rapid Creek floodplain is estimated at \$44 million.</p>

### RECOMMENDATION 7:

The Northern Territory Government and the Department of Defence develop a joint stormwater management plan for the Ludmilla Creek Catchment and implement appropriate mitigation measures including the construction of storm water detention basins on land owned by the Commonwealth and the Territory.

#### **Defence:**

- Defence Support Central & West has sought in-principle agreement from Head Defence Support Operations to provide an initial contribution to facilitate site selection and design for the flood mitigation elements on Defence land, and to fund the flood mitigation works on RAAF Base Darwin once final scope has been agreed.

Acknowledged by the Committee

#### **Ludmilla Creek Landcare:**

- Supports a joint stormwater management plan between NT Government and Department of Defence. Retention basin works on Defence land is strongly supported.

Acknowledged by the Committee

### RECOMMENDATION 8:

Mitigation works for the Ludmilla catchment to the estimated value of \$7.5 million to be funded from the Flood Mitigation Fund in accordance with the Works Plan – Ludmilla Creek Catchment.

#### **City of Darwin:**

- Supports work plan in Report
- The NT Government is responsible for the implementation of the work plan and any flooding of Ludmilla Creek.

Acknowledged by the Committee

#### **Plan: the Planning Action Network Inc**

- Local knowledge should be respected in fine tuning natural drainage. Advantage should be taken of the lay of the land, and ground truthing to direct run-off. Large concrete installations should be avoided.
- Clearing of vegetation, artificial filling, and built developments and structures in the Ludmilla Catchment should be almost entirely avoided.

The Committee is recommending a detention basin and a Winnellie West trunk drain as per the Works Plan which addresses the flooding issues which stem from the upper catchment.

<p><b>Ludmilla Creek Landcare:</b></p> <ul style="list-style-type: none"> <li>- Ludmilla creek landcare does not have expertise in man-made drainage design. It is noted however, that the Bagot Road entry points to the storm water drains (which flow under Ludmilla School grounds) to the creek are at least 500mm lower than the height of the Ludmilla School grounds. Thus there is a barrier which if could be lowered, provides an improved flow of storm water across the school grounds to the next “low point” being Ludmilla Creek “flood-out”/floodplain area. Propose the lowering of the Bagot Road footpath on the “downstream” side of Bagot Road. In conjunction, landscaping works (including a swale) could be done on an open space currently within Ludmilla Primary School grounds to allow a much greater flow of water from the low point of Bagot road, across the open space school ground area and drain in the Ludmilla Creek “flood-out” area during intense stormwater flood events.</li> <li>- Improving drainage infrastructure to Sadgroves Creek is strongly supported.</li> <li>- Supportive of a ground truthing survey, and suggest active engagement with Landcare as a local group with knowledge of water flows in the Ludmilla Creek area.</li> </ul>	<p>The Committee confirms that this measure was one of the measures assessed by the flood mitigation study. The recommended approach is to address flooding from the upper catchment (through measures such as the augmentation of the Winnellie West trunk drain) to reduce the flood impact to those residents most affected.</p>
<ul style="list-style-type: none"> <li>- Supports flood proofing, rezoning and a safety alert strategy</li> <li>- Supports flood resilience measures for individual dwellings and for early warning systems.</li> <li>- Strongly opposes the 35m wide concrete lined drain in previous SMEC study as would result in unnecessary and significant damage to the environmental fabric of the Ludmilla Creek area whilst not necessarily moving stormwater significantly faster, as the fall between Bagot Road and Dickward Drive is minimal.</li> </ul>	<p>Acknowledged by the Committee</p>
<p><b>RECOMMENDATION 9:</b></p>	
<p>Mitigation works for the Wadham Lagoon catchment to the value of \$300,000 to be granted to the Litchfield Council from the Flood Mitigation Fund in accordance with the Works Plan – Wadham Lagoon.</p>	
<p><b>Residents Howard Springs:</b></p> <ul style="list-style-type: none"> <li>- Concerned regarding the impact on their property downstream of Wadham Lagoon. In particular;</li> <li>- Reduced accessible lot size</li> <li>- Devalued property value</li> <li>- Drainage maintenance costs (refer to comment against Recommendation 1)</li> <li>- Increased volume of water and flow rate through the drain in their property (and an increase in insurance premium relating to their property)</li> <li>- Deforestation of boundary due to works to regrade the drain.</li> <li>- Concerned that the impact on the downstream properties as a result of the scope of works has not been considered.</li> <li>- Concerned regarding timing of works and protection of downstream properties to ensure floodwaters are not directed downstream if changes are done upstream to flow and volume of storm water.</li> </ul>	<p>The Committee confirms the downstream properties were considered in the flood mitigation study. The Committee recommends that DLPE works with the residents to address their concerns.</p>

<p><b>Power and Water Corporation:</b></p> <p>The watermain proposed to be lowered on Madsen St is a PWC asset and any work associated with it should be done by Water Services.</p>	<p>The Committee agrees that the watermain works is to be approved by Water Services, PWC.</p>
<p><b>RECOMMENDATION 10:</b></p> <p>Mitigation works for the Yarrowonga catchment to the value of \$3,230,000 to be funded from the Flood Mitigation Fund in accordance with the Works Plan – Yarrowonga Catchment.</p>	
<p><b>City of Palmerston:</b></p> <ul style="list-style-type: none"> <li>- Supports funding for this stormwater legacy issue</li> </ul>	<p>Acknowledged by the Committee</p>
<p><b>RECOMMENDATION 11:</b></p> <p>Mitigation works for the Pinelands catchment to the value of \$900,000 to be granted to the City of Palmerston from the Flood Mitigation Fund in accordance with the Works Plan – Pinelands.</p>	
<p><b>City of Palmerston:</b></p> <ul style="list-style-type: none"> <li>- Supports funding for this stormwater legacy issue</li> </ul>	<p>Acknowledged by the Committee</p>

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