



Carnarvon Floodplain Management Working Group Report

May 2022



Department of Primary Industries
and Regional Development
Department of Water and
Environmental Regulation



FOR A SAFER STATE

Carnarvon Floodplain Management Working Group report

Floodplain management for the Carnarvon horticultural industry

Acknowledgments

The Carnarvon Floodplain Management Working Group acknowledges the Traditional Owners of Country, the Yinggarda people, the many lands that we work on, their language groups throughout Western Australia and recognise their continuing connection to the land and waters. We respect their continuing culture and the contribution they make to the life of our regions, and we pay our respects to Elders past, present and emerging.

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Executive summary

Periodic flooding of the lower Gascoyne River floodplain at Carnarvon is a natural event. The flooding results from cyclonic and thunderstorm activity in the catchment, with the risk period generally from November to May, associated with the wet season in the north of WA. The Carnarvon horticultural area has suffered considerable damage following flooding of the Gascoyne River in 1960, 1961, 1974, 1980, 1995, 2000, 2009, 2010/11 and 2021.

The WA Government has undertaken restoration programs to replace soil lost for most of these major flooding events. Apart from the soil loss and risks of permanent damage to the natural resource, the costs and delivery of the restoration programs have failed to improve soil conservation and land management practices, and therefore the business resilience, of many in the current industry. A more enduring model is required for a sustainable Carnarvon horticultural industry.

Carnarvon horticultural area accounts for about eight per cent of the gross value of production for WA's horticulture industries, through the production of counter seasonal solanaceous and cucurbit vegetable crops, early season temperate fruit crops, mid-season tropical crops, as well as year-round production of bananas.

In February 2021, a slow moving tropical low system caused widespread flooding along the Gascoyne River. As a result of floodwaters, Carnarvon horticultural properties were inundated, experiencing varying impacts including soil and crop loss from paddocks, access to farms and farm tracks washed away, and, horticultural waste/rubbish was transported onto other properties, into the ocean and then deposited on beaches along the WA coastline.

Assessments undertaken by the Department of Primary Industries and Regional Development (DPIRD) indicated impacts were localised to properties near floodways, and the Kingsford and the western end North River Road locations. The majority of properties impacted were predominately growing annual crops. Properties growing perennial crops with ground cover in major floodway areas, such as Lewers Creek, reported minimal soil or crop loss (pers comm Working Group member 2021).

To assist the horticulture industry to recover and reduce future impacts, the WA Government convened the Carnarvon Floodplain Management Working Group (the Working Group) to review factors that contributed to the impacts of the flood.

This report has been prepared by the Working Group and provides initiatives for consideration by the Minister for Agriculture and Food. The initiatives focus on improving management of the floodplain and, most importantly, its soils on which the Carnarvon horticultural industry relies on for profitable and sustainable production.

The purpose of this floodplain management report for the Carnarvon horticulture industry is to provide direction for investment and suggest action to support understanding of this dynamic system and its effective management.

The Working Group's vision is to build a flood resilient community in which the Carnarvon community, businesses, and government agencies, including Traditional Owners, are aware of flooding and work together to better manage flood risks and

strengthen the resilience of our industry, local economy, infrastructure, and environment.

The Working Group has focused on five critical success factors to resolve the current issues and be better prepared for future events. These are:

1. Governance
2. Flood planning and mapping
3. Waterways management
4. Soil conservation and land management, and
5. Waste management

The following provides a brief context to each of these critical success factors, followed by recommendations on page 6.

1. Governance

The response to floodplain management by the horticultural industry requires coordination and long-term strategic leadership to implement and maintain sustainable practices. A floodplain is a dynamic system that evolves, changes and reacts differently to the intensity and location of rainfall delivered to its catchment. The constant in the Carnarvon floodplain is that floods are inevitable and effective management of the floodplain must evolve and change in response to meet the challenges for business and community.

Coordination of the roles, responsibilities and strategic intent of the relevant agencies could assist the horticultural industry to better prepare, mitigate, respond to, and recover from flood events. To deliver this coordinated long-term management of the floodplain, it is proposed that the Working Group should continue, comprising the key stakeholders, Horticultural industry representatives, Shire of Carnarvon, Department of Water and Environmental Regulation (DWER), DPIRD, Department of Fire and Emergency Services (DFES), and other entities or businesses as required.

The management of the floodplain is a shared responsibility, and no single stakeholder should be burdened with it. The collective entities/agencies outlined above must work together, as they all have a role in effective management of the floodplain. Initiatives undertaken by the Working Group should link in with the existing Local Emergency Management Committee.

The roles and responsibilities of each entity need to be clearly defined; and the regulatory powers of each authority communicated to stakeholders. All parties, including growers must acknowledge they are accountable for delivering on their responsibilities as outlined in Table 1 of this report.

2. Flood planning and mapping

A greater understanding of the full range of expected flood events is required to support improved land use and land use planning, flood emergency response planning, infrastructure design, and community flood preparedness.

A refined digital elevation model could help better understand how local factors and the levees contributed to the difference between the 2021 flooding, and the height of flood levels previously observed. The digital elevation model includes:

- Lidar survey of the river and floodplain areas within the Carnarvon horticultural district.
- Land survey along the banks of the Gascoyne River to confirm location and height of privately constructed bunds, and
- Bathymetry to define riverbed levels within temporary/permanent pools, at time of Lidar capture.

These up to date and high-resolution surveys have the potential to support future flood modelling and help determine the impact of land management activities on flood behaviour. The DWER assessment of the February 2021 flood (DWER 2021) illustrated that some localised areas are not well represented by the current modelling. Current flood mapping needs to reflect the changes that have occurred within floodplain over the past 20 years. This also needs to include an assessment of the impact on flooding of climate change. The current floodplain model used for flood mapping was constructed more than 20 years ago. The model has been updated to include major infrastructure developments but it's time for renewed data to help address the issues identified.

To assist stakeholders, consistency in the reporting of peak flood levels (height) could enable comparison between events and help emergency personnel and the community take appropriate actions to reduce the risks and impacts of flooding. Communication in relevant languages is required to assist all community members to better understand the risks associated with an impending flood.

3. Waterways management

Remediation of riverbanks and floodways is vital to protect properties and livelihoods from future flooding and damage.

New GIS data sets are available to provide greater clarity on the location, class, and ownership of floodways. The development of this information into maps of all floodways could assist management by landholders.

To improve the management of floodways located on growers' properties, recommended practices need to be reviewed, in consultation with industry. A farm management practices guide detailing the current recommended practices should be developed, and updated, as required.

Where a floodway exists across several properties, a management plan for the full length of the water course should be developed, in consultation with landowners. The management plan should detail the current and ongoing maintenance required to ensure the floodway's function remains effective. This could ensure the floodway is managed consistently and provide clarity to all stakeholders on the standard that must be maintained. The management plan should outline short, medium, and long-term management activities to be undertaken, and the entities accountable for these actions.

Government agencies need to work together to engage landowners and support effective compliance with the requirements of management plans for floodways.

Funding sources need to be identified and applications submitted to assist the planning, remediation, and coordinated management of riverbanks and public floodway activities.

4. Soil conservation and land management

The cycle of soil loss due to flood events and subsequent Government supported soil restoration programs are unsustainable. The WA Government has undertaken restoration programs to replace soil loss in response to flooding in 1960, 1961, 1974, 1980, 1995, 1999, 2000, 2010/2011 and 2021.

A model of education, access to technical information, more informed business decisions, and clear government directions could empower industry to improve soil conservation and land management practices on the floodplain.

A dedicated Development Officer located at Carnarvon could lead education and engagement with growers to extend improved practices in land, soil and crop management aimed at mitigating the impact of flood events and reducing soil loss on horticultural properties.

A review of the *Farm Management Practices for the Prevention of Soil Erosion in the Carnarvon Horticultural Area, (2003)* guideline should be initiated. This review would confirm the management practices that are still relevant and identify areas that need further research or demonstration. This should include economic research to support more informed decision making and the timing of crop management practices, as well as economic evidence that good practices lead to greater returns over time. A contemporary farm management practices guide should be released and communicated to growers in the Carnarvon horticulture area.

All growers should be encouraged to participate in existing programs to build the capacity of businesses to adopt new practices and manage disruption events.

In anticipation of future flood events, a formal WA Government policy position on soil restoration programs could be developed to assist the horticultural industry to manage expectations of the support available after future flood events. The policy could include direction on:

- Sites identified with suitable topsoil
- Pre-approval for access to sites
- Commercial or industry arrangements for future programs.
- Guidelines defining the conditions under which soil can be accessed, and
- How the pit will be managed and conditions of access.

A clear policy may influence how growers manage the soil resource in future.

5. Waste management

The current high level of unmanaged waste in the Carnarvon horticultural area is unacceptable and places the industry's social license to operate at risk. An immediate and ongoing focus to improve waste management throughout the horticultural area is required. Through the Working Group, the Carnarvon Growers Association (CGA), Shire of Carnarvon and DWER should develop a strategy to coordinate activities to ensure landholders effectively address rubbish/waste management on-farm. The focus of the strategy could include the key components of communication, education, recycling, and compliance.

Recommendations

The Carnarvon Floodplain Management Working Group (Working Group) has developed recommendations across the five critical success factors. These recommendations are:

1. Establish a governance structure to promote a coordinated and long-term strategic approach to floodplain management

- 1.1 The current Working Group continue to provide the coordination and long-term strategic leadership for the management of the floodplain, including the implementation of the endorsed recommendations. The Working Group should be maintained and actively engaged in the long term for the benefit of the horticultural industry.
- 1.2 The Working Group be represented on the Local Emergency Management Committees to ensure effective communication, collaboration, and preparedness for pending floods.
- 1.3 The Commissioner of Soil and Land Conservation, DPIRD, DWER, Shire of Carnarvon and DFES clearly define and communicate expectations and regulatory powers to landholders, with support from CGA.
- 1.4 The Working Group develop a conflict resolution pathway to assist mediation of on-farm issues between stakeholders and communicate that pathway to all stakeholders.

2. Undertake flood planning and mapping to increase understanding

- 2.1 DWER and Shire of Carnarvon develop a high-resolution digital elevation model through comprehensive surveys of the river and floodplain. The digital elevation model will assist the understanding of sand build-up in the channel and floodways; identify and capture recent changes (such as private levees and infilling of low areas); comparison of Government-constructed levees with as-constructed drawings.
- 2.2 DWER and Shire of Carnarvon develop a new floodplain model to better understand flood behaviour; assess the impact of local structures added since the last model was developed (20 years ago); inform potential new engineering solutions, such as increasing

breakouts upstream or additional levee structures downstream; and guide land use planning. The study should include benefit-cost assessments for all potential mitigation options considered.

- 2.3 DWER working with Bureau of Meteorology (BoM) and DFES prepare and deliver consistent communication on how the flood level measurement are reported, including how this relates to previous events.
- 2.4 Shire of Carnarvon and DWER consider the installation of visual gauge boards along the river for growers to observe local river levels to improve awareness and decision making.

3. Reduce impacts through waterways management

- 3.1 DPIRD review the existing and new information with industry representatives to:
 - Identify all flood prone areas susceptible to impact using new data sets.
 - develop up to date maps of floodway areas,
 - Identify where a road may constrain flow of a floodway, and
 - develop recommended soil management practices (cultivation practice and vegetation cover) for privately owned floodways.
- 3.2 Where there is joint ownership of a floodway, a management plan facilitated with all landowners by the DPIRD Development Officer.
- 3.3 DPIRD, Shire of Carnarvon and DWER develop a management plan for publicly owned floodways and riverbanks. This includes where floodway flow may be impeded by a road or other infrastructure.
- 3.4 DPIRD, together with the Working Group, develop a process for engaging and encouraging landowners who are reluctant to commit to preparing and implementing management plans for improved floodplain management.
- 3.5 DPIRD work with the Shire of Carnarvon and DWER to identify riverbank and floodways work that could form community projects.
- 3.6 Shire of Carnarvon and DPIRD develop a budget for initial remediation of publicly owned floodways and their ongoing maintenance.
- 3.7 Shire of Carnarvon with assistance from DWER and DPIRD, develop grant applications to fund the initial clean-up program and ongoing maintenance of floodways.
- 3.8 DPIRD and Shire of Carnarvon develop a grant application for a riverbank management plan.

4. Reduce loss through improved soil conservation and land management practices

- 4.1 DPIRD employ a dedicated Development Officer based at Carnarvon, for at least three and up to five years, to lead education and engagement with growers in the Carnarvon horticultural area, and promote better land, soil, and crop management practices to mitigate the impact of flood events and reduce soil loss from horticultural properties.
- 4.2 In consultation with industry, DPIRD develop, publish, and promote a guide of contemporary farm management practices for the Carnarvon horticultural area. It should include practical management options, landholder compliance requirements and obligations, and flood and cyclone preparation checklists.
- 4.3 DPIRD and CGA encourage all growers to participate in existing programs, such as Building Horticulture Business Capacity, Farm Business Resilience, and Freshcare Environmental Code of Practice.
- 4.4 DPIRD, with industry, develop the WA Government policy on future soil restoration within the Carnarvon horticultural area

5. Improve waste management

- 5.1 CGA, DWER and Shire of Carnarvon develop a strategy to regularly encourage growers to appropriately dispose all waste and rubbish from their property.
- 5.2 Good practice waste management guidelines be developed by a grower group with DWER, Carnarvon Growers Association (CGA), Keep Australia Beautiful Council, and DPIRD.
- 5.3 The State Government co-invest with industry to engage and audit growers in relation to the management of on-farm waste/rubbish.
- 5.4 A waste management compliance plan be developed for implementation by DWER and the Shire of Carnarvon.
- 5.5 Department of Planning, Lands and Heritage be invited to address the Working Group to outline their plan on managing rubbish on Crown land.
- 5.6 DPIRD and CGA investigate options to manage excess agricultural produce, using incentives available under WasteSorted grants.
- 5.7 DPIRD and CGA will work with industry to investigate and support proposals to devise solutions for horticultural and chemical waste management.

Funding the recommendations

The Working Group have identified the priority recommendations to improve management of the floodplain. DPIRD, DWER and Shire of Carnarvon acknowledge that the recommendations in the report aren't currently budgeted. These agencies are working collaboratively, with industry, to secure funding. Without secure funding some recommendations are unable to be initiated.

Several recommendations of the Working Group are already funded and/or being actioned. These include the recruitment of a Development Officer by DPIRD, and to develop and submit funding applications to undertake flood planning, mapping and waterways management.

The working group identified a potential funding source that could contribute to completing some of the recommendations relating to flood planning, flood mapping and waterways management. A funding application for this work was prepared and submitted.

Introduction

The Gascoyne River Catchment is the longest in Western Australia (WA) and has a catchment covering approximately 79,000 square kilometres (Figure 1). The Gascoyne River has an active delta from Rocky Pool, located 40 kilometres (km) upstream, to the river mouth. The Carnarvon horticulture area is situated on the 15 to 20km area of fertile delta, near the mouth of the Gascoyne River.

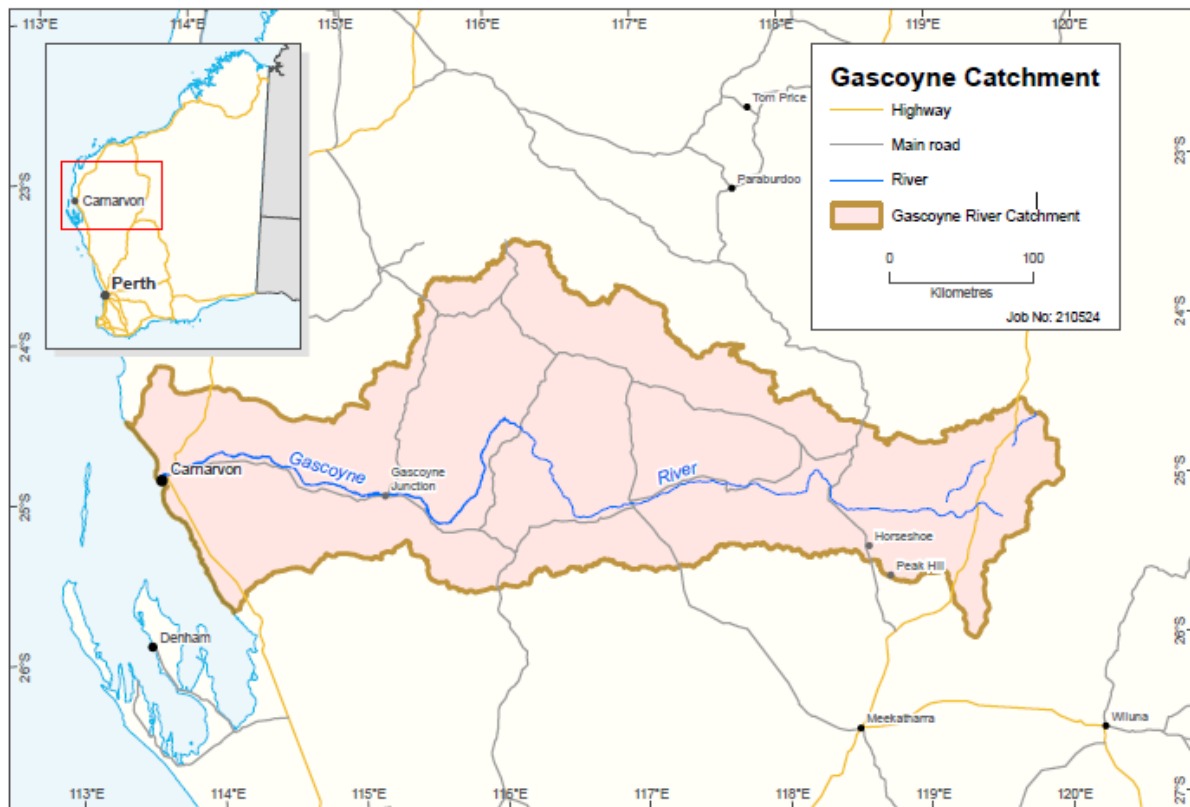


Figure 1 Gascoyne River Catchment

The Carnarvon horticulture area comprises approximately 170 plantations that farm a yearly average of 1200 hectares (ha) of land. The estimated wholesale value of annual production from the area is \$100 million, made up of the State's counter seasonal vegetables, early season temperate fruit crops, mid-season tropical crops, and year-round banana production.

Periodic flooding of the lower Gascoyne River floodplain at Carnarvon is a natural event. The flooding results from cyclonic and thunderstorm activity in the catchment, with the risk period generally from November to May, associated with the wet season in the north of WA. The Carnarvon horticultural area has suffered considerable damage following flooding of the Gascoyne River in 1960, 1961, 1974, 1980, 1995, 2000, 2009, 2010/11, and 2021. Floods in the Gascoyne River with potential to cause soil and crop losses are expected on average every nine to 10 years.

In February 2021, a slow moving tropical low system caused widespread flooding in the Gascoyne Region. Rainfall in the Gascoyne River catchment commenced on 2 February 2021 and lasted until the 6 February. The highest recorded total rainfall in the catchment over this period was near Gascoyne Junction (the confluence of the Gascoyne and Lyons rivers).

In response to the rainfall in the catchment, moderate flooding was recorded on 5 February along the Gascoyne River to Jimba Jimba. On 6 February, the Gascoyne River reached 7.06 metres at the Nine Mile Bridge streamflow gauge at Carnarvon. This recorded level exceeds the moderate flood level of 6.50m but is below the major flood height of 7.60m.

In Carnarvon, the Bureau of Meteorology (BoM) measured 172 millimetres (mm) of rainfall in the days leading up to 6 February, with 137mm recorded in the 24 hours to 9 am on 5 February. Whilst the rainfall in Carnarvon did not contribute to the peak flow in the Gascoyne River, it did result in localised drainage issues and erosion in the horticultural area.

The levees constructed in 2015 by the State Government, with State and Federal funding protected some plantations in the Carnarvon horticultural area from flooding in 2021. These levees were designed to mitigate damage more broadly across the horticultural area during larger flood events, such as in March 2000, and December 2010. The levees constructed in 2015 complement the network of levees constructed over the past 60 years to reduce flood risk to the Carnarvon townsite area (Figure 2).

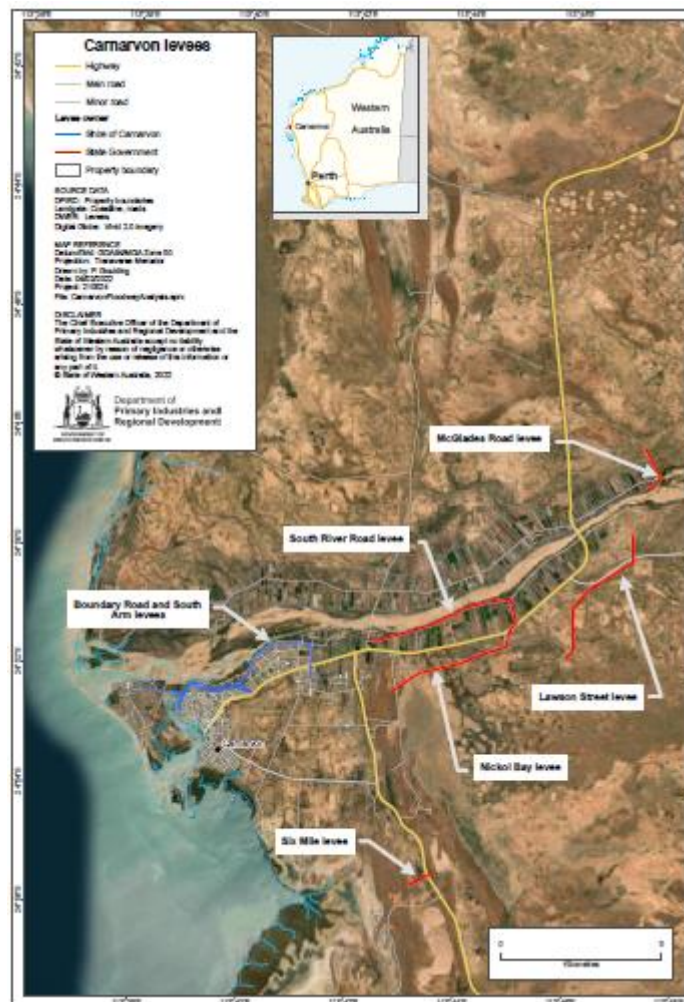


Figure 2 Network of levees in Carnarvon

Approximately 40 per cent (%) of plantations in the Carnarvon horticultural area requested assessment by DPIRD for damage following the Gascoyne River flooding in 2021.

The impact of flooding to Carnarvon horticultural properties included, soil and crop loss from paddocks; access to farms and farm tracks washed away; horticultural waste/rubbish being transported onto other properties, into the ocean, and deposited on beaches along the WA coastline. The impacts varied in severity and there is some evidence that cultural practices, crop selection and farm management had some influence on the damage.

The damage assessment undertaken by DPIRD indicated impacts were localised to properties near floodways, Kingsford and western end of North River Road.

Based on the height of the 2021 flood, compared to previous floods, growers indicated the impacts were greater than anticipated. Affected growers felt their properties were more vulnerable due to the levees.

As a 2021 election commitment, the Labor Government pledged to support growers affected by the flood in Carnarvon. In March 2021, the reinstated State Government announced the establishment of a \$1m fund, consisting of programs for soil restoration, floodplain management, and a review of catchment management.

Methodology

The Working Group was established, comprising representatives of key stakeholders, DWER, DFES, Shire of Carnarvon, and CGA, chaired by DPIRD.

The purpose of the Working Group was to complete a review to inform Government and industry of the factors that contribute to impacts during a flood event, identify mitigation strategies and management options, while providing clarity on responsibilities, accountabilities, and authority to ensure all stakeholders understand their role in minimising the impact of future flood events.

To assist the Working Group, DPIRD conducted community consultation with growers, industry, and the community to capture issues. The responses from the community consultation were presented to the Working Group.

The Working Group met four times from August to December 2021, to define issues, legislative mechanisms, and technical information, and consider potential options to formulate the recommendations included in this report.

The review process was captured in issues papers that were circulated to Working Group members for comment, and the issues papers were subsequently used to inform this report.

The report and recommendations were finalised by the Working Group for consideration by the Minister for Agriculture and Food.

DPIRD, DWER and Shire of Carnarvon acknowledge that the recommendations in the report aren't currently budgeted. These agencies are working collaboratively, with industry, to secure funding.

To leverage momentum, some recommendations were unanimously endorsed by the Working Group, and implemented. These include the recruitment of a Development Officer by DPIRD and the development and submission of a funding application to undertake flood planning and mapping, and waterways management, under the Preparing Australian Communities program.

Community consultation

A community consultation process was undertaken to assist the Working Group to understand the horticultural industry and the concerns of property owners and community about the 2021 flood.

Growers and related industry stakeholders were invited to participate through several mediums, including a focus group, individual meetings, and/or written submissions.

Focus groups held at DPIRD's Carnarvon Research Facility, and individual meetings on farm were conducted during August and September 2021. Maps were provided at these sessions to aid discussions. Written submissions were accepted until December 2021.

Participants provided an insight into the issues and suggested solutions, for consideration by the Working Group. The participants' concerns were captured and summarised in themes to be covered by the Working Group.

The focus groups were attended by 22 growers, complemented by six (6) written submissions, and five (5) individual meetings conducted by phone or farm visit.

The preliminary findings of the consultation were presented to the Working Group.

A summary of responses for consideration by the Working Group were:

Flood management

- Has the new mitigation infrastructure changed the height and velocity of flooding, from what was modelled?
- Are properties in Kingsford and North River Road now being more impacted due to the new mitigation infrastructure?
- Does the current modelling include all private and public infrastructure?
- What is the official flood level and how does this relate to previous events?
- Is sand mining impacting the river flow?
- Breakout points failed to work in this flood. Could new breakouts upriver be reinvestigated to reduce flows into Carnarvon?
- Is there a need for further mitigation infrastructure, such as a new levee to protect Kingsford properties?

Soil restoration program

- Will there be soil restoration programs for future flooding events, who will be eligible and how will this be delivered faster than in 2021?
- Where can growers access soil for future events, if the Government isn't going to support the community?

- Some producers are growing annual vegetable crops in flood prone areas. Why are they getting soil when they are undertaking poor practices that fail to protect the soil resource?
- Why weren't roads/tracks covered in the soil program?
- How do you afford to change practices to perennials? One grower identified they previously had perennials which were damaged in a flood/cyclone. Easier to go into annuals than invest in perennials where the payback [period] is much longer and [perennials] take time to reestablish.

Waste management

- Chemical drums are laying around properties and being left in gullies. Other waste is being thrown into gullies and on Crown land.
- Plastic that is used as a weed suppressor in crops is being incorporated into soil or being left in piles on, or adjacent to, properties.
- General farm rubbish, such as pipes and stakes, is laying around sheds, making it susceptible to floodwaters.

Riverbank and floodway management

- The riverbanks are heavily eroded in areas and, without intervention, will soon start impacting properties.
- Ownership of floodways is unclear.
- Floodways are heavily vegetated, have been dumped with rubbish and waste, and are being used for production and roadways. Whose responsibility is this?
- We need management of floodways that have multiple owners, as neighbours have different approaches.
- Flowlines and breakouts no longer in operation have been filled in or silted up. For example, Burnt Gully is full of debris and silt, so is not working.
- Public and private ownership of floodways and management is unclear.
- North River Road has been built up and prevents water flowing away from floodways, as intended.

Land management

- Structures have been approved without considering the flow of flood water. For example, the Caravan Park in Kingsford has been able to install a Colorbond fence that prevents water flowing through, creating a barrier to water and potentially creating erosive streams.
- Natural and man-made structures have been installed that impact on neighbours. These include:
 - Levees, driveways, and windbreaks.
 - Bamboo, shrubs, or other natural hedgerows, and
 - Fences, both enclosed and open wire, which cause a buildup of soil.
- There is a lack of management of illegal and legal structures on properties that impact neighbours.
- Who checks current and historical structures to ensure approvals were granted, or accommodation and buildings on properties are built to reflect town planning regulations?

- Gullies on the western end on North River Road are still being used for annual production. New land was substituted on the northern side of the road however, this land was issued with new, separate titles and not joined to the existing title, so can be sold off as separate properties.
- In the 1970s, growers moved from the western end of North River Road to McGlades Road. Could highly impacted properties be resumed or access new land?
- Land was provided in about 2000 to remove unsuitable production land from production. Gullies on North River Road are now being used for annual production. Land blocks failed to be connected so can be sold off as separate properties, and new owners are unfamiliar with the arrangement.

Industry development

- The value of all land has dropped due to flooding. This impacts all growers, with many unable to exit with dignity.
- Perception investors are unwilling to purchase land due to issues with flood mitigation.

Improving preparation for flooding and recovery

- Growers are unable to access disaster relief assistance as many are protected by levees, so the total value of the damage is below thresholds for access to Category C scheme.
- Improved guidance [is required] on what will happen if there is a flood over summer. What can growers and the community expect?
- Providing information in a range of languages
- There is stress and anxiety about the next cyclone season, and assistance [is required] for the community to manage this proactively.

Defining the physical nature of the problem

The Working Group considered the responses from the community consultation and defined the problems for resolution as:

- Entities have roles and responsibilities on the floodplain and are operating in an uncoordinated way to effect change.
- Collaboration efforts should be coordinated into existing emergency response groups to improve preparation, mitigation, response and recovery activities.
- Roles and responsibilities for each entity, including government agencies, industry groups and landowners, need to be clarified and understood. This lack of understanding impacts effectiveness of issues resolution.
- Unregulated and historical private infrastructure and works on horticultural properties impact other landowners during a flood.
- Floodplain mapping and the corresponding development strategy for the Gascoyne River were last updated in 2002 and need to include data from the last 20 years. This data could include the December 2010 flood event, which was the largest recorded on the Gascoyne River since records began in 1959.

Current flood mapping should reflect private and public infrastructure in the floodplain and determine whether these have increased impacts at specific locations.

- Are there structural options, such as breakouts, further upriver and/or new levees to reduce the flows/flooding in Carnarvon?
- Consistent communication of flood information is required.
- There needs to be recognition that landowners located near a floodway are more likely to be impacted by floodwater.
- Floodways were observed to be full of vegetation, silt, and rubbish, and used for roadways and annual crop production, and the flow constrained by infrastructure.
- The riverbank has been heavily eroded and undermined. Private properties will be impacted if erosion continues.
- The WA Government has undertaken restoration programs to replace soil loss in response to flooding in 1960, 1961, 1974, 1980, 1995, 1999, 2000, 2010/2011 and 2021. This approach is unsustainable due to cost and resource degradation.
- Current soil conservation and land management practices by some landowners need to change to reduce degradation of the resource.
- An audit undertaken by DWER and Keep Australia Beautiful Council revealed the Carnarvon horticultural industry is failing to manage waste appropriately.
- Horticultural production and waste dumping (unregulated) exists on public lands.

Working Group review

Purpose

The purpose of this floodplain management report for Carnarvon horticulture industry is to provide a direction for action and investment to support the management, improvement in functions, and understanding of this dynamic system.

Vision

Build a flood resilient community in which Carnarvon communities, businesses, Government agencies and Traditional Owners work together to better manage flood risk and strengthen the resilience of our industry, local economy, infrastructure and environment.

A framework for review

The following framework was used to consider the issues:

1. Determining a vision and a purpose for the group.
2. Defining the physical nature of the problem.
3. Roles and responsibilities of each of the stakeholders.
4. Consultation and community engagement.
5. Business viability analysis.
6. Consistency of information.
7. Local preparedness for flood events.

Principles

The Working Group was guided by the following principles:

- Overarching objective of a vibrant cohesive community.
- A long-term model to break the cycle of flood-to-crisis.
- Ensuring shared responsibilities, as no single stakeholder should be burdened with the whole problem.
- Ensuring clarity of shared roles and responsibilities, and transparency of information.
- Providing options, as no one solution will be successful. A coordinated approach is essential.

Critical success factors

Five critical success factors were identified where action is focused for improved floodplain management for the horticultural industry. These are governance, flood planning and mapping, soil conservation and land management, waterways management, and waste management.

Critical success factors for improved floodplain management

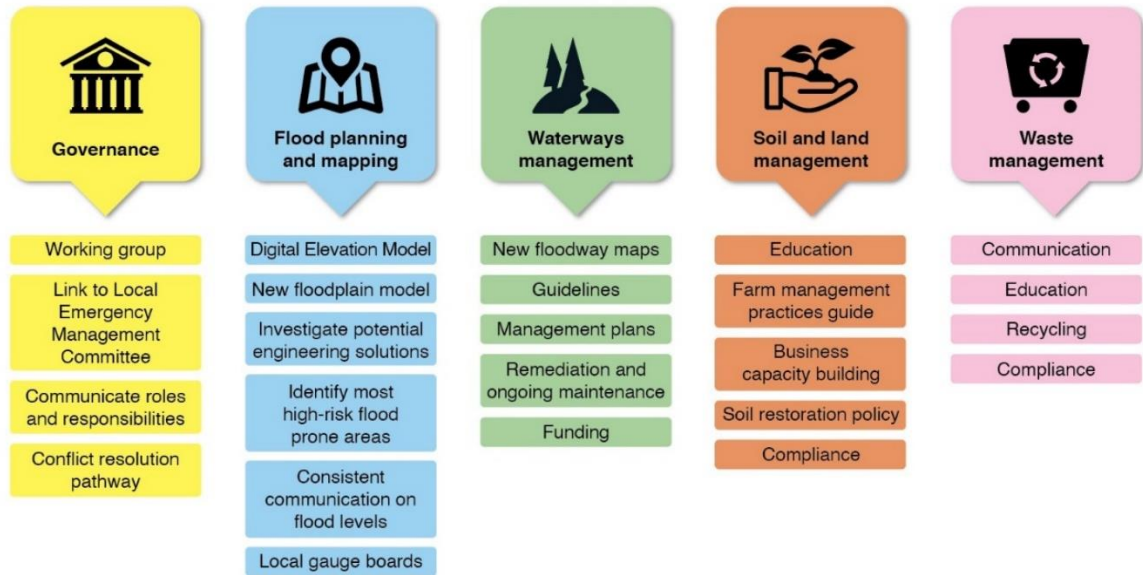


Figure 3: Five critical success factors were identified in which actions could be focused for improved floodplain management

Governance

Coordinated leadership

The issue:

Periodic flooding of the lower Gascoyne River floodplain at Carnarvon is a natural event. The Carnarvon horticultural area suffered considerable damage following flooding of the Gascoyne River in 1960, 1961, 1974, 1980, 1995, 2000, 2009, 2010/11 and 2021.

The WA Government has undertaken restoration programs to replace soil loss in response to flooding for most of these events. Apart from the soil loss and risks of permanent damage to the natural resource, the costs and delivery of the restoration programs have failed to improve soil conservation and land management practices, and therefore the business resilience of many growers in the industry. A more enduring model is required for a sustainable Carnarvon horticultural industry.

Federal, State, local and industry agencies have a role and responsibilities (Table 1) on floodplain management or horticulture industry leadership, focused on their strategic direction. Currently, initiatives to improve horticultural production practices and floodplain management are delivered in an uncoordinated and short-term approach.

To assist the horticulture industry to recover and reduce future impacts, the WA Government convened the Carnarvon Floodplain Management Working Group to review the contributing factors to the impacts of the flood.

The Working Group prepared this report for consideration by the Minister for Agriculture and Food. Initiatives in the report focus on improving management of the floodplain and most importantly, the soils on which the Carnarvon horticultural industry rely for profitable and sustainable production.

The purpose of this floodplain management report for Carnarvon horticulture industry is to provide direction for investment, and suggest action to support the effective management, improvement in functions, and understanding of this dynamic system. In the 1990's, the Shire of Carnarvon led the Carnarvon Flood Advisory Committee to successfully support a coordinated approach to floodplain management. This group disbanded in 2009.

An ongoing coordinated and collaborative approach from Governments and industry is required.

Working Group response

The response to floodplain management by the horticultural industry requires coordination and long-term strategic leadership to implement and maintain sustainable practices.

A floodplain is a dynamic system that evolves, changes and reacts to the intensity and location of rainfall delivered to its catchment. Floods are inevitable in Carnarvon, and effective management of the floodplain must evolve and change in response to the challenges for business and community.

The coordination of roles, responsibilities and strategic intent of the relevant agencies could assist the industry to better prepare, mitigate, respond and recover from flood events. To deliver a coordinated long-term management plan for the floodplain, the Working Group, comprising key stakeholders, horticultural industry representatives, Shire of Carnarvon, DWER, DPIRD, DFES and other entities as required, should continue.

The Working Group has recommended initiatives to improve floodplain management and ensure coordinated delivery. The Working Group will continue to:

- Lead the implementation of the recommendations.
- Ensure representation on existing Local Emergency Management Committees to enable strong communication and preparedness for flooding, and
- Ensure there is a permanent entity for ongoing management of the floodplain.

Representation on the existing Local Emergency Management Committee will ensure initiatives undertaken for the horticultural industry are embedded in the broader planning, preparation, response and recovery arrangements.

Recommendations

- 1.1 The current Working Group continue to provide the coordination and long-term strategic leadership for the management of the floodplain, including the implementation of the endorsed recommendations. The Working Group should be maintained and actively engaged in the long term for the benefit of the horticultural industry.
- 1.2 The Working Group be represented on the Local Emergency Management Committees to ensure effective communication, collaboration, and preparedness for future floods.

Table 1: Roles and responsibilities of Carnarvon stakeholders in flood management

Organisation	Role and responsibilities	Relevant legislation
Bureau of Meteorology (BoM)	Australia's national weather, climate and water agency. Operates a network of 51 rainfall gauges in the catchment, including 13 rainfall intensity sites to help flood forecasting. Prepares and issues flood watches and warnings.	<i>Water Act 2007</i> <i>Meteorology Act 1955</i>
Carnarvon Growers Association (CGA)	Supplier of products for member growers. Assists growers with production practices. Educate members about key issues Advocates for the industry.	

Organisation	Role and responsibilities	Relevant legislation
Department of Fire and Emergency Services (DFES)	<p>Overall responsibility for risk reduction aspects of flood events, within the limitations of legislation, resource capabilities and capacity</p> <p>Develops plans and arrangements based on risk assessments across the continuum of prevention, preparedness, response, and recovery</p> <p>Establishes, maintains, and enhances capabilities and whole-of-sector interoperability needed to cope with and recover from floods</p> <p>Supports the resilience of communities by promoting activities to raise hazard awareness and strengthen core capabilities necessary to manage future risks.</p> <p>Responsible for the coordination of a response to a flood event.</p>	<p><i>Fire and Emergency Services Act 1998</i></p> <p><i>Emergency Management Act 2005</i></p>
Department of Planning, Lands and Heritage (DPLH)/ WA Planning Commission	<p>State level land use planning and management.</p> <p>Responsible for developing, reviewing and implementing the land use planning system in WA.</p> <p>Reviews local Government town planning schemes. Manages and maintains flood mitigation infrastructure.</p>	<p><i>Planning and Development Act 2005</i></p>
Department of Primary Industries and Regional Development (DPIRD)	<p>Protects the sustainability of natural resources and accelerates ongoing economic growth, job creation and regional development.</p> <p>Soil Commissioner administers Act to mitigate and prevent land degradation, promote soil conservation, and educate landholders and the general public on land management.</p> <p>Supports horticultural industry recovery after flood to return to production.</p> <p>Provides guidance and access to programs to improve management practice and business success to horticultural producers.</p>	<p><i>Soil and Land Conservation Act 1945</i></p> <p><i>Biosecurity and Agriculture Management Act 2007</i></p>
Department of Water and Environmental Regulation (DWER)	<p>Manages and regulates the State's environment and water resources.</p> <p>The lead agency for river monitoring and floodplain management, including near real-time river level data, inventory of flooding information and flood damage assessments for past events.</p> <p>Develop state legislation, policy and standard for floodplain management, and provides input to national flood management policy.</p>	<p><i>Environmental Protection Act 1986</i></p> <p><i>Environmental Protection (Clearing of Native Vegetation) Regulations 2004</i></p>

Organisation	Role and responsibilities	Relevant legislation
	<p>Supports and assists communities to implement flood mitigation measures to reduce the risk of flooding to existing developments.</p>	<p><i>Rights in Water and Irrigation Act 1914</i></p> <p><i>Water Agencies Powers Act (1984)</i></p>
<p>Flood Warning Consultative Committee (FWCC)</p>	<p>Provides strategic guidance on overall development of flood warning service in WA.</p> <p>Members relevant agencies (DFES, DWER, MRWA, WALGA, Water Corp, others).</p> <p>Meets twice a year.</p>	
<p>Landowners</p>	<p>Adhere to Federal, State and Local government legislative and policy requirements in relation to their landholding and farm management.</p> <p>Be aware of local flood hazards and local flood emergency management plans.</p> <p>Responsible for personal safety and property during a flood.</p>	
<p>Main Roads WA (MRWA)</p>	<p>Ensures the maintenance and protection of MRWA structures such as bridges, floodways, and culverts across the floodplain.</p> <p>Responsible for the preparation of State, regional and local flood emergency management plans.</p>	<p><i>Main Roads Act 1930</i></p>
<p>Shire of Carnarvon</p>	<p>Incorporates floodplain management into town planning schemes, and controls development and works on the floodplain.</p> <p>Manages local flood mitigation infrastructure in accordance with agreed levels of service.</p> <p>Assists in the development and implementation of flood emergency management plans.</p> <p>Supports community flood risk awareness and education</p> <p>Leads the community recovery process</p>	<p><i>Local Government Act 1995</i></p> <p><i>Building Act 2011</i></p> <p><i>Building Regulations 2012</i></p> <p><i>Local Planning Scheme 13</i></p> <p><i>Planning and Development (Local Planning Schemes) Regulations 2015</i></p>

Roles and responsibilities

The issue:

The terms of reference (Appendix 1) for the Working Group sought to provide clarity of the roles and responsibilities for each entity, with an emphasis on identifying the accountable party to resolve issues. The Working Group recognised that this approach wasn't straight forward, as many issues were a shared responsibility, that any one entity could struggle to resolve.

For example, during the 2021 floods, approved and unapproved infrastructure and works on horticultural properties impacted other landowners. Specific land management practices that contributed to erosion damage included:

- Unapproved natural and man-made structures:
 - Levees
 - Driveways
 - Windbreaks
 - Bamboo, shrubs or other natural hedgerows
 - Shipping containers, and
 - Fences, both enclosed and open wire, which cause a buildup of soil and debris.
- Approved structures that restrict or alter floodwater flow, such as solid fences at private properties and caravan parks in Kingsford.
- Use of Crown land and easements that are adjacent to horticultural properties, for waste dumping and farm infrastructure.

The Shire of Carnarvon identified the challenging nature of progressing resolution of land management complaints under current Local Government, Environmental Health and Planning and Development Acts due to timeframes, collection of evidence and financial burden. The Shire also acknowledged challenges with resourcing compliance and regulation to effect change by landowners on horticultural properties.

The roles and responsibilities of the key stakeholders (Table 1) need to be jointly understood to identify the best and most appropriate mechanism for resolution. In some circumstances, a coordinated approach to identifying, communicating, and resolving issues could improve management practices of the horticultural industry.

Working Group response

Management of the floodplain is a shared responsibility. No single stakeholder should be burdened with the responsibility to ensure the appropriate outcomes occur. The collective entities/agencies responsible for the floodplain need to work together on its effective management.

Whilst State and Local Governments have a legislated role in management, industry and landowners play an important part in communicating and ensuring activities to reduce the risk of flood impacts are carried out. Whilst the regulatory entities are clear about their roles, the Working Group identified that some landowners need to better understand their responsibilities.

The Working Group identified there is an important role for industry associations in providing leadership to assist growers to undertake their responsibilities as landholders. Industry associations can promote the practices expected of their members through a joint understanding of the situation and with a non-regulatory approach.

The roles and responsibilities of each entity need to be clearly defined and the regulatory powers of each authority communicated to stakeholders. All parties, including growers, must understand they are accountable for delivering on their responsibilities outlined in Table 1.

To manage local issues between neighbours and entities, a conflict resolution pathway (the pathway) could be developed for implementation prior to commencing legal processes. The pathway could follow a process of several steps that escalate from education to mediation to compliance. The pathway is jointly understood by agencies and growers as an avenue to resolve the issue.

The pathway should detail what happens at each step, to assist all parties to understand the escalation process.

There may be an option for the Working Group to define the pathway, which could subsequently be communicated to all stakeholders.

Recommendations

- 1.3 The Commissioner of Soil and Land Conservation, DPIRD, DWER, Shire of Carnarvon and DFES clearly define and communicate their regulatory powers and expectations of landholders, supported by Carnarvon Growers Association (CGA).
- 1.4 The Working Group develop a conflict resolution pathway to assist mediation of on-farm issues between stakeholders and communicate that pathway to all stakeholders.

Flood planning and mapping

The issue:

In February 2021, a slow moving tropical low system caused widespread flooding in the Gascoyne Region. Rainfall in the Gascoyne River catchment commenced on 2 February 2021 and lasted until the 6 February. The highest recorded total rainfall in the catchment over this period was near Gascoyne Junction (the confluence of the Gascoyne and Lyons rivers). In response to the rainfall in the catchment, moderate flooding was recorded on 5 February along the Gascoyne River to Jimba Jimba. On 6 February, the Gascoyne River reached 7.06 metres at the Nine Mile Bridge streamflow gauge at Carnarvon. This recorded level exceeds the moderate flood level of 6.50m but is below the major flood height of 7.60m.

In Carnarvon, the Bureau of Meteorology (BoM) measured 172 millimetres (mm) of rainfall in the days leading up to 6 February, with 137mm recorded in the 24 hours to 9 am on 5 February. Whilst the rainfall in Carnarvon did not contribute to the peak flow in the Gascoyne River, it did result in localised drainage issues and contributed to erosion in the horticultural area.

In 2015, the WA Government constructed levees to reduce the impacts of large flooding events (such as those of March 2000 and December 2010) to the horticultural area adjacent to the town. The levees, located in the horticulture area, complement the network of levees constructed over the past 60 years to reduce flood risk to the Carnarvon townsite area.

In 2021, these levees protected some plantations in the Carnarvon horticultural area, but the full benefits of the levee design could not be assessed as the flooding did not reach levels that would inundate the majority of horticultural area. Approximately 40 per cent of plantations in the Carnarvon horticultural area requested assessment by DPIRD for damage following the Gascoyne River flooding in 2021.

The impact of flooding to Carnarvon horticultural properties included, soil and crop loss from paddocks; access to farms and farm tracks washed away; horticultural waste/rubbish being transported onto other properties, into the ocean, and deposited on beaches along the WA coastline. The impacts varied in severity and there is some evidence that cultural practices, crop selection and farm management had some influence on the damage.

The damage assessment undertaken by DPIRD indicated impacts were localised to properties near floodways, Kingsford and western end of North River Road.

In the past, growers equated the depth of the Gascoyne River at Nile Mile Bridge with an understanding of how the flood will impact their property. Experience built up over many events, and technical knowledge acquired from flood planning and mapping, has created a perception of how flood waters will behave.

Based on the river depth reported at the Nine Mile streamflow gauge, growers felt the impacts were greater than anticipated. Growers in Kingsford and on North River Road felt the impacts were the result of higher floodwater levels and faster velocities than modelled. Growers questioned whether the new flood mitigation infrastructure directed floodwaters onto their properties.

Floodplain mapping and the corresponding development strategy for the Gascoyne River is based on work by Sinclair Knight Merz in 2002. The flood modelling needs updating to include data from the past 20 years. The Gascoyne River flood of December 2010 was the largest event recorded since records began in 1959, flood mapping should reflect changes that have occurred within the catchment and floodplain and consider future impacts of climate change.

Several privately owned 'permanent' levees have been constructed by landowners on both banks of the river to protect land and property from flooding during major flows. The location, material, and current condition of the private levees is unknown.

Solid permanent fencing and temporary bunds have also been constructed to protect buildings and other infrastructure. This infrastructure may have localised impacts on flood levels and velocities on neighbouring properties, but the impacts have not been assessed.

Working Group response

An understanding of the full range of expected flood events is required to support land use planning, flood emergency response planning, infrastructure design, and community flood preparedness.

Survey

A digital elevation model (DEM) of the river and plantation areas could better define the riverbank breakouts and hydraulic conditions on the floodplain. A DEM could be developed using the following:

- Lidar survey of the river and floodplain areas within the Carnarvon horticultural district.
- Land survey along the banks of the river to confirm location and height of privately constructed bunds, and
- Bathymetry to define river-bed levels within temporary/permanent pools at time of Lidar capture.

The information would assist assessment of how local factors and the levees contributed to the difference between the 2021 flooding and the flood levels previously observed. The DEM could support future flood modelling and the impact of land management activities on flood behaviour.

New floodplain model

In 2002, the Lower Gascoyne River Carnarvon Floodplain Management Study was undertaken by Sinclair Knight Merz to assess flood management options and develop a floodplain management plan for Carnarvon.

Current flood modelling needs to reflect the changes that have occurred in floodplain (e.g., privately owned and installed bunds and levees, roads, and bridge upgrades) over the past 20 years. The DWER assessment of the February 2021 flood illustrated some localised areas are not well represented by the current modelling.

As part of the design of the 2015 levees the model was updated to include major infrastructure developments since 2002 (e.g., replacement Nine Mile Bridge, 2015 levee design). However, there have been many other developments and changes within the floodplain and it's time for renewed data and modelling to help address the issues identified. Consideration of the impact of climate change on flood risk should also be undertaken.

The new model could be used to:

- Guide future planning and development to ensure new buildings include acceptable levels of flood protection. Tangible benefits to the community could include reduced property and contents damage, and intangible benefits to health and wellbeing. The general manager of risk at the Insurance Council of Australia (pers comm. 2021) indicates that flood insurance premiums to customers should reduce once information for the full flood risk profile for a property is understood. Currently, without flood risk information across all possible events, the insurance industry takes a conservative approach to the cost of a premium to ensure it can cover property damage in large events.
- Increase efficiency of emergency response agencies by enabling them to target actions to suit the needs and priorities identified by the modelling of flood behaviour.
- Identify high risk flood prone horticultural land. Removing land with a high flood risk from horticultural use and managing it to reduce potential flood damage to neighbouring properties could reduce flood damage without significant engineering effort or cost. Options to manage high risk flood prone land have been highlighted for a more comprehensive study if required.
- Assess the benefit from additional levees, such as extending a levee through Kingsford, between Bibbawarra Road and Boundary Road, and structures at Sheridan Gully and other northern breakouts.
- Review breakouts further upriver and other structural and non-structural solutions previously proposed.

Flood height reporting

DWER and BoM currently report river depth at Nine Mile Bridge. In 2002, Nine Mile Bridge was replaced with a taller structure, changing the hydraulic conditions. Prior to the Nine Mile Bridge replacement, the streamflow gauge was located immediately upstream of the bridge. Due to its design, water levels during floods banked-up at the old bridge creating a higher upstream water level. The new bridge is taller and has less impact on upstream water levels.

At Nine Mile Bridge the riverbed is sandy and easily modified by flow events, so the riverbed height (in relation to sea level) changes frequently. The level from which river depth is reported can change between flood events by up to about a metre. As a result, river depth is not an appropriate measure for comparing water levels between flood events

DWER and BoM's reported levels from the Nine Mile Bridge streamflow gauge are not corrected or adjusted to account for impacts of the old bridge and are unable to be directly compared to the levels marked on the staff gauge. Figure 4 provides a visual interpretation of the impact of the new bridge on previous flood events.

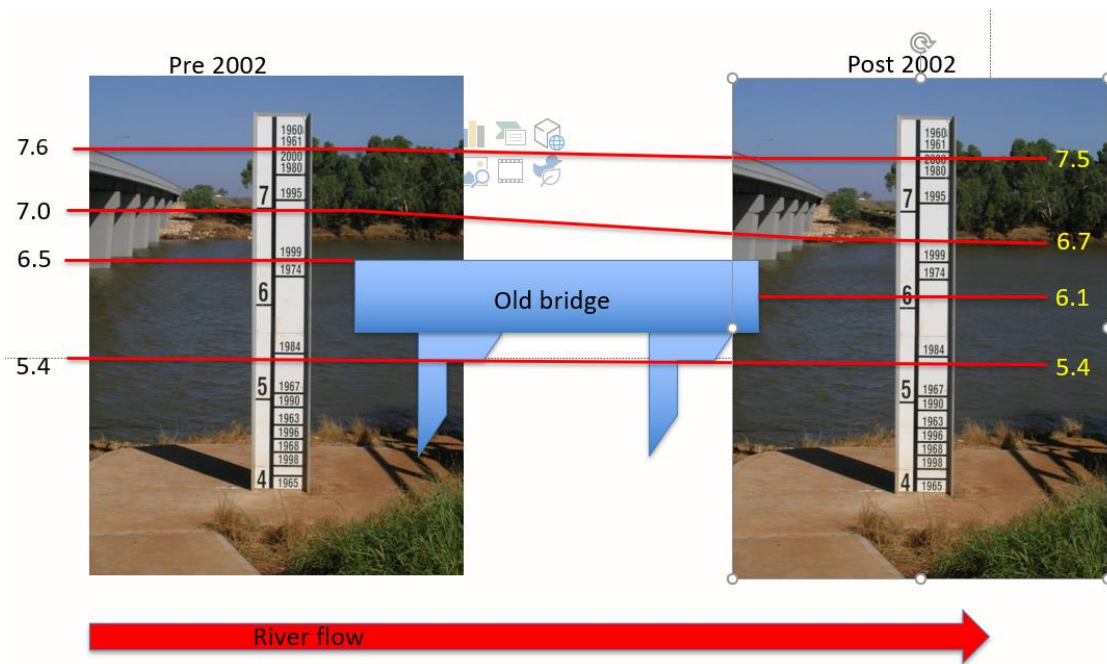


Figure 4: River height adjusted levels post erection of new Nine Mile Bridge

For the 2021 event, the recorded river level at Nine Mile Bridge for 2021 was 7.04m. However, after adjusting for the changes in the sandy river-bed and the new bridge, a comparison level at the community gauge board of just below 7.0 m has been calculated. The river is reported at this height to allow comparison with previous events.

If there was no accounting for infrastructure changes and previous events, the river height in 2021 would be approximately 6.7 m on the community gauge board.

DWER has previously published information which relates observations of the impacts from past flood events to water levels at the Nine Mile Bridge. These levels have been updated to take into consideration the new bridge and are available in *Assessing the 2021 Gascoyne River flood at Carnarvon, Preliminary report (2021)* (the DWER Preliminary report).

To assist growers understanding when comparing events, the DWER Preliminary report revealed field observations between the 2021 and 1995 events were similar in extent and peak levels.

With exceptions, through Kingsford, flood levels were ~0.2m higher in 2021 than in the 1995 event. Through Lyalls, Fahls and Burnt Gullies, the limited data suggest flood levels were also slightly higher than in 1995.

Consistency in how peak flood levels (height) are reported is required to enable comparison between events. This could assist stakeholders, help emergency personnel and the community to take appropriate actions to reduce the risks and impacts of flooding. Communication in relevant languages is also required to assist all community members to better understand the risks associated with the impending flood. Gauging boards erected along the river at regular intervals could assist growers to observe local river levels for decision making.

Recommendations

- 2.1 DWER and Shire of Carnarvon develop a high-resolution digital elevation model through comprehensive surveys of the river and floodplain. The digital elevation model will assist the understanding of sand build-up in the channel and floodways; identify and capture recent changes (such as private levees and infilling of low areas); comparison of Government-constructed levees with as-constructed drawings.
- 2.2 That DWER and Shire of Carnarvon develop a new floodplain model to better understand flood behaviour; assess the impact of local structures added since the last model was developed (20 years ago); inform potential new engineering solutions, such as increasing breakouts upstream or additional levee structures downstream; and guide land use planning. The study should include benefit-cost assessments for all potential mitigation options considered.
- 2.3 DWER working with BoM and DFES prepare and deliver consistent communication on how the flood level measurement are reported, including how this relates to previous events.
- 2.4 Shire of Carnarvon and DWER consider the installation of visual gauge boards along the river for growers to observe local river levels to improve awareness and decision making.

Waterways management

The issue:

The assessment undertaken by DPIRD after the 2021 flood event revealed a significant proportion of the 44 000 cubic metres of soil lost to erosion was associated within or adjacent to floodways.

In 2003, David Parr published a classification system to describe the floodplain drainage features in *Farm Management Practices for the Prevention of Soil Erosion in the Carnarvon Horticultural Area*. The classification system categorised three floodway categories (Class A, B, C) based on land susceptible to flooding. These are:

- Class A floodways are the major drainage features that are considered essential for the free flow of water away from or to the mainstream. These drainage features are active at Gascoyne River flows with flood frequency expressed as an annual exceedance probability (AEP) of about 25% (one in four years). They are clearly defined watercourses.
- Class B floodways are those not connected directly to the mainstream but having a secondary drainage role. These floodways become active at Gascoyne River flows of about 10% AEP (i.e., one in ten years). They are clearly defined watercourses.
- Class C flood paths are those areas subject to inundation only in floods with an AEP of 1 to 10% (1 in ten years) and larger. They are undefined watercourses. This class represents almost all land in the irrigation area.

The floodways and flood paths occur on private and publicly owned land.

After the 2021 flood event, it was observed that the Class A floodways:

- Failed to flow effectively due to rubbish, vegetation, and silt build up.
- Filled in with soil to be used for annual horticulture production.
- Unable to flow across North River Road as intended
- Were highly eroded by floodwaters, and
- Created breakouts that forced floodwaters onto growers' properties, leading to soil and crop loss and infrastructure damage.

Class A floodways located in the horticultural area take only a small percentage of the total volume of flood waters from the main channel.

Until 2009, the Shire of Carnarvon maintained several public and private floodways in the Carnarvon horticultural area. Since then, the floodways have had little coordinated management.

As floodways may occur across several publicly or privately owned properties, the management differs depending on the landowner. For example, in Sheridan's Gully, current management includes annual and perennial production. When flooding occurs, this can impact neighbours. When neighbours have raised complaints, some growers have been reluctant to implement new management.

As part of the soil replacement program following the 2021 flood, it was decided soil was unable to be restored on the areas of properties within floodways or within a 50m buffer. Some growers were unaware that a floodway or flood path occurred on their property until maps for soil restoration were provided.

Riverbanks

In the main channel of the river, the velocity of the river flow eroded the riverbanks adjoining several horticultural properties. The erosion was severe, scouring the bank away. Landowners are concerned that without intervention the scours will continue to erode in future events and encroach beyond the river reserve onto their properties. Landowners recognise that repairing the damage to the banks (Crown Land) to prevent future impacts is beyond their technical and financial capacity as individual property owners.

Working Group response

Remediation and ongoing management and maintenance of riverbanks and floodways is vital to protect properties from future flooding and damage.

In 2003, mapping and descriptions of the floodways was completed at a scale that lacked detail on individual properties. New geographic information system data sets are available to provide greater clarity on the location, class definition and ownership of floodways. The development of this information into new maps of all floodways will assist management by landowners.

In consultation with industry, the recommended horticultural practices within floodways could be reviewed. Improved management of floodways located on growers' properties could help reduce future flood damages. A revised guideline detailing the recommended practices should be released to industry.

Where a floodway flows across a number of properties, a management plan for its full length should be developed in consultation with affected landowners. The management plan will detail an agreed horticultural practice within the floodway and the approach for managing any ongoing maintenance. This will ensure the floodway is managed consistently and clarify for all stakeholders the standards that must be maintained. The management plan will outline short, medium and long-term management activities to be undertaken and the accountable entities to lead the actions.

Flows in floodways that cross, or meet with, a road must not be impeded, and floodwaters should continue to flow away as intended. Engineering solutions may be needed to resolve issues where roads have been constructed that impede flows in floodways.

Relevant agencies will need to work together to define a process for engaging and encouraging reluctant landowners to comply with management plans for floodways.

Funding sources will need to be identified and applications submitted to assist the planning, remediation and coordinated management of riverbanks and floodways activities for public and potentially private land. Community involvement in remediation projects could be considered by agencies to build ownership and increase local capacity and capability for the waterway management.

Recommendations

- 3.1 DPIRD review existing and new information with industry to:
 - Identify all flood prone areas susceptible to impact using new data sets.
 - Develop up to date maps of floodway areas,
 - Identify where a road/track may impede flow of a floodway, and
 - Develop recommended soil management practices (cultivation practice and vegetation cover) for privately owned floodways.
- 3.2 Where there is joint ownership of a floodway, develop a management plan with all landowners, facilitated by the DPIRD Development Officer.
- 3.3 DPIRD, Shire of Carnarvon and DWER to develop a management plan for publicly owned floodways and riverbanks. This includes where floodway flow may be impeded by a road.
- 3.4 DPIRD, together with the Working Group, develop a process for engaging and encouraging landowners who are reluctant to commit to preparing and implementing management plans for improved floodplain management.
- 3.5 DPIRD work with the Shire of Carnarvon and DWER to identify riverbank and floodways work that could form community projects.
- 3.6 DPIRD, with Shire of Carnarvon, develop a budget for initial remediation of publicly owned floodways and their ongoing maintenance.
- 3.7 Shire of Carnarvon, with assistance from DWER and DPIRD, develop grant applications to fund the initial clean-up program and ongoing maintenance of floodways.
- 3.8 DPIRD and Shire of Carnarvon develop a grant application for a riverbank management plan.

Soil conservation and land management

The Carnarvon horticultural area has suffered considerable soil loss as a result of flooding of the Gascoyne River. A Government supported soil restoration program has been required in 1960, 1961, 1974, 1980, 1995, 1999, 2000, 2010/2011 and 2021.

Whilst the alluvial soils are highly erodible due to high silt content, poor structure and low organic, assessments of soil and crop loss after flood events have consistently referred to land use practices contributing to the erosion impact.

These land use practices in the horticultural area include:

- Removal of native vegetation and ground cover.
- Shifting from perennial tree crops to annual vegetable production.
- Unregulated construction of fences, levee banks and other earthworks, and
- Unregulated use of public lands along the riverbank and floodways (Clement 2002).

In response to flooding in 2021, 64 of the 170 Carnarvon horticultural properties requested a damage assessment. The assessment revealed that 46 properties had lost 44 000 cubic metres of soil and a sizeable portion of this soil was lost to erosion associated with practices not recommended within or adjacent to drainage lines. Most properties impacted were growing annual crops. Properties with perennial crops and ground cover in major floodway areas, such as Lewers Creek, reported minimal soil or crop loss.

Ongoing losses of soil are unsustainable and risk permanent damage to the resource base on which the industry and the natural environment relies.

After the soil loss experienced in the Carnarvon horticultural area in 2000, the guideline, *Farm Management Practices for the Prevention of Soil Erosion in the Carnarvon Horticultural Area* was released in 2003 to provide direction for the Carnarvon area in several areas. These included good soil management, vegetation cover, cultivation practice, mulching crop residue, conservation tillage, crop rotation, buildings and other construction, and tracks and roads. The guideline highlighted that the cropping techniques practiced by growers had increased the risk of soil erosion on properties. These practices include:

- Vegetable production accounted for 70% of total production and the erosion potential of land used for vegetable cropping is very high, or 2.5 to 4 times that of perennials.
- The widespread culture of always keeping land in a cultivated state, leaving no plants or plant roots systems to bind the soil, and
- Small property size results in multiple crops cycles each year to maximise the cropped area and returns.

These practices remain prevalent in 2021.

Since the release of the guideline in 2003, there has been limited ongoing extension to support growers to implement and maintain good management practices. New industry entrants have purchased properties in the horticultural area without understanding the management practices required to protect the soil resource.

Limited compliance under the *Soil and Land Conservation Act 1945* practices has been undertaken in the horticultural area, until recently.

Working Group response

The cycle of soil loss due to flood events and subsequent Government supported soil restoration programs are unsustainable. Apart from soil loss and risk of permanently damaging the resource, the cost and delivery of restoration programs have failed to improve soil conservation and land management practices. A more enduring model is required in the horticultural industry.

A model of education, access to technical information, building better businesses, and clear government direction will assist industry to move to a better soil conservation and land management approach.

Education

A dedicated Development Officer located in Carnarvon could lead education and engagement with growers and extend good practice in land, soil and crop management aimed at mitigating the impact of flood events and reducing soil loss on horticultural properties.

The officer could assist growers with the development of land management plans for their properties, research new management options, and develop helpful information materials.

A commitment of at least three to five years will likely be required to facilitate the necessary changes in management practices.

New soil and land management guideline

An initial review of the *Farm Management Practices for the Prevention of Soil Erosion in the Carnarvon Horticultural Area* guideline identified that most management practices are still relevant. However, the level of soil loss recorded from the 2010/11 and 2021 floods indicate that most growers do not practice conservation tillage in Class A, B and C floodways. Recommendations related to annual horticulture production in Class A, B and C floodways could be reviewed with the aim of reconsidering this as a recommended practice.

To ensure the most current information is available to growers, a review of the *Farm Management Practices for the Prevention of Soil Erosion in the Carnarvon Horticultural Area* guideline be undertaken in consultation with industry. This review would confirm the management practices that remain relevant and identify areas that require further research or demonstration. Research that provides economic evidence that good practices lead to better returns over time could support decision making and timing on cropping.

Appendix 2 of *Farm Management Practice for the Prevention of Soil Erosion in the Carnarvon Horticultural Area* refers to the creation of individual property management plans. The updated guideline could include an individual property management plan template for use in the development of plans for all properties. An annual cyclone season checklist to assist growers to prepare their properties for potential flooding events.

A contemporary guideline could then be released and communicated to growers in the Carnarvon horticulture area. This, and the development of individual property plans could assist in identifying issues between neighbours and commence the resolution process.

This process includes managing:

- Obstructions and structures that divert or concentrate flow, particularly within floodways.
- Vehicle access and disturbance to riverbanks, and
- Building roads and tracks that are resilient to flooding.

Better business practices

All growers should be encouraged to participate in existing programs to build the capacity of businesses to adopt new practices and manage disruption events. These programs include:

The **Building Horticulture Business Capacity** program, which provides high quality, tailored business training to individual vegetable and apple enterprises. Participants learn skills in business analysis and data collection and receive expert advice and an examination of their farm management practices, improving the viability of their business.

The **Farm Business Resilience** program is focused on the long term and aims to build the resilience of farm businesses before they experience hardship. The program gives farmers and their staff access to subsidised learning and development opportunities in strategic business management, farm risk management and decision-making, natural resource management, and personal and social resilience.

The **Freshcare Environmental Code of Practice (ENV3)** is designed to aid the achievement and of environmental outcomes on-farm. Participating growers and grower-packers achieve best practice resource management and demonstrate environmental stewardship outcomes.

WA Government soil restoration policy

In anticipation of future flood events, the development of a formal WA Government policy position on soil restoration programs could assist the horticultural industry to manage expectations of support after future flood events. The policy will consider a grower managed program and other options. A clear policy could help encourage changes to how growers manage the resource.

Consultation with growers, industry, and relevant WA Government stakeholders in the development of the policy will assist in communicating the position and increase the willingness for change.

The policy could include direction on:

- Sites identified with suitable topsoil
- Pre-approval for access to sites
- Commercial or industry arrangements for future programs.
- Guidelines defining the conditions under which soil can be accessed, and
- How the pit will be managed and conditions of access.

Compliance

There is a strong focus on improving practices through positive strategies. The Working Group was clear that a role for compliance remains. The Working Group supported the role of the Commissioner of Soil and Land Conservation, especially the recent involvement in resolving local land management issues.

The Working Group supported that where land degradation is likely to result from an agricultural practice, action is taken to prevent that practice from continuing, after all avenues of education have been exhausted.

Recommendations

- 4.1 DPIRD employ a dedicated Development Officer based at Carnarvon for at least three and up to five years to lead education and engagement with growers in the Carnarvon horticultural area, and promote better land, soil, and crop management practices to mitigate the impact of flood events and reduce soil loss from properties.
- 4.2 In consultation with industry, DPIRD develop, publish, and promote a guide of contemporary farm management practices for the Carnarvon horticultural area. It should include practical management options, landholder compliance requirements and obligations, and flood and cyclone preparation checklists. It should include practical management options, landholder compliance requirements and obligations, and flood and cyclone preparation checklists.
- 4.3 DPIRD and CGA encourage all growers to participate in existing programs, such as Building Horticulture Business Capacity, Farm Business Resilience Program, and Freshcare Environmental Code of Practice.
- 4.4 DPIRD, with industry, develop the WA Government policy on future soil restoration within the Carnarvon horticultural area.

Waste management

Waste disposal practices throughout the Carnarvon horticultural area were highlighted after the 2021 floods when chemical drums, plastics, horticultural trash, and general rubbish was observed to be flowing across properties, through floodways and into the main channel of the river and reported to DWER's Pollution Watch branch. Waste attributable to the horticulture area was found on the beaches of significant marine ecosystems at Shark Bay World Heritage Area and Ningaloo Coast.

In response to the reported observations, DWER and Keep Australia Beautiful Council Services conducted a waste audit in August 2021 to identify the volume and type of dumped waste in the Carnarvon horticultural area. Horticultural and domestic waste was located in waterways, road reserves, and on unallocated Crown land. Excessive stockpiling of used production materials was noted on both private and public land.

Most of the waste identified was generated by the horticultural industry, with some rubbish likely dumped by external parties not residing within the horticultural area.

The audit conservatively estimated 1,474 cubic metres of waste material, with the true volume considered to be significantly higher. Sites were categorised as either high, medium or low risk, based on the type of materials encountered onsite and the distance from a river or watercourse. A total of 78 sites was recorded, with 24 sites containing high risk materials. Of these, 22 sites were located within 50m of a watercourse. Nine sites contained high risk materials such as chemical drums, asbestos, or hydrocarbons.

The extent of observed rubbish demonstrated that some landowners had carried out poor waste management practices over an extended period.

Compliance efforts are complex, as waste may be kept on properties or dumped on Crown land until a flood removes it. In these scenarios, it is difficult to prove responsibility for the rubbish and successfully prosecute.

DFES identified that waste on Crown land and properties also poses a risk in fire responses.

Working Group response

The current level of waste and management in the Carnarvon horticultural area is unacceptable and affects the entire industry's social license to operate. Consumers have increasingly higher expectations regarding agricultural production systems, with heightened mainstream and social media awareness of how the production of foods they consume impacts the environment. The industry's environmental management credibility is at risk when waste from the horticultural area impacts significant marine ecosystems at Shark Bay World Heritage Area and Ningaloo Coast.

The level of waste identified in the audit indicates that poor waste management behaviours are common among some landowners and have become normalised. Many growers are managing their waste appropriately, however, a small group of growers are impacting the reputation of the industry.

An immediate and ongoing focus on improving waste management on horticultural properties is needed. The Working Group, with the CGA, Shire of Carnarvon and DWER, should develop a strategy to coordinate activities to affect change.

The strategy could focus on education, recycling, value add opportunities, and compliance.

Whilst the preference is to improve practices through education, the level of waste and embedded behaviours also warrants a focus on compliance. Implementation of compliance and enforcement action will send a message that inappropriate practices will not be tolerated. Much of the waste dumped off farm is located on Crown land. Guidance is needed from Department of Planning, Lands and Heritage on how our agencies can cooperate to manage this issue.

The CGA as industry leaders must encourage improved waste management behaviours through existing or new platforms:

- Growers should be reminded of their responsibility to dispose of chemical containers they purchased, and the options for disposal, which include return of chemical drums for drumMUSTER to CGA or utilising the Shire of Carnarvon's Browns Range waste facility.
- The Freshcare program is currently undertaken by growers in the Carnarvon horticultural area to access markets. For fresh produce growers and grower-packers, there are two standards available for on-farm production: Food safety and quality, and Environmental. The Freshcare Environmental Code of Practice (ENV3) program was designed to assist growers to achieve and demonstrate real environmental outcomes on-farm and provide customers with assurance that produce has been grown and packed with care for the environment. The Environmental Code includes a criterion associated with waste.
- A waste management program to engage and audit growers on-farm about management of waste, and
- DPIRD and industry to investigate options to manage excess produce and recycling options for the industry.
- Implementation of the Plan for Plastics initiative (State legislated requirements) is imperative and will require a holistic and multi-faceted approach by a broad range of stakeholders to ensure effective implementation.

There is a high cost to run a waste facility and the Shire of Carnarvon will bear considerable expense to manage the disposal of the volume of rubbish currently in the horticultural area. The Working Group will continue discussions with the Shire of Carnarvon to identify options to manage their expenses and costs to producers, to undertake best practice waste management.

Recommendations

- 5.1 CGA, DWER and Shire of Carnarvon develop a strategy to regularly encourage growers to appropriately dispose all waste and rubbish from their property.
- 5.2 Good practice waste management guidelines be developed by a grower group with DWER, Carnarvon Growers Association (CGA), Keep Australia Beautiful Council and DPIRD.
- 5.3 The State Government co-invest with industry to engage and audit growers in the management of on-farm waste and rubbish.

- 5.4 A waste management compliance plan be developed for implementation by DWER and Shire of Carnarvon.
- 5.5 Department of Planning, Lands and Heritage be invited to present to the Working Group on its plan for the management of rubbish on Crown land.
- 5.6 DPIRD and CGA investigate options to manage excess agricultural produce, using incentives available under WasteSorted grants.
- 5.7 DPIRD and CGA work with industry to investigate and support proposals to devise solutions for horticultural and chemical waste management.

Appendices

Appendix 1: Carnarvon Floodplain Management Working Group - Terms of reference

Review of the Carnarvon Floodplain – Assessment of factors contributing to impacts, management options and responsibilities

Background

The Gascoyne River Catchment is the largest in Western Australia, covering about 79,000 square kilometres. The river has an active delta from Rocky Pool, located 40km upstream, to the river mouth. (Par 2003).

The wholesale value of annual production in Carnarvon is approaching \$100m and the region supplies a significant proportion of the State's counter seasonal vegetables, early season temperate fruit crops, and mid-season tropical crops, as well as year-round production of bananas.

Periodic flooding results in the area from cyclonic and thunderstorm activity in the catchment, with a risk period from November to May, associated with the wet season in the north of WA. Floods in 1974, 1980, 1995, 1999, 2000, and 2011 lead to soil erosion that impacted the productivity of horticultural properties in the floodplain. Flows in the Gascoyne River that cause soil and crop losses are expected on average once every 10 years.

Levees to reduce flooding and related damage to parts of the horticultural district were constructed in 2015 by the State Government with State and Federal funding. Informed by modelling, the 2015 levees were designed to mitigate damage from larger flood events, such as those experienced in March 2000, and December 2010.

Continued soil loss is unsustainable to both the State and industry. As an election commitment, the WA Government committed to support fruit and vegetable Industries in Carnarvon by restoring pre flood capacity and reducing future flood risk through consolidated and coordinated management.

Purpose

The purpose of the report is to inform Government and industry on the factors that contribute to impacts during a flood event, identify mitigation strategies and management options, and provide clarity on responsibilities, accountability, and authority. The aim is to ensure all stakeholders understand their role in minimising the impact of future flood events on horticultural industries that farm on the Carnarvon floodplain.

Scope

- Investigate contributing factors to flood impacts across the Carnarvon floodplain, including but not limited to:
 - On farm practices, crop types, management practices.
 - On farm structures, earthen structures, wind breaks, fencing.
 - Floodway, flow line, gully management and maintenance.
 - Land use planning.
 - Basic Raw Material Extraction.
- Identify the accountable party for the factor contributing to adverse outcomes and define the responsibility for each factor.
- Identify and agree on the most appropriate legal mechanism available to ensure management of the contributing factors to manage adverse outcomes.
- Identify the agency with responsibility for compliance activities to support implementation and appropriate on-going management.
- Provide advice on actions to minimise the impact on future flood events based on the information above.

Principles

The agencies participating in the review will adhere to the following principles:

- Transparency and consistency in decision making. A summary of all decisions will be provided.
- Work collaboratively across Government agencies and industry Working Groups to ensure deliverables align with the purpose of the study and deliver high value outcomes.
- All decisions with a budget and financial implications are subject to scrutiny.

Responsibilities

As the lead agency for primary industries, DPIRD has responsibility for convening, reporting on, and managing the process, provided by authority through the Government's election commitment.

Carnarvon Floodplain Management Working Group

DPIRD

Chair: Carl Binning – Deputy Director General - Primary Industries Development

- Cecelia McConnell - Commissioner of Soil and Land Conservation
- Melanie Strawbridge – Director, Agriculture Resource Management and Assessment
- Rohan Prince – Director, Horticulture and Irrigated Agriculture
- Vicki McAllister – Manager, Horticulture and Irrigated Agriculture
- Henry Smolinski – Senior Research Scientist, Agriculture Resource Management and Assessment

Department of Water and Environmental Regulation

- Jason Moynihan - Executive Director, Science and Planning
- Simon Rodgers - Supervising Engineer, Surface Water Assessment and Flood Risk Science
- Fleur Coaker - Regional Manager, Mid West Gascoyne Region

Shire of Carnarvon

- Eddie Smith - President
- Andrea Selvey – Chief Executive Officer

Carnarvon Growers Association

- Nic Cuthbert - Manager
- Paul Shain – President
- Rod Sweetman – Grower representative

Department of Fire and Emergency Services

- Matthew Holland – Area Officer Carnarvon

References

Clement, J 2002 Review of soil conservation legislation: Carnarvon horticultural area. Department of Agriculture and Food, Western Australia Report 1/2003

Parr, D 2003 Farm Management Practices for the Prevention of Soil Erosion in the Carnarvon Horticultural Area. Lower Gascoyne Management Strategy, Department of Agriculture, Western Australia

Rodgers S, Greening L, Watson 2021 Assessing the 2021 Gascoyne River flood at Carnarvon, Preliminary report, Department of Water and Environmental Regulation