PLANNING INVESTIGATIONS **3** **2017-222**

NATIONAL CARP CONTROL PLAN

Engineering options for the NCCP

This suite of documents contains those listed below.

NCCP TECHNICAL PAPERS

1. Carp biocontrol background
2. Epidemiology and release strategies
3. Carp biocontrol and water quality
4. Carp virus species specificity
5. Potential socio-economic impacts of carp biocontrol
6. NCCP implementation
7. NCCP engagement report
8. NCCP Murray and Murrumbidgee case study
9. NCCP Lachlan case study

NCCP RESEARCH (peer reviewed)

Will carp virus biocontrol be effective?

1. 2016-153: Preparing for Cyprinid herpesvirus 3: A carp biomass estimate for eastern Australia
2. 2018-120: Population dynamics and carp biomass estimates for Australia
3. 2017-148: Exploring genetic biocontrol options that could work synergistically with the carp virus
4. 2016-170: Development of hydrological, ecological and epidemiological modelling
5. 2017-135: Essential studies on Cyprinid herpesvirus 3 (CyHV-3) prior to release of the virus in Australian waters
6. 2020-104: Evaluating the role of direct fish-to-fish contact on horizontal transmission of koi herpesvirus
7. 2019-163 Understanding the genetics and genomics of carp strains and susceptibility to CyHV-3
8. 2017-094: Review of carp control via commercial exploitation

What are the carp virus biocontrol risks and how can they be managed?

9. 2017-055 and 2017-056: Water-quality risk assessment of carp biocontrol for Australian waterways
10. 2016-183: Cyprinid herpesvirus 3 and its relevance to humans
11. 2017-127: Defining best practice for viral susceptibility testing of non-target species to Cyprinid herpesvirus 3
12. 2019-176: Determination of the susceptibility of Silver Perch, Murray Cod and Rainbow Trout to infection with CyHV-3
13. 2016-152 and 2018-189: The socio-economic impact assessment and stakeholder engagement
    Appendix 1: Getting the National Carp Control Plan right: Ensuring the plan addresses
    community and stakeholder needs, interests and concerns
    Appendix 2: Findings of community attitude surveys
    Appendix 3: Socio-economic impact assessment—commercial carp fishers
    Appendix 4: Socio-economic impact assessment—tourism sector
    Appendix 5: Stakeholder interviews
    Appendix 6: Socio-economic impact assessment—native fish breeders and growers
    Appendix 7: Socio-economic impact assessment—recreational fishing sector
    Appendix 8: Socio-economic impact assessment—koi hobbyists and businesses
    Appendix 9: Engaging with the NCCP: Summary of a stakeholder workshop
14. 2017-237: Risks, costs and water industry response
15. 2017-054: Social, economic and ecological risk assessment for use of Cyprinid herpesvirus 3
    (CyHV-3) for carp biocontrol in Australia
    Volume 1: Review of the literature, outbreak scenarios, exposure pathways and case studies
    Volume 2: Assessment of risks to Matters of National Environmental Significance
    Volume 3: Assessment of social risks
16. 2016-158: Development of strategies to optimise release and clean-up strategies
17. 2016-180: Assessment of options for utilisation of virus-infected carp
18. 2017-104: The likely medium- to long-term ecological outcomes of major carp population reductions
19. 2016-132: Expected benefits and costs associated with carp control in the Murray-Darling Basin

NCCP PLANNING INVESTIGATIONS

1. 2018-112: Carp questionnaire survey and community mapping tool
2. 2018-190: Biosecurity strategy for the koi (*Cyprinus carpio*) industry
3. 2017-222: Engineering options for the NCCP
4. NCCP Lachlan case study (in house) (refer to Technical Paper 9)
5. 2018-209: Various NCCP operations case studies for the Murray and Murrumbidgee river systems
   (refer to Technical Paper 8)

National Carp Control Plan
High Biomass Clean-up Options, Planning and Execution Workshop

Workshop Outcomes Report

The Wedge Group Pty Ltd

Karl Mathers

Geordie McKinlay

September 2018

FRDC Project No 2017 - 222

Rev 0.1 September 2018

National Carp Control Plan - High Biomass Clean-upOptions, Planning and Execution Workshop Report

2017 - 222

2018

The Fisheries Research and Development Corporation plans, invests in and manages fisheries research and development throughout Australia. It is a statutory authority within the portfolio of the federal Minister for Agriculture, Fisheries and Forestry, jointly funded by the Australian Government and the fishing industry.

Researcher Contact Details		**FRDC Contact Details**	
Name:	Karl Mathers, The Wedge Group Pty Ltd	Address:	25 Geils Court
Address:	8 Percy Street, Echuca Vic 3564		Deakin ACT 2600
Phone:	0423 378 803	Phone:	02 6285 0400
Fax:		Fax:	02 6285 0499
Email:	karl.mathers@thewedgegroup.com.au	Email:	frdc@frdc.com.au
		Web:	www.frdc.com.au

In submitting this report, the researcher has agreed to FRDC publishing this material in its edited form.

Contents

Tables

Figures

Abbreviations

FRDC – Fisheries Research and Development Corporation

NCCP – National Carp Control Plan

CyHV-3 - Cyprinid herpesvirus 3

TWG – The Wedge Group

MDB – Murray-Darling Basin

Executive Summary

The Wedge Group was engaged by the Fisheries Research and Development Corporation (FRDC) on behalf of the National Carp Control Program (NCCP), to deliver a project exploring possible engineering and technology options to address the range of high-biomass clean-up and disposal scenarios associated with possible deployment of the Cyprinid herpesvirus 3 (CyHV-3, hereafter 'the carp virus') as a biocontrol agent for carp (*Cyprinus carpio*) in south eastern Australia. The project was identified as a priority by the NCCP Operations Working Group to provide operational, engineering, logistics and contracting knowledge to support high biomass clean-up planning and execution.

The overall objective of the project was to support the ongoing refinement of the NCCP Operational Strategy through identification of a range of suitable works and measures that will effectively and efficiently reduce the impact of large scale carp mortality in inland waterways.

Specific objectives for the project were:

- to identify and assess clean-up technologies and methods suitable for high volume biomass removal (including collection, extraction, removal/transport) to accommodate scenarios across the range of inland water body types,
- identify the human resources and arrangements required for the range of technologies and methods,
- identify logistical and contracting constraints and potential delivery issues for high volume biomass clean-up and;
- provide indicative costs (where available) for the preferred high biomass removal methods.

The delivery methodology for the project involved the following key tasks:

- expert identification and solicitation,
- engagement with experts on the project scope and willingness to participate,
- a facilitated workshop designed around targeted case study sites and;
- cost estimation (for preferred options), based on a region wide case study.

The facilitated workshop was held in Mildura on 27/28 June 2018. The workshop was successful in bringing a broad range of delegates together from across both the public and private sectors with a range of system operation, industry and research groups represented.

The purpose of the workshop was to:

- bring together the experts identified during the planning phase,
- present them with a range of scenarios across South Australia, New South Wales and Victoria and;
- challenge them to work together to identify site conditions, opportunities, difficulties, knowledge gaps and clean-up options.

The project team identified a suite of aquatic environments within the Murray-Darling Basin that best characterised the typical water bodies within the system. These were used as suitable project case studies to assist workshop participants in identifying possible clean-up options, issues to be considered, and possible constraints. The case study sites included:

- Moira Lake,
- Mildura Weir, Kings Billabong, Lake Hawthorn,
- Gravity Irrigation Districts (Goulburn Murray Water and Murray Irrigation Limited,)

- Yatco Lagoon, Lake Bonney,
- Lakes Alexandrina and Albert,
- Lake Cargelligo,
- Warrego River and;
- Lake Burley Griffin.

The workshop session also looked at the scalability of clean-up solutions identified across an area that possessed many of the characteristics of the individual case study sites.

Photo ES1 – Workshop participants at Lake Hawthorn, Mildura.

Workshop ideas were collated into a mind map (Appendix 2) which identified 5 key themes or strategies to facilitate effective high biomass site clean-up. The key themes are as follows:

Clean-up Solutions – Innovative solutions and techniques adapted from conventional fish harvesting methods and the solid and liquid waste management industry.

Aggregation of Carp – Referring to the natural or manipulated aggregation of carp (through flow, structures or stimulants) to maximise virus effectiveness and concentrate clean-up activities.

River Operations – Exploring use of operational flow and control measures to aggregate carp, flush dead carp, isolate reaches or features and provide flows to address water quality issues. Isolation & Segregation – Exploring operational tools to isolate sensitive sites and or segregate sites with higher biomasses.

Surveillance & Monitoring – Exploring both techniques and timing to monitor carp throughout the project lifecycle.

Using the Environment to Advantage – Capitalising on natural conditions including prevailing winds, river and stream geomorphology and the ephemeral nature of some tributaries to effect a better outcome for the project.

Attendees were also asked to provide comment and feedback on other key issues which will impact on the success of a carp clean-up program, these we identified as follows:

Resourcing and Management – Identification of a preferred delivery model that will provide both the resource certainty and delivery flexibility to meet clean-up objectives.

Communication & Engagement – With a focus on local level 'two-way' engagement commencing from the planning phase.

Roles and responsibilities – Ensuring that clear organisational arrangements are established and communicated during the planning phase and reinforced during the delivery phase.

Conclusions

A range of conclusions relating to the delivery of effective high-biomass site clean ups and the broader NCCP were identified through the workshop process and subsequent reporting. These are summarised as key issues and ideas warranting further investigation and are presented in the following lists, aligned to project implementation phases, and should be considered further by the NCCP in the development of the operational strategy.

Planning and Pre-Release Phase:

- Understand clearly the built and natural environments that will be impacted and developing site or system specific plans and strategies.
- Explore tactics to clean-up carp while they are still alive (post infection) might be more efficient
- Explore pre- screening of major offtakes and pumping stations (including the development of guidelines and advice for the vast number of direct diverters.
- Develop a communications and engagement strategy that engages extensively with local communities during the planning stage.
- Operational equipment will need to be prepositioned at designated locations likely to need clean-up operations. Resources will need to be on short response standby
- Pre virus carp control (for example netting or electro-fishing) at sensitive locations to reduce biomass where access and or clean-up effectiveness may be an issue
- Ongoing stakeholder engagement and communications needs to occur continuously aligned to operational delivery
- Operational fatigue is possible given the long-term nature of bio-control, this needs to be carefully considered in the overall resource planning

Operations Phase:

- Use of water regulation is critical to enhance virus distribution and clean-up efficiencies
- Waterways could be sectioned by booms to allow focussed operations and concentration of carp
- Explore carp 'wrangling' with attractants to contain then clean-up carp at operational ready locations (e.g. no obstructions, good access)
- Booming of water body edges, where appropriate, could assist in management of dead carp
- Clean-up and 'processing' (which could be in the form of adapted 'wood chipper' technology) to concentrate biomass for disposal. The 'wood chipper' approach may provide for the humane treatment of infected fish.

- Carp degrade rapidly creating an organics slime that will also impact water quality, the use of adapted liquid waste management technology (for example conventional sucker trucks) should be explored further.
- Complementary river operations need to be further explored, for example: aggregating fish through attraction flows; moving infected fish towards collection points using flow manipulation; releasing flushing flows to mitigate potential water quality problems; using operational structures and to exclude movement (segregation) to zones where clean-up programs were not scheduled or could be practicably delivered.

Post Operations Phase:

- Once carp are removed explore opportunities to screen offtakes and wetlands to avoid carp re-infestation
- Engage with environmental water holders in the development of post carp removal watering strategies to optimise water quality and environmental enhancement opportunities
- Planning should include an understanding, and clear definition, of when clean-up operations would/could cease and include this in the communications strategies.
- Ensure adequate ongoing monitoring and evaluation.

Recommendations

The following recommendations, gleaned from the workshop, should be further considered by the NCCP team so as to inform the development of the operational strategy.

1. The presence of carp aggregations are likely to be key factors influencing selection of timing and locations for possible virus deployment. The ability to predict aggregations sites, and or influence aggregations (timing and location) through the use of flow manipulation, should be fully explored so as to be able to better plan for and execute the clean-up of high biomass sites.

2. If carp are infected, released and die before transmission of the virus occurs then the spread and kill rate may be adversely affected. There is a need to determine whether carp that are infected in a natural or artificial (flow cued) aggregation are likely to cease aggregating and limit the ongoing transmission of the virus.

3. In exploring the timing and application of various clean-up techniques and technologies a number of assumptions were made regarding the percentage mortality. The assumptions were 75% of population killed, 10% consumed by predators, 10-15% not able to be cleaned up and leaving 50% of total biomass requiring clean-up operations. The project needs to confirm, as far as is practically possible, the likely mortality levels across representative sites so as to inform planning and resourcing strategies prior to implementation.

4. The way in which carp behave once initially infected isn't clear and there exists some uncertainty about the rate and speed of infection, hence mortalities. This was raised in the context of dealing with uncertainty in the planning and delivery of clean-up operations. Consideration should be given to investigations aimed at better understanding how carp might behave once infected and the implications of that behaviour on both transmission, mortalities and clean-up requirements.

5. Encouraging aggregation was raised during the workshop as a means of efficiently harvesting carp via conventional commercial fishing and recovery techniques prior to infection so as to reduce the biomass required to be cleaned up post release. This proposition is likely to be continually raised throughout the consultation and approvals phase. Whilst it can be assumed

this method will impact on virus efficacy, and so effectiveness of the virus it should be further investigated and where possible quantified to as to arrive at a preferred position on the method for both consultation and operational planning.

6. There is potential to commence clean-up while carp are still alive as they are understood to move to the surface and gulp for air in the final stages of infection. This may result in significant cost savings and reduction in risks to water quality, however, it is not known if removing moribund fish might impact on transmission efficiency. This should be further explored by the NCCP in completing the epidemiological investigations.

7. Queries raised that have potential to effect the project planning and in particular the clean-up, included: how does the virus operate in the short, medium and long term; and how the natural behaviour of the carp could be leveraged to maximise infection and clean-up. Both questions should be fully addressed in developing the operational strategy.

8. In developing the operational plan it is important from both a consultation and delivery perspective to clearly define and communicate the operating conditions to would determine when a release event could be considered practically complete allowing clean-up resources to be re-deployed and post clean-up monitoring and treatments to commence.

Overall the workshop process was extremely well received by participants. The high level of participant enthusiasm (many of whom were unknown to each other prior to participating) contributed to the successful identification of a range of ideas and issues warranting further evaluation.

Participants identified significant value in holding further workshops to ‘road test’ some of the ideas coming out of the Mildura session, particularly given their greater appreciation for the spatial and temporal challenges that may be faced.

Introduction

The Fisheries Research and Development Corporation is leading development of a National Carp Control Plan (NCCP), exploring merits of the use of the virus known as Cyprinid herpesvirus 3 (CyHV-3, hereafter 'the carp virus') as a biocontrol agent to control invasive common carp, *Cyprinus carpio*, in Australian freshwater environments.

The plan will inform governments on the technical feasibility of releasing the carp virus, the associated costs, benefits and risks and the views of communities and stakeholders. It will also identify if further work is required to inform release of the virus, should this be shown to be feasible.

The Wedge Group was engaged by FRDC under the auspices of the National Carp Control Plan (NCCP) to deliver a project exploring possible engineering and technology options that could be employed to address the range of clean-up and disposal scenarios associated with large possible carp mortalities that might occur if the carp virus is released.
The project has been identified as a priority by the NCCP Operations Working Group and is intended to provide operational, engineering, logistics and contracting knowledge to support high biomass clean-up planning and execution.

This initial project revolved around the design, consultation, delivery and reporting of a *High Biomass Clean-up Options Workshop*.

The key objective of the workshop was to identify and evaluate options for large-scale carp clean-up and disposal following possible high biomass carp kills across a wide range of public and private water bodies.

Participants were invited from a diverse cross section of private and public sector organisations spanning waterway and infrastructure operations, to commercial fishers and industry leaders in aquatic waste management.

The *High Biomass Clean-up Options Workshop* was designed and delivered to complement other NCCP activities.

Objectives

The overall objective of the project was to support the ongoing refinement of the NCCP Operational Strategy. This was proposed to be achieved through the identification of a range of suitable works and measures that will significantly remove the numbers of dead and dying carp and mitigate the impacts of dead fish in inland waterways in an efficient manner.

The specific objectives identified for the project were:

- to identify and assess clean-up technologies and methods suitable for high volume biomass removal (including collection, extraction, removal/transport) to accommodate scenarios across the range of inland water body types,
- identify the human resources and arrangements required for the range of technologies and methods,
- identify logistical and contracting constraints and potential delivery issues for high volume biomass clean-up and;
- provide indicative costs (where available) for the preferred high biomass removal methods.

These objectives are further explained in the following sections and addressed in detail in the Results and Discussion section.

Clean-up Technologies and Methods

An important goal of the workshop was to identify pre-existing water borne harvesting methods and how they might be adapted to meet the requirements of the NCCP.

The project team were keen to better understand the existing capacity, capability and desire of contractors and technology developers to engage with the project. This included exploring the mobility of operations and the ability to adapt or scale up their existing plant and equipment.

The workshop format was seen as an opportunity for contractors to outline their current technologies and methods and relay their experiences operating across a range of environments with different accessibility, public exposure and statutory requirements. This workshop interaction was seen as a valuable opportunity to encourage connections to be made across various platforms and geographies.

Human Resources

Understanding the human resource, legal and procurement requirements of clean-up are crucial to ensure that:

1. approvals for clean-up works can be gained early, and can progress without delay, as and when required.
2. disposal arrangements and sites for the biomass are prepared well in advance of need.
3. operations are identified and resourced well in advance of the release date activities that could be planned and resourced well before release include:
    a. management structures and works contracts for labour and plant and machinery.
    b. deployment locations for the duration of likely clean-up operations (aligned to likely biomass concentrations).

c. mobility and timeliness requirements of the clean-up task. This would include such things as 7 day rostering and logistics planning (travel and accommodation etc)
d. ensuring appropriate task training is delivered and Heath, Safety and Environmental (HSE) management provisions are addressed.

Logistical and Contracting Constraints

The clean-up effort required at a national scale is considerable however possible if sound project management principles are applied such as:

- obtaining ‘upfront and early’ approvals,
- ensuring an appropriate level of resource planning is undertaken,
- the challenge is divided into manageable pieces of work, and shared among a sufficient workforce.

Clean-up work schedules can be developed that reflect virus transmissivity and fish movement and the logistical requirements and challenges can be mapped onto specific water bodies for contractors to develop clean-up methodologies and quotations.

Understanding the level of expertise in Australia, including the adaptability of companies and the quantum of available plant and labour, will inform the need for further capacity and capability building so as to be able to meet the needs of an extensive clean-up program.

Having a sound understanding of the current and required resource base will influence the type of delivery model or models considered for the clean-up engagements; particularly if companies intend on exploring substantial investments in design, construction and/or purchase of new equipment.

Indicative Costings

Indicative costings have been developed based on the Torrumbarry Region case study and are based on the indicative biomass assessments developed for that region and the outcomes of the workshop deliberations regarding applicable techniques and site prioritisation.

The indicative costings will be provided to the NCCP Cost Benefit project.

Method

The methodology adopted to deliver the project involved the following key tasks:

- expert identification and solicitation,
- engagement with experts on the project scope and willingness to participate,
- a facilitated workshop designed around targeted case study sites and;
- cost estimation (for preferred options), based on a region wide case study.

Expert identification and engagement

To facilitate creative ideas about clean-up opportunities, a broad range of participants were engaged from both the public and private sectors, from the following fields:

- River Operations
- Rural and Urban Water Suppliers
- Commercial Fishers
- Commercial Aquatic Weed Harvesters
- Transport & Logistics
- Incident Operations
- Environmental Water Management
- Research Scientists

A wide variety of attendees were identified by the project team with each being contacted regarding their level of interest, ideas for workshop design and their availability to attend a two day workshop in Mildura.

Twenty-nine (29) participants were selected from an initial possible attendee list of 50 people. Participants were ultimately chosen to ensure representation across of range of disciplines and expertise.

Facilitated workshop

Preparation

Participants were provided with information prior to the workshop which included: the scale and dynamics of the problem including (spatially in the form of case study site sheets) and a cross-section of the type of waterways that could be considered representative of the possible high biomass clean-up sites. The types of waterways included:

- regulated streams (with varying velocities and regulation),
- unregulated streams,
- reservoirs, lakes and large impoundments,
- shallow lakes and wetlands (Regulated and Unregulated) and;
- off-river gravity irrigation networks.

Mildura was selected as the preferred location for the workshop given its geographic location (proximity to participants, but also its isolation), appropriate facilities and an ability to visit a number of representative case study water bodies within a short distance of the workshop location.

Workshop participants were provided with a short background paper prior to the workshop. This paper (identified in Figure 1 below) provided a summary of key information relating to the form of biological control (Cyprinid Herpes Virus 3 (CyHV-3)), the types of response planning to be considered and some emerging positions on what might be considered 'High Biomass' in the context of an operational response. A summary of this background information is provided in the following sections.

The workshop also involved presentations and information on certain topics to frame workshop discussions including the following topics:

1. The science of virus release
2. Current operational planning ideas
3. Defining the high biomass operational challenge

Figure 1 Workshop Paper (Background information for participants)

Framing the discussion – The science of virus release

CyHV-3 is a highly infectious and, under the right conditions, fatal pathogen that causes acute clinical symptoms resulting in death only to *Cyprinus carpio*. All carp in Australian waterways are *Cyprinus carpio* and are therefore potentially susceptible to the carp virus.

Research shows that mortality rates following exposure to the virus is influenced by water temperature, the concentration of virus and carp aggregations. The permissive temperature range for the virus (16-28°C) and presence of carp aggregations are likely to be key factors influencing selection of timing for possible deployment as a biocontrol agent.

Carp may become infected through direct contact with an infected carp, through exposure to virus particles in the water or attached to fomites (mechanical vectors of the virus).

To ensure effective control of carp, administration of the virus should only occur when: there is a high likelihood of the release zone remaining within the permissive range of the virus for at least one month; and when carp are aggregating.

To reduce the risk of unintended spread of the virus through flowing systems, the release strategy may involve sequential virus release (virus release, biomass clean-up and utilisation/disposal activities) moving from downstream to upstream using manmade and natural barriers to upstream fish passage as boundaries to discrete management zones.

Concurrent virus release (release and clean-up in multiple catchments) may also be effective. For example, coastal drainage systems could be treated concurrently with inland systems, or reaches of multiple river tributaries could be treated at the same time and/or in conjunction with private water bodies such as farm storages and off-river irrigation systems.

A number of assumptions were applied to the case studies, based on published literature and advice from the NCCP team regarding the epidemiology, including:

- Permissive temperatures (16-28C, numerous large spring/summer aggregations)
- Percentage mortality - assumed 75% of population killed, 10% consumed by predators, 10-15% not able to be cleaned up, leaving 50% of total biomass requiring clean-up operations (need to confirm likely mortality levels prior to implementation)
- Time duration of mortality events - 6 week period
- Average tonnes per day to be clean-up= 50% of Biomass Estimate/42days
- Peak biomass removal will be required around 2 weeks after virus release which could increase the average clean-up per day by 2.5 times.

Framing the discussion – Operational Planning

An operational response to the virus release will involve:

- rapid assessment of all accessible virus related carp deaths where their number, proximity to populated communities or where the risks are deemed to require a response,
- regional operations involving experts, relevant authorities across government, and communities (including indigenous),
- operational response and possible clean-up where risks are high,
- professional high biomass response and clean-up capability (the focus of this project and report) and;
- flexible, adaptive and documented responses to deal with uncertainties and to learn from prior actions.

In some instances carp mortality will not need to be cleaned up as the virus release strategy will target carp aggregations which are located in areas where the risks to public amenity and the local environment are reduced (this will be further informed by the NCCP's suite of investigations into ecological consequences of virus release).

It is also likely to be beneficial to retain some biomass and associated nutrients within affected waterbodies to support the growth of other species and allow the aquatic ecosystems to recover. However, the quantum has not been defined.

Thorough adaptive response planning is critical for operations and to effectively mitigate the risks of carp mortality causing significant environmental, economic or social impacts.

Framing the discussion – defining 'High Biomass' and how could it relate to an operational response

The virus release will cause carp mortality that has the potential to result in adverse social, economic and environmental impacts.

The priorities for clean-up and the triggers for response are still being developed under the NCCP, and will be informed by a range of biomass and epidemiology research, investigations and case studies. This 'work in progress' has developed a number of scenarios and decision support tools that have been applied to a range of case studies including the Lachlan Catchment.

As a means of informing discussions around the case study sites workshopped in Mildura, the project utilised the priority matrix from the Lachlan case study which is reproduced in Table 1 below.

The matrix relates carcass biomass and proximity to sites where water body hypoxia, odour, aesthetics and water consumption issues are likely to exist.

Four thresholds of biomass (less than 100kg/ha, 100 to 250kg/ha, 250 to 500kg/ha and more than 500kg/ha) and four thresholds of proximity (within/adjacent, less than 1km, between 1km and 5km and more than 5km) have been selected to help determine risk and therefore priority for clean up.

Table 1 Criteria to assist decision making about response and possible clean-up activities to carp mortality events

Criteria for response decision making		Expected numbers (biomass) of carcasses in waterway			
		Very large numbers (>500 kg/ha)	Large numbers (250-500 kg/ha)	Moderate numbers (100-250 kg/ha)	Low numbers (<100 kg/ha)
Proximity to Town Water Supply (TWS) intake	Waterway is a Town Water Supply (TWS) storage	Very high	Very high	Very high	High
	Site is within 1km of a TWS intake pump	Very high	High	Moderate	Low
	Site is within 5km of a TWS intake pump	High	Moderate	Low	Low
	Site is more than 5km from a TWS intake pump	Low	Low	Very low	Very low
Proximity to urban, residential & commercial areas	Site is within or adjacent to urban/residential/commercial area	Very high	Very high	High	High
	Site is within 1km of a urban/residential/commercial area	Very high	High	Moderate	Low
	Site is within 5km of a urban/residential/commercial area	High	Moderate	Low	Low
	Site is more than 5km from a urban/residential/commercial area	Low	Very low	Very low	Very low
Proximity to recreation or tourism area	Site is within or adjacent to recreation/tourism area	Very high	Very high	High	High
	Site is within 1km of recreation/tourism area	High	High	Moderate	Low
	Site is within 5km of recreation/tourism area	Moderate	Moderate	Low	Very low
	Site is more than 5km from recreation/tourism area	Low	Very low	Very low	Very low
Proximity to threatened aquatic species (gill breathing species) at risk of hypoxia	Site is within or adjacent to core threatened species habitat	Very high	High	High	Moderate
	Site is within 1km of core threatened species habitat	High	Moderate	Low	Low
	Site is within 5km of core threatened species habitat	Moderate	Low	Low	Low
	Site is more than 5km from core threatened species habitat	Low	Very low	Very low	Very low

Workshop Delivery

The purpose of the workshop was to:

1. bring together experts identified during the planning phase,
2. present them with a range of clean-up scenarios across South Australia, New South Wales and Victoria and;
3. challenge them to work together to identify site conditions, opportunities, difficulties, knowledge gaps and clean-up options

Case Studies

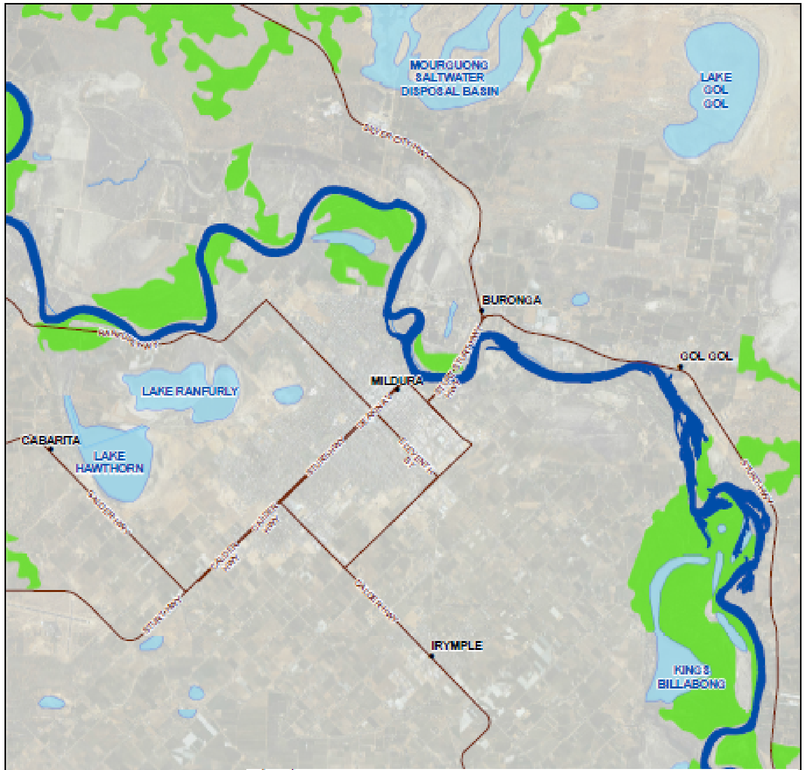
The project team developed a number of case study sites across a range of regions and water body types to assist participants in identifying possible clean-up options, issues to be considered and possible constraints. The case study sites included:

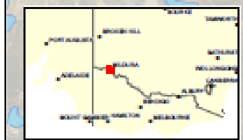
- Moira Lake
- Mildura Weir, Kings Billabong, Lake Hawthorn
- Gravity Irrigation Districts (Goulburn Murray Water and Murray Irrigation Limited)
- Yatco Lagoon, Lake Bonney
- Lakes Alexandrina and Albert
- Lake Cargelligo
- Warrego River
- Lake Burley Griffin

In addition to the eight sites detailed above, a workshop session was delivered to look at the scalability of the clean-up approach across an area that possesses many of the characteristics of the individual case study sites.

The Torrumbarry Area was selected as a case study meeting these requirements. The region selected runs from Torrumbarry Weir on the Murray River downstream of Echuca, through to Swan Hill and encompasses a wide variety of private and public, regulated and unregulated water bodies with varying carp biomass estimates. The Torrumbarry case study is discussed further in the Outcomes and Discussions section.

An example of the case study site sheets used in the workshop is provided below. The full set of site sheets provided in Appendix 1.





Epidemiology
Assumptions - permissive temperature, numerous large spring time aggregations.
Percentage mortality - Assume 75% of population killed, 10% consumed by predators, 10% not able to be cleaned up = 55% (requiring clean up operations) *Biomass Estimate .

Time duration of mortality = 6 week period

Average tonnes per day to be clean up = 55% of Biomass Estimate/42days

Peak biomass removal required around 2 weeks after virus release maybe up to 2.5 * Average Cleanup per day.

Facts and Figures:

Kings Billabong
- 157hA Surface area when full
- Supplied water by Psyche Bend Pump Station
- Used by Lower Murray Water as a storage for irrigation pumping.
- Regulated by LMW and normally disconnected from the Murray
- Preliminary Biomass Estimate 86ton +/- 71.

Lock 11 (Mildura Weir)
- 3480hA, 36600ML Impounded, 232km Pool.
- Creates a pool of water for recreational, irrigation and urban use.
- A Denil fishway was constructed in 2010
- Regulated by G-MW on behalf of the MDBA
- Preliminary Biomass Estimate 609ton +/- 435.

Lake Hawthorn
- Reportedly the original source of Carp in the Murray Darling Basin.
- Introduced in the mid 1850's.
- Unintentionally released into Lake Hawthorn in the 1960's and spread from there.
- Now a highly saline and typically dry lake.

Note - The NCCP Biomass Investigations are ongoing. The Preliminary Biomass numbers presented in the case studies for the workshop are estimates developed by the project team based on published information and extrapolated to the case study sites for workshop evaluation purposes only. They are not to be taken as outputs from the NCCP project.

For Consideration:

Threatened Species
Access for boats
Land Tenure
Proximity of public
Urban and Irrigation Supply Impacts
Disposal Site Location and Distance

Notes:

THE WEDGE GROUP

Legend

Locality, Lock, Main Highway, Watercourse, River Murray, Lake, Wetland Extent, Native Vegetation

NCCP PROJECT

KINGS BILLABONG, LAKE HAWTHORN AND LOCK/WEIR 11

Figure 2 Example Case Study Sheet

Case-study Biomass Estimates

In developing the case study sheets an estimate of the possible biomass to be managed was made by the project team. This was provided so participants could give consideration to the scale of the challenge when considering the possible clean-up methods and logistical challenges.

It must be stressed the NCCP Biomass Investigations were ongoing at the time of the workshop. The preliminary biomass numbers presented in the case studies are estimates developed by the project team based on published information and extrapolated to the case study sites for workshop evaluation purposes only.

The biomass assessments for each of the case study sites is provided in Table 2 below. It should also be noted that, based on the research to date, when fish are aggregating the numbers presented could go up by an order of magnitude.

Case							Biomass Unit					
Area	Site	Area (ha)	Volume (ML)	Ave. Depth (m)	Length (km)	Ave. Width	kg/ha	+/-	Biomass Estimate	Cleanup ~55%	Ave. Per Day Removal (6 Week Cleanup)	Comment
Mildura	Kings Billabong	157					550	450	86 ton+/- 71 ton	47 ton+/- 39 ton	1.1 ton+/- 0.9 ton	
	Lock 11	3480	36600	Varies	232	150	175	125	609 ton+/- 435 ton	335 ton+/- 239 ton	8 ton+/- 5.7 ton	
	Lake Hawthorn	224	4802	2.8			Total		695 ton +/-506	382 ton +/-278	9 ton +/-7	Dry, Saline
Barmah	Moira Lake	1500					220	30	330 ton+/- 45 ton	182 ton+/- 25 ton	4.3 ton+/- 0.6 ton	
SA Lower Lakes	Lake Albert	16500	282000	1.7			121.95	36.6	2012 ton+/- 604 ton	1107 ton+/- 332 ton	26.3 ton+/- 7.9 ton	
	Lake Alexandrina	64500	1630000	2.8			121.95	36.6	7866 ton+/- 2361 ton	4326 ton+/- 1298 ton	103 ton+/- 30.9 ton	
							Total		9878 ton +/-2965	5433 ton +/-1631	129 ton +/-39	
Canberra	Lake Burley Griffin	664	33000	4.00			550	450	365 ton+/- 299 ton	201 ton+/- 164 ton	4.8 ton+/- 3.9 ton	
Irrigation Systems	Murray Irrigation Limited	2770			2770	10	75	25	208 ton+/- 69 ton	114 ton+/- 38 ton	2.72 ton+/- 0.91 ton	
	Goulburn-Murray Irrigation District	6300			6300	10	75	25	473 ton+/- 158 ton	260 ton+/- 87 ton	6.19 ton+/- 2.06 ton	
	Torrumbarry (G-MW) **Wetlands** National Channel Lagoons											
	Kow Swamp	2674					550	450	1471 ton+/- 1203 ton	809 ton+/- 662 ton	19.3 ton+/- 15.8 ton	
	Reedy Lake	194					550	450	107 ton+/- 87 ton	59 ton+/- 48 ton	1.4 ton+/- 1.1 ton	
	Middle Lake	185					550	450	102 ton+/- 83 ton	56 ton+/- 46 ton	1.3 ton+/- 1.1 ton	
	Third Lake	226					550	450	124 ton+/- 102 ton	68 ton+/- 56 ton	1.6 ton+/- 1.3 ton	
	Little Lake Charn	68					550	450	37 ton+/- 31 ton	21 ton+/- 17 ton	0.5 ton+/- 0.4 ton	
	Lake Charm	517					550	450	284 ton+/- 233 ton	156 ton+/- 128 ton	3.7 ton+/- 3 ton	
	Racecourse Lake	219					550	450	120 ton+/- 99 ton	66 ton+/- 54 ton	1.6 ton+/- 1.3 ton	
	Kangaroo Lake	966					550	450	531 ton+/- 435 ton	292 ton+/- 239 ton	7 ton+/- 5.7 ton	
	Lake Boga	900					550	450	495 ton+/- 405 ton	272 ton+/- 223 ton	6.5 ton+/- 5.3 ton	
							Total		**3272 ton +/-2677**	**1800 ton +/-1472**	**43 ton +/-35**	
	Rivers											
	Murray (Swan Hill to Torrumbarry Weir)	1512			378	40	550	450	832 ton+/- 680 ton	457 ton+/- 374 ton	10.9 ton+/- 8.9 ton	
	Loddon River (Kerang to Murray)	53.25			71	7.5	550	450	29 ton+/- 24 ton	16 ton+/- 13 ton	0.4 ton+/- 0.3 ton	
	Little Murray River	46.5			62	7.5	550	450	26 ton+/- 21 ton	14 ton+/- 12 ton	0.3 ton+/- 0.3 ton	
							Total		**1147 ton +/-938**	**631 ton +/-516**	**15 ton +/-12**	
	Main Channels											
	National Channel	148.5			27	55	75	25	11 ton+/- 4 ton	6 ton+/- 2 ton	0.15 ton+/- 0.05 ton	
	No. 2 Channel to Loddon River	67.5			37.5	18	75	25	5 ton+/- 2 ton	3 ton+/- 1 ton	0.07 ton+/- 0.02 ton	
	Pyramid Creek - Loddon River	88.4			68	13	75	25	7 ton+/- 2 ton	4 ton+/- 1 ton	0.09 ton+/- 0.03 ton	
	No. 1 Channel to Outfall	70.8			59	12	75	25	5 ton+/- 2 ton	3 ton+/- 1 ton	0.07 ton+/- 0.02 ton	
	No. 7 Channel to Boga	28			28	10	75	25	2 ton+/- 1 ton	1 ton+/- 0 ton	0.03 ton+/- 0.01 ton	
	6/7 Channel to Little Murray	8			8	10	75	25	1 ton+/- 0 ton	0 ton+/- 0 ton	0.01 ton+/- 0 ton	
	No. 9 Channnel	31.5			31.5	10	75	25	2 ton+/- 1 ton	1 ton+/- 0 ton	0.03 ton+/- 0.01 ton	
	No. 10 Channel	14.4			18	8	75	25	1 ton+/- 0 ton	1 ton+/- 0 ton	0.01 ton+/- 0 ton	
							Total		**34 ton +/-11**	**19 ton +/-6**	**0.45 ton +/-0.15**	
							System Total		**4193 ton +/-3414**	**2305.98 ton +/-1877.57**	**54.9 ton +/-44.7**	
River Murray	Lock 3 -4											
	Yatco Lagoon	346					175	125	61 ton+/- 43 ton	33 ton+/- 24 ton	0.79 ton+/- 0.57 ton	
	Lake Bonney	1625					175	125	284 ton+/- 203 ton	156 ton+/- 112 ton	3.72 ton+/- 2.66 ton	
							Total		**345 ton +/-246**	**190 ton +/-136**	**5 ton +/-3**	
	Warrego River	2070			1380	15	0.2					Ephemeral, Pools
Lachlan	Lake Cargellico	1440	36000	3.7m			300	50	432 ton+/- 72 ton	238 ton+/- 40 ton	5.66 ton+/- 0.94 ton	

Table 2 Case Study Site Biomass Estimates

The Workshop

The workshop was held over 27/28 June in Mildura with an agenda designed to provide a high level of participant interaction and engagement in the identification of suitable clean-up methods and the range of challenges that would be faced across differing waterbodies.

Day one involved visits to three local waterbodies (Kings Billabong, Lake Hawthorn and Mildura Weir/Lock 11). The visits presented opportunity for participants to engage outside of a formal workshop setting whilst getting an appreciation for the range of clean-up challenges that could be faced.

The three sites selected also constituted one of the case study sheets with the site inspections providing an opportunity to introduce the case studies, possible biomass ranges and the framework for the following days' workshop sessions.

Photo 1 - Workshop participants at Lake Hawthorn

Photo 2 – Mildura Weir

Photo 3 – Psyche Bend Pump Station (Kings Billabong)

Photo 4 – Kings Billabong

Day two of the workshop followed a formal workshop structure, commencing with a round-table discussion to capture key observations from the previous day's site inspections and to better understand participant's expectations leading into day two.

The second session focussed on setting the scene for the case study evaluations with a series of short presentations covering:

- the current status and future directions of the NCCP (Matt Barwick)
- the current Epidemiological investigations and understanding (Andy Huxham)
- the findings to date and next steps regarding the wider carp biomass assessments and modelling (Ivor Stuart) and;
- planning, contracting and logistical considerations (Greg Stevens).

The bulk of the workshop was dedicated to the evaluation of applicable clean-up options, opportunities and constraints delivered through the case study breakout sessions. Tables were set up to ensure diversity of skill sets across each table of participants. Groups were given two sites to work through chosen from the following:

- Lake Burley Griffin
- Murray Irrigation Limited and Goulburn-Murray Irrigation Districts
- Lake Cargelligo
- Lower Lakes - Alexandrina and Albert
- Lock 4 to Lock 3 Wetlands
- Mildura – Lock 11, Kings Billabong, Lake Hawthorn
- Moira Lake
- Warrego River

Following the conclusion of the clean-up brain storming, including each group reporting back their key points, the group collectively turned its attention to the Torrumbarry Irrigation Area operated by Goulburn-Murray Water in Victoria.

This region was selected for a collective discussion because it encapsulates many key features from the sites previously addressed and is in a highly connected waterway environment with many competing users (irrigation, urban supply, stock & domestic, lifestyle, and environment).

The discussion topics from each of the case study site evaluations were captured and collated, these are reported in the 'mind map' in Appendix 2, with the key points discussed further in the following Outcomes and Discussion section.

Photo 5 – The workshop, late on day 2!

Torrumbarry ‘Scaled Up’ Case Study

In addition to the key themes arising from a review of the eight case study sites captured above, a workshop session was delivered to look at the scalability of the clean-up challenge across an area that possesses many of the characteristics of the individual case study sites.

The Torrumbarry Irrigation Area (TIA) is part of the Goulburn-Murray Irrigation District and is located between Echuca and Swan Hill in North West Victoria (refer Figure 3).

The TIA contains a variety of:

- Natural creeks used to supply water;
- Wetlands and Water bodies to store and deliver water;
- Constructed and heavily regulated channels fed by natural creeks, wetlands and pump stations;
- Surface drainage networks with a level of connectivity between on-farm water bodies and the natural creeks and rivers, and
- These water features all present different challenges to any proposed clean-up.

Clean-up Methods

Proposed clean-up methods for the TIA are shown below and have been classified into the following water body types including: main river channel, tributary systems (low biomass), and tributary systems (high biomass).

The proposed clean-up methods assume a progressive infection of carp starting near Swan Hill and spreading upstream towards the National Channel offtake at Torrumbarry. This requires that, where possible, carp be excluded from travelling up and down fish ladders and locks in the region.

Main River channel

The methodology proposed to be adopted for linear systems such as the Murray River, Little Murray River and Gunbower Creek is to engage netting boats along with land based surveillance to patrol the waterway when the virus is active and fish are presenting on the surface.

Tributary systems – Low Biomass

It was identified that the current predicted biomass for a number of regulated tributaries and the irrigation channel systems are quite low and may not warrant extensive clean-up effort. However, it may be possible to draw down channel systems over the winter prior to the virus release to reduce biomass in these systems prior to screening river intakes on spring refill thus potentially mitigating the need for any significant effort in these areas.

Tributary systems – High Biomass

The proposed clean-up methods for higher biomass tributary systems and lakes is via netting boats with mechanical harvesting crews to manage larger, concentrated volumes.

As the name suggests netting boats essentially involve hand netting from boats, using clean-up boats as platforms for fish collection and storage in bulk bins or bags for subsequent transfer to trucks. The mechanical harvesting crew concept employs existing aquatic weed harvesters and floating waste collection vessels, adapted to collect and transport dead and decaying carp. Both concepts are further discussed in the 'Outcomes and Discussion' section.

This method is intended to target specific waterways, lakes and irrigation supply channels with:

- Urban Supply Offtakes, for example Murray River, Little Murray River, Gunbower Creek, National Channel;
- High social value (e.g. water supply, recreation, private frontage), such as Lakes Boga and Charm and Kangaroo Lake;
- Good access for boat launching and efficient clean-up execution, and
- Vacant areas at the shoreline biomass handling.

A number of waterbodies with potentially high biomass were considered to have very limited access along with significant on-water navigation/clean-up challenges, including high concentrations of standing timber and/or shallow heavily vegetated areas. Examples include Kow Swamp and Reedy, Middle and Third Lake. These sites were assumed (for the purposes of the case study) to be excluded from biomass recovery activities given the identified access issues and the fact that they have primarily agricultural frontage with comparatively lower abutting residential densities. It is acknowledged that these sites do have a number of significant ecological values requiring further investigation prior to the release of the virus and as a minimum they would require close monitoring with preparedness for land based clean-up if required.

Photo 6 – Torrumbarry Weir

Photo 7 - Kow Swamp (looking west)

Operational Resourcing

The following section provides a summary of the resourcing needs identified to address a Torrumbarry case study area clean-up.

A number of assumptions were made in assessing the resource requirements (and cost estimates) for the Torrumbarry case study, these include:

- There will be significant aggregations of carp at sites of high social value requiring higher production/removal rates (e.g. urban offtakes, town weirs, boat launches, camp grounds, etc.).
- In developing a resource plan a 50% contingency provides for doubling of netting boat resources or securing a second mechanical harvesting crew in the event of increased fish deaths.
- Landfill cell(s) constructed no greater than 30 minutes one-way travel time (average) of primary shoreline handling locations.
- Sourcing of select clay material for landfill, within 20km of the nominated landfill cell(s).

Manual 'Boat and Net' Recovery

The response team for manual removal consists of the following:

- Site engineer: to control scope, quality and costs
- Site supervisor: to oversee daily activities, personnel safety and attend to local community enquiries
- 6 No. netting boats: to capture small-medium quantities of carp over a large waterway length

- 1 No. shuttle truck: to support netting boat operations, and
- 1 No. mechanical harvesting crew: to capture large quantities over a small waterway area

Photo 8 - Example of commercial boat and net clean-up following a fish kill (Photograph courtesy of Keith Bell)

Mechanical Removal

The project team engaged workshop attendees, Australian Waterway Management Solutions (Joel Eaton) to provide advice on the range of fit-for-purpose plant and equipment that would meet the needs of the larger waterbodies and higher biomass sites, noting some modifications would be required to deal with animal rather than plant based biomass.

The response team for mechanical removal applied to the cost estimation consists of the following:

- HV2600 Harvester (see Figures 5 and 6)
- HV2600 Launch Trailer
- HV2600 HV Tow Vehicle
- HV Tipper Units Sealed T/G
- Shore Conveyor Systems
- Tilt Tray 7mtr
- Support Boat
- Service Vehicles Utes
- 3 Operators & 1 Supervisor

Photo 10 - Australian Waterway Management Solutions HV2600 Harvester and truck (Photograph Courtesy of Joel Eaton, Australian Waterway Management Solutions)

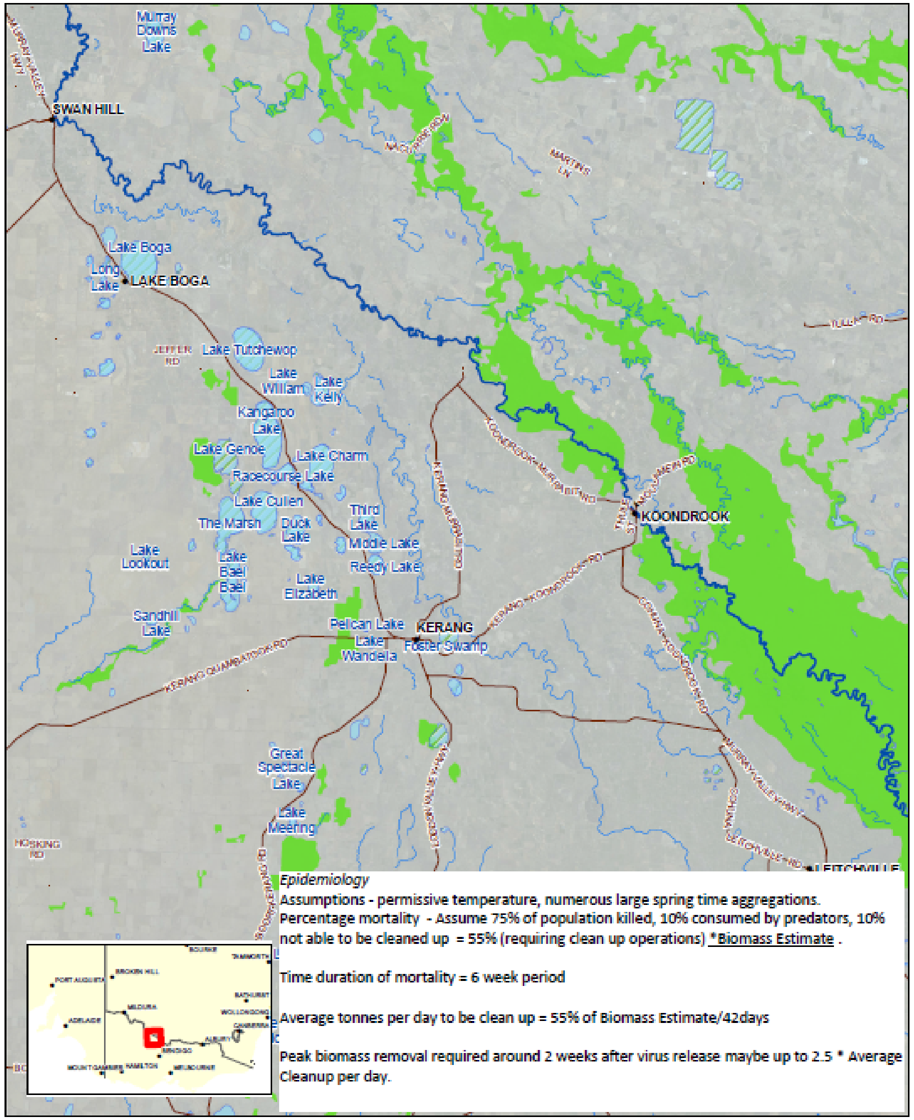
Photo 11 - Australian Waterway Management Solutions HV2600 Harvester in operation (Photograph Courtesy of Joel Eaton, Australian Waterway Management Solutions)

Disposal

Resource estimates for disposal activities were based on disposal estimates of 4,000,000kg of carp biomass with 50% removed as part of the clean-up program. To meet these disposal requirements one larger landfill site was provided for the entire area to dispose of material. Depending on the final recovery methodology adopted two sites might be required but these could be half the size of the larger site.

Other disposal case study design criteria included:

- Landfill cell(s) should be located within 30 minutes (average) of primary shoreline handling locations.
- 50% recovery (targeting that period of surface aggregation prior to mortality).
- 6 weeks on site (42 days) for the Torrumbarry area from the date of virus deployment to demobilising from a region
- 2kg average weight per carp.
- 10 hour working days.
- 8 productive hours per day (unproductive time includes daily pre-starts, road/ water travel, boat launching, shoreline handling, etc.).



Epidemiology

Assumptions - permissive temperature, numerous large spring time aggregations.

Percentage mortality - Assume 75% of population killed, 10% consumed by predators, 10% not able to be cleaned up = 55% (requiring clean up operations) *Biomass Estimate .

Time duration of mortality = 6 week period

Average tonnes per day to be clean up = 55% of Biomass Estimate/42days

Peak biomass removal required around 2 weeks after virus release maybe up to 2.5 * Average Cleanup per day.

Facts and Figures:

Torrumbarry Irrigation area is supplied from the National Offtake upstream of Torrumbarry Weir. Comprises a mixture of modified and unmodified Natural carriers (National Channel, Gunbower and Pyramid Creek), Water bodies (Kow Swamp, Reedy/Middle/Third Lakes, Lake Charm/Kangaroo/Racecourse/Boga) and Constructed irrigation channels, River Murray Pump Stations & Pipelines

Estimated area of Water Bodies & Biomass

Kow Swamp (2674hA)	1471ton +/-1203
Reedy Lake (194hA)	107ton +/-87
Middle Lake (185hA)	102ton +/-83
Third Lake (226 hA)	124ton +/-102
Little Lake Charm (68hA)	37ton +/-31
Lake Charm (517hA)	284ton +/-233
Racecourse Lake (219hA)	120ton +/-99
Kangaroo Lake (966hA)	531ton +/-435
Lake Boga (900hA)	495ton +/-405

Rivers

Murray (Swan Hill to Torrumbarry Weir) 832 ton+/- 680 ton
Loddon (Kerang to Murray) 29 ton+/- 24 ton
Little Murray River 26 ton+/- 21 ton

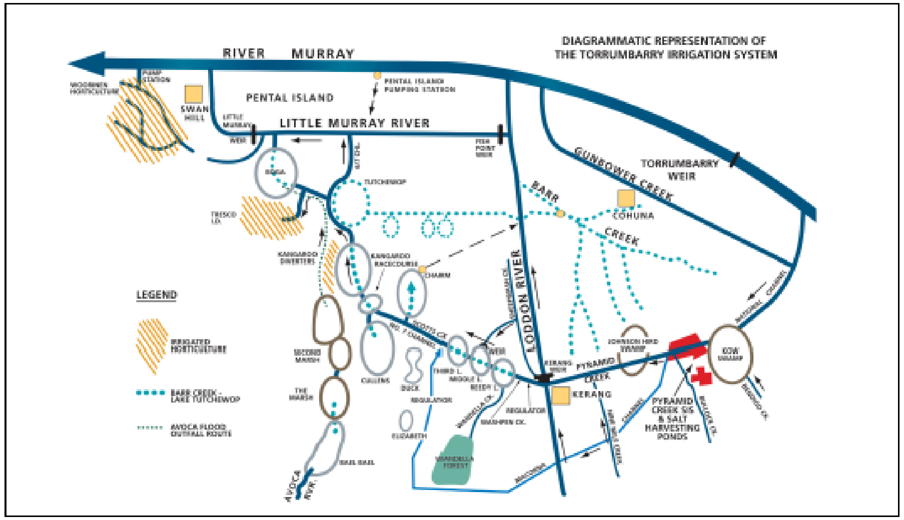
Main Channels

National Channel 11 ton+/- 4 ton
No. 2 Channel to Loddon River 5 ton+/- 2 ton
Pyramid Creek - Loddon River 7 ton+/- 2 ton
No. 1 Channel to Outfall 5 ton+/- 2 ton
No. 7 Channel to Boga 2 ton+/- 1 ton
6/7 Channel to Little Murray 1 ton+/- 0 ton
No. 9 Channel 2 ton+/- 1 ton
No. 10 Channel 1 ton+/- 0 ton

Note - The NCCP Biomass Investigations are ongoing. The Preliminary Biomass numbers presented in the case studies for the workshop are estimates developed by the project team based on published information and extrapolated to the case study sites for workshop evaluation purposes only. They are not to be taken as outputs from the NCCP project.

For Consideration:

Regional Population ~20,000
Ramsar Wetlands
Multiple threatened species



Legend

• Locality	Watercourse	Wetland Extent
■ Lock	River Murray	Native Vegetation
Main Highway	Lake	

THE WEDGE GROUP

Figure 3

TORRUMBARRY WEIR TO SWAN HILL

Outcomes and Discussion

The following common discussion themes or topics were developed from a 'mind map' analysis (Appendix 2):

1. **Clean-up Solutions –** Innovative clean-up solutions and techniques adapted from conventional fish harvesting methods and the solid and liquid waste management industry.
2. **Aggregation of Carp** – Referring to the natural or manipulated aggregation of carp (through flow, structures or stimulants) to maximise virus effectiveness and concentrate clean-up activities.
3. **River Operations** – Exploring the use of operational flow and control measures to aggregate carp, flush dead carp, isolate reaches or features and provide flows to address water quality issues.
4. **Isolation & Segregation** – Exploring operational tools to isolate sensitive sites and or segregate sites with higher biomasses.
5. **Surveillance & Monitoring** – Exploring both techniques and timing to monitor carp throughout the project lifecycle.
6. **Using the Environment to Advantage** – Capitalising on natural conditions including prevailing winds, river and stream geomorphology and the ephemeral nature of some tributaries to effect a better outcome for the project.

Attendees were also asked to provide comment and feedback on other matters they felt strongly about, with key issues highlighted below:

1. Resourcing and Management – Referring to the identification of a preferred delivery model that will provide both the resource certainty and delivery flexibility to meet the clean-up objectives.
2. Communication & Engagement – with a focus on local level 'two-way' engagement from the planning phase.
3. Roles and responsibilities – Ensuring that clear organisational arrangements are established and communicated during the planning phase and reinforced during the delivery phase. The Lake Boga (Northern Victoria) drying related fish kill was provided as an example of the issues that may be encountered if there is uncertainty around organisation responsibility.

Other queries raised that have potential to effect the project and in particular, the clean-up and delivery, included: how does the virus operate in the short, medium and long term; and how the natural behaviour of the carp could be leveraged to maximise infection and clean-up.

The following sections provide a summary of the key discussion points and outcomes from the case study site discussions under the identified themes.

Clean-up Solutions

A range of innovative clean-up solutions and technologies were identified as suitable for use at the case study locations These solutions and technologies ranged from the application of conventional commercial fishing techniques and manual 'boat and net' methods applied to previous fish kills, through to exploring new technologies adapted from of a range of existing solid and liquid waste management technologies. The range of options explored are summarised in the following sections.

Conventional commercial fishing techniques

It was discussed that in sites that provided for effective boat access and operation, it would be desirable to recover carp when on the surface prior to death or immediately after they float and prior to the advanced stages of decomposition. Given this, combined with the benefits of flow manipulation and aggregation, it was thought that conventional commercial seine netting may be applied where significant infected aggregations are easily identified in the water column or presenting at the surface.

Hand netting from boats is another suitable commercial fishing technique that was discussed. This method uses clean-up boats as platforms for fish collection for subsequent transfer to trucks. Floating carcasses would be collected using dip nets and disposed of in bulk storage bins located in the boat (see Photo 8). Based on previous clean-up efforts in the Nicholson River (Victoria) it was shown that the bins had the capacity of holding approximately 700 decaying fish, carrying a weight of about 650 kg in total. The boats had the capacity of transporting two bins. After filling up the bins, the boats were driven to the bank where a crane truck would transfer the bins from boat to truck for disposal.

Adapted waste management technologies

There were a number of workshop participants currently engaged in the management of both liquid and sold waste in aquatic environments. They identified that existing techniques and technologies could be readily applied to the carp clean-up challenge. For example liquid waste management equipment ('Vacuum Trucks') could be adapted, with extended suctions or barge mounting, so they could be deployed to manage late stage decomposition at sensitive areas such as town water supply offtakes.

Other ideas included using existing aquatic weed harvesters and floating waste collection vessels, adapted to collect and transport dead and decaying carp. This technique would require suitable bank and on-water access. It was acknowledged that the technology would need to be adapted to hold and convey fish across all stages of decomposition. A number of industry participants are already engaged in research and development in this area.

A more radical idea involved the concept of fitting high speed cutting blades to the intake section of aquatic weed harvesters. This would see them operate similar to a conventional 'wood chipper' that could both quickly dispatch infected carp on the surface as well as breaking down the dead and decaying carp so they could be efficiently pumped from the vessel to waiting trucks.

Containing and corralling ideas were also discussed including the use of a the range of commercial floating booms and silt curtains to contain the carp clean-up challenge to specific convenient areas. This equipment may be deployed as a means of both asset protection (excluding dead carp from water supply offtakes for example) and for aggregation and containment of floating dead fish to improve the efficiency of collection techniques. In addition it was thought that conventional 'oil soaker booms' could be deployed to manage residual water quality issues following high biomass site clean-ups.

New technologies

There were also many clean-up ideas sourced from the technology sector such as autonomous robotic waterway cleaning/monitoring devices (designed for trash). The solar powered units already in development use GPS, laser, and vision sensors to identify and collect floating debris and have capacity to live stream vision to the internet.

Robotic units being, developed by Orion Integration Pty Ltd, have the following features:

- Solar generator powered, so could be left in the field indefinitely
- Options of autonomous or remote operator driven
- Designed for swarm coordination, allowing a fleet to share data in real time to cover large areas
- Shallow draft to allow collection right up to the river bank
- Uses electric rudderless thrust vectoring for propulsion/steering so as to avoid getting caught in aquatic vegetation and the like.

Currently Orion are undertaking field trials with full scale units which are approximately 3m long with a payload of up to 1,000 kg. They are also exploring technology to automatically dock, tow, and transfer payload to floating barges. This could remove dead/dying carp from the water without returning to base.

Aggregation of Carp

It is understood that virus transmission depends significantly on fish-to-fish contact between carp. The method of initial manual infection was discussed but the rate of spread amongst the population needs to be determined and is expected to vary greatly across the various waterbodies.

If carp are infected, released and die before transmission of the virus occurs then the spread and kill rate may be adversely affected. Similarly, there is a need to determine whether carp that are infected in a natural or artificial (flow cued) aggregation are likely to cease aggregating and limit the ongoing transmission of the virus.

The way in which carp behave once initially infected wasn't clear and there was some uncertainty about rate and speed of infection, hence mortalities. This was raised in the context of dealing with uncertainty in the planning and delivery of clean-up operations.

Aggregation was raised by a number of participants as a means of harvesting carp via conventional fishing and recovery techniques prior to infection to reduce the biomass. This method may impact on virus efficacy, and so effectiveness of the virus

River Operations

River Operation experts from water and irrigation authorities provided many ideas about how to use river operations to complement carp control operations.

Complementary river operations were discussed including:

- aggregating fish through attraction flows,
- moving infected fish towards collection points using flow manipulation,
- releasing flushing flows to mitigate potential water quality problems and;
- using operational structures to exclude movement (segregation) to zones where clean-up programs were not scheduled or could be practicably delivered.

The preliminary biomass estimates for open channels did not seem to be concerning to river operators. However concerns were raised about pump stations sourcing water from rivers undergoing fish kills and how this might affect water quality in a 'pump to channel' or 'pump to farm' scenario. In particular many farms do not have potable water and even though the raw water is not fit for drinking it is evident that some properties use it for domestic consumption with limited/no treatment.

Screening of pump stations was raised as a potential important activity to mitigate impacts on water extraction. Many pump stations do not have screening that would prevent carp carcasses being drawn through the suction lines, being pulverised in the impellors and delivered into the discharge pipework. This was identified as a particular challenge for the horticultural sector with a high likelihood of system fouling.

Another idea was oil skimmers to minimise floating decayed material being drawn into pump stations.

Water operators expressed a clear desire for early planning and communication between all parties to ensure appropriate messages and mitigating strategies could be communicated to water users.

Isolation and Segregation

Isolating and segregating key waterbodies is an important operational tool to prevent carp movement or dispersal away from operational zones, or into sensitive zones. This strategy has been demonstrated to be effective at Moira Lake (with live harvesting occurring in 2001, 2004 and 2018), Gunbower lagoons and numerous South Australian Murray wetlands.

Segregation methods could be used again at high biomass areas like Moira Lake (or similar waterbodies). The method would involve first reducing the water level to cue natives to leave, then closing regulator (or installation of stop nets) to prevent carp leaving after infection. In such isolated areas this may be preferable to infecting and releasing the aggregation because clean-up may not be possible (for example access may not be possible to some sites). Any long term isolation and segregation of waterbodies is likely to be counterproductive to native fish populations.

Surveillance and Monitoring

Understanding when to commence clean-up, where best to focus effort and the effectiveness of the measures implemented will be important elements of any program.

Resources for clean-up activities will be finite. It will be crucial for a successful program to ensure that effort is deployed when appropriate and needed.

The potential to commence clean-up while carp are still alive as they are understood to move to the surface and gulp for air in the final stages of infection. This may result in significant saving, and reduction in risk to water quality, however it is not clear if removing moribund fish might impact on transmission efficiency.

It is also important to clarify when a release event would be considered practically complete allowing clean-up resources to be re-deployed.

The means of achieving surveillance over large areas was discussed with emphasis on remote monitoring using drones and community feedback via smart phone based applications. Developing these methods comes with significant lead time, development and operational cost that would need to be further considered.

Using the Environment to Advantage

A strong theme that arose during discussion was maximising use of the natural environment in the clean-up program. For example by using wind to direct fish kill events to suitable clean-up locations.

In large water bodies with large biomass estimates (Lake Albert, Alexandrina) this was viewed of as perhaps one of the only practical ways to manage the virus release in these areas.

Using drag nets to move fish to a manageable areas along the foreshore for recovery was also raised as a potential method (as considered in the previous Lachlan case study).

Resourcing and Management

The Workshop identified a need for appropriate resourcing and a suitable operational management structure to implement operations

There is likely to remain some uncertainty about effectiveness of the virus, and this is likely to change with circumstance. Clean-up resourcing and planning will therefore need to be scalable.

The adage “No plan survives first contact with the enemy” is almost certain to apply in the highly variable environments encountered across carp infested locations across Australia. Any proposed plan must adopt clear adaptive management principles informed by monitoring and be sufficiently flexible to change rapidly and respond to local conditions or emergent situations.

Communication & Engagement

Early engagement with affected communities was a high priority for attendees.

Workshop participants identified that established emergency response and communication protocols could be considered as a starting point for the development of the release and clean-up response communications strategy.

Preliminary NCCP operational directions highlight the value of the regions and local communities in undertaking clean-up planning and operations. The workshop identified that local a ‘district/system’ level engagement in the planning stage will greatly assist in:

a. understanding local nuances like site access, system behaviours and possible site prioritisation,
b. the assessment risks to water supplies and to irrigated agriculture along with the development of site specific mitigation strategies and;
c. the dissemination of advice and strategies to address carp mortalities in smaller scale private water bodies (such as farm dams and on-farm irrigation systems).

Roles and Responsibilities

If approved and implemented, the clean-up program is understood to be a multi-jurisdictional challenge covering a wide range of jurisdictional, legislative and operational boundaries. Navigating the Federal, State and local planning approvals processes is unlikely to be straightforward.

Any planning requirements associated with the clean-up should be completed well in advance of the time for release to ensure access, operations and disposal permissions are in place.

The expectation is that these organisational arrangements will be refined and agreed to well in advance of the decision to release and form an integral part of the wider communications and engagement strategy.

Conclusions and Recommendations

Conclusions

A range of conclusions relating to the delivery of effective high-biomass site clean up and the broader NCCP were identified through the workshop process and subsequent reporting. These are summarised as key issues and ideas warranting further investigation and are presented in the following lists, aligned to project implementation phases, and should be considered further by the NCCP in the development of the operational strategy.

Planning and Pre-Release Phase:

- Understand clearly the built and natural environments that will be impacted and developing site or system specific plans and strategies.
- Explore tactics to clean-up carp while they are still alive (post infection) might be more efficient
- Explore pre- screening of major offtakes and pumping stations (including the development of guidelines and advice for the vast number of direct diverters.
- Develop a communications and engagement strategy that engages extensively with local communities during the planning stage.
- Operational equipment will need to be prepositioned at designated locations likely to need clean-up operations. Resources will need to be on short response standby.
- Pre virus carp control (for example netting or electro-fishing) at sensitive locations to reduce biomass where access and or clean-up effectiveness may be an issue.
- Ongoing stakeholder engagement and communications needs to occur continuously aligned to operational delivery.
- Operational fatigue is possible given the long-term nature of bio-control, this needs to be carefully considered in the overall resource planning.

Operations Phase:

- Use of water regulation is critical to enhance virus distribution and clean-up efficiencies.
- Waterways could be sectioned by booms to allow focussed operations and concentration of carp.
- Explore carp ‘wrangling’ with attractants to contain then clean-up carp at operational ready locations (e.g. no obstructions, good access).
- Booming of water body edges, where appropriate, could assist in management of dead carp.
- Clean-up and ‘processing’ (which could be in the form of adapted ‘wood chipper’ technology) to concentrate biomass for disposal. The ‘wood chipper’ approach may provide for the humane treatment of infected fish.
- Carp degrade rapidly creating an organics slime that will also impact water quality, the use of adapted liquid waste management technology (for example conventional sucker trucks) should be explored further.
- Complementary river operations need to be further explored, for example: aggregating fish through attraction flows; moving infected fish towards collection points using flow manipulation; releasing flushing flows to mitigate potential water quality problems; using operational structures and to exclude movement (segregation) to zones where clean-up programs were not scheduled or could be practicably delivered.

Post Operations Phase:

- Once carp are removed explore opportunities to screen offtakes and wetlands to avoid carp re-infestation.
- Engage with environmental water holders in the development of post carp removal watering strategies to optimise water quality and environmental enhancement opportunities.

- Planning should include an understanding, and clear definition, of when clean-up operations. would/could cease and include this in the communications strategies.
- Ensure adequate ongoing monitoring and evaluation.

Recommendations

The following recommendations, gleaned from the workshop, should be further considered by the NCCP team so as to inform the development of the operational strategy.

9. The presence of carp aggregations are likely to be key factors influencing selection of timing and locations for possible virus deployment. The ability to predict aggregations sites, and or influence aggregations (timing and location) through the use of flow manipulation, should be fully explored so as to be able to better plan for and execute the clean-up of high biomass sites.

10. If carp are infected, released and die before transmission of the virus occurs then the spread and kill rate may be adversely affected. There is a need to determine whether carp that are infected in a natural or artificial (flow cued) aggregation are likely to cease aggregating and limit the ongoing transmission of the virus.

11. In exploring the timing and application of various clean-up techniques and technologies a number of assumptions were made regarding the percentage mortality. The assumptions were 75% of population killed, 10% consumed by predators, 10-15% not able to be cleaned up and leaving 50% of total biomass requiring clean-up operations. The project needs to confirm, as far as is practically possible, the likely mortality levels across representative sites so as to inform planning and resourcing strategies prior to implementation.

12. The way in which carp behave once initially infected isn’t clear and there exists some uncertainty about the rate and speed of infection, hence mortalities. This was raised in the context of dealing with uncertainty in the planning and delivery of clean-up operations. Consideration should be given to investigations aimed at better understanding how carp might behave once infected and the implications of that behaviour on both transmission, mortalities and clean-up requirements.

13. Encouraging aggregation was raised during the workshop as a means of efficiently harvesting carp via conventional commercial fishing and recovery techniques prior to infection so as to reduce the biomass required to be cleaned up post release. This proposition is likely to be continually raised throughout the consultation and approvals phase. Whilst it can be assumed this method will impact on virus efficacy, and so effectiveness of the virus it should be further investigated and where possible quantified to as to arrive at a preferred position on the method for both consultation and operational planning.

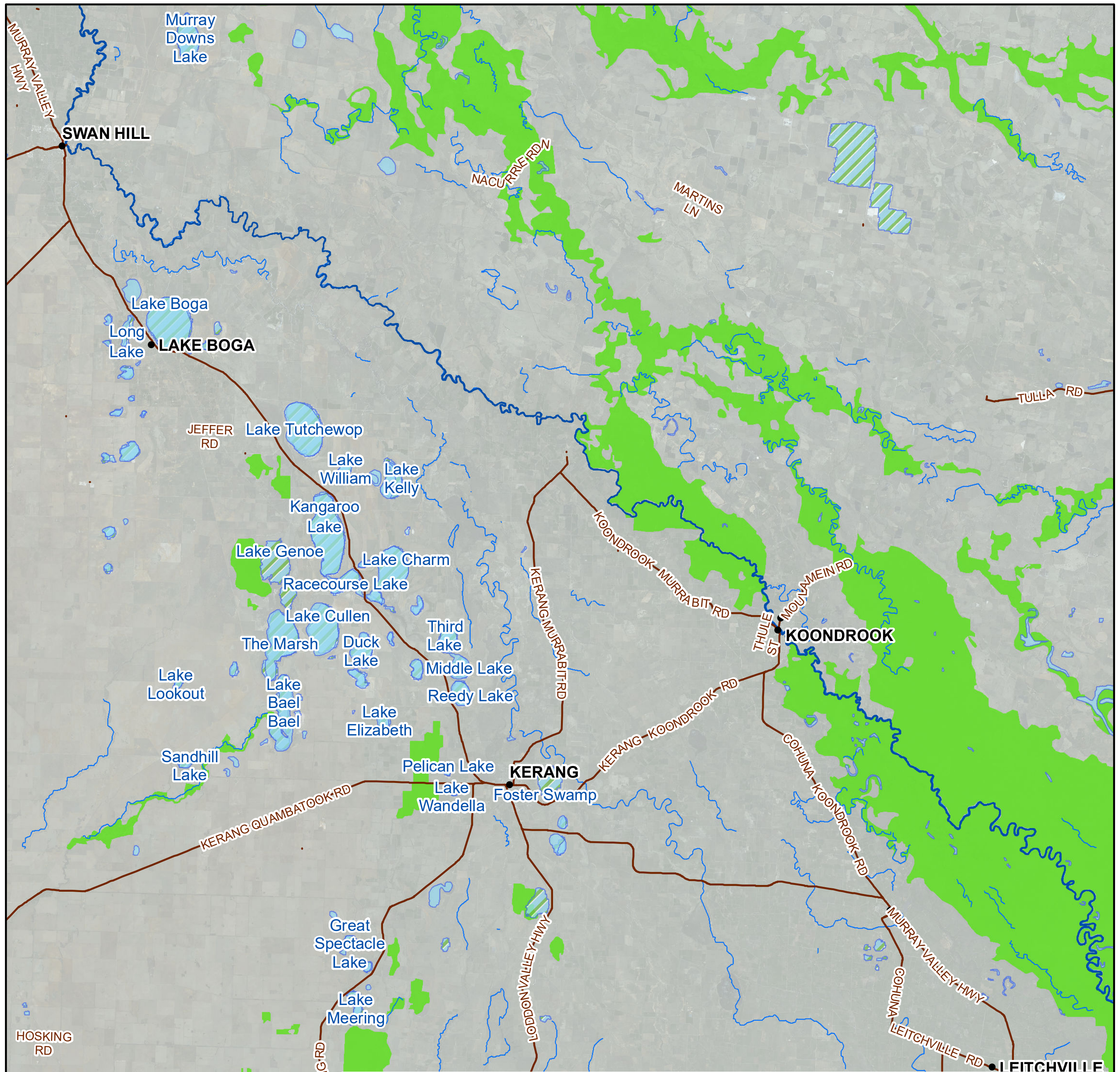
14. There is potential to commence clean-up while carp are still alive as they are understood to move to the surface and gulp for air in the final stages of infection. This may result in significant cost savings and reduction in risks to water quality, however, it is not known if removing moribund fish might impact on transmission efficiency. This should be further explored by the NCCP in completing the epidemiological investigations.

15. Queries raised that have potential to effect the project planning and in particular the clean-up, included: how does the virus operate in the short, medium and long term; and how the natural behaviour of the carp could be leveraged to maximise infection and clean-up. Both questions should be fully addressed in developing the operational strategy.

16. In developing the operational plan it is important from both a consultation and delivery perspective to clearly define and communicate the operating conditions to would determine when a release event could be considered practically complete allowing clean-up resources to be re-deployed and post clean-up monitoring and treatments to commence.

Appendix 1

Case Study Site Sheets



Epidemiology

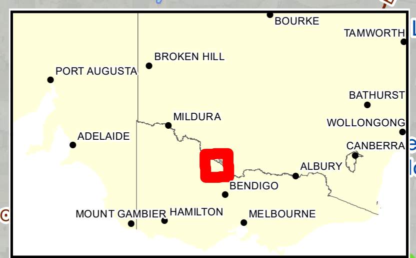
Assumptions - permissive temperature, numerous large spring time aggregations.

Percentage mortality - Assume 75% of population killed, 10% consumed by predators, 10% not able to be cleaned up = 55% (requiring clean up operations) *Biomass Estimate .

Time duration of mortality = 6 week period

Average tonnes per day to be clean up = 55% of Biomass Estimate/42days

Peak biomass removal required around 2 weeks after virus release maybe up to 2.5 * Average Cleanup per day.



Facts and Figures:

Torrumbarry Irrigation area is supplied from the National Offtake upstream of Torrumbarry Weir. Comprises a mixture of modified and unmodified Natural carriers (National Channel, Gunbower and Pyramid Creek), Water bodies (Kow Swamp, Reedy/Middle/Third Lakes, Lake Charm/Kangaroo/Racecourse/Boga) and Constructed irrigation channels, River Murray Pump Stations & Pipelines

Estimated area of Water Bodies & Biomass

Kow Swamp (2674hA)	1471ton +/-1203
Reedy Lake (194hA)	107ton +/-87
Middle Lake (185hA)	102ton +/-83
Third Lake (226 hA)	124ton +/-102
Little Lake Charm (68hA)	37ton +/-31
Lake Charm (517hA)	284ton +/-233
Racecourse Lake (219hA)	120ton +/-99
Kangaroo Lake (966hA)	531ton +/-435
Lake Boga (900hA)	495ton +/-405

Rivers

Murray (Swan Hill to Torrumbarry Weir) 832 ton+/- 680 ton
Loddon (Kerang to Murray) 29 ton+/- 24 ton
Little Murray River 26 ton+/- 21 ton

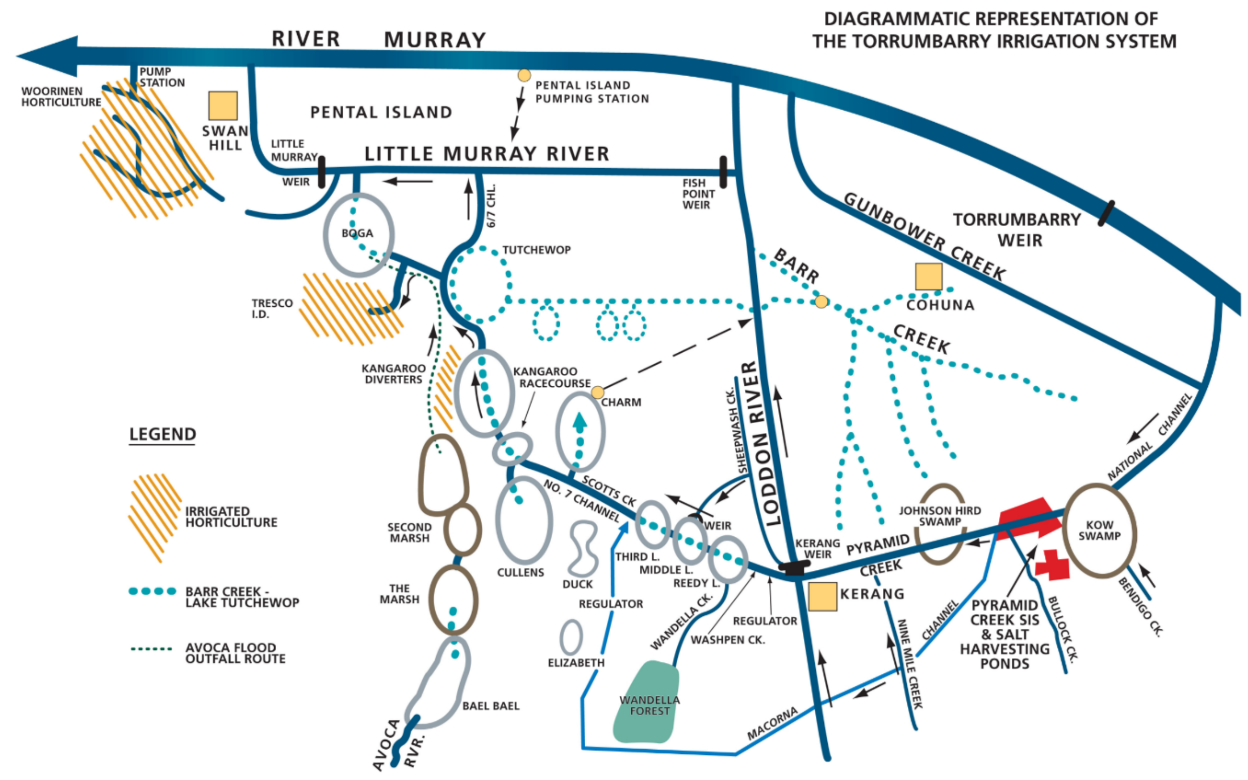
Main Channels

National Channel 11 ton+/- 4 ton
No. 2 Channel to Loddon River 5 ton+/- 2 ton
Pyramid Creek - Loddon River 7 ton+/- 2 ton
No. 1 Channel to Outfall 5 ton+/- 2 ton
No. 7 Channel to Boga 2 ton+/- 1 ton
6/7 Channel to Little Murray 1 ton+/- 0 ton
No. 9 Channnel 2 ton+/- 1 ton
No. 10 Channel 1 ton+/- 0 ton

Note - The NCCP Biomass Investigations are ongoing. The Preliminary Biomass numbers presented in the case studies for the workshop are estimates developed by the project team based on published information and extrapolated to the case study sites for workshop evaluation purposes only. They are not to be taken as outputs from the NCCP project.

For Consideration:

Regional Population ~20,000
Ramsar Wetlands
Multiple threatened species



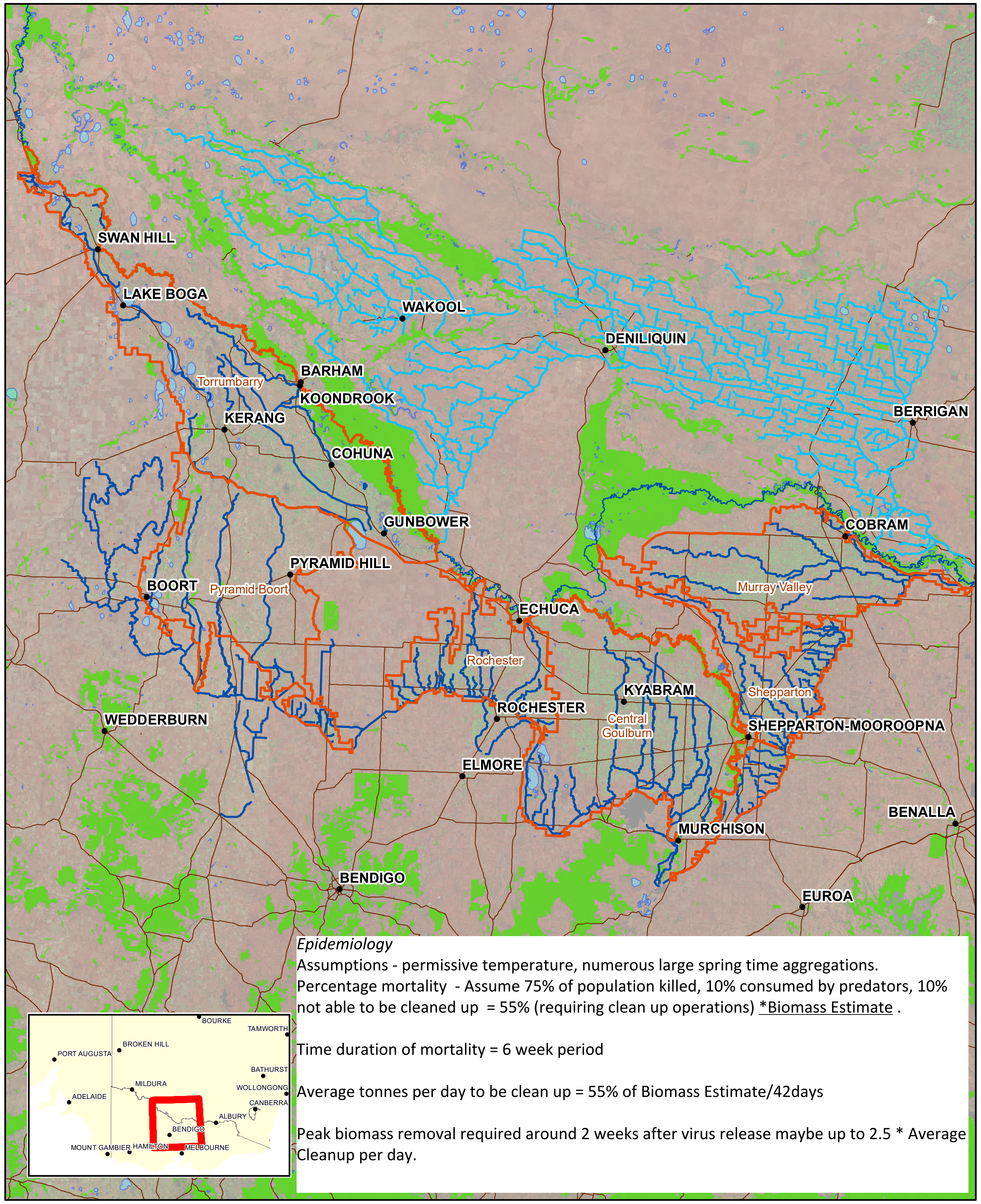
THE WEDGE GROUP

Legend

Locality	Watercourse	Wetland Extent
Lock	River Murray	Native Vegetation
Main Highway	Lake	

Figure 3

TORRUMBARRY WEIR TO SWAN HILL



Epidemiology

Assumptions - permissive temperature, numerous large spring time aggregations.
Percentage mortality - Assume 75% of population killed, 10% consumed by predators, 10% not able to be cleaned up = 55% (requiring clean up operations) *Biomass Estimate .

Time duration of mortality = 6 week period

Average tonnes per day to be clean up = 55% of Biomass Estimate/42days

Peak biomass removal required around 2 weeks after virus release maybe up to 2.5 * Average Cleanup per day.

Facts and Figures:

Murray Irrigation Limited (NSW)
- 2777km of gravity irrigation supply channels
-2153 Landholdings Supplied
- Area of operation covers some ~750,000hA
-1314 S&D supplies
-862 Regulators
- Mulwala canal has a capacity similar to River Murray at Barmah Choke
- Preliminary Biomass Estimate (supply channels only) 208ton +/- 69.

Goulburn Murray Irrigation District (Vic)
- 6300km of gravity irrigation channels (pre modernisation)
- 23,000 customer outlets
- 800km of natural water ways
- Area of operation covers some ~990,000hA
- Preliminary Biomass Estimate 473ton +/- 158.

For Consideration:

Very large area with substantial lengths of excavated channels and use of natural water bodies and carriers as supply and storage sources.

Note - The NCCP Biomass Investigations are ongoing. The Preliminary Biomass numbers presented in the case studies for the workshop are estimates developed by the project team based on published information and extrapolated to the case study sites for workshop evaluation purposes only. They are not to be taken as outputs from the NCCP project.

Notes:

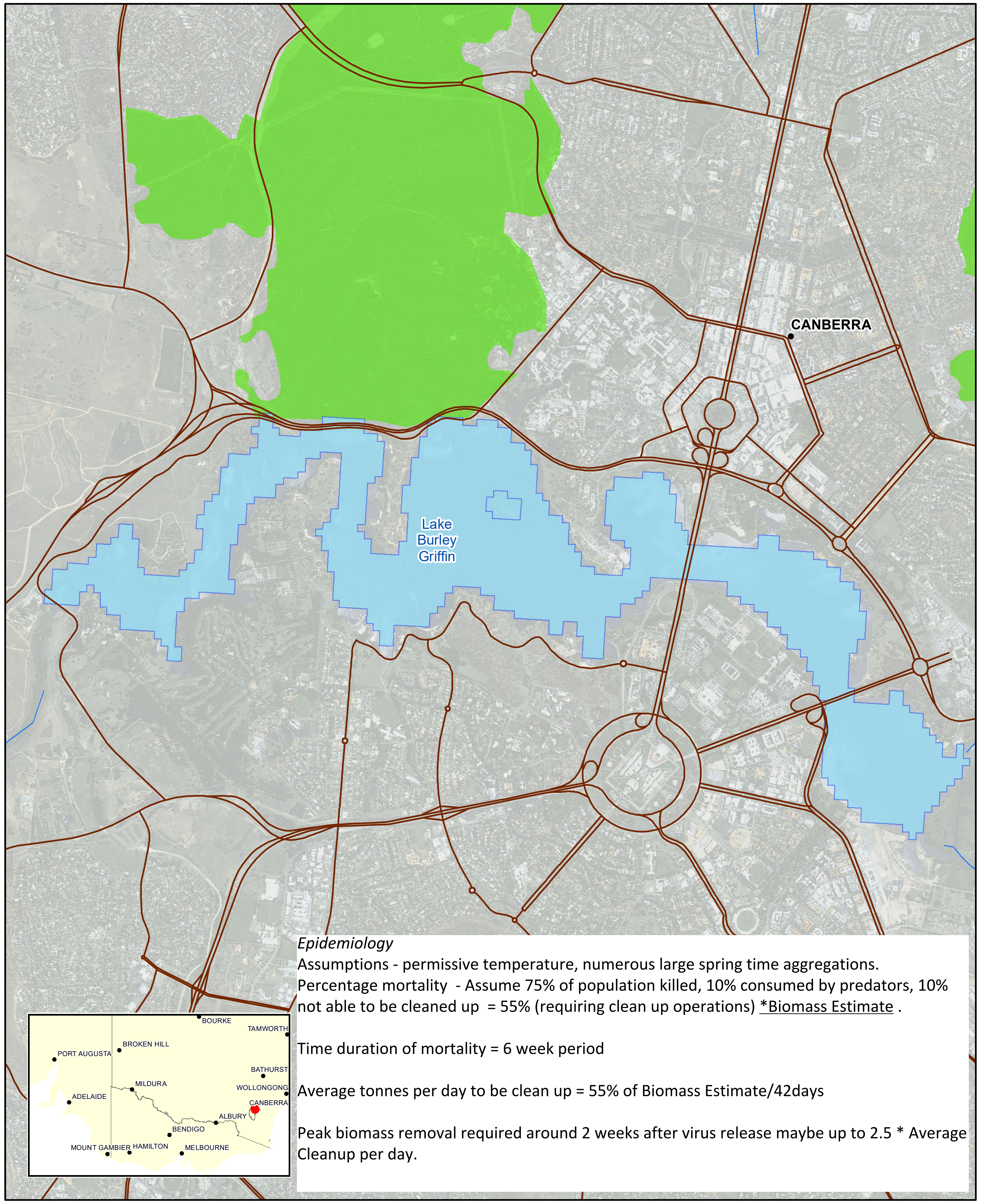
THE WEDGE GROUP

Legend

Locality	Major Channel (G-MW)	Lake
Lock	Irrigation Channel (MIL)	Native Vegetation
Main Highway	River Murray	G-MW Irrigation District

NCCP PROJECT

Goulburn Murray Irrigation District & Murray Irrigation Limited



Epidemiology

Assumptions - permissive temperature, numerous large spring time aggregations.

Percentage mortality - Assume 75% of population killed, 10% consumed by predators, 10% not able to be cleaned up = 55% (requiring clean up operations) *Biomass Estimate .

Time duration of mortality = 6 week period

Average tonnes per day to be clean up = 55% of Biomass Estimate/42days

Peak biomass removal required around 2 weeks after virus release maybe up to 2.5 * Average Cleanup per day.

Facts and Figures:

Lake Burley Griffen

- Created by Scrivener Dam.
- 667hA Surface area when full.
- Supplied water by the Molonglo River from Molonglo Dam
- Highly popular venue for water sports.
- Regulated by Sunwater.
- Preliminary Biomass Estimate 365ton +/- 299.

For Consideration:

Capital city of Australia - Population 400,000
Lake Burley Griffen extends through Urban and Business areas
Appears to be limited access for boats

Note - The NCCP Biomass Investigations are ongoing. The Preliminary Biomass numbers presented in the case studies for the workshop are estimates developed by the project team based on published information and extrapolated to the case study sites for workshop evaluation purposes only. They are not to be taken as outputs from the NCCP project.

Notes:

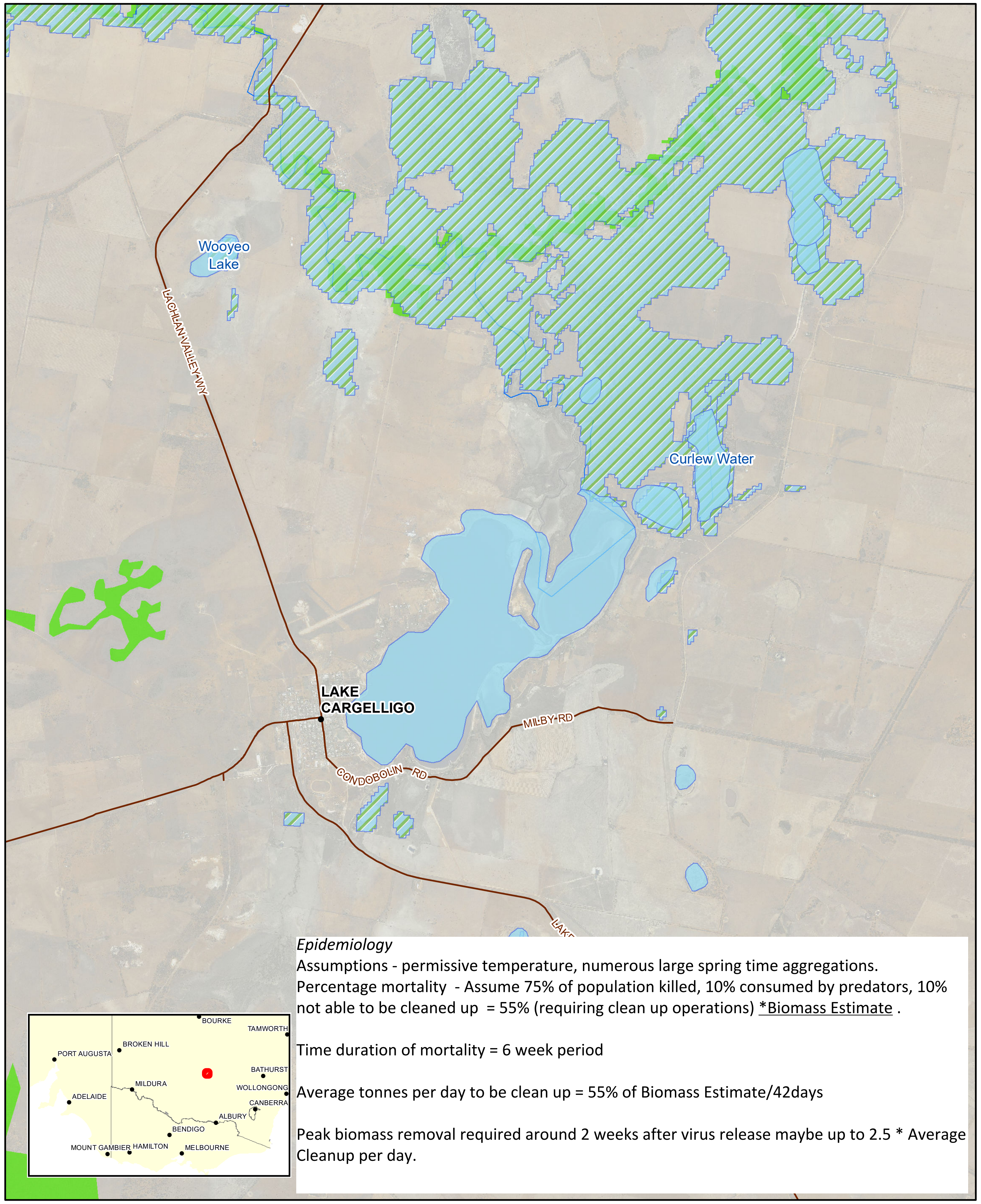
THE WEDGE GROUP

Legend

- Locality
- Lock
- Main Highway
- Watercourse
- River Murray
- Lake
- Wetland Extent
- Native Vegetation

NCCP PROJECT

LAKE BURLEY GRIFFEN



Epidemiology

Assumptions - permissive temperature, numerous large spring time aggregations.

Percentage mortality - Assume 75% of population killed, 10% consumed by predators, 10% not able to be cleaned up = 55% (requiring clean up operations) *Biomass Estimate .

Time duration of mortality = 6 week period

Average tonnes per day to be clean up = 55% of Biomass Estimate/42days

Peak biomass removal required around 2 weeks after virus release maybe up to 2.5 * Average Cleanup per day.

Facts and Figures:

Lake Cargelligo

- Offstream lake filled from the Lachlan River
- Created by a series of levees and embankments
- 1440hA Surface area when full.
- 36,000 ML Capacity
- 3.7m Average Depth.
- Population ~1500
- Highly popular venue for tourism
- Preliminary Biomass Estimate 432ton +/- 72.

For Consideration:

Small rural town

Nearest rural center is Griffith (100km South)

Note - The NCCP Biomass Investigations are ongoing. The Preliminary Biomass numbers presented in the case studies for the workshop are estimates developed by the project team based on published information and extrapolated to the case study sites for workshop evaluation purposes only. They are not to be taken as outputs from the NCCP project.

Notes:

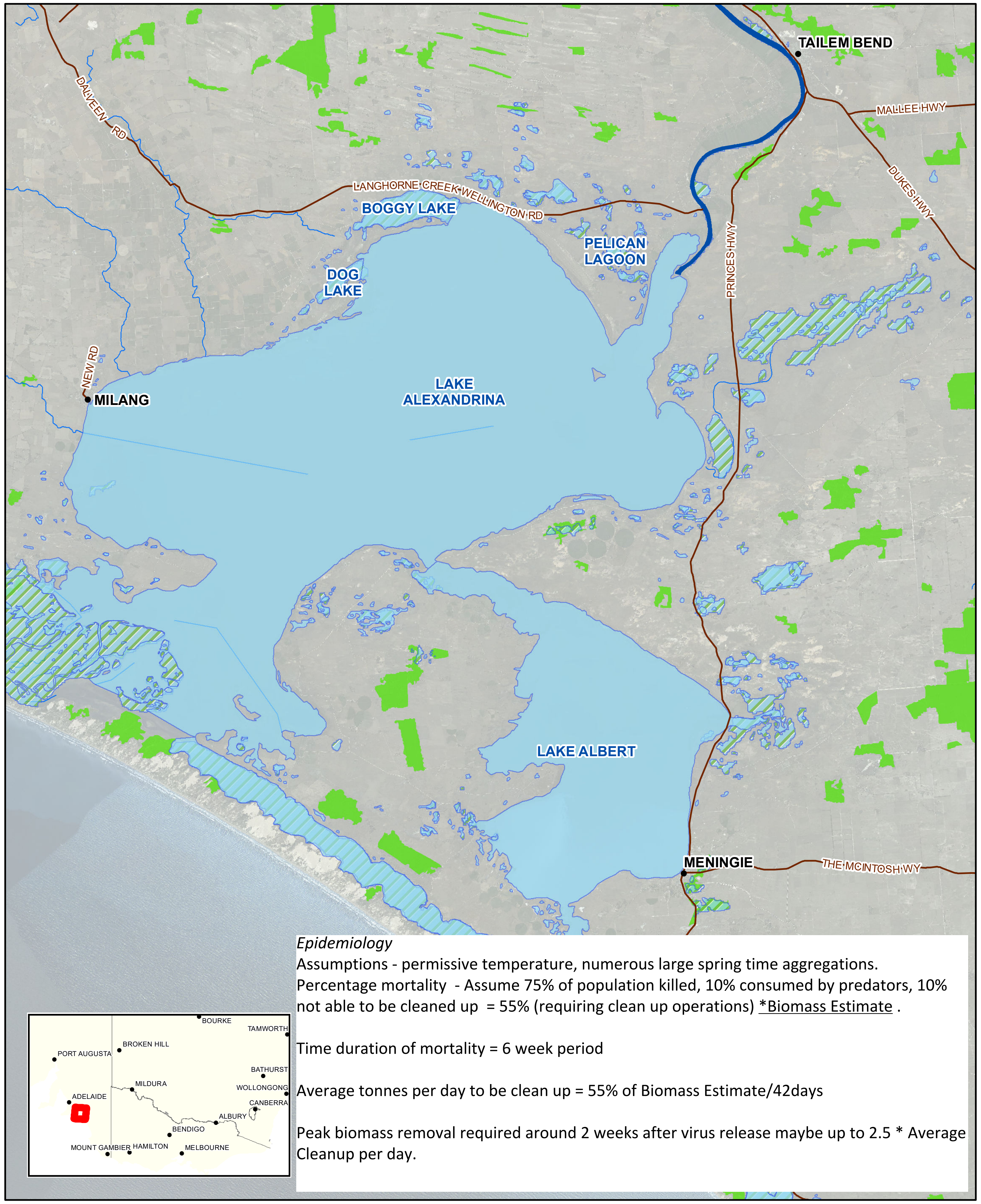
THE WEDGE GROUP

Legend

Locality	Watercourse	Wetland Extent
Lock	River Murray	Native Vegetation
Main Highway	Lake	

NCCP PROJECT

LAKE CARGELLIGO



Epidemiology

Assumptions - permissive temperature, numerous large spring time aggregations.

Percentage mortality - Assume 75% of population killed, 10% consumed by predators, 10% not able to be cleaned up = 55% (requiring clean up operations) <u>*Biomass Estimate</u> .

Time duration of mortality = 6 week period

Average tonnes per day to be clean up = 55% of Biomass Estimate/42days

Peak biomass removal required around 2 weeks after virus release maybe up to 2.5 * Average Cleanup per day.

Facts and Figures:

Lake Alexandrina

- 64,500hA Surface area when full.
- 1630 GL Volume.
- Supplied by River Murray.
- Preliminary Biomass Estimate 7866ton +/- 2631.

Lake Albert

- 16,500hA, 282GL Volume.
- Preliminary Biomass Estimate 2012ton +/- 604

Note - The NCCP Biomass Investigations are ongoing. The Preliminary Biomass numbers presented in the case studies for the workshop are estimates developed by the project team based on published information and extrapolated to the case study sites for workshop evaluation purposes only. They are not to be taken as outputs from the NCCP project.

For Consideration:

Townships of Meningie (Pop 5264), Milang (Pop 512) and Clayton Bay (Pop 240) are near the Lakes.
Adelaide (Pop 1.3M) is approximately 100km NW of the Lakes.
Remote area.
Significant surface area to be managed.

Notes:

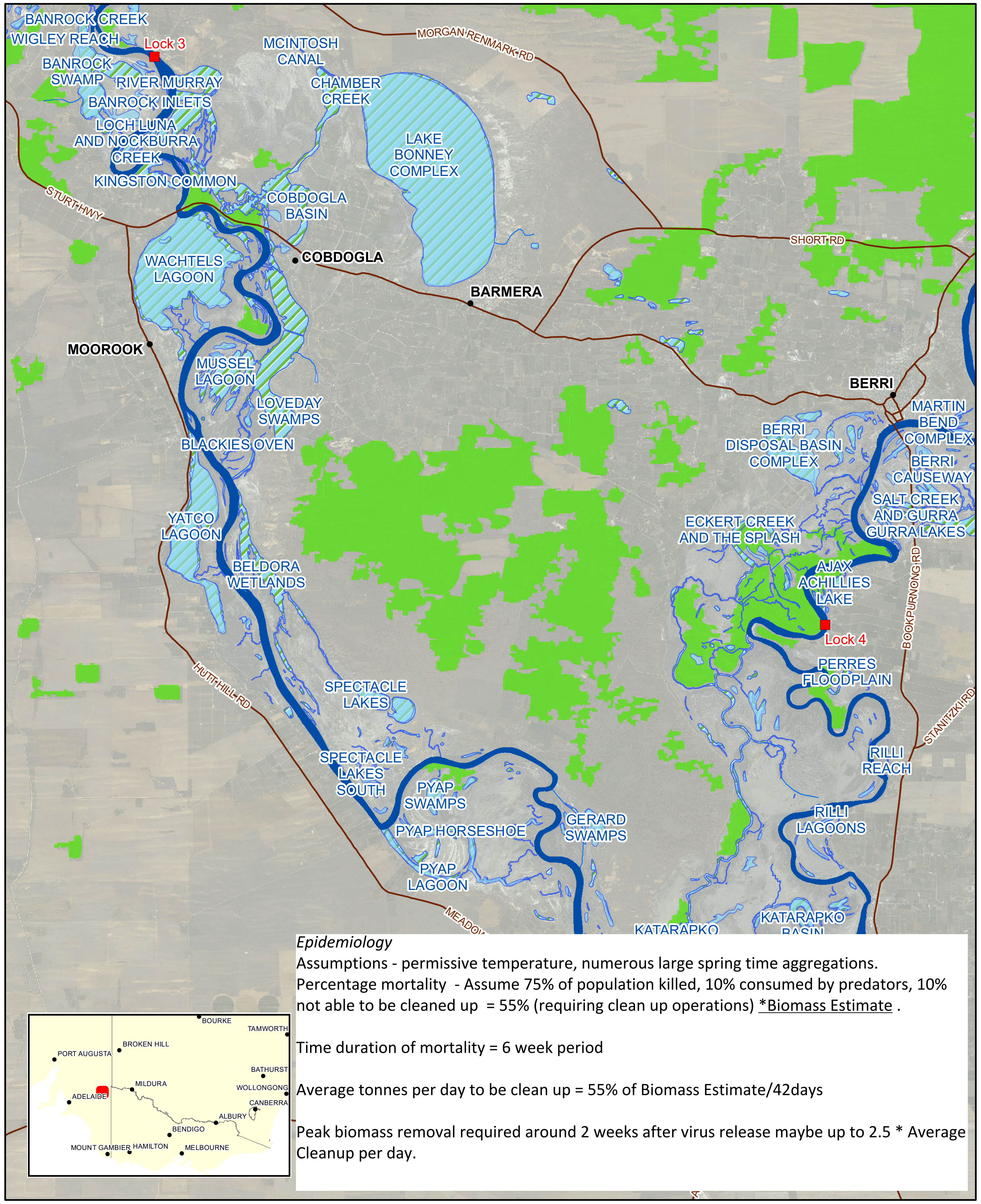
THE WEDGE GROUP

Legend

Locality	Watercourse	Wetland Extent
Lock	River Murray	Native Vegetation
Main Highway	Lake	

NCCP PROJECT

LAKE ALEXANDRINA & LAKE ALBERT



Epidemiology

Assumptions - permissive temperature, numerous large spring time aggregations.

Percentage mortality - Assume 75% of population killed, 10% consumed by predators, 10% not able to be cleaned up = 55% (requiring clean up operations) *Biomass Estimate .

Time duration of mortality = 6 week period

Average tonnes per day to be clean up = 55% of Biomass Estimate/42days

Peak biomass removal required around 2 weeks after virus release maybe up to 2.5 * Average Cleanup per day.

Facts and Figures:

Lake Bonney

- 1625hA at Lock 3 Pool Level
- Regulator installed in 2007 (to reduce evap losses) removed in 2010
- Close proximity to Barmera (~2000 people)
- High recreational use
- Preliminary Biomass Estimates 284ton +/-203

Yatco Lagoon

-Immediately upstream of Moorook

-Two lagoons (shallow depressions) totaling 346hA

- Maximum depth 2.5m, majority 0.5-1.5m
- Regulated (culverts) connectivity to Murray
- Preliminary Biomass Estimate 61ton +/- 43

Note - The NCCP Biomass Investigations are ongoing. The Preliminary Biomass numbers presented in the case studies for the workshop are estimates developed by the project team based on published information and extrapolated to the case study sites for workshop evaluation purposes only. They are not to be taken as outputs from the NCCP project.

For Consideration:

Ability to enhance aggregation through Weir Pool manipulation and individual wetland regulation (where available)

Numerous threatened species (Small Bodied Natives)

Mussel Lagoon dried out in 1994/95 with an estimated 70ton of Carp

Notes:

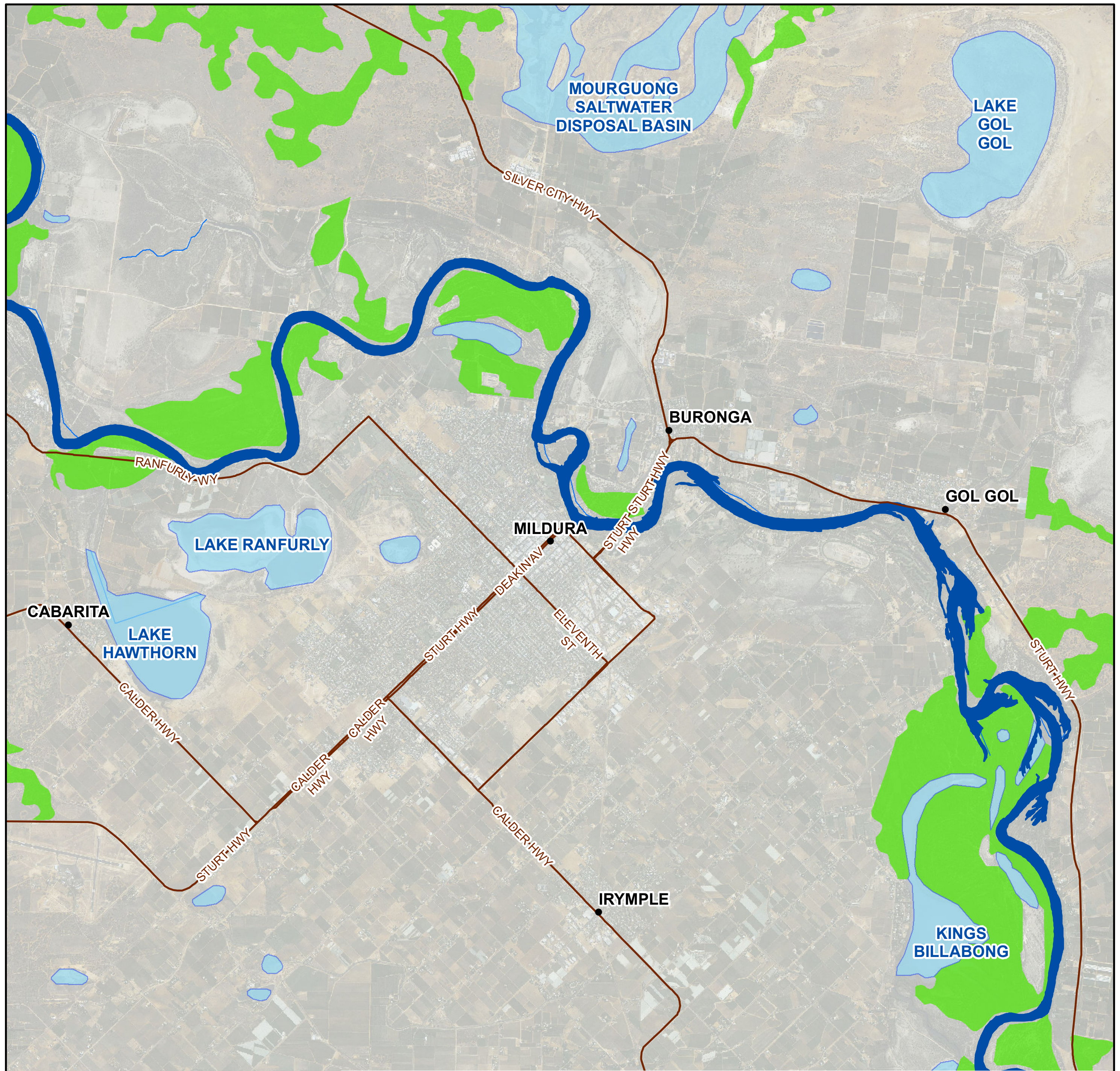
THE WEDGE GROUP

Legend

Locality	Watercourse	Wetland Extent
Lock	River Murray	Native Vegetation
Main Highway	Lake	

NCCP PROJECT

LOCK 4 TO LOCK 3 WETLANDS - YATCO LAGOON & LAKE BONNEY

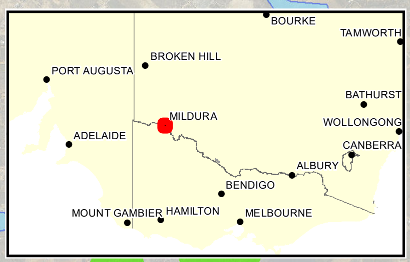


Epidemiology
Assumptions - permissive temperature, numerous large spring time aggregations.
Percentage mortality - Assume 75% of population killed, 10% consumed by predators, 10% not able to be cleaned up = 55% (requiring clean up operations) *Biomass Estimate .

Time duration of mortality = 6 week period

Average tonnes per day to be clean up = 55% of Biomass Estimate/42days

Peak biomass removal required around 2 weeks after virus release maybe up to 2.5 * Average Cleanup per day.



Facts and Figures:

Kings Billabong
- 157hA Surface area when full
- Supplied water by Psyche Bend Pump Station
- Used by Lower Murray Water as a storage for irrigation pumping.
- Regulated by LMW and normally disconnected from the Murray
- Preliminary Biomass Estimate 86ton +/- 71.

Lock 11 (Mildura Weir)
- 3480hA, 36600ML Impounded, 232km Pool.
- Creates a pool of water for recreational, irrigation and urban use.
- A Denil fishway was constructed in 2010
- Regulated by G-MW on behalf of the MDBA
- Preliminary Biomass Estimate 609ton +/- 435.

Lake Hawthorn
- Reportedly the original source of Carp in the Murray Darling Basin.
- Introduced in the mid 1850's.
- Unintentionally released into Lake Hawthorn in the 1960's and spread from there.
- Now a highly saline and typically dry lake.

Note - The NCCP Biomass Investigations are ongoing. The Preliminary Biomass numbers presented in the case studies for the workshop are estimates developed by the project team based on published information and extrapolated to the case study sites for workshop evaluation purposes only. They are not to be taken as outputs from the NCCP project.

For Consideration:

Threatened Species
Access for boats
Land Tenure
Proximity of public
Urban and Irrigation Supply Impacts
Disposal Site Location and Distance

Notes:

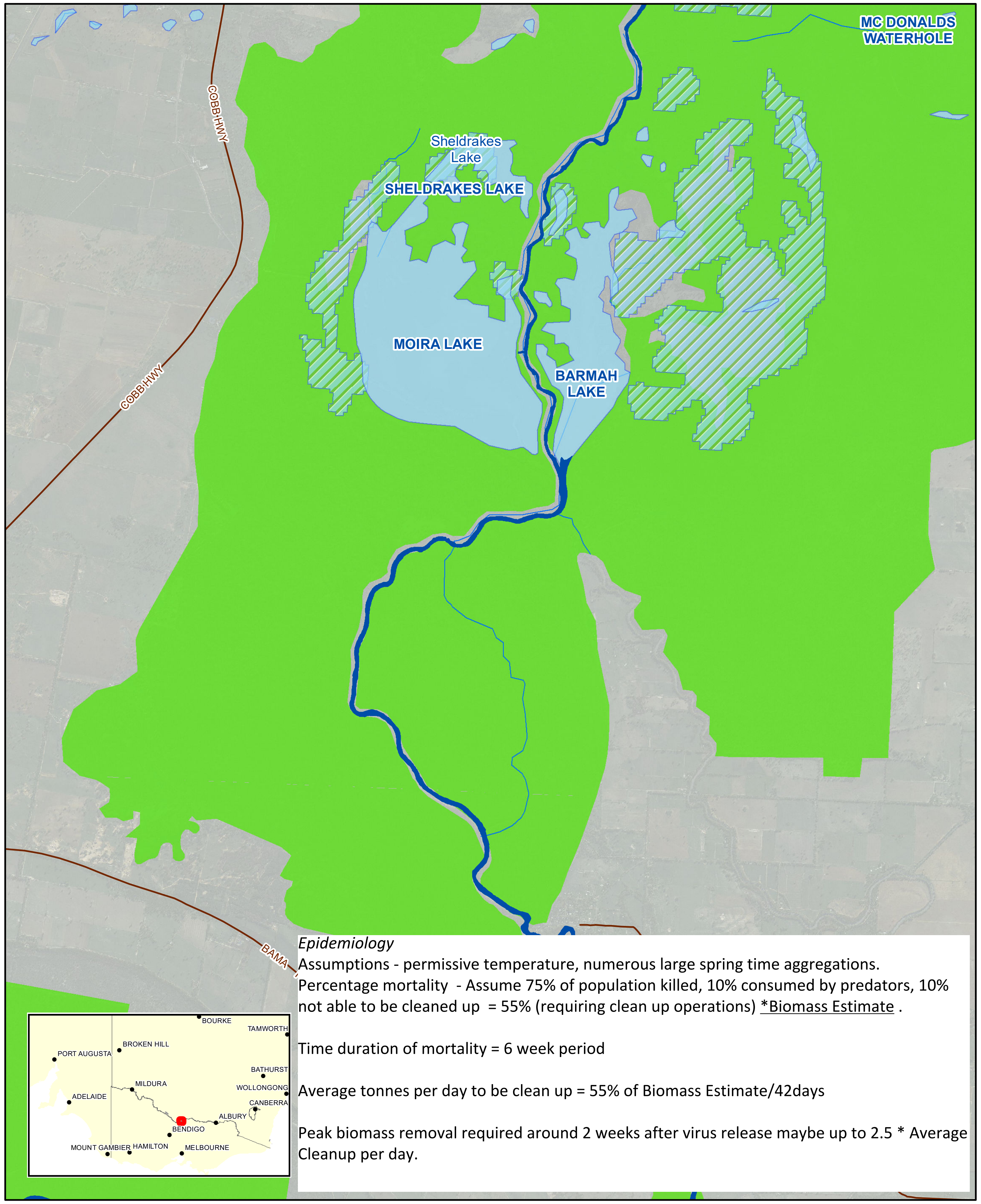
THE WEDGE GROUP

Legend

• Locality	Watercourse
Lock	River Murray
Main Highway	Lake
Wetland Extent	Native Vegetation

NCCP PROJECT

KINGS BILLABONG, LAKE HAWTHORN AND LOCK/WEIR 11



Epidemiology

Assumptions - permissive temperature, numerous large spring time aggregations.

Percentage mortality - Assume 75% of population killed, 10% consumed by predators, 10% not able to be cleaned up = 55% (requiring clean up operations) *Biomass Estimate .

Time duration of mortality = 6 week period

Average tonnes per day to be clean up = 55% of Biomass Estimate/42days

Peak biomass removal required around 2 weeks after virus release maybe up to 2.5 * Average Cleanup per day.

Facts and Figures:

Moira Lake

- Filled from the Murray River
- 1500hA Surface area when full.
- Highly popular venue for tourism.
- Preliminary Biomass Estimate 330ton +/- 45.
- History of Carp harvesting (2001 - 80ton, 2004 - 40ton)

For Consideration:

Small rural town, Barmah, population 1500.
Nearby Echuca, population 13,000

Note - The NCCP Biomass Investigations are ongoing. The Preliminary Biomass numbers presented in the case studies for the workshop are estimates developed by the project team based on published information and extrapolated to the case study sites for workshop evaluation purposes only. They are not to be taken as outputs from the NCCP project.

Notes:

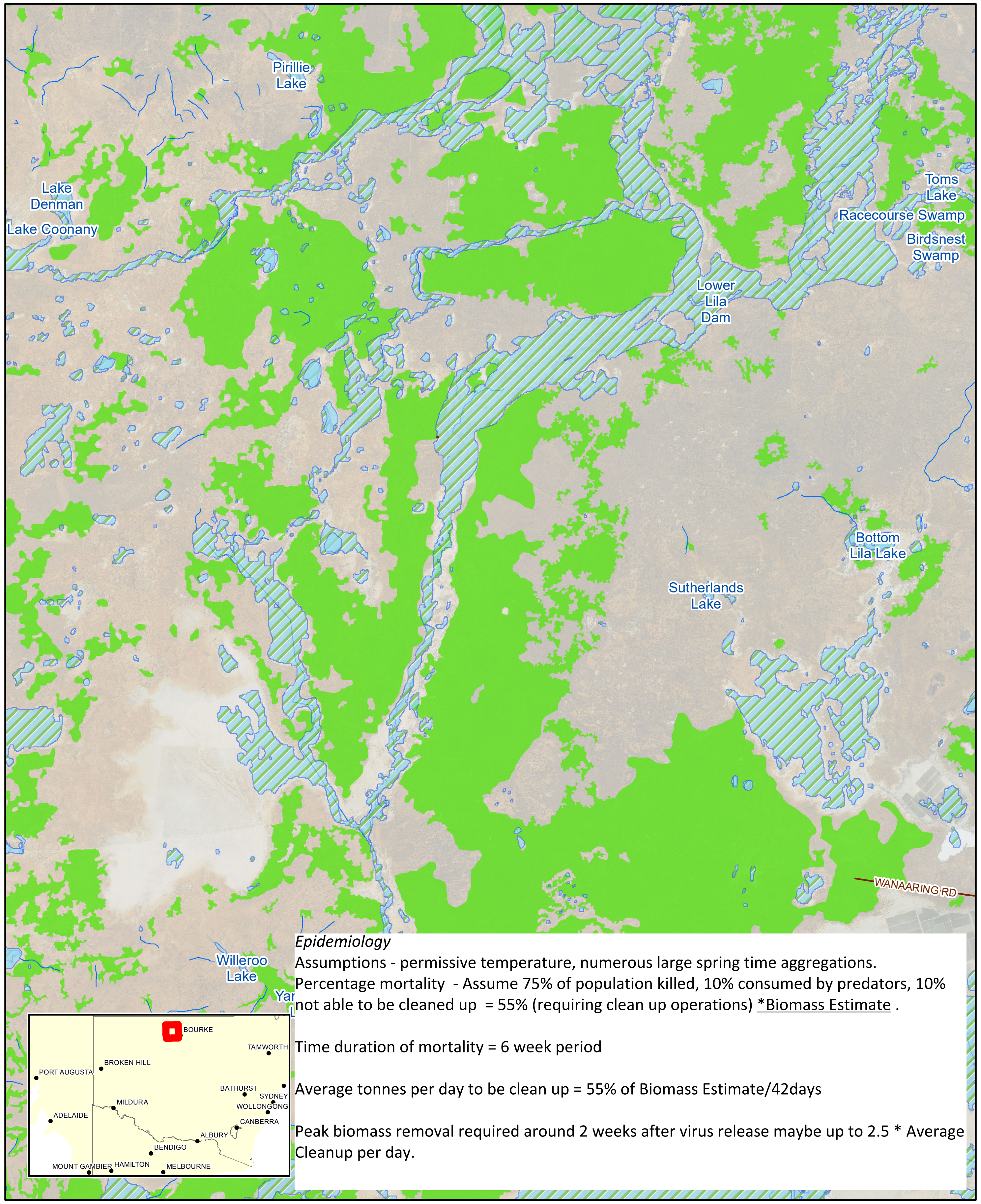
THE WEDGE GROUP

Legend

Locality	Watercourse	Wetland Extent
Lock	River Murray	Native Vegetation
Main Highway	Lake	

NCCP PROJECT

MOIRA LAKE



Epidemiology

Assumptions - permissive temperature, numerous large spring time aggregations.

Percentage mortality - Assume 75% of population killed, 10% consumed by predators, 10% not able to be cleaned up = 55% (requiring clean up operations) *Biomass Estimate .

Time duration of mortality = 6 week period

Average tonnes per day to be clean up = 55% of Biomass Estimate/42days

Peak biomass removal required around 2 weeks after virus release maybe up to 2.5 * Average Cleanup per day.

Facts and Figures:

- Ephemeral river with pools and the northernmost tributary of the Darling River
- 1,380km in length
- Seven Dams/Waterholes
- Annual stream flow 422GL
- Four Towns (Augathella, Charleville, Wyandra and Cunnamulla) ~5000 people in total
- One of the only places in the MDB where Silver Perch breed naturally
- Preliminary Biomass Estimates in the order of 200kg/hA

Note - The NCCP Biomass Investigations are ongoing. The Preliminary Biomass numbers presented in the case studies for the workshop are estimates developed by the project team based on published information and extrapolated to the case study sites for workshop evaluation purposes only. They are not to be taken as outputs from the NCCP project.

For Consideration:

- Limited road access relative to river length
- Relatively high biomass (200kg/hA), based on ephemeral pools

Notes:

THE WEDGE GROUP

Legend

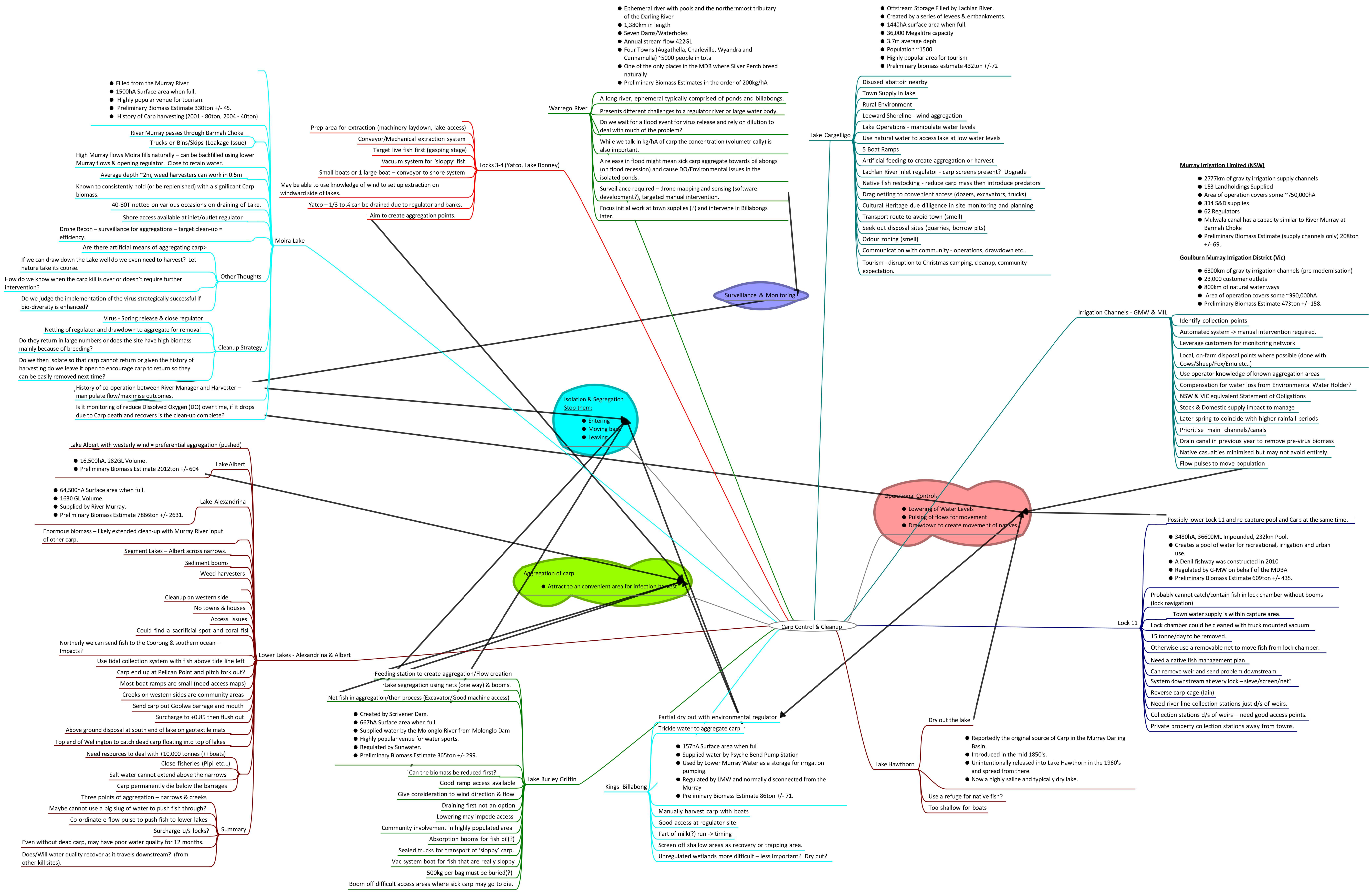
Locality
Lock
Main Highway
Watercourse
River Murray
Lake
Wetland Extent
Native Vegetation

NCCP PROJECT

WARREGO RIVER

Appendix 2

Workshop Output – Mind Map



Carp Control & Cleanup
Moira Lake
Filled from the Murray River
1500hA Surface area when full.
Highly popular venue for tourism.
Preliminary Biomass Estimate 330ton +/- 45.
History of Carp harvesting (2001 - 80ton, 2004 - 40ton)
River Murray passes through Barmah Choke
Trucks or Bins/Skips (Leakage Issue)
High Murray flows Moira fills naturally – can be backfilled using lower Murray flows & opening regulator. Close to retain water.
Average depth ~2m, weed harvesters can work in 0.5m
Known to consistently hold (or be replenished) with a significant Carp biomass.
40-80T netted on various occasions on draining of Lake.
Shore access available at inlet/outlet regulator
Drone Recon – surveillance for aggregations – target clean-up = efficiency.
Are there artificial means of aggregating carp>
Other Thoughts
If we can draw down the Lake well do we even need to harvest? Let nature take its course.
How do we know when the carp kill is over or doesn't require further intervention?
Do we judge the implementation of the virus strategically successful if bio-diversity is enhanced?
Cleanup Strategy
Virus - Spring release & close regulator
Netting of regulator and drawdown to aggregate for removal
Do they return in large numbers or does the site have high biomass mainly because of breeding?
Do we then isolate so that carp cannot return or given the history of harvesting do we leave it open to encourage carp to return so they can be easily removed next time?
History of co-operation between River Manager and Harvester – manipulate flow/maximise outcomes.
Is it monitoring of reduce Dissolved Oxygen (DO) over time, if it drops due to Carp death and recovers is the clean-up complete?
Locks 3-4 (Yatco, Lake Bonney)
Prep area for extraction (machinery laydown, lake access)
Conveyor/Mechanical extraction system
Target live fish first (gasping stage)
Vacuum system for 'sloppy' fish
Small boats or 1 large boat – conveyor to shore system
May be able to use knowledge of wind to set up extraction on windward side of lakes.
Yatco – 1/3 to ¼ can be drained due to regulator and banks.
Aim to create aggregation points.
Warrego River
Ephemeral river with pools and the northernmost tributary of the Darling River
1,380km in length
Seven Dams/Waterholes
Annual stream flow 422GL
Four Towns (Augathella, Charleville, Wyandra and Cunnamulla) ~5000 people in total
One of the only places in the MDB where Silver Perch breed naturally
Preliminary Biomass Estimates in the order of 200kg/hA
A long river, ephemeral typically comprised of ponds and billabongs.
Presents different challenges to a regulator river or large water body.
Do we wait for a flood event for virus release and rely on dilution to deal with much of the problem?
While we talk in kg/hA of carp the concentration (volumetrically) is also important.
A release in flood might mean sick carp aggregate towards billabongs (on flood recession) and cause DO/Environmental issues in the isolated ponds.
Surveillance required – drone mapping and sensing (software development?), targeted manual intervention.
Focus initial work at town supplies (?) and intervene in Billabongs later.
Lake Cargelligo
Offstream Storage Filled by Lachlan River.
Created by a series of levees & embankments.
1440hA surface area when full.
36,000 Megalitre capacity
3.7m average depth
Population ~1500
Highly popular area for tourism
Preliminary biomass estimate 432ton +/-72
Disused abattoir nearby
Town Supply in lake
Rural Environment
Leeward Shoreline - wind aggregation
Lake Operations - manipulate water levels
Use natural water to access lake at low water levels
5 Boat Ramps
Artificial feeding to create aggregation or harvest
Lachlan River inlet regulator - carp screens present? Upgrade
Native fish restocking - reduce carp mass then introduce predators
Drag netting to convenient access (dozers, excavators, trucks)
Cultural Heritage due dilligence in site monitoring and planning
Transport route to avoid town (smell)
Seek out disposal sites (quarries, borrow pits)
Odour zoning (smell)
Communication with community - operations, drawdown etc..
Tourism - disruption to Christmas camping, cleanup, community expectation.
Irrigation Channels - GMW & MIL
Murray Irrigation Limited (NSW)
2777km of gravity irrigation supply channels
153 Landholdings Supplied
Area of operation covers some ~750,000hA
314 S&D supplies
62 Regulators
Mulwala canal has a capacity similar to River Murray at Barmah Choke
Preliminary Biomass Estimate (supply channels only) 208ton +/- 69.
Goulburn Murray Irrigation District (Vic)
6300km of gravity irrigation channels (pre modernisation)
23,000 customer outlets
800km of natural water ways
Area of operation covers some ~990,000hA
Preliminary Biomass Estimate 473ton +/- 158.
Identify collection points
Automated system -> manual intervention required.
Leverage customers for monitoring network
Local, on-farm disposal points where possible (done with Cows/Sheep/Fox/Emu etc..)
Use operator knowledge of known aggregation areas
Compensation for water loss from Environmental Water Holder?
NSW & VIC equivalent Statement of Obligations
Stock & Domestic supply impact to manage
Later spring to coincide with higher rainfall periods
Prioritise main channels/canals
Drain canal in previous year to remove pre-virus biomass
Native casualties minimised but may not avoid entirely.
Flow pulses to move population
Surveillance & Monitoring
Isolation & Segregation
Stop them:
Entering
Moving bas
Leaving
Operational Controls
Lowering of Water Levels
Pulsing of flows for movement
Drawdown to create movement of natives
Aggregation of carp
Attract to an convenient area for infection harvest
Lock 11
Possibly lower Lock 11 and re-capture pool and Carp at the same time.
3480hA, 36600ML Impounded, 232km Pool.
Creates a pool of water for recreational, irrigation and urban use.
A Denil fishway was constructed in 2010
Regulated by G-MW on behalf of the MDBA
Preliminary Biomass Estimate 609ton +/- 435.
Probably cannot catch/contain fish in lock chamber without booms (lock navigation)
Town water supply is within capture area.
Lock chamber could be cleaned with truck mounted vacuum
15 tonne/day to be removed.
Otherwise use a removable net to move fish from lock chamber.
Need a native fish management plan
Can remove weir and send problem downstream
System downstream at every lock – sieve/screen/net?
Reverse carp cage (lain)
Need river line collection stations just d/s of weirs.
Collection stations d/s of weirs – need good access points.
Private property collection stations away from towns.
Lower Lakes - Alexandrina & Albert
Lake Albert with westerly wind = preferential aggregation (pushed)
Lake Albert
16,500hA, 282GL Volume.
Preliminary Biomass Estimate 2012ton +/- 604
Lake Alexandrina
64,500hA Surface area when full.
1630 GL Volume.
Supplied by River Murray.
Preliminary Biomass Estimate 7866ton +/- 2631.
Enormous biomass – likely extended clean-up with Murray River input of other carp.
Segment Lakes – Albert across narrows.
Sediment booms
Weed harvesters
Cleanup on western side
No towns & houses
Access issues
Could find a sacrificial spot and coral fisl
Northerly we can send fish to the Coorong & southern ocean – Impacts?
Use tidal collection system with fish above tide line left
Carp end up at Pelican Point and pitch fork out?
Most boat ramps are small (need access maps)
Creeks on western sides are community areas
Send carp out Goolwa barrage and mouth
Surcharge to +0.85 then flush out
Above ground disposal at south end of lake on geotextile mats
Top end of Wellington to catch dead carp floating into top of lakes
Need resources to deal with +10,000 tonnes (++boats)
Close fisheries (Pipi etc...)
Salt water cannot extend above the narrows
Carp permanently die below the barrages
Summary
Three points of aggregation – narrows & creeks
Maybe cannot use a big slug of water to push fish through?
Co-ordinate e-flow pulse to push fish to lower lakes
Surcharge u/s locks?
Even without dead carp, may have poor water quality for 12 months.
Does/Will water quality recover as it travels downstream? (from other kill sites).
Lake Burley Griffin
Feeding station to create aggregation/Flow creation
Lake segregation using nets (one way) & booms.
Net fish in aggregation/then process (Excavator/Good machine access)
Created by Scrivener Dam.
667hA Surface area when full.
Supplied water by the Molonglo River from Molonglo Dam
Highly popular venue for water sports.
Regulated by Sunwater.
Preliminary Biomass Estimate 365ton +/- 299.
Can the biomass be reduced first?
Good ramp access available
Give consideration to wind direction & flow
Draining first not an option
Lowering may impede access
Community involvement in highly populated area
Absorption booms for fish oil(?)
Sealed trucks for transport of 'sloppy' carp.
Vac system boat for fish that are really sloppy
500kg per bag must be buried(?)
Boom off difficult access areas where sick carp may go to die.
Kings Billabong
Partial dry out with environmental regulator
Trickle water to aggregate carp
157hA Surface area when full
Supplied water by Psyche Bend Pump Station
Used by Lower Murray Water as a storage for irrigation pumping.
Regulated by LMW and normally disconnected from the Murray
Preliminary Biomass Estimate 86ton +/- 71.
Manually harvest carp with boats
Good access at regulator site
Part of milk(?) run -> timing
Screen off shallow areas as recovery or trapping area.
Unregulated wetlands more difficult – less important? Dry out?
Lake Hawthorn
Dry out the lake
Reportedly the original source of Carp in the Murray Darling Basin.
Introduced in the mid 1850's.
Unintentionally released into Lake Hawthorn in the 1960's and spread from there.
Now a highly saline and typically dry lake.
Use a refuge for native fish?
Too shallow for boats

Workshop Notes – Mind Map Components

Locks 3-4 (Yatco, Lake Bonney)

- Prep area for extraction (machinery laydown, lake access)
- Conveyor/Mechanical extraction system
- Target live fish first (gasping stage)
- Vacuum system for 'sloppy' fish
- Small boats or 1 large boat – conveyor to shore system
- May be able to use knowledge of wind to set up extraction on windward side of lakes.
- Yatco – 1/3 to ¼ can be drained due to regulator and banks.
- Aim to create aggregation points.

Warrego River

- Ephemeral river with pools and the northernmost tributary of the Darling River
- 1,380km in length Seven Dams/Waterholes
- Annual stream flow 422GL
- Four Towns (Augathella, Charleville, Wyandra and Cunnamulla) ~5000 people in total
- One of the only places in the MDB where Silver Perch breed naturally Preliminary Biomass Estimates in the order of 200kg/hA

- A long river, ephemeral typically comprised of ponds and billabongs.
- Presents different challenges to a regulator river or large water body.
- Do we wait for a flood event for virus release and rely on dilution to deal with much of the problem?
- While we talk in kg/hA of carp the concentration (volumetrically) is also important.
- A release in flood might mean sick carp aggregate towards billabongs (on flood recession) and cause DO/Environmental issues in the isolated ponds.
- Surveillance required – drone mapping and sensing (software development?), targeted manual intervention.
- Focus initial work at town supplies (?) and intervene in Billabongs later.

Moira Lake

- Filled from the Murray River
- 1500hA Surface area when full.
- Highly popular venue for tourism.
- Preliminary Biomass Estimate 330ton +/- 45.
- History of Carp harvesting (2001 - 80ton, 2004 - 40ton)

- River Murray passes through Barmah Choke
- Trucks or Bins/Skips (Leakage Issue)
- High Murray flows Moira fills naturally – can be backfilled using lower Murray flows & opening regulator. Close to retain water.
- Average depth ~2m, weed harvesters can work in 0.5m
- Known to consistently hold (or be replenished) with a significant Carp biomass.
- 40-80T netted on various occasions on draining of Lake.
- Shore access available at inlet/outlet regulator
- Drone Recon – surveillance for aggregations – target clean-up = efficiency.
- Other Thoughts
- Are there artificial means of aggregating carp>
- If we can draw down the Lake well do we even need to harvest? Let nature take its course.
- How do we know when the carp kill is over or doesn't require further intervention?
- Do we judge the implementation of the virus strategically successful if bio-diversity is enhanced?
- Cleanup Strategy
- Virus - Spring release & close regulator
- Netting of regulator and drawdown to aggregate for removal
- Do they return in large numbers or does the site have high biomass mainly because of breeding?
- Do we then isolate so that carp cannot return or given the history of harvesting do we leave it open to encourage carp to return so they can be easily removed next time?
- History of co-operation between River Manager and Harvester – manipulate flow/maximise outcomes.
- Is it monitoring of reduce Dissolved Oxygen (DO) over time, if it drops due to Carp death and recovers is the clean-up complete?

Lower Lakes

Lake Albert

- 16,500hA, 282GL Volume.
- Preliminary Biomass Estimate 2012ton +/- 604

Lake Alexandrina

- 64,500hA Surface area when full. 1630 GL Volume.
- Supplied by River Murray.
- Preliminary Biomass Estimate 7866ton +/- 2631.

- Lake Albert with westerly wind = preferential aggregation (pushed)
- Enormous biomass – likely extended clean-up with Murray River input of other carp.
- Segment Lakes – Albert across narrows.
- Sediment booms
- Weed harvesters
- Cleanup on western side
- No towns & houses
- Access issues
- Could find a sacrificial spot and coral fish
- Northerly we can send fish to the Coorong & southern ocean – Impacts?
- Use tidal collection system with fish above tide line left
- Carp end up at Pelican Point and pitch fork out?
- Most boat ramps are small (need access maps)
- Creeks on western sides are community areas
- Send carp out Goolwa barrage and mouth
- Surcharge to +0.85 then flush out
- Above ground disposal at south end of lake on geotextile mats
- Top end of Wellington to catch dead carp floating into top of lakes
- Need resources to deal with +10,000 tonnes (++boats)
- Close fisheries (Pipi etc…)
- Salt water cannot extend above the narrows
- Carp permanently die below the barrages
- Summary
- Three points of aggregation – narrows & creeks
- Maybe cannot use a big slug of water to push fish through?
- Co-ordinate e-flow pulse to push fish to lower lakes
- Surcharge u/s locks?
- Even without dead carp, may have poor water quality for 12 months.
- Does/Will water quality recover as it travels downstream? (from other kill sites).

Lake Cargelligo

- Offstream Storage Filled by Lachlan River.
- Created by a series of levees & embankments.
- 1440hA surface area when full.
- 36,000 Megalitre capacity
- 3.7m average depth
- Population ~1500
- Highly popular area for tourism Preliminary biomass estimate 432ton +/-72

- Disused abattoir nearby
- Town Supply in lake
- Rural Environment
- Leeward Shoreline - wind aggregation
- Lake Operations - manipulate water levels
- Use natural water to access lake at low water levels
- 5 Boat Ramps
- Artificial feeding to create aggregation or harvest
- Lachlan River inlet regulator - carp screens present? Upgrade
- Native fish restocking - reduce carp mass then introduce predators
- Drag netting to convenient access (dozers, excavators, trucks)
- Cultural Heritage due dilligence in site monitoring and planning
- Transport route to avoid town (smell)
- Seek out disposal sites (quarries, borrow pits)
- Odour zoning (smell)
- Communication with community - operations, drawdown etc..
- Tourism - disruption to Christmas camping, cleanup, community expectation.
- Surveillance & Monitoring

Irrigation Channels - GMW & MIL

Murray Irrigation Limited (NSW)

- 2777km of gravity irrigation supply channels
- 153 Landholdings Supplied
- Area of operation covers some ~750,000hA
- 314 S&D supplies
- 62 Regulators
- Mulwala canal has a capacity similar to River Murray at Barmah Choke
- Preliminary Biomass Estimate (supply channels only) 208ton +/- 69.

Goulburn Murray Irrigation District (Vic)

- 6300km of gravity irrigation channels (pre modernisation)
- 23,000 customer outlets
- 800km of natural water ways
- Area of operation covers some ~990,000hA
- Preliminary Biomass Estimate 473ton +/- 158.

- Identify collection points
- Automated system -> manual intervention required.
- Leverage customers for monitoring network
- Local, on-farm disposal points where possible (done with Cows/Sheep/Fox/Emu etc..)
- Use operator knowledge of known aggregation areas
- Compensation for water loss from Environmental Water Holder?
- NSW & VIC equivalent Statement of Obligations
- Stock & Domestic supply impact to manage
- Later spring to coincide with higher rainfall periods
- Prioritise main channels/canals
- Drain canal in previous year to remove pre-virus biomass
- Native casualties minimised but may not avoid entirely.
- Flow pulses to move population

Lock 11

- Possibly lower Lock 11 and re-capture pool and Carp at the same time.
- 3480hA, 36600ML Impounded, 232km Pool.
- Creates a pool of water for recreational, irrigation and urban use.
- A Denil fishway was constructed in 2010 Regulated by G-MW on behalf of the MDBA Preliminary Biomass Estimate 609ton +/- 435.

- Probably cannot catch/contain fish in lock chamber without booms (lock navigation)
- Town water supply is within capture area.
- Lock chamber could be cleaned with truck mounted vacuum
- 15 tonne/day to be removed.
- Otherwise use a removable net to move fish from lock chamber.
- Need a native fish management plan
- Can remove weir and send problem downstream
- System downstream at every lock – sieve/screen/net?
- Reverse carp cage (Iain)
- Need river line collection stations just d/s of weirs.
- Collection stations d/s of weirs – need good access points.
- Private property collection stations away from towns.

Lake Hawthorn

- Reportedly the original source of Carp in the Murray Darling Basin.
- Introduced in the mid 1850's.
- Unintentionally released into Lake Hawthorn in the 1960's and spread from there.
- Now a highly saline and typically dry lake.

- Dry out the lake
- Use a refuge for native fish?
- Too shallow for boats

Kings Billabong

- 157hA Surface area when full
- Supplied water by Psyche Bend Pump Station Used by Lower Murray Water as a storage for irrigation pumping.
- Regulated by LMW and normally disconnected from the Murray Preliminary Biomass Estimate 86ton +/- 71.

- Partial dry out with environmental regulator
- Trickle water to aggregate carp
- Manually harvest carp with boats
- Good access at regulator site
- Part of milk(?) run -> timing
- Screen off shallow areas as recovery or trapping area.
- Unregulated wetlands more difficult – less important? Dry out?

Lake Burley Griffin

- Created by Scrivener Dam.
- 667hA Surface area when full.
- Supplied water by the Molonglo River from Molonglo Dam
- Highly popular venue for water sports.
- Regulated by Sunwater.
- Preliminary Biomass Estimate 365ton +/- 299.

- Feeding station to create aggregation/Flow creation
- Lake segregation using nets (one way) & booms.
- Net fish in aggregation/then process (Excavator/Good machine access)
- Can the biomass be reduced first?
- Good ramp access available
- Give consideration to wind direction & flow
- Draining first not an option
- Lowering may impede access
- Community involvement in highly populated area
- Absorption booms for fish oil(?)
- Sealed trucks for transport of 'sloppy' carp.
- Vac system boat for fish that are really sloppy
- 500kg per bag must be buried(?)
- Boom off difficult access areas where sick carp may go to die.

Isolation & Segregation

- Stop them: Entering Moving back Leaving

Operational Controls

- Lowering of Water Levels Pulsing of flows for movement Drawdown to create movement of natives

Aggregation of carp

- Attract to a convenient area for infection, harvest.

- Ephemeral river with pools and the northernmost tributary of the Darling River
- 1,380km in length
- Seven Dams/Waterholes
- Annual stream flow 422GL
- Four Towns (Augathella, Charleville, Wyandra and Cunnamulla) ~5000 people in total
- One of the only places in the MDB where Silver Perch breed naturally
- Preliminary Biomass Estimates in the order of 200kg/hA

Warrego River

- A long river, ephemeral typically comprised of ponds and billabongs.
- Presents different challenges to a regulator river or large water body.
- Do we wait for a flood event for virus release and rely on dilution to deal with much of the problem?
- While we talk in kg/hA of carp the concentration (volumetrically) is also important.
- A release in flood might mean sick carp aggregate towards billabongs (on flood recession) and cause DO/Environmental issues in the isolated ponds.
- Surveillance required – drone mapping and sensing (software development?), targeted manual intervention.
- Focus initial work at town supplies (?) and intervene in Billabongs later.

- Offstream Storage Filled by Lachlan River.
- Created by a series of levees & embankments.
- 1440hA surface area when full.
- 36,000 Megalitre capacity
- 3.7m average depth
- Population ~1500
- Highly popular area for tourism
- Preliminary biomass estimate 432ton +/-72

Lake Cargelligo

- Disused abattoir nearby
- Town Supply in lake
- Rural Environment
- Leeward Shoreline - wind aggregation
- Lake Operations - manipulate water levels
- Use natural water to access lake at low water levels
- 5 Boat Ramps
- Artificial feeding to create aggregation or harvest
- Lachlan River inlet regulator - carp screens present? Upgrade
- Native fish restocking - reduce carp mass then introduce predators
- Drag netting to convenient access (dozers, excavators, trucks)
- Cultural Heritage due dilligence in site monitoring and planning
- Transport route to avoid town (smell)
- Seek out disposal sites (quarries, borrow pits)
- Odour zoning (smell)
- Communication with community - operations, drawdown etc..
- Tourism - disruption to Christmas camping, cleanup, community expectation.

Murray Irrigation Limited (NSW)

- 2777km of gravity irrigation supply channels
- 153 Landholdings Supplied
- Area of operation covers some ~750,000hA
- 314 S&D supplies
- 62 Regulators
- Mulwala canal has a capacity similar to River Murray at Barmah Choke
- Preliminary Biomass Estimate (supply channels only) 208ton +/- 69.

Goulburn Murray Irrigation District (Vic)

- 6300km of gravity irrigation channels (pre modernisation)
- 23,000 customer outlets
- 800km of natural water ways
- Area of operation covers some ~990,000hA
- Preliminary Biomass Estimate 473ton +/- 158.

Irrigation Channels - GMW & MIL

- Identify collection points
- Automated system -> manual intervention required.
- Leverage customers for monitoring network
- Local, on-farm disposal points where possible (done with Cows/Sheep/Fox/Emu etc..)
- Use operator knowledge of known aggregation areas
- Compensation for water loss from Environmental Water Holder?
- NSW & VIC equivalent Statement of Obligations
- Stock & Domestic supply impact to manage
- Later spring to coincide with higher rainfall periods
- Prioritise main channels/canals
- Drain canal in previous year to remove pre-virus biomass
- Native casualties minimised but may not avoid entirely.
- Flow pulses to move population

- Lock 11
  - Possibly lower Lock 11 and re-capture pool and Carp at the same time.
  - 3480hA, 36600ML Impounded, 232km Pool.
  - Creates a pool of water for recreational, irrigation and urban use.
  - A Denil fishway was constructed in 2010
  - Regulated by G-MW on behalf of the MDBA
  - Preliminary Biomass Estimate 609ton +/- 435.
  - Probably cannot catch/contain fish in lock chamber without booms (lock navigation)
  - Town water supply is within capture area.
  - Lock chamber could be cleaned with truck mounted vacuum
  - 15 tonne/day to be removed.
  - Otherwise use a removable net to move fish from lock chamber.
  - Need a native fish management plan
  - Can remove weir and send problem downstream
  - System downstream at every lock – sieve/screen/net?
  - Reverse carp cage (Iain)
  - Need river line collection stations just d/s of weirs.
  - Collection stations d/s of weirs – need good access points.
  - Private property collection stations away from towns.

- Lake Hawthorn
  - Dry out the lake
  - Reportedly the original source of Carp in the Murray Darling Basin.
  - Introduced in the mid 1850's.
  - Unintentionally released into Lake Hawthorn in the 1960's and spread from there.
  - Now a highly saline and typically dry lake.
  - Use a refuge for native fish?
  - Too shallow for boats

- Kings Billabong
  - Partial dry out with environmental regulator
  - Trickle water to aggregate carp
    - 157hA Surface area when full
    - Supplied water by Psyche Bend Pump Station
    - Used by Lower Murray Water as a storage for irrigation pumping.
    - Regulated by LMW and normally disconnected from the Murray
    - Preliminary Biomass Estimate 86ton +/- 71.
  - Manually harvest carp with boats
  - Good access at regulator site
  - Part of milk(?) run -> timing
  - Screen off shallow areas as recovery or trapping area.
  - Unregulated wetlands more difficult – less important? Dry out?

- Lake Burley Griffin
  - Feeding station to create aggregation/Flow creation
  - Lake segregation using nets (one way) & booms.
  - Net fish in aggregation/then process (Excavator/Good machine access)
    - Created by Scrivener Dam.
    - 667hA Surface area when full.
    - Supplied water by the Molonglo River from Molonglo Dam
    - Highly popular venue for water sports.
    - Regulated by Sunwater.
    - Preliminary Biomass Estimate 365ton +/- 299.
  - Can the biomass be reduced first?
  - Good ramp access available
  - Give consideration to wind direction & flow
  - Draining first not an option
  - Lowering may impede access
  - Community involvement in highly populated area
  - Absorption booms for fish oil(?)
  - Sealed trucks for transport of 'sloppy' carp.
  - Vac system boat for fish that are really sloppy
  - 500kg per bag must be buried(?)
  - Boom off difficult access areas where sick carp may go to die.

Lower Lakes - Alexandrina & Albert

- Lake Albert with westerly wind = preferential aggregation (pushed)
- Lake Albert
  - 16,500hA, 282GL Volume.
  - Preliminary Biomass Estimate 2012ton +/- 604
- Lake Alexandrina
  - 64,500hA Surface area when full.
  - 1630 GL Volume.
  - Supplied by River Murray.
  - Preliminary Biomass Estimate 7866ton +/- 2631.
- Enormous biomass – likely extended clean-up with Murray River input of other carp.
- Segment Lakes – Albert across narrows.
- Sediment booms
- Weed harvesters
- Cleanup on western side
- No towns & houses
- Access issues
- Could find a sacrificial spot and coral fish
- Northerly we can send fish to the Coorong & southern ocean – Impacts?
- Use tidal collection system with fish above tide line left
- Carp end up at Pelican Point and pitch fork out?
- Most boat ramps are small (need access maps)
- Creeks on western sides are community areas
- Send carp out Goolwa barrage and mouth
- Surcharge to +0.85 then flush out
- Above ground disposal at south end of lake on geotextile mats
- Top end of Wellington to catch dead carp floating into top of lakes
-
  - Need resources to deal with +10,000 tonnes (++boats)
  - Close fisheries (Pipi etc...)
  - Salt water cannot extend above the narrows
  - Carp permanently die below the barrages
- Summary
  - Three points of aggregation – narrows & creeks
  - Maybe cannot use a big slug of water to push fish through?
  - Co-ordinate e-flow pulse to push fish to lower lakes
  - Surcharge u/s locks?
  - Even without dead carp, may have poor water quality for 12 months.
  - Does/Will water quality recover as it travels downstream? (from other kill sites).

- Moira Lake
  - Filled from the Murray River
    - 1500hA Surface area when full.
    - Highly popular venue for tourism.
    - Preliminary Biomass Estimate 330ton +/- 45.
    - History of Carp harvesting (2001 - 80ton, 2004 - 40ton)
  - River Murray passes through Barmah Choke
  - Trucks or Bins/Skips (Leakage Issue)
  - High Murray flows Moira fills naturally – can be backfilled using lower Murray flows & opening regulator. Close to retain water.
  - Average depth ~2m, weed harvesters can work in 0.5m
  - Known to consistently hold (or be replenished) with a significant Carp biomass.
  - 40-80T netted on various occasions on draining of Lake.
  - Shore access available at inlet/outlet regulator
  - Drone Recon – surveillance for aggregations – target clean-up = efficiency.
  - Other Thoughts
    - Are there artificial means of aggregating carp>
    - If we can draw down the Lake well do we even need to harvest? Let nature take its course.
    - How do we know when the carp kill is over or doesn't require further intervention?
    - Do we judge the implementation of the virus strategically successful if bio-diversity is enhanced?
  - Cleanup Strategy
    - Virus - Spring release & close regulator
    - Netting of regulator and drawdown to aggregate for removal
    - Do they return in large numbers or does the site have high biomass mainly because of breeding?
    - Do we then isolate so that carp cannot return or given the history of harvesting do we leave it open to encourage carp to return so they can be easily removed next time?
  - History of co-operation between River Manager and Harvester – manipulate flow/maximise outcomes.
  - Is it monitoring of reduce Dissolved Oxygen (DO) over time, if it drops due to Carp death and recovers is the clean-up complete?

- Locks 3-4 (Yatco, Lake Bonney)
  - Prep area for extraction (machinery laydown, lake access)
  - Conveyor/Mechanical extraction system
  - Target live fish first (gasping stage)
  - Vacuum system for 'sloppy' fish
  - Small boats or 1 large boat – conveyor to shore system
  - May be able to use knowledge of wind to set up extraction on windward side of lakes.
  - Yatco – 1/3 to ¼ can be drained due to regulator and banks.
  - **Aim to create aggregation points.**

NATIONAL CARP CONTROL PLAN

The National Carp Control Plan is managed by the
Fisheries Research and Development Corporation

Tel: 02 6285 0400
Post: Locked Bag 222, Deakin West ACT 2600

www.carp.gov.au