TECHNICAL PAPER 9

NATIONAL CARP CONTROL PLAN

NCCP Lachlan case study

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
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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)

Technical Paper 9: NCCP Lachlan Case Study

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2. Background

The National Carp Control Plan (NCCP) has assessed the feasibility of using a virus called Cyprinid herpesvirus 3 (CyHV-3, hereafter 'the carp virus', or 'the virus') as a biocontrol agent for invasive European Carp, or common carp (*Cyprinus carpio*, hereafter 'carp') in Australia. This Technical Paper outlines how a possible virus release could be implemented in the Lachlan catchment (NSW).

The ideas in this report have been developed in collaboration with Lachlan stakeholders and regional experts through a number of workshops. The Lachlan case study is one of three in the NCCP. These case studies are intended to demonstrate how deployment of CyHV-3 and subsequent carcass management would be implemented at a regional scale, if Australian governments choose to proceed with carp biocontrol after amassing and evaluating the information necessary for informed decision making and obtaining relevant legislative approvals.

This case study was completed before finalisation of NCCP research. It demonstrates how the carp virus could potentially be deployed and managed in the Lachlan catchment. If governments do ultimately decide to implement a carp biocontrol program, more detailed regional planning will be required. This case study could be used as a starting point for that planning.

NCCP modelling indicates that, if successfully deployed, CyHV-3 could reduce and suppress highly resilient carp populations by approximately 40–60% and less resilient populations by approximately 60–80%. These modelled outcomes depend on some assumptions about CyHV-3 transmission and the susceptibility of Australian carp to the disease caused by the virus.

While sustained, broadscale carp reductions of any magnitude could potentially bring benefits, NCCP research indicates that reduction of carp impacts may benefit from an integrated approach in which virus deployment is preceded by targeted harvesting (Durr et al., 2019). However, this technical paper focuses only on biological control, reflecting the NCCP's primary focus. If governments decide to proceed towards development of an integrated control approach incorporating both biological control and targeted harvesting, the design, costing, and implementation of the latter will require separate consideration.

3. Case study area

The Lachlan catchment lies in central western NSW and extends over 85,000 km^2. The headwaters are located near Gunning and Oberon. Major tributaries include the Abercrombie, Crookwell, Belubula and Boorowa Rivers. The river generally terminates in the Great Cumbung Swamp near Oxley over 1,500 river kilometres downstream, only discharging to the Murrumbidgee River during very large flood events.

Wyangala Dam (1,220,000 ML) on the junction of the Lachlan and Abercrombie Rivers about 50 km upstream of Cowra is the main impoundment. Carcoar Dam (36,000 ML) impounds the Belubula River near Blayney and there are two off-river storages (Lake Cargelligo and Lake Brewster) in the middle

reaches which support valuable wetland fauna and flora communities. Lake Brewster is often dry but Lake Cargelligo is semi-permanent.

Downstream of Lake Brewster there are three major effluent creek systems (Merrowie, Willandra and Muggabah) which have been modified to supply stock and domestic water to rural properties on the northern floodplain. Annual replenishment flows are usually delivered to these systems in winter. Bland Creek arises near Cootamundra and Young and generally terminates in Lake Cowal and Bogandillon Swamp upstream of Condobolin. The Jemalong Irrigation District (96,000 ha) is located on the south side of the river between Forbes and Lake Cowal and receives water (approximately 40,000 ML/year) from the Lachlan River via approximately 300 km of channel diverted at Jemalong Weir (Jemalong Irrigation, 2020).

In the east, the catchment is characterised by moderate to steep, hilly and rocky landscapes with incised streams. The middle reaches are flat with meandering streams and numerous billabongs and anabranches (e.g. Wallamundary, Wallaroi, Nerathong, Bumbuggan and Goobang Creeks). The western reaches are very flat and traverse a semi-arid landscape with broad floodplains and numerous distributary creeks and extensive ephemeral wetlands.

Urban centres are located at Forbes, Parkes, Cowra, Blayney, Canowindra, Grenfell, Boorowa, Condobolin, and Lake Cargelligo. The catchment extends across 22 Local Government Areas (LGAs)—Upper Lachlan, Hilltops, Oberon, Bathurst Regional, Cootamundra-Gundagai, Yass Valley, Goulburn-Mulwaree, Palerang, Cowra, Blayney, Cabonne, Parkes, Weddin, Forbes, Temora, Bland, Lachlan, Cobar, Carathool, Hay, Balranald and Central Darling.

4. Carp distribution and abundance

The Lachlan catchment has a significant carp problem. Graham et al. (2005) indicated that Carp occurred across 98% of the catchment. Carp are widespread through the catchment, and are most abundant in permanent off-channel waterbodies. NCCP habitat suitability modelling indicates that there are approximately 50 carp sub-populations located throughout the catchment, highlighting the system's disconnected nature (Durr et al., 2019). Some parts of the catchment above Wyangala Dam remain carp-free.

High carp densities (more than 500 kg/ha) occur in sections of the Lachlan River from Forbes to Hillston and in the major off-channel water bodies (Stuart et al., 2019). Carp biomass and its distribution within the catchment as estimated during summer 2017–18 is shown in Table 1.

Table 1 Indicative biomass of common carp, *Cyprinus carpio*, and its distribution in the Lachlan River catchment, New South Wales (NCCP Biomass estimate, 2019).

Location	Tonnes
Upstream of Wyangala	145
Wyangala to Jemalong	1901
Lake Cowal and upper drainage area	917

Jemalong to Brewster	866
Lake Cargeligo	208
Lake Brewster	1077
Willandra Creek	7491
Brewster to Great Cumbung	4977
TOTAL	**17000 tonnes**

Carp abundance varies considerably in response to hydrological conditions. Floods create large expanses of suitable habitat, while during dry conditions carp become concentrated in permanent waterbodies or die in ephemeral systems as they dry.

Gilligan (pers. comm.) advises that carp are absent from:

- Carcoar Dam and the Belubula River and tributaries upstream of the dam,
- the Belubula River and Cadiangullong Creek upstream of the confluence,
- the upper Crookwell River, and
- Blakney Creek.

NCCP biomass density assessments (Stuart et al., 2019) indicates that high biomass of Carp (more than 500 kg/ha) occurs in the vicinity of:

- Lake Brewster and Brewster weir,
- Lake Cargelligo,
- the Belubula River downstream of Carcoar Dam,
- the Lachlan River upstream of Wyangala Dam,
- the Abercrombie River upstream of Wyangala Dam, and
- Burraga Lake.

Biomass information mainly relates to the main river and storages where comprehensive fish sampling has been undertaken. There are thousands of billabongs, lagoons, floodplain lakes and farm dams throughout the catchment that have never been sampled but also hold carp.

5. Hydrology and water management

Mean annual flow in the Lachlan is around 1,325 GL/year (Barma Water Resources, 2011). Flows are highly variable ranging from 4% to 550% of mean annual flow (Wettin et al., 2007). The main tributaries of the Lachlan include the Abercrombie, Belubula, Mandagery, Crookwell and Boorowa Rivers. These rivers as well as the Lachlan upstream of Reids Flat and the Belubula upstream of Carcoar Dam are unregulated streams relying on natural stream flow. Bland Creek is also unregulated and a mostly endorheic system terminating in Lake Cowal and Bogandillon swamp.

GIS analysis indicates there is approximately 34,000 ha of waterway in the catchment including nearly 8,000 ha of linear waterway (4th order and above creek, river and irrigation channel) plus 26,000 ha of lakes (more than half of which is within Lakes Cowal and Brewster). During extended dry periods, a large proportion (>70%) of this habitat is dry.

The Lachlan River downstream of Wyangala Dam and the Belubula River downstream of Carcoar Dam are "regulated rivers" (a legal term indicating that flow rates can be controlled by varying releases from the dams). Water is released from both dams to meet town water, domestic, stock, irrigation and environmental needs for the length of the river to the Great Cumbung Swamp. Flows are managed by WaterNSW in accordance with the Water Sharing Plan for the Lachlan Regulated River Water Source and the Water Sharing Plan for the Belubula Regulated River Water Source respectively. Water is also distributed amongst several anabranches and distributary creek systems including Merrimajeel, Muggabah, Torriganny, Box, Wallamundry, Wallaroi, Booberoi, Willandra and Merrowie Creeks to meet domestic, stock, irrigation, and environmental needs.

Lake Cargelligo and Lake Brewster are offstream storages used to help maintain flows in the lower river. There are numerous gated weirs (and several fishways) within the system that enable the control of flow rates within specific sections of river and to lakes. These could be managed to a certain extent to assist virus release and carcass clean-up operations. For example, virus transmission is likely optimised by bodily contact between fish (Kirkland and Hick, 2022), so manipulation of flows to help aggregate carp at weirs/regulators or encourage spawning aggregations may be used to assist virus transmission.

The Lachlan Water Sharing Plan (WSP) makes provision for three environmental flow rules for the Lachlan Regulated River Water Source—translucent flows, environmental water allowances (EWAs) and a water quality allowance (WQA). Translucency is managed by the river operators (WaterNSW) according to a set of fixed rules that specify the nature of releases required for environmental purposes. Triggering of translucent flow releases is effectively 'automatic' under the conditions specified in the WSP, and are essentially linked to inflows into Wyangala Dam and the Lachlan resource (water availability) assessment.

Two environmental water allowances (Wyangala and Lake Brewster EWAs) are managed by the Office of Environment and Heritage (OEH) with advice from the Lachlan Environmental Water Advisory Group (EWAG). Releases from these EWA accounts can be made for environmental purposes, such as to support water-bird breeding, native-fish breeding and passage, wetland inundation and flow variability, and environmental assets and functions that have been identified as water-dependent Aboriginal cultural values.

A water quality allowance (WQA) is available on 1 July each water year and is managed by the NSW Department of Industry—Crown Lands and Water (formerly DPI Water). Rules determining the volume and timing of water releases credited to the WQA account will be specified in accordance with procedures established by the Minister who may also seek the advice of the Lachlan EWAG in making releases under this clause.

The water quality allowance (WQA) could potentially be used to help manage water-quality issues associated with the virus release and clean-up operations. Water from the EWA accounts (if available at the time) could also be made available for strategic actions that improve native fish survival, for

example by providing refugia, and promoting population recovery following carp population reductions.

When this case study was completed in 2019, the Commonwealth Environmental Water Holder (CEWH) held nearly 88 GL of General Security entitlement which translates to 37 GL of Long-Term Average Annual Yield. There was a 200% carryover limit. OEH holds 38 GL of entitlement. Only 2% of the 126 GL combined total was "high security". The availability of water in any one year depends on the annual resource assessment. Some or all of the available water may be available to assist virus release and carcase clean-up operations. This would need to be negotiated with the CEWH and OEH closer to any future virus release date (if governments choose to proceed).

Purchase of allocated water via the water-trading system is another option for securing water to assist virus release and/or mitigation of water-quality impacts associated with decomposing carp carcasses (Technical Paper 3). Consideration of this option could not realistically take place before 3 to 4 months prior to virus release as the availability of water is very much dependent on seasonal conditions and anticipated commodity prices.

Liaison with catchment water managers (Water NSW, DoI Crown Lands & Water, Lachlan EWAG, Lachlan Valley Water Users Association and Jemalong Irrigation among others) would need to commence approximately 12 months prior to release of the virus in the catchment and continue until clean-up operations are finalised. Analysis of water in storage, water in environmental accounts, and predicted inflows will inform development of options for manipulating flows throughout the catchment to optimise the effective release of the virus and management of water quality.

6. Risk assessment

Table 2 summarises the main risks and impacts associated with carp biocontrol in the Lachlan catchment, with mitigation options.

Table 2 Risk summary, with mitigation options, for carp biocontrol in the Lachlan River catchment, New South Wales.

Risk	Possible impacts	Risk mitigation
Environmental		
Native fish nursery sites e.g. Olive Perchlet and Southern Pygmy Perch	Low if water quality maintained and normal Lachlan river flows	Strategic carcass management upstream by booms
Macquarie Perch breeding in the Abercrombie River	Low if water quality maintained and normal Lachlan river flows	Strategic carcass management upstream by booms
Pelican rookery at Lake Brewster	Could be impacted if water quality not maintained	Virus deployment during a non- breeding season
Lake Cowal	Low due to variable carp populations	No virus deployment
Endangered Ecological Community (EEC) downstream of Wyangala Dam	Low due to cold water temperatures	No virus deployment
Social		
Town water offtakes	Low due to treatment capability	Water treatment and carcass management

Major towns—Forbes, Booligal, Condobolin, Hillston and Cargelligo	May impact amenity	Focussed carcass management
Lake Brewster	Low as no public access. Could affect water quality	Water regulation to manageme carcass impacts
Lake Cargelligo	High amenity value and likely high number of carcasses. Possible short-term impacts	Use of wind and booms to corral carcasses to specific shorelines to reduce impacts
Irrigation offtakes	Numerous offtakes likely low impact	Intake screening
Weirs	Low impact	Operational approvals

Threatened species and ecological impacts will be assessed under the *Environment Protection and Biodiversity Conservation Act 1999* strategic assessment and relevant jurisdictional legislation. This section gives an overview of threatened species and their habitats. The NCCP risk assessment project (Beckett et al., 2019) provides a national assessment of ecological risks.

Gill breathing aquatic species (fish, invertebrates and tadpoles) in particular may be at risk from hypoxia caused by decomposition of carp carcases (Technical Paper 3). It will be important to ensure that carp-control operations do not jeopardise the survival of any threatened species, populations or communities.

Threatened species, populations and ecological communities known to occur in the Lachlan catchment are listed in Table 3.

Table 3 Threatened species, populations and ecological communities of gill breathing organisms known to occur in the Lachlan catchment

Common Name	**Scientific name**	**Listing under *Environment Protection & Biodiversity Conservation Act 1999***	**Listing under *Fisheries Management Act***	**Listing under *Biodiversity Conservation Act***	**Distribution within catchment**
Macquarie Perch	*Macquaria australasica*	Endangered	Endangered	NA	Abercrombie River, Lachlan River upstream of Wyangala dam
Murray Cod	*Maccullochella peeli*	Vulnerable	NA	NA	Lachlan River, Wyangala Dam
Southern Pygmy Perch	*Nannoperca australis*	NA	Endangered	NA	Blakney Creek
Olive Perchlet (Agassiz's Chanda Perch)	*Ambassis agassizzi*	NA	Endangered population	NA	Brewster weir pool, Lachlan River downstream of Brewster weir, Mountain Creek
Silver Perch	*Bidyanus bidyanus*	Critically endangered	Vulnerable	NA	Lachlan River

Freshwater Catfish	*Tandanus tandanus*	NA	Endangered population	NA	Lachlan River and anabranches
Lower Lachlan Aquatic Ecological Community	NA	NA	Endangered Ecological Community	NA	Lachlan River & all associated creeks and waterways downstream of Wyangala Dam

7. Implementation considerations

The Lachlan catchment has several characteristics that will shape and constrain carp biocontrol operations. In the catchment's ephemeral streams, carp population density is sufficiently low that virus deployment may not be warranted (see Technical Papers 1 and 2). A substantial portion of the Lachlan River is also affected by cold-water pollution from Wyangala and Carcoar Dams. Water temperatures in these reaches will be below the permissive range for the disease caused by the carp virus during periods when water is being released from the dams.

The Lachlan River is not navigable, so physical collection of carp carcasses would generally be restricted to shore-based operations. Adjoining major floodplain waterbodies are navigable but have extensive shallow areas that will restrict operations. Access to some parts of the catchment is also restricted by private property and limited public road access. Operations will therefore be restricted to strategic locations at weir points and settlements.

Large dams and larger undershot weirs/regulators (those with lift gates) are the most effective fish-passage barriers for fish attempting to move upstream. Flow velocities through undershot weirs/regulators are typically too high for most fish to negotiate. During high flows, gates are sometimes lifted clear of the water to minimise impact upon flooding. During these times, upstream fish passage may be possible but these conditions are infrequent and virus release would not be undertaken during a flood event (although a flood could occur during the virus release period). Four weirs/regulators include fishways (Booligal weir, Lake Cargelligo weir, Island Creek weir and Bumbuggan Creek weir). One or more of these may need to be closed for the duration of virus release and clean-up operations to prevent fish passage.

7.1. Water temperature and virus release

Water temperature is one of the most critical considerations in planning for the release of the virus (Technical Paper 2; Durr et al., 2019). Water temperature follows a predictable annual cycle rising during spring from a minimum in June/July, peaking in January/February and then declining again through autumn and early winter (Figures 1, 2, 3, 4).

The virus can cause disease in carp between approximately 18–28 ^{o}C, but is likely to do so most effectively within a narrower range of approximately 22–24 °C (see Technical Paper 2 for a more detailed discussion). The virus does not generally cause disease in carp below 13 ^{o}C or above 30 ^{o}C (Technical Paper 2). The target temperature for virus release is 18 °C. Water temperature in the Lachlan catchment generally falls within the permissive range from early- to mid-October through to early- to mid-April, although timing varies across the catchment depending upon elevation and the impact of cold-water releases from dams (Figures 1, 2, and 3.) River temperatures exceeding 30 ^{o}C are

rare in river channels of the Lachlan catchment (just 56 of 43,594 or 0.1% of observations over 17 gauging stations between 2010 and 2017). Nevertheless, temperatures exceeding 30 °C are likely to be more common in lagoons, billabongs and other lentic waterways and possibly along the shallow margins of streams at the peak of summer. A review of temperature data from various ad hoc wetland monitoring projects in the Lachlan catchment indicated 64 of 1,065 observations (6%) exceeded 30 °C. Temperatures exceeding 30 °C mostly occur at the height of summer, suggesting that October/November (i.e. before temperatures reach their summer peak) would be optimal for virus release.

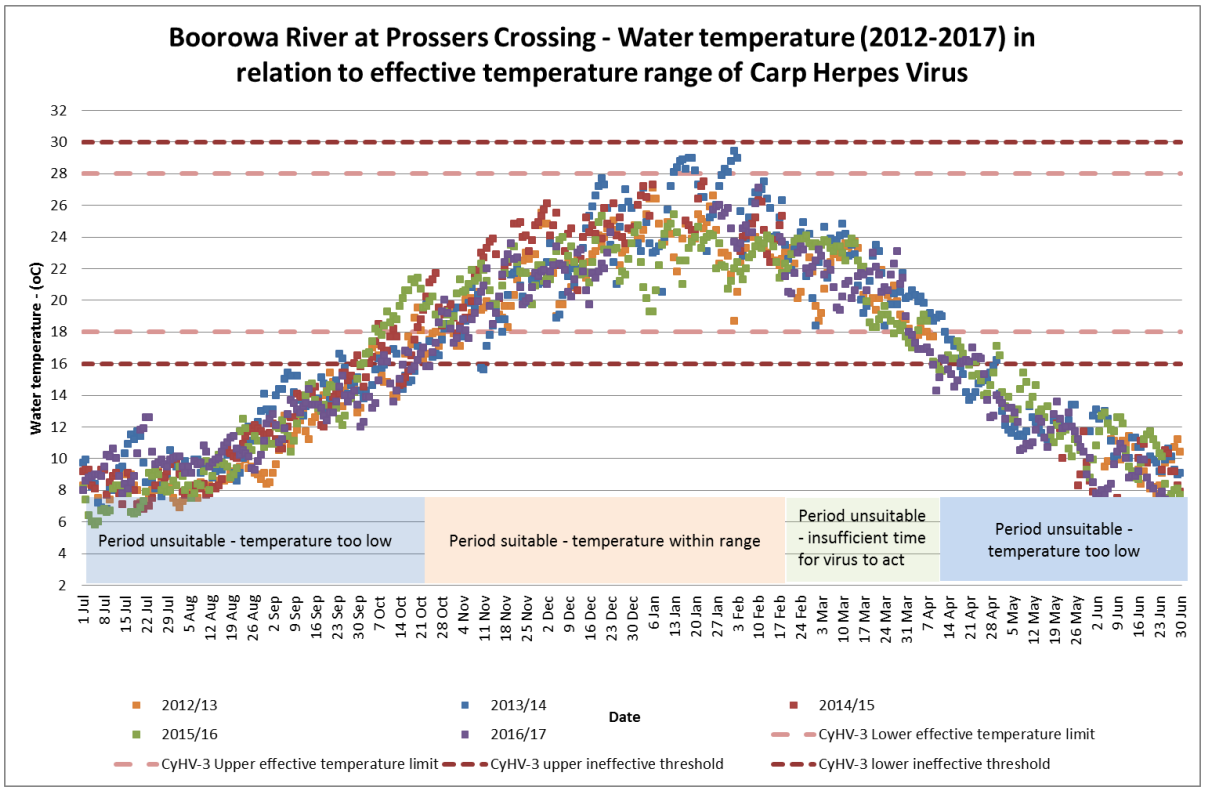

Figure 1 Scatter plot of water temperature in relation to the permissive temperature range for Cyprinid herpesvirus 3 (CyHV-3) infection and disease in the Boorowa River.

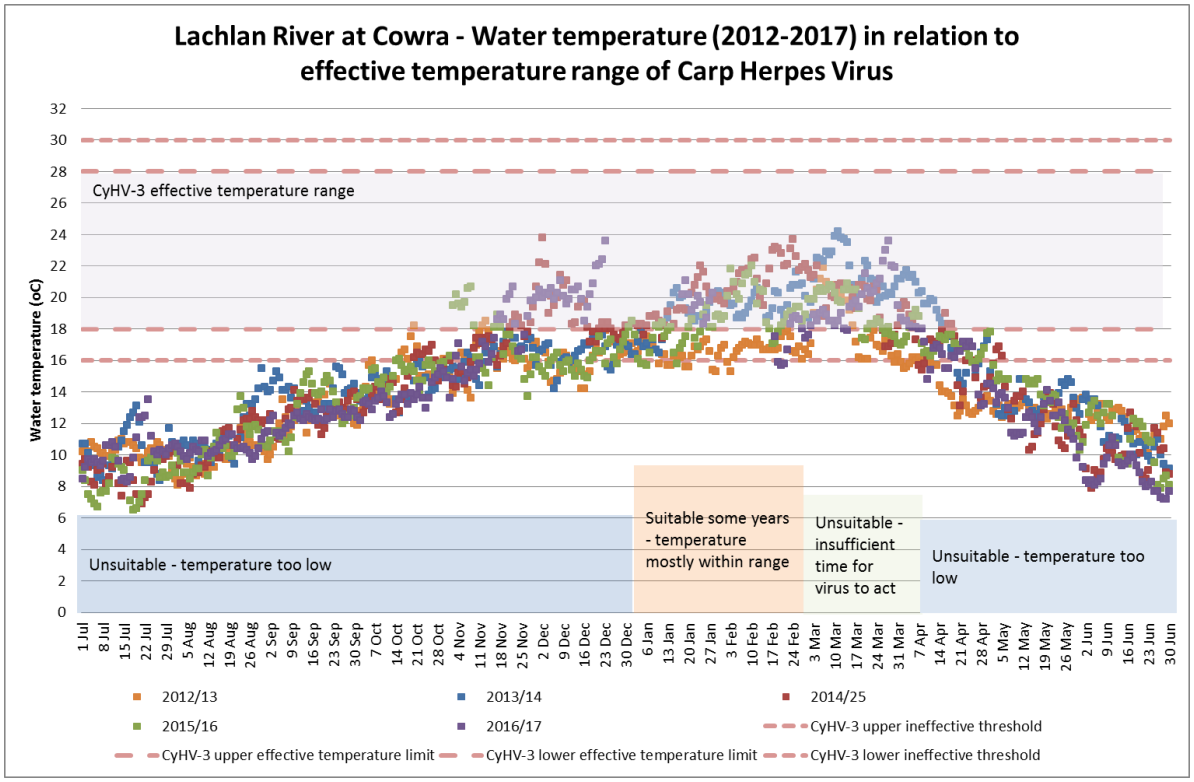

Figure 2 Scatter plot of water temperature in relation to the permissive temperature range for Cyprinid herpesvirus 3 (CyHV-3) infection and disease in the Lachlan River at Cowra.

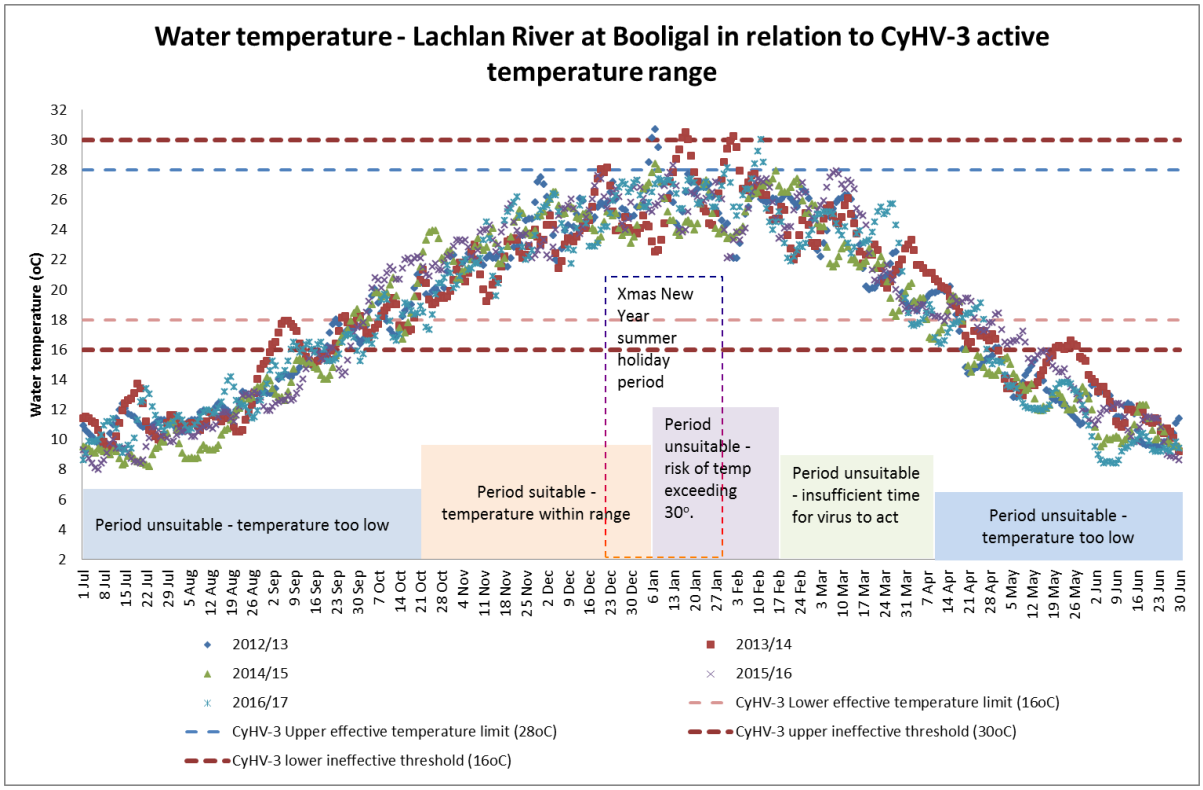

Figure 3 Scatter plot of water temperature in relation to the permissive temperature range for Cyprinid herpesvirus 3 (CyHV-3) infection and disease in the Lachlan River at Booligal.

Water release from both Wyangala and Carcoar Dams suppress spring/summer temperatures in the Lachlan and Belubula Rivers for tens to hundreds of kilometres downstream and this may limit the "window of opportunity" to release the virus within these river reaches.

As indicated in Figure 4, water temperature downstream of Wyangala Dam may fail to reach the lower temperature threshold of 18°C for consecutive years due to thermal (cold water) pollution. This typically occurs when the dam is full or near full and water users have large water allocations (dam releases tend to be large and continuous under these conditions). If these conditions prevail, virus release in the reaches downstream of Wyangala and Carcoar Dams may need to be postponed or alternative population reduction techniques such as netting or electrofishing may need to be used.

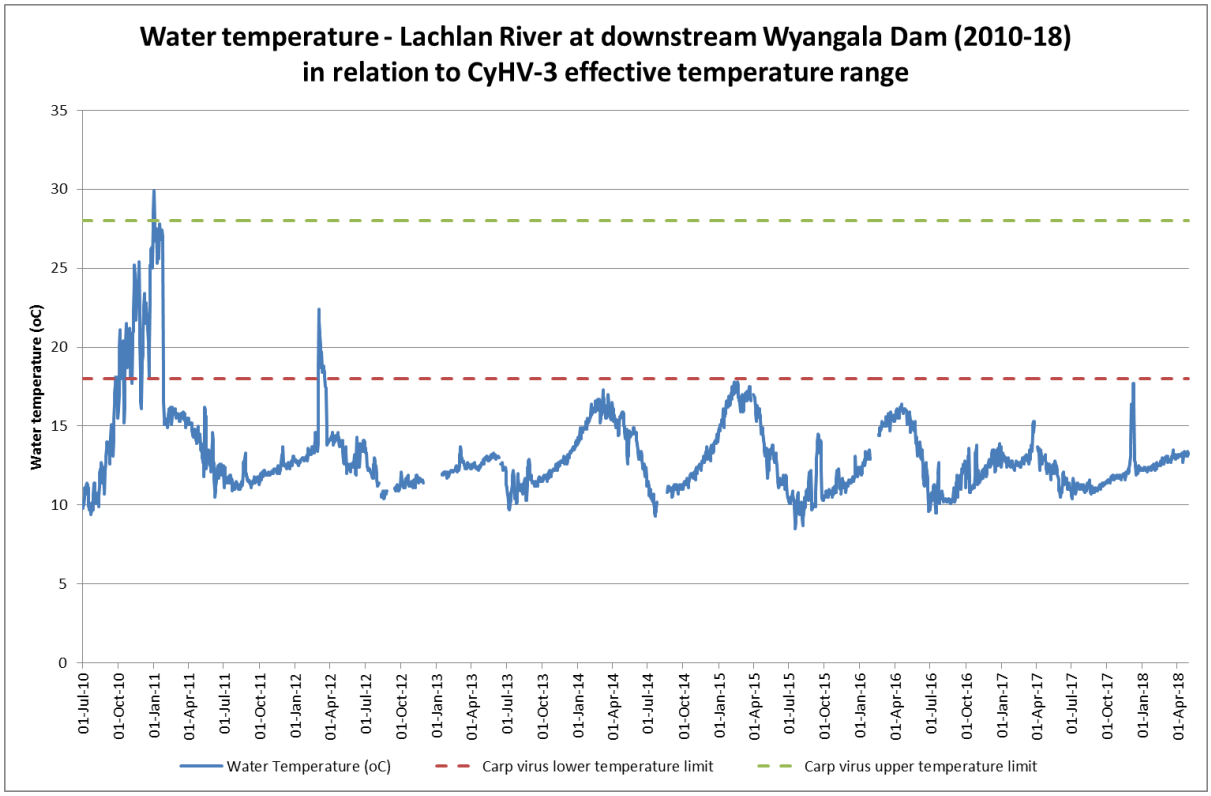

Figure 4 Water temperature downstream of Wyangala Dam in comparison with the permissive temperature range for Cyprinid herpesvirus 3 (CyHV-3) infection and disease.

8. Implementation strategy

8.1. Objectives

Implementation objectives for carp biocontrol have been developed from the NCCP Implementation Strategy. The objectives are:

- widespread reduction and suppression (for at least 5–10 years) of carp populations and the damage they cause in Australian aquatic ecosystems,
- management of environmental risks,
- management of risks to water quality for town water supply, stock and domestic water needs, irrigation, and cultural and recreational purposes, and

- effective and efficient virus deployment and carcass management, where the latter is required.

8.2. Outcomes

40-60% mortality in targeted carp subpopulations

NCCP modelling indicates that initial virus deployment into targeted carp subpopulations will cause disease outbreaks that reduce carp populations by 40–60% relative to their pre-deployment size.

Ongoing suppression of targeted carp subpopulations

NCCP modelling indicates that, following initial virus deployment and carp knockdown, targeted carp subpopulations will remain around 40–60% of pre-deployment densities for at least 10 years and potentially much longer, depending on the evolution of genetic resistance and/or emergence of herd immunity (see Technical Paper 2 for further discussion). Post-deployment carp suppression is expected to result from the combined effects of the initial knockdown and reactivation of latent infections (Technical Paper 2).

8.3. Catchment control area

The Lachlan catchment is large with a variety of different waterways. Catchment control areas will need to be decided to optimise the efficiency of operations. These areas will include forward control locations and central control locations.

Carp biocontrol operations for the entire Lachlan catchment could be managed through one Catchment Control Area (CCA) (Figure 4). Central command could be located in Forbes and forward commands could be located at Condobolin, Hillston, and Oxley. The Oxley forward command could be included in the Murrumbidgee CCA. Most operational activity will occur along the 300 kms of river between Forbes and Booligal.

8.4. Phases of implementation

NCCP implementation is proposed over a 10-year timeframe with activities primarily focussed in the first four years. Specific timings are dependent on implementation planning and adaptive management. The phases or periods of implementation include:

1. planning—one or two years of implementation planning before virus deployment,
2. operations (initial deployment)—two or three years of virus deployment and carcass management,
3. operations (post deployment)—five to seven years of significantly reduced operations and ongoing surveillance, and
4. completion.

The above phases occur sequentially however overlaps and delays between the different phases are expected (for example, suitable pre-conditions for deployment may take some time to eventuate).

Knocking the population down to a level where the impacts upon the environment are minimal appears achievable for the Lachlan catchment. Brown and Gilligan (2014) have suggested that the biomass density threshold for minimal adverse impacts upon aquatic ecosystems is 88 kg/ha (see also Technical Paper 1 for a discussion of carp ecological impacts).

8.5. Operations phase

8.5.1. Carp virus deployment strategy

If carp biocontrol were to proceed, the virus would be deployed into high-density carp populations above 100 kg/ha as shown at Figure 5 as a priority and potentially then through the whole catchment, except for areas where viral biocontrol is unlikely to be effective (e.g. river reaches affected by cold-water pollution). Tactical deployment is also possible given the disconnected characteristics of the Lachlan system.

The following sections of the Lachlan catchment would be targeted for CyHV- 3 deployment:

- Lachlan River and adjoining systems between Forbes and Booligal at numerous weir points,
- Lake Brewster,
- Lake Cargeligo,
- Booberoi Creek,
- Strategic locations on the Abercrombie River where carp aggregations are known to occur, and
- Strategic locations below Wyangala Dam and Carcoar Dam to Forbes where carp aggregations are known to occur. These areas can be affected by cold-water pollution when releases are occurring from dams, so biocontrol operations would need to occur outside these periods. water pollution.

These areas hold the Lachlan catchment's highest carp biomass and are also carp spawning sites. Risks in these areas can be managed with appropriate coordination and resourcing. These locations encompass more than 20 carp sub-populations.

Deployment needs to occur across as many aggregations as possible within each carp sub-population. Carp subpopulations have been mapped through the NCCP epidemiology research project (Durr et al., 2019).

Carp aggregations mostly occur:

- downstream of fish passage barriers (weirs and road crossings),
- in response to suitable spawning conditions (warm water in association with submerged aquatic plants or flooded terrestrial vegetation), and
- in response to fresh inflows into or out of non-flowing bodies of water (wetlands, lakes, lagoons, billabongs etc).

Artificial aggregations of carp can also be created by the use of bait or berley and by creating an artificial flow circulation (e.g. by pumping).

Flow is an important factor in creating aggregations and virus-release planning will need to incorporate the knowledge and expertise of local water managers (WaterNSW, OEH, DPI Water, Jemalong Irrigation, Lachlan Valley Water, Willandra Creek Water Users Association, Lower Lachlan Landcare Group). There may be opportunities to manipulate flow at a regional or local scale to promote aggregations of carp that could be targeted for virus release (depending on the virus-release strategy used). For example, releasing water into effluent or anabranch creeks such as Willandra or

Booberoi may encourage carp inhabiting refuge pools along in these creeks to move upstream to the regulator.

8.5.2. Carcass management strategy

Carcass management in the Lachlan catchment would focus on areas where the virus has been deployed into carp aggregations and where risks are highest. Operations more generally would focus on the 300 km zone between Forbes and Booligal (Figure 5).

The purpose of carcass management is to reduce the risk of significant adverse environmental and socio-economic impacts. The Lachlan catchment is large and includes numerous waterway types, many of which are remote and difficult to access. Clean-up operations will not be possible, or necessary, in all waterways. There are numerous, historical examples of large fish kills in the Lachlan catchment (and others) where no clean-up was undertaken without any significant adverse impact upon social, economic or environmental values. International experience following carp kills caused by CyHV-3 in the Rock River, Wisconsin, USA, was similar. As noted in Technical Paper 3, the extent to which water-quality issues are likely to occur following major carp kills is largely a function of carp density (kg/ha) and the extent to which river flow, wave action, and other processes prevent stratification in the water column.

Only a proportion of all carcasses may need to be removed from the river providing favourable flow conditions are available to maintain water quality. More carcasses may need to be removed from Lakes Brewster and Cargelligo, where flow is limited or non-existent. The following measures and tactics could be applied to manage risks

- strategic cross river booms to corral downstream moving carcasses into shore-based removal locations,
- containment booming and removal of carcasses from aggregations below weir pools, and
- regulation of Lake Brewster to isolate carp carcasses.

Workshops highlighted considerable opportunities to synchronise water regulation planning with potential virus deployment. Using water releases to assist with carcass management would reduce the need for costly and laborious manual carcass-removal activities.

Virus deployment needs to occur within the period from early/mid-October to mid/late-February (depending on the specific location within the catchment) to coincide with the optimal temperature range for infection and disease. Virus release could be programmed to take place according to the following considerations:

- prevailing hydrological conditions (wet, median, dry etc.),
- long range weather outlook (El Niño, La Niña),
- epidemiological modelling of virus transmission and effectiveness within the catchment,
- availability of resources to disseminate the virus and undertake carcass clean up, and
- practical experience in other catchments where the virus was released earlier.

The Christmas and New Year holiday period occurs in the middle of the optimal season for virus release. This creates challenges from two perspectives:

1. Availability of personnel to organise and undertake virus release and carcass clean up.
2. Potential conflict with peak waterway recreational and tourism usage.

Virus deployment would be managed as much as possible to avoid the possibility of 'peak kill' during the Christmas New Year holiday period.

Virus deployment, if possible, would ideally be targeted towards a moderately dry climatic period. Dry periods confer several advantages for virus deployment compared with wet periods including:

- likely concentration of carp resulting in better virus transmission throughout the population,
- reduced area of available habitat, meaning clean-up operations are less extensive, and
- reduced risk that large waterbird breeding events (which could be susceptible to failure if the birds are heavily reliant on carp as a food source, see Beckett et al. (2019)) will be occurring concurrently.

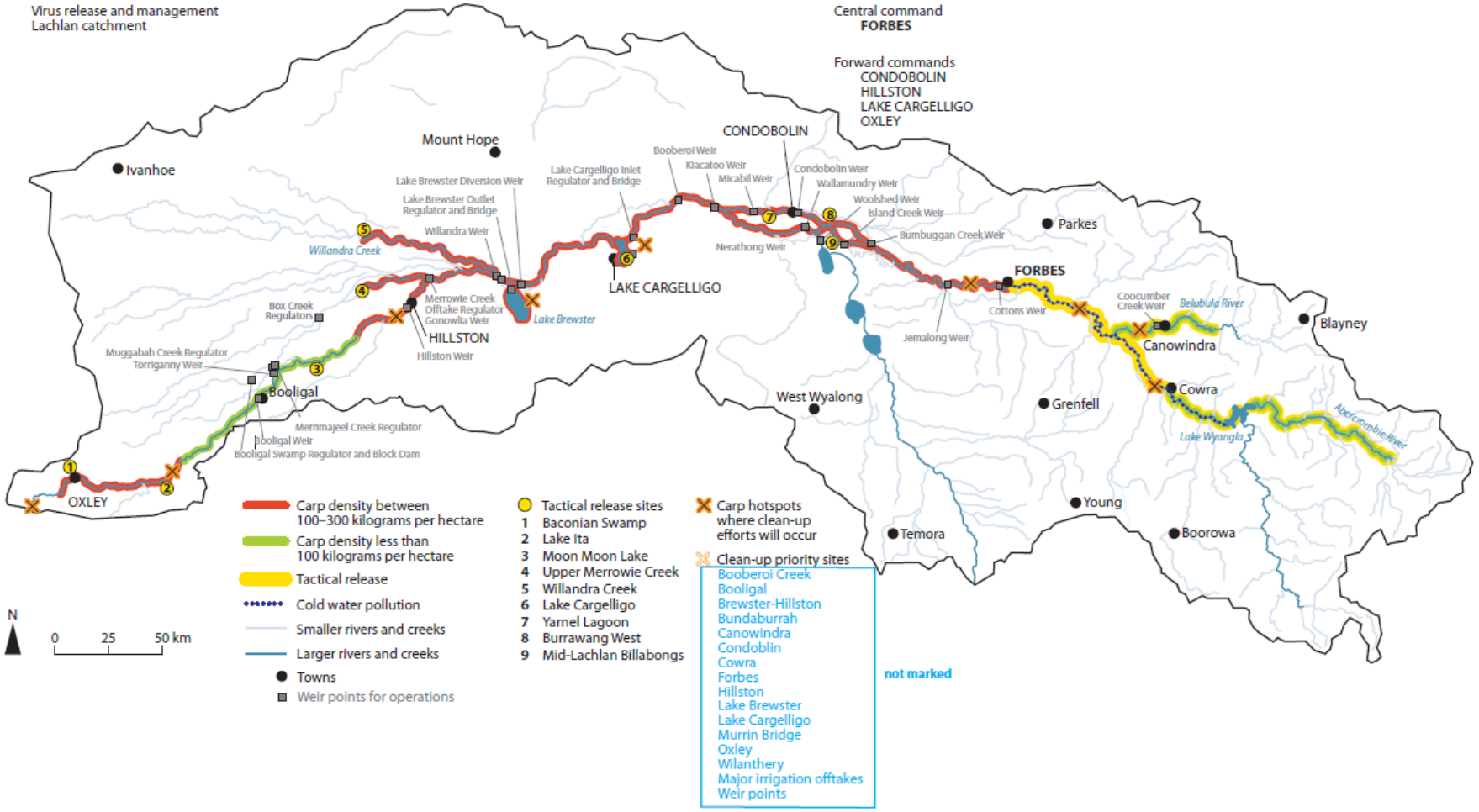

Figure 5: Potential carp biocontrol implementation in the Lachlan catchment

8.5.3. Priority carcass management locations

Workshops have highlighted priority carcass management locations as shown at Figure 5. In these locations, clean-up of carcasses may be required.

Social, environmental and economic features and values within or adjacent to waterways that could potentially be impacted by dead carp include:

- town water supply (TWS) weirs and intake pumps (where there is a risk of causing taste and odour problems in potable water and increasing treatment costs for water utilities),
- residential/urban/commercial areas (where there is a risk of offensive odours and impacts on aesthetics),
- recreation/tourist sites (where there is a risk of offensive odours and impacts on aesthetics and use of the waterway),
- threatened aquatic species habitat (where there is a risk of hypoxia causing death of gill breathing organisms and/or a risk of ammonia toxicity—see Technical Paper 3 for discussion).

The priority for carcass management will be determined by use of a decision matrix as illustrated at Table 4 which relates carcass biomass and proximity to sites where waterbody hypoxia, odour, aesthetics and water consumption issues are likely to occur. Four thresholds of live-carp biomass (less than 100 kg/ha, 100 to 250 kg/ha, 250 to 500 kg/ha and more than 500 kg/ha) and four thresholds of proximity (within/adjacent, less than 1 km, between 1 km and 5 km and more than 5 km) have been selected to help determine risk and therefore priority for carcass management.

The ecological community of fish and aquatic invertebrates in the Lachlan River catchment downstream of Wyangala Dam is listed as an Endangered Ecological Community (EEC) under the provisions of Part 7A of the *Fisheries Management Act 1994*. This effectively means that all native fish and aquatic invertebrates within the lower reaches of the river and associated tributaries are considered to be threatened. Similarly, several species or populations of fish within the Lachlan Catchment (including Macquarie Perch, Silver Perch, Olive Perchlet and Freshwater Catfish) are listed as threatened species or populations. Hypoxia due to large numbers of decomposing carp carcases poses a risk to these species. Consequently, locations where known populations of these species intersect with high carp densities will need to be identified and prioritised for clean-up.

There are thousands of private stock and domestic pumps on waterways throughout the Lachlan catchment. Individually targeted carcass-management operations would not be practical for all of these. Owners of such pumps will be encouraged to fill their tanks or dams prior to release of the virus to minimise the need to pump water when carp carcasses may be present in the waterway.

Forty (40) priority clean up locations are specified in Table 5. They are labelled with a map code in the format **LacPCS0XX** – i.e. **Lac**hlan **P**riority **C**arcass management **S**ite number **0XX**.

Table 4 Priorities for management of carp carcasses based of biomass and proximity to sensitive sites and values.

		Expected biomass of carcases in waterway			
		Very large (>500 kg/ha)	**Large (250-500 kg/ha)**	**Moderate (100-250 kg/ha)**	**Low (<100 kg/ha)**
Proximity to **Town Water Supply** (TWS) intake	Waterway is a 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** (risk of odour, impacts upon health, aesthetics etc)	Site is within or adjacent to urban/residential/commercial area	Very high	Very high	High	High
	Site is within 1km of an urban/residential/commercial area	Very high	High	Moderate	Low
	Site is within 5km of an urban/residential/commercial area	High	Moderate	Low	Low
	Site is more than 5km from an urban/residential/commercial area	Low	Very low	Very low	Very low
Proximity to **recreation or tourism area** (risk of odour, impacts upon health, aesthetics, recreation etc)	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
Risk of secondary **algal bloom** (from nutrients released from decomposing carcases)	Site is high risk for algal bloom (very low gradient, history of frequent blooms)	Very high	High	Moderate	Low
	Site is moderate risk for algal bloom (low gradient, history of blooms)	High	Moderate	Low	Very low
	Site is low risk for algal blooms (moderate to steep gradient, no history of blooms)	Moderate	Low	Very low	Very low

Table 5 Priority carcass management locations

Catchment	LGA	Waterway	Section or area	Map Code	Residential area	Recreation area	Tourist facility	Town Water Supply	Environmentally sensitive	Possible accumulation area (weir etc)	Other	Indicative length of bank or shoreline (km)	Indicative area of lake/pond (ha)	Boat based cleanup	Land based cleanup	Notes
Lachlan	Carrathool	Willandra Creek	Willandra Homestead & camp ground	LacPCS001		x	x			x		4			x	
Lachlan	Forbes	Bundaburrah Creek	Waterskiing area	LacPCS002		x						2		x	x	
Lachlan	Blayney	Belubula River	Upstream & downstream of Carcoar township	LacPCS003	x	x						5			x	
Lachlan	Cabonne	Mandagery Creek	Eugowra township	LacPCS004	x							2			x	
Lachlan	Cabonne	Belubula River	Upstream & downstream of Canowindra township	LacPCS005	x							3			x	
Lachlan	Carrathool	Lachlan River	Brewster Weir pool and Lake Brewster Inlet Regulator	LacPCS006		x			x	x			10	x	x	Olive Perchlet habitat
Lachlan	Carrathool	Lachlan River	Upstream & downstream of Hillston township	LacPCS007	x	x						3		x	x	

Catchment	LGA	Waterway	Section or area	Map Code	Residential area	Recreation area	Tourist facility	Town Water Supply	Environmentally sensitive	Possible accumulation area (weir etc)	Other	Indicative length of bank or shoreline (km)	Indicative area of lake/pond (ha)	Boat based cleanup	Land based cleanup	Notes
Lachlan	Carrathool	Mountain Creek	Brewster outlet regulator	LacPCS008						x			1	x	x	
Lachlan	Carrathool	Mountain Creek	Bensons Drop Weir	LacPCS009					x	x			1	x	x	Olive Perchlet habitat
Lachlan	Carrathool	Lachlan River	Hillston weir	LacPCS010						x			1	x	x	
Lachlan	Carrathool	Lachlan River	Willandra Weir	LacPCS011						x			2	x	x	
Lachlan	Carrathool	Lachlan River	Cargelligo Weir	LacPCS012		x			x	x		5		x	x	Olive Perchlet habitat
Lachlan	Cobar	Lachlan River	Booberoi Weir	LacPCS013		x		x		x		2		x	x	
Lachlan	Cobar	Lachlan River	Euabalong	LacPCS014	x							2			x	
Lachlan	Cobar	Lachlan River	Murrin Bridge	LacPCS015	x							2		x	x	
Lachlan	Cowra	Lachlan River	Wyangala village	LacPCS016	x	x						1			x	
Lachlan	Cowra	Lachlan River	Darbys Falls	LacPCS017		x						1			x	
Lachlan	Cowra	Lachlan River	Goologong township	LacPCS018	x							1		x	x	
Lachlan	Cowra	Lake Wyangala	Dam wall and outlet works	LacPCS019		x				x		3		x	x	
Lachlan	Cowra	Lake Wyangala	Wyangala Waters Holiday Park	LacPCS020		x						5		x	x	

Catchment	LGA	Waterway	Section or area	Map Code	Residential area	Recreation area	Tourist facility	Town Water Supply	Environmentally sensitive	Possible accumulation area (weir etc)	Other	Indicative length of bank or shoreline (km)	Indicative area of lake/pond (ha)	Boat based cleanup	Land based cleanup	Notes
Lachlan	Cowra	Lachlan River	Upstream & downstream of Cowra township	LacPCS021	x	x						5		x	x	
Lachlan	Forbes	Lake Forbes	All	LacPCS022	x	x						4	10	x	x	
Lachlan	Forbes	Gum Swamp/Lake	Southern shore	LacPCS023		x						1			x	Bird-watching hide
Lachlan	Forbes	Lachlan River	Upstream & downstream of Cottons Weir	LacPCS024		x				x			2	x	x	
Lachlan	Forbes	Lachlan River	Upstream & downstream of Jemalong Weir	LacPCS025		x				x			5	x	x	
Lachlan	Forbes	Goobang Creek	Goobang Creek weir	LacPCS026			x						5	x	x	Tourist development (Pickles)
Lachlan	Forbes	Lachlan River	Upstream & downstream of Forbes township	LacPCS027	x							5		x	x	

Catchment	LGA	Waterway	Section or area	Map Code	Residential area	Recreation area	Tourist facility	Town Water Supply	Environmentally sensitive	Possible accumulation area (weir etc)	Other	Indicative length of bank or shoreline (km)	Indicative area of lake/pond (ha)	Boat based cleanup	Land based cleanup	Notes
Lachlan	Hay	Lachlan River	Upstream & downstream of Booligal township	LacPCS028	x					x		2		x	x	
Lachlan	Hilltops	Boorowa River	Water supply weir	LacPCS029				x		x			10	x	x	
Lachlan	Hilltops	Boorowa River	Upstream & downstream of Boorowa township	LacPCS030	x							5			x	
Lachlan	Hilltops	Lake Wyangala	Adjacent to Grabine Lakeside State Park	LacPCS031		x						5		x	x	
Lachlan	Lachlan	Lake Cargelligo	Most of lake	LacPCS032	x	x						3	100	x	x	
Lachlan	Lachlan	Gum Bend Lake	All	LacPCS033		x						2	10	x	x	
Lachlan	Lachlan	Goobang Creek	Goobang Creek weir (in Condobolin)	LacPCS034		x				x		2		x	x	
Lachlan	Lachlan	Lachlan River	Micabil weir	LacPCS035		x		x		x		2		x	x	
Lachlan	Lachlan	Lachlan River	Kiacatoo Weir	LacPCS036		x				x		2		x	x	

Catchment	LGA	Waterway	Section or area	Map Code	Residential area	Recreation area	Tourist facility	Town Water Supply	Environmentally sensitive	Possible accumulation area (weir etc)	Other	Indicative length of bank or shoreline (km)	Indicative area of lake/pond (ha)	Boat based cleanup	Land based cleanup	Notes
Lachlan	Lachlan	Lachlan River	Condobolin township, Condobolin weir	LacPCS037	x	x	x			x		5		x	x	
Lachlan	Forbes	Lachlan River	Bedgerebong	LacPCS038	x	x						2		x	x	
Lachlan	Oberon	Burraga Dam (Thompsons Creek Dam)	Near dam wall and camping area	LacPCS039		x				x		2		x	x	
Lachlan	Parkes	Goobang Creek	Adjacent to city	LacPCS040	x	x						5			x	

8.5.4. Expected quantities of carcasses

GIS analysis indicates there is approximately 34,000 ha of waterway in the catchment including nearly 8,000 ha of linear waterway (fourth order and above creek, river and irrigation channel) plus 26,000 ha of lakes (more than half of which is within Lakes Cowal and Brewster). During extended dry periods, a large proportion (>70%) of this habitat would be dry.

In the Lachlan catchment, the Lake Cargelligo system is likely to represent the worst-case scenario. There is likely to be over 200 tonnes of carp in this system (1440 ha x 700 kg/ha). Assuming 10% are not affected by the virus and 10% are consumed by predators and 20% of the system is not cleaned up and 90% of carcases are collected, then around 100 tonnes of carp carcases will need to be collected and disposed of. If the carcases were to be buried, a trench 4 m wide by 2 m deep by 20 m long would be required.

It is also important to recognise that Carp will not all die simultaneously. Deaths are likely to occur over a period of four to six weeks with a peak around two weeks after release of the virus. Prior to any future virus release, more detailed calculations of biomass would need to be undertaken to help inform clean-up preparations.

8.5.5. Carcass management techniques

There are a range of methods for managing carp carcasses as shown below. Figure 6 shows some of the techniques.

Manipulating movement and distribution of live carp before CyHV-3 release:

- Manipulating river flow and water level, including the use of permanent infrastructure (e.g. weirs, wetland regulators) to promote aggregation and concentration of carp in targeted subpopulations into low risk locations.
- Manually removing carp (e.g. by netting or electrofishing) from targeted subpopulations in areas where viral biocontrol will not be effective (e.g. downstream of large dams where water temperature may be below the permissive range due to cold water releases).
- Manually removing carp from targeted subpopulations in areas where carp density and habitat traits pose risks to water quality.

Movement and distribution of infected live carp:

- Using permanent and temporary infrastructure (e.g. floating booms and nets) to restrict movement of infected live carp into areas or habitat types where water-quality impacts are more likely to occur and/or have serious consequences.
- Using permanent and temporary infrastructure to contain infected live carp in areas or habitat types where water-quality impacts are less likely to occur and/or have serious consequences.

Movement and distribution of carp carcasses and nutrients:

- Using regulated water flows and permanent infrastructure to assist the flushing of carp carcasses and nutrients.
- Using regulated flow conditions and permanent and temporary infrastructure to intercept and remove carp carcasses at strategic locations.
- Using regulated water flows and permanent and temporary infrastructure to divert carp carcasses away from locations where water-quality impacts are more likely to occur and/or have serious consequences.

- Using permanent and temporary infrastructure to contain carp carcasses in situ at locations where water-quality impacts are less likely to occur and/or have serious consequences.

Clean up and disposal of carp carcasses:

- Physically remove (clean up) carp carcasses from locations where their accumulation cannot be avoided and water-quality impacts are more likely to occur.
- Physically remove (clean up) carp carcasses at upstream strategic locations to mitigate downstream impacts.

Manipulating movement and distribution of live carp before CyHV-3 deployment:

- Manipulating river flow and water level, including the use of permanent infrastructure (e.g. weirs, wetland regulators) to promote aggregation and concentration of carp in targeted subpopulations.
- Manually removing carp (e.g. by netting or electrofishing) from targeted sub-populations in areas where CyHV-3 will not kill carp effectively (e.g. downstream of large dams where water temperature may be below the permissive range due to cold water releases).
- Manually removing carp from targeted subpopulations in areas where carp density and habitat traits pose risks to water quality, or in other areas where strategically effective.

Movement and distribution of infected live carp:

- Using permanent and temporary infrastructure (e.g. floating booms and nets) to restrict movement of infected live carp into areas or habitat types where water-quality impacts are more likely to occur and/or have serious consequences.
- Using permanent and temporary infrastructure to contain infected live carp in areas or habitat types where water quality impacts are less likely to occur and/or have serious consequences.

Movement and distribution of carp carcasses and nutrients:

- Using regulated water flows and permanent infrastructure to assist the flushing of carp carcasses and nutrients.
- Using regulated flow conditions and permanent and temporary infrastructure to intercept and remove carp carcasses at strategic locations.
- Using regulated water flows and permanent and temporary infrastructure to divert carp carcasses away from locations where water-quality impacts are more likely to occur and/or have serious consequences.
- Using permanent and temporary infrastructure to contain carp carcasses in situ at locations where water-quality impacts are less likely to occur and/or have serious consequences.

Strategic removal and disposal of carp carcasses:

- Physically remove carp carcasses from locations where their accumulation cannot be avoided and water-quality impacts are more likely to occur and/or have serious consequences.
- Physically remove carp carcasses from strategic locations (e.g. where carcass accumulation and / or ease of access facilitates collection, mitigating downstream impacts).

Mitigating impacts of decomposing carp carcasses:

- Aeration of waterways.
- Flushing of cyanobacterial blooms.
- Native fish breeding and restocking plans (focused on micro-endemic species, and noting that this measure could also address potential prey-switching impacts, as detailed by Beckett et al. (2019)).

No single technique will be suited to all waterway types and quantities of carcases. Waterway navigability as determined by waterway depth, presence of submerged and aquatic vegetation and snags, and proximity to waterway access points (boat ramps) will be the main determinants of which techniques can be utilised. Mechanical collection is likely to be most efficient and will be utilised wherever possible although it is likely to be limited to open, easily navigable waterways. Within the Lachlan catchment, Lake Cargelligo and parts of Lake Wyangala are likely to be the most suited to mechanical collection.

Table 6 Suitability of various carcass management techniques in relation to waterway type

	Waterway type							
Carcass collection techniques	**Small creek, irrigation drain, irrigation channel (unnavigable)**	**Large creek, (navigable for small vessels)**	**Large creek or river (navigable for large vessels)**	**Wetland (shallow water, heavily vegetated)**	**Lake or impoundment (open water)**	**Lake or Impoundment (dead trees)**	**Urban pond**	**Notes**
1. Manual, land-based collection with nets, hooks, gaffs etc. Manual handling into fish bins, bags etc.	✓	✓	✓	✓	✓	✓	✓	
2. Manual, boat-based collection with nets, hooks, gaffs etc. Manual handling into fish bins bags etc.	✘	✓	✓	✓	✓	✓	✓	
3. Boat-based collection with surface seine net. Mechanical bulk handling into skip bins.	✘	✘	✓	✘	✓	✘	✘	Requires semi-formal boat ramp and access for trucks and machinery to shoreline. Best suited to relatively clear and snag-free waterway with sufficient water depth for vessel operation.
4. Mechanical collection by “weed harvester” or “rubbish collector” vessel and mechanical bulk handling into skip bins.	✘	✘	✓	✘	✓	✘	✘	Requires formal boat ramp and access for trucks and machinery to shoreline. Best suited to clear and snag free waterway with sufficient water depth for vessel operation.
5. Vacuum truck or vessel.	✘	✘	✓	✘	✓	✘	✓	Trucks would require access to shoreline. Vacuums would suit situations where carcasses are washing downstream and accumulating as a solid mass against a weir or boom.

Aquatic weed harvester which could be adapted to collect carp carcasses.

Rubbish removal machine which could be adapted to collect carp carcasses.

Rubbish skimmer barge that could be adapted to collect carp carcasses.

Shore-based part manual, part mechanical clean up.

Manual boat-based clean up.

	Vacuum truck used to suck carcases out of the waterway.
 Boom across a river used to collect litter. Booms could be similarly used to concentrate carcases to enable easier collection.	 Boom deployed across the Georges River to contain fish carcases.
 Manual collection of dead carp.	 Disposal of dead carp to a constructed pit.

Figure 6 Examples of equipment and techniques that could be adopted depending upon the suitability of the waterway and the quantity of carcases.

8.5.6. Disposal of carcasses

Disposal of waste in NSW, including disposal of animal carcasses, is governed by the provisions of the *Protection of the Environment Operations Act 1997* (POEO Act) and the *Protection of the Environment Operations (Waste) Regulation 2014* (POEOW Reg). Activities listed in Schedule 1 to the *POEO Act* 1997 (e.g. composting, livestock processing activities, waste disposal and waste processing) require an environment protection licence if above the prescribed thresholds. The *Protection of the Environment Operations (Waste) Regulation* 2014 can be used to grant exemption from certain provisions of the POEO Act and the regulation itself.

Disposal of carp carcasses should be undertaken in parallel with the collection of the carcasses. Numerous carcass-disposal options exist. The availability of disposal methods will vary from area-to-area. Ready access to one or more disposal options that can be integrated with the collection of carcasses is likely to be a factor in selection of collection methods.

Potential disposal options for carp carcasses may include:

- deep burial using existing approved landfill site,

- deep burial using new greenfield site and construction,
- above-ground burial using existing approved landfill site,
- above-ground burial using new greenfield site and construction,
- rendering at a commercial facility,
- industrial disposal (e.g. power station),
- incineration at commercial facility,
- composting using existing approved facility or site,
- composting using greenfield or new site,
- leave lying on ground (nil treatment except remove from water), may be varied by ploughing/discing into ground,
- burning with solid fuel such as wood,
- burning with fuel such as coal, and/or
- commercial use (e.g. carp fertiliser).

The outcomes for some options may be enhanced by additional treatments. For example, increasing the surface area of carcass biomass by chipping or equivalent may enhance the outcomes from composting.

8.5.7. Selection of methods to dispose of carp carcasses

Selection of a disposal method should be on a case-by-case basis. An appreciation or similar decision-support tool and risk assessment should inform the decision to select disposal methods. Potential factors for selection of a disposal option(s) may include:

- existing availability and access to disposal option(s) and the need to develop greenfield options,
- predicted biomass of carp carcasses over time for disposal,
- cost including the immediate costs such as cost per tonne for use of existing facilities, construction costs for greenfield sites, and on-going long-term costs such as ground-water monitoring,
- local environmental affects that may be both positive and negative (this does not take account of long term affects such as contribution to climate change),
- lead time for preparation of the option,
- legislative requirements and approvals,
- resource needs and availability,
- risks including those relating to workplace health and safety, and
- social factors such as amenity and community support.

8.5.8. Beneficial use

Ideally, carcasses would be used for beneficial purposes wherever possible. However, beneficial use may not be possible in many areas due to absence of suitable facilities within reasonable cartage distance and/or inability to meet required standards (i.e. carcases have decomposed). The need to attain certain standards of freshness or limit daily quantities should not constrain clean-up activities.

Rendering or composting of animal carcases are activities that require an Environment Protection Licence under the provisions of the *POEO Act* if quantities exceed prescribed thresholds. There are eight business within or near the Lachlan catchment that are licenced for “rendering” or “composting”

and may be interested in taking quantities of carp carcasses. There may also be mobile processing facilities to process carcasses on site.

The Clean-up Coordinator would be responsible for contacting potential beneficial use businesses in the months prior to virus release to confirm:

- Their willingness and ability to accept carp carcasses,
- Standards for freshness and/or contaminants. For example, are partly decomposed fish acceptable or do they need to be fresh? Is inclusion of water, plant fragments, soil etc with the carp acceptable?
- Transport standards (to prevent odour issues within urban areas and spillage onto roads).
- Total and daily quantity limits.
- Delivery days and times.
- Responsibility for cartage costs etc.

8.5.9. Existing approved/licenced waste facilities

Most councils operate waste-disposal facilities and waste-transfer stations although some rely on regional facilities operated by private companies. Larger waste-disposal facilities are licenced under the POEO Act. Smaller facilities are generally not licenced since they receive less than the threshold quantity of waste per year.

Dead fish are classified as 'general solid waste (putrescible)' in accordance with Part 3 Division 1 of Schedule 1 of the POEO Act. Not all existing waste disposal facilities are approved to accept putrescible waste.

Facility operators will require advanced warning to ensure that the facility is configured and staffed to cope with a large quantity of carp carcasses over a short period of time. The Clean Up Coordinator will be responsible for contacting potential waste disposal facilities in the weeks and months prior to virus release to confirm:

- standards (e.g. carcases may need to be bagged to reduce the risk of spillage and odour),
- total and daily quantity limits,
- delivery dates and times, and
- Dumpage costs etc.

8.5.10. Constructed burial pits

Where carp carcasses cannot be used for a beneficial purpose and there is no approved landfill facility able to dispose of putrescible waste within a reasonable cartage distance, it will be necessary to construct burial pits. Guidelines for the construction of burial pits are provided in Appendix 1. Burial pits will only be located in previously disturbed areas including grazing and cropping paddocks well away from waterbodies to ensure there is minimal risk of impacts upon water quality, threatened fauna or flora and cultural heritage sites.

Construction of burial pits may require four to five hours of excavator work once the machinery is on-site. If burial pits are required, they need to be constructed soon after virus release to ensure they are ready to receive carcasses immediately

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Appendix 1 Guidelines for Disposing of deceased stock

From: https://www.dpi.nsw.gov.au/climate-and-emergencies/emergency/community/after-an-emergency/disposing-of-deceased-stock

After a natural disaster has passed through an area, landholders may have to dispose of deceased stock through burial.

When planning for on-farm burial there are several factors that need to be considered. These issues include the environmental, statutory controls, logistics and safety.

As a guide a burial site should be located:

- on heavier soil of low permeability and good stability,
- on elevated land but with a slope of less than 5% (preferably less than 2%),
- at least 200 metres from any surface water (creek, river, lake, spring, dam),
- greater than 200 metres from any ground water supply (stock and domestic bore),
- above the one in 100 year flood level,
- greater than 300 metres from any sensitive use (such as a neighbouring house),
- a safe distance from underground and above-ground infrastructure (such as a powerlines, telephone lines, gas lines, water pipes, sewerage), and
- well away from the view of the general public.

Pit construction should ensure:

- there is at least two metres from the base of the pit to the level of the water table,
- carcases are covered with at least two metres of soil, and
- where necessary, excavate cut-off drains up slope of the burial pit to direct surface run-off away from the pit.

Following deposition of the carcases into the pit, slightly mound pits after backfilling to allow for subsidence and promote runoff rather than infiltration.

Where possible, plan destruction activities close to the burial site so carcases can easily and safely be placed into the pit and plant machinery has safe access.

You should also consider any disturbance to threatened plants or animals during the operation. Unless it's absolutely critical it is preferable to ensure that carcases are not moved from one location to another.

Appendix 2 Town Water Supply systems within the Lachlan Catchment that could be potentially affected by water quality decline

Catchment	Population served	Residential connections	Annual Demand (ML/a)	Description of works	Water Utility	Treatment works Capacity (ML/day)	Type of Treatment Works	Dead carp likely to be an issue?
Lachlan	50	21	10	Intake on Lachlan River	Forbes Shire Council			Yes
Lachlan	1,211	587	224	Dam on Boorowa River	Boorowa Council	3	Lagoon sedimentation	Yes
Lachlan	65			Dam on Burraga Creek	Oberon Council			Yes
Lachlan	199			Intake on Western Bland Creek + rainwater tanks	Weddin Shire Council			Yes
Lachlan	2,800	1353	1223	Intake on Goobang Creek	Lachlan Shire Council	7.5	Conventional water treatment	Yes
Lachlan	8,700	4219	2840	Intake on Lachlan River near Cowra	Cowra Shire Council	29	Conventional water treatment	Yes
Lachlan	57	24	16	Intake on Lachlan River	Cowra Shire Council			Yes
Lachlan	153	74	44	Intake on Lachlan River at Eubalong	Cobar Shire Council	0.5		Yes
Lachlan	6,806	3293	1620	Intake on Lachlan River	Forbes Shire Council	26	Conventional water treatment	Yes
Lachlan	1996			BS from Central Tablelands supplemented by Bogolong Spring Dam on Ooma Creek	Weddin Shire Council			Yes
Lachlan	996	288	483	Intake on Lachlan River (regulated)	Carrathool Shire Council	10.4	Chlorination	Yes
Lachlan	1252	605	547	Intake on Lake Cargellico	Lachlan Shire Council	4.5	Dissolved Air Floatation,Microfiltration	Yes
Lachlan	10,880	5123	4002	Lake Endeavour & Beargamil Dams, Intake on Lachlan River	Parkes Shire Council	8.6	Conventional water treatment	Yes
Lachlan	299	145	131	Supplied from Forbes WS +	Lachlan Shire Council	1.1	Conventional water treatment,Lagoon sedimentation	Yes
Lachlan	51	22	15		Cowra Shire Council			Yes

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