Risk assessment and threat prioritisation: Bulloo, Paroo, Warrego and Nebine catchments

Stream and Estuary Assessment Program: June 2012

Water Planning Ecology
Department of Science, Information Technology, Innovation and the Arts

Queensland Government

Document history

Version	Date	Status	Key changes made	Author/s	Reviewer/s
1	15/6/2012	Draft	Initial development	Peter Negus, Alisha Steward, Sara Clifford, Joanna Blessing	
2	9/7/2012	Draft	DSITIA template	Peter Negus	
	1/08/2012	Draft	Content added	Alisha Steward	

Prepared by: Peter Negus[1], Alisha Steward[1], Joanna Blessing[1], Sara Clifford[1], Delwyn Hansen[2] and Ben Hammill[2]

[1]Water Planning Ecology, Department of Science, Information Technology, Innovation and the Arts

[2]Department of Natural Resources and Mines

© The State of Queensland 2012

Disclaimer

This document has been prepared with all due diligence and care, based on the best available information at the time of publication. The department holds no responsibility for any errors or omissions within this document. Any decisions made by other parties based on this document are solely the responsibility of those parties. Information contained in this document is from a number of sources and, as such, does not necessarily represent government or departmental policy.

Citation

Negus P, Steward A, Blessing J, Clifford C, Hansen D & Hammill B. 2012. Stream and Estuary Assessment Program Risk Assessment and Threat Prioritisation: Warrego, Paroo, Bulloo and Nebine catchment.Brisbane: Department of Science Information Technology, Innovation and the Arts, Queensland Government.

Table of contents

Background

The Stream and Estuary Assessment Program (SEAP) is an enhanced monitoring program for the assessment and reporting of ecological condition for Queensland aquatic ecosystems. The intention of the program is to implement best-practice approaches for aquatic ecosystem monitoring, assessment and reporting, within the constraints of the resources available to the program and the environment being assessed. This is achieved partly by learning from other programs and adopting, adapting or developing operationally efficient and statistically rigorous approaches to address each component step in the monitoring and assessment framework (Figure 1).

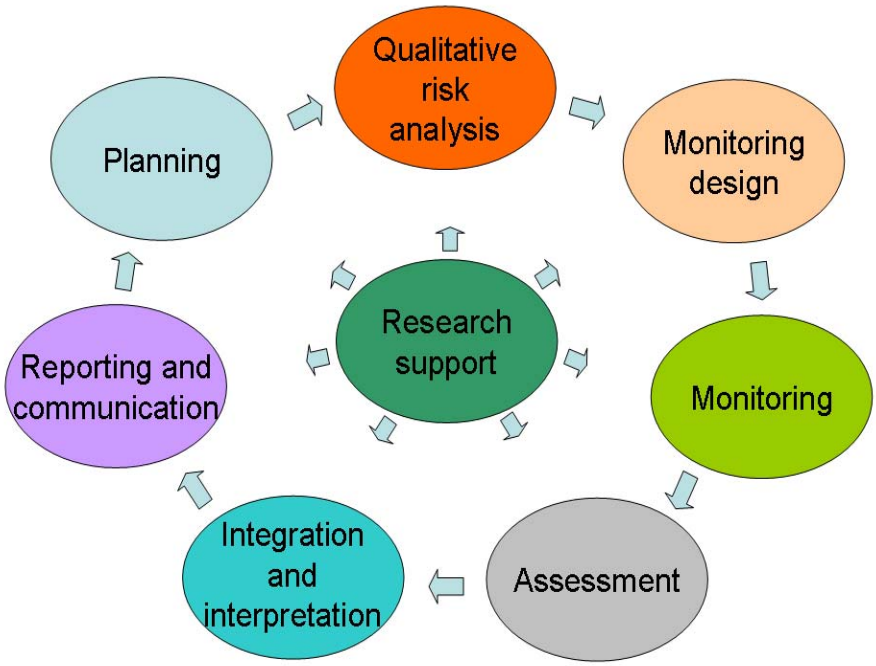

Figure 1. Monitoring and assessment framework summary

The riverine component of SEAP initially uses a risk assessment approach to identify key threats for targeted assessment. The selection of indicators is based on the results of the risk assessment and the Pressure-Stressor-Ecological Response (PSR) conceptual understanding of aquatic ecosystems. SEAP aims to integrate current monitoring, assessment and reporting programs, validating and building on current knowledge of threatening processes to ecosystem condition. The objectives of SEAP are to:

1. Report on the overall condition of the State's aquatic ecosystems based on a PSR risk assessment framework;
2. Report on how the condition of the State's aquatic ecosystems is changing over time;
3. Improve our understanding of ecosystem processes and threats; and
4. Guide natural resource management decision making processes

The inclusion of threatening processes to a condition assessment program is to identify what broad-scale natural resource management issues are current and emerging. These interpretations are based on relationships defined by the current understanding of ecosystem processes and concepts. Conceptual models describing this understanding are used to frame ecosystem processes into major components: human pressures, physical/ chemical/ biological stressors and ecological responses. Fifteen broad-scale generic threats (defined as an unnatural change in a stressor) have been identified as applicable threats to Queensland river ecosystems (Table 1). The importance of individual threats will differ across Queensland due to the highly variable processes, functioning and ecological structures of the state's riverine ecosystems. Generic state-wide conceptual models (Marshall et al 2006b) are used to guide interpretation and understanding of potentially relevant threats to a focused reporting region.

Table 1. List of threats applicable to Queensland aquatic ecosystems

Threats
Acid soil runoff
Climate Change
Direct biota removal or disturbance
Flow management
Instream habitat removal or disturbance (Instream disturbance /Instream Connectivity)
Instream pest species (Instream Pest Flora/Instream Pest Fauna)
Nutrients
Organic Matter
Pathogens
Riparian habitat removal or disturbance (Riparian disturbance /Riparian Habitat Connectivity
Riparian pest species (Riparian Pest Flora/Riparian Pest Fauna)
Salinity
Sediments (Suspended/Deposited)
Thermal Alteration
Toxicants (Pesticides)

A qualitative risk analysis is a major component of the monitoring and assessment framework (Figure 1). This risk analysis is aimed at prioritising threats in a focus region. The process used is to compile all available information related to the generic threats in the reporting area being assessed and use expert opinion to provide information where there are gaps in understanding. This process also identifies relevant sub-threats or additional threats to the focus region. Surveys are used to obtain opinions from scientific experts and natural resource managers, with results providing risk scores for all relevant threats. Risk scores are used to prioritse the threats in the reporting area and guide further monitoring and investigation. All risk scores have asscoiated confidence scores which are used to identify current lack in knowledge.

Previous SEAP assessments have used 'freshwater biogeographic provinces' as the reporting scale. However, as the SEAP Framework (Negus et al. 2009) is applicable at any scale, the current assessment is being undertaken at the river catchment scale to coincide with and enhance ecological assessments for the ten-year review of the Warrego, Paroo, Bulloo and Nebine Water Resource Plan. This report details the activities and results from reviews of information; surveys; risk assessment and threat prioriotisation undertaken on these selected catchments (Figure 2).

This report details the activities and results from reviews of information; surveys and risk assessment and prioriotisation undertaken on the Bulloo, Paroo, Warrego and Nebine catchments (Figure 2).

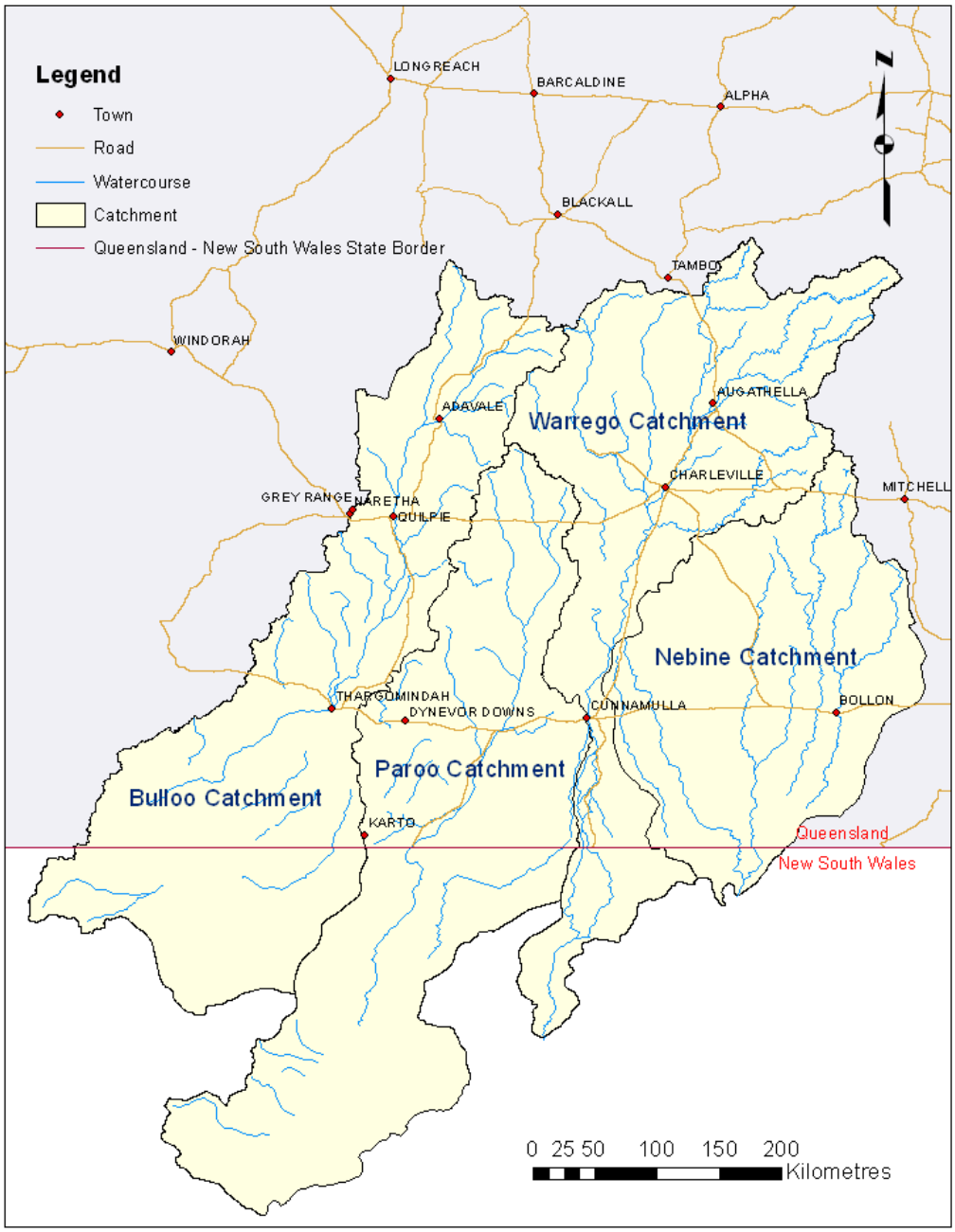

Figure 2. Bulloo, Paroo, Warrego, and Nebine catchments

Methods

Ecological risk is defined for the program as the probability of an undesirable effect on the aquatic ecosystem condition occurring as a result of human activities. Qualitative risk assessments for SEAP derive a value for risk as the product of two measures:

- likelihood of a change in a generic stressor being applicable in a province; and
- the ecological consequence of a change to a model stressor.

The risk scores are used to rank and prioritise the relative importance of threats for the focus region (Figure 3). Confidence in both scoring the likelihood and consequence is recorded and used to identify gaps in current understanding of threats in the province. In cases where consequence and likelihood scores from surveys conflict with available current information, adjustments are made. Monitoring and further investigation is used to confirm the importance of the threats in the reporting areas - a validation process. A trade-off between potential monitoring activities and the resources available is then applied. Data collected from this further investigation takes the form of a more quantitative assessment on risk to condition and condition assessments of those prioritised stressors. The overall confidence scores are used to direct further research.

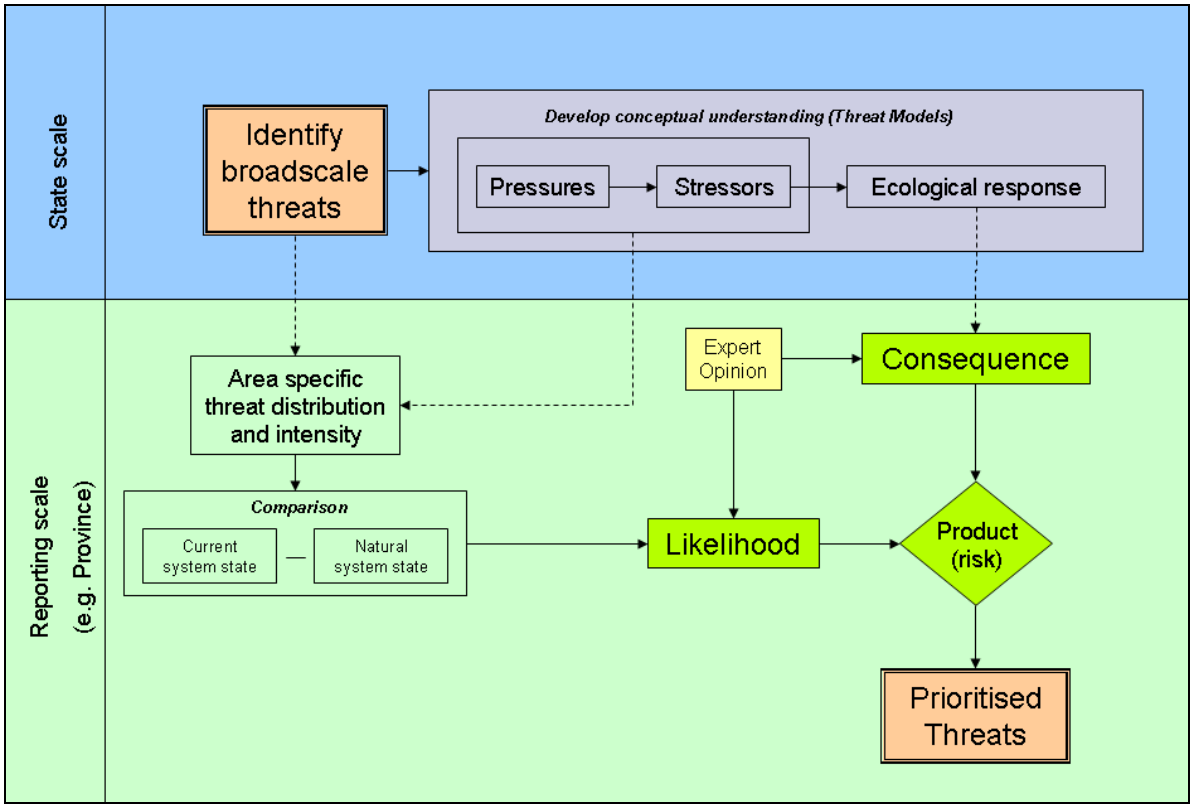

Figure 3. The process for prioritising threats to rivers in Queensland

Risk assessment scoring

A range of experts with knowledge of riverine ecosystems in the reporting areas were approached to contribute their expertise on priority threats. Participants (Appendix B) were asked to provide their expertise by completing a survey table (Appendix C). There was no requirement to complete the entire table and it was dependent on each expert's perceived knowledge and willingness to make a judgement on threatening processes. A combination of survey results and current information sources (compiled by staff from the Water Planning Ecology Unit of DSITIA and Planning staff from Natural Resources and Mines) was used in a final review of each threat. The final review provides a consensus on the risk of each threat to the selected Murray Darling and Bulloo catchment rivers and is the final scores presented in the results.

Likelihood and consequence was scored on a five point scale (Tables 2 and 3) and the confidence of each measure scored on a 3 point scale (Table 4). Risk is calculated as the product of the likelihood and consequence scores, with consequence considered first and likelihood considered in the context of the consequence happening. The assessment was at the catchment scale only; meaning if a threat only occurs in a particular waterhole or sub-catchment then the level of likelihood for the catchment is lower. This could be approached by considering a number of random spots throughout the catchment and considering if the threat is likely to occur anytime at each spot.

Table 2. Consequence scoring definitions

Consequence categories	Score	Definition
Insignificant	1	Negligible / undetectable ecosystem response
Minor	2	Detectable but not of concern – i.e. minor reduction in species abundance, change in food resource availability
Moderate	3	Obvious and of concern – i.e. change in community structure (local loss of rare and sensitive species), moderate habitat disturbance
Major	4	Functional change in the ecosystem – including loss of functional groups, major changes in food resources and food webs
Catastrophic	5	Reporting scale loss of species, dramatic changes to communities, dramatic changes to functions etc., replaced with generalists, exotic biota, etc.

Table 3. Likelihood scoring definitions

Likelihood categories	Score	Definition
Almost certain	5	Is expected to occur in most circumstances – i.e. will be evident anywhere in the reporting area
Likely	4	Will probably occur in most circumstances – i.e. has a high probability to occur anywhere in the reporting area
Moderately likely	3	Could occur anywhere in the reporting area
Unlikely	2	Could occur but not expected
Rare	1	Occurs only in exceptional circumstances

Table 4. Confidence scoring definitions

Confidence categories	Score	Definition
High	3	Are very confident of the score and can back this with collected information and anecdotal evidence to support the scores applicability across the reporting area
Medium	2	Have some confidence in the score but knowledge may not be across the reporting area and the collected information and other evidence to support this is not complete
Low	1	Are not confident with the score due to a lack of scientific information and other evidence available and / or little expertise on the area of concern

The final risk assessment scores have been categorised by importance for consideration (Table 5). High risk scores are those considered as being essential to further investigation in monitoring and assessment. Moderate risk scores are those that should be considered for inclusion in monitoring and assessment depending on resources available. Low risk scores are those threats that will produce moderate or minor consequences or are only moderately likely or unlikely to occur.

Table 5. Risk matrix highlighting moderate risk (yellow) and high risk (orange) categories and corresponding scores. Low risk scores are not highlighted

		Consequence				
		Insignificant	Minor	Moderate	Major	Catastrophic
Likelihood		(1)	(2)	(3)	(4)	(5)
Almost Certain	(5)	5	10	15	20	25
Likely	(4)	4	8	12	16	20
Moderately Likely	(3)	3	6	9	12	15
Unlikely	(2)	2	4	6	8	10
Rare	(1)	1	2	3	4	5

Results

The consequence, likelihood, respective confidences, total score (consequence x likelihood), and the sum confidence (consequence confidence + likelihood confidence), produced by the final review are shown in Table 6. The range of scores and number of contributing survey responses that have been calculated for each threat are listed in Appendix D.

Table 6. Final prioritisation and risk scores for threats (Coloured risk scores based on high and moderate risk from table 5; coloured confidence scores based on risks with combined confidence score of 2)

Threats	Warrego						Paroo						Bulloo						Nebine					
	Consequence	Confidence (consequence)	Likelihood	Confidence (likelihood)	Risk	Sum of confidences	Consequence	Confidence (consequence)	Likelihood	Confidence (likelihood)	Risk	Sum of confidences	Consequence	Confidence (consequence)	Likelihood	Confidence (likelihood)	Risk	Sum of confidences	Consequence	Confidence (consequence)	Likelihood	Confidence (likelihood)	Risk	Sum of confidences
Instream pests: All	3.8	2.1	4.5	2.4	16.9	4.5	3.8	2.2	4.6	2.6	17.2	4.8	4.0	2.0	4.2	2.3	16.7	4.3	3.8	2.0	3.8	2.2	14.7	4.2
Instream pests: Carp													5.0	3.0	3.0	3.0	15.0	6.0						
Instream pests: Goldfish and Gambusia													3.0	3.0	5.0	3.0	15.0	6.0						
Deposited sediment	5.0	1.9	2.9	1.8	14.5	3.7	5.0	1.9	2.9	1.8	14.5	3.7	5.0	1.9	2.9	1.8	14.5	3.7	5.0	1.9	2.9	1.8	14.5	3.7
Riparian pests	3.0	2.3	4.0	2.3	12.0	4.7	3.1	2.1	4.1	2.1	13.0	4.3	3.0	2.0	3.8	2.0	11.4	4.0	3.0	2.2	3.8	2.3	11.5	4.5
Riparian weeds	3.0	2.3	3.4	2.4	10.3	4.7	3.0	2.4	3.3	2.4	9.9	4.9	3.0	2.3	3.3	2.3	10.0	4.7	2.8	2.5	3.7	2.5	10.4	5.0
Hydrology: waterhole persistence	5.0	1.0	2.0	1.0	10.0	2.0	5.0	1.0	2.0	1.0	10.0	2.0	5.0	1.0	2.0	1.0	10.0	2.0	5.0	1.0	2.0	1.0	10.0	2.0
Riparian disturbance	3.2	2.2	2.7	2.1	8.5	4.3	3.0	2.2	2.1	2.2	6.3	4.4	3.0	2.0	2.4	2.1	7.3	4.1	3.1	2.0	3.0	1.9	9.4	3.9
Suspended sediment	2.3	2.0	3.2	2.4	7.4	4.4	2.6	1.9	3.5	2.6	9.1	4.5	2.3	2.0	3.1	2.4	7.2	4.4	2.1	2.0	3.0	2.2	6.3	4.2
Nutrients	2.5	2.1	2.6	2.0	6.6	4.1	2.4	2.0	2.1	1.9	5.2	3.9	2.8	1.8	2.4	2.0	6.7	3.8	2.8	1.7	2.5	2.0	7.1	3.7
Biota removal	2.7	2.2	2.8	2.4	7.5	4.6	2.9	2.0	2.8	2.3	8.1	4.3	2.8	2.0	2.2	2.2	6.2	4.2	2.8	2.0	2.3	2.3	6.2	4.3
Climate change	2.5	1.5	3.5	1.5	8.8	3.0	2.4	1.6	3.2	1.6	7.7	3.2	1.7	1.7	3.7	1.3	6.1	3.0	2.7	1.7	3.7	1.3	9.8	3.0
Hydrology: waterhole level fluctuation	3.0	1.0	2.0	1.0	6.0	2.0	3.0	1.0	2.0	1.0	6.0	2.0	3.0	1.0	2.0	1.0	6.0	2.0	3.0	1.0	2.0	1.0	6.0	2.0
Organic matter	2.8	1.8	2.6	1.8	7.3	3.6	2.8	1.7	2.0	1.8	5.7	3.5	3.0	1.5	2.0	1.8	6.0	3.3	2.5	1.5	2.3	1.8	5.6	3.3
Hydrology: flow regime general	3.4	2.1	2.6	2.1	8.9	4.3	4.0	2.5	2.1	2.3	8.5	4.8	3.3	2.2	1.7	2.2	5.6	4.3	3.3	2.0	2.7	1.7	8.9	3.7
Pathogens	2.8	1.6	2.0	1.6	5.6	3.2	2.5	1.7	1.7	1.7	4.2	3.3	3.0	1.5	1.8	1.5	5.3	3.0	3.0	1.5	2.0	1.5	6.0	3.0

Threats	Warrego						Paroo						Bulloo						Nebine					
	Consequence	Confidence (consequence)	Likelihood	Confidence (likelihood)	Risk	Sum of confidences	Consequence	Confidence (consequence)	Likelihood	Confidence (likelihood)	Risk	Sum of confidences	Consequence	Confidence (consequence)	Likelihood	Confidence (likelihood)	Risk	Sum of confidences	Consequence	Confidence (consequence)	Likelihood	Confidence (likelihood)	Risk	Sum of confidences
Hydrology: connectivity	3.5	2.2	2.6	2.0	8.9	4.2	3.2	2.1	1.8	2.1	5.7	4.2	3.3	2.3	1.6	2.1	5.2	4.4	3.5	2.0	2.7	2.0	9.3	4.0
Hydrology: Interbasin transfer	5.0	3.0	1.0	2.0	5.0	5.0	5.0	3.0	1.0	2.0	5.0	5.0	5.0	3.0	1.0	2.0	5.0	5.0	5.0	3.0	1.0	2.0	5.0	5.0
Hydrology: seasonality	3.0	1.5	1.5	2.0	4.5	3.5	3.0	2.0	1.0	3.0	3.0	5.0	3.0	1.5	1.5	2.0	4.5	3.5	3.0	2.0	1.0	3.0	3.0	5.0
Instream habitat disturbance	3.0	2.3	2.0	2.3	6.0	4.6	2.8	2.5	1.3	2.6	3.5	5.1	2.7	2.2	1.7	2.3	4.4	4.5	2.9	2.1	2.0	1.9	5.7	4.0
Instream weeds	2.3	1.9	2.1	1.7	4.9	3.6	2.6	2.0	1.9	2.0	4.8	4.0	2.4	2.0	1.8	2.0	4.3	4.0	2.5	1.8	1.8	1.3	4.6	3.2
Acid soil runoff	3.2	1.5	1.6	1.6	5.1	3.1	2.9	1.7	1.3	1.8	3.8	3.5	2.8	1.6	1.5	1.8	4.2	3.4	2.8	1.6	1.4	1.6	3.9	3.2
Hydrology: Longitudinal connectivity	4.0	2.0	1.0	2.0	4.0	4.0	4.0	2.0	1.0	2.0	4.0	4.0	4.0	2.0	1.0	2.0	4.0	4.0	4.0	2.0	1.0	2.0	4.0	4.0
Hydrology: high flow change	3.5	1.5	1.5	2.0	5.3	3.5	3.5	1.5	1.0	1.5	3.5	3.0	3.5	1.0	1.0	1.0	3.5	2.0	3.5	1.0	1.0	1.0	3.5	2.0
Salinity	2.8	1.6	2.0	1.6	5.6	3.2	3.0	1.7	1.3	1.7	4.0	3.3	2.3	1.5	1.5	1.5	3.4	3.0	2.3	1.5	2.0	1.5	4.5	3.0
Toxicants	2.7	1.9	1.9	1.7	5.0	3.6	2.9	1.9	1.1	2.0	3.2	3.9	2.7	1.8	1.2	1.8	3.1	3.7	2.7	1.8	1.5	1.7	4.0	3.5
Hydrology: floodplain inundation	3.0	3.0	2.0	3.0	6.0	6.0	3.0	3.0	1.0	3.0	3.0	6.0	3.0	3.0	1.0	3.0	3.0	6.0	3.0	3.0	1.0	3.0	3.0	6.0
Hydrology: In-channel flow variability	3.0	2.0	2.0	2.0	6.0	4.0	3.0	2.0	1.0	2.0	3.0	4.0	3.0	2.0	1.0	2.0	3.0	4.0	3.0	2.0	1.0	2.0	3.0	4.0
Thermal alteration	2.0	1.7	1.4	1.7	2.9	3.4	2.0	1.8	1.1	1.9	2.3	3.6	2.0	1.7	1.0	1.7	2.0	3.3	2.0	1.5	1.2	1.5	2.3	3.0

Information on priority threats

During the development of this risk assessment a large amount of information was gathered on all threats that have been considered. We have tried to interpret this information for each catchment assessment, however in many cases this information pertained to the Murray Darling Basin generally. Where this generalisation has occurred we have considered in the context of potentially all catchments. The following sections present a summary of the findings for each of the priority threats in Table 6 (i.e. those threats with an orange or yellow coloured cell).

Instream pest fauna

The review of available information on the threat of instream pests identified 4 species of concern to the Bulloo, Paroo, Warrego and Nebine catchments. Table 7 indicates the catchments where the presence of each of these 4 species has been recorded or has the potential to be found. The review has compiled a number of references pertaining to these species which are listed under each section below.

Table 7. Presence of instream pest fauna species in the 4-pack catchments

Species	Bulloo	Paroo	Warrego	Nebine
Cyprinus carpio (European carp)	NO (High potential)	YES	YES	YES
Gambusia holbrooki (Eastern mosquitofish)	YES (expert review)	YES	YES	YES (expert review)
Carassius auratus (Goldfish)	YES (expert review)	YES	YES	YES (expert review)
Cherax quadricarinatus (Redclaw crayfish)	NO (high potential)	NO	NO	NO

European carp

European carp (*Cyprinus carpio*) are taxonomically placed into the Family Cyprinidae, which originates from China and has spread throughout Asia. Three different varieties of carp have been introduced to and established in Australian waters. These are the common or European carp (generally referred to as 'carp'), the mirror carp and the koi carp. All of these varieties are the same species and all declared noxious in Queensland. Carp have been identified across the Murray-Darling Basin – see Figure 4 (Lintermans 2007) and Figure 5, where they can comprise up to 20-30 % of total fish population. Currently the the Bulloo River is thought to be carp-free, however there is a high potential for dispersal into this catchment from the neighbouring Paroo, which at times of extreme high flows is connected hydrologically. Interbasin transfer of water to the Bulloo also has the potential to transfer carp, however the likelihood of this happening is unknown.

Carp are a large, long-lived and rapidly-growing species which are tolerant of a wide range in environmental conditions including those in habitats that are highly degraded. While there is no

direct evidence of competition or predation with / on native fish species, these characteristics would indicate that their ability to consume large amounts of food resources has the potential to impact on native species. This, combined with their destructive bottom-feeding habits that lead to increased turbidity and benthic disturbance (Department of Agriculture, Fisheries and Forestry 2012a), identifies carp as having economic costs to tourism, fishing, agriculture and water industries and degraded environmental values.

Carp are also carriers of anchor worm, *Lernaea cyprinacea*, which in heavy infestations may prevent spawning and can be fatal for large adult Murray Cod and Golden Perch larvae (Booringa Shire Council 2005).

Carp are declared noxious in Queensland (*Fisheries Act 1994*, *Fisheries Regulation 1998*). It is unlawful to possess carp alive or dead, or to use them as bait, and it is illegal to place or release carp alive or dead into Queensland waterways. Penalties of up to $200,000 apply (Department of Agriculture, Fisheries and Forestry, 2012a).

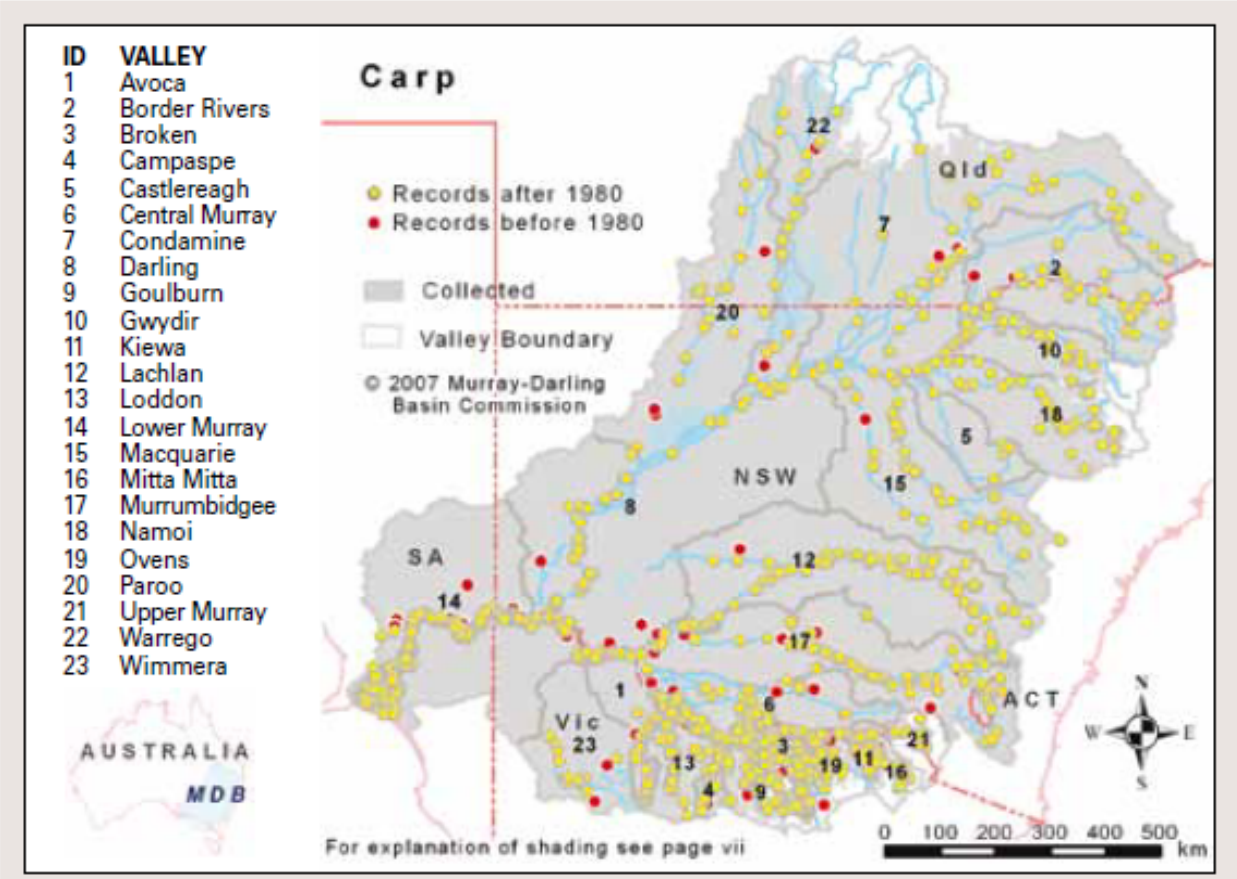

Figure 4. Distribution of European carp in the Murray-Darling catchments (taken from Lintermans 2007)

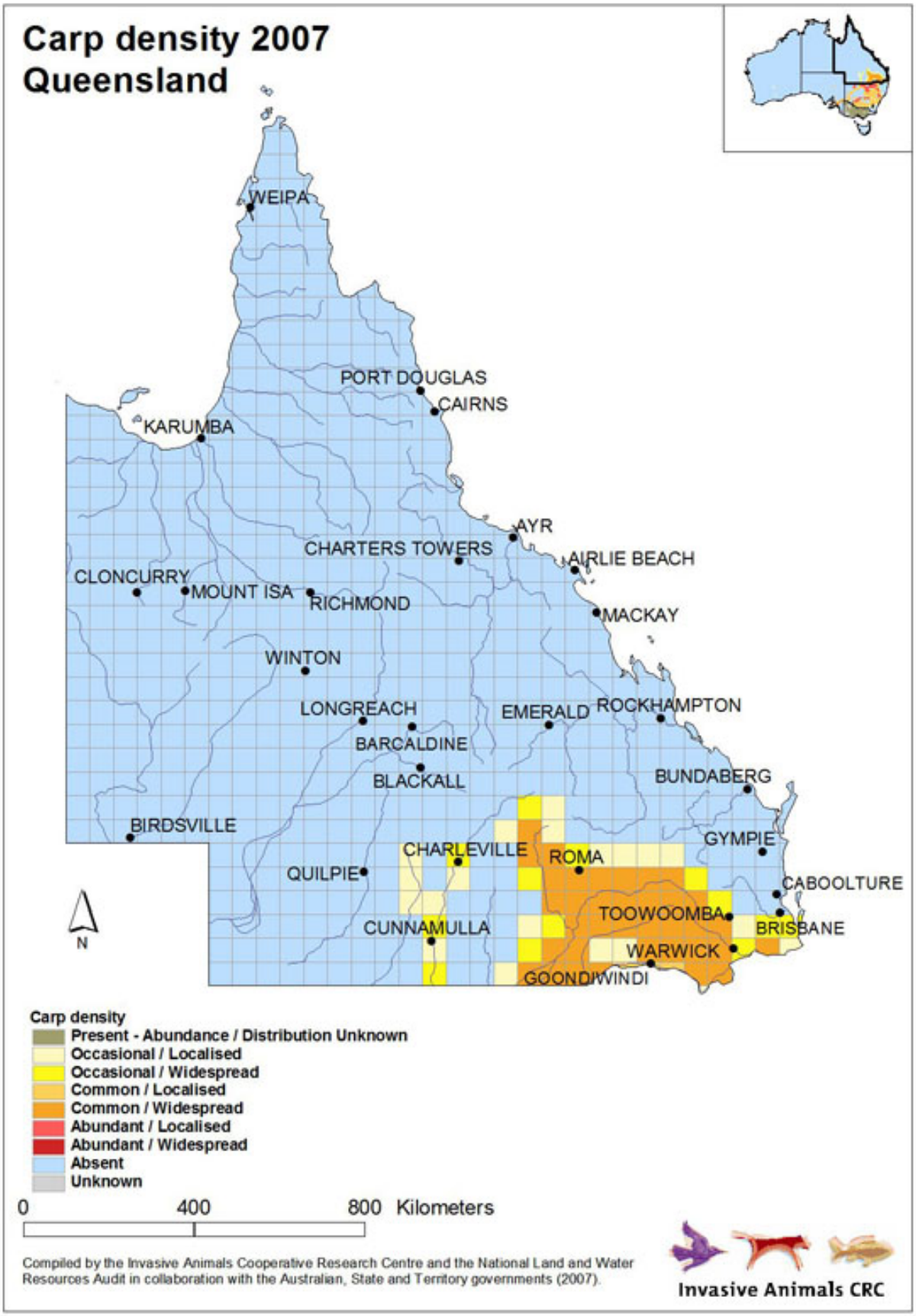

Figure 5. Distribution of European carp in Queensland (Invasive Animals CRC 2007)

Goldfish

Introduced to Australia from Asia over a century ago, goldfish (*Carassius auratus*) are a popular aquarium species. Since released into the wild, these species have colonised many freshwater ecosystems in southern Australia. Their distribution now extends to south-east, south-west and central Queensland – see Figure 6. They have been recorded from all 4 catchments being investigated in this report. Goldfish originate in sub-tropical waters but prefer cooler conditions. They have a varied diet with aquatic plants, macroinvertebrates and detritus commonly consumed. They are long-lived (30 years), a relatively large species (up to 45 cm) and range in colour from a silver appearance to black and yellow or even mottled.

Goldfish are often mistaken for carp but do not have the characteristic barbels of carp and have been generally regarded as having few, if any, impacts to aquatic ecosystems (Lintermans 2007).

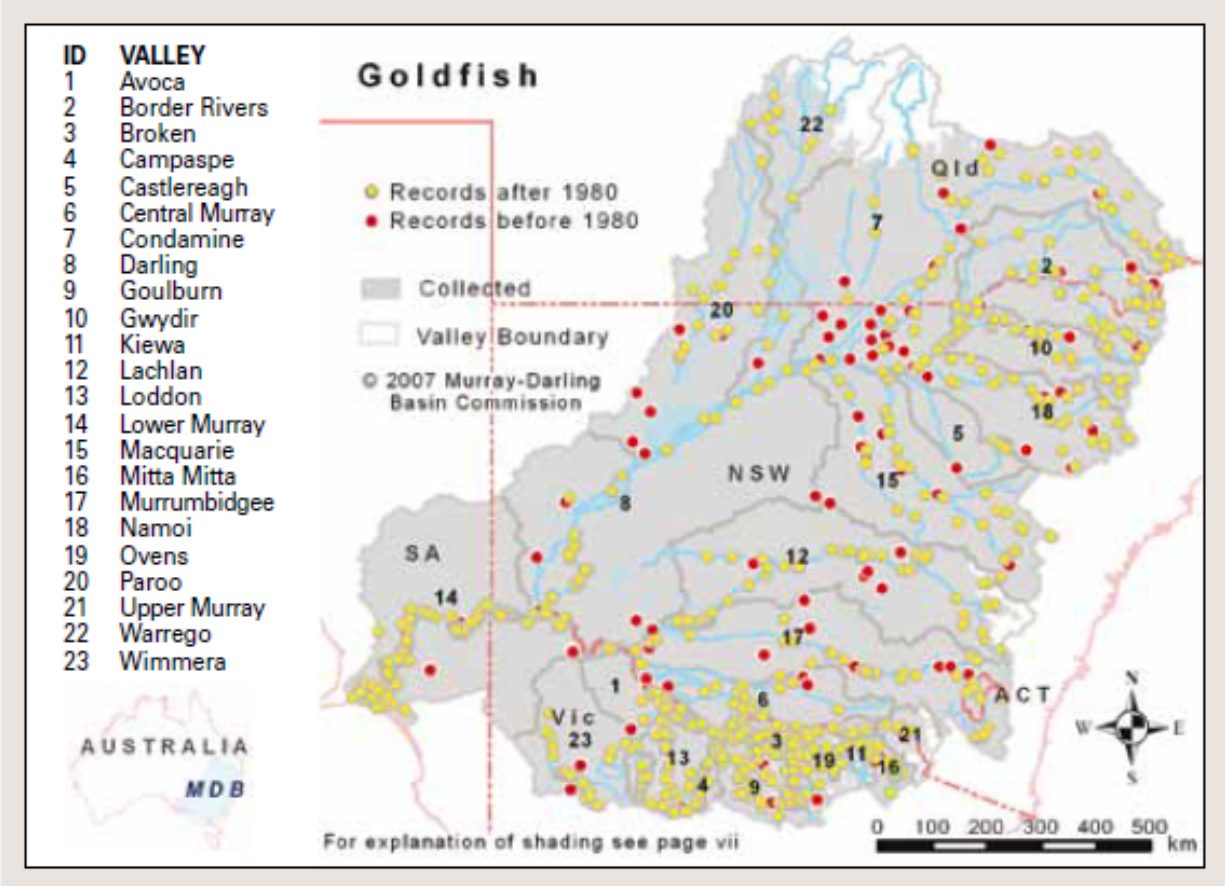

Figure 6. Distribution of Goldfish in the Murray Darling catchments (taken from Lintermans 2007).

Eastern gambusia, mosquitofish

Eastern gambusia, or mosquitofish (*Gambusia holbrooki*) are widespread and abundant throughout the Murray-Darling Basin and are common even in dams, slow flowing waters and shallow wetlands – see Figure 7 (Lintermans 2007). Gambusia were introduced to eastern Australia in 1929 for mosquito control; however, mosquito larvae do not make up a significant part of their diet

(Lintermans 2007). Their life history characteristics include being live bearers of young, an early breeding maturity and a high reproductive rate. They are aggressive and are known for fin-nipping and predation of native fish eggs. There is anectdotal evidence that several native fish species have disappeared following gambusia introduction. Gambusia are very tolerant of harsh conditions including high temperatures and low oxygen, and combined with their life history and behaviour characteristics present a significant threat to aquatic ecosystems in these catchments and Australia.

Gambusia are declared noxious in Queensland (*Fisheries Act 1994*, *Fisheries Regulation 1998*). It is unlawful to possess Gambusia alive or dead, or to use them as bait, and it is illegal to place or release Gambusia alive or dead into Queensland waterways. Penalties of up to $200,000 apply (Department of Agriculture, Fisheries and Forestry, 2012b).

Figure 7. Distribution of *Gambusia holbrooki* in the Murray-Darling catchments (taken from Lintermans 2007)

Redclaw crayfish

Redclaw crayfish (*Cherax quadricarinatus*) are a freshwater crayfish native to the rivers of the Northern Territory and the Gulf of Carpentaria area of Queensland. This species is thought to have been introduced to farm dams across Queensland, and have now been caught in the upper areas of the Lake Eyre Basin catchments. Expert opinion gathered during this project has identified the potential for redclaw to be found within the Bulloo River system, although it was not caught in the

Bulloo River during recent sampling in the Lake Eyre and Bulloo catchments by the SEAP project. It is unknown what impacts that redclaw can have on aquatic ecosystems, but it is likely that they will compete with the native blueclaw crayfish (*Cherax destructor*) found in the Bulloo catchment.

Riparian pests

Many introduced fauna species to Australia have established sustaining populations and can be considered pests to Australian ecosystems. Some common terrestrial species that are known to impact on Australian ecosystems include those listed in Table 8. Impacts on riverine ecosystems can also occur and are largely the result of the need to obtain a supply of water, and also to some extent food or even habitat. In semi-arid areas like the Bulloo, Paroo, Warrego and Nebine catchments, waterholes and any other more permanent surface water will attract pest animals. There are several species identified as occurring within the focus catchments (Table 8); however, the consequences of their impact will differ. Cattle grazing also can impact on waterholes and are an introduced species, however they need to be managed differently to feral species. Cattle grazing is the dominant landuse across all of Queensland, which needs to be managed with appropriate stocking rates and access to water sources.

Table 8. Presence of riparian pest species in the catchments

Species	Bulloo	Paroo	Warrego	Nebine
Sus scrofa (Feral pig)	YES	YES	YES	YES
Vulpes vulpes (European red fox)	YES	YES	YES	YES
Felis catus (Feral cat)	YES	YES	NO	NO
Oryctolagus cuniculus (Rabbit)	YES	YES	YES	NO
Capra hircus (Feral goat)	YES	YES	YES	YES
Rhinella marinus (Cane toad)	NO	NO	YES	unknown
Canis familiaris (Wild dog)	YES	YES	YES	YES

Feral pigs

Domestic pigs (*Sus scrofa*) were introduced to Australia by early settlers. Releases to the wild ('ferals') have established throughout Australia. Pigs are capable of moving large distances in search of water and food and commonly travel along watercourses. While they do travel to access resources, they tend to stay in a home range with a consistent watering point. They are affected by high temperatures during which they require drinking water, and they have a common behaviour to wallow in wet areas to cool off (Department of Primary Industries and Fisheries 2008). Feral pigs in the focus catchments are listed in the relevant Shire Council Pest Management Plans as a current

or potential problem (Bulloo Shire Council, Murweh Shire Council, Quilpie Shire Council, Paroo Shire Council). They are noted to be widespread and common even in National Parks.

The impacts pigs produce are to agriculture and stock by direct damage, and they can transfer disease and spread weeds (Department of Agriculture, Fisheries and Forestry 2012c). They also create ecological damage to aquatic ecosystems by digging up areas in search of food ('rooting') and as part of their wallowing behaviour. Rooting has the consequence of habitat removal and detrimentally changing water quality (Department of Primary Industries and Fisheries, 2008), but can also impact on populations of targeted food sources (e.g. molluscs). Damage by rooting is evident most of the time, except immediately following rains and floods when pigs can access water more readily across the landscape.

In many areas including National Parks feral pig trapping, baiting and shooting are management practices employed to reduce pig numbers.

Feral cats, foxes and wild dogs

Feral cats, foxes and wild dogs are widespread throughout Australia, including the semi-arid catchments of focus in this document. However, while these species do impact on ecosystems by predation of native species, it is unlikely that impacts occur on aquatic ecosystems, with the exception of water birds.

Rabbits

Rabbits (*Oryctolagus cuniculus*) are a major pest of agricultural and native ecosystems. Rabbits compete with both native species and agricultural animals for food and resources, and are known to extensively damage any vegetation in an area (Department of Agriculture, Fisheries and Forestry 2012d). This extensive grazing and burrowing behaviour contribute to soil erosion and subsequent siltation in aquatic ecosystems.

Feral goats

Feral goats (*Capra hircus*) were introduced to Australia with the First Fleet and have significant established populations in semi-arid areas of Queensland (Department of Agriculture, Fisheries and Forestry, 2012e). Feral goats compete with stock animals for resources, but are also harvested in some areas when prices are high. Due to their competition with other stock, overgrazing is a common issue created by feral goats (Department of Agriculture, Fisheries and Forestry, 2012e). While feral goats most likely have no direct impact on riverine ecosystems, overstocking can lead to increased rates of soil erosion, which can contribute to impacts on riverine processes.

Cane toads

Cane toads (*Rhinella marinus*) were introduced to Queensland in 1935 as a control agent for beetle pests of cane plants (Freeland, 1984; Lever, 2001). Cane toads have now spread into the Northern Territory, New South Wales and even into Western Australia (Sutherst et al., 1995; Urban et al., 2007; Kearney et al. 2008). Williamson (1999) indicates that cane toads are found in the upper tributaries of the Murray-Darling catchments in Queensland; therefore, since this time it is likely that cane toads have continued to disperse into other Murray-Darling catchments.

All life history forms of cane toads contain toxins, which have been implicated in the decline of native species which are likely to prey on them. However, there is no direct evidence to show cane

toads impact directly on aquatic ecosystems. Cane toads require wet areas, however they do not cope with being permanently wet – instead living on the fringes of permanent water and even breeding in the wet pug marks created by cattle coming to drink at waterholes.

Deposited sediment

While some investigation into suspended sediment and the source of suspended sediment has been undertaken for Murray-Darling catchments by the Water Planning Ecology group, little is known on the likelihood or consequence of deposited sediment in the Bulloo, Paroo, Warrego and Nebine catchments. DeRose et al. (2003) showed the results of Sednet modelling in the Murray-Darling Basin. Their Figure 6 copied below indicates small increases in bedload, which is most likely the fraction of sediment contributing to sedimentation. Small areas of the Warrego have relatively large accumulations and this may relate to waterholes indicating that waterholes are a potential impact site of sediment. South West NRM (2011) has also listed sediment as a potential threat in the Nebine catchment; however, little information has been compiled to support this.

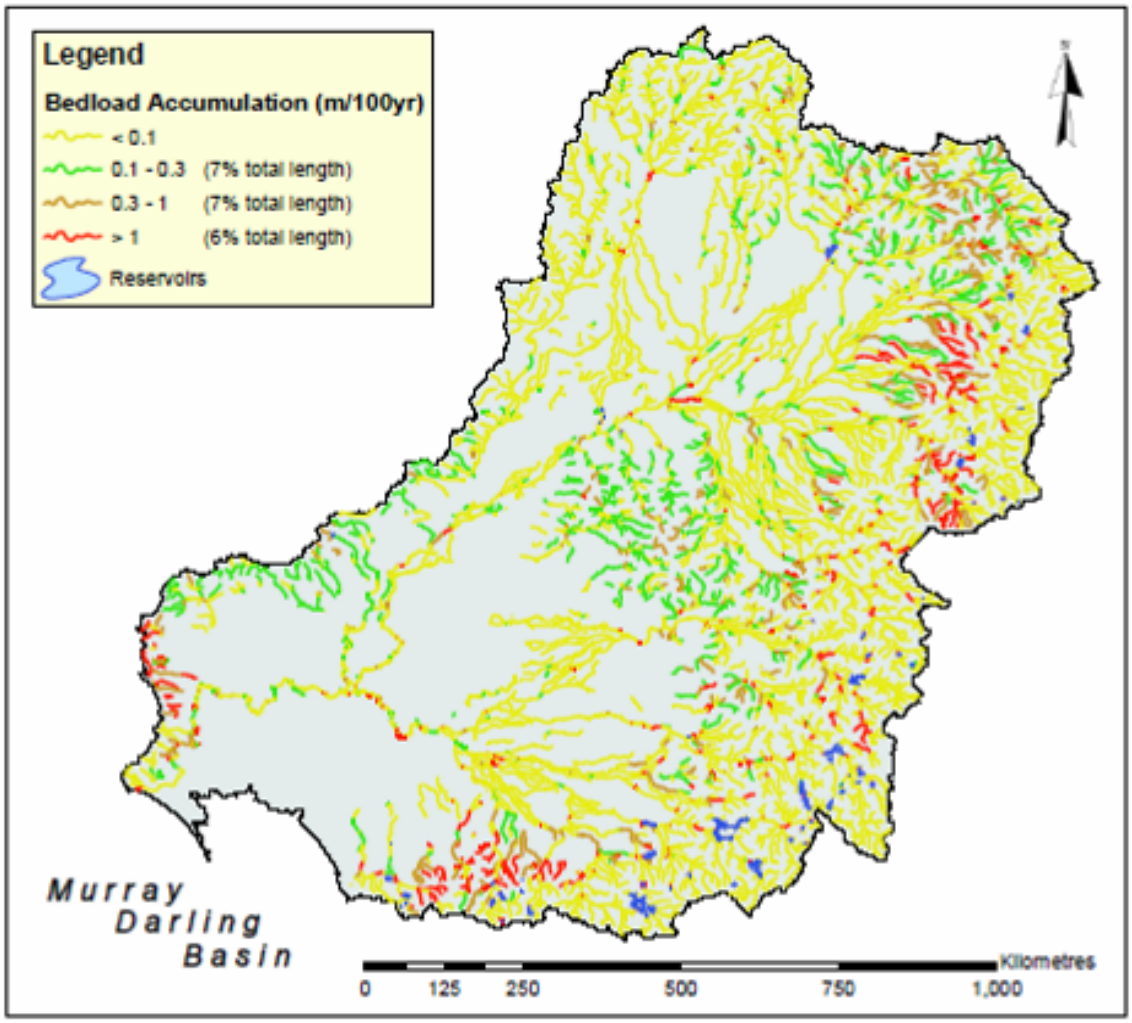

Figure 6: *Predicted bedload accumulation for the Murray-Darling Basin.*

Conclusions

This prioritisation process has resulted in a list of priority threats for the Queensland Warrego, Paroo, Bulloo and Nebine catchments. Of the detailed models, instream pest fauna was the only threat considered as a high risk across all four catchments. Overall, 3 models were considered above low risk in at least one of the four catchments (Table 6):

1. Instream pest fauna - considered a high risk in all four catchments,
2. Riparian pest fauna - considered a medium risk in all four catchments, and
3. Deposited sediment - Considered a medium/high risk in all four catchments

The above three threats (highlighted in purple, Table 6) and those with low confidence scores (i.e. knowledge gaps) will be considered in the design of the SEAP field assessment activities. It should be noted that the assessment has been carried out at the catchment scale only and that other threats may be high in more localised areas.

References

Booringa Shire Council (2005). Pest Management Plan 2005-2009. http://www.southwestnrm.org.au/sites/default/files/uploads/ihub/booringa-shire-pest-management-plan-2005-2009-draft.pdf Last accessed 3/08/2012.

Bulloo Shire Council (undated). Local Government Area Pest Management Plan 2004-2008. http://www.southwestnrm.org.au/sites/default/files/uploads/ihub/bulloo-pest-plan2004-2008.pdf Last accessed 6/08/2012.

Department of Agriculture, Fisheries and Forestry (2012a). Carp. http://www.daff.qld.gov.au/28_13606.htm Website last accessed 1/08/2012.

Department of Agriculture, Fisheries and Forestry (2012b). Gambusia or mosquitofish. http://www.daff.qld.gov.au/28_13877.htm Website last accessed 1/08/2012.

Department of Agriculture, Fisheries and Forestry (2012c). Feral pig. http://www.daff.qld.gov.au/4790_8280.htm Website last accessed 6/08/2012.

Department of Agriculture, Fisheries and Forestry (2012d). Rabbit. http://www.daff.qld.gov.au/4790_8288.htm Website last accessed 6/08/2012.

Department of Agriculture, Fisheries and Forestry (2012e). Feral goat. http://www.daff.qld.gov.au/4790_8279.htm Website last accessed 6/08/2012.

Department of Primary Industries and Fisheries (2008). Fact sheet PA6: Feral pigs in Queensland - distribution, ecology and impact.

DeRose, R., Prosser, I.P., Weisse, M. & Hughes, A.O. (2003). Patterns of erosion and sediment and nutrient transport in the Murray-Darling Basin, CSIRO Land and Water, Canberra. Technical Report 32/03.

Freeland, W.J. (1984). Cane toads: a review of their biology and impact on Australia. (Parks and Wildlife Unit, Conservation Commission of the Northern Territory Winnellie).

Kearney, M, Phillips, B.L., Tracy, C.R., Christian, K.A., Betts, G. & Porter, W.P. (2008). Modelling species distributions without using species distributions: the cane toad in Australia under current and future climates. *Ecography* 31: 423–434.

Lever, C. (2001). The cane toad: the history and ecology of a successful colonist. Westbury Academic and Scientific Publishing, West Yorkshire, United Kingdom.

Lintermans, M. (2007). Fishes of the Murray-Darling Basin: An introductory guide. Murray-Darling Basin Authority Canberra.

Marshall, J., Prior, A., Steward, A., McGregor, G. (2006a). Freshwater Bioregionalisation of Queensland's Riverine Ecosystems :Development of Interim Freshwater Biogeographic Provinces, Queensland Government, Aquatic Ecosystems Technical Report No. 56.

Marshall, J., McGregor, G., Marshall, S., Radcliffe, T., Lobegeiger, J. (2006b). Development of Conceptual Pressure-Vector –Response Models for Queensland's Riverine Ecosystem, Aquatic Ecosystems Technical Report No. 57, Queensland Government, Department of Natural Resources Mines and Water.

Murweh Shire Council (undated). DRAFT Pest Management Plan 2005-2009. http://www.southwestnrm.org.au/sites/default/files/uploads/ihub/murweh-pest-plan-v2-2.pdf Website last accessed 6/08/2012.

Negus, P., Moller, G., Blessing, J., Davis, L., Marshall, J., Dobbie, M. (2009). Stream and Estuary Assessment Program - an assessment framework for riverine ecosystems, Brisbane: Queensland Department of Environoment and Resource Management, Queensland Government.

Paroo Shire Council (undated). Local Government Area Pest Management Plan 2004-2008. http://www.southwestnrm.org.au/sites/default/files/uploads/ihub/latest-paroo-pest-plan-2004-2008.pdf Last accessed 6/08/2012.

Quilpie Shire Council (undated). Pest Management Plan 2005-2009. http://www.southwestnrm.org.au/sites/default/files/uploads/ihub/quilpie-shire-council-pmp1-2.pdf Website last accessed 6/08/2012.

South West NRM Ltd. (2011). DRAFT Consultation Report for the South West Queensland Healthy Waters Management Plan. Initial Consultation Report–Community Environmental Values for Water Quality within the South West NRM Region of Queensland.

Sutherst, R.W., Floyd, R.B., Maywald, G.F. (1995). The Potential Geographical Distribution of the Cane Toad, *Bufo marinus* L. in Australia. *Conservation Biology* 10: 294-299.

Urban, M., Phillips, B.L., Skelly, D.K., Shine, R. (2007). The cane toad's (*Chaunus marinus*) increasing ability to invade Australia is revealed by a dynamically updated range model. *Proceedings of the Royal Society B* 274: 1413–1419.

Williamson, I. (1999). Competition between the larvae of the introduced cane toad *Bufo marinus* (Anura: Bufonidae) and native anurans from the Darling Downs area of southern Queensland. *Australian Journal of Ecology* 24: 636–643.

Appendix A. Common threat models

Threat: Acid soil runoff – water from soils usually containing iron sulphides that have been exposed to the air

Human pressures

Land clearing, particularly deep rooted trees
Disturbance of acid sulphate soils
Draining of coastal wetlands and marshes

Physical and chemical stressors

Instream	*Riparian*
Fe precipitation – habitat smothering	↓ Soil pH
Complex alteration of physical and chemical properties of the water	↑ Al, Fe and Mn in riparian soil
↓ Food Resources	↓ Ca, Mg and K in riparian soil
	↓ Nutrient availability

Mediating factors and management

Geomorphic setting
Soil type
Geology type

Ecological responses

Instream	*Riparian*
↑ Fish disease and fish kills	↑ Plant pathogens
↑ Fish gill damage	↓ Soil microbes
Weaker shell structure in shellfish	
Altered aquatic macrophyte communities	
↑ Biota movement	
↓ Spawning and recruitment	

Threat: Climate change – change in weather patterns

Human pressures

Land clearing
Urbanisation

Physical and chemical stressors

Direct	*Indirect*
Change in rainfall patterns	Change in hydrology
Change in extreme weather conditions	Change in water quality
Change in temperature	
Change in humidity	
Change in cloud cover	

Mediating factors and management

Current climatic conditions

Ecological responses

Instream	*Riparian*
↓ Sensitive species	↓ Sensitive species
Changed biotic community composition	Vegetation community composition

Threat: Direct biota removal or disturbance – removal, loss or disturbance of individual organisms or a specific species (e.g. fishing)

Human pressures

Commercial fishing & harvesting
Recreational fishing
Traditional fishing and bait collection
Tourism

Physical and chemical stressors

Habitat alteration
↓habitat heterogeneity

Mediating factors and management

Habitat connectivity
Refugia habitat
Population size and structure

Ecological responses

Primary responses

Behavioural changes
↓Population
↓Species / individuals (locally / globally)

Secondary responses

Biotic community change – alteration of predator / prey and competitive interactions

Threat: Flow management – impoundment, extraction and augmentation of water

Human pressures

Water infrastructure (e.g. Dams, barriers, levees, impoundments, weirs)
Management of overland flow (e.g. land cover, farm dams, impermeable surfaces)
water extraction (including groundwater),
Irrigation and agricultural industries

Physical and chemical stressors

Primary (hydrology) process

Change in:
Magnitude of flow events
Timing / seasonality of flow events
Baseflow / flood flows
No flow spells
Rise and fall of hydrograph

Secondary process

↓Hydraulic habitat types and occurrences
↑erosivity, ↑bank stability, ↓habitat connectivity, drown out of riparian habitats (e.g. nesting sites), ↓refuges
Loss or disruption of reproductive cues
↓Synchrony of reproduction and resource availability
Change to water quality
Change to deposited sediments

Mediating factors and management

Interaction between managed and natural flow (additive or subtractive)
Groundwater recharge
Climate change

Ecological responses

↓Sensitive species (flow dependent)
↓Recruitment opportunity
Change biotic community composition
↑Local extinctions
↑Generalist species
↑Genetic bottle necks
↑Plant pathogens
Change to riparian vegetation extent

Threat: Instream habitat removal or disturbance – removal, loss or disturbance of instream habitats

Human pressures

Dredging and extractive operations (e.g. sand and gravel mining)
Habitat removal (e.g. associated with urban and industrial development, roads, bridges, channelisation, foreshore development, grazing, aquaculture)
Vegetation clearing (loss of riparian buffer to streams)
Tourism
Modification of drainage pathways

Physical and chemical stressors

- ↓ Stream bank and bed stability
  - ↑ Undercut banks
  - ↓ Organic matter retention
  - ↓ Biofilm / microbial biomass
  - ↓ Sediment / nutrient input to streams
  - ↓ woody debris and hard substrate
  - ↓ Habitat for burrowing organisms (e.g. platypus, turtle, water rat)
- ↓ Habitat heterogeneity
- ↓ Connectivity (lateral, longitudinal, vertical)
  - ↓ Recruitment opportunity
  - ↓ Bed permeability (groundwater/surface water interaction)

Mediating factors and management

Geomorphic setting

Ecological responses

- ↓ Littoral zone productivity
- ↓ Habitat and food resource sensitive species
- Altered biotic communities
- ↓ Recruitment success
- ↑ Generalist species
- ↓ Gene flow
- ↑ Pest species

Threat: Instream pests – obligate instream, exotic, invasive or translocated organisms

Human pressures

Aquaculture industry
Aquarium / stocking release
Release or transport of pest species

Physical and chemical stressors

- ↑ Predation / competitive interaction
- ↑ Barriers to migration / movement
- ↓ Bank stability
- ↓ Water quality
- ↓ Change in available food resources
- Altered habitat
- ↑ Pest species abundance

Mediating factors and management

Disturbed sites more susceptible to invasive species
Habitat availability

Ecological responses

Behavioural responses – avoidance, resource use change
Change in community composition
Extinctions
- ↑ Genetic pollution
- ↑ Pathogens

Threat: Nutrients – change in concentration, loads or bioavailability of chemical compounds used by organisms for growth

Human pressures

Point sources (e.g. sewage treatment plants, aquaculture, industrial)
Diffuse sources (e.g. catchment runoff, storm water discharge, human and animal wastes)
Sewage discharge from vessels

Physical and chemical stressors

Habitat alteration
↑ smothering – ↓ habitat heterogeneity
↑ diurnal DO and pH fluctuation
↑ sediment anoxia
Food resource change
Accumulation of C due to ↓palatability
↓ Resources for 2^0 consumers (e.g. fish)
Production of secondary metabolites (e.g. algal toxins, allelopathic compounds)

Mediating factors and management

Bioavailability, speciation (N, P, Fe etc)
Existing nutrient status
Light environment
Flow, surface / groundwater interactions

Ecological responses

Primary responses	*Secondary responses*
↑ Primary productivity	Biotic community change
↑ Algal biomass	changes in composition (↑ weedy species)
↑ Macrophyte biomass	Fish kills

Threat: Organic matter – carbon based material from plants or animals in either dissolved or particulate forms

Human pressures

Diffuse sources (e.g. catchment runoff, storm water discharge, human and animal wastes)
Point sources (e.g. sewage treatment plants, aquaculture, industrial)
Algal blooms and nuisance growth of aquatic macrophytes

Physical and chemical stressors

Habitat alteration
smothering – ↓ habitat heterogeneity
diurnal DO and pH fluctuation
BOD
frequency of sediment anoxia

Food resource change
Accumulation of C due to ↓palatability

Mediating factors and management

Flow (water residence time)
Surface water / groundwater interaction

Ecological responses

Food resource change
↓ Resources for 2^0 consumers (e.g. fish)
Biotic community change
changes in composition (e.g. ↑ Weedy and / or exotic species)
↓ biodiversity
Biota kills

Threat: Pathogens – e.g. bacteria, viruses, fungi, protozoa

Human pressures

Aquaculture industry – accidental release
Diffuse sources (e.g. catchment runoff, storm water discharge, human and animal wastes
Point sources (e.g. sewage treatment plants)
Exotic species
Imported feeds (e.g. aquaculture, agriculture)

Physical and chemical stressors

Mediating factors and management

All populations harbour pathogens
Other stressors may increase susceptibility, prevalence or severity

Ecological responses

Acute response

↑ Disease (e.g. fish lesions)
Death
↑ Occurrence of mass biota kills
↓ Sensitive species
↓ Species with sensitive life history or development stages

Chronic response

↑ Plant pathogens
↓ Fecundity and reproductive success
Behavioural changes
Alteration of population structure

Threat: Riparian habitat removal or disturbance – removal, loss or disturbance of riparian habitats

Human pressures

Dredging and extractive operations (e.g. sand and gravel mining)
Habitat removal (e.g. associated with urban and industrial development, roads, bridges, channelisation, foreshore development, grazing, aquaculture)
Vegetation clearing
Tourism
Modification of drainage pathways

Physical and chemical stressors

Riparian

↓ Stream bank stability
Alteration to soil moisture / wetting regime
Microclimate alteration
↑ Allelopathy
Change to channel morphology
↓ Connectivity to groundwater

Instream

↓ Allochthonous food resources
Changed food types
↑ Sediment / nutrient source
↓ Woody debris
Change in substrate sediment
Changed habitat types
↓ Water quality
↑ Light attenuation

Mediating factors and management

Geomorphic setting

Ecological responses

Riparian

↓ Riparian vegetation abundance, diversity
↓ Colonisation of vegetation
Change in riparian vegetation community composition
↓ Adult aquatic insect abundance

Instream

↑ Algal biomass
Changed food web structure
Altered aquatic biota communities
↑ Biota movement
↓ Spawning and recruitment

Threat: Riparian pests – exotic, invasive or translocated organisms that occur in the riparian zone

Human pressures

Agricultural production
Dumping of garden refuse / rubbish
Escape of garden weeds
Release / transport of pest species

Physical and chemical stressors

Instream

Changed light availability
Change in food resources / organic matter
Allelopathy
↑Nutrients, sediment

Riparian

↓Soil structure
↑Bank stability
Changed light availability
↑Smothering (e.g. vines)
Allelopathy
Competition for resources
↑Abundance of pest species

Mediating factors and management

Disturbed sites are more susceptible to invasive species
Habitat availability

Ecological responses

Instream

Altered biotic communities
↑Biota movement
↓Spawning and recruitment'
Extinctions

Riparian

↑Plant pathogens and disease
↓Soil microbes
Altered biotic communities
Extinctions

Threat: Salinity – composition and concentration of ions in surface or groundwater

Human pressures

Dryland or secondary salinisation
Vegetation clearing
Surface and groundwater extraction
Industrial and mining saline water disposal
Reduced freshwater input with high evaporation
Marine water intrusion

Physical and chemical stressors

Instream

Altered contaminant interactions and bioavailability
Altered nutrient, carbon and trace metal bioavailability
↓Habitat (e.g. macrophytes)
↑Conductivity
Change in ionic composition

Riparian

↓Riparian habitat due to dryland salinisation

Mediating factors and management

Geological setting
Hydrological setting
Natural state of conductivity and ionic composition

Ecological responses

Physiological responses
lethal threshold exceeded which leads to:
* death and loss of sensitive species
* ↓reduced recruitment / altered population structure for species with sensitive life history
↑Physiological regulation leading to ↓metabolism/growth ↓feeding ↓reproduction
Altered microbial activity leading to ↓nutrient cycling ↓primary productivity ↓in algal C food source with ↑detrital C
↑Behavioural modification (e.g. avoidance, barrier to dispersal / migration)
↑Stress which leads to ↑susceptibility to other stressors
↑Abundance of exotic, opportunistic and/or tolerant species

Threat: Sediments – loads, concentration, distribution / movement patterns, settlement / resuspension rates, grain size of suspended or deposited sediments

Human pressures

Soil disturbance and vegetation clearing
Dredging and extractive operations (e.g. sand and gravel mining)
Modification of hydrodynamics and drainage pathways
Diffuse sources (e.g. catchment runoff – rural and urban)
Foraging of pest species (aquatic and terrestrial)

Physical and chemical stressors

Suspended	*Deposited (blanketing sediment)*
↓Light penetration	↓Instream habitat
↓Instream visibility	↑Algal/macrophyte biomass
↑Photochemical processes	↓Blanketing of immobile organisms
Altered contaminant/nutrient bioavailability	and life history stages (e.g. eggs)
Erosivity ↑ bank scouring ↓ habitat	↓Food resources
↓Rate of contaminant decay	↓Nutrient and carbon cycling
↑Thermal stratification	↑Substrate anoxia
↑Suspended particles / gill clogging	
Change in temperature	

Mediating factors and management

Geomorphic setting
Natural sediment status

Ecological responses

Suspended	*Deposited*
↓Primary productivity	↓Primary productivity
Food web alterations	↓Sensitive species
↓Sensitive species	↓Recruitment of biota
Food web alterations	Biotic community changes
Change in predator / prey interactions	Food web alterations
↓Filter feeders	

Threat: Thermal alteration – elevation or depression in surface water temperature

Human pressures

Climate change
Industrial and municipal discharge
Hypolimnetic reservoir release
Power station release water

Physical and chemical stressors

	Riparian
↓Synchrony of temperature regime and hydrology (i.e. triggers)	↓Soil pH
↓Habitat (e.g. macrophytes)	↑Al, Fe and Mn in riparian soil
Change in instream temperature	↓Ca, Mg and K in riparian soil
	↓Nutrient availability

Mediating factors and management

Timing of release and assimilative capacity of the receiving water system (i.e. dilution factors)

Ecological responses

Physiological changes
↑Deaths where lethal threshold exceeded
Change in metabolism / growth
Change in feeding behaviour
↑Disruption of reproduction

Behavioural changes
altered migratory behaviour / movement (e.g. avoidance, barrier)

↑Loss of sensitive species
Changed microbial activity
↑Pest species

Threat: Toxicants – e.g. pesticides, herbicide organics, oils, hydrocarbons, metals, metalloids, organometallics, radiation

Human pressures

Diffuse sources (e.g. catchment runoff, storm water discharge, aerial spraying)
Point sources (sewage treatment plants, industrial, mining)
Accidental release or illegal dumping
Harmful algal blooms
Hypolimnetic reservoir releases

Physical and chemical stressors

↑ concentration or bioavailability
↓ Habitat (i.e. riparian and instream)
Barrier to movement

Mediating factors and management

Transport (e.g. hydrology)
Bioavailability
Speciation
Toxicant interactions
Temperature
Degradation pathways (e.g. UV, microbial)
Buffering capacity
Dilution

Ecological responses

Acute responses

Death
↑ biota kills
↓ sensitive species

Chronic responses

Adverse biotic effects (e.g. ↑ disease, lesions, mutations, aberrant growth, and reproduction, imposex, neurological and respiratory dysfunction, physiological change)

Changed or ↓ community composition
Avoidance (e.g. fragmented habitat, barriers)
Riparian damage (e.g. dead vegetation)

Appendix B. Participants

The participants of this survey included staff from Water Planning Ecology (DSITIA), regional departmental staff, staff from the Department of Natural Resources and Mines (DNRM) and other scientific experts on the Bulloo, Paroo, Warrego and Nebine catchments (Table 7).

Staff from the Department of Science, Information Technology, Innovation and the Arts and Department of Natural Resources and Mines were also consulted once survey results were amalgamated to ensure the prioritised threats reflect current departmental data/knowledge of these regions. Slight adjustments were made where appropriate.

Table 7. Survey respondents and consulted experts

Name	Organisation
Peter Negus (SEAP Project Leader)	DSITIA - Water Planning Ecology (Brisbane)
Joanna Blessing (SEAP)	DSITIA - Water Planning Ecology (Brisbane)
Sara Clifford (SEAP)	DSITIA - Water Planning Ecology (Brisbane)
Alisha Steward (SEAP)	DSITIA - Water Planning Ecology (Brisbane)
Jonathan Marshall	DSITIA - Water Planning Ecology (Brisbane)
Glenn McGregor	DSITIA - Water Planning Ecology (Brisbane)
James Fawcett	DSITIA - Water Planning Ecology (Brisbane)
Ryan Woods	DSITIA - Water Planning Ecology (Brisbane)
Jaye Lobegeiger	DSITIA - Water Planning Ecology (Brisbane)
Charles Ellway	Biodiversity Services, DNRM (Toowoomba)
Suzi Johnson	DNRM - Water Planning South West (Brisbane)
Delwyn Hansen	DNRM - Healthy Waters Policy (Brisbane)
Bruce Wilson	DSITIA - Biodiversity & Ecosystem Sciences (QLD Herbarium)
Adam Kerezsy	Bush Heritage Australia
Jennifer Silcock	University of Queensland
Darren Smallwood	DAFF
Brian Timms	University of Newcastle
Mark Silburn	Biodiversity Services, DNRM (Toowoomba)
Glen Moller	NRM
Paul Webb	QMDC
Julie Coysh	NRM
Stephen Balcombe	Griffith University

Appendix C. Survey table sent to participants

Threats	Sub-threats	Bulloo				Paroo				Warrego				Nebine				Comments (potential PSR indicators, information sources, reasoning for scores given)
		Consequence	Confidence	Likelihood	Confidence	Consequence	Confidence	Likelihood	Confidence	Consequence	Confidence	Likelihood	Confidence	Consequence	Confidence	Likelihood	Confidence	
Sediments	Suspended																	
	Deposited																	
Acid soil runoff																		
Direct biota removal or disturbance (e.g. fishing)																		
Flow management	Connectivity																	
	Flow regime change																	
Instream habitat removal or	Instream																	

Threats	Sub-threats	Bulloo				Paroo				Warrego				Nebine				Comments (potential PSR indicators, information sources, reasoning for scores given)
		Consequence	Confidence	Likelihood	Confidence	Consequence	Confidence	Likelihood	Confidence	Consequence	Confidence	Likelihood	Confidence	Consequence	Confidence	Likelihood	Confidence	
disturbance (e.g. removal of snags, deepening of waterholes)																		
Riparian habitat removal or disturbance (e.g. clearing of riparian vegetation, trampling of dry river beds or floodplains)	Riparian																	
Nutrients (e.g. point sources, diffuse sources)																		
Organic matter																		
Pathogens																		

Threats	Sub-threats	Bulloo				Paroo				Warrego				Nebine				Comments (potential PSR indicators, information sources, reasoning for scores given)
		Consequence	Confidence	Likelihood	Confidence	Consequence	Confidence	Likelihood	Confidence	Consequence	Confidence	Likelihood	Confidence	Consequence	Confidence	Likelihood	Confidence	
(diseases and parasites)																		
Riparian non-endemic species (exotic and translocated)	Riparian flora																	
	Riparian fauna																	
Instream non-endemic species (exotic and translocated)	Instream flora																	
	Instream fauna																	
Salinity (e.g. ionic composition, conductivity)																		

Threats	Sub-threats	Bulloo				Paroo				Warrego				Nebine				Comments (potential PSR indicators, information sources, reasoning for scores given)
		Consequence	Confidence	Likelihood	Confidence	Consequence	Confidence	Likelihood	Confidence	Consequence	Confidence	Likelihood	Confidence	Consequence	Confidence	Likelihood	Confidence	
Toxicants (e.g. pesticides and other chemical and physical factors that are not naturally occurring)	Pesticides																	
Thermal alteration																		
Climate change																		

Appendix D. Threat score ranges and number of responses

Threats	Warrego					Paroo					Bulloo					Nebine				
	Range of survey scores					Range of survey scores					Range of survey scores					Range of survey scores				
	Consequence	Confidence in consequence	Likelihood	Confidence in Likelihood	Responses	Consequence	Confidence in consequence	Likelihood	Confidence in Likelihood	Responses	Consequence	Confidence in consequence	Likelihood	Confidence in Likelihood	Responses	Consequence	Confidence in consequence	Likelihood	Confidence in Likelihood	Responses
Instream pests: All	2	2	2	1	8	2	2	2	2	9	2	2	2	2	6	2	2	3	2	6
Deposited sediment	4	2	4	2	11	4	2	3	2	11	3	2	3	2	8	3	2	3	2	8
Riparian pests	0	1	2	1	6	1	1	2	1	7	0	2	2	2	5	0	2	2	2	6
Riparian weeds	2	3	3	2	7	2	3	3	1	7	2	3	3	2	6	2	3	2	1	6
Riparian disturbance	2	2	2	3	10	2	2	3	3	10	2	2	3	3	7	2	2	2	3	8
Suspended sediment	3	2	4	1	10	3	2	4	1	10	2	2	4	3	7	2	2	4	2	9
Nutrients	3	2	3	2	8	2	2	3	2	9	1	1	3	2	5	1	1	3	2	6
Biota removal	2	1	4	1	6	2	2	3	1	7	2	0	3	1	5	2	0	3	1	4
Climate change	3	1	3	1	4	3	1	3	1	5	1	1	3	1	3	4	1	3	1	3
Organic matter	2	1	3	2	5	3	1	2	2	6	2	1	2	2	4	1	1	3	2	4
Hydrology: flow regime	3	2	1	2	8	3	1	2	1	8	3	1	2	1	6	3	2	1	1	7
Pathogens	1	1	2	1	5	2	1	1	1	6	0	1	1	1	4	0	1	2	1	4
Hydrology: connectivity	3	2	2	2	10	3	1	2	1	8	2	2	1	3	7	2	2	3	2	6
Hydrology: seasonality	0	1	1	2	2	2	1	1	1	6	0	1	1	2	2	0	0	0	0	1
Instream habitat disturbance	4	1	2	2	9	3	2	1	3	10	3	1	2	1	6	3	1	2	2	7
Instream weeds	2	2	3	2	7	0	0	0	0	1	2	2	3	2	5	2	2	3	1	6
Acid soil runoff	4	2	1	2	6	3	1	1	1	8	4	2	1	2	5	4	2	1	2	5
Hydrology: high flow change	1	1	1	0	2	2	2	3	2	7	1	0	0	0	2	1	0	0	0	2
Salinity	3	1	2	1	5	3	1	1	1	6	2	1	1	1	4	2	1	2	1	4
Toxicants	3	2	2	1	7	3	2	1	2	8	3	2	1	2	6	3	2	2	1	6
Thermal alteration	2	1	1	1	7	2	1	1	1	8	2	1	0	1	6	2	1	1	1	6