Assessing Development Risks to the Ecological Values of the Free Flowing Rivers of Kati Thanda-Lake Eyre Basin (Qld)

An Independent Scientific Expert Panel Report prepared for the Department of Environment and Science, Queensland Government

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Cover Photo: Banjo Paterson's "Waltzing Matilda" Combo Waterhole, Diamantina River, Kynuna (Credit: Darren Fielder, 2016)

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Executive Summary

Purpose of the report

The Queensland Government is reviewing state policy, legislation and administrative frameworks to ensure the long-term ecological sustainability of Queensland's free flowing rivers. The Queensland Government has committed (GEC958) to '*work with Traditional Owners, stakeholders and communities to ensure the State's pristine rivers are protected. This will include a review of the extent to which the Regional Planning Interests Act 2014 provides adequate protection for these rivers*'. The goal of the review is to protect and avoid widespread and irreversible impacts on rivers with all, or nearly all, of their environmental attributes intact. The legislative review is focused on if the *Regional Planning Interests Act* provides adequate protection for the catchments relevant to the Channel Country SEA, including the Georgina, Diamantina and Cooper Creek river catchments. These catchments are collectively referred to as the Lake Eyre Basin Queensland (LEB Qld).

From this legislative and policy review, the Department of Environment and Science (DES) has commissioned Redleaf Environmental to undertake an independent Scientific Expert Panel (SEP) to deliberate on Kati Thanda-Lake Eyre Basin and its river catchments in Queensland. Experts were invited from a broad cross section of academic, consulting, industry and government (commonwealth and state) scientific organisations, including past and current members of the Independent Expert Scientific Committee on Coal Seam Gas (CSG) and large coal mining development and LEB Scientific Advisory Panel. The primary purpose for the SEP was to provide scientific advice, complete a risk assessment of potential impacts from the activities of conventional and unconventional petroleum and gas, mining, agricultural practices, tourism and infrastructure, and to provide recommendations to inform the government election commitment review.

Internationally significant ecological values of the LEB (Qld)

The Lake Eyre Basin (LEB) covers nearly one sixth of the Australian continent and is one of the largest internally draining river basins in the world. It supports very high values of national and international significance. The vast riverine ecosystems and wetlands of the LEB cover 73,903 km^2 and are in a pristine condition when compared to the more developed basins such as the neighbouring Murray-Darling Basin. The Georgina, Diamantina and Cooper Creek river systems of the LEB (Qld) have very limited anthropogenic disturbance and all presently lack major structures that would regulate flow. The iconic LEB and its distributary systems was recognised in the Lake Eyre Basin Intergovernmental Agreement 2001 as one of the last arid-zone water catchments around the globe to flow intermittently without interruption, and therefore of high conservation significance on a world scale.

Rather than being a permanent flowing, discrete river channel, the LEB (Qld) rivers are typically a series of anastomosing channels and anabranches situated in a broad floodplain, filling every few years after long dry periods with flood waters from upstream rainfall (sometimes drought breaking). During the wet periods, habitat complexity and availability in LEB (Qld) catchments is immense with extensive flooding producing a complex system of swamps, channels, lakes, billabongs and waterholes on the distributary floodplains. In dry periods these rivers usually are reduced to a series of waterholes in the channels and isolated wetlands on the floodplain. These refugial waterholes represent the only permanent aquatic habitat during extended periods of low or no flow and are critical components of a functioning 'source and sink' system for aquatic organisms (fish, turtles) in arid and semi-arid landscapes.

Several native fish species are under threat of extinction in the LEB (Qld). The Cooper Creek Catfish *Neosiluroides cooperensis* is dependent on permanent waterholes and is becoming critically endangered. The red-finned blue eye *Scaturiginichthys vermeilipinnis* and the Edgbaston goby *Chlamydogobius squamigenus* are both spring dependant and listed as endangered under the *Nature Conservation Act 1992* and endangered and vulnerable under the *Environment Protection and Biodiversity Conservation Act 1999*, respectively. In addition, the riverine ecosystems and associated wetlands of LEB are internationally and nationally important supporting waterbird breeding including major waterbird breeding colonies, large populations of waterbirds (several million during major floods) and high numbers of some migratory bird species.

Kati Thanda-Lake Eyre along with several, large, ephemeral terminal or sub-terminal lakes (e.g., Lake Yamma Yamma, Lake Mipia, Lake Machattie, Lake Galilee, Lake Buchanan, Bilpa Morea Claypan) are significant for their unique geological features, water regimes and assemblage of fauna (including invertebrates) that is adapted to these ephemeral systems. Like all terminal river systems, these wetlands are largely depend on upstream flows to persist. Planning decisions on future water resource management that impacts any of these identified water assets in LEB (Qld) are especially important because the values are highly dependent on protection of river flows and connected pathways.

The globally significant Great Artesian Basin (GAB) springs (numbering about 6,308) contain unique flora and fauna and have experienced considerable habitat loss and extinction due to the unrestricted extraction of water and physical modification. The mapped groundwater dependent artesian springs in the LEB (Qld) contain numerous endemic and threatened flora and fauna species evolved to live in these springs. There are thought to be approximately 98 taxa of plant, fish, amphipods and isopods that are only found in GAB springs. Of these taxa, 33 are undescribed species and nearly half (44%) are narrow endemics, whereby a taxon is found in only one spring complex(Anderson *et al.* 2016). The vulnerability of these spring communities is extreme due to their variable size, isolated locations and reliance on permanent groundwater supplies from the GAB aquifers. These water assets are of high priority for maintaining Australia's unique aquatic biota and for terrestrial species as a permanent source of water during dry periods in the largely terrestrial environments of LEB (Qld).

Many aquatic systems within the LEB could be considered of World Heritage value with significant ecological assets, least of which is Kati Thanda-Lake Eyre itself. As a terminal lake, Kati Thanda-Lake Eyre, along with the many rivers and wetlands within the LEB (Qld) rely on floods to maintain their ecological functioning and processes that support biota across the basin, including migratory waterbird species of national and international conservation significance.

Potential impacts from petroleum and gas, mining and infrastructure

There is currently minimal unconventional and conventional petroleum and gas production and mining development activity in the LEB (Qld). However, the summarised potential impacts include:

- Direct loss, degradation and fragmentation of habitats (rivers, wetlands, riparian trees and habitat, remnant vegetation) from the disturbance footprint associated with linear and static infrastructure
- Direct impacts to threatened species that reside in permanent waterholes
- Declines in water pressure and changes to water quality, water level, temperature and ecosystem structure (including GDEs) in the GAB through groundwater drawdown
- Changes to groundwater quality in upper aquifers from leaks into overlying aquifer from production casing or via offset wells vertical migration of fluid along faults/ fractures improperly completed or plugged offset wells
- Surface water and groundwater quality impacts from well failure as a result of induced seismicity (from hydraulic fracturing and dewatering of coal seams)
- Groundwater quality impacts from reinjection of flowback water and produced water, including induced seismicity
- Groundwater and surface water impacts from spills of drilling fluids, fracturing fluids, flowback and produced water during treatment and disposal
- Changes to surface water quality from treated/untreated CSG water discharges to watercourses
- Unauthorised releases of poor quality water from open cut mines during flooding events
- Changes to the quantity of water flowing through ephemeral watercourses resulting from direct discharges of CSG water
- Potential changes to overland flow paths through subsidence

- Altered flow paths to wetlands resulting from infrastructure placement and design
- Loss of connectivity from linear infrastructure (roads, pipelines, wells, water ponds, pits etc.) creating barriers on floodplains diverting flows away from natural wetlands or water dependent species and communities
- Groundwater and surface water level/quality impacts from produced water leaching or overflowing from pits/storage ponds, or leaking from pipelines (from flooding/ structural failure)
- Groundwater level impacts from CSG and mine dewatering and associated impacts on GDEs and springs
- Watercourse diversions and realignment from mines
- Abandoned storage ponds/pits remain onsite with contamination at base (due to evaporation) and potential groundwater quality impacts through leaching
- Groundwater impacts from acid mine drainage, and leaching of tailings dams and other extraction/processing waste storage areas

Potential impacts from agricultural practices and tourism

While agriculture and more specifically overgrazing poses some risk to the LEB (Qld), the existing agricultural industry in the basin has successfully maintained a healthy coexistence with the free flowing ecosystems of the basin for over 150 years. Acknowledging the successes in sustainable agricultural systems, some of the challenges for the grazing pastoral sector in the LEB (Qld) are to maintain land condition and productive capability while minimising degradation and pasture decline. One area of potential loss of ecosystem function for waterholes is the degradation of riparian areas through overgrazing. There is also the potential for water quality impacts from use of agricultural chemicals such as pesticides, herbicides, fertilisers and hormones. The SEP also considered the potential impacts from aquaculture including water quality impacts from waste, disruption to water flows from artificial structures, and introduction of non-native/endemic species (noxious fish and non-indigenous fish).

In addition, organically produced beef in Australia is a large industry that is internationally recognised and growing as demand for chemical free protein increases. Much of Australia's organically certified beef is produced in the LEB. The implications of allowing large scale petroleum and mining development in the LEB (Qld) could be extremely detrimental to this industry.

The SEP identified several emerging threats from increased visitors and tourism to the LEB (Qld). These included overfishing and illegal fishing threatening the long-term viability of aquatic species in some areas and the killing of aquatic wildlife (turtles) caught in illegal nets in some highly visited waterholes. Other threats from increased visitors include harvesting of dead and living timber for campfires, which is becoming unsustainable at some waterholes. The loss of logs and tree hollows is a significant threat to riparian faunal biodiversity. These high impacts at a small number of localised waterholes and other environmental impacts remain poorly understood. The management of potential impacts from tourism such as the four wheel drive market is increasingly becoming a priority for desert landscapes and the LEB (Qld).

Risk assessment

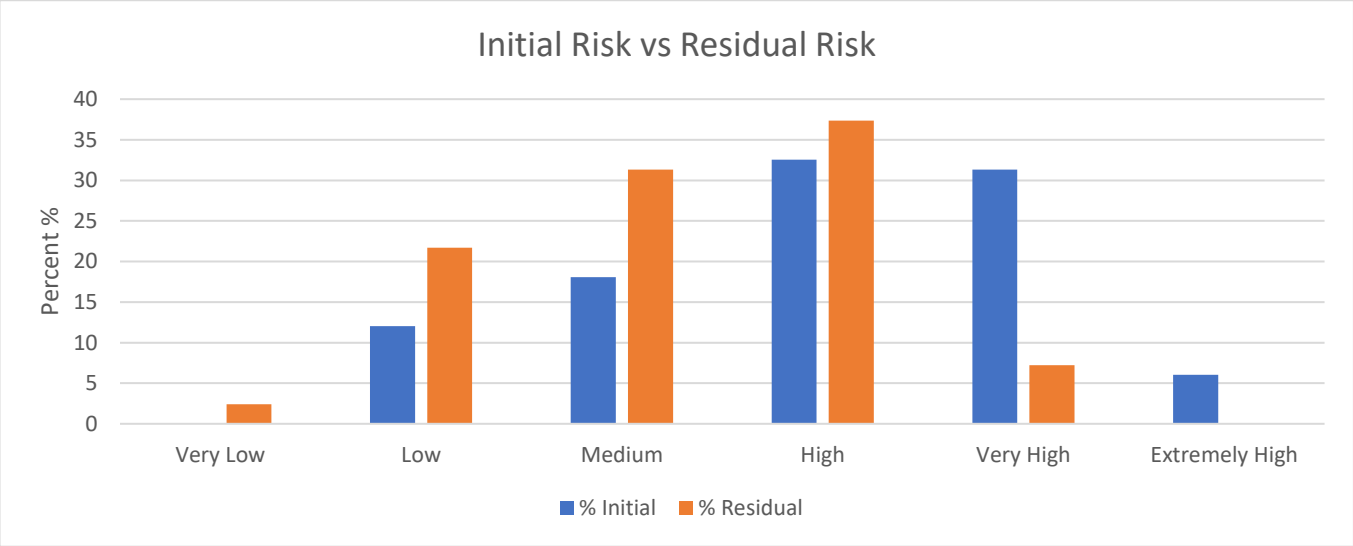
The SEP was able to assess the potential impacts and threats from conventional and unconventional petroleum and gas, mining, agricultural practices, tourism and infrastructure using a risk-based precautionary approach. The risk assessment framework utilised in this report examined the potential risks associated with these activities without any substantial controls in place (initial risk). A second risk assessment was applied to the potential impacts from these activities after considering the roles of specific planning, policy and legislative mechanisms that may reduce the consequence and / or likelihood of a particular risk to LEB (Qld) ecological assets. This latter rating was called the residual risk.

From the two-day workshop, the SEP rated the initial risk and residual risk (Very Low, Low, Medium, High, Very High, Extremely High) across 8 issues and 82 potential impacts which are summarised in Appendix E of this report.

The SEP also documented the assumptions, caveats or other pertinent contextual information for the rating assessments for each risk output. The eight issues rated were:

1. Transport, storage, mixing and use of relevant chemicals in petroleum/gas and mining industries
2. Construction and ongoing operation of supporting infrastructure for mining and petroleum/gas activities (on-lease)
3. Construction and ongoing operation of supporting infrastructure for mining and petroleum/gas activities (off-lease) and other industries such as agriculture or tourism
4. Water take in petroleum/gas and mining industries
5. Operations of petroleum/gas and mining industries including drilling, hydraulic fracturing, dewatering, extraction and processing
6. Waste treatment and disposal petroleum/gas and mining industries
7. Agricultural practices
8. Increased visitor access from tourism.

From the initial risk assessment across all 82 potential impacts, the SEP determined 70% were either High, Very High or Extremely High rating risk activities for the LEB (Qld). After theoretically applying the current legislative framework for development activities across the eight issues, this figure was reduced to 45% of the activities having a residual risk rating of High or Very High.



Percent initial risk verses residual risk following the application of legislative mechanism to avoid, mitigate and/or offset the impacts

Recommendations

The scientific literature was gleaned for insight and understanding on the ecological values, functioning and processes which sustain the biota of the LEB (Qld) catchments. This was combined with the collective understanding and experience of the SEP members to determine the risks associated with certain activities in the LEB (Qld). A long-term outlook of +50 year timeframe was adopted. This was an attempt to account for cumulative impacts such as the collective loss of riparian vegetation across the broader landscape resulting from individual infrastructure projects over many years. The SEP did note the potential impacts from climate change were not directly assessed in this process, however, it is a key consideration in the sustainable management of the LEB (Qld).

From these deliberations, several recommendations were provided by the SEP. These are summarised below.

Groundwater dependent ecosystems

Groundwater dependent ecosystems or artesian springs were also highlighted by the SEP for special protection requirements to ensure their continued existence in supporting endemic and critically endangered species. Recommendations included

1. Impose restrictions on groundwater extraction and drilling methods in the Georgina catchment because of the potential impacts to GDEs and SGDEs
2. Ensure artesian springs are a high priority for protection under legislation. This is because they are significant for maintaining Australia's unique aquatic biota and for terrestrial species being permanent source of water during dry periods in the largely terrestrial environments of LEB
3. Ensure development does not lead to the spread of invasive species in artesian springs as they could be devastating to previously undisturbed ecosystems and can out-compete endemic species (e.g., endangered fish)
4. The legislative framework should include the level/pressure as an aspect to monitor or consider, especially near to GAB springs

Riverine and floodplain ecosystems

The riverine and floodplain ecosystems are very significant for the long-term sustainability of the LEB (Qld). Several recommendations were aimed at the preservation of these ecosystems and their biota. They included:

5. Infrastructure for mining and petroleum/gas activities should not be allowed in the floodplains because of flow alterations, fish passage issues and major impacts to floodplain ecosystems
6. Quarry extraction from rivers for construction of infrastructure such as roads should not be allowed to occur in the waterways and floodplains
7. Changes to surface water flow/levels and overland flow, water quality, temperature and ecosystem structure needs to consider the impacts to threatened species that reside in permanent waterholes such as the endangered Cooper Creek catfish *Neosiluroides cooperensis*
8. Storage ponds for resource development (e.g., tailings dams) should not be placed on the floodplain due to the risk of structural integrity issues, from flooding, and spillage of wastes. It would be necessary to have restrictions on capacity of dams during a wet season
9. Limit the construction of large, raised infrastructure in the floodplain
10. Manage permanent waterholes across the LEB (Qld) region, not as individual waterholes, but as a system of intermittently connected waterholes along the length of the rivers and channels, and on the floodplains
11. Protect and maintain threatened species and their habitats for their continued survival and resilience through dry periods
12. Enforce speed limits to reduce likelihood of hitting threatened animals

Conventional and unconventional petroleum and gas, mining and infrastructure

There were numerous recommendations focussed on the management and mitigation of conventional and unconventional petroleum and gas, mining and infrastructure. Some of these recommendations were targeted to the floodplain areas of the LEB (Qld) while others addressed impacts to surface and groundwater resources. Several key recommendations were:

13. Open cut mining should not be allowed within the LEB (Qld)
14. Environmental conditions need to be specific to the ecosystems of the project area
15. RPI Act should regulate location of bores, amount of water taken from certain places, proximity to sensitive locations and species
16. The production phase of mining incurs a higher risk, and cumulative impacts need to be considered. Adequate provision is necessary many years postproduction phase for the rehabilitation and monitoring
17. Ensure that ground water monitoring is undertaken to monitor leaks into overlying aquifers from production casing or via offset wells
18. Old legacy bores from the early days may pose a risk if they were not constructed to current specifications. Ensure that ground water monitoring in these areas are undertaken
19. Tailings dams need to be managed according to industry best practice with erosion and sediment controls in place along with appropriate rehabilitation of tailings dams as a legacy issue
20. Leaching of produced water from petroleum/gas and mining needs restrictions to ensure it prevents impacts to waterholes
21. Exclude gas wells and ponds from frequently flooded areas
22. Regulation and checks on the procedures and management is required to ensure the legislation is being enforced e.g., auditing of systems

Environmental Attributes

The SEP was asked to consider which of the environmental attributes under the RPI Regulation are relevant to the Channel Country SEA. From this question, the following recommendations were provided by the SEP:

23. Incorporate all environmental attributes listed in Table 1
24. Amend the wording for each environmental attribute to better reflect the support of biodiversity and ecosystem processes as outlined in this report
25. Expand the examples given for each environmental attribute to better identify and protect the threatened flora and threatened and migratory fauna of the riverine ecosystems, GDEs and artesian springs in the LEB (Qld)

Strategic Environmental Area

In addition, the SEP were also asked to review the Channel Country Strategic Environmental Area (SEA).

26. Several proposed expansions for the SEA were considered:
    a) Extending the SEA to include all the floodplain
    b) Buffering the floodplain area by a distance (e.g., 1 km) to ensure indirect impacts from proposed activities can be included under the RPI Act and RIDA framework.
    c) Buffer the artesian springs using the recovery plan and condition assessment (Fensham *et al.* 2007; Fensham *et al.* 2010; Anderson *et al.* 2016). Refer to these reports for a potential framework to determine the appropriate buffers to be applied.
    d) Expanding the SEA to incorporate the entire LEB (Qld) basin boundary.

Although consensus was not reached, most of the SEP members supported the implementation of option d). There was concern expressed by some regarding the economic and social burden on towns and agriculture to expand the SEA to the LEB (Qld) boundary (e.g., depopulation leading an inability to control pests and weeds through a lack of private incentive and a lack of labour)

27. Lake Galilee and Lake Buchanan should be included as part of the SEA for additional protection from future development in the SEA area
28. Increase restrictions under the RPI Act to ensure activities are not carried out in sensitive areas (such as near to springs) or in an improper fashion (over-extraction) throughout the entire LEB (Qld)
29. Expand the DP or SEA to include larger areas around main channels and floodplains, and the GDEs
30. Expand the SEA/DP to include all floodplain areas
31. Expand the SEA to include other sensitive areas in the LEB (Qld) including the north west region of the basin where the topography is not within the floodplain (i.e., extensive karst systems)
32. The significance of the floodplain was raised continuously throughout the workshop. The SEP members agreed that if the health of the LEB (Qld) ecosystems is to be preserved all floodplains must be included in the Channel Country SEA, and development in floodplains must be restricted
33. Additional protection is needed for previously protected areas under Wild Rivers legislation

Designated Precinct

34. Unconventional petroleum and gas production be an unacceptable use in the Designated Precinct (DP)
35. Recommend excluding gas wells and ponds from frequently flooded areas
36. The spatial extent of the DP be extended to include the artesian wetlands, extended floodplain and significant wetlands/lakes
37. The SEA/DP be expanded to include all known springs

Invasive species and conservation management

38. A prioritised management action plan to address emerging invasive species is required to minimise their impacts on native species and ecosystems
39. Encouragement of integrated catchment management programs (for controlling or eradicating invasive pest species)
40. Public and private conservation efforts need to continue whilst ensuring the attitudes and management that has achieved this continues through appropriate legislation and incentives.
41. Utilise relevant biodiversity predictive models focussed on connectivity and condition of riverine landscapes to help prioritise potential areas for protected estate, conservation and management

Agricultural practices and tourism

42. Exclude livestock and tourists from the banks of permanent waterholes, but not restricting access to the entire riparian and floodplain system
43. In addition to the high ecological values of the Georgina River catchment, there are significant cultural values to be preserved such as the Pituri sacred areas, the Bilpa Morea Claypan European heritage area and the Camooweal Caves which are a popular tourist destination
44. Need to allow sustainable development in the LEB (Qld) but ensure that they are the right developments
45. Grandfathering of existing licenses for irrigation in the basin
46. Keep aquaculture out of the floodplain and well away from water courses flowing in. Use endemic LEB species only

47. Management of recreation and tourism is required. A possible solution is the allocation of formal areas to camp and park with amenities and facilities
48. Education of tourists and general public (large signage: “You are now entering a near-pristine river basin, one of the last natural arid-zone riverine ecosystems in the world; please do not bring any weeds in mud on your vehicle; and do NOT release any animals/fish caught elsewhere”)
49. Enforcement and education along applying with bag limits, the banning of gill nets and a reduction in bycatch
50. Consider development activities that will build the region’s population and creating smart options to build wealth through sustainable management of the natural environmental assets (e.g., weed and pest control on private land is incentivised by reducing impacts on production)
51. New schemes could be instated to grow wealth by protecting natural assets
52. Access to high ecological value waterholes or ecosystems could benefit from water hole fencing scheme and waterpoint relocation to protect them from direct access by livestock to prevent trampling and overgrazing impacts
53. Further research into building private incentives to protect the LEB (Qld) such as through a CRC or Centre for Excellence would promote a cross-disciplinary approach to understand the interactions across the basin’s natural, cultural, and socioeconomic assets

Future reviews of this report

54. The deliberations of the SEP occurred over a two-day workshop and not an extended timeframe of months or years as other similar processes have taken. Should DES allocate additional resources in the future, the SEP could reconvene to refine, and build on, the outputs of this risk assessment and to provide additional context on the assumptions and ratings provided in this report.

1 Introduction

The Queensland Government is reviewing state policy, legislation and administrative frameworks to ensure the long-term ecological sustainability of Queensland's free flowing rivers. The Queensland Government has committed (GEC958) to '*work with Traditional Owners, stakeholders and communities to ensure the State's pristine rivers are protected. This will include a review of the extent to which the Regional Planning Interests Act 2014 provides adequate protection for these rivers*'. The goal of the review is to protect and avoid widespread and irreversible impacts on rivers with all, or nearly all, of their environmental attributes intact. The purpose of the review by the State Government is to:

- achieve a balance between future economic prosperity for the State and Lake Eyre Basin (LEB (Qld)) and ecological sustainability
- ensure any impacts to environmental attributes continue to be managed and mitigated through the regulatory framework
- evaluate the effectiveness of existing planning and environmental regulations that protect identified values that are unique to the LEB (Qld)
- ensure Queensland has the most effective and responsive planning and environmental regulatory framework for protections, based on the best available science

1.1 Legislative and policy context

Resource activities in Queensland are primarily regulated through resource and environmental legislation. Other (non-resource) environmentally relevant activities are primarily regulated through environmental and planning legislation. This framework provides where and how the activity may be undertaken. In addition, specific environmental and / or access impacts not addressed through the primary regulatory framework are typically regulated through a range of associated and subordinate existing legislation.

1.1.1 Queensland legislation

Government uses the regulatory framework to manage risks that may affect environmental, social, cultural and economic values. Important objectives of the regulatory system include environmental protection, optimising access to resources, and addressing land-use conflict. Key pieces of legislation relevant to activities in the LEB (Qld) include:

- *Mineral and Energy Resources (Common Provisions) Act 2014* sets out best practice for authority holders to communicate with owners and occupiers of land, enter and carry out authorised activities, and minimise erosion
- *Waste Reduction and Recycling Act 2011* promotes waste avoidance and reduction, and resource recovery and efficiency actions
- *Petroleum and Gas (Production and Safety) Act 2004* sets requirements for the safe conduct of petroleum activities that include management of well integrity
- *Mineral Resources Act 1989* sets out requirements for mineral tenure with the objectives to encourage and facilitate prospecting and exploring of mining of minerals
- *Nature Conservation Act 1992* sets out native species protection
- *Environmental Protection Act 1994* provides for Environmental Authority assessments
- *Vegetation Management Act 1999* provides for protection of wooded ecosystems such as mulga
- *Environmental Offsets Act 2014* requires that significant residual impacts on prescribed environmental matters are counteracted through the use of environmental offsets
- *Water Act 2000* provides for water plans and licensing, and protection of vegetation in watercourse, lakes and springs

- *State Development and Public Works Organisation Act 1971* provides for assessment of major projects, and Environmental Impact Statements
- the Queensland *Environmental Protection (Water) Policy 2009* also prescribes environmental attributes and water quality objectives in all Queensland waters, including groundwater

The Queensland Government planning framework includes:

- the *Regional Planning Interests Act 2014* (RPI Act) which describes Strategic Environmental Areas (SEA)
- Regional policies contained in regional plans and 'required outcomes' under the RPI Act
- *Planning Act 2016* (PA)
- State Planning Policy

1.1.2 Commonwealth Legislation

Key pieces of Commonwealth legislation relevant to activities in the LEB (Qld) include:

- *Environment Protection and Biodiversity Conservation Act 1999* provides triggers for Matters of National Environmental Significance, such as Threatened Species or Migratory Species
- *Lake Eyre Basin Intergovernmental Agreement Act 2001* provides for the development or adoption, and implementation of policies and strategies concerning water and related natural resources in the Lake Eyre Basin Agreement Area to avoid or eliminate so far as reasonably practicable adverse cross-border impacts

1.1.3 Regional Planning Interests Act

The RPI Act manages the impact of resource and regulated activities on areas of regional interest. These areas contribute, or are likely to contribute, to Queensland's economic, social and environmental prosperity. The RPI Act identifies five SEAs within Queensland, including:

- Cape York SEA (as per the Cape York Regional Plan)
- Channel Country SEA (prescribed under regulation)
- Fraser Island SEA (prescribed under regulation)
- Gulf Rivers SEA (prescribed under regulation)
- Hinchinbrook Island SEA (prescribed under regulation)

The Queensland Government has committed to review the extent to which the RPI Act provides adequate protection for the State's rivers. The election commitment review focusses on the catchments relevant to the Channel Country SEA, including the Georgina, Diamantina and Cooper Creek river catchments. These catchments are collectively referred to as the LEB (Qld).

There are significant differences between the environmental attributes protected in the Channel Country compared to other SEAs (Table 1). The environmental attributes of the Channel Country SEA are based broadly around the criteria of:

- natural hydrological processes
- natural water quality
- the beneficial flooding of land that supports flood plain grazing and ecological processes (this criteria is only attributed to the Channel Country SEA)

Other SEAs in Queensland also consider:

- natural geomorphic processes
- functioning riparian processes
- functioning wildlife corridors

The *Regional Planning Interests Regulation 2014* further defines designated precincts (DP) within parts of a SEA. These precincts consist of portions of an SEA where a higher level of protection applies than in the wider SEA. In the Channel Country SEA, the DP parallels the whole of the SEA. The RPI Regulation identifies the following activities as unacceptable uses in a DP of the Channel Country SEA where they do not already exist:

- open cut mining
- broadacre cropping
- water storage (dam)

New or expanded resource and regulated activities are restricted in SEAs, unless a Regional Interests Development Approval (RIDA) has been granted or the activity is exempt under certain circumstances. A RIDA is a land use approval, analogous to a development approval under the *Planning Act 2016*. The Department of State Development Manufacturing, Infrastructure, and Planning (DSDMIP) are the administering agency for all RIDA applications and provide application materials to the relevant assessing agencies. DSDMIP receive advice from the relevant assessing agencies and issue or refuse the RIDA. For a RIDA in a SEA, the assessing agencies are DES and DNRME.

Table 1. Environmental attributes within the RPI Regulation 2014

Attribute number[1]	Description	Examples
1	Natural hydrologic processes	(i) natural, unrestricted flows in and along stream channels and the channel network in the area (ii) overflow from stream channels and the channel network onto the flood plains of the area, or the other way (iii) natural flow paths of water across flood plains connecting waterholes, lakes and wetlands in the area (iv) groundwater sources, including the Great Artesian Basin and springs, that support waterhole persistence and ecosystems in the area
2	Natural water quality	(i) the natural water quality in the stream channels and aquifers and on flood plains in the area
3	Beneficial flooding of land	(i) the beneficial flooding of land that supports flood plain grazing and ecological processes in the area
4	Natural geomorphic processes	(i) natural erosion (ii) the transport and deposit of sediment by water throughout the catchments and along the watercourse systems to their respective estuaries
5	Functioning riparian processes	(i) native riparian vegetation associated with watercourses, estuaries, lakes, floodplains and wetlands
6	Functioning wildlife corridors	(i) natural habitat in the watercourse systems (ii) permanent waterholes and springs

1.2 Study area

The Lake Eyre Basin (LEB) covers nearly one sixth of the Australian continent and is one of the largest internally draining river basins in the world. It supports very high values of national and international significance (Morton *et al.* 1995a; Dunn 2000; Lake Eyre Basin Ministerial Forum 2017). Much of its surface area is covered with aeolian dunes of the Simpson, Tirari and Strzelecki Deserts (Habeck-Fardy and Nanson 2014) and within Queensland the distinctive Channel Country bioregion is a prominent feature. The vast riverine ecosystems and wetlands of the LEB

[1] Grey attributes do not currently apply to the Channel Country Strategic Environmental Area.

cover 73,903 km^2 and are in a pristine condition when compared to the more developed basins such as the neighbouring Murray-Darling Basin (Kingsford *et al.* 2013; Pisanu *et al.* 2015; Kingsford *et al.* 2017). This is partly due to the general aridity of the basin and a small human population. There has been little human alteration of water regimes or the broader landscape, other than rangeland grazing, which has allowed the diverse and rich biodiversity to persist across much of its area (Lake Eyre Basin Ministerial Forum 2017). The Queensland section of the LEB contains parts of the Georgina, Diamantina and Cooper Creek catchments which flow towards Kati Thanda-Lake Eyre situated 15 m below sea level (Figure 1).

The LEB (Qld) is sparsely populated (approximately 12,387 residents) with Blackall, Barcaldine, Longreach, Windorah, Bedourie, Winton, Birdsville, Boulia and Camooweal being the main towns within the region. The two key economic drivers of the region are mining and petroleum industries and pastoral grazing (EHP 2016). There are significant mineral deposits including opals, coal, phosphate, gypsum, uranium, oil and natural gas (Hall *et al.* 2015). Cattle and sheep grazing have been the dominant land use across the LEB (Qld) for more than 150 years, resulting in some negative effects to the integrity of LEB ecosystems (Tothill and Gillies 1992). However, the harsh and changeable climate has resulted in relatively low stocking rates and lower impacts when compared to other areas such as the Murray–Darling Basin (Ford 1995).

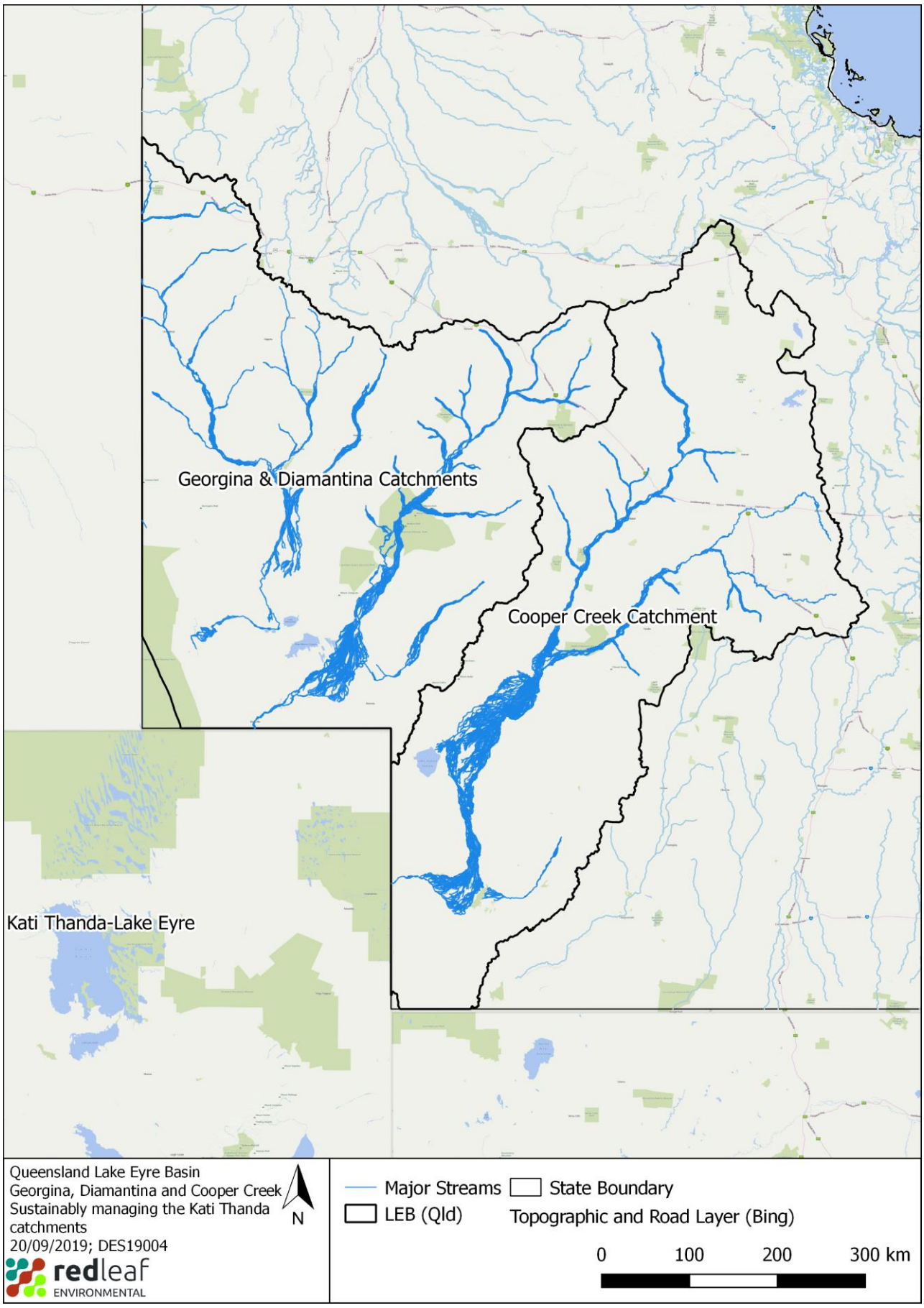


Figure 1. The Queensland section of Kati Thanda-Lake Eyre Basin containing the Georgina, Diamantina and Cooper Creek catchments

1.3 Purpose of the scientific expert panel

From this legislative and policy review, the Department of Environment and Science (DES) has commissioned Redleaf Environmental to undertake an independent Scientific Expert Panel (SEP) to deliberate on Kati Thanda-Lake Eyre Basin and its river catchments in Queensland. This panel was held over two consecutive days in Brisbane (28-29 August 2019). The Terms of Reference for the SEP are set out in Appendix B and the workshop agenda is provided in Appendix C. The primary purpose for the SEP is to provide scientific advice and recommendations to inform the government election commitment review. Specifically, the SEP is to identify the potential environmental impact/s or gaps in scientific knowledge of:

1. unconventional gas (coal seam, shale, and tight gas) industry
2. agricultural practices
3. infrastructure

The Terms of Reference also provide constraints on the scope of inquiry.

1.3.1 Environmental attributes

Environmental attributes are defined in the *Regional Planning Interests Regulation 2014* (RPI Reg); and are largely based on the natural values defined in the repealed *Wild Rivers Act 2005*. However, under the RPI Reg, the environmental attributes have been revised to emphasise specific aspects of the environmental attribute, remove certain environmental attributes from consideration in certain SEAs, and add beneficial flooding as an environmental attribute in the Channel Country SEA. Spatial characteristics included under the Wild Rivers framework were: wild river area, high preservation area, preservation area, floodplain management area, special floodplain management area, designated urban area and nominated waterways. These spatial areas have been replaced by the SEA and DP. A map showing the current SEA and DP along with the protected estate within the LEB (Qld) is provided in Appendix D.

Specifically, the SEP was asked to consider the Channel Country SEA.

1. Which of the environmental attributes are relevant to the SEA (in addition to those already listed in Table 1), and if so, how are they represented locally?
    a) the natural geomorphic processes of the area (e.g. natural erosion; the transport and deposit of sediment by water throughout the catchments and along the watercourse systems and distributaries)
    b) the functioning riparian processes of the area (e.g. native riparian vegetation associated with watercourses, lakes, floodplains and wetlands)
    c) the functioning wildlife corridors of the area (e.g. natural habitat in the watercourse systems; freely moving fish populations and communities (including fin fish and invertebrates); permanent waterholes and springs)
2. Are there other attributes (environmental or cultural) relevant to the Kati Thanda-Lake Eyre Basin that should be considered? If so, what is the evidence and justification for inclusion?
3. Are the current spatial parameters for the Channel Country SEA adequate?
    a) does the SEA spatially provide sufficient protection to riverine ecology in the LEB (Qld)?
    b) does the DP represent the area that requires a higher level of protection?
    c) what are the spatial implications of including additional attributes under questions 1-2?

1.3.2 Issues risk assessments – initial and residual ratings

As part of the SEP, an analysis and risk assessment was undertaken on eight issues and 82 potential impacts relating to the areas of unconventional gas, conventional gas, mining, agricultural practices, tourism and infrastructure. These issues were:

1. transport, storage, mixing and use of relevant chemicals in petroleum/gas and mining industries
2. construction and ongoing operation of supporting infrastructure for mining and petroleum/gas activities (on-lease)
3. construction and ongoing operation of supporting infrastructure for mining and petroleum/gas activities (off-lease) and other industries such as agriculture or tourism

4. water take in petroleum/gas and mining industries
5. operations of petroleum/gas and mining industries including drilling, hydraulic fracturing, dewatering, extraction and processing
6. waste treatment and disposal petroleum/gas and mining industries
7. agricultural practices
8. increased visitor access from tourism.

Eight separate tables were prepared for the panel's assessment of these issues. For each issue, the panel considered the following:

1. what is the risk of each impact **without** management?
2. what is the risk **after** the regulatory framework has been applied?
3. are all relevant environmental attributes listed?
4. are some attributes at greater risk than others?
5. are there particularly sensitive areas at risk of the impact?
6. are there any additional impacts in the LEB (Qld) that should be considered?
7. what could be done to improve the residual risk ratings?

The panel was asked to consider the questions in the context of direct, indirect and cumulative impacts. This report documents these findings and provides recommendations for consideration of the review of legislation and policies within the Queensland State Government.

1.4 Report assumptions and limitations

Excluded from the scope and Terms of Reference is any detailed risk analysis resulting from climate change. Climate change was acknowledged by the SEP as presenting a significant emerging threat with the potential for direct and indirect effects on water resources, riverine ecosystems, biodiversity and endemic species. The findings of this report also do not consider the broader landscape impacts from the effects of fire management and broad-scale vegetation clearing.

This report does not address the social or economic aspects of the activities, nor does it address human health effects from any of these activities. These issues have been reviewed in recent studies (Kelly and Phelps 2019; Phelps and Kelly 2019). Identification of Traditional Owner cultural attributes and cultural flows will be provided via a LEB (Qld) Traditional Owner Forum Report and presented separately to this scientific report.

It is also acknowledged that tourism was discussed in a cursory analysis by the SEP in comparison to the other topics. Tourism was nonetheless included in the deliberations by the SEP because of the potential impacts of tourism on the ecological values and assets of the LEB (Qld). This topic is worthy of additional investigations and a more comprehensive study including industry representatives to discuss the effects of tourism on the LEB (Qld).

Other assumptions included the restriction of the SEP to focus on only those activities listed in this report. No areas outside of the LEB (Qld) were included in the deliberations (except in the context of the Lake Eyre Basin Intergovernmental Agreement 2001 obligations). The risk assessment relied on a range of datasets, scientific information and the expert opinion of panel members who attended the workshop. The contents and SEP recommendations are provided in recognition of the time constraints of this project.

The risk assessments presented in this report were at a higher landscape scale with a 50 year time horizon. The risk analysis does not replace the need for site-specific and action specific assessments which would still be required for development assessments. The risk ratings are contingent on the panel's assumptions, caveats and other pertinent contextual information. The panel generally assumed best practice is implemented for all activities and all regulation is enforced. This report does, however, meet the objectives of providing a fundamental understanding of potential risk of exposure of the LEB (Qld) nationally and internationally significant riverine ecosystems, groundwater dependent ecosystems, water assets and the biota that rely on them to impacts from conventional and unconventional petroleum and gas activities, mining, agricultural practices, tourism and infrastructure in the LEB (Qld).

The deliberations of the SEP occurred over a two-day workshop and not an extended timeframe of months or years as other similar processes have taken. Should DES allocate additional resources in the future, the SEP could reconvene to refine the outputs of this risk assessment and provide additional context on the assumptions and ratings provided in this report.

2 Activities considered by the SEP

A brief summary of the scope of activities considered by the panel is provided below with a focus on conventional and unconventional petroleum and gas activities, mining, agricultural practices, tourism and infrastructure. These issues were considered important for SEP discussions and were identified as key areas for further development by past scientific panel forums (Cullen 2003; Cullen 2004a). There have been several major reviews of conventional and unconventional petroleum and gas activities and the potential impacts to the environment undertaken by state and commonwealth governments, industry groups, universities and research institutions across Australia (Moran and Vink 2010; USQ 2011; DMP 2015; Anderson *et al.* 2016; Geoscience Australia 2017b; Geoscience Australia 2017a; Pepper *et al.* 2018; Huddlestone-Holmes *et al.* 2018; OGIA 2019). These substantial reports are not reproduced here. We recommend the reader seeks these reports out for a more detailed discussion and information on the definitions and descriptions summarised below.

2.1 Gas processing and extraction associated activities

2.1.1 Hydraulic fracturing and stimulation

The hydraulic fracturing involves the injection of fluid at high pressure into a well to widen existing fractures and make new fractures in sedimentary formations. These fractures allow gas to escape more freely to the surface of the well. The fluid used in this process is made up of predominantly water and sand or proppant (e.g. nutshells, ceramics or bauxite) (99 %) and a small percentage of chemicals (e.g., sodium hypochlorite, detergent additives, vinegar) which holds the fractures open after the initial injection.

The fluid itself is quite viscous to keep the proppant suspended and consistently distributed within the fluid. The risk to public health or to the environment from these fluids is considered negligible by the Commonwealth Government and as reported elsewhere (Payne *et al.* 2014). The use of certain BTEX chemicals (benzene, toluene, ethylbenzene, xylene) as fracking agents has been banned from use by the New South Wales government. While Queensland permits BTEX chemicals being included in hydraulic fluids, their concentrations are restricted to a level, that it may be considered an essential ban on their use.

2.1.2 Gas production, compression, liquification

Gas extracted from a well is transported via pipeline (gathering) to a field compressor station and then moved to a central processing plant. From here, it travels onto a liquification plant via a steel trunkline. The field compressor stations and processing plants are required to dry and compress the gas in an upstream environment. Pipelines are required to transport gas from the wells to facilities and to the coastline for export or domestic use. Each of the processing facilities use a variety of chemicals and processes to treat the natural gas (e.g., triethylene glycol) and can be sources of noise and air pollution. During processing outages gas is vented and burnt via the use of a flare pipe.

2.2 Conventional petroleum and gas

The term “conventional” describes oil and gas extracted after the drilling operations, just by the natural pressure of the wells and pumping or compression operations. In conventional petroleum systems, oil and gas are generated through, and partly expelled due to, various physical and chemical processes in an organic-rich source rock (Figure 1). The expelled petroleum migrates upwards through the sediment mass as a result of natural forces such as buoyancy. This migration through sedimentary sequences requires porous and permeable sedimentary rocks such as sandstones, fractured rock and permeable faults, to allow enough flow. Petroleum accumulates within porous reservoirs that are sealed or capped by impervious rock beds, salt domes or clay layers that prevent further upward migration (Huddlestone-Holmes *et al.* 2018). When a well is drilled, gas migrates to the surface and does not require much pumping or fracking. Further characteristics associated with conventional gas extraction are summarised in Table 2.

2.3 Unconventional petroleum and gas

Unconventional means are used when the resources are dispersed and difficult to move through the rocks. In unconventional petroleum systems, oil and gas have accumulated in a reservoir that does not fit conventional

reservoir models (Huddlestone-Holmes *et al.* 2018). Unconventional resources are natural resources which require greater than industry-standard levels of technology or investment to exploit. In the case of unconventional hydrocarbon resources, additional technology, energy and capital must be applied to extract the gas or oil, replacing the natural action of the geological processes of the petroleum system (Geoscience Australia 2019). Examples of unconventional gas resources include CSG, Shale Gas and Tight Gas. The differences between unconventional gas extraction types and extraction methods are present below and in Table 2. A diagrammatic description is provided in Figure 2.

2.3.1 Coal seam gas

Coal Seam Gas (CSG) is a naturally occurring methane gas found in most coal seams and is like conventional natural gas. In Australia the commercial production of CSG commenced in 1996 in the Bowen Basin, Queensland (USQ 2011). Since then production has increased rapidly, particularly during the first decade of the 21st century. CSG has now become an integral part of the gas industry in eastern Australia, particularly in Queensland.

The activity of CSG production involves extracting quantities of groundwater from coal formations to reduce the water pressure in the coal seams. This dewatering operation releases the gas that is attached to the coal. The CSG dewatering process produces significantly more water (about 18,000 ML/yr in the Surat and Bowen Basins) than conventional petroleum and gas production (about 1,800 ML/yr) (OGIA 2019).

CSG, or coal bed methane (CBM), is a form of natural gas, typically extracted from coal seams at depths of 300-1,200 metres. It is a colourless, odourless, non-toxic mixture of several gases but mostly made up of methane (generally 95-97 per cent pure methane). Further characteristics associated with CSG extraction are summarised in Table 2.

Hydraulic fracturing is occasionally required in CSG gas production as some coal seam formations will not yield enough gas to be commercially viable using the regular dewatering method of extraction. When Hydraulic fracturing is required the process is usually completed in one (1) stage as opposed to the several stages required for a tight or shale gas well. Approximately 10% of CSG wells in the Queensland have been hydraulically fractured (Huddlestone-Holmes *et al.* 2018).

2.3.2 Shale gas and Tight Gas

The only major difference between tight gas and shale gas extraction is that shale gas is extracted from low permeable and non-porous shale formations and tight gas is extracted from low permeable and non-porous sandstone rock formations or low permeability carbonate rocks (DMP 2015). Typically, shale formations are found at a greater depth than sandstone, therefore the drilling depth is generally deeper in shale gas extraction than in tight gas extraction. Drilling depth information for these activities can be found in Table 2.

The pore spaces in these rock formations are tiny and not connected so it is difficult for the gas to move through the rock. Hydraulic fracturing or stimulation is required to create cracks in these rock formations and increase permeability and connectivity.

The scale of development for shale and tight gas and oil and CSG is similar because they both need many wells to develop the resource. The amount of gas or oil recovered from each well is lower than for conventional petroleum wells.

Drilling technologies used in shale gas and oil development, including horizontal sections, are very much the same as used for deep conventional gas and oil resources. Hydraulic fracturing, which is used for shale/tight gas resources and CSG, has been used extensively in other unconventional petroleum resources in South Australia and the Northern Territory. The drilling fluids and hydraulic fracturing fluids used are also much the same.

The main differences for shale/tight gas and oil compared with CSG (and conventional petroleum resources) is the prevalence of hydraulic fracturing. Shales and tight sands will always require hydraulic fracturing to yield gas; CSG only requires hydraulic fracturing in some wells; and conventional petroleum developments rarely require hydraulic fracturing. As a result, shale/tight gas and oil activities will use water differently to CSG activities. On a per well basis:

- Shale/tight gas and oil will require more water up-front for drilling and hydraulic fracturing than CSG activities

- Shale/tight gas and oil will have more flowback water (hydraulic fracturing fluid that flows back out of the well after hydraulic fracturing is complete) than CSG activities
- Shale/tight gas and oil will have less produced water (water that comes from the resource during production) than CSG activities since CSG wells need to be dewatered to allow gas production

Shale/tight gas and oil resources are also deeper than CSG resources, so different drilling rigs will be used that can reach deeper and drill long horizontal sections once they reach the resource. This will also allow multiple wells to be drilled from a single well pad. The well pads will be bigger for shale/tight gas and oil than for CSG wells, although the drilling of multiple wells from a single pad will mean a decreased footprint overall (Huddlestone-Holmes *et al.* 2018). More information on aspects of shale and tight gas in comparison to other gas types can be found in Table 2.

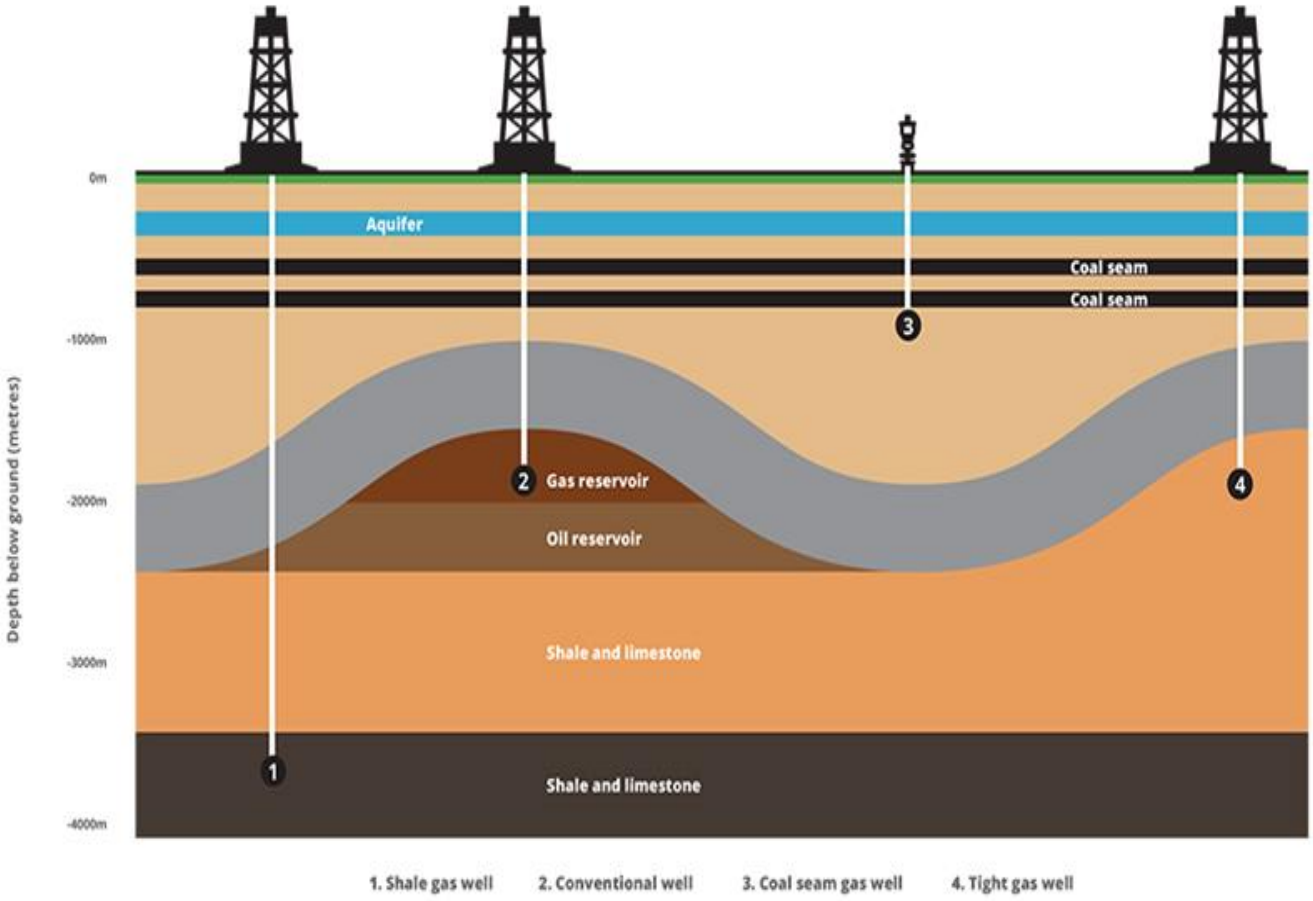


Figure 2. Diagram depicting conventional and unconventional gas drilling (Ref: Energy Information Australia)

2.4 Mining

This report considered mining to include open cut mining (surface) and underground mining (sub-surface). Open cut mining is more common with a range of impacts to the local environment including removal of surface vegetation and layers of bedrock to expose the buried ore deposits. Sub-surface mining consists of constructing shafts into the earth to reach buried ore deposits. Open cut mining is an unacceptable use in the DP of the Channel Country SEA where it does not already exist.

2.5 Agricultural Practices

For the purpose of this panel workshop agricultural practices refers to all agricultural practices such as cropping, intensive and extensive production, but particularly focussing on the extensive cattle and sheep grazing industry that already exists in the basin. Broadacre cropping and construction of water storage dams are unacceptable uses under the Channel Country DP.

2.6 Tourism

Tourism encapsulates recreational visitors to the LEB (Qld) through organised tours (coaches) and self-drive visitors (four-wheel driving and caravanning) to experience the natural landscapes, towns, tourist attractions, local culture, camping and eco-tourism. The SEP consider the potential impact of these activities along with the associated infrastructure needs on the ecological ecosystems and values of the LEB (Qld). The associated infrastructure needs incorporate the provision of fuel, accommodation, rest stops, camping sites and other infrastructure like access roads and service centres like local towns.

2.7 Infrastructure

For the purpose of this panel workshop infrastructure encompasses large scale infrastructure in relation to increased human presence in the basin, from gas production, mining or resource activities, roads, pipelines, urban footprint through to tourism (e.g., roads, bridges, culverts, invert drains, buildings, fences, hardstand pads, formal camping grounds). Water storage dams and open cut coal mining are currently unacceptable uses within the DP of the Channel Country SEA.

*Table 2. Summary of conventional and unconventional gas types in Australia**

	Conventional Gas	Unconventional Gas		
		Coal Seam Gas	Tight Gas	Shale Gas
Drilling depth	1000 – 3000m	300 – 1200m	1000 – 5000m	3000 – 5000m
Source formation	Porous/permeable sedimentary rock formations (sandstones or limestones) capped with impermeable rock (usually shale) [3]	Coal seams – gas typically held in place by water	low permeability and low porosity sedimentary reservoirs (sandstones or limestones)	low permeability and low porosity shale reservoirs
Drilling time	Dependent on formation of reservoir	Up to 1 week	Approximately 2-8 weeks	Approximately 2-8 weeks
Hydraulic fracturing required	Rarely	Sometimes (currently only 10% of Queensland's CSG wells are hydraulically fractured)[1]. This statistic is changing where some proponents in Qld are using hydraulic fracturing for 100% of wells.	Almost always (100%)	Almost always (100%)
Water consumption (drilling, stimulation, work over)	Low – 1-2ML (dependant on well depth, diameter and geological conditions)[2]	Low	High	High - between 5-20ML per well (dependent on local conditions)[1]
Produced water volume	Low	High	Low	Low
Above ground infrastructure density	Sparse – dependent on locations of trapped gas. One well can be used to tap large reservoir due to porosity of formation.	Dense (wells can be as close as 700m apart in block developments)	Less frequent, but larger than CSG – multiple wells often drilled from one well pad. Horizontal drilling also common	Less frequent, but larger than CSG – multiple wells often drilled from one well pad. Horizontal drilling also common
Required associated infrastructure	Well pad (up to 2 ha) Access tracks (10 m wide) Gas pipelines Treatment facilities	Well pad (1 ha) Access tracks (6 m wide) Gas pipelines Water pipelines Treatment facilities Large associated water storage ponds Low consequence dams (lined frac ponds) – when applicable	Well pad (up to 2 ha) Access tracks (10 m wide) Gas pipelines Treatment facilities Low consequence dams (lined frac ponds)	Well pad (up to 2 ha) Access tracks (10 m wide) Gas pipelines Treatment facilities Low consequence dams (lined frac ponds)
Waste	Drill cuttings Wastewater from drilling Condensate (hydrocarbon by-product from gas drying) Camp related wastes Stimulation fluid	Drill cuttings Wastewater from drilling Stimulation fluid (frac) Condensate (hydrocarbon by-product from gas drying) Produced water Salt (by-product of produced water treatment) Camp related wastes	Drill cuttings Wastewater from drilling Stimulation fluid (frac) Condensate (hydrocarbon by-product from gas drying) Camp related wastes	Drill cuttings Wastewater from drilling Stimulation fluid (frac) Condensate (hydrocarbon by-product from gas drying) Camp related wastes

* Table summarises general attributes associated with different methods of gas extraction. It is not exhaustive and there are exceptions to some statements. It is intended to give workshop attendees a general idea of risks associated with each activity.

1 Huddlestone-Holmes *et al.* 2018

2 CSIRO Gas Industry Social and Environmental Research Alliance, Unearthing Conventional Gas - https://gisera.csiro.au/news/unearthing-conventional-gas/ (Accessed August 2019)

3 (Image) Energy Information Australia: Formation and Extraction - https://www.energyinformationaustralia.com.au/oil-and-gas-explained (Accessed August 2019)

3 Methods

3.1 Expert panel

3.1.1 Facilitator

The SEP was facilitated by Dr Darren Fielder (Principal Scientist, Redleaf Environmental) who has a 25-year career in biodiversity planning and assessment from the public and private sectors. In 2012, Darren undertook a risk assessment of water dependent threatened species and communities and water assets of southwest Queensland from CSG and coal mining (Fielder 2012). Other key achievements include being part of the team which implemented the first Biodiversity Planning Assessment (BPA) undertaken by the Queensland State Government in 2002 for the New England Tablelands Bioregion. Darren was instrumental in the development and implementation for the Southern Brigalow Belt and Mulga Lands BPAs.

Darren also co-authored the Queensland State Government Aquatic Biodiversity Assessment and Mapping Method (AquaBAMM) and Aquatic Conservation Assessment (ACA) which was applied to all riverine and non-riverine wetlands across Queensland (Clayton *et al.* 2006). Darren went on to lead multi-disciplined teams in the development and implementation of several ACAs (Queensland Murray Darling Basin, LEB, Condamine River Catchment, NSW Murray Darling Basin, Brisbane City Council). He has facilitated over 25 ACA or BPA expert panel (1-2 day) workshops since their implementation in the early 2000's.

3.1.2 Panel members

The SEP consisted of 12 panel members appointed to ensure expertise from a range of specialisation including (but not limited to):

- Hydrogeology
- Hydrology
- Ecology
- Toxicology
- Agriculture
- Geology

The invited experts were from a broad cross section of academic, consulting, industry and government (commonwealth and state) scientific organisations, including past and current members of the Independent Expert Scientific Committee on CSG and large coal mining development and LEB Scientific Advisory Panel. The initial consultation list of potential members was developed by DES and was further added to after consultation with various technical experts providing recommendations for additional potential members. The aim of the SEP composition was to have approximately two experts across each of the discipline areas of hydrogeology, hydrology, ecology, toxicology, agriculture and geology. Where someone was unable to attend, another potential member was invited with similar experience and skill set. Invitations were sent out until 12 panel members had agreed to attend the workshop.

Table 3. Panel member organisation and expertise

Panel Member	Profile	Hydrogeology	Hydrology	Ecology	Toxicology	Agriculture	Geology
Emeritus Professor Angela Arthington	Australian Rivers Institute, Griffith University Current member: LEB Scientific Advisory Panel Previous member: Independent Expert Scientific Committee on CSG and large coal mining development		x	x			
Emeritus Prof Des Connell	Emeritus Professor of Environmental Chemistry, Griffith University				x		
Emeritus Prof Peter G Flood	Honorary Professor of Geosciences, University of Sydney Previous member: Independent Expert Scientific Committee on CSG and large coal mining development	x					x
Ms Katharine Glanville	Ecosystem Survey and Mapping Department of Environment and Science	x					
Dr Kate Holland	Principle Research Scientist, CSIRO Currently the Cooper Basin and CSIRO Project leader for the Geological and Bioregional Assessment Program	x		x			
Mr Roger Jaensch	Jaensch Ornithology and Conservation			x			
Mr Jim McDonald	Director Marianker Partnership Previous member: Independent Expert Scientific Committee on CSG and large coal mining development		x	x		x	
Dr Steve Morton	Honorary Professional Fellow Charles Darwin University and CSIRO Ecosystem Sciences Current Chair: LEB Scientific Advisory Panel			x			
Dr David Phelps	Principal Scientist/Flood Recovery Coordinator, DAF Adjunct Professor CQU					x	
Dr Tim Ransley	Geoscience Australia Current member: LEB Scientific Advisory Panel	x	x				
Mr Tim Ryan	Ecosystem Survey and Mapping Department of Environment and Science	x		x			
Mr Todd Symons	Owner Daly Drilling Bros Pty Ltd						x

3.2 Walking the basin

As part of the panel deliberations and discussions, a large fabric printed map (7 x 7 m) of the entire LEB catchments within Queensland was laid out on the floor of the room. The SEP members were able to undertake 'walking the basin' as a group. By using this large map, the panel members were able to discuss the ecological processes, ecological functions, connectivity and ecological values for each catchment in the LEB (Qld). This was an effective tool in gaining unique insights from the panel members and for gaining a common understanding of the ecological functioning of the LEB (Qld) landscape.

The facilitation technique was loosely based on the Department of Environment and Science's 'Walking the landscape' framework which has been applied to many river catchments across Queensland. The full method is documented in the Department of Environment and Heritage Protection (2012).

Walking the basin – LEB (Qld) map

Photo Credit Lindsey Jones, Department of Environment and Science 2019

3.3 Case examples

Two case examples (or scenarios) were provided to the SEP to allow for discussion and thought on the challenges to the LEB (Qld) on emerging and cumulative risk likelihoods. The first example was titled, "Proposed Petroleum (CSG) Activity 2019 – Current regulatory framework". This example asked the SEP to examine the hypothetical scenario of a development application for a petroleum activity which included 250 production wells and ancillary infrastructure to be developed on a petroleum lease in the Diamantina River floodplain. This scenario was to be assessed under the current regulatory framework in Queensland. The second case example was titled, "Proposed Petroleum (CSG) activity year 2070 – Current regulatory framework". This second scenario was like the first one but assumed the LEB (Qld) was developed into a significant resource hub, with mining and petroleum activities, rail access, improved and unimproved roadways. An additional 250 production wells and ancillary infrastructure is now proposed (hypothetically) to be developed on a petroleum lease. The second example asked the SEP to address cumulative impacts from 50 years of development.

3.4 Risk assessment matrix

The following likelihood definitions, consequence definitions and risk ratings (Tables 4, 5, and 6) were determined based on the definitions from existing risk assessments of conventional and unconventional petroleum and gas potential impacts from other regions of Australia (DMP 2015; Huddlestone-Holmes *et al.* 2018; Pepper *et al.* 2018; Hatton *et al.* 2018). The risk matrices from these assessments were reviewed and ISO 1300 risk management was consulted by the SEP to determine the final spectrum of risk ratings along with defensible descriptions used elsewhere in the literature.

Table 4. Likelihood definitions[2]

Category	Description
Rare	Very unlikely, one event in 100-1000 years
Unlikely	Not expected, unlikely but may occur at some time (e.g., at least once every 10-100 years)
Possible	Expected, history of similar issues with past activities (e.g., at least once every 3-10 years)
Likely	Expected, history of frequent occurrences with past activities (e.g., once every 1-3 years)
Almost certain	Expected, history of continuous occurrences with past activities (e.g., more than once per year)

Table 5. Consequence definitions[2] *(maximum reasonable consequences)*

Category	Description (scale, intensity, duration)
Insignificant	Impacts of minimal significance
Minor	Impacts of limited significance: • occurs in an existing disturbed, or isolated/contained area (e.g. up to a square/ linear kilometre), and • can be easily remediated, or • last days-months.
Moderate	Impacts of moderate significance: • occurs beyond an existing disturbed area or over a localised area (e.g. from 1-10 square/linear kilometres), or • lasts months-years, and/or • may be remediated.
Major	Impacts of high significance: • occurs across a widespread area (e.g. 10-100 square/linear kilometres), or • lasts years-decades, and • may/may not be remediated – (high cost or difficult to remediate)
Extreme	Impacts of major significance: • occurs across a widespread area (e.g. at least 100 square/linear kilometres), and/or • cannot be remediated and is irreversible.

[2] Risk definitions and ratings have been prepared based on consideration of three separate reports:

- Independent Scientific Panel Inquiry into Hydraulic Fracture Stimulation in Western Australia 2018
- Scientific Inquiry into Hydraulic Fracturing in the Northern Territory 2018
- CSIRO Assessment of scientific knowledge of shale has and shale oil potential impacts 2018 (confidential)

Table 6. Risk rating matrix[2]

Likelihood	**Almost certain**	Medium	Medium	High	Very High	Extremely High
	Likely	Medium	Medium	High	Very High	Very High
	Possible	Low	Medium	High	High	Very High
	Unlikely	Low	Low	Medium	High	High
	Rare	Very Low	Low	Low	Medium	High
		Insignificant	**Minor**	**Moderate**	**Major**	**Extreme**
		Consequences				

4 Results

4.1 Walking the basin

The following information is presented as a summary of issues, ecological values, specific locations of interest and discussions by the SEP during the 'Walking the basin' exercise. The information was enhanced through the incorporation of scientific literature where appropriate.

Flow in a river system and associated floodplain wetlands is widely recognised as a key driver of ecological processes (Boulton and Brock 1999; Bunn and Arthington 2002; Cullen 2003). Australia's aquatic biodiversity has evolved in a highly unpredictable environment with flow variability of some Australian semi-arid zone rivers at the extreme end in the world (Davies *et al.* 1994; Puckridge *et al.* 1998; Puckridge *et al.* 2000; Kingsford 2000; Bunn and Arthington 2002; Bunn *et al.* 2006b; Bunn *et al.* 2006a; Kingsford 2017). The river systems of western Queensland, such as the Georgina, Diamantina and Cooper Creek catchments have been subjected to relatively low anthropogenic disturbance and all presently lack major structures that would regulate flow. They are characterised by extreme flow variability by virtue of their geographical locations in the semi-arid and arid areas of southwest Queensland (Kerezsy 2010). Most flow is derived from variable monsoonal rainfall in the uppermost (northern) zones of the catchments; runoff in the inner zones of the basin is infrequent but can provide substantial benefit to the wetland ecosystems. Rather than being a permanent flowing, discrete river channel, these rivers are typically a series of anastomosing channels and anabranches situated in a broad floodplain, filling every few years after long dry periods with flood waters from upstream rainfall (sometimes drought breaking). During the wet periods, habitat complexity and availability in these inland river catchments is vast with extensive flooding producing a complex system of swamps, channels, lakes, billabongs and waterholes on the distributary floodplains. In dry periods these rivers usually are reduced to a series of waterholes in the channels and isolated wetlands on the floodplain; these habitats serve as refuges for obligate aquatic species (Bunn *et al.* 2006a) and many dry up completely in prolonged drought.

The waterholes and channels of the LEB (Qld) occupy a unique and iconic place in Australian folklore largely due to their crucial role in the pastoral industry in the harsh conditions of a dry climate (Silcock 2009; Kerezsy 2010; Silcock 2010). The iconic LEB and its distributary systems was recognised in the Lake Eyre Basin Intergovernmental Agreement 2001 as one of the last arid-zone water catchments around the globe to flow intermittently without interruption, and therefore of high conservation significance on a world scale. The LEB (Qld) river systems do not require intensive management such as provision of 'environmental flows' as described by Acreman *et al.* (2014) because they have very limited alterations from their natural flow regimes. These systems are, at times, fully connected from the headwaters of the streams to the floodplains and ultimately through to the terminal lakes (e.g., Kati Thanda-Lake Eyre). This connectivity longitudinally along the river and laterally to adjacent floodplain wetlands supports ecological processes essential to sustaining the biota in these rivers and associated wetlands (Leigh *et al.* 2010; Arthington and Balcombe 2011; Kerezsy *et al.* 2014; Reid 2017).

In addition to flow regimes, water quality plays an important role in the spatial and temporal dynamics of ecological processes in dryland rivers (Sheldon and Fellows 2010). The physical and chemical properties of water quality at any time of year and location depend on factors that operate at a broad scale including geology, soils, vegetation and catchment land-use through to local-scale factors such as evaporation and groundwater interactions, and biological processes within a waterhole. For example, the salinity values within the LEB are high for some terminal lakes in South Australia where the shallow saline groundwater is exposed to on-going evaporation (Tweed *et al.* 2011).

These highly variable spatial and temporal patterns combined with water parameter variations (fresh or saline, turbid or clear, etc), wetland position in the landscape, shape, depth and drying pattern make for a diversity of habitats for aquatic organisms to exploit (Kingsford 2000). Similarly, the biological responses to differing hydrological and environmental characteristics is evident in the spatial and temporal diversity of biota across ecosystems and catchments in the LEB (Costelloe *et al.* 2003). Aquatic species of dryland river catchments display several adaptations to benefit from the 'boom and bust' dynamics of floods and droughts (Leigh *et al.* 2010; Sheldon *et al.* 2010). Waterbirds colonise flooded swamps to breed, then disperse to other areas of Australia during dry periods, while frogs burrow to avoid prolonged droughts (Kingsford 2000; Jaensch 2004; Jaensch 2009; Kingsford *et al.* 2013; Kingsford *et al.* 2017). Plants may lay dormant in root stocks with little growth, or in seed banks for

many years, to regenerate after floods. In addition, the LEB (Qld) exhibits the highest diversity of all terrestrial classes of vertebrates with some 22 species of frogs, 130 reptiles, 230 birds, and 35 mammals (Morton *et al.* 1995b).

4.1.1 Cooper Creek Catchment

Cooper Creek is the eastern catchment within the LEB in Queensland. The Thompson River and Barcoo River are significant tributaries feeding Cooper Creek beginning north of Longreach and flowing southwest toward Windorah, where the Cooper Creek continues to the South Australian border and onwards to Kati Thanda-Lake Eyre. Within South Australia, many sub-terminal lakes must be filled before Cooper Creek can deliver water to Kati Thanda-Lake Eyre—an infrequent occurrence. Located in the headwaters of the Thompson River are two large groundwater fed lakes which can also fill from local runoff. Lake Buchanan (saline) and Lake Galilee (fresh to saline) are unique in Queensland and support a wide variety of freshwater and salt tolerant wetland species. Lake Galilee is hydrologically diverse in that the eastern half supports plant species characteristic of fresh water such as canegrass, and belalie trees, whereas the western half is dominated by samphire. When the lake is high and as one continuous water body, the eastern water is milky. As levels steadily fall, the lake breaks up into inner basins and the deeper western basins become saline. They are also essential to many migratory bird species, with Lake Galilee at times supporting breeding and foraging of up to 100,000 water birds (Reid *et al.* 2010).

Lake Galilee and Lake Buchanan are not currently included in the Channel Country SEA. There are currently petroleum exploration permits (EPP) covering Lake Galilee as well as coal and petroleum exploration permits (EPC and EPP) surrounding Lake Buchanan. The consensus amongst panel members was that these two lakes should be included as part of the SEA for additional protection from future development in the SEA area.

Groundwater connectivity in the Cooper Creek catchment is vital to the health of the basin and regional towns in the area. There are numerous artesian springs in this catchment with most falling outside of the existing Channel Country SEA/DP. Based on discussions within the workshop the SEP recommended that all known springs should be included in the SEA going forward. These springs are intimately linked with the waters of the GAB which is a key water source in Queensland. Interference with groundwater sources, pressures and levels within the vicinity of springs of the LEB could have a catastrophic impact on their conservation values across the LEB (Qld) (Arthington and Balcombe 2011; Kerezsy *et al.* 2014). There was support within the SEP for increased restrictions under the RPI Act to ensure activities are not carried out in sensitive areas (such as near to springs) or in an improper fashion (over-extraction) throughout the entire LEB (Qld).

From the 'walking the basin' discussions, there was recognition by the SEP of the minor variation of slope gradients within the basin. This shallow slope means the movement of surface water can be quite gradual, especially during times of low flow. Most of the permanent waterholes in the Cooper Creek rely on surface water flow. A lot of these waterholes support boom and bust ecosystems where dry times are as important as wet times and require periods of dry weather and limited or no flow to remain healthy. Deeper lagoons remain permanent due to water provisions during intermittent channel and flood flow events. If there are no flood events for more than two consecutive years, some permanent waterholes dry up (Bunn et al. 2006a). Significantly, there is a predicted 30% decrease in water levels in waterholes within Cooper Creek as a result of climate change (A. Arthington, 2019, pers comm, 28 August). Although waterbirds being highly mobile can repopulate the LEB (Qld) wetlands from afar, all other obligate aquatic species (invertebrates, fish) rely on permanent waterholes during dry periods and loss of depth and habitat is critical (Arthington and Balcombe 2011). Importantly, fish are totally dependent on the waterholes which can be reduced to a small number of points in the landscape.

Due to the flat topography of the basin, disturbance to natural ground level in the basin will impact aquatic ecosystems downstream of disturbance by either cutting off, redirecting and/or concentrating existing flow paths, as well as potentially impacting water quality (turbidity, dissolved oxygen, algal blooms). For this reason, any development with the ability to significantly impact natural floodplain and channel flow paths (including overland flow) and/or downstream water quality of waterholes must be restricted. Existing oil/gas extraction on the Cooper floodplain in Queensland has illustrated the impacts to overland flow of minor structures such as graded roads and cleared seismic lines, with grader spoil forming barriers to minor flows.

This is especially important on floodplains as drainage lines are used by fish returning to permanent waterholes in times of flood recession. Most fish species in the Cooper Creek catchment area (and by implication, also the other

LEB Qld catchments) use the floodplains to feed and grow during flood events. It is critical that interference with natural flow paths does not occur on the floodplains. The significance of the Cooper Creek floodplain was raised continuously throughout the workshop and all panel members agreed that if the health of the LEB (Qld) ecosystems is to be preserved all floodplains in the Cooper Basin and greater LEB (Qld) must be included in the Channel Country SEA, and development in floodplains must be restricted.

Several native fish species are under threat of extinction in the LEB (Qld). The Cooper Creek Catfish *Neosiluroides cooperensis* is dependent on permanent waterholes and is becoming critically endangered (it is under review for inclusion on the IUCN Red List of Threatened Species, A. Arthington pers comm.). The red-finned blue eye *Scaturiginichthys vermeilipinnis* and the Edgbaston goby *Chlamydogobius squamigenus* are both spring dependant and listed as endangered under the *Nature Conservation Act 1992* and endangered and vulnerable under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), respectively. These two species are endemic to artesian springs located near the town of Aramac. The invasive mosquito fish *Gambusia holbrooki* has been identified as a problem species impacting populations of these threatened spring endemic fish (Kerezsy and Fensham 2019). Development in areas significant to endangered species could potentially introduce invasive species to ecosystems previously not impacted by them.

Other invasive species that are becoming an increasing problem in the LEB (Qld) due to human interference include cane toads *Bufo marinus*, red claw crayfish *Cherax quadricarinatus*, sleepy cod *Oxyeleotris lineolata*, prickly Acacia *Vachellia nilotica,* Parthenium *Parthenium hysterophorus* and Parkinsonia, *Parkinsonia aculeata*. Further development in sensitive ecosystems could be devastating to previously undisturbed ecosystems as invasive species may be given opportunity to spread and out-compete endemic species.

The Barcoo Shire has semi-aquatic plant species that rely on flood water to germinate. Riparian vegetation is also very important in the LEB (Qld) as the root systems provide structural complexity and habitat for aquatic species. River red gum *Eucalyptus camaldulensis* populations along the channels of the Cooper Creek provide essential habitat for fauna, including semi-aquatic fauna and migratory birds. Protection of these riparian trees is crucial for fauna habitat and corridor movements in an otherwise mostly treeless terrestrial landscape.

Lake Yamma Yamma, situated near the South Australian border and which fills directly from Cooper Creek, is the largest freshwater ephemeral lake in Queensland. It is considered by the Directory of Important Wetlands in Australia (DIWA) as a Nationally Important Wetland and plays a vital role in the migration of many migratory bird species, at times supporting thousands of shorebird species as well as up to 20,000 nesting Australian Pelicans *Pelecanus conspicillatus* (Environment Australia 2001). Lake Yamma Yamma is also dependent on connectivity to groundwater.

4.1.2 Diamantina River Catchment

The Diamantina River catchment is centrally located within the LEB (Qld). Its headwaters start near Kynuna and the river eventually flows through Birdsville into Kati Thanda-Lake Eyre in South Australia. The Diamantina River proper and Mayne River are the main tributaries to this catchment, with the Diamantina River running the length of the basin and into Kati Thanda-Lake Eyre. There are National Parks on the Diamantina River that protect several endemic endangered species such as the Night Parrot *Pezoporus occidentalis*, Greater Bilby *Macrotis lagotis* and the Edgbaston goby *Chlamydogobius squamigenus*. Astrebla Reserve is one of the last natural refuges for the Greater Bilby in Queensland (Bradley *et al.* 2015). Panel members raised concerns for park management methods currently being practised in these national parks, such as extensive grazing of livestock within the national park boundaries. Although, in some circumstances grazing can have benefits to biodiversity (e.g., reduced fuel load and restoration of land condition) (Mavromihalis *et al.* 2012).

The Diamantina River catchment is unique in providing water most frequently to Kati Thanda-Lake Eyre than either the Georgina or Cooper Creek systems. The reason for this is that there are very few large lakes in the Diamantina catchment, which would capture much of the flood water (cf. Cooper Creek), and much of the lower reaches of the system has a distinct single channel. Floodplain swamps nevertheless occur on both sides of the State border and, in Queensland, sedge/shrub swamps at the edges are a breeding place for the Australian Painted-snipe *Rostratula australis* which is listed as Endangered under the EPBC Act. The largest-known breeding colony of mixed waterbird species in the LEB is in swamp of lignum *Duma florulenta* and belalie *Acacia stenophylla* on the Diamantina

floodplain (Costelloe *et al.* 2004). Rainfall events occur usually in a north-west to south-east direction across the top of the LEB (Qld) catchments. Nearly always, water from every flood event in the Diamantina River will reach Kati Thanda-Lake Eyre. Conversely, flood events in the Cooper do not always reach the South Australian border because much of the flood water is held in large lakes and wetlands upstream of Lake Eyre, and the Georgina system spills into the Simpson Desert before joining the Diamantina at Goyders Lagoon, South Australia. For this reason, it is essential that flow paths are not disturbed, to ensure the Diamantina River can continue to serve as a major part of the life blood for Kati Thanda-Lake Eyre.

Throughout the Diamantina Basin, groundwater systems in the alluvia support vegetation communities. Impacts to groundwater levels could be catastrophic, not just to these ecosystems, but also to the organic beef industry that uses the basin for extensive grazing of beef cattle. Panel members highlighted the possible need to exclude livestock and tourists from the banks of permanent waterholes, but not restricting access to the entire riparian and floodplain system.

4.1.3 Georgina River Catchment

Of the three catchments within the LEB (Qld), the Georgina River and its ecological values has been the least studied. Its headwaters drain areas of the Northern Territory before flowing into westernmost parts of Queensland. The Georgina and Hamilton Rivers and King Creek are the primary tributaries of the catchment and their confluence is near Bedourie, upstream of Lake Machattie. From here they join to become Eyre Creek which then channels flood waters through the South Australian border and eventually into Kati Thanda-Lake Eyre. A third source of water in the Georgina catchment is the Mulligan River. This section of the Georgina has been the most studied; however, it is rare for water from the Mulligan River to make it to Kati Thanda-Lake Eyre (only approximately every 50-60 years).

Lake Machattie serves as a breeding place for tens of thousands of pelicans when deeply inundated and supports migratory shorebirds when it is shallow. In extensive shrub swamps dominated by lignum *Duma florulenta* and belalie *Acacia stenophylla* on floodplain extending through to Lake Mipia, mixed-species breeding colonies of waterbirds (ibises, herons, spoonbills) form during major floods. Outer parts of the Eyre Creek floodplain support internationally important numbers of migratory shorebirds, principally Little Curlew *Numenius minutus* and Sharp-tailed Sandpiper *Calidris acuminata* (Costelloe *et al.* 2004; Reid *et al.* 2010). The Mulligan River includes sub-terminal lakes used by migratory shorebirds and has saline waterholes that are considered rare in the Channel Country—which, unlike arid southern Australia, is dominated by freshwater ecosystems—and may support unique ecosystems that require preservation. More study is required in this part of the LEB so that significant environmental aspects may be identified and documented.

Groundwater dependant ecosystems (GDEs) and subsurface groundwater dependent ecosystems (SGDEs) are common in the upper channels of the Georgina catchment. For example, the Camooweal Caves National Park features caves that serve as groundwater dependant subterranean ecosystems (limestone caves and karsts). The ecological values of these ecosystems are not well understood and are often overlooked. Their connectivity to other ecosystems and aquifer permeability means there are unknown risks from water abstraction which may impact on the ecological values and water quality (Tomlinson and Boulton 2010). Consequently, the SEP identified imposing restrictions on groundwater extraction and drilling methods in the Georgina catchment because of the potential impacts to GDEs and SGDEs.

In addition to the high ecological values of the Georgina River catchment, there are significant cultural values to be preserved such as the Pituri sacred areas, the Bilpa Morea Claypan European heritage area and the Camooweal Caves which are a popular tourist destination.

4.2 Issues risk assessment

Whilst scientific understandings and insights are progressively being added to the literature, there is still limited data yet to be fully understood or investigated, especially in relation to the ecological functioning and processes of the LEB (Qld) catchments and waterways. Managing the threats from the activities assessed in this report (conventional and unconventional petroleum and gas, mining, agricultural practices, tourism and infrastructure) must involve using a risk-based precautionary approach. The risk assessment framework utilised here has examined the potential risks associated with these activities without any substantial controls in place (initial risk) in the first instance. The second risk assessment applied to the potential impacts from these activities has attempted to

consider the roles of specific planning, policy and legislative mechanisms that may reduce the consequence and / or likelihood of a particular risk to LEB (Qld) ecological assets. This latter rating is called the residual risk.

From the two-day workshop, the SEP rated the initial risk and residual risk across 8 issues and 82 potential impacts which are summarised in Appendix E.

Each issue and potential impact was assessed by the SEP through group discussion and consensus within the group. Where a group consensus could not be agreed upon, two potential risk ratings (e.g., Low/Medium) where recorded for an issue and topic. The SEP also documented the assumptions, caveats or other pertinent contextual information for the rating assessments for each risk output. Three topics were not rated due to time limits during the workshop. These are recorded in detail in Appendix E.

The eight issues rated were:

1. Transport, storage, mixing and use of relevant chemicals in petroleum/gas and mining industries
2. Construction and ongoing operation of supporting infrastructure for mining and petroleum/gas activities (on-lease)
3. Construction and ongoing operation of supporting infrastructure for mining and petroleum/gas activities (off-lease) and other industries such as agriculture or tourism
4. Water take in petroleum/gas and mining industries
5. Operations of petroleum/gas and mining industries including drilling, hydraulic fracturing, dewatering, extraction and processing
6. Waste treatment and disposal petroleum/gas and mining industries
7. Agricultural practices
8. Increased visitor access from tourism

From the initial risk assessment across all 82 potential impacts, the SEP determined 70% were either High, Very High or Extremely High rating risk activities for the LEB (Qld). After theoretically applying the current legislative framework for development activities across the eight issues, this figure was reduced to 45% of the activities having a residual risk rating of High or Very High (Figure 3).

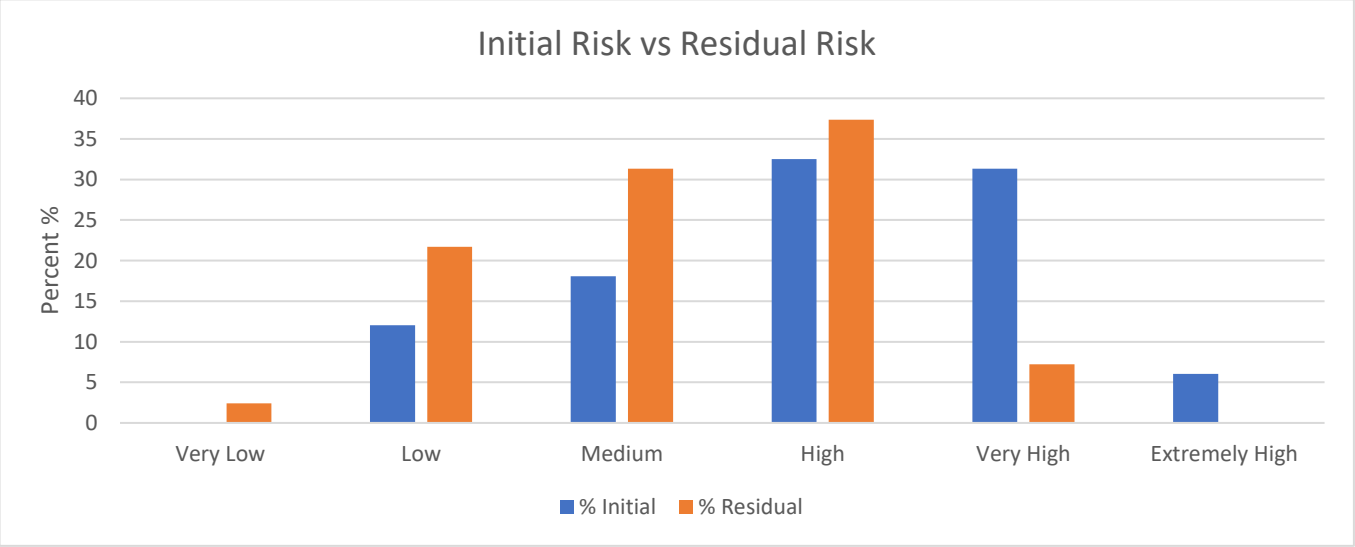


Figure 3. Percent initial risk verses residual risk following the application of legislative mechanism to avoid, mitigate and/or offset the impacts

4.2.1 Key findings

The key results and recommendations from the SEP risk assessment for each issue are briefly discussed:

1. Transport, storage, mixing and use of relevant chemicals in petroleum/gas and mining industries
    - Most of the potential impacts for conventional petroleum/gas, shale and tight petroleum/gas, CSG and minerals/coal mining were rated High or Very High for the initial risk.
    - The worst-case scenario was applied by the SEP members in their consideration of this issue.
    - Three potential impacts had a residual rating of High or Very High relating to groundwater and surface water impacts from accidental spills (CSG and mining) and leaching of contaminants or overflow from storage treatment ponds (mining).
    - Accidental spills and their risk to surface water quality and shallow groundwater impacts are very site specific, and dependent on the substance, in their potential impact to ecological values of the LEB (Qld). For example, a spill event on a road reserve or open flood plain with no environmentally sensitive area nearby would be a low risk. However, a spill into a riverine waterhole or wetland would lead to a fish kill and contamination of surface waters.
    - Tailing dams just outside the SEA could overflow in flood events and impact downstream ecosystems with the SEA/DP.
    - There was a recommendation from several SEP members that open cut mining should not be allowed within the LEB (Qld). The consequences of open cut mines are catastrophic internationally with acid mine drainage and water wash a major impact in some areas of the world. This recommendation potentially expands on the existing RIDA framework where open cut mining is considered an unacceptable use in the DP.
2. Construction and ongoing operation of supporting infrastructure for mining and petroleum/gas activities (on-lease)
    - Five of the activities were rated Very High or Extremely High for the initial risk. These related to the alteration of overland flow, vegetation clearing, ground disturbance, invasive plants and animals and impacts to riparian zones.
    - The residual rating for these five issues was High.
    - Within the context of the floodplain ecosystems, relatively small changes to gradient such as grader spoil from roads or presumed shot lines for seismic work can impact flows. These can divert overland flows in moderate floods such that entire sections of floodplain, and some waterholes off the main channel, will miss out on water supply.
    - The SEP stated the frequency of small floods every 1-2 years along with the concentration of flows resulting from diverting watercourses, or diversion of overland flows, will be a major consequence to the riverine ecosystems. This is because of the significance in these small floods to the resilience of the aquatic biota.
    - Weed invasion and spreading during construction in a relatively weed-free region was also rated as almost certain with major consequences for waterbird breeding sites. Potential risks of spreading and importing weeds without any controls is very significant.
    - An awareness of breeding colonies of waterbirds that depend on intact lignum and belalie (*Acacia stenophylla*) shrublands within floodplain wetlands is important to reduce the potential impacts of introducing weeds and impacts from vegetation clearing to riparian functioning, species habitats and wildlife corridors.
    - Impacts to fauna from riparian vegetation clearing for road access and other infrastructure were considered almost certain with major consequence to threatened species. Threatened species killed on roads is major impact due to delicate populations and sensitive locations. A recommendation by the SEP was to enforce speed limits to reduce likelihood of hitting threatened animals.

- Environmental conditions for the extraction of quarry material from rivers need to be specific to the ecosystems of the project area. For example, conditions should be in place to ensure material is not extracted during times of low flow or heavy flow.
- The SEP noted that unimpeded fish passage may be an issue in low to moderate flows in higher parts of the floodplain and in tributaries impacted by construction.

3. Construction and ongoing operation of supporting infrastructure for mining and petroleum/gas activities (off-lease) and other industries such as agriculture or tourism
   - Five activities had a potential impact risk rating of High or Very High. These included alterations of flows, vegetation clearing, ground disturbance, impacts to riparian vegetation and fauna and fish passage issues from extraction of sand and gravel from streams.
   - The five activities had a residual rating of High or Very High with little change after applying the existing management tools.
   - The risk assessment by the SEP for this issue assumed best practice was being implemented by all activities
   - Diversion of watercourses is a key issue particularly in the arid environment where flow paths are easily disrupted. Consequence of any activity relating to water diversion will always be major.
   - Infrastructure for mining and petroleum/gas activities should not be allowed in the floodplains because of flow alterations, fish passage issues and major impacts to floodplain ecosystems.
   - Waterbird habitat in the riparian and floodplain is at risk from clearing. For example, the floodplain communities of lignum and belalie are crucial for breeding habitat for waterbirds and other species including Grey grasswrens.
   - Early action and prevention crucial for the prevention, containment and/or eradication of invasive species. The legislation provides a framework for controlling or eradicating invasive species, however, the programs are costly and resource intensive. There needs to be an encouragement of integrated catchment management programs.
   - Quarry extraction from rivers for construction of infrastructure such as roads should not be allowed to occur in the waterways and floodplains. If they occur, they should be heavily regulated i.e., depths and quantities and specified materials (quality) are relevant to likely impacts.
   - Gaps in the legislative framework were discussed by the SEP regarding where there are different rules applied to different sectors of the community (e.g., council's wanting to develop water security for towns). The SEP stated that there needs to be an allowance for sustainable development in the LEB (Qld).
4. Water take in petroleum/gas and mining industries
   - All activities (8) relating to groundwater extraction and drawdown, surface water flows, surface and groundwater quality and ecosystem structure were given an initial rating of High, Very High or Extremely High.
   - Five of the eight activities had a residual rating of High. These related to groundwater extraction for conventional petroleum/gas, shale and tight petroleum/gas, CSG, and mineral/coal mining activities.
   - The residual impact from groundwater extraction/drawdown to GDEs and springs was considered high. The flow path of groundwater sustaining springs is not included in the current legislation. If a spring is located outside SEQ/DP boundary map they are not protected by the RIDA. This is a significant gap in the management tools for the LEB (Qld). The SEP recommend the SEA/DP be expanded to include all springs.
   - The residual rating from groundwater extraction/drawdown would be Very High where there are springs with rare endemic species, or threated or critically endangered organisms.
   - The legislative framework should include the level/pressure as an aspect to monitor or consider, especially near to GAB springs.

- Destratification of water in a stratified waterbody could bring deoxygenated (DO) water to the surface and result in possible fish kills. This may be very serious for significant riverine waterholes given their great importance as fish refugia for repopulating the system during floods.
- For shale and tight petroleum/gas activities, the RPI Act should regulate the location of bores, amount of water taken from certain places, proximity to sensitive locations and species. This may mean a slower development of unconventional wells, especially ones near springs with sensitive species and ecosystems. Water should not be taken from these ecosystems. Developers should be required to go further afield for a sustainable water source.
- Changes to surface water flow/levels and overland flow, water quality, temperature and ecosystem structure needs to consider the impacts to threatened species that reside in permanent waterholes such as the endangered Cooper Creek catfish *Neosiluroides cooperensis*.
- Groundwater extraction/drawdown and changes to water quality, temperature and ecosystem structure for CSG on a well by well basis water take for an individual well is quite minor. Risks are like that of conventional gas. However, the cumulative impact of dense block development would incur higher risks and consequences.
- Associated water from CSG needs to be released to the environment after treatment. The nature of boom and bust ecosystems of the LEB needs to be taken into consideration so that aquatic ecosystems that require times of dry are not saturated /flooded, causing disruption of the bath-tub algal ring.
- Well failures are a possibility and can cause contamination of aquifers within 10 years of existence. There are concerns about this.
- It is important to note that open cut mines are unacceptable activities in the SEA/DP, but they are allowed upstream of these mapped areas (e.g., north west minerals province) which could be extremely detrimental to the basin ecosystems.
- Impacts from mining to surface water flow/levels and changes to overland flow, water quality, temperature and ecosystem structure is potentially a greater contamination risk to water quality than gas extraction.
- There is potential for cross contaminated aquifers for all phases of mining.
- Production phase of mining uses the most water and would threaten above ground and below ground ecosystems due to the amount of water take necessary.
- The production phase of mining incurs a higher risk, and cumulative impacts need to be considered. Adequate provision necessary for rehabilitation postproduction phase. Rehabilitation and monitoring required many years postproduction.

5. Operations of petroleum/gas and mining industries including drilling, hydraulic fracturing, dewatering, extraction and processing

- Nine of the activities were rated a High or Very High for the initial impacts: from leaks into aquifers from wells, dewatering impacts on GDES, groundwater quality impacts, overland flows, subsidence issues and groundwater drawdown.
- Four of these potential impacts had a residual rating of High or Very High after the management tools were applied. These related to potential impacts to GDES, overland flows and groundwater impacts from mining.
- Artesian springs and GDEs are very location specific with a high level of uncertainty surrounding the potential impacts and mitigation measures for dewatering of coal seams. There remain significant unknown risks for these ecosystems.
- The SEP recommend expanding the DP or SEA to include larger areas around main channels and floodplains, and the GDEs.
- Open-cut mining is unsuitable for the LEB (Qld). The SEP recommend the expansion of SEA to include other sensitive areas in the LEB (Qld) including the NW portion of the basin where the topography is not within the floodplain (i.e., extensive karst systems).

- Dewatering during extraction can cause depressurisation leading to new pathways opening.
- Groundwater levels in general aquifers changing through draw down from the CSG extraction process.
- Ensure that ground water monitoring is undertaken to monitor leaks into overlying aquifers from production casing or via offset wells.
- Old legacy bores from early days may pose risk, if they were not constructed to current specifications. Ensure that ground water monitoring in these areas are undertaken. Groundwater impacts from leaks into overlying aquifer from production casing or via offset wells and drainage along geological faults improperly completed or plugged offset wells.
- Impact to groundwater quality from loss of drilling fluid during drilling from CSG increases due to intensity of more wells in concentrated areas.
- Acid leachate impacts on water quality to surface waters and groundwater. Tailings dams need to be managed according to industry best practice with erosion and sediment controls in place along with appropriate rehabilitation of tailings dams as a legacy issue.
- Additional protection is needed for previously protected areas under Wild Rivers legislation.

6. Waste treatment and disposal petroleum/gas and mining industries

- 15 activities were given an initial risk rating of High or Very High. These included groundwater and surface water contamination from structural failure, overtopping or leaky ponds, water quality issues from discharged wastewater, impacts from flowback water (including fracturing fluids) and drill cuttings, and acid mine impacts from tailings dams or other processing ponds, and mine voids.
- Of the 15, nine activities were left with a residual rating of High.
- Storage ponds should not be placed on the floodplain due to the risk of structural integrity issues, from flooding, and spillage of wastes. It would be necessary to have restrictions on capacity of dams during a wet season.
- Leaching of produced water from petroleum/gas and mining needs restrictions to ensure it prevents impacts to waterholes. Any action needs to be aware of the importance of waterholes as refuges in all river channels and floodplain areas. The level of risk from produced water depends on the morphology (area, depth, habitat structure) of the floodplains and waterholes.
- The SEP recommended excluding gas wells and ponds from frequently flooded areas. That is, having greater restrictions to more sensitive areas (i.e. 1 in 3-year flood areas and lower level restrictions to the areas that flood every 3-10 years). Mapping could represent these restricted areas.
- There is a risk of the spread of invasive pest species as there is clearly a gap in the legislation because these issues are currently happening in conventional gas activities (e.g., spread of the alien pest fish *Gambusia holbrooki*).
- Expand the SEA/DP to include all floodplain areas. The SEP stated that these activities are not acceptable in SEA areas or surrounding floodplain areas. This is because they pose too great a risk to the health of the sensitive ecosystems found within floodplain, and to the biota that use the floodplain during floods but return to waterholes as floods recede. There is a vast fish biomass generated from floodplain ecosystems during wet seasons.
- Regulation and checks on the procedures and management is required to ensure the legislation is being enforced e.g., auditing of systems.
- When you send a large amount of water down an intermittent arid-zone river system you can disrupt the ecological processes and health of the ecosystems.
- Limit the construction of large, raised infrastructure in the floodplain.
- Floodplain and aquatic systems are highly sensitive to change in levels (pH, salinity and chemicals) if water is untreated.

- Groundwater impacts from acid mine drainage is hard to contain on a large scale particularly with pyrite.

7. Agricultural practices
   - Three activities were rated with an initial risk of High or Very High. These included grazing and trampling impacts to riparian vegetation, waterholes and springs, impacts from aquaculture and from increased number and abundance of pest species.
   - Impacts from increased pest species and grazing impacts to riverine ecosystems and springs were left with a residual rating of High or Very High.
   - Potential for incentives to fence off waterholes. Fencing of permanent waterholes from livestock access to reduce impacts on water quality due to livestock. Essentially a good strategy provided fencing is not washed away in some stronger flow areas. Need to consider the overall impacts of shifting dispersed cattle impacts on large waterholes to intense impacts at new watering points off-channel.
   - Weeds and pests are certainly a big issue: pigs, prickly *Acacia*, parthenium, goats and camels. These and other species have had big impacts in very remote parts of Australia (Alice Springs region, Gulf Plains) and we should therefore not be complacent that they won't become big issues out in this pristine river system.
   - Keep aquaculture out of the floodplain and well away from water courses flowing in. Use endemic LEB species only. The fact that anything can be washed in and/or follow the river system is an added concern.
   - SEP recommended the grandfathering of existing licenses for irrigation in the basin
8. Increased visitor access from tourism.
   - All activities associated with increased visitor access from tourism were rated the same for initial and residual being either High or Very High.
   - The potential and current impacts are highly localised and restricted to certain areas.
   - Management of recreation and tourism is required. A possible solution is the allocation of formal areas to camp and park with amenities and facilities. Providing more of these areas strategically across the LEB (Qld) – not necessarily right at the best waterholes – could help in the long term to manage these values.
   - Education of tourists and general public (large signage: "You are now entering a near-pristine river basin, one of the last natural arid-zone riverine ecosystems in the world; please do not bring any weeds in mud on your vehicle; and do NOT release any animals/fish caught elsewhere")
   - The SEP emphasised the need for enforcement and education along with bag limits, the banning of gill nets and a reduction in bycatch.
   - Noxious alien fish and non-indigenous fish translocated from other catchments is a significant impact on native species and the LEB (Qld) ecosystem. Note: carp is not yet in LEB (Qld), but is in Warrego and other Murray-Darling Basin rivers and wetlands.

5 Discussion

This section of the report provides a literature review and discussion of the LEB (Qld) ecological assets, functioning and processes, pest species, the potential impacts from petroleum/gas and mining, agriculture and tourism to support the information, observations and recommendations of the SEP.

5.1 Ecological assets, functioning and processes

5.1.1 Waterbirds

The riverine ecosystems and associated wetlands of LEB are internationally and nationally important with many component sites supporting waterbird breeding including major waterbird breeding colonies, large populations of waterbirds (several million during major floods) and high numbers of some migratory species (Kingsford and Porter 1993; Kingsford *et al.* 1999; Jaensch 1999; Environment Australia 2001; Costelloe *et al.* 2004; Jaensch 2009; Reid *et al.* 2010; Kingsford *et al.* 2013; Reid 2017). These wetlands offer a network of habitats for waterbirds to utilise at different times of their lifecycle and the complex linkages and biological interactions requires integrated management of the floodplain to consider these values (Costelloe *et al.* 2004). In particular, the natural functioning of the network of wetlands of the Georgina, Diamantina and Cooper Creek catchments is important in the national context for waterbird breeding success over the long term, especially in view of the decline of the Murray Darling Basin for breeding by waterbirds. This also applies in an international context for maintaining and sustaining migratory species for which Australia has signed international agreements and which are a Matter of National Environmental Significance under the *EPBC Act 1999*. The key driver for waterbird usage in the LEB is free flow of the Basin's rivers.

Kati Thanda-Lake Eyre along with several, large, ephemeral terminal or sub-terminal lakes (e.g., Lake Yamma Yamma, Lake Mipia, Lake Machattie, Lake Galilee, Lake Buchanan, Bilpa Morea Claypan) are significant for their unique geological features, water regimes and assemblage of fauna (including invertebrates) that is adapted to these ephemeral systems (Timms and Boulton 2001; Timms 2008; Byrne *et al.* 2008; Morton *et al.* 2011). Like all terminal river systems, these wetlands largely depend on upstream flows to persist (Kingsford *et al.* 1999). Planning decisions on future water resource management that impacts any of these identified water assets in LEB (Qld) are especially important because the values are highly dependent on protection of river flows and connected pathways.

The SEP highlighted that connected pathways from riverine systems to floodplain wetlands are critical linkages in the relatively flat landscape of the LEB (Qld) catchments. Even minor changes to heights on the floodplains may redirect overland flow during floods away from water assets and therefore causing changes to their hydrology (Jaensch 2004; Thoms *et al.* 2005; QWC 2012). The key risks are within and immediately adjacent to the intricate network of anastomosing channels – especially during low flows where a bank as low as 10 cm can divert flows that could otherwise 'top-up' key waterholes.

The SEP noted the significant breeding sites for colonial waterbirds across the LEB (Qld) region are particularly vulnerable, being relatively rare sites in an otherwise dry landscape. These breeding sites may be susceptible to floodplain barriers blocking feeder channels with the redirection of shallow floodwaters away from these sites, thereby diminishing their value to waterbirds. Positioning of linear infrastructure associated with conventional and unconventional petroleum and gas and mining requires careful consideration, particularly upstream of the significant water assets. Conservation outcomes for the important wetlands and rivers of the LEB (Qld) region in many cases rely on land management strategies at the floodplain or reach level to ensure ecosystem processes are sustained. Connected wetlands and rivers through water flow and species dispersal and migration, for example, should be a key outcome from targeted catchment level management and legislative controls.

5.1.2 Waterholes

In addition to the significant role of floodplain wetlands in sustaining Australia's waterbirds, the SEP identified the water assets such as the permanent waterholes and non-riverine wetlands of the region as significant refugia for aquatic organisms during dry years or dry seasons. Apart from the major flooding events that cover vast floodplains, the riverine ecosystems exist for much of the time as discrete waterholes. Most waterholes within the LEB (Qld) are filled by surface flows with little evidence of groundwater contributions (Bunn *et al.* 2006b). There are

exceptions to this with some waterholes in the upper streams of the Cooper Creek and Georgina catchments where groundwater discharge contributes to their persistence. For the waterholes reliant on surface flows, their permanence is largely determined by waterhole morphology and evaporative loss. The interconnections between sand-dunes and waterholes and sand-dune outflow contribution also is a factor to water hole permanence. Hamilton *et al*. (2005) estimated that most Cooper Creek waterholes would dry up within 22 months if not replenished by channel flows or flooding; after 24 months of no flow, only four of the named waterholes along Cooper Creek would remain. Thus few waterholes can persist for more than two years without surface flow connection (Bunn *et al.* 2006b; Silcock 2009; Silcock 2010).

These refugial waterholes represent the only permanent aquatic habitat during extended periods of low or no flow (Knighton and Nanson 1994; Morton *et al.* 1995b; Silcock 2009) and are critical components of a functioning 'source and sink' system for aquatic organisms (fish, turtles) in arid and semi-arid landscapes (Pulliam 1996; Kerezsy 2010; Duguid *et al.* 2016). During dry periods, species maintain their populations in these isolated permanent waterholes (source) and then disperse to less favourable habitats during extensive flooding when some of the populations are lost (sink) following the drying of these ephemeral wetlands and waterholes. They experience variable patterns of connection and disconnection which are a fundamental driver of ecological processes that are essential for dispersal and survival of diverse populations in these riverine environments (Arthington *et al.* 2005; Sheldon *et al.* 2010; Morton *et al.* 2011; Marshall *et al.* 2016).

Many breeding colonies of cormorants and other fish-eating waterbirds, generally of moderate size, occur at waterholes within the Channel Country (Costelloe *et al.* 2004; Reid *et al.* 2010). While some of these typically operate during flood events, others are active later in the cycle when certain fish species may be more abundant or accessible to the birds.

5.1.3 Connected landscapes and resilient ecosystems

During dry spells, aquatic food webs are driven by algal production in the shallow littoral zone, or what is sometimes referred to as the 'bathtub ring' (Bunn and Davies 1999; Bunn *et al.* 2003; Bunn *et al.* 2006b; Fellows *et al.* 2009). Any activity or management strategy that interferes with the generation or stability of the waterhole food web has potential to threaten aquatic biota, including fish (Bunn *et al*., 2006b; Leigh *et al*., 2010). Sustaining ecological processes becomes an important consideration when assessing potential impacts from development activities that may alter flow regimes and food web structure. Altered conditions during dry periods can lead to an increase in the frequency and duration of channel flow pulses due to elevated base flows (Bunn *et al.* 2006b).

The SEP discussed that maintaining natural patterns of longitudinal and lateral connectivity is essential to the viability of populations of many riverine species (Bunn and Arthington 2002). It is known that modifications to both flow regime and hydrological connectivity can result in reduced movement opportunities for fish in ephemeral rivers where they utilise a network of waterholes over their lifespan (making movements of up to 70 km in only a few days) (Marshall *et al.* 2016). Management and conservation strategies should aim to maintain movement opportunities at large spatial scales to preserve population resilience (Kerezsy *et al.* 2014; Kerezsy and Fensham 2019). It is therefore important to manage these permanent waterholes across the LEB (Qld) region, not as individual waterholes, but as a system of intermittently connected waterholes along the length of the rivers and channels, and on the floodplains.

5.1.4 Threatened species

As reported in the literature and identified by the SEP, there are several threatened and iconic species and communities that inhabit the aquatic environments of the LEB (Qld). Most of these have habitat requirements that are directly linked to the health of the rivers and associated floodplain wetlands. One example is the 'endangered' Cooper Creek catfish *Neosiluroides cooperensis* (draft IUCN Red List, A. Arthington 2019, pers comm, 29 August) that resides in permanent waterholes. The catchment linkages through connected (and at times disconnected) flow paths are crucial conduits for sustaining healthy populations and resilient biota of the dryland rivers and wetlands. Riparian vegetation and floristic communities in an arid landscape are a significant component providing food, shelter and water resources in an otherwise dry landscape. Flow regimes determine the successional evolution of riparian plant communities and ecological processes (Nilsson and Svedmark 2002). In addition, protection and

maintenance of their habitats is vital for their continued survival and as a measure to ensure a species population's resilience through dry periods (Arthington *et al.* 2010).

5.1.5 Springs

The SEP members discussed the very high ecological values of artesian springs found in the LEB (Qld). From a review of the literature, the Great Artesian Basin (GAB) springs are globally significant with few groundwater systems in the world larger than the GAB (Morton *et al.* 1995a). There are 6,308 individual GAB springs grouped into 326 complexes across 13 supergroups (Anderson *et al.* 2016). The unique flora and fauna of the GAB have experience considerable habitat loss and extinction due to the unrestricted extraction of water and physical modification (Fensham *et al.* 2010). The mapped artesian springs in the LEB contain numerous endemic and threatened flora and fauna species that have evolved to live in these springs which are very restricted in total available habitat and geographically isolated from other springs (Ponder 1986; Morton *et al.* 1995a; Fensham and Fairfax 2003; Fensham *et al.* 2010). There are thought to be approximately 98 taxa of plant, fish, amphipods and isopods that are only found in GAB springs (Anderson *et al.* 2016). Of these taxa, 30% are undescribed species and nearly half (44%) are narrow endemics, whereby a taxon is found in only one spring complex (Anderson *et al.* 2016).

Molluscs make up 52% of the listed taxa with fish being 8% (Anderson *et al.* 2016). There are seven fish species endemic to GAB springs; the Dalhousie catfish (*Neosiluris gloveri),* Dalhousie hardyhead (*Craterocephalus dalhousiensis*), red-finned blue-eye (*Scaturiginichthys vermeilipinnis*), three localised species of gobies (*Chlamydogobius gloveri*, *C. micropterus* and *C. squamigenus*) and the Dalhousie mogurnda (*Mogurnda thermophila*). The Edgbaston Springs within the Springsure supergroup contain two endemic species - the Edgbaston goby, *C. squamigenus and* the endangered redfin blue eye *Scaturiginichthys vermeilipinnis* (EHP 2016). The vulnerability of these spring communities is extreme due to their variable size, isolated locations and reliance on permanent groundwater supplies from the GAB aquifers (Anderson *et al.* 2016). These water assets are of high priority for maintaining Australia's unique aquatic biota and for terrestrial species as a permanent source of water during dry periods in the largely terrestrial environments of LEB (Ponder 1986; Morton *et al.* 1995a).

5.1.6 Cross border values

The Lake Eyre Basin Intergovernmental Agreement 2001 provides for the sustainable management of the water and natural resources associated with the river systems of the Lake Eyre Basin Agreement Area (Balmarks *et al.* 2018). With this agreement in mind, there are significant aquatic systems of the South Australian section of the LEB which could be considered of World Heritage value (Morton *et al.* 1995a). These systems are the Cooper and Warburton Creek drainages, Coongie Lakes, Goyder Lagoon, and Kati Thanda-Lake Eyre North and South. These significant ecological assets rely on floods from Queensland to maintain their ecological functioning and processes that support biota across the basin, including migratory waterbird species of national and international conservation significance (Mancini 2017). These long distance longitudinal effects of floods are important, delivering flows far downstream through channels and wetland complexes (Stafford-Smith and Morton 2004; Leigh *et al.* 2010). The SEP emphasised these values in their deliberations on the risk assessment ratings for various activities.

5.2 Pest species

The native aquatic fauna and flora communities of the LEB (Qld) catchments appear to be largely intact, with a low incidence of exotic plants and animals (Bunn and McMahon 2004). A study by Costelloe *et al.* (2010) suggests the naturally variable hydrological regimes and native-dominated fish assemblages of the LEB (Qld) afford some resistance to the establishment and proliferation of alien fishes. However, largely because the LEB (Qld) has managed to avoid these issues that are common in coastal catchments, invasive species, including aquatic pests and terrestrial animals and plants, represent the greatest potential risk to riverine ecosystems and biodiversity (Lake Eyre Basin Ministerial Forum 2017).

The SEP identified that some of the emerging threats from invasive species include cane toads *Bufo marinus*, red claw crayfish *Cherax quadricarinatus*, sleepy cod *Oxyeleotris lineolata* and prickly Acacia *Vachellia nilotica*. When introduced to new habitats outside its natural range, sleepy cod is a serious conservation risk to native fish species. Records of sleepy cod (an Australian native species translocated to the LEB (Qld) from coastal catchments) show it

has colonised many ephemeral streams and refugial waterholes of Cooper Creek within a decade of the first record or capture (Sternberg and Cockayne 2018). Sleepy cod is considered a serious potential threat to the 'endangered' Cooper Creek Catfish.

There are more than 240 exotic terrestrial plants recorded in the entire LEB including 20 weeds of national significance (Firn *et al.* 2013). Based on an assessment by Firn *et al.* (2013), the top five most cost-effective strategies to control invasive plants in the LEB were: the management of parkinsonia *Parkinsonia aculeata*, chinee apple *Ziziphus mauritiana*, mesquite *Prosopis* spp., rubber vine *Cryptostegia grandiflora* and bellyache bush *Jatropha gossypifolia*.

The SEP emphasised that further development in sensitive ecosystems could be devastating to previously undisturbed ecosystems as invasive species may be given opportunity to spread and out-compete endemic species. Climate change also presents a significant emerging threat with the potential for direct and indirect effects on water resources, riverine ecosystems, biodiversity and endemic species.

5.3 Potential impacts from petroleum/gas and mining activities

5.3.1 Surface water impacts

A University of Southern Queensland report (Moran and Vink 2010) summarises the impacts associated with the CSG industry operations on the surface waters of the Murray-Darling Basin. Two identified impacts to surface waters were from the addition of groundwater discharge to surface waters (both quantity and quality issues), and the redistribution of groundwater that may lead to changes to the water quality of GAB aquifers. For example, the Condamine River downstream of Chinchilla may see increased flows (2-17 %) resulting from the discharge of treated CSG water, although this was not a preferred option by the industry. Other associated potential impacts to surface waters include the physical and ecological implications of changes to water quantity and quality and timing of any discharge into the system (Moran and Vink 2010).

In addition to issues surrounding water quality of surface waters, subsidence effects due to aquifer compaction are predicted to be minor in absolute measurements (Moran and Vink 2010). The SEP noted that even minor changes to the land surface from aquifer subsidence may alter overland flow paths potentially altering the hydrological regimes of surface water ecosystems. The extent of this impact for mining areas in Queensland remains unknown.

Surface water contamination from petroleum and gas activities is also a potential impact to the LEB (Qld) riverine ecosystems. These impacts can include surface water contamination from structural failure, overtopping or leaky ponds, water quality issues from discharged wastewater, impacts from flowback water (including fracturing fluids) and drill cuttings. In addition, accidental spills on the floodplains of the LEB (Qld) could result in a waterhole or wetland being contaminated potentially leading to fish kills.

The production of water from CSG activities in Queensland is averaging 11,000 ML/well/year with the highest use being the start of a well's production (Huddlestone-Holmes *et al.* 2018). Produced water is usually saline. In comparison, shale/tight gas wells are unlikely to produce significant volumes of water during production. Produced water is likely to be highly saline, and may contain organic compounds (e.g., BTEX) and heavy metals. Shale production requires fewer water treatment and storage facilities because the volume of produced water will likely be less than for CSG. However, more water quality treatment infrastructure to remove specific impurities such as H20, H2S, CO2 and mercury from shale gas and oil may be required (Huddlestone-Holmes *et al.* 2018). These treatments are required to minimise any potential impact from flowback water, produced water and unused hydraulic fracturing fluids to surface water quality for secondary use off-lease.

5.3.2 Groundwater impacts

Some recent studies from the Surat Basin in Queensland include quantitative estimates around predicted levels of cumulative impacts of CSG activities to groundwater resources. These impacts include expected levels of water pressure declines and subsequent recovery periods and expected levels of water abstraction over the life of the CSG industry. In the absence of mitigation measures such as reinjection of water back into the aquifers, the expected level of water pressure decreases over the medium to long term operational period range from 0.5-150 m (QWC 2012). This range depended on the underlying geology (i.e., sandstone formations such as the Walloon

Coal Measures). The spatial extent of the drawdown extends beyond the boundary of the gas field production area (Moran and Vink 2010). The expected timing for the maximum impacts to manifest will differ depending on the sequence of CSG development and variable natural water movement through the affected aquifers. Generally these impacts will be experienced in the coal formations towards the end of the life of the CSG industry between 2030 and 2050. For more remote aquifers the maximum drop in water pressure will occur much later.

Recovery from these expected impacts will not occur until well after the cessation of the CSG activities (Moran and Vink 2010). Without reinjection of treated CSG water into affected aquifers or similar mitigation measures, recovery of water levels will only commence after maximum impact occurs with the recovery rate slowing over time (QWC 2012). The aquifers affected in the Surat Basin of the QMDB are predicted to have a 50 % recovery 30 to 50 years after maximum impact. The average volume of water produced by petroleum tenure holders is predicted to be 95,000 ML/yr with most water being extracted early in the life of the industry and reducing over time (QWC 2012). The SEP noted in its discussions (Issues 6.6 and 6.12) reinjection is not currently undertaken in the LEB (Qld).

Hydraulic interconnectivity between GAB aquifers also means that there is potential for changes to water quality within individual aquifers through direct or indirect induced leakage caused by dewatering of the coal seams and shale production. Upward migration of contaminated groundwater from saline formation or hydraulic fracturing fluids is a potential impact into shallow or intermediate groundwater systems. As noted by Huddlestone-Holmes (2018) report, the potential impacts related to wells for CSG and shale gas and oil resources are similar. Wells are developed using similar drilling processes with the possibilities of drilling fluid losses to aquifers equally likely. Whilst shale gas wells are usually deeper than CSG wells, both methods case off and cement shallow aquifers to protect them from possible impact while deeper parts of the well are being drilled.

In addition, the risk for cross contamination of groundwater aquifers is minimised for shale wells where there is 600 m between the reinjection zone and the nearest potable water aquifer (Huddlestone-Holmes et al. 2018). The more likely scenario where migration of hydraulic fracturing fluids to drinking water resources may occur is where oil and gas resources coexist with drinking water resources (e.g. the Eromanga Basin and GAB) (Huddlestone-Holmes et al. 2018). The SEP also cautioned where dewatering during extraction can cause depressurisation leading to new pathways opening and ground water levels in aquifers changing. There is little information available on the long-term human and ecosystem health risks posed by migration of hydraulic fracturing fluids to the surface (Huddlestone-Holmes *et al.* 2018).

5.3.3 Potential impacts to springs

The impact of conventional and unconventional petroleum and gas and mining operations to artesian springs can include drawdown of water pressure leading to declines in the extent of spring habitat expressed at the surface, or spring extinction, including loss of the fauna and flora communities that relied on groundwater dependent habitat (Anderson *et al.* 2016). Although not always quantifiable, the water quality and quantity of springs may be impacted from these operations in the surrounding landscape.

By way of example, the Draft Underground Water Impact Report (QWC 2012) identified water level impacts in the source aquifer feeding water to five of the identified spring complexes within the Surat Cumulative Management Area will exceed 0.2-1.3 m drawdown in the long term. The ecological consequences of groundwater decline for GAB springs and the resident biota may be substantial. However, they can also be difficult to detect due to time lags and long response times and potentially difficult to reverse (Anderson *et al.* 2016). It is also a challenge to quantify the hydrogeological processes that shape and sustain the distinctive biotic assemblages of artesian springs. Mitigation measures for impacts of unconventional and conventional petroleum and gas and mining activities might include reducing the impact of existing artesian bores, reinjecting treated water into source aquifers and managing the water extraction regime to reduce impacts along with implementing buffer zones around these significant ecosystems and their endemic assemblages from proposed new developments.

5.3.4 Mining impacts

Extractive mining creates several impacts on the environment before, during and after mining operations. The associated infrastructure and heavy machinery, stockpiles of overburden material and construction equipment can lead to localised impacts. Environmental impacts resulting from mining are not limited to the footprint of the mining operations with some impacts moving 'off-site' to affect nearby ecosystems, with aquatic ecosystems the most

vulnerable. This is particularly relevant to ensure that downstream riverine ecosystems are not affected by proposed mines located outside of the delineation SEA/DP area for the LEB (Qld).

Mining operations, in some cases, require access to a large amount of water resources for their production of minerals or coal. At the higher end of the scale for example, the Olympic Dam uranium mine located in South Australia uses 12,000 ML from the Great Artesian Basin every year. The by-product of the operation of mining activities is 'contaminated' water which often must be stored before treatment and reuse. A potential risk for groundwater is the leaching of contaminated water into shallow aquifers before it can be treated to a minimum standard required by government regulations.

Depending on the resource being mined, heavy metals can occur naturally occur in the ore. These are often released during mining operations and subsequently these metals (e.g., arsenic, cobalt, copper, cadmium, lead, silver and zinc) contained in excavated material may be leached out and carried downstream by flowing water. Similarly, processing chemicals used in mining can move off the mine site through spills, leaking or leaching into nearby wetlands or rivers. Impacts to surface water can include water abstraction (overland flow interception) or discharge of production water (treated or untreated) to natural wetland systems. Large mines can require the clearing and modification of the landscape including drainage of wetland habitats or the realignment of creeks or adjustments to flows paths across a floodplain.

The SEP emphasised the risk of acid mine drainage to the pristine rivers and environment of the LEB (Qld). The consequences of acid mine drainage impacts have been catastrophic internationally because once this process is started it is very hard to control or contain, particularly on a large scale and/or with pyrite. Acid leachate impacts on water quality in both groundwater and surface water and requires best practice in the construction and operation of tailings dams. Rehabilitation of tailings dams or other processing ponds also creates a legacy issue for mines on closing the operations.

5.3.5 Ground disturbance

The footprints associated with unconventional/conventional petroleum and gas (drilling wells, ponding water, treating water, access and gathering tracks and pipelines) and mining infrastructure cause direct loss and disturbance of ecological values in the landscape. These associated activities can result in the loss and fragmentation of vegetation, species and communities including wetlands and riverine riparian zones. The cumulative impacts of the static and linear infrastructure can adversely affect connectivity and ecosystem functioning through physical barriers to overland flow, changes to hydrological regimes and the bisection of ecosystems across the landscape.

5.3.6 Cumulative risks

The known impacts of gas production and mining on the ecological assets of an area can be severe and irreversible (e.g., loss of springs and the endemic fauna and flora associated with them; and loss of wetland habitats) (Fensham *et al.* 2010; Anderson *et al.* 2016). Other impacts are less well understood but may lead to long-term effects on ground and surface water resources including changes to water quality and quantity (reduced / increased from natural conditions). Reduced water pressure in the GAB as a result of CSG production was anticipated elsewhere. For example, the Condamine Balonne aquifers were predicted to have a 20-150 m drawdown with a 50% recovery not expected until 30 to 50 years after maximum impact (QWC 2012). Water consumption from CSG and mining developments is currently low but cumulative amounts over the life of the industries are predicted to be significant for parts of Queensland's water resources (including the GAB).

Similar data from a US study has revealed a sharp increase in the water use for hydraulic fracturing and wastewater production in major US shale gas and oil production regions (Kondash *et al.* 2018). The authors note that the water used for hydraulic fracturing is retained within the shale formation with only a small fraction of the fresh water injected into the ground returns as flowback water. The water which does return to the surface as flowback is highly saline, difficult to treat, and often disposed through deep injection wells. This means that despite lower water intensity of use (i.e., the leftover flowback water) compared to other energy resources, the permanent loss of water use for hydraulic fracturing from the surface over time could outweigh its relatively lower water intensity compared with other gas production activities (Kondash *et al.* 2018).

Similarly, Huddlestone-Holmes *et al.* (2018) identified the taking of groundwater and/or surface water for hydraulic fracturing processes for shale gas to have a medium level intensity. That is, volumes taken for an individual well are unlikely to be significant, but the cumulative impacts are likely to be greater over time compared to CSG activities. The result being water use for hydraulic fracturing in shale gas and oil resources is likely to be more than for CSG over the long-term of a project life-cycle.

Accompanying the water quantity impacts on ecological assets through consumption in mining, there is an uncertain level of impacts associated with take of overland flow and modification of critical flow paths of importance to identified water assets and their associated values. The location, design and extent of linear infrastructure (roads, pipelines) on floodplains require considered planning if they are to minimise their impact to flow paths. These cumulative impacts for mining can overtime result in modification and loss of ecological values.

The number of production wells (gas and petroleum) within the LEB (Qld) is low compared to the expected 30,000 to 40,000 wells located throughout the Surat and Bowen Basins of Queensland. However, there is no available data at present on the predicted number of wells being developed in the LEB (Qld), nor can it be predicted what plans the gas companies have for developing these resources in this region. Similarly, there are few existing mines in production in LEB (Qld) but there are extensive areas of mineral and coal exploration areas located across the LEB (Qld).

The current levels of conventional and unconventional petroleum and gas production and mining are small, and it could be concluded that there are limited realised impacts to the ecological assets in the LEB (Qld). The free flowing rivers of the LEB (Qld) can benefit from the learning's of CSG and mining developments in other parts of Australia (e.g., Condamine Balonne catchment of the Surat Basin). These other regions experiencing advanced planning and implementation phases of development could provide insights into predicted levels of impact (including cumulative) and practical management strategies to minimise impacts from potential expansion of the petroleum and gas and mining industries in the LEB (Qld). The positive planning context for LEB (Qld) is that it is in a good position to identify the significant ecological assets (including terrestrial values not addressed here), undertake necessary research and investigations to better understand those assets and to plan for their management and protection into the future. This will allow adverse impacts from CSG and coal mining developments to be minimised through appropriate legislative controls and informed decision making.

5.3.7 Summary of impacts

In summary, there are several impacts from petroleum and gas activities and mining production to natural ecosystems identified from the literature. Not all these impacts are fully understood nor their magnitude quantifiable. Several of these impacts could be very difficult or impossible to reverse in the short and medium time frames. Within the LEB (Qld), a further uncertainty remains about the full extent of unconventional and conventional gas production and mining activities planned for the foreseeable future (5-50+ years). Projected numbers of CSG wells in Queensland is in the order of 30,000 – 40,000 (limited to the Surat and Bowen Basins). There is currently minimal unconventional and conventional petroleum and gas production and mining development activity in the LEB (Qld). However, the summarised potential impacts include:

- Direct loss, degradation and fragmentation of habitats (rivers, wetlands, riparian trees and habitat, remnant vegetation) from the disturbance footprint associated with linear and static infrastructure
- Direct impacts to threatened species that reside in permanent waterholes
- Declines in water pressure and changes to water quality, water level, temperature and ecosystem structure (including GDEs) in the GAB through groundwater drawdown
- Changes to groundwater quality in upper aquifers from leaks into overlying aquifer from production casing or via offset wells vertical migration of fluid along faults/ fractures improperly completed or plugged offset wells
- Surface water and groundwater quality impacts from well failure as a result of induced seismicity (from hydraulic fracturing and dewatering of coal seams)
- Groundwater quality impacts from reinjection of flowback water and produced water, including induced seismicity

- Groundwater and surface water impacts from spills of drilling fluids, fracturing fluids, flowback and produced water during treatment and disposal
- Changes to surface water quality from treated/untreated CSG water discharges to watercourses
- Unauthorised releases of poor quality water from open cut mines during flooding events
- Changes to the quantity of water flowing through ephemeral watercourses resulting from direct discharges of CSG water
- Potential changes to overland flow paths through subsidence
- Altered flow paths to wetlands resulting from infrastructure placement and design
- Loss of connectivity from linear infrastructure (roads, pipelines, wells, water ponds, pits etc.) creating barriers on floodplains diverting flows away from natural wetlands or water dependent species and communities
- Groundwater and surface water level/quality impacts from produced water leaching or overflowing from pits/storage ponds, or leaking from pipelines (from flooding/ structural failure)
- Groundwater level impacts from CSG and mine dewatering and associated impacts on GDEs and springs
- Watercourse diversions and realignment from mines
- Abandoned storage ponds/pits remain onsite with contamination at base (due to evaporation) and potential groundwater quality impacts through leaching
- Groundwater impacts from acid mine drainage, and leaching of tailings dams and other extraction/processing waste storage areas

5.4 Potential challenges for agriculture

Organically produced beef in Australia is a large industry that is internationally recognised and growing as demand for chemical free protein increases. Much of Australia's organically certified beef is produced in the LEB. The implications of allowing large scale petroleum and mining development in the LEB (Qld) could be extremely detrimental to this industry. The risk and the likelihood of chemicals being released into the system accidentally would be high if activities were permitted within sensitive areas, such as floodplains. Increased traffic carrying potential contaminants crossing waterways would also pose a risk to downstream systems where cattle are grazed. While agriculture and more specifically overgrazing poses some risk to the LEB (Qld), the existing agricultural industry in the basin has successfully maintained a healthy coexistence with the free flowing ecosystems of the basin for over 150 years (Phelps *et al.* 2003; Kelly and Phelps 2019).

Acknowledging the successes in sustainable agricultural systems, some of the challenges for the grazing pastoral sector in the LEB (Qld) are to maintain land condition and productive capability while minimising degradation and pasture decline. One area of potential loss of ecosystem function for waterholes is the degradation of riparian areas through overgrazing (Bunn and McMahon 2004). These issues can be addressed through establishing guidelines for safe stocking strategies, understanding the management of pasture and the more highly fertile systems on the floodplains, and addressing issues such as invasive weeds and feral animals (Tothill and Gillies 1992). The grazing industry relies heavily on the relatively nutrient rich floodplains which can have extensive pasture benefits following medium and large flow events (Phelps *et al.* 2003). For example, peak yields of 7,000 kg/ha of dry matter were recorded at one site on the Cooper Creek following the 2000 flood (Phelps *et al.* 2003). The smaller events preceding major flood events help to prime the dry riverbeds and channels. Thereby allowing the next flow to travel further downstream and spread wider due the water being slowed down by freshly grown natural vegetation (grasses, sedges, forbs). They also allow a greater discharge onto the surrounding floodplains (Knighton and Nanson 2001) which are important for grazing enterprises.

There is also the potential for water quality impacts from use of agricultural chemicals such as pesticides, herbicides, fertilisers and hormones. The SEP also considered the potential impacts from aquaculture including water quality impacts from waste, disruption to water flows from artificial structures, and introduction of non-native/endemic species (noxious fish and non-indigenous fish).

Finally, members of the SEP identified the need to consider development activities to build the region's population and creating smart options to build wealth through sustainable management of the natural environmental assets (e.g., weed and pest control on private land is incentivised by reducing impacts on production). New schemes could be instated to grow wealth by protecting natural assets. For example, 'eco-agri-tourism' could result in greater private environmental protection areas.

5.5 Potential challenges for tourism

Tourism is a commonly promoted tool for economic development but can prove challenging to existing infrastructure, iconic landscapes, protected areas and environmental values of a region (Carson and Carson 2011). The SEP identified several emerging threats not related to the alteration of flow regimes are being recognised from increased visitors and tourism to the LEB (Qld). For example, overfishing and illegal fishing are widespread and intensive in some areas threatening the long-term viability of aquatic species. There is also evidence of the injuring and drowning of mature turtles caught in illegal nets in some highly visited waterholes. Other threats from increased visitors include harvesting of dead and living timber for campfires, which is becoming unsustainable at some waterholes. The loss of logs and tree hollows is a significant threat to riparian faunal biodiversity (Bunn and McMahon 2004). These high impacts at a small number of localised waterholes and other environmental impacts are poorly understood (Carson and Taylor 2008). The management of potential impacts from tourism such as the four wheel drive market is increasingly becoming a priority for desert landscapes in Australia (Carson and Taylor 2008) and genuine engagement with rangeland communities to improve the tourism sector is needed (Friedel and Chewings 2011). In the case of protected areas, proper assessment and monitoring of the impacts of tourism would strengthen the case for additional funding to pursue conservation and development responsibilities (Tremblay 2008).

6 Recommendations

The scientific literature was gleaned for insight and understanding on the ecological values, functioning and processes which sustain the biota of the LEB (Qld) catchments. This was combined with the collective understanding and experience of the SEP members to determine the risks associated with certain activities in the LEB (Qld). A long-term outlook of +50 year timeframe was adopted. This was an attempt to account for cumulative impacts such as the collective loss of riparian vegetation across the broader landscape resulting from individual infrastructure projects over many years. The SEP did note the potential impacts from climate change were not directly assessed in this process, however, it is a key consideration in the sustainable management of the LEB (Qld).

Connected floodplain landscapes and riverine ecosystems was also an important component for maintaining resilient populations of species over time. As Professor Peter Cullen put it, "In the Lake Eyre Basin, we have to consider rivers, the waterholes and the terminal wetlands, in the context of the surface catchments and the groundwater systems that connect the bits." (Cullen 2004b). His point being, what we do in one part of the catchment is likely to affect other parts of the catchment.

The SEP emphasised the uniqueness of the free flowing rivers of the LEB (Qld) and how exceptional these pristine environments are within Queensland, Australia and globally. The SEP noted the high levels of endemic biota and super abundance of some species under certain circumstances (e.g., waterbirds) can be across the LEB (Qld) vast riverine ecosystems and artesian springs (GDEs). One of the most important problems of sustainably managing the Kati Thanda-Lake Eyre Basin is the risk of a "death by a thousand cuts" (Stafford-Smith and Morton 2004). This is a serious consideration and challenge for the regulatory framework in Queensland in dealing with the potential cumulative impacts of the activities discussed in this report.

The cumulative impacts, whilst appearing trivial in local effects, can amount to major losses of values at a catchment scale (Stafford-Smith and Morton 2004). The water abstraction, infrastructure development and vegetation clearing in the Murray-Darling Basin culminated in major negative interactions and degradation at the broader basin and national scale. To avoid the failings in other basins like the Murray-Darling and Surat Basins, we need to understand these complex interactions in the landscape and wetland systems. The productivity and the value of these lands is directly related to how well the connections that drive the wetland ecosystems and landscape processes remain functioning and intact.

From these deliberations, several recommendations were provided by the SEP. These are summarised below.

6.1 Groundwater dependent ecosystems

Groundwater dependent ecosystems or artesian springs were also highlighted by the SEP for special protection requirements to ensure their continued existence in supporting endemic and critically endangered species. Recommendations included

1. Impose restrictions on groundwater extraction and drilling methods in the Georgina catchment because of the potential impacts to GDEs and SGDEs
2. Ensure artesian springs are a high priority for protection under legislation. This is because they are significant for maintaining Australia's unique aquatic biota and for terrestrial species being permanent source of water during dry periods in the largely terrestrial environments of LEB
3. Ensure development does not lead to the spread of invasive species in artesian springs as they could be devastating to previously undisturbed ecosystems and can out-compete endemic species (e.g., endangered fish)
4. The legislative framework should include the level/pressure as an aspect to monitor or consider, especially near to GAB springs

6.2 Riverine and floodplain ecosystems

The riverine and floodplain ecosystems are very significant for the long-term sustainability of the LEB (Qld). Several recommendations were aimed at the preservation of these ecosystems and their biota. They included:

5. Infrastructure for mining and petroleum/gas activities should not be allowed in the floodplains because of flow alterations, fish passage issues and major impacts to floodplain ecosystems
6. Quarry extraction from rivers for construction of infrastructure such as roads should not be allowed to occur in the waterways and floodplains
7. Changes to surface water flow/levels and overland flow, water quality, temperature and ecosystem structure needs to consider the impacts to threatened species that reside in permanent waterholes such as the endangered Cooper Creek catfish *Neosiluroides cooperensis*
8. Storage ponds for resource development (e.g., tailings dams) should not be placed on the floodplain due to the risk of structural integrity issues, from flooding, and spillage of wastes. It would be necessary to have restrictions on capacity of dams during a wet season
9. Limit the construction of large, raised infrastructure in the floodplain
10. Manage permanent waterholes across the LEB (Qld) region, not as individual waterholes, but as a system of intermittently connected waterholes along the length of the rivers and channels, and on the floodplains
11. Protect and maintain threatened species and their habitats for their continued survival and resilience through dry periods
12. Enforce speed limits to reduce likelihood of hitting threatened animals

6.3 Conventional and unconventional petroleum and gas, mining and infrastructure

There were numerous recommendations focussed on the management and mitigation of conventional and unconventional petroleum and gas, mining and infrastructure. Some of these recommendations were targeted to the floodplain areas of the LEB (Qld) while others addressed impacts to surface and groundwater resources. Several key recommendations were:

13. Open cut mining should not be allowed within the LEB (Qld)
14. Environmental conditions need to be specific to the ecosystems of the project area
15. RPI Act should regulate location of bores, amount of water taken from certain places, proximity to sensitive locations and species
16. The production phase of mining incurs a higher risk, and cumulative impacts need to be considered. Adequate provision is necessary many years postproduction phase for the rehabilitation and monitoring
17. Ensure that ground water monitoring is undertaken to monitor leaks into overlying aquifers from production casing or via offset wells
18. Old legacy bores from the early days may pose a risk if they were not constructed to current specifications. Ensure that ground water monitoring in these areas are undertaken
19. Tailings dams need to be managed according to industry best practice with erosion and sediment controls in place along with appropriate rehabilitation of tailings dams as a legacy issue
20. Leaching of produced water from petroleum/gas and mining needs restrictions to ensure it prevents impacts to waterholes
21. Exclude gas wells and ponds from frequently flooded areas
22. Regulation and checks on the procedures and management is required to ensure the legislation is being enforced e.g., auditing of systems

6.4 Environmental Attributes

The SEP was asked to consider which of the environmental attributes under the RPI Regulation are relevant to the Channel Country SEA. As described in Section 1.3.1 of this report, environmental attributes are used to assess projects for a determination of approval under a RIDA. The State Government then must identify if an activity would likely result in a widespread or irreversible impact on an environmental attribute of a SEA and possible actions to

manage or minimise an impact. The Department of State Development, Manufacturing, Infrastructure and Planning assesses the application and considers advice provided by the assessing agencies, then either issue or refuse the RIDA as appropriate.

There was unanimous agreement from the SEP members that the currently listed environmental attributes are limited in their scope and number. To rectify this, the SEP recommends:

23. Incorporate all environmental attributes listed in Table 1
24. Amend the wording for each environmental attribute to better reflect the support of biodiversity and ecosystem processes as outlined in this report
25. Expand the examples given for each environmental attribute to better identify and protect the threatened flora and threatened and migratory fauna of the riverine ecosystems, GDEs and artesian springs in the LEB (Qld)

6.5 Strategic Environmental Area

The SEP deliberated on the spatial extent of the SEA as it is currently presented in the RPI Reg. There was support from the SEP to expand the current spatial extent to better include the key ecosystems, ecosystem processes and functioning across the broader LEB (Qld) landscape. Some of the identified deficiencies with the existing map extent were:

- It doesn't currently protect the critically endangered artesian springs or their endemic species from potential impacts from unconventional and conventional petroleum and gas activities or from mining
- It doesn't include all the relevant floodplain areas within the LEB (Qld)
- It doesn't include significant wetlands important for waterbird breeding events and other aquatic fauna and flora communities (e.g., Lake Galilee, Lake Buchanan)
- There isn't any buffer around the significant floodplain and riverine ecosystems to account for indirect impacts or cumulative impacts from potential activities
- It doesn't consider the whole of the LEB (Qld) catchment across the broader landscape where international and nationally significant ecological values are present

26. Several proposed expansions for the SEA were considered:
    a) Extending the SEA to include all the floodplain
    b) Buffering the floodplain area by a distance (e.g., 1 km) to ensure indirect impacts from proposed activities can be included under the RPI Act and RIDA framework.
    c) Buffer the artesian springs using the recovery plan and condition assessment (Fensham *et al.* 2007; Fensham *et al.* 2010; Anderson *et al.* 2016). Refer to these reports for a potential framework to determine the appropriate buffers to be applied.
    d) Expanding the SEA to incorporate the entire LEB (Qld) basin boundary.

Although consensus was not reached, most of the SEP members supported the implementation of option d). There was concern expressed by some regarding the economic and social burden on towns and agriculture to expand the SEA to the LEB (Qld) boundary (e.g., depopulation leading an inability to control pests and weeds through a lack of private incentive and a lack of labour). Other recommendations by the SEP regarding the SEA:

27. Lake Galilee and Lake Buchanan should be included as part of the SEA for additional protection from future development in the SEA area
28. Increase restrictions under the RPI Act to ensure activities are not carried out in sensitive areas (such as near to springs) or in an improper fashion (over-extraction) throughout the entire LEB (Qld)
29. Expand the DP or SEA to include larger areas around main channels and floodplains, and the GDEs
30. Expand the SEA/DP to include all floodplain areas

31. Expand the SEA to include other sensitive areas in the LEB (Qld) including the north west region of the basin where the topography is not within the floodplain (i.e., extensive karst systems)
32. The significance of the floodplain was raised continuously throughout the workshop. The SEP members agreed that if the health of the LEB (Qld) ecosystems is to be preserved all floodplains must be included in the Channel Country SEA, and development in floodplains must be restricted
33. Additional protection is needed for previously protected areas under Wild Rivers legislation

6.6 Designated Precinct

The RPI Regulation 2014 identifies the following activities as unacceptable uses in a DP of the Channel Country SEA where they do not already exist:

- open cut mining
- broadacre cropping
- water storage (dam)

The SEP supported these activities as unacceptable uses within the DP. In addition, the SEP recommends:

34. Unconventional petroleum and gas production be an unacceptable use in the Designated Precinct (DP)
35. Recommend excluding gas wells and ponds from frequently flooded areas
36. The spatial extent of the DP be extended to include the artesian wetlands, extended floodplain and significant wetlands/lakes
37. The SEA/DP be expanded to include all known springs

6.7 Invasive species and conservation management

Invasive aquatic species are a major threat and concern for the LEB (Qld) riverine ecosystems. A prioritised management action plan to address emerging invasive species is required to minimise their impacts on native species and ecosystems. As raised by the SEP, the mosquito fish *Gambusia holbrooki* is a major concern for the threatened fish of the artesian springs along with the progressive invasion of cane toads *Bufo marinus*, red claw crayfish *Cherax quadricarinatus*, and sleepy cod *Oxyeleotris lineolata.* Cattarino *et al.* (2015) presents a novel approach for prioritising multiple alternative actions for a pest fish which may provide a management tool for the LEB (Qld). There are now priority threat management approaches for invasive animals which consider the effects of climate change on the dynamics of invasive and threatened species, amongst other issues (Firn *et al.* 2015; Carwardine *et al.* 2018).

Substantial tracks of the LEB (Qld) are within protected estate (i.e., Diamantina, Astrebla Downs, Wellford, Munga-Thirri National Parks) and in private conservation areas or as covenants with private companies (e.g., the Mulligan River, NAPCO). These areas set aside for conservation are actively contributing to biodiversity protection. For example, the private stewardship in protecting species such as the night parrot managed by Bush Heritage. These public and private conservation efforts need to continue whilst ensuring the attitudes and management that has achieved this continues through appropriate legislation and incentives.

Notwithstanding these existing conservation areas, the SEP identified a lack of protected areas for the significant riverine ecological values in the Georgina, Diamantina and Cooper Creek catchments. The existing protected estate is limited in its protection of key aquatic environmental assets and ecological processes in the LEB (Qld). The CARE principles of comprehensiveness, adequacy, representativeness and efficiency provides a conservation planning framework for the systematic assessment and protection of freshwater ecosystems which also accounts for the connected nature of rivers and floodplains (Linke *et al.* 2011). There are also relevant biodiversity predictive models in a GIS format which are focussed on connectivity and condition of riverine landscapes to help prioritise potential areas for conservation and management (e.g., Linke *et al.* 2012; Reis *et al.* 2019).

38. A prioritised management action plan to address emerging invasive species is required to minimise their impacts on native species and ecosystems

39. Encouragement of integrated catchment management programs (for controlling or eradicating invasive pest species)
40. Public and private conservation efforts need to continue whilst ensuring the attitudes and management that has achieved this continues through appropriate legislation and incentives.
41. Utilise relevant biodiversity predictive models focussed on connectivity and condition of riverine landscapes to help prioritise potential areas for protected estate, conservation and management

6.8 Agricultural practices and tourism

Access to high ecological value waterholes or ecosystems could benefit from water hole fencing scheme and waterpoint relocation to protect them from direct access by livestock to prevent trampling and overgrazing impacts. The level of risk is highly dependent of livestock type and density, where in many instances stock numbers are low and cause little to no lasting impact by walking down to water level to drink.

Other considerations for managing the potential impacts included the use of excess (mining or petroleum and gas water) to be used to benefit the towns and agriculture (including intensive irrigation crops i.e., not broad-acre cropping). The use of wastewater could allow for new industries to contribute to regional resilience. Further research into building private incentives to protect the LEB (Qld) such as through a CRC or Centre for Excellence would promote a cross-disciplinary approach to understand the interactions across the basin's natural, cultural, and socioeconomic assets.

42. Exclude livestock and tourists from the banks of permanent waterholes, but not restricting access to the entire riparian and floodplain system
43. In addition to the high ecological values of the Georgina River catchment, there are significant cultural values to be preserved such as the Pituri sacred areas, the Bilpa Morea Claypan European heritage area and the Camooweal Caves which are a popular tourist destination
44. Need to allow sustainable development in the LEB (Qld) but ensure that they are the right developments
45. Grandfathering of existing licenses for irrigation in the basin
46. Keep aquaculture out of the floodplain and well away from water courses flowing in. Use endemic LEB species only
47. Management of recreation and tourism is required. A possible solution is the allocation of formal areas to camp and park with amenities and facilities
48. Education of tourists and general public (large signage: "You are now entering a near-pristine river basin, one of the last natural arid-zone riverine ecosystems in the world; please do not bring any weeds in mud on your vehicle; and do NOT release any animals/fish caught elsewhere")
49. Enforcement and education along applying with bag limits, the banning of gill nets and a reduction in bycatch
50. Consider development activities that will build the region's population and creating smart options to build wealth through sustainable management of the natural environmental assets (e.g., weed and pest control on private land is incentivised by reducing impacts on production)
51. New schemes could be instated to grow wealth by protecting natural assets
52. Access to high ecological value waterholes or ecosystems could benefit from water hole fencing scheme and waterpoint relocation to protect them from direct access by livestock to prevent trampling and overgrazing impacts
53. Further research into building private incentives to protect the LEB (Qld) such as through a CRC or Centre for Excellence would promote a cross-disciplinary approach to understand the interactions across the basin's natural, cultural, and socioeconomic assets

6.9 Future reviews of this report

54. The deliberations of the SEP occurred over a two-day workshop and not an extended timeframe of months or years as other similar processes have taken. Should DES allocate additional resources in the future, the SEP could reconvene to refine, and build on, the outputs of this risk assessment and to provide additional context on the assumptions and ratings provided in this report.

6.10 Quick reference recommendation table

A list of recommendations from the report was compiled into a single reference table (Table 7).

Table 7. Quick reference recommendation table

#	Description	Reference	Page
	Groundwater Dependent Ecosystems - Springs		
1.	Impose restrictions on groundwater extraction and drilling methods in the Georgina catchment because of the potential impacts to GDEs and SGDEs	S4.1.3	22
2.	Ensure artesian springs are a high priority for protection under legislation. This is because they are significant for maintaining Australia's unique aquatic biota and for terrestrial species being permanent source of water during dry periods in the largely terrestrial environments of LEB	S5.1.5	31
3.	Ensure development does not lead to the spread of invasive species in artesian springs, as they could be devastating to previously undisturbed ecosystems and can out-compete endemic species (e.g., endangered fish)	S5.2	31
4.	The legislative framework should include the level/pressure as an aspect to monitor or consider, especially near to GAB springs	Issue 4.	25
	Riverine and floodplain ecosystems		
5.	Infrastructure for mining and petroleum/gas activities should not be allowed in the floodplains because of flow alterations, fish passage issues and major impacts to floodplain ecosystems	Issue 3.	25
6.	Quarry extraction from rivers for construction of infrastructure such as roads should not be allowed to occur in the waterways and floodplains.	Issue 3.	25
7.	Changes to surface water flow/levels and overland flow, water quality, temperature and ecosystem structure needs to consider the impacts to threatened species that reside in permanent waterholes such as the endangered Cooper Creek catfish *Neosiluroides cooperensis*	Issue 4.	25
8.	Storage ponds for resource development (e.g., tailings dams) should not be placed on the floodplain due to the risk of structural integrity issues, from flooding, and spillage of wastes. It would be necessary to have restrictions on capacity of dams during a wet season	Issue 6.	27
9.	Limit the construction of large, raised infrastructure in the floodplain	Issue 6.	27
10.	Manage permanent waterholes across the LEB (Qld) region, not as individual waterholes, but as a system of intermittently connected waterholes along the length of the rivers and channels, and on the floodplains	S5.1.3	30
11.	Protect and maintain threatened species and their habitats for their continued survival and resilience through dry periods	S5.1.4	30
12.	Enforce speed limits to reduce likelihood of hitting threatened animals	Issue 2.	24
	Conventional and unconventional petroleum and gas, mining and infrastructure		
13.	Open cut mining should not be allowed within the LEB (Qld)	Issue 1.	24
14.	Environmental conditions need to be specific to the ecosystems of the project area	Issue 2.	24

#	Description	Reference	Page
15.	RPI Act should regulate location of bores, amount of water taken from certain places, proximity to sensitive locations and species	Issue 4.	25
16.	The production phase of mining incurs a higher risk, and cumulative impacts need to be considered. Adequate provision is necessary many years postproduction phase for the rehabilitation and monitoring	Issue 4.	25
17.	Ensure that ground water monitoring is undertaken to monitor leaks into overlying aquifers from production casing or via offset wells	Issue 5.	26
18.	Old legacy bores from the early days may pose a risk if they were not constructed to current specifications. Ensure that ground water monitoring in these areas are undertaken.	Issue 5.	26
19.	Tailings dams need to be managed according to industry best practice with erosion and sediment controls in place along with appropriate rehabilitation of tailings dams as a legacy issue	Issue 5.	26
20.	Leaching of produced water from petroleum/gas and mining needs restrictions to ensure it prevents impacts to waterholes	Issue 6.	27
21.	Exclude gas wells and ponds from frequently flooded areas	Issue 6.	27
22.	Regulation and checks on the procedures and management is required to ensure the legislation is being enforced e.g., auditing of systems	Issue 6.	27
	Environmental Attributes		
23.	Incorporate all environmental attributes listed in Table1 into the RPI Act for the LEB (Qld).	Environmental Attributes	39
24.	Amend the wording for each environmental attribute to better reflect the support of biodiversity and ecosystem processes as outlined in this report	Environmental Attributes	39
25.	Expand the examples given for each environmental attribute to better identify and protect the threatened flora and threatened and migratory fauna of the riverine ecosystems, GDEs and artesian springs in the LEB (Qld).	Environmental Attributes	39
	Strategic Environmental Area		
26.	Several proposed expansions for the SEA were considered: a) Extending the SEA to include all the floodplain. b) Buffering the floodplain area by a distance (e.g., 1 km) to ensure indirect impacts from proposed activities can be included under the RPI Act and RIDA framework. c) Buffer the artesian springs using the recovery plan and condition assessment (Fensham *et al.* 2007; Fensham *et al.* 2010; Anderson *et al.* 2016). Refer to these reports for a potential framework to determine the appropriate buffers to be applied. d) Expanding the SEA to incorporate the entire LEB (Qld) basin boundary. Although consensus was not reached, most of the SEP members supported the implementation of option d). There was concern expressed by some regarding the economic and social burden on towns and agriculture to expand the SEA to the LEB (Qld) boundary (e.g., depopulation leading an	SEA	40

#	Description	Reference	Page
	inability to control pests and weeds through a lack of private incentive and a lack of labour).		
27.	Lake Galilee and Lake Buchanan should be included as part of the SEA for additional protection from future development in the SEA area	S4.1.1	20
28.	Increase restrictions under the RPI Act to ensure activities are not carried out in sensitive areas (such as near to springs) or in an improper fashion (over-extraction) throughout the entire LEB (Qld)	S4.1.1	20
29.	Expand the DP or SEA to include larger areas around main channels and floodplains, and the GDEs	Issue 5.	26
30.	Expand the SEA/DP to include all floodplain areas	Issue 6.	27
31.	Expand the SEA to include other sensitive areas in the LEB (Qld) including the NW portion of the basin where the topography is not within the floodplain (i.e., extensive karst systems)	Issue 5.	26
32.	The significance of the floodplain was raised continuously throughout the workshop. The SEP members agreed that if the health of the LEB (Qld) ecosystems is to be preserved all floodplains must be included in the Channel Country SEA, and development in floodplains must be restricted	S4.1.1	20
33.	Additional protection is needed for previously protected areas under Wild Rivers legislation	Issue 5.	26
	Designated Precinct		
34.	Unconventional petroleum and gas production be an unacceptable use in the DP	DP	41
35.	Recommend excluding gas wells and ponds from frequently flooded areas	DP	41
36.	The spatial extent of the Designated Precinct be extended to include the artesian wetlands, extended floodplain and significant wetlands / lakes	DP	41
37.	The SEA/DP be expanded to include all known springs	Issue 4.	25
	Invasive species and conservation management		
38.	A prioritised management action plan to address emerging invasive species is required to minimise their impacts on native species and ecosystems		41
39.	Encouragement of integrated catchment management programs (for controlling or eradicating invasive pest species).	Issue 3.	25
40.	Public and private conservation efforts need to continue whilst ensuring the attitudes and management that has achieved this continues through appropriate legislation and incentives.		41
41.	Utilise relevant biodiversity predictive models focussed on connectivity and condition of riverine landscapes to help prioritise potential areas for protected estate, conservation and management		41
	Agriculture and tourism		
42.	Exclude livestock and tourists from the banks of permanent waterholes, but not restricting access to the entire riparian and floodplain system	S4.1.2	21
43.	In addition to the high ecological values of the Georgina River catchment, there are significant cultural values to be preserved such as the Pituri sacred	S4.1.3	22

#	Description	Reference	Page
	areas, the Bilpa Morea Claypan European heritage area and the Camooweal Caves which are a popular tourist destination		
44.	Need to allow sustainable development in the LEB (Qld) but ensure that they are the right developments	Issue 3.	25
45.	Grandfathering of existing licenses for irrigation in the basin	Issue 7.	28
46.	Keep aquaculture out of the floodplain and well away from water courses flowing in. Use endemic LEB species only	Issue 7.	28
47.	Management of recreation and tourism is required. A possible solution is the allocation of formal areas to camp and park with amenities and facilities	Issue 8.	28
48.	Education of tourists and general public (large signage: "You are now entering a near-pristine river basin, one of the last natural arid-zone riverine ecosystems in the world; please do not bring any weeds in mud on your vehicle; and do NOT release any animals/fish caught elsewhere")	Issue 8.	28
49.	Enforcement and education along applying with bag limits, the banning of gill nets and a reduction in bycatch	Issue 8.	28
50.	Consider development activities that will build the region's population and creating smart options to build wealth through sustainable management of the natural environmental assets (e.g., weed and pest control on private land is incentivised by reducing impacts on production)	S5.4	36
51.	New schemes could be instated to grow wealth by protecting natural assets	S5.5	37
52.	Access to high ecological value waterholes or ecosystems could benefit from water hole fencing scheme and waterpoint relocation to protect them from direct access by livestock to prevent trampling and overgrazing impacts		42
53.	Further research into building private incentives to protect the LEB (Qld) such as through a CRC or Centre for Excellence would promote a cross-disciplinary approach to understand the interactions across the basin's natural, cultural, and socioeconomic assets		42
54.	Should DES allocate additional resources in the future, the SEP could reconvene to refine, and build on, the outputs of this risk assessment and to provide additional context on the assumptions and ratings provided in this report		43

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Appendix A – Acronym and abbreviation list

Acronym/abbreviation	Definition
ACA	Aquatic Conservation Assessment
ACH Act	*Aboriginal Cultural Heritage Act 2003*
ALUM Classification	Agriculture Land Use and Management Classification
ATP	Authority to Prospect
AquaBAMM	Aquatic Biodiversity Assessment and Mapping Method
BPA	Biodiversity Planning Assessment
CPP	Central Processing Plant
CSG	Coal Seam Gas
Cwth	Commonwealth
DA	Development Approval
DES	Department of Environment and Science
DP	Designated Precinct
EA	Environmental Authority
EO Act	*Environmental Offsets Act 2014*
EP Act	*Environmental Protection Act 1994*
EPBC Act	*Environmental Protection and Biodiversity Conservation Act 1999*
EP Regulation	Environmental Protection Regulation 2008
EPP Air	Environmental Protection (Air) Policy 2008
EPP Noise	Environmental Protection (Noise) Policy 2008
ERA	Environmentally Relevant Activity
ERC	Estimated Rehabilitation Cost
ESA	Environmentally Sensitive Area
EVNT	Endangered, Vulnerable or Near Threatened
FCS	Field Compressor Station
GAB	Great Artesian Basin
GDE	Groundwater Dependent Ecosystem
GES	General Ecological Significance
HES	High Ecological Significance
ILUA	Indigenous Land Use Agreement
LEB	Lake Eyre Basin
LEB (Qld)	Queensland section of the Lake Eyre Basin
MCU	Material Change of Use
MERCP Act	*Mineral and Energy Resources (Common Provisions) Act 2014*
MR Act	*Mineral Resources Act 1989*
MSES	Matters of State Environmental Significance
NC Act	*Nature Conservation Act 1992*
PAA	Priority Agricultural Activity
PALU	Priority Agricultural Land Use
P&G Act	*Petroleum and Gas (Production and Safety) Act 2004*
P&G Regulation	Petroleum and Gas (Safety) Regulation 2018
PL	Petroleum Lease
RE	Regional Ecosystem
RIDA	Regional Interests Development Approval
RO	Reverse Osmosis
RPI Act	*Regional Planning Interests Act 2014*
RPI Regulation	Regional Planning Interests Regulation 2014
SARA	State Assessment and Referral Agency
SDAP	State Development Assessment Provisions
SEA	Strategic Environmental Area

Acronym/abbreviation	Definition
SEP	Scientific Expert Panel
SGDE	Subsurface Groundwater Dependent Ecosystem
SRI	Significant Residual Impact
STP	Sewage Treatment Plant
TO	Traditional Owner
TO Act	*Transport Operations (Road Use Management) Act 1995*
VM Act	*Vegetation Management Act 1999*
WRR Act	*Waste Reduction and Recycling Act 2011*

Appendix B – SEP Terms of Reference

Pristine Rivers Scientific Expert Panel
Terms of Reference

1. Background

The Queensland Government is reviewing state policy, legislation and administrative frameworks to ensure the long-term ecological sustainability of our Free Flowing Rivers. The term 'free flowing' describes rivers that consist of all or nearly all their natural ecological values.

The government has committed (GEC958) to work with Traditional Owners, stakeholders and communities to ensure the State's Pristine Rivers are protected. This will include a review of the extent to which the *Regional Planning Interests Act 2014* provides adequate protection for these rivers.

The Free Flowing Rivers policy goal is to protect and avoid widespread and irreversible impacts on rivers with all, or nearly all, of their environmental attributes intact.

2. Purpose

The purpose of the review is to:

- achieve a balance between future economic prosperity for the State and Lake Eyre Basin (LEB (Qld)) and ecological sustainability
- ensure any impacts to environmental attributes continue to be managed and mitigated through the regulatory framework
- evaluate the effectiveness of existing planning and environmental regulations that protect identified values that are unique to the LEB (Qld)
- ensure Queensland has the most effective and responsive planning and environmental regulatory framework for protections, based on the best available science.

A scientific, evidence-based approach will be undertaken to determine the impacts of current and potential resource and regulated activities on the environmental attributes of the LEB (Qld). Constraints on activities provided through existing environmental, legislative and administrative frameworks will also be considered.

Information gathered will assist the Queensland Government to evaluate the effectiveness of the current legislative frameworks that aim to protect the region's social, cultural, ecological values and economic opportunities, and achieve ecologically sustainable development.

3. Role

The Free Flowing Rivers Scientific Expert Panel (SEP) will provide advice and recommendations to be included in an Issues and Options paper for consideration of the Free Flowing Rivers Interdepartmental Committee.

The SEP will undertake the following:

through a review, provided by the Department of Environment and Science, of literature and/or case examples from confidential and publicly available resources (See Attachment 1 Free Flowing Rivers Scientific Expert Panel Literature List);

- identify the potential environmental impact/s or gaps in scientific knowledge of:
    1. Unconventional gas (coal seam, shale, and tight gas) industry,
    2. agricultural practices; and
    3. infrastructure

on the following environmental *attributes in Lake Eyre Basin (Qld) including:

> Environmental Attributes of Channel Country Strategic Environmental Area
> (a)the natural hydrologic processes of the area characterised by—
> (i)natural, unrestricted flows in and along stream channels and the channel network in the area; and
> (ii)overflow from stream channels and the channel network onto the flood plains of the area, or the other way; and
> (iii)natural flow paths of water across flood plains connecting waterholes, lakes and wetlands in the area; and
> (iv)groundwater sources, including the Great Artesian Basin and springs, that support waterhole persistence and ecosystems in the area;
> (b)the natural water quality in the stream channels and aquifers and on flood plains in the area;
>
> (c)the beneficial flooding of land that supports flood plain grazing and ecological processes in the area.

> Additional Environmental Attributes relevant to other Strategic Environmental Areas as described in the Regulation including:
> (d)the natural geomorphic processes of the area characterised by—
> (i)natural erosion; and
> (ii)the transport and deposit of sediment by water throughout the catchments and along the watercourse systems and estuaries;
> (e)the functioning riparian processes of the area characterised by native riparian vegetation associated with watercourses, estuaries, lakes, floodplains and wetlands;
> (f)the functioning wildlife corridors of the area characterised by—
> (i)natural habitat in the watercourse systems; and
> (ii)permanent waterholes and springs;
> (g)the natural water quality in the watercourse channels and aquifers and on flood plains in the area characterised by physical, chemical and biological attributes that support and maintain natural aquatic

- For the coal seam, shale and tight gas industry, consideration should be given to:
  - The probable impact of the volume of water produced or required to conduct the petroleum and gas activities in general.
  - The source of water used for undertaking petroleum and gas activities in general.
  - The probable impact of the take or interference with groundwater resources through the petroleum & gas industry exercising “Underground Water Rights” under Chapter 3 of the *Water Act 2000*.
  - The extent and probable impacts of well failures during exploration and production, drilling and gas operations.
  - The probable health impacts of chemical additives to fracking fluids used for hydraulic fracking of gas wells.
  - The probable impact of fluids used for hydraulic fracking of gas wells and the contamination/pollution of freshwater aquifers.
  - The probable impact of escaped hydraulic fracking fluids from holding storages on soil and water contamination.
  - The probable impacts to land, water, air of petroleum & gas infrastructure (roads, tracks and pipelines, well pads, storage, compressor stations, pump stations, etc.).

- The probability of consequence from current activities and future scenarios to be included in the development of a risk matrix.

For agricultural practices including grazing, consideration should be given to:

- The probable impact of agricultural practices including pesticide, fertilizer and hormone use, grazing, irrigation, soil tillage, crop rotation, fencing, and burning on water resources and environmental attributes.

For infrastructure, consideration should be given to:

- The probable impact of infrastructure including roads, levees, pipelines, channels, culverts, weirs, viaducts, and dams on environmental attributes and/or values.

Guidance for spatial consideration of options development:

- What methodology, criteria and thresholds should inform mapping 'Free Flowing Rivers' in the LEB (Qld), including as a channel, channel network or a connected network of water bodies, of natural origin and exhibiting overland flow in which the biological, hydrological and geomorphological processes associated with river flow; and the biological, hydrological and geomorphological processes in those parts of the catchment with which the river is linked; to identify rivers which have not been significantly altered since European settlement?

The SEP will have a particular focus to contribute to the development of strategic policy options regarding the *Regional Planning Interests Act 2014.* This work may identify:

- What knowledge is known and accepted?
- Relevant case examples, current and future scenarios
- What are the knowledge gaps and
- What are the risks associated with these knowledge gaps?

The Pristine Rivers team, Department of Environment and Science, will include advice and recommendations as appropriate to ensure continued momentum and focus on the LEB (Qld).

*Identification of Traditional Owner cultural attributes and cultural flows will be provided via a Lake Eyre Basin (Qld) Traditional Owner Forum Report

4. Deliverables

The panel members will:

- attend a two-day meeting in the 3rd quarter of 2019.

The Facilitator will:

- prepare a report including recommendations on the topics above.

The report will inform an Issues and Options paper to be submitted to the Interdepartmental Committee.

5. Membership

5.1 Facilitator

The Facilitator is independent and is appointed through a standing offer arrangement with the Department of Environment and Science.

5.2 Members

The SEP will consist of up to 12 individuals to ensure expertise from a range of specialisation including (but not limited to) hydrogeology, hydrology, ecology, toxicology, agriculture, and geology from:

- Academic
- Consulting
- Industry
- Government

The Pristine Rivers team will provide logistical support and assistance to the SEP as appropriate. Members of the Pristine Rivers team will not directly participate in the SEP.

5.3 Appointment process

The Pristine Rivers team, Department of Environment and Science, will assess and nominate potential members for the Facilitator's consideration based on expertise and specialisation. The Facilitator will determine final membership based on expertise, specialisation, interest, and availability.

6. Operation

The Facilitator and members of the SEP will declare actual or perceived conflicts of interest; fairly represent the interests of their sector, provide advice in their areas of expertise to deliver required outcomes, commit to finding common ground in implementation of actions for the benefit of the LEB (Qld).

Employees of the public service (Commonwealth, State, or local) may be engaged for their knowledge and/or expertise as independent members of the SEP.

It is recognised that in some instances, an employee of the public service, may provide advice or a recommendation that is inconsistent with current Government (Commonwealth, State, or local) policy.

The advice of employees of a public service, engaged as part of the SEP is not considered as government policy.

Members will be remunerated for their participation and reimbursed for reasonable costs associated with travel and accommodation as appropriate.

Meeting agendas and minutes will be prepared by the Facilitator and circulated to members at least one week in advance of meetings.

Confidentiality

Any business transacted in the meetings including findings, conclusions and proposed recommendations prior to release of the report is to be treated as commercial and strictly confidential.

7. Reporting

The SEP will provide a draft and final report, through the Facilitator, to the Department of Environment and Science, approximately 2-4 weeks upon completion of the two meetings or an alternate timeframe as agreed in writing.

8. Support

Logistical support will be provided by the Pristine Rivers team from the Queensland Government Department of Environment and Science.

The Pristine Rivers team will maintain records for the committee and its working groups, circulate agendas, papers and minutes.

9. Disclaimer

The State of Queensland gives no warranty in relation to advice provided by the SEP (including without limitation, accuracy, reliability, completeness or fitness for a particular purpose). To the maximum extent permitted by applicable law, in no event shall the department be liable for any special, incidental, indirect, or consequential loss whatsoever (including, but not limited to, damages for loss of profits or confidential or other information, for business interruption, for personal injury, for loss of privacy, for failure to meet any duty including of good faith or of reasonable care, for negligence, for any other pecuniary or other loss whatsoever including, without limitation, legal costs on a solicitor own client basis) arising out of, or in any way related to, the use of or inability to use the advice of the SEP.

Attachment 1 Free Flowing Rivers Scientific Expert Panel Literature List

Inquiries and Reports

Inquiry into onshore unconventional gas in Victoria; https://www.parliament.vic.gov.au/images/stories/committees/SCEP/GAS/Report/EPC_58-03_Text_WEB.pdf.

Final Report Review - Scientific Inquiry into Hydraulic Fracturing in the Northern Territory; https://frackinginquiry.nt.gov.au/inquiry-reports/final-report.

Inquiry into unconventional gas (fracking): submission from the South

Australian Government; http://energymining.sa.gov.au/__data/assets/pdf_file/0009/263457/Inquiry_into_Unconventional_Gas_Fracking_-_SA_Government_Submission.pdf.

Unconventional Gas (Fracking) in the South East of South Australia Final Report; www.parliament.sa.gov.au/.../TabledPapersandPetitions.aspx?...Unconventional-Gas-Fracking-Final-Report-pdf.pdf

Independent Scientific Panel Inquiry into Hydraulic Fracture Stimulation in Western Australia; https://frackinginquiry.wa.gov.au/sites/default/files/final_report.pdf.

Improving Habitat Condition and Connectivity in South Australia's Channel Country;

www.naturalresources.sa.gov.au/files/.../channel_country_summary_report_web.pdf.

Lake Eyre Basin State of the Basin 2016; http://lakeeyrebasin.gov.au/resources/publications

Coal Seam Gas in the Tara Region Report 2013; https://publications.qld.gov.au/dataset/8dc04bd9-8784-429e-b6ac-769d2f270295/resource/66dfcde4-4bd7-44d9-95af763af3cdc605/download/taracoalseamreport.pdf.

Fraccing and BTEX Information sheet 2016; https://environment.des.qld.gov.au/assets/documents/regulation/rs-is-fraccing-and-btex.pdf

CSIRO EP165346 July 2018' *Assessment of scientific knowledge of shale gas and shale oil potential impacts*. *Not publically released.

The Geological and Bioregional Assessment Program assessment the potential impacts of shale and tight gas development on water and the environment Stage 1 and 2 Reports. https://www.bioregionalassessments.gov.au/geological-and-bioregional-assessment-program

Papers

Report on the potential impacts of Unconventional Gas development on the Agricultural Industries in the Coastal Wide Bay Burnett Region 2018; https://www.bdbcanegrowers.com.au/wp-content/uploads/2018/09/Wide-Bay-Burnett-Groundwater-Report-V8-Final-Version.pdf.

Cumulative risk management, coal seam gas, sustainable water, and agriculture in Australia 2015; https://www.researchgate.net/publication/276242862_Cumulative_risk_management_coal_seam_gas_sustainable_water_and_agriculture_in_Australia.

Toward an Understanding of the Environmental and Public Health Impacts of Unconventional Natural Gas Development: A Categorical Assessment of the Peer-Reviewed

Scientific Literature, 2009-2015; https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0154164.

Hydraulic Fracturing – Is Industry Standard Practice the Best Practice? The Case for Waterless Fracking 2018; http://www.futuredirections.org.au/wp-content/uploads/2018/06/SAP-NALC-LNG-Fracking.pdf.

Between the Cracks: Water Governance in Queensland, Australia and Potential Cumulative Impacts from Mining Coal Seam Gas 2013; https://www.researchgate.net/publication/289241348_Between_the_cracks_Water_governance_in_Queensland_Australia_and_potential_cumulative_impacts_from_mining_coal_seam_gas.

Fish Distribution in Far Western Queensland, Australia: The Importance of Habitat, Connectivity and Natural Flows 2014; https://www.researchgate.net/publication/272648779_Fish_Distribution_in_Far_Western_Queensland_Australia_The_Importance_of_Habitat_Connectivity_and_Natural_Flows.

Lake Eyre Basin Rivers: Environmental, Social and Economic Importance 2017; https://books.google.com.au/books?hl=en&lr=&id=IA9CDwAAQBAJ&oi=fnd&pg=PP1&dq=lake+eyre+basin+water+birds&ots=bWcIrjNnRR&sig=lr3LVPV8n9CJ8NCLmddXwh3RHPM.

Phelps 2003 Sustainable grazing in the channel country floodplains MLA Final Report (attached)

Phelps et al 2007 Sustainable grazing in the channel country floodplains (Phase 2) MLA Final Report (attached)

Cooper Creek Flood rules of thumb https://futurebeef.com.au/wp-content/uploads/2017/04/Cooper_Flood_Rules_-of_Thumb_Nov06_A3.pdf

Diamantina Flood rules of thumb https://futurebeef.com.au/wp-content/uploads/2017/04/Diamantina_Flood_Rules_of_Thumb_Nov06_A3.pdf

Georgina Flood rules of thumb https://futurebeef.com.au/wp-content/uploads/2017/04/Georgina_Flood_Rules_of_Thumb_Nov08_A3.pdf

Forage value in the Channel country

https://futurebeef.com.au/wp-content/uploads/2011/09/Forage_value_in_the_Channel_Country_a_photographic-guide.pdf

Guidance for spatial consideration of options development

Stein, JL, Stein, JA & Nix, HA 1998, *The Identification of Wild Rivers - Methodology and Database Development*, Environment Australia., Canberra.

https://wetlandinfo.des.qld.gov.au/wetlands/resources/tools/assessment-search-tool/wild-rivers-model/

National wilderness inventory

http://www.environment.gov.au/node/20141

Aquatic Ecosystems Task Group (2012). Aquatic Ecosystems Toolkit. *Case Study 1: Lake Eyre Basin*. Department of Sustainability, Environment, Water Population and Communities, Canberra.

The publication can be accessed at http://www.environment.gov.au/water

Aquatic Ecosystems Task Group (2012). Aquatic Ecosystems Toolkit. *Module 3: Guidelines for Identifying High Ecological Value Aquatic Ecosystems (HEVAE)*. Australian Government Department of Sustainability, Environment, Water, Population and Communities, Canberra.

http://www.environment.gov.au/water

Appendix C – SEP Agenda

SUSTAINABLY MANAGING KATI THANDA-LAKE EYRE BASIN
SCIENTIFIC EXPERT PANEL AGENDA

Objectives

To provide scientific and evidence based advice on the following:

A) Environmental attributes and spatial extent of the Channel Country Strategic Environmental Area (SEA)

1. Which of the environmental attributes below, are relevant to the SEA, and if so, how are they represented locally?
    a. the natural geomorphic processes of the area (e.g. natural erosion; the transport and deposit of sediment by water throughout the catchments and along the watercourse systems and distributaries)
    b. the functioning riparian processes of the area (e.g. native riparian vegetation associated with watercourses, lakes, floodplains and wetlands)
    c. the functioning wildlife corridors of the area (e.g. natural habitat in the watercourse systems; freely moving fish populations and communities (including fin fish and invertebrates); permanent waterholes and springs)
2. Are there other attributes (environmental or cultural) relevant to the Kati Thanda-Lake Eyre Basin that should be considered? If so, what is the evidence and justification for inclusion?
3. Are the current spatial parameters for the Channel Country SEA adequate?
    a. does the SEA spatially provide sufficient protection to riverine ecology in the LEB (QLD)?
    b. does the designated precinct represent the area that requires a higher level of protection?
    c. what are the spatial implications of including additional attributes under questions 1-2?

B) Risk analysis

4. Considering potential impacts on environmental attributes, assign an initial and residual risk rating to the following activities, after the application of a range of management tools:
    1. transport, storage, mixing and use of relevant chemicals in petroleum/gas and mining industries
    2. construction and ongoing operation of supporting infrastructure for mining and petroleum/gas activities (on-lease)
    3. construction and ongoing operation of supporting infrastructure for mining and petroleum/gas activities (off-lease) and other industries such as agriculture or tourism
    4. water take in petroleum/gas and mining industries
    5. operations of petroleum/gas and mining industries including drilling, hydraulic fracturing, dewatering, extraction and processing
    6. waste treatment and disposal petroleum/gas and mining industries
    7. agricultural practices
    8. increased visitor access from tourism.

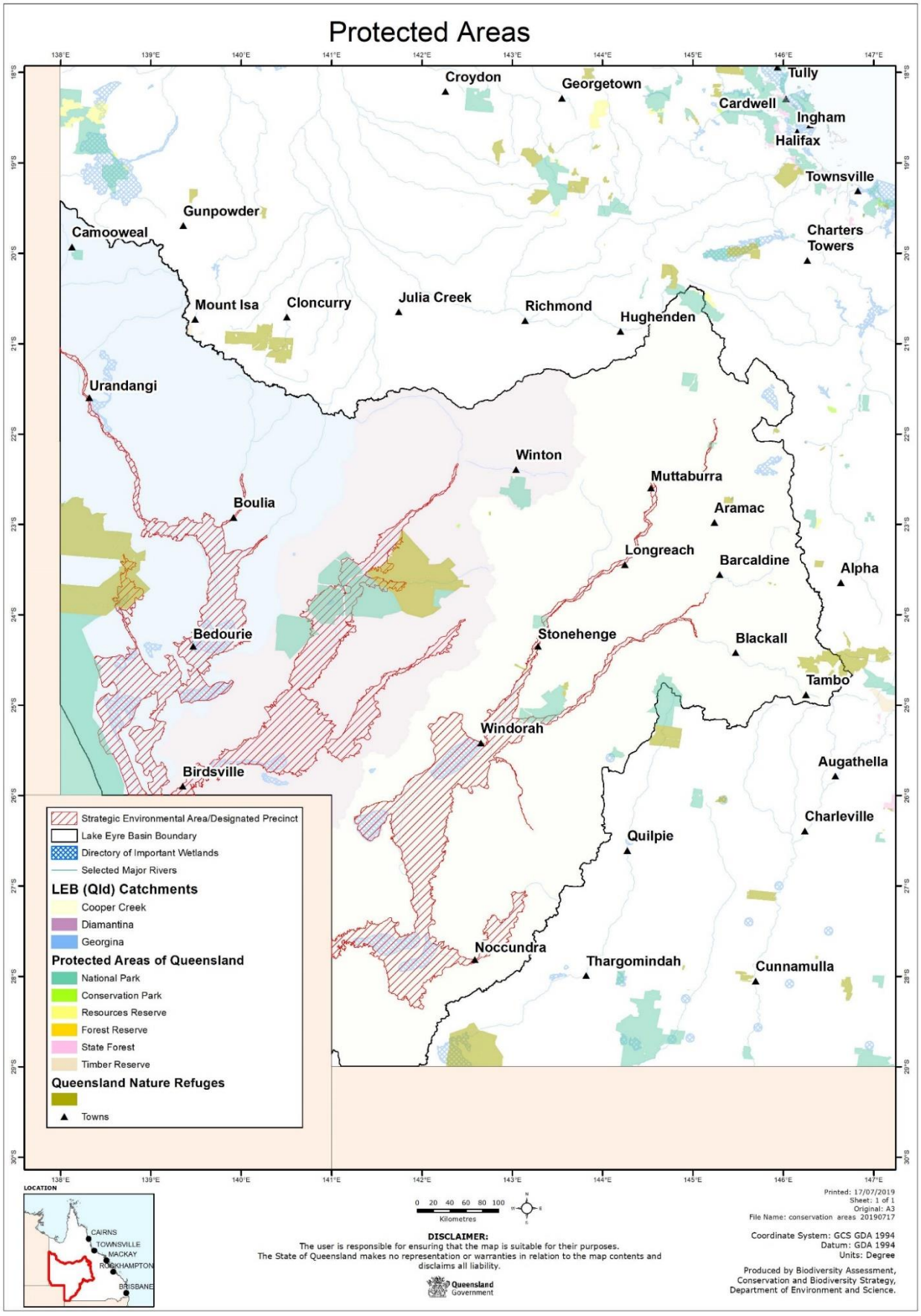
28-29th August 2019

Level 3 – Room, 400 George Street Brisbane

Item	Discussion and Action	By Whom
DAY 1 – 28th August		
9:15	Coffee and register	
9:30	Introductions and welcome – Facilitator Darren Fielder	Darren
9:45	Setting the scene – Queensland Government election commitment and review scope	Lindsey Jones
10:30	**Morning Tea**	
10:50	Walking the basin – familiarisation with Kati Thanda-Lake Eyre Basin (LEB)	Darren
11:45	Summarising the ecological assets, landscape processes, ecological functions, condition and threats for Kati Thanda-Lake Eyre Basin	Darren
LUNCH 12:30 – 1:15		
1:15	Hypothetical development case examples – break into two groups Case example 1 - 2019 - Kati Thanda-Lake Eyre Basin (LEB) - proposed Petroleum (CSG) activity year 2019 Case example 2 - 2070 - Kati Thanda-Lake Eyre Basin (LEB) - proposed Petroleum (CSG) activity year 2070	Darren
2.00pm	Groups report back on emerging issues/gaps	Groups
2:15	**Calibration** of risk analysis and residual ratings table – one group 1. Transport, storage, mixing and use of relevant chemicals in petroleum/gas and mining industries	
3:00	**Afternoon tea**	
3:15	Risk analysis and residual ratings assessment – break into groups 2. Construction and ongoing operation of supporting infrastructure (off-lease resource activities and other industries) 3. Construction and ongoing operation of supporting infrastructure for mining and petroleum/gas activities (on-lease)	Darren
4:15	Groups report back and review residual risks	Groups
4:45	**Close of Day 1**	

Item	Discussion and Action	By Whom
DAY 2 – 29th August		
8:15	Coffee. Welcome and outline for the day	Darren
8:30 am	Hypothetical development case examples – break into two groups Case example 3 2019 - Kati Thanda-Lake Eyre Basin (LEB) – p roposed integrated Petroleum (CSG) and irrigated grazing activity year 2019 Case example 4 2070 - Kati Thanda-Lake Eyre Basin (LEB) - proposed integrated Petroleum (CSG) and irrigated grazing activity year 2070	Darren
8.45 am	Groups report back on emerging issues/gaps	Groups
9:30	Risk analysis and residual ratings assessment - break into groups 4. Water take in petroleum/gas and mining industries 5. Operations of petroleum/gas and mining industries including drilling, hydraulic fracturing, dewatering, extraction and processing	Groups
10:30	**Morning tea**	
10.45	(Continued) Risk analysis and residual ratings assessment - break into groups 4. Water take in petroleum/gas and mining industries 5. Operations of petroleum/gas and mining industries including drilling, hydraulic fracturing, dewatering, extraction and processing	
12.00pm	Groups report back and review residual risks	Groups
LUNCH 12:30 – 1:15		
1.15pm	Risk analysis and residual ratings assessment - break into groups 6. Waste treatment and disposal petroleum/gas and mining industries	
2.15pm	Groups report back and review residual risks	Groups
2.30pm	Risk analysis and residual ratings assessment - break into groups 7. Agricultural practices 8. Tourism	
2.50 pm	Groups report back and review residual risks	Groups
3:00	**Afternoon tea**	
3:15	Discussion – one group • Summary of important environmental attributes and key risks • Recommendations based on scientific evidence: 1. spatial constraints to environmental attributes based on risk 2. assessment of cumulative impact in LEB (Qld)	Darren
4:30	**Workshop closure**	

Appendix D – Channel Country SEA, DP and Protected Areas Map


Protected Areas
Croydon
Georgetown
Tully
Cardwell
Ingham
Halifax
Townsville
Gunpowder
Camooweal
Charters Towers
Mount Isa
Cloncurry
Julia Creek
Richmond
Hughenden
Urandangi
Winton
Muttaburra
Boulia
Aramac
Longreach
Barcaldine
Alpha
Bedourie
Stonehenge
Blackall
Tambo
Windorah
Birdsville
Augathella
Charleville
Quilpie
Noccundra
Thargomindah
Cunnamulla
Strategic Environmental Area/Designated Precinct
Lake Eyre Basin Boundary
Directory of Important Wetlands
Selected Major Rivers
LEB (Qld) Catchments
Cooper Creek
Diamantina
Georgina
Protected Areas of Queensland
National Park
Conservation Park
Resources Reserve
Forest Reserve
State Forest
Timber Reserve
Queensland Nature Refuges
Towns
LOCATION
CAIRNS
TOWNSVILLE
MACKAY
ROCKHAMPTON
BRISBANE
0 20 40 60 80 100
Kilometres
DISCLAIMER:
The user is responsible for ensuring that the map is suitable for their purposes.
The State of Queensland makes no representation or warranties in relation to the map contents and disclaims all liability.
Queensland Government
Printed: 17/07/2019
Sheet: 1 of 1
Original: A3
File Name: conservation areas 20190717
Coordinate System: GCS GDA 1994
Datum: GDA 1994
Units: Degree
Produced by Biodiversity Assessment, Conservation and Biodiversity Strategy, Department of Environment and Science.

Appendix E – Issues tables risk assessment

Issue 1 – Transport, storage, mixing and use of relevant chemicals in petroleum/gas and mining industries (such as hydraulic fracturing chemicals, drilling fluids or liquid hydrocarbons)

Line no.	Potential impact/ threat to LEB (Qld) river systems	Environmental attributes impacted		Initial risk	Management tool in LEB (Qld)	Residual risk	Panel notes
		Existing attributes	Potential attributes				
Conventional petroleum/gas							

1.1	Surface water quality and shallow groundwater impacts from accidental spills	Natural water quality	Functioning riparian processes
			
			Functioning wildlife corridors including springs
				Likelihood: Likely
				
				Consequence: Minor
				
				Overall rating: Medium
					• Environmental authority (EA) conditions under the *Environmental Protection Act 1994* (EP Act), commensurate to risk of activity, for:
					  ○ chemical storage/monitoring and reporting of leaks/spills
					  ○ drilling activities commensurate to risk of activity, including prohibiting synthetic muds
					• *Transport Operations (Road Use Management) Act 1995* (TO Act) requirements for transporting chemicals/hazardous goods
					• *Petroleum and Gas (Production and Safety) Act 2004* (P&G Act)
						Likelihood: Possible
						
						Consequence: Minor
						
						Overall rating: Medium
							Worst case scenario: highest value environmentally sensitive area with the worst chemical type.
							Proximity to locality will change the clean-up time and processes – worst case scenario used.
							
							Discussion around the reduction in likelihood and consequence to reduce the risk rating.
							
							Where human error in involved there is always a risk.
							
							The chemical type and the attributes impacted will depend on the contaminant in the system
							
							Additional Attributes:

Line no.	Potential impact/ threat to LEB (Qld) river systems	Environmental attributes impacted		Initial risk	Management tool in LEB (Qld)	Residual risk	Panel notes
		Existing attributes	Potential attributes				
							Attributes are dependent on location and chemical types. On open flood plain or on isolated road with no environmentally sensitive area not too much of a concern, in a waterhole or wetland, spill will lead to fish kill and contamination of water. Depends on proximity to emergency services - would change the consequence Spills are site specific. If you spill diesel in the catchment not as detrimental as a spill of frac fluid in the flood plain - changes the consequence
1.2	Groundwater and surface water/quality impacts from drilling fluids/chemicals leaching or	Natural hydrologic processes Natural water quality	Natural geomorphic processes Functioning riparian processes	**Likelihood: Possible** **Consequence: Moderate**	• EA conditions under the EP Act, commensurate to risk of activity, for: ○ drilling activities, including prohibiting synthetic muds, commensurate to risk of activity ○ construction and reporting requirements for structures which	**Likelihood: Unlikely** **Consequence: Moderate**	Water storage dam infrastructure is different to storage pond infrastructure in the purpose of the activity. Resource activity also required RIDA.

Line no.	Potential impact/ threat to LEB (Qld) river systems	Environmental attributes impacted		Initial risk	Management tool in LEB (Qld)	Residual risk	Panel notes
		Existing attributes	Potential attributes				
	overflowing from storage ponds, pits or tanks (from flooding/structural failure)		Functioning wildlife corridors including springs	**Overall rating: High**	are dams or levees constructed as part of environmentally relevant activities (ERAs) ○ management of water quality on-site and incident management • Regional Interests Development Approval (RIDA) assessment of land use suitability on/adjacent to floodplains under *Regional Planning Interests Act 2014* (RPI Act) (as a resource activity under *Petroleum and Gas (Production and Safety) Act 2004* (P&G Act))	**Overall rating: Medium**	Assumed: Tributary floodplain Likely to occur Gulf flooding in 2009 area 10's of KM's Differentiation between operational and the drilling phase. Timing of works (drilling during dry season due to risk in wet season too high) Structure failure unlikely Flooding only occurs seasonally Seasonality changes risk rating
Shale and tight petroleum/gas							
1.3	Surface water quality and shallow groundwater impacts from accidental spills	Natural water quality	Functioning riparian processes Functioning wildlife corridors including springs	**Likelihood: Likely** **Consequence: Moderate** **Overall rating: High**	• Statutory restrictions on chemical additives for hydraulic fracturing fluids (EP Act and Environmental Protection Regulation 2008 (EP Regulation)) • EA conditions for chemical storage/monitoring and reporting of leaks/spills, commensurate to the environmental risk	**Likelihood: Unlikely** **Consequence: Moderate** **Overall rating: Medium**	

Line no.	Potential impact/ threat to LEB (Qld) river systems	Environmental attributes impacted		Initial risk	Management tool in LEB (Qld)	Residual risk	Panel notes
		Existing attributes	Potential attributes				
				Notes from previous studies: Inadvertent. Intensity likely to be high due to chemicals concentrations (but dependent on toxicity and dilution). Duration days-weeks. Impacts scale limited to localised.	• TO Act requirements for transporting chemicals/hazardous goods		
1.4	Groundwater and surface water level/quality impacts from hydraulic fracturing fluids leaching or overflowing from storage ponds, pits or tanks (from flooding/ structural failure)	Natural hydrologic processes Natural water quality	Natural geomorphic processes Functioning riparian processes Functioning wildlife corridors including springs	**Likelihood: Likely** **Consequence: Moderate** **Overall rating: High** **Notes from previous studies:** Inadvertent to low frequency. Intensity likely to	• Statutory restrictions on chemical additives for hydraulic fracturing fluids (EP Act and Regulation) • EA conditions under the EP Act, commensurate to risk of activity, for: ○ drilling activities, including prohibiting synthetic muds, commensurate to risk of activity ○ construction and reporting requirements for structures which are dams or levees as ERAs ○ management of water quality on-site and incident management • RIDA assessment of land use suitability on/adjacent to floodplains under RPI	**Likelihood: Possible** **Consequence: Minor** **Overall rating: Medium**	

Line no.	Potential impact/ threat to LEB (Qld) river systems	Environmental attributes impacted		Initial risk	Management tool in LEB (Qld)	Residual risk	Panel notes
		Existing attributes	Potential attributes				
				be low as chemical concentrations are diluted. Duration days-weeks. Impacts scale limited-localised.	Act (as a resource activity under P&G Act)		
Coal seam gas							
1.5	Surface water quality and shallow groundwater impacts from accidental spills	Natural water quality	Functioning riparian processes Functioning wildlife corridors including springs	**Likelihood: Likely** **Consequence: Moderate** **Overall rating: High** **Notes from previous studies:** As for tight and shale operations, with potentially lower frequency and intensity (as less complex chemicals are required for shallower	• EA conditions for chemical storage/monitoring and reporting of leaks/spills, commensurate to risk of activity • Statutory restrictions on chemical additives for hydraulic fracturing fluids (EP Act and Regulation) • TO Act requirements for transporting chemicals/hazardous goods	**Likelihood: Possible** **Consequence: Minor** **Overall rating: Medium**	Based on Surat experience, high density. Data to inform the panel not available Milk truck roll over paper testing these data against real reported data SA report has loss of containment Queensland Some challenge on the consequence from initial to the residual Possible Moderate – High and Possible Minor – Medium. This is our best guess but recommend testing this against real reported issues and nonconformances. Couldn't reach consensus.

Line no.	Potential impact/ threat to LEB (Qld) river systems	Environmental attributes impacted		Initial risk	Management tool in LEB (Qld)	Residual risk	Panel notes
		Existing attributes	Potential attributes				
				resources, comparative to shale/tight).			
1.6	Groundwater and surface water level/quality impacts from hydraulic fracturing fluids leaching or overflowing from storage ponds, pits or tanks (from flooding/structural failure)	Natural hydrologic processes Natural water quality	Natural geomorphic processes Functioning riparian processes Functioning wildlife corridors including springs	**Likelihood: Likely** **Consequence: Moderate** **Overall rating: High** **Notes from previous studies:** As per tight and shale gas but possible lower intensity due to less complex chemicals used for shallower depths.	• Statutory restrictions on chemical additives for hydraulic fracturing fluids (EP Act and Regulation) • EA conditions, commensurate to risk of activity, for: ○ drilling activities, including prohibiting synthetic muds, commensurate to risk of activity ○ construction and reporting requirements for structures which are dams or levees constructed as part of ERAs ○ management of water quality on-site and incident management • RIDA assessment of land use suitability on/adjacent to floodplains under RPI Act (as a resource activity under P&G Act)	**Likelihood: Likely** **Consequence: Moderate** **Overall rating: High**	
Minerals/coal mining							
1.7	Surface water quality and shallow groundwater impacts from accidental spills	Natural water quality	Functioning riparian processes Functioning wildlife	**Likelihood: Likely** **Consequence: Major**	• TO Act requirements for transporting chemicals/hazardous goods • EA conditions regarding management of water quality on-site and incident management, commensurate to risk of activity	**Likelihood: Likely** **Consequence: Major**	Gulf example relevant here, open tailing dam and pits flowing from upstream into downstream. Spills in adjacent catchments impacting LEB

Line no.	Potential impact/ threat to LEB (Qld) river systems	Environmental attributes impacted		Initial risk	Management tool in LEB (Qld)	Residual risk	Panel notes
		Existing attributes	Potential attributes				
			corridors including springs	**Overall rating: Very High**		**Overall rating: Very High**	Will coal /mineral mining ever happen in the LEB? Yes, there is potential for this to be a reality. Recommendation that open cut mining due to high risk should not be allowed within the basin. Based on the fact these industries are still occurring. Train roll overs have happened recently carting minerals from mines during flood events impacting large areas up to 1000 ha Consequences of open cut mines are catastrophic internationally; acid mine drainage water wash impact is huge. How can it be allowed in the basin – recommend no open cut mining in the basin

Line no.	Potential impact/ threat to LEB (Qld) river systems	Environmental attributes impacted		Initial risk	Management tool in LEB (Qld)	Residual risk	Panel notes
		Existing attributes	Potential attributes				

1.8	Groundwater and surface water level/quality impacts from contaminants leaching or overflowing from storage/treatment ponds (from flooding/structural failure)	Natural hydrologic processes
		
		Natural water quality
			Natural geomorphic processes
			
			Functioning riparian processes
			
			Functioning wildlife corridors including springs
				Likelihood: Likely
				
				Consequence: Major
				
				Overall rating: Very High
					• EA conditions, commensurate to risk of activity, for:
					  ○ management of water quality on-site and incident management
					  ○ construction and reporting requirements for structures which are dams or levees constructed as part of ERAs
					• RIDA assessment of land use suitability on/adjacent to floodplains under RPI Act (as a resource under *Mineral Resources Act 1989* (MR Act))
					• Prohibition on open-cut mining activities in designated precinct under RPI Regulation
						Likelihood: Possible
						
						Consequence: Major
						
						Overall rating: High
							Tailing dams just outside strategic environmental area could overflow in flood event and impact downstream ecosystems

Issue 2 – Construction and ongoing operation of supporting infrastructure for mining and petroleum/gas activities (on-lease)

Line no.	Potential impact/ threat to LEB (Qld) river systems	Environmental attributes impacted		Initial risk	Management tool in LEB (Qld)	Residual risk	Panel notes
		Existing attributes	Potential attributes				
Construction and ongoing operation of supporting infrastructure for mining and petroleum/gas activities on lease areas							

2.1	Alteration of overland flow from infrastructure construction, including diverting watercourses	Natural hydrologic processes
		
		Beneficial flooding of land
			Natural geomorphic processes
			
			Functioning riparian processes
			
			Functioning wildlife corridors including springs
				Likelihood: Likely
				
				Consequence: Major
				
				Overall rating: Very High
				
				Notes from previous studies: Frequency likely to be high as all operations require associated infrastructure, intensity high, scale limited-local depending on site. Cumulative impacts potentially significant. Duration years-decades.
					• Regional Interests Development Approval (RIDA) under *Regional Planning Interests Act 2014* (RPI Act) for resource activities in the strategic environmental area (SEA) – includes land use suitability assessment
					• Prohibition on water storage dams in designated precinct under Regional Planning Interests Regulation 2014 (RPI Regulation)
					• Environmental authority (EA) standard conditions for petroleum activities under *Environmental Protection Act 1994* (EP Act), commensurate to risk of environmental impact, examples include:
					  ○ restrictions on scope of activities permitted in designated precinct and SEA under RPI Act
					  ○ non-linear infrastructure setbacks from wetlands, lakes, springs and watercourses
					  ○ timing of linear infrastructure works based on flow conditions
					• EA conditions for petroleum activities relating to setbacks from wetlands, springs and groundwater dependent ecosystems (GDEs), and activities in
						Likelihood: Likely
						
						Consequence: Moderate
						
						Overall rating: High
							All potential attributes to be considered
							
							Likelihood rating is likely due to frequency of small floods every 1 – 2 years
							
							Major consequence due to concentration of flows, diverting overland flow
							
							Yes, Major consequence (initial risk). Relatively small features such as grader spoil from roads can divert overland flows in moderate floods such that entire sections of floodplain, and some waterholes off the main channel, will

Line no.	Potential impact/ threat to LEB (Qld) river systems	Environmental attributes impacted		Initial risk	Management tool in LEB (Qld)	Residual risk	Panel notes
		Existing attributes	Potential attributes				
					floodplains, commensurate to risk of activity • EA standard conditions for pipelines (where relevant) • EA conditions for mining activities relating to temporary interference with waterways and watercourse diversions, commensurate to risk of activity • Other site-specific EA conditions where required • Water Act licencing requirements under the *Water Act 2000* and guideline for works that interfere with water in a watercourse for a resource activity		miss out on water supply. Look at Google Earth image of Cooper floodplain near junction with Wilson River to see how even (presumed) shot lines for seismic work have impacted flows. Changed to moderate because of conditions Agree strongly that these potential attributes should be included.
2.2	Vegetation clearing, resulting in impacts to riparian function, wildlife corridors, overland flow or groundwater levels (where	Natural hydrologic processes Natural water quality Beneficial flooding of land	Natural geomorphic processes Functioning riparian processes Functioning wildlife corridors	**Likelihood: Almost Certain** **Consequence: Major** **Overall rating: Very High** **Notes from previous studies:** Frequency likely to be high as all operations require	• Op works approval for vegetation clearing against State Development Assessment Provisions (SDAP) state code 16 under the *Vegetation Management Act 1999* (VM Act) • Protected plants clearing permit under the *Nature Conservation Act 1992* (NC Act) • EA conditions for petroleum activities under EP Act, commensurate with risk of environmental impact, examples include:	**Likelihood: Possible** **Consequence: Moderate** **Overall rating: High**	All clearing work likely to introduce weeds into what is a relatively weed-free region. Within floodplain wetlands, need to be aware of locations of breeding colonies of waterbirds that depend on intact lignum and belalie

Line no.	Potential impact/ threat to LEB (Qld) river systems	Environmental attributes impacted		Initial risk	Management tool in LEB (Qld)	Residual risk	Panel notes
		Existing attributes	Potential attributes				
	relevant to GDEs)		including springs Aboriginal culture	associated infrastructure, intensity high-medium depending on type of infrastructure, scale limited-regional depending on site. Duration years-decades depending on type of infrastructure and specific values.	○ restrictions on scope of activities permitted in designated precinct and SEA under RPI Act ○ non-linear infrastructure setbacks from wetlands, lakes, springs and watercourses ○ timing of linear infrastructure works based on flow conditions • Other site-specific EA conditions where required • *Environmental Offsets Act 2014* (EO Act) framework for offsetting significant residual impacts		(*Acacia stenophylla*) shrublands for siting of nests. Locations of most of the colonies are known from projects, such as ARIDFLO, if not necessarily in govt databases.
2.3	Ground disturbance activities resulting in soil disturbance, sedimentation, increased surface water turbidity and flow-on effects to riparian function and corridors	Natural hydrologic processes Natural water quality	Natural geomorphic processes Functioning riparian processes Functioning wildlife corridors including springs Aboriginal culture	**Likelihood: Almost Certain** **Consequence: Major** **Overall rating: Very High** **Notes from previous studies:** Frequency likely to be high as all operations require associated infrastructure, intensity high-medium depending on type of infrastructure, scale	• EA mining/petroleum conditions for soil erosion and associated management plans, and rehabilitation, commensurate to risk of activity • EA standard conditions for pipelines (where relevant) • EA standard conditions for petroleum activities under EP Act, commensurate to risk of environmental impact, examples include: ○ restrictions on scope of activities permitted in designated precinct and SEA under RPI Act ○ non-linear infrastructure setbacks from wetlands, lakes, springs and watercourses	**Likelihood: Likely** **Consequence: Moderate** **Overall rating: High**	All potential attributes necessary Environmental Authority conditions would need to be specific to the ecosystems of the project area Over the life of the project and sediment is contained on site what happens to the sediment then.

Line no.	Potential impact/ threat to LEB (Qld) river systems	Environmental attributes impacted		Initial risk	Management tool in LEB (Qld)	Residual risk	Panel notes
		Existing attributes	Potential attributes				
				limited-local depending on site. Duration years-decades depending on type of infrastructure.	○ timing of linear infrastructure works based on flow conditions • Other site-specific EA conditions where required • Section 13 of the Land Access Code under the *Mineral and Energy Resources (Common Provisions) Act 2014*, including access arrangements to assist with erosion control • Restricted land entry conditions including buffers from certain areas (e.g. bore, dam or storage facility) without landholder consent		Hard to imagine how the systems could become more turbid than is naturally.
2.4	Shallow groundwater or surface water quality impacts from use of untreated water for dust suppression or other construction purposes	Natural water quality	Functioning riparian processes Functioning wildlife corridors including springs Aboriginal culture	**Likelihood: Possible** **Consequence: Insignificant** **Overall rating: Low** **Notes from previous studies:** High frequency, low intensity (as chemicals are diluted), localised impacts with duration months-years.	• EA conditions for petroleum/mining activities reuse of water, commensurate with risk of activity • Other site-specific EA conditions where required • Optional registration for resource producer and compliance with end of waste code for associated water under *Waste Reduction and Recycling Act 2011* • Coal Seam Gas Water Management Policy	**Likelihood: Unlikely** **Consequence: Insignificant** **Overall rating: Low**	Current attributes acceptable Impact of untreated water on ground water and surface water would be low because it is not a high-risk activity as it takes a lot to impact quality of groundwater from this activity
2.5	Impacts to riparian vegetation	Natural water quality	Functioning riparian processes	**Likelihood: Almost Certain**	• EA conditions for managing impacts of mining and petroleum activities,	**Likelihood: Possible**	Threatened species killed on roads is major impact due to

Line no.	Potential impact/ threat to LEB (Qld) river systems	Environmental attributes impacted		Initial risk	Management tool in LEB (Qld)	Residual risk	Panel notes
		Existing attributes	Potential attributes				
	(and associated fauna) from increased traffic/dust		Functioning wildlife corridors including springs Aboriginal culture	**Consequence: Major** **Overall rating: Very High** **Notes from previous studies:** High frequency as use of unsealed roads is common, low intensity over limited scale (in immediate vicinity of sites), duration for years.	including limits in the Environmental Protection (Air) Policy 2008 (EPP Air)	**Consequence: Moderate** **Overall rating: High**	delicate populations and sensitive locations Daylight driving hours only would be necessary Speed limits to reduce likelihood of hitting animals Dust is an insignificant issue as impact to vegetation and fauna is minor
2.6	Impacts to riparian vegetation (and associated fauna) from introduction of invasive species (including invasive plants, invasive animals, noxious fish	Natural hydrologic processes Natural water quality	Functioning riparian processes Functioning wildlife corridors including springs Aboriginal culture	**Likelihood: Almost Certain** **Consequence: Extreme** **Overall rating: Extremely High** **Notes from previous studies:** Inadvertent frequency, medium intensity, local scale, duration years.	• *Biosecurity Act 2014* • EA conditions for managing environmental impacts, commensurate to risk • Section 15 of the Land Access Code under the *Mineral and Energy Resources (Common Provisions) Act 2014* including requirements relating to the prevention of spread of pests/weeds	**Likelihood: Possible** **Consequence: Moderate** **Overall rating: High**	All potential attributes applicable Potential risks of spreading and importing weeds without any controls is very significant. CSIRO invasive report noted. Controls do have a large impact on risks Vehicle washdowns

Line no.	Potential impact/ threat to LEB (Qld) river systems	Environmental attributes impacted		Initial risk	Management tool in LEB (Qld)	Residual risk	Panel notes
		Existing attributes	Potential attributes				
	and tramp ants)						
2.7	Light, air and noise impacts during equipment use resulting in adverse impacts to flora, fauna in the riparian zone	Natural water quality	Functioning riparian processes Functioning wildlife corridors including springs Aboriginal culture	**Likelihood: Likely** **Consequence: Minor** **Overall rating: Medium** **Notes from previous studies:** High frequency, low intensity, limited-local scale. Months-years duration.	• EA conditions related to managing impacts to air, noise and biodiversity values, commensurate with risk of activity, including limits in EPP Air and Environmental Protection (Noise) Policy 2008 (EPP Noise)	**Likelihood: Possible** **Consequence: Insignificant** **Overall rating: Low**	All potential attributes to be added Controls have a significant impact as this aspect can be easily engineered and controlled to reduce impact Limit noise and light at night
2.8	Surface water quality impacts from extraction of quarry material from rivers for construction of infrastructure such as roads	Natural hydrologic processes	Natural geomorphic processes Aboriginal culture	**Likelihood: Almost Certain** **Consequence: Minor** **Overall rating: Medium**	• Development permit under SDAP code 15 removal of quarry material from a watercourse or lake • Quarry material allocation (or other equivalent approval) under the Water Act, *Forestry Act 1959, Transport Infrastructure Act 1994* or *Local Government Act 2009* • EA for extractive environmentally relevant activity (ERA), where meeting the relevant threshold • Op works approval for vegetation clearing against SDAP code under VM Act (where relevant)	**Likelihood: Possible** **Consequence: Minor** **Overall rating: Medium**	Separate potential effects into water quality, fish passage. Conditions should be in place to ensure material is not extracted during times of low flow or heavy flow
Other impacts associated with construction and ongoing operation of supporting infrastructure for mining and petroleum/gas activities on lease areas (if identified by the panel)							

Line no.	Potential impact/ threat to LEB (Qld) river systems	Environmental attributes impacted		Initial risk	Management tool in LEB (Qld)	Residual risk	Panel notes
		Existing attributes	Potential attributes				
2.9	Fish passage to be regarded as separate aspect to consider.				DAF Fisheries Act 1995 – Waterway Barrier Works		Unimpeded fish passage may be an issue in low to moderate flows in higher parts of the floodplain and in tributaries impacted by construction etc.

Issue 3 – Construction and ongoing operation of supporting infrastructure for mining and petroleum/gas activities (off-lease) and other industries such as agriculture or tourism

Line no.	Potential impact/ threat to LEB (Qld) river systems	Environmental attributes impacted		Initial risk	Management tool in LEB (Qld)	Residual risk	Panel notes
		Existing attributes	Potential attributes				
Construction and ongoing operation of supporting infrastructure for mining and petroleum/gas activities (off-lease areas) and other industries such as agriculture or tourism							
3.1	Alteration of overland flow from infrastructure construction, including diverting watercourses	Natural hydrologic processes Beneficial flooding of land	Natural geomorphic processes Functioning riparian processes Functioning wildlife corridors including springs	**Likelihood: Almost Certain** **Consequence: Major** **Overall rating: Very High** **Notes from previous studies (relevant to shale):** Frequency likely to be high as all operations require associated infrastructure, intensity high, scale limited-local depending on site. Cumulative impacts potentially significant. Duration years-decades.	• Prohibition on water storage dams in designated precinct under the Regional Planning Interests Regulation 2014 (RPI Regulation) • Water licence under the *Water Act 2000* (exemption for stock or domestic purposes) • Environmental authority (EA) and development approval (DA)/material change of use (MCU) for relevant environmentally relevant activities (ERAs), and other assessments under the *Planning Act 2016* (by the State Assessment and Referral Agency (SARA) or local council) • Development permit under State Development Assessment Provisions (SDAP) code 10 for taking or interfering with water • Development permit under SDAP code 18 for constructing	**Likelihood: Almost Certain** **Consequence: Moderate** **Overall rating: High**	Diversion of watercourses is a key issue particularly in the arid environment where flow paths are easily disrupted Ecology and grazing values. Minor water courses support shrub species for grazing for native fauna and domestic species. Even a fence creates some interference in the flood plain, E.g., accumulation of vegetation during return of flood waters to channels. Can we make an informed decision based on limited

Line no.	Potential impact/ threat to LEB (Qld) river systems	Environmental attributes impacted		Initial risk	Management tool in LEB (Qld)	Residual risk	Panel notes
		Existing attributes	Potential attributes				
					or raising waterway barrier works in fish habitats • Development permit under SDAP code 19 for category 3 levees • Development permit under SDAP code 22 for ERAs		understanding of legislative processes? There are gaps in places where legislation is too tough and constrained for different people, e.g., councils for developing water security for towns Diversion of watercourses requires permits under Water Act How effective in real circumstances? Consequence of any activity relating to water diversion will always be Major. Still need to allow sustainable development in the LEB, we need to ensure that they are the right developments

Line no.	Potential impact/ threat to LEB (Qld) river systems	Environmental attributes impacted		Initial risk	Management tool in LEB (Qld)	Residual risk	Panel notes
		Existing attributes	Potential attributes				
							Concerns regarding small embankments such as from grader spoil will apply on lease as well as off lease, on the floodplain. Impact off lease may even be greater because the lease may be small whereas an access road may run for many km along the floodplain (sometimes lengthwise as much as possible, to minimise channel crossings).
3.2	Vegetation clearing, resulting in impacts to riparian function, wildlife corridors, overland flow or groundwater levels (where relevant to GDEs)	Natural hydrologic processes Natural water quality Beneficial flooding of land		**Likelihood: Almost Certain** **Consequence: Moderate** **Overall rating: High** **Notes from previous studies (relevant to shale):** Frequency likely to be high as all	• Op works approval for vegetation clearing against SDAP code 10 under *Vegetation Management Act 1999* (VM Act – issued under Planning Act by SARA) • Protected plants clearing permit under *Nature Conservation Act* (NC Act) • *Environmental Offsets Act 2014* (EO Act) framework for offsets where relevant	**Likelihood: Almost Certain** **Consequence: Moderate** **Overall rating: High**	Clearing occurs within the agricultural sector, clearing of riparian veg is protected under VM Act Lignum and belalie (*Acacia stenophylla*), which often occurs together is crucial for breeding habitat for waterbirds and other

Line no.	Potential impact/ threat to LEB (Qld) river systems	Environmental attributes impacted		Initial risk	Management tool in LEB (Qld)	Residual risk	Panel notes
		Existing attributes	Potential attributes				
				operations require associated infrastructure, intensity high-medium depending on type of infrastructure, scale limited-regional depending on site. Duration years-decades depending on type of infrastructure and specific values.			species including Grey grasswrens. The risk in this remains unchanged it is related to the chance of avoiding the protected species and Regional Ecosystems. Continued focus is required on this area.
3.3	Ground disturbance activities resulting in soil disturbance, sedimentation, increased surface water turbidity and flow-on effects to riparian function and corridors	Natural hydrologic processes Natural water quality	Natural geomorphic processes Functioning riparian processes Functioning wildlife corridors including springs	**Likelihood: Almost Certain** **Consequence: Major** **Overall rating: Very High** **Notes from previous studies (relevant to shale):** Frequency likely to be high as all operations require associated infrastructure, intensity high-medium depending on type of infrastructure, scale	• Assessment against local planning scheme which may include assessment of erosion/sediment control, depending on application/specific planning scheme • EA and DA/MCU for relevant ERAs and other assessments under the Planning Act 2016 (by SARA or local council)	**Likelihood: Almost Certain** **Consequence: Minor** **Overall rating: Medium**	Implementation of best practice particularly in grazing and agriculture Assuming best practice for all activities.

Line no.	Potential impact/ threat to LEB (Qld) river systems	Environmental attributes impacted		Initial risk	Management tool in LEB (Qld)	Residual risk	Panel notes
		Existing attributes	Potential attributes				
				limited-local depending on site. Duration years-decades depending on type of infrastructure.			
3.4	Shallow groundwater or surface water quality impacts from use of untreated water for dust suppression or other construction purposes	Natural water quality	Functioning riparian processes Functioning wildlife corridors including springs	**Likelihood: Almost Certain** **Consequence: Minor** **Overall rating: Medium** **Notes from previous studies (relevant to shale):** High frequency, low intensity (as chemicals are diluted), localised impacts with duration months-years.	• Optional registration for resource producer and compliance with end of waste code for associated water under *Waste Reduction and Recycling Act 2011* (where relevant) • EA and DA/MCU for relevant ERAs and other assessments under the Planning Act 2016 (by SARA or local council)	**Likelihood: Almost Certain** **Consequence: Insignificant** **Overall rating: Medium**	Careful administration and regulation required for this to treat water or test water to reduce risk to environment and human health
3.5	Impacts to riparian vegetation (and associated fauna) from increased traffic/dust	Natural water quality	Functioning riparian processes Functioning wildlife corridors including springs	**Likelihood: Almost Certain** **Consequence: Insignificant** **Overall rating: Medium** **Notes from previous studies (relevant to shale):** High frequency as use of unsealed	• Assessment against local planning scheme which may include assessment of air quality depending on application/specific planning scheme • Environmental Protection (Air) Policy 2008 (EPP Air) limits • EA and DA/MCU for relevant ERAs and other assessments under the Planning Act 2016 (by SARA or local council)	**Likelihood: Almost Certain** **Consequence: Insignificant** **Overall rating: Medium**	This is not really a big issue; this is location specific depends on flora and fauna and their sensitivity.

Line no.	Potential impact/ threat to LEB (Qld) river systems	Environmental attributes impacted		Initial risk	Management tool in LEB (Qld)	Residual risk	Panel notes
		Existing attributes	Potential attributes				
				roads is common, low intensity over limited scale (in immediate vicinity of sites), duration for years.			
3.6	Impacts to riparian vegetation (and associated fauna) from introduction of invasive species (including invasive plants, invasive animals, noxious fish and tramp ants)	Natural hydrologic processes Natural water quality	Functioning riparian processes Functioning wildlife corridors including springs	**Likelihood: Almost Certain** **Consequence: Extreme** **Overall rating: Extremely High** **Notes from previous studies (relevant to shale):** Inadvertent frequency, medium intensity, local scale, duration years.	• Assessment against local planning scheme which may include assessment of pest and weed management, depending on application/specific planning scheme • EA and DA/MCU for relevant ERAs and other assessments under the Planning Act 2016 (by SARA or local council) • *Biosecurity Act 2014* requirements • Regional biosecurity plans and local government biosecurity plans (note this does not get conditioned in the planning approvals)	**Likelihood: Likely** **Consequence: Extreme** **Overall rating: Very High**	The legislation provides some framework however, the programs required are costly and people intensive. All efforts need to be made for containment and management or eradication of invasive species. Encouragement of integrated management programs is a must. The consequence is probably much the same as on lease where off-lease is floodplain. Early action and prevention crucial. Risk assessment of this threat (Cattarino *et al.* 2015; Carwardine *et al.*

Line no.	Potential impact/ threat to LEB (Qld) river systems	Environmental attributes impacted		Initial risk	Management tool in LEB (Qld)	Residual risk	Panel notes
		Existing attributes	Potential attributes				
							2018) (i.e. CSIRO report mentioned above).
3.7	Light, air and noise impacts during equipment use resulting in adverse impacts to flora, fauna in the riparian zone	Natural water quality	Functioning riparian processes Functioning wildlife corridors including springs	**Likelihood: Possible** **Consequence: Insignificant** **Overall rating: Low** **Notes from previous studies (relevant to shale):** High frequency, low intensity, limited-local scale. Months-years duration.	• Assessment against local planning scheme which may include assessment of light, noise and air quality impacts, depending on application/specific planning scheme • Limits in EPP Air and Environmental Protection (Noise) Policy 2008 (EPP Noise) • EA and DA/MCU for relevant ERAs and other assessments under the Planning Act 2016 (by SARA or local council)	**Likelihood: Possible** **Consequence: Insignificant** **Overall rating: Low**	There is no requirement for additional legislation
3.8	Surface water quality impacts from extraction of quarry material from rivers for construction of infrastructure such as roads (and associated impacts to fish passage)	Natural hydrologic processes	Natural geomorphic processes	**Likelihood: Likely** **Consequence: Major** **Overall rating: Very High**	• Development permit under SDAP code 15 removal of quarry material from a watercourse or lake • Development permit under SDAP code 18: Constructing or raising waterway barrier works in fish habitats • Quarry material allocation (or other equivalent approval) under the Water Act, *Forestry Act 1959, Transport*	**Likelihood: Possible** **Consequence: Major** **Overall rating: High**	Associated impacts to fish passage also other fauna. Creation of linkage to other flow systems These activities should not be allowed to occur in the waterways and floodplains. If they occur, they should be heavily regulated -

Line no.	Potential impact/ threat to LEB (Qld) river systems	Environmental attributes impacted		Initial risk	Management tool in LEB (Qld)	Residual risk	Panel notes
		Existing attributes	Potential attributes				
					Infrastructure Act 1994 or *Local Government Act 2009* • EA for extractive ERA (where meeting the relevant threshold) • Op works approval for vegetation clearing against SDAP code under VM Act (where relevant)		depths and quantities and specified materials (quality) are relevant to likely impacts. Local government use sand for road building materials

Issue 4 – Water take in petroleum/gas and mining industries

Line no.	Potential impact/ threat to LEB (Qld) river systems	Environmental attributes impacted		Initial risk	Management tool in LEB (Qld)	Residual risk	Panel notes
		Existing attributes	Potential attributes				
Conventional petroleum/gas							
4.1	Groundwater extraction/drawdown and changes to water quality, water level/pressure, temperature and ecosystem structure (including groundwater dependent ecosystems)	Natural hydrologic processes Natural water quality	Functioning riparian processes Functioning wildlife corridors including springs	**Likelihood: Likely** **Consequence: Major** **Overall rating: Very High** **Notes from previous studies:** Likely to have lower frequency and intensity than unconventional gas as only very limited hydraulic fracturing required (if any) and a smaller number of wells/surface area required. Potentially similar duration/scale.	• Water licence for taking non-associated water under the *Water Act 2000* with conditions on amounts and locations – if the aquifer is in a water plan area this includes assessment against the relevant water plan • Water permit for taking non-associated water under the Water Act for shorter term projects • Environmental authority (EA) conditions under the *Environmental Protection Act 1994* (EP Act) and underground water impact report requirements every three years under Chapter 3 of the *Water Act 2000* for unlimited underground water rights where the taking of water happens as a result of authorised activities (associated water) under *Petroleum and Gas (Production and Safety) Act 2004* (P&G Act)	**Likelihood: Possible** **Consequence: Moderate** **Overall rating: High**	Are petroleum activities drawing more water than agricultural activities? Include level/pressure as an aspect to consider, especially near to GAB springs Extraction licence necessary for Great Artesian Basin Likelihood would reduce due to regulations regarding proximity of bores to springs. However, need more understanding of drawdown effects on individual springs. Flow path of groundwater sustaining springs is not included in current legislation. If a spring is located outside the grey zone on the Free Flowing Rivers boundary map (this is a gap) expand the protected grey zone to include all springs

Line no.	Potential impact/ threat to LEB (Qld) river systems	Environmental attributes impacted		Initial risk	Management tool in LEB (Qld)	Residual risk	Panel notes
		Existing attributes	Potential attributes				
					• Other EA conditions for managing impacts to water values, commensurate to the risk of the activity • Make-good requirements under Chapter 3 of the Water Act – outlines arrangements for tenure holders to 'make good' the impact bores as a result of exercising underground water rights under the P&G Act • Regional Interests Development Approval (RIDA) under the *Regional Planning Interests Act 2014* (RPI Act) (as a resource activity under P&G Act) in a strategic environmental area (SEA) – this includes assessment of land use suitability and may include conditions regarding environmental attributes		Some parts of the landscape at higher risk of being impacted by drawing down water levels and pressures, e.g., places of higher ecological value, water available, water/groundwater level Organisms living in springs vary widely depending on the spring, some endemic species have very limited distributions in springs, and some spring ecosystems are more delicate or threatened than others (see Risk assessment in Anderson et al. 2016 report by IESC). Rating would be very high where there are springs with rare endemic species, or threated or critically endangered organisms Destratification of water in a stratified waterbody could bring deoxygenated (DO) water to the surface and result in possible fish kills.

Line no.	Potential impact/ threat to LEB (Qld) river systems	Environmental attributes impacted		Initial risk	Management tool in LEB (Qld)	Residual risk	Panel notes
		Existing attributes	Potential attributes				
							This may be very serious for significant riverine waterholes given their great importance as fish refugia for repopulating the system during floods. Need to consider effects on groundwater dependent terrestrial vegetation.
4.2	Impacts to surface water flow/levels and changes to overland flow, water quality, temperature and ecosystem structure	Natural hydrologic processes Natural water quality Beneficial flooding of land	Natural geomorphic processes Functioning riparian processes Functioning wildlife corridors including springs	**Likelihood: Almost Certain** **Consequence: Moderate** **Overall rating: High** **Notes from previous studies:** Likely to have lower frequency and intensity than unconventional gas as only very limited hydraulic fracturing required (if any) and a	• Water licence for taking water under the Water Act (or water permit for shorter term projects) • EA conditions for managing impacts to water values, commensurate to the risk of the activity • RIDA under RPI Act (as a resource activity under P&G Act) in SEA – this includes assessment of land use suitability and may include conditions regarding environmental attributes	**Likelihood: Possible** **Consequence: Minor** **Overall rating: Medium**	Water take legislation reduces impact significantly assuming quantities and locations are restricted, and not in locations with rare, threatened or endangered species. Consideration needs to be given to whether waterholes are permanent or semi-permanent and different regulations applied to each type. i.e. which waterholes are important ecological refuges in dry seasons. May be impractical to apply because permanence varies so much.

Line no.	Potential impact/ threat to LEB (Qld) river systems	Environmental attributes impacted		Initial risk	Management tool in LEB (Qld)	Residual risk	Panel notes
		Existing attributes	Potential attributes				
				smaller number of wells/surface area required. Potentially similar duration/scale.			There also needs to be consideration to threatened species that reside in permanent waterholes such as the endangered Cooper Creek catfish *Neosiluroides cooperensis*.
Shale and tight petroleum/gas							
4.3	Groundwater extraction/drawdown and changes to water quality, temperature and ecosystem structure (including groundwater dependent ecosystems)	Natural hydrologic processes Natural water quality	Functioning riparian processes Functioning wildlife corridors including springs	**Likelihood: Almost Certain** **Consequence: Major** **Overall rating: Very High** **Notes from previous studies:** High frequency as all wells require fracking in shale/tight operations. Intensity of individual well use relatively small but cumulative impact much greater.	• Water licence for taking non-associated water under the Water Act (or water permit for shorter term projects) • EA under the EP Act and underground water impact report requirements under Chapter 3 of the Water Act for unlimited underground water rights to associated water under P&G Act • Other EA conditions for managing impacts to water values, commensurate to the risk of the activity • Make-good requirements under Chapter 3 of the Water Act • RIDA under RPI Act (as a resource activity under P&G Act) in SEA – this includes	**Likelihood: Possible** **Consequence: Moderate** **Overall rating: High**	Regulation should regulate location of bores, amount of water taken from certain places, proximity to sensitive locations and species. It might mean a slower development of unconventional wells especially ones near springs with delicate species and ecosystems as water should not be taken from such places and developers would be required to go further afield for a sustainable water source. There is no mention of legislation relating to the GAB

Line no.	Potential impact/ threat to LEB (Qld) river systems	Environmental attributes impacted		Initial risk	Management tool in LEB (Qld)	Residual risk	Panel notes
		Existing attributes	Potential attributes				
				Duration may last weeks-decades. Likely to have a broader scale of impact (potentially regional).	assessment of land use suitability and may include conditions regarding environmental attributes		– or is it covered under the water Act? Note that EPBC Act protects the community of GAB groundwater–dependent ecosystems (check wording of Act)
4.4	Impacts to surface water flow/levels and changes to overland flow, water quality, temperature and ecosystem structure	Natural hydrologic processes Natural water quality Beneficial flooding of land	Natural geomorphic processes Functioning riparian processes Functioning wildlife corridors including springs	**Likelihood: Almost Certain** **Consequence: Major** **Overall rating: Very High** **Notes from previous studies:** High frequency as all wells in shale/tight operations require fracking. Intensity of individual well use relatively small but cumulative impact much greater. Duration weeks-months	• Water licence for taking water under the Water Act (or water permit for shorter term projects) • EA conditions for managing impacts to water and biodiversity values, commensurate to the risk of the activity • RIDA under RPI Act (as a resource activity under P&G Act) in SEA – this includes assessment of land use suitability and may include conditions regarding environmental attributes	**Likelihood: Likely** **Consequence: Minor** **Overall rating: Medium**	As long as legislation stipulates that water amounts are restricted and proximity to sensitive areas are restricted

Line no.	Potential impact/ threat to LEB (Qld) river systems	Environmental attributes impacted		Initial risk	Management tool in LEB (Qld)	Residual risk	Panel notes
		Existing attributes	Potential attributes				
				(longer-term likely to use groundwater). Likely to have a broader scale of impact (potentially regional).			
Coal seam gas							
4.5	Groundwater extraction/drawdown and changes to water quality, temperature and ecosystem structure (including groundwater dependent ecosystems)	Natural hydrologic processes Natural water quality	Functioning riparian processes Functioning wildlife corridors including springs	**Likelihood: Likely** **Consequence: Major** **Overall rating: Very High** **Notes from previous studies:** As for tight and shale operations, with lower frequency (as generally only 10% of wells are fractured). *However, water take of produced groundwater is much higher than shale/tight. – are*	• Water licence for taking non-associated water under the Water Act (or water permit for shorter term projects) • EA under the EP Act and underground water impact report requirements under Chapter 3 of the Water Act for unlimited underground water rights to associated water under P&G Act • Other EA conditions for managing impacts to water values, commensurate to the risk of the activity • Make-good requirements under Chapter 3 of the Water Act • RIDA under RPI Act (as a resource activity under P&G Act) in SEA – this includes assessment of land use	**Likelihood: Possible** **Consequence: Moderate** **Overall rating: High**	On a well by well basis water take for an individual well is quite minor, however the cumulative impact of dense block development would incur higher risks and consequences Risks are similar to that of conventional gas as water take could be quite similar. However still need to consider cumulative impacts in the particular locations Rising soil salinity in the water table is possible. – effect on vegetation likely. Especially in the far south-western area such as lower Mulligan River.

Line no.	Potential impact/ threat to LEB (Qld) river systems	Environmental attributes impacted		Initial risk	Management tool in LEB (Qld)	Residual risk	Panel notes
		Existing attributes	Potential attributes				
				we talking about produced water, because we only spoke about water take for operations such as drilling, fracking and construction of associated infrastructure	suitability and may include conditions regarding environmental attributes		Impact of water added to system after fracking may have ecological consequences, e.g. adding large volumes during dry periods can disrupt the "bath tub" algal ring that sustains the food web of isolated waterholes (Bunn et al. papers). Water take is highest in development phase of CSG as large amount of water required for construction of associated infrastructure such as FSC, CPP, RO, Camps STP and large storage ponds.
4.6	Impacts to surface water flow/levels and changes to overland flow, water quality, temperature and ecosystem structure	Natural hydrologic processes Natural water quality Beneficial flooding of land	Natural geomorphic processes Functioning riparian processes Functioning wildlife corridors	**Likelihood: Almost Certain** **Consequence: Moderate** **Overall rating: High** **Notes from previous studies:** As for tight and	• Water licence for taking water under the Water Act (or water permit for shorter term projects) • EA conditions for managing impacts to water values, commensurate to the risk of the activity • RIDA under RPI Act (as a resource activity under P&G Act) in SEA – this includes assessment of land use	**Likelihood: Possible** **Consequence: Minor** **Overall rating: Medium**	Associated infrastructure has not been considered and needs to be considered for each aspect and the size of the project Volume of water is not so much the problem but the depth at which you get it from.

Line no.	Potential impact/ threat to LEB (Qld) river systems	Environmental attributes impacted		Initial risk	Management tool in LEB (Qld)	Residual risk	Panel notes
		Existing attributes	Potential attributes				
			including springs	shale operations, with lower frequency (as generally only 10% of wells are fractured).	suitability and may include conditions regarding environmental attributes		Is there enough water in the LEB to spare to support large scale production of unconventional gas projects without negatively impacting the almost pristine arid zone riverine environment that currently exists there? Keeping in mind water use by current infrastructure like towns, tourism, recreational use, farming etc. Water use during construction of well pads, ponds, roads, CPP, FCS, RO. Associated water from CSG needs to be released to the environment after treatment. The nature of boom and bust ecosystems of the LEB needs to be taken into consideration so that aquatic ecosystems that require times of dry are not saturated /flooded, causing disruption of the bath-tub algal ring (see text above).

Line no.	Potential impact/ threat to LEB (Qld) river systems	Environmental attributes impacted		Initial risk	Management tool in LEB (Qld)	Residual risk	Panel notes
		Existing attributes	Potential attributes				
							And in fact the releases could be beneficial if wisely planned and directed—but it would be better if possible to not introduce them. For example, waterbirds attracted to releases from the Jackson processing plant between the Cooper and the Wilson.
Minerals/coal mining							
4.7	Groundwater extraction/drawdown and changes to water quality, temperature and ecosystem structure (including groundwater dependent ecosystems)	Natural hydrologic processes Natural water quality	Functioning riparian processes Functioning wildlife corridors including springs	**Likelihood: Almost Certain** **Consequence: Extreme** **Overall rating: Extremely High**	• Water licence for taking water under the Water Act (or water permit for shorter term projects) • EA under the EP Act and underground water impact report requirements under Chapter 3 of the Water Act (or under an associated water licence under Chapter 9 of the Water Act where relevant) for underground water rights to associated water under the *Mineral Resources Act 1989* (MR Act) • Other EA conditions for managing impacts to water values, commensurate to the risk of the activity	**Likelihood: Possible** **Consequence: Moderate** **Overall rating: High**	It is important to note that currently open cut mines are not allowed to be constructed in the grey areas, but they are allowed upstream of the grey area (e.g., north west minerals province) which could be extremely detrimental to the basin ecosystems. We have mainly been discussing the development phase. Production phase of mining would incur a higher risk and cumulative impact needs to be considered

Line no.	Potential impact/ threat to LEB (Qld) river systems	Environmental attributes impacted		Initial risk	Management tool in LEB (Qld)	Residual risk	Panel notes
		Existing attributes	Potential attributes				
					• Annual monitoring/reporting requirements under MR Act and Mineral Resources Regulation 2013 • Make-good requirements under Chapter 3 of the Water Act • RIDA under RPI Act (as a resource activity under MR Act) in SEA – this includes assessment of land use suitability and may include conditions regarding environmental attributes		Adequate provision necessary for rehab All phases there is potential for cross contaminated aquifers
4.8	Impacts to surface water flow/levels and changes to overland flow, water quality, temperature and ecosystem structure	Natural hydrologic processes Natural water quality Beneficial flooding of land	Natural geomorphic processes Functioning riparian processes Functioning wildlife corridors including springs	**Likelihood: Almost Certain** **Consequence: Extreme** **Overall rating: Extremely High**	• Water licence for taking water under the Water Act (or water permit for shorter term projects) • EA conditions for monitoring impacts to surface water flows and quality, commensurate to risk of the activity • RIDA under RPI Act (as a resource activity under MR Act) in SEA – this includes assessment of land use suitability and may include conditions regarding environmental attributes	**Likelihood: Possible** **Consequence: Major** **Overall rating: High**	Open cut coal mining can occur 10-15 years, no social licence. Mining is potentially a greater contamination risk to water quality than gas extraction Production phase of mining uses the most water and would threaten above ground and below ground ecosystems due to the amount of water take necessary
Other impacts identified by the panel for CSG and Mining							

Line no.	Potential impact/ threat to LEB (Qld) river systems	Environmental attributes impacted		Initial risk	Management tool in LEB (Qld)	Residual risk	Panel notes
		Existing attributes	Potential attributes				
4.9	Drilling many wells with long lifespans through aquifers				Controls should include regular groundwater and gas well monitoring so that failures are detected as soon as possible.		Well failures are a possibility and can cause contamination of aquifers within 10 years of existence. There are concerns about this.
4.10	Mines built and abandoned before suitable rehabilitation completed				Financial assurance, fines to companies attempting to abandon mines prior to successful rehabilitation		Postproduction phase of mining – mine footprint, residual infrastructure, mine pits, pollution, algae, weeds, aliens, visual implications, rehabilitation (legacy). All need to be considered re ecological impacts. Rehabilitation and monitoring required many years postproduction
							There are essentially 3 phases of development 1. Risks during establishment phase 2. Risks during operational phase 3. Postproduction phase. We have mainly discussed development phase.
							Aquifer injection of treated water would be an option.

Line no.	Potential impact/ threat to LEB (Qld) river systems	Environmental attributes impacted		Initial risk	Management tool in LEB (Qld)	Residual risk	Panel notes
		Existing attributes	Potential attributes				
							Provision for beneficial use. Indigenous food, medicinal algae, etc. Does it just have to be for use by farmers? Companies should fund research for beneficial use of treated water.
							Sensitivity in saying anyone can use the water. This needs to be regulated and distributed fairly and used without environmental impacts. At the end of the day the main aim is to keep the pristine rivers and their floodplain and springs pristine while balancing the economic and environmental aspects effectively

Issue 5 – Operations of petroleum/gas and mining industries including drilling, hydraulic fracturing, dewatering, extraction and processing

Line no.	Potential impact/ threat to LEB (Qld) river systems	Environmental attributes impacted		Initial risk	Management tool in LEB (Qld)	Residual risk	Panel notes
		Existing attributes	Potential attributes				
Conventional petroleum/gas							
5.1	Groundwater quality impacts from loss of drilling fluid during drilling	Natural water quality	Functioning riparian processes Functioning wildlife corridors including springs	**Likelihood: Likely** **Consequence: Minor** **Overall rating: Medium** **Notes from previous studies:** Inadvertent frequency, low intensity (likely to be diluted), limited scale over days-weeks.	• Environmental authority (EA) conditions under the *Environmental Protection Act 1994* (EP Act), commensurate to risk of activity, for: ○ managing impacts of drilling activities, including prohibiting synthetic muds ○ managing impacts to water values • Regional Interests Development Approval (RIDA) under the *Regional Planning Interests Act 2014* (RPI Act) in a strategic environmental area (SEA) (as a resource activity under the *Petroleum and Gas (Production and Safety) Act 2004* (P&G Act)) – includes land use suitability assessment • Code of practice for construction and abandonment of wells under the Petroleum and Gas (Safety) Regulation 2018 (P&G Regulation)	**Likelihood: Possible** **Consequence: Minor** **Overall rating: Medium**	Base on bentonite and plant base polymer as fluid. Fluid loss happens, the extent of impact not known. Dependant on the location of the loss within the system, is it in an aquifer? Process usually stops when a leak is identified. Fluid is used to fill the hole until casing is installed, it is to provide a balanced/neutral plug. Depends on substrates e.g. limestone has higher loss rates.

Line no.	Potential impact/ threat to LEB (Qld) river systems	Environmental attributes impacted		Initial risk	Management tool in LEB (Qld)	Residual risk	Panel notes
		Existing attributes	Potential attributes				
					• Duty of care requirements under the *Aboriginal Cultural Heritage Act 2003* (ACH Act)		

5.2	Groundwater quality impacts from loss of hydraulic fracturing fluid in the target formation	Natural water quality	Functioning riparian processes
			
			Functioning wildlife corridors including springs
				Likelihood: Rare
				
				Consequence: Minor
				
				Overall rating: Low
				
				Notes from previous studies: Low frequency as hydraulic fracturing rarely required. Low intensity (likely to be diluted), potentially regional scale over decades.
					• EA conditions, commensurate to risk of activity, for:
					  ○ managing impacts of hydraulic fracturing, including risk assessments for each well
					  ○ managing impacts to water values
					• Statutory restrictions on chemical additives for hydraulic fracturing fluid under EP Act and Environmental Protection Regulation 2008 (EP Regulation)
					• RIDA under RPI Act in SEA (as a resource activity under P&G Act) – includes land use suitability assessment
					• Code of practice for construction and abandonment of wells under P&G Regulation
						Likelihood: Rare
						
						Consequence: Minor
						
						Overall rating: Low
							Locational dependant on substrate
							There is sealed packing between aquifers and prior to the Fracking formation.
							
							Regulation of the chemical used is important
							
							Conventional is unlikely to use Fracking

5.3	Groundwater impacts from:
	- leaks into overlying aquifer from production casing or via offset wells
		Natural water quality	Functioning riparian processes
			
			Functioning wildlife corridors
				Likelihood: Possible
				
				Consequence: Moderate
				
				Overall rating: High
					• EA conditions, commensurate to risk of activity, for:
					  ○ managing impacts of drilling activities, including prohibiting synthetic muds
					  ○ managing impacts to water values, commensurate to risk of activity
						Likelihood: Unlikely
						
						Consequence: Moderate
						
						Overall rating: Medium
							Ensure that Ground Water monitoring in these areas are undertaken
							
							Contamination of an aquifer impacts on drinking water

Line no.	Potential impact/ threat to LEB (Qld) river systems	Environmental attributes impacted		Initial risk	Management tool in LEB (Qld)	Residual risk	Panel notes
		Existing attributes	Potential attributes				
	- drainage along geological faults - improperly completed or plugged offset wells		including springs		• RIDA under RPI Act in SEA (as a resource activity under P&G Act) – includes land use suitability assessment • Code of practice for construction and abandonment of wells under P&G Regulation		Old legacy bores from early days may pose risk, if they were not constructed to spec.
Shale and tight petroleum/gas							
5.4	Groundwater quality impacts from loss of drilling fluid during drilling	Natural water quality	Functioning riparian processes Functioning wildlife corridors including springs	**Likelihood: Likely** **Consequence: Minor** **Overall rating: Medium** **Notes from previous studies:** Inadvertent frequency, low intensity (likely to be diluted), limited scale over days-weeks.	• EA conditions, commensurate to risk of activity, for: ○ managing impacts of drilling activities, including prohibiting synthetic muds ○ managing impacts to water values • RIDA under RPI Act in SEA (as a resource activity under P&G Act) – includes land use suitability assessment • Code of practice for construction and abandonment of wells under P&G Regulation	**Likelihood: Possible** **Consequence: Minor** **Overall rating: Medium**	Comparable to conventional
5.5	Groundwater quality impacts from loss of hydraulic fracturing fluid	Natural water quality	Functioning riparian processes Functioning wildlife	**Likelihood: Rare** **Consequence: Minor** **Overall rating: Low**	• EA conditions, commensurate to risk of activity, for: ○ managing impacts of hydraulic fracturing, including risk assessments for each well	**Likelihood: Rare** **Consequence: minor**	

Line no.	Potential impact/ threat to LEB (Qld) river systems	Environmental attributes impacted		Initial risk	Management tool in LEB (Qld)	Residual risk	Panel notes
		Existing attributes	Potential attributes				
	in the target formation		corridors including springs	**Notes from previous studies:** High frequency as hydraulic fracturing will be required for all wells. Low intensity (likely to be diluted), potentially regional scale over decades.	○ managing impacts to water values • Statutory restrictions on chemical additives for hydraulic fracturing fluid under EP Act and EP Regulation • RIDA under RPI Act in SEA (as a resource activity under P&G Act) – includes land use suitability assessment • Code of practice for construction and abandonment of wells under P&G Regulation	**Overall rating: Low**	
5.6	Groundwater impacts in upper aquifers from: - leaks into overlying aquifer from production casing or via offset wells - vertical migration of fluid along faults/ fractures - improperly completed or	Natural water quality	Functioning riparian processes Functioning wildlife corridors including springs	**Likelihood: Possible** **Consequence: Moderate** **Overall rating: High** **Notes from previous studies:** Inadvertent frequency, low intensity as concentrations are likely to be diluted, limited scale due to	• EA conditions, commensurate to risk of activity, for: ○ managing impacts of hydraulic fracturing, including risk assessments for each well ○ managing impacts to water values • RIDA under RPI Act in SEA (as a resource activity under P&G Act) – includes land use suitability assessment • Code of practice for construction and abandonment of wells under P&G Regulation	**Likelihood: Unlikely** **Consequence: Moderate** **Overall rating: Medium**	

Line no.	Potential impact/ threat to LEB (Qld) river systems	Environmental attributes impacted		Initial risk	Management tool in LEB (Qld)	Residual risk	Panel notes
		Existing attributes	Potential attributes				
	plugged offset wells			small water volumes, likely to be local/aquifer scale impact for vertical migration. Duration years.			

5.7	Surface water and groundwater quality impacts from well failure as a result of induced seismicity (from hydraulic fracturing)	Natural water quality	Functioning riparian processes
			
			Functioning wildlife corridors including springs
				Likelihood: Rare
				
				Consequence: Minor
				
				Overall rating: Low
				
				Notes from previous studies: Inadvertent frequency, low intensity, limited-local scale. Duration between seconds to months (depending on seismic event).
					• EA conditions, commensurate to risk of activity, for:
					  ○ managing impacts of hydraulic fracturing, including risk assessments for each well
					  ○ managing impacts to water values
					• EA site-specific assessment required for reinjection – EA standards specifically preclude this from standard/variation applications
					• RIDA under RPI Act in SEA (as a resource activity under P&G Act) – includes land use suitability assessment
						Likelihood: Rare
						
						Consequence: Minor
						
						Overall rating: Low
							Dependant on geological setting, ensure that geological assessment of the areas are undertaken. See Bioregional Assessments IESC. (US examples? Oklahoma?)
							
							LEB appears to be stable. In what sense? It is highly variable in hydrology.
							
							Wastewater disposal in shale processes.
							
							Microcosmic monitoring of activity

Coal seam gas							
5.8	Groundwater quality impacts from loss of drilling fluid during drilling	Natural water quality	Functioning riparian processes	**Likelihood: Likely** **Consequence: Minor**	• EA conditions, commensurate to risk of activity, for: ○ managing impacts of drilling activities, including prohibiting synthetic muds	**Likelihood: Likely** **Consequence: Minor**	Due to intensity more holes in concentrated areas increases the likelihood even after the implementation of regulatory frameworks

Line no.	Potential impact/ threat to LEB (Qld) river systems	Environmental attributes impacted		Initial risk	Management tool in LEB (Qld)	Residual risk	Panel notes
		Existing attributes	Potential attributes				
			Functioning wildlife corridors including springs	**Overall rating: Medium** **Notes from previous studies:** Inadvertent frequency, low intensity (likely to be diluted), limited scale over days-weeks.	○ managing impacts of hydraulic fracturing/stimulation, including risk assessments for each well ○ managing impacts to water values • RIDA under RPI Act in SEA (as a resource activity under P&G Act) – includes land use suitability assessment • Code of practice for construction and abandonment of wells under P&G Regulation	**Overall rating: Medium**	Chemical components of Coal layer BTEX benzene etc
5.9	Groundwater quality impacts from loss of hydraulic fracturing fluid in the target formation	Natural water quality	Functioning riparian processes Functioning wildlife corridors including springs	**Likelihood: Unlikely** **Consequence: Minor** **Overall rating: Low** **Notes from previous studies:** As per tight and shale gas but lower frequency as not all wells require hydraulic fracturing.	• EA conditions, commensurate to risk of activity, for: ○ managing impacts of hydraulic fracturing, including risk assessments for each well ○ managing impacts to water values • Statutory restrictions on chemical additives for hydraulic fracturing fluid under EP Act and EP Regulation • RIDA under RPI Act in SEA (as a resource activity under P&G Act) – includes land use suitability assessment	**Likelihood: Unlikely** **Consequence: minor** **Overall rating: Low**	Lower use of fracturing fluid in CSG extraction.

Line no.	Potential impact/ threat to LEB (Qld) river systems	Environmental attributes impacted		Initial risk	Management tool in LEB (Qld)	Residual risk	Panel notes
		Existing attributes	Potential attributes				
					• Code of practice for construction and abandonment of wells under P&G Regulation		
5.10	Groundwater impacts in upper aquifers from: - leaks into overlying aquifer from production casing or via offset wells - vertical migration of fluid along faults/ fractures - improperly completed or plugged offset wells	Natural water quality	Functioning riparian processes Functioning wildlife corridors including springs	**Likelihood: Possible** **Consequence: Moderate** **Overall rating: High** **Notes from previous studies:** As per tight and shale gas but possibly greater intensity due to shallower target formations (and therefore closer to aquifers).	• EA conditions, commensurate to risk of activity, for: ○ managing impacts of hydraulic fracturing, including risk assessments for each well ○ managing impacts to water values • RIDA under RPI Act in SEA (as a resource activity under P&G Act) – includes land use suitability assessment	**Likelihood: Unlikely** **Consequence: Moderate** **Overall rating: Medium**	Dewatering during extraction can cause depressurisation leading to new pathways opening up, others may close off. Water Quality Ground water levels in general aquifers changing through draw down from the CSG extraction process.
5.11	Surface water and groundwater quality impacts from well failure as a result of induced	Natural water quality	Functioning riparian processes Functioning wildlife corridors	**Likelihood: Rare** **Consequence: Minor** **Overall rating: Low**	• EA conditions, commensurate to risk of activity, for: ○ managing impacts of hydraulic fracturing, including risk assessments for each well ○ managing impacts to water values	**Likelihood: Rare** **Consequence: Minor** **Overall rating: Low**	Insufficient info or understanding of this process.

Line no.	Potential impact/ threat to LEB (Qld) river systems	Environmental attributes impacted		Initial risk	Management tool in LEB (Qld)	Residual risk	Panel notes
		Existing attributes	Potential attributes				
	seismicity (from hydraulic fracturing and dewatering of coal seams)		including springs		• EA site-specific assessment required for reinjection – EA standards specifically preclude this from standard/variation applications • RIDA under RPI Act in SEA (as a resource activity under P&G Act) – includes land use suitability assessment		
5.12	Groundwater level impacts from dewatering of coal seams and associated impacts on GDES	Natural hydrologic processes Natural water quality	Functioning riparian processes Functioning wildlife corridors including springs	**Likelihood: Almost Certain** **Consequence: Major** **Overall rating: Very High**	• EA conditions for monitoring impacts to groundwater levels and reporting requirements, commensurate to risk of activity • Make-good agreements under Chapter 3 of the Water Act – outlines arrangements for tenure holders to 'make good' the impact bores as a result of exercising underground water rights under the MR Act • RIDA under RPI Act in SEA (as a resource activity under P&G Act) – includes land use suitability assessment	**Likelihood: Almost Certain** **Consequence: Moderate** **Overall rating: High**	Controversial issue – Artesian springs and GDEs, very location specific. High level of uncertainty for this issue. Consequence is reduced if regulation is applied. So long as best practice is implemented. Are make good bores and agreements fixing issues or causing more? Is it CSG or is it other industry or climate change/drought? Previous approval mechanisms were not good and as a result there are significant unknown risks

Line no.	Potential impact/ threat to LEB (Qld) river systems	Environmental attributes impacted		Initial risk	Management tool in LEB (Qld)	Residual risk	Panel notes
		Existing attributes	Potential attributes				
							Office of Groundwater Impact Assessment (OGIA) Reports Ground Water telemetry monitoring
Minerals/coal mining							
5.13	Groundwater level impacts from mine dewatering and associated impacts on GDEs and springs	Natural hydrologic processes Natural water quality	Functioning riparian processes Functioning wildlife corridors including springs	**Likelihood: Almost Certain** **Consequence: Major** **Overall rating: Very High**	• EA conditions for monitoring impacts to groundwater levels and reporting requirements, commensurate to risk of activity • RIDA under RPI Act in SEA (as a resource activity under the *Mineral Resources Act 1989* (MR Act)) • Prohibition on open-cut mining in designated precinct under the Regional Planning Interests Regulation 2014 (RPI Regulation)	**Likelihood: Likely** **Consequence: Moderate** **Overall rating: High**	Level of uncertainty Prohibition to be retained for this activity within the Sensitive Environmental Area Limiting the activity within the sensitive areas Look at expanding the Designated precinct or Sensitive Environmental Areas to include larger areas. Avoid GDEs
5.14	Groundwater quality impacts from drainage along geological faults	Natural water quality	Functioning riparian processes Functioning wildlife corridors	**Likelihood: Possible** **Consequence: Moderate**	• EA conditions for managing impacts to groundwater including quality triggers and limits, reporting requirements etc. commensurate to risk of activity • RIDA under RPI Act in SEA (as a resource activity under MR Act) –	**Likelihood: Unlikely** **Consequence: Moderate**	Assume Tailings dam, mine pits. Geotechnical assessment to reduce risk of construction on fault

Line no.	Potential impact/ threat to LEB (Qld) river systems	Environmental attributes impacted		Initial risk	Management tool in LEB (Qld)	Residual risk	Panel notes
		Existing attributes	Potential attributes				
			including springs	**Overall rating: High**	includes land use suitability assessment • Prohibition on open-cut mining in designated precinct under RPI Regulation	**Overall rating: Medium**	Lining of dams to minimise risk Extreme rainfall and flow conditions to be considered. Activity to remain prohibited in these Sensitive Environmental areas and Designated Precinct Additional protection is needed for previously protected areas under Wild Rivers legislation.
5.15	Overland flow and hydrology impacts from: - open-cut pits and associated diversion of watercourses -subsidence from underground operations	Natural hydrologic processes Beneficial flooding of land	Natural geomorphic processes Functioning riparian processes Functioning wildlife corridors including springs	**Likelihood: Almost Certain** **Consequence: Moderate** **Overall rating: High**	• RIDA under RPI Act in SEA (as a resource activity under MR Act) – includes land use suitability assessment • Prohibition on open-cut mining in designated precinct under RPI Regulation • Water licence under the Water Act • EA conditions for managing impacts of watercourse diversions, commensurate to risk of activity	**Likelihood: Possible** **Consequence: Moderate** **Overall rating: High**	Unsuitable for the LEB in DP Some areas in the northern portion of basin, those with topography not the flood plain SEA expansion to include other sensitive areas

Line no.	Potential impact/ threat to LEB (Qld) river systems	Environmental attributes impacted		Initial risk	Management tool in LEB (Qld)	Residual risk	Panel notes
		Existing attributes	Potential attributes				
5.16	Surface water quality impacts from increased erosion (for example from ponding and cracking as a result of subsidence)	Water Quality	Natural geomorphic processes	**Likelihood: Likely** **Consequence: Major** **Overall rating: Very High**	• EA conditions for sediment controls, commensurate to risk of activity • RIDA under RPI Act in SEA (as a resource activity under MR Act) – includes land use suitability assessment • Prohibition on open-cut mining in designated precinct under RPI Regulation	**Likelihood: Unlikely** **Consequence: Moderate** **Overall rating: Medium**	Acid leachate impacts on water quality Tailings dams Best practice ESC Rehabilitation of Tailings Dams – Legacy issue
5.17	Surface water quality impacts from use of untreated water for coal washing	Water Quality	Functioning riparian processes Functioning wildlife corridors including springs	**Likelihood: Almost Certain** **Consequence: Moderate** **Overall rating: High**	• Optional registration for resource producer and compliance with end of waste code for associated water under *Waste Reduction and Recycling Act 2011* • RIDA under RPI Act in SEA (as a resource activity under MR Act) – includes land use suitability assessment • Prohibition on open-cut mining in designated precinct under RPI Regulation	**Likelihood: Rare** **Consequence: Insignificant** **Overall rating: Very Low**	Managed on site using evaporation – can't release to the environment
Other impacts associated with resource activities operations including drilling, hydraulic fracturing, dewatering, extraction and processing (if identified by panel)							
	-				•		

Issue 6 – Waste treatment and disposal petroleum/gas and mining industries

Line no.	Potential impact/ threat to LEB (Qld) river systems	Environmental attributes impacted		Initial risk	Management tool in LEB (Qld)	Residual risk	Panel notes
		Existing attributes	Potential attributes				
Conventional petroleum/gas							
6.1	Groundwater and surface water level/quality impacts from produced water leaching or overflowing from pits/storage ponds, or leaking from pipelines (from flooding/ structural failure)	Natural hydrologic processes Natural water quality	Natural geomorphic processes Functioning riparian processes Functioning wildlife corridors including springs	**Likelihood: Almost Certain (if in the flood plain) for surface water quality** **Consequence: Moderate** **Overall rating: High**	• Environmental authority (EA) standard conditions for pipelines under the *Environmental Protection Act 1994* (EP Act) – or site-specific EA where required • Construction and reporting requirements under EA conditions for structures which are dams or levees constructed as part of environmentally relevant activities (ERAs), commensurate to risk of activity • Regional Interests Development Approval (RIDA) under Regional Planning Interests Act 2014 (RPI) Act in a strategic environmental area (SEA) (as a resource activity under the Petroleum and Gas (Production and Safety) Act 2004 (P&G Act)) –	**Likelihood: Possible** **Consequence: Moderate** **Overall rating: High**	It could be more beneficial to have higher restrictions to more sensitive areas (i.e. 1 in 3-year flood areas and lower level restrictions to the areas that flood every 3-10 years). Mapping could represent these restriction areas. Need to be aware of the importance of waterholes as refuges in all river channels and floodplain areas Depends on the morphology (area, depth, habitat structure) of the particular flood plains and waterholes. There are some waterholes that are outliers from the main tributary system that would need to be included as a sensitive area. Designated Precinct around more frequently flooded areas could be a desired

Line no.	Potential impact/ threat to LEB (Qld) river systems	Environmental attributes impacted		Initial risk	Management tool in LEB (Qld)	Residual risk	Panel notes
		Existing attributes	Potential attributes				
					includes land use suitability assessment • Consideration of flooding frequency using land types (infrequently flooded flood plains only) exclude swamps, waterholes and depressions		outcome from this workshop. Are outlying waterholes in C1 land use type? What kind of infrastructure is allowed in certain areas (ponds, treatment plants, wells) It would be necessary to have restrictions on capacity of dams during wet season. Storage ponds should not be placed on the floodplain due to the risk of structural integrity issues, from flooding, and spillage of wastes. Recommend excluding gas wells and ponds from frequently flooded areas (1-3 years, C1 and C3 land types?) Include areas within wild rivers legislation to

Line no.	Potential impact/ threat to LEB (Qld) river systems	Environmental attributes impacted		Initial risk	Management tool in LEB (Qld)	Residual risk	Panel notes
		Existing attributes	Potential attributes				
							environmentally sensitive areas
6.2	Impacts to surface water flow/levels and changes to water quality from discharge of wastewater	Natural hydrologic processes Natural water quality	Natural geomorphic processes Functioning riparian processes Functioning wildlife corridors including springs	**Likelihood: Almost Certain** **Consequence: Moderate** **Overall rating: High**	• EA under EP Act for managing environmental impacts (no model conditions – site specific assessment and potentially considered in an environmental impact statement (EIS)) • RIDA under RPI Act in SEA (as a resource activity under P&G Act) – includes land use suitability assessment	**Likelihood: Almost Certain** **Consequence: Moderate** **Overall rating: High**	Conventional gas has lower initial risk than unconventional gas due to the nature of drilling activities and the properties of the water that is extracted from the wells (not as saline, oil is removed) When you send a large amount of water down an intermittent arid-zone river system you can disrupt the ecological processes and health of the ecosystems Risk of spread of invasive or pest species There is clearly a gap in legislation because these issues are currently happening in conventional gas activities, e.g. the alien pest fish (*Gambusia holbrooki*)

Line no.	Potential impact/ threat to LEB (Qld) river systems	Environmental attributes impacted		Initial risk	Management tool in LEB (Qld)	Residual risk	Panel notes
		Existing attributes	Potential attributes				
							Using current activities in Cooper basin as an example. Eromanga water discharged to ephemeral flows off floodplains e.g., Jackson creek – if discharge is constant or in time of dry, it will disrupt algae production, food web structure and ecosystem health.
6.3	Groundwater and surface water impacts from spills of produced water and chemicals during treatment and disposal	Natural water quality	Functioning riparian processes Functioning wildlife corridors including springs	**Likelihood: Almost Certain** **Consequence: Minor** **Overall rating: Medium**	• EA conditions, commensurate to risk of activity, for: ○ waste management, including specific requirements for drill fluids ○ managing impacts to water values, including monitoring and reporting of leaks/spills ○ construction and reporting requirements for structures which are dams or levees constructed as part of ERAs	**Likelihood: Possible** **Consequence: Minor** **Overall rating: Medium**	Very low risk from low volumes of low risk products, higher risk for chemicals such as hydrocarbons and biocides.

Line no.	Potential impact/ threat to LEB (Qld) river systems	Environmental attributes impacted		Initial risk	Management tool in LEB (Qld)	Residual risk	Panel notes
		Existing attributes	Potential attributes				
					• Optional registration for resource producer and compliance with end of waste codes under the *Waste Reduction and Recycling Act 2011* (WRR Act), including for 'associated water' • RIDA under RPI Act in SEA (as a resource activity under P&G Act) – includes land use suitability assessment		
6.4	Abandoned storage ponds/pits remain onsite with contamination at base (due to evaporation) and potential groundwater quality impacts through leaching	Natural water quality	Functioning riparian processes Functioning wildlife corridors including springs	**Likelihood: Likely** **Consequence: Minor** **Overall rating: Medium**	• Decommissioning and rehabilitation requirements under EA conditions for structures which are dams or levees constructed as part of ERAs, commensurate to risk of activity • RIDA under RPI Act in SEA (as a resource activity under P&G Act) – includes land use suitability assessment	**Likelihood: Unlikely** **Consequence: Insignificant** **Overall rating: Low**	Based on everything removed from site the residual risk would be very low. If site was abandoned and left *in situ* with liner and formed turkey nest storages, the risk would be the same as initial risk. Disposal of pond liners to licensed landfill and surface rehabilitation.
6.5	Surface water and groundwater quality impacts from disposal	Natural water quality	Functioning riparian processes	**Likelihood: Almost Certain**	• EA conditions for drill cuttings waste, commensurate to risk of activity	**Likelihood: Possible/Unlikely**	

Line no.	Potential impact/ threat to LEB (Qld) river systems	Environmental attributes impacted		Initial risk	Management tool in LEB (Qld)	Residual risk	Panel notes
		Existing attributes	Potential attributes				
	of drill cuttings and other solid wastes		Functioning wildlife corridors including springs	**Consequence: Moderate** **Overall rating: High**	• RIDA under RPI Act in SEA (as a resource activity under P&G Act) – includes land use suitability assessment	**Consequence: Minor** **Overall rating: Medium / Low**	
Shale and tight petroleum/gas							
6.6	Groundwater quality impacts from reinjection of flowback water and produced water, including induced seismicity	Natural water quality	Functioning riparian processes Functioning wildlife corridors including springs	**Likelihood: Unlikely** **Consequence: Insignificant** **Overall rating: Low** **Notes from previous studies:** Frequency is variable as water disposal will be required for all wells but other options can be reused (e.g. treatment and reuse or pond evaporation). Intensity of individual well use relatively small but cumulative impact much greater.	• Statutory restrictions on chemical additives for hydraulic fracturing fluid under the EP Act and Environmental Protection Regulation 2008 (EP Regulation) • EA site-specific assessment required for reinjection and water impacts – EA standards specifically preclude this from standard/variation applications • Optional registration for resource producer and compliance with end of waste code for associated water under WRR Act, including standards where bores will be used	**Likelihood: Rare** **Consequence: Insignificant** **Overall rating: Very Low**	Reinjection of flowback into aquifer does not occur. We have assumed reinjection water is used for fracking of next well. Assume during fracking in target reservoir there is no leakage to aquifers from 2-4 km below surface.

Line no.	Potential impact/ threat to LEB (Qld) river systems	Environmental attributes impacted		Initial risk	Management tool in LEB (Qld)	Residual risk	Panel notes
		Existing attributes	Potential attributes				
				Duration years-decades. Note that comparative to CSG, wastewater will be lower. Impacts likely to be localised.	for stock or domestic purposes • RIDA under RPI Act in SEA (as a resource activity under P&G Act) – includes land use suitability assessment		
6.7	Groundwater and surface water level/quality impacts from flowback or produced water leaching or overflowing from storage ponds, or leaking from pipelines (from flooding/ structural failure)	Natural hydrologic processes Natural water quality	Natural geomorphic processes Functioning riparian processes Functioning wildlife corridors including springs	**Likelihood: Almost Certain** **Consequence: Moderate** **Overall rating: High** **Notes from previous studies:** Frequency inadvertent-low. Intensity likely to be medium as water may have high salinity, residual hydrocarbons or hydraulic fracturing chemical additives. Duration days-weeks. Impacts likely to be limited-localised.	• Statutory restrictions on chemical additives for hydraulic fracturing fluids (EP Act and Regulation) • EA standard conditions for pipelines (or site-specific EA where required) • Construction and reporting requirements under EA conditions for structures which are dams or levees constructed as part of ERAs, commensurate to risk of activity • RIDA under RPI Act in SEA (as a resource activity under P&G Act) – includes land use suitability assessment	**Likelihood: Possible** **Consequence: Moderate** **Overall rating: High**	Like conventional gas except for the presence of more frack fluid.

Line no.	Potential impact/ threat to LEB (Qld) river systems	Environmental attributes impacted		Initial risk	Management tool in LEB (Qld)	Residual risk	Panel notes
		Existing attributes	Potential attributes				
6.8	Impacts to surface water flow/levels and changes to water quality from discharge of wastewater (flowback water and produced water)	Natural hydrologic processes Natural water quality	Natural geomorphic processes Functioning riparian processes Functioning wildlife corridors including springs	**Likelihood: Possible** **Consequence: Moderate** **Overall rating: High** **Notes from previous studies:** Frequency is variable as water disposal will be required for all wells but other options can be reused (e.g. treatment and reuse or pond evaporation). Intensity of individual well use relatively small but cumulative impact much greater. Duration months-years. Impacts likely to be localised.	• EA under EP Act for managing environmental impacts (no model conditions – site specific assessment and potentially may be included in an EIS) • Statutory restrictions on chemical additives for hydraulic fracturing fluids (EP Act and EP Regulation) • RIDA under RPI Act in SEA (as a resource activity under P&G Act) – includes land use suitability assessment	**Likelihood: Unlikely** **Consequence: Moderate** **Overall rating: Medium**	Not much water in shale and tight gas.
6.9	Groundwater and surface water impacts from spills of drilling fluids, fracturing fluids, flowback and	Natural water quality	Functioning riparian processes	**Likelihood: Almost Certain** **Consequence: Moderate**	• EA conditions, commensurate to risk of activity, for: ○ waste management, including specific	**Likelihood: Possible** **Consequence: Moderate**	Less water more chemicals.

Line no.	Potential impact/ threat to LEB (Qld) river systems	Environmental attributes impacted		Initial risk	Management tool in LEB (Qld)	Residual risk	Panel notes
		Existing attributes	Potential attributes				
	produced water during treatment and disposal		Functioning wildlife corridors including springs	**Overall rating: High** **Notes from previous studies:** Frequency inadvertent, with low to medium intensity depending on composition of fluids. Scale potentially limited to well pad. Duration likely days to weeks.	requirement for drill fluids ○ construction and reporting requirements for structures which are dams or levees constructed as part of ERAs ○ managing impacts to water values, including monitoring and reporting of leaks/spills • Optional registration for resource producer and compliance with end of waste code for associated water under WRR Act (where relevant) • RIDA under RPI Act in SEA (as a resource activity under P&G Act) – includes land use suitability assessment	**Overall rating: High**	
6.10	Abandoned storage ponds remain onsite with contamination at base (due to evaporation) and	Natural water quality	Functioning riparian processes	**Likelihood: Likely** **Consequence: Minor**	• Statutory restrictions on chemical additives for hydraulic fracturing fluids (EP Act and Regulation)	**Likelihood: Unlikely** **Consequence: Minor**	There is good regulation for this aspect, not so much for placement but the process required for decommissioning of low

Line no.	Potential impact/ threat to LEB (Qld) river systems	Environmental attributes impacted		Initial risk	Management tool in LEB (Qld)	Residual risk	Panel notes
		Existing attributes	Potential attributes				
	potential groundwater quality impacts through leaching		Functioning wildlife corridors including springs	**Overall rating: Medium** **Notes from previous studies:** Frequency likely to be inadvertent. Intensity medium due to concentrated chemicals. Duration days-weeks. Scale limited as remaining volumes would be small.	• Decommissioning and rehabilitation requirements under EA conditions for structures which are dams or levees constructed as part of ERAs, commensurate to risk of activity • RIDA under RPI Act in SEA (as a resource activity under P&G Act) – includes land use suitability assessment	**Overall rating: Low**	consequence dams is regulated. More chemicals than conventional gas due to fracking frequency.
6.11	Surface water and groundwater quality impacts from disposal of drill cuttings and other solid wastes	Natural water quality	Functioning riparian processes Functioning wildlife corridors including springs	**Likelihood: Almost Certain** **Consequence: Moderate** **Overall rating: High** **Notes from previous studies:** Frequency likely to be low, intensity low-medium, limited scale (disposal site/well pad scale),	• EA conditions for managing impacts related to drill cuttings waste, commensurate to risk of activity • RIDA under RPI Act in SEA (as a resource activity under P&G Act)	**Likelihood: Unlikely** **Consequence: Minor** **Overall rating: Low**	All these risk ratings have been designated to areas not on floodplains. These activities are not at all acceptable in SEA areas or surrounding floodplain areas as they are too high risk to the health of the sensitive ecosystems found within floodplain, and to the biota that use the floodplain during floods but return to waterholes as floods recede. Huge fish biomass is generated off floodplains.

Line no.	Potential impact/ threat to LEB (Qld) river systems	Environmental attributes impacted		Initial risk	Management tool in LEB (Qld)	Residual risk	Panel notes
		Existing attributes	Potential attributes				
				duration years to decades.			
Coal seam gas							
6.12	Groundwater quality impacts from reinjection of flowback water and produced water, including induced seismicity	Natural water quality	Functioning riparian processes Functioning wildlife corridors including springs	**Likelihood: Almost Certain** **Consequence: Major** **Overall rating: Very High** **Notes from previous studies:** As per tight and shale gas but higher frequency due to significantly more produced water in CSG operations (from coal seam dewatering). Intensity possibly lower due to less complex chemicals present in flowback water (due to shallower depths).	• Statutory restrictions on chemical additives for hydraulic fracturing fluids (EP Act and Regulation) • EA site-specific assessment required for reinjection and water impacts – EA standards specifically preclude this from standard/variation applications • Optional registration for resource producer and compliance with end of waste code for associated water under WRR Act, including standards where bores will be used for stock or domestic purposes • Coal Seam Gas Water Management Policy – provides guidance to assist CSG operators and the administering authority for the EP Act to	**Likelihood: Unlikely** **Consequence: Minor** **Overall rating: Low**	Wastewater should be treated prior to being reused. Water is highly saline. Reverse osmosis plant utilised. Other chemical contaminants. Location of reinjections sites. Just don't do it on the floodplain.

Line no.	Potential impact/ threat to LEB (Qld) river systems	Environmental attributes impacted		Initial risk	Management tool in LEB (Qld)	Residual risk	Panel notes
		Existing attributes	Potential attributes				
					determine management solutions • RIDA under RPI Act in SEA (as a resource activity under P&G Act) – includes land use suitability assessment		
6.13	Groundwater and surface water level/quality impacts from flowback or produced water leaching or overflowing from storage ponds, or leaking from pipelines (from flooding/ structural failure)	Natural hydrologic processes Natural water quality	Natural geomorphic processes Functioning riparian processes Functioning wildlife corridors including springs	**Likelihood: Almost Certain** **Consequence: Major** **Overall rating: Very High** **Notes from previous studies:** As per tight and shale gas but higher frequency due to significantly more produced water in CSG operations (from coal seam dewatering). Intensity possibly lower due to less complex chemicals present in flowback	• EA standard conditions for pipelines (or site-specific EA where required) • EP Act restrictions on use of CSG evaporation dams • Construction and reporting requirements under EA conditions for structures which are dams or levees constructed as part of ERAs, commensurate to risk of activity • RIDA under RPI Act in SEA (as a resource activity under P&G Act) – includes land use suitability assessment	**Likelihood: Possible** **Consequence: Major** **Overall rating: High**	Increase salinity with the flood system – impact of water quality. Susceptibility of basin to infrastructure and large flows as the system is local, flat, wide and vast and doesn't get the flush to ocean like other systems. Limit the construction of large raised infrastructure in the floodplain. Social licence for these activities is not there. Unlikely they will be approved but possible.

Line no.	Potential impact/ threat to LEB (Qld) river systems	Environmental attributes impacted		Initial risk	Management tool in LEB (Qld)	Residual risk	Panel notes
		Existing attributes	Potential attributes				
				water (due to shallower depths).			The regulator needs to exercise their due diligence as this activity is too risky. There has to be a thorough look at implications of these developments across the basin as a whole, particularly on the floodplain and near to springs. E.g., storage dam at Mary Kathleen east of Mt Isa (radioactive material).
6.14	Impacts to surface water flow/levels and changes to water quality from discharge of wastewater (flowback water and produced water)	Natural hydrologic processes Natural water quality	Natural geomorphic processes Functioning riparian processes Functioning wildlife corridors including springs	**Likelihood: Almost Certain** **Consequence: Extreme** **Overall rating: Extremely High** **Notes from previous studies:** As per tight and shale gas but higher frequency due to significantly more produced	• EA under EP Act for managing environmental impacts (no model conditions – site specific assessment and potentially considered through EIS for whole of project) • Statutory restrictions on chemical additives for hydraulic fracturing fluids (EP Act and Regulation) • RIDA under RPI Act in SEA (as a resource activity under P&G Act)	**Likelihood: Unlikely** **Consequence: Extreme** **Overall rating: High**	Floodplain and aquatic systems are highly sensitive to change in levels (pH, salinity and chemicals) if water is untreated. Mitigation is necessary to prevent this from happening. Regulation is required to ensure the legislation is being enforced e.g., auditing of systems

Line no.	Potential impact/ threat to LEB (Qld) river systems	Environmental attributes impacted		Initial risk	Management tool in LEB (Qld)	Residual risk	Panel notes
		Existing attributes	Potential attributes				
				water in CSG operations (from coal seam dewatering). Intensity possibly lower due to less complex chemicals present in flowback water (due to shallower depths).	• Coal Seam Gas Water Management Policy – provides guidance to assist CSG operators and the administering authority for the EP Act to determine management solutions		
6.15	Groundwater and surface water impacts from spills of drilling fluids, fracturing fluids, flowback and produced water during treatment and disposal	Natural water quality	Functioning riparian processes Functioning wildlife corridors including springs	**Likelihood: Likely** **Consequence: Moderate** **Overall rating: High** **Notes from previous studies:** As per tight and shale gas but higher frequency due to significantly more produced water in CSG operations (from coal seam dewatering). Intensity possibly lower due to less complex chemicals	• EA conditions, commensurate to risk of activity, for: ○ waste management, including specific requirement for drill fluids ○ construction and reporting requirements for structures which are dams or levees constructed as part of ERAs ○ managing impacts to water values, including monitoring and reporting of leaks/spills	**Likelihood: Unlikely** **Consequence: Moderate** **Overall rating: Medium**	Site specific controls, operation manuals.

Line no.	Potential impact/ threat to LEB (Qld) river systems	Environmental attributes impacted		Initial risk	Management tool in LEB (Qld)	Residual risk	Panel notes
		Existing attributes	Potential attributes				
				present in flowback water (due to shallower depths).	• Optional registration for resource producer and compliance with end of waste codes under WRR Act, including for 'associated water' and 'coal seam gas drilling mud' • RIDA under RPI Act in SEA (as a resource activity under P&G Act) – includes land use suitability assessment		
6.16	Abandoned storage ponds remain onsite with contamination at base (due to evaporation) and potential groundwater quality impacts through leaching	Natural water quality	Functioning riparian processes Functioning wildlife corridors including springs	**Likelihood: Almost Certain** **Consequence: Major** **Overall rating: Very High** **Notes from previous studies:** As per tight and shale gas but potentially lower intensity due to less complex chemicals (due to shallower depths).	• Statutory restrictions on chemical additives for hydraulic fracturing fluids (EP Act and Regulation) • Decommissioning and rehabilitation under EA conditions for structures which are dams or levees constructed as part of ERAs, commensurate to risk of activity • RIDA under RPI Act in SEA (as a resource activity under P&G Act) – includes land use suitability assessment	**Likelihood: Possible** **Consequence: Major** **Overall rating: High**	E.g., Mary Kathleen abandoned ponds.

Line no.	Potential impact/ threat to LEB (Qld) river systems	Environmental attributes impacted		Initial risk	Management tool in LEB (Qld)	Residual risk	Panel notes
		Existing attributes	Potential attributes				
6.17	Surface water and groundwater quality impacts from disposal of drill cuttings and other solid wastes	Natural water quality	Functioning riparian processes Functioning wildlife corridors including springs	**Likelihood: Unlikely** **Consequence: Minor** **Overall rating: Low** **Notes from previous studies:** As per tight and shale gas.	• EA conditions for drill cuttings waste, commensurate to risk of activity • RIDA under RPI Act in SEA (as a resource activity under P&G Act) – includes land use suitability assessment	**Likelihood: Unlikely** **Consequence: Minor** **Overall rating: Low**	This is deemed as being low risk.
Minerals/coal mining							
6.18	Groundwater and surface water level/quality impacts from overflowing storage/treatment ponds (from flooding/ structural failure)	Natural hydrologic processes Natural water quality	Natural geomorphic processes Functioning riparian processes Functioning wildlife corridors including springs	**Likelihood: Possible** **Consequence: Major** **Overall rating: High**	• Construction and reporting requirements under EA conditions for structures which are dams or levees constructed as part of ERAs, commensurate to risk of activity • RIDA under RPI Act in SEA (as a resource activity under *Mineral Resources Act 1989* (MR Act)) – includes land use suitability assessment • Prohibition on open-cut mining in designated precinct under Regional Planning Interests	**Likelihood: Unlikely** **Consequence: Major** **Overall rating: High**	**E**.g., Mary Kathleen, Ranger uranium, Location based, Sensitive Environmental Areas need to be defined, Designated Precinct is adequate but increase the protected area.

Line no.	Potential impact/ threat to LEB (Qld) river systems	Environmental attributes impacted		Initial risk	Management tool in LEB (Qld)	Residual risk	Panel notes
		Existing attributes	Potential attributes				
					Regulation 2014 (RPI Regulation)		
6.19	Impacts to surface water flow/levels and changes to water quality from discharge of wastewater	Natural hydrologic processes Natural water quality	Natural geomorphic processes Functioning riparian processes Functioning wildlife corridors including springs	**Likelihood: Almost Certain** **Consequence: Major** **Overall rating: Very High**	• EA conditions for managing impacts of contaminant releases, including mine affected water, commensurate to risk of activity • RIDA under RPI Act in SEA (as a resource activity under MR Act) – includes land use suitability assessment • Prohibition on open-cut mining in designated precinct under RPI Regulation	**Likelihood: Possible** **Consequence: Major** **Overall rating: High**	Regulation and checks on the procedures and management.

6.20	Groundwater impacts from acid mine drainage, and leaching of tailings dams and other extraction/processing waste storage areas	Natural water quality	Functioning riparian processes
			
			Functioning wildlife corridors including springs
				Likelihood: Almost Certain
				
				Consequence: Major
				
				Overall rating: Very High
					• EA conditions for managing impacts for:
					  ○ tailings disposal and general waste management
					  ○ management of water quality (e.g. adapted Fitzroy EA model conditions)
					• RIDA under RPI Act in SEA (as a resource activity under MR Act) – includes
						Likelihood: Possible
						
						Consequence: Major
						
						Overall rating: High
							Once this process has started this process is hard to contain on a large scale particularly with pyrite.
							
							This is an ongoing issue.

Line no.	Potential impact/ threat to LEB (Qld) river systems	Environmental attributes impacted		Initial risk	Management tool in LEB (Qld)	Residual risk	Panel notes
		Existing attributes	Potential attributes				
					land use suitability assessment • Prohibition on open-cut mining in designated precinct under RPI Regulation		
6.21	Surface water and groundwater quality impacts from disposal of solid wastes	Natural water quality	Functioning riparian processes Functioning wildlife corridors including springs	**Likelihood: Likely** **Consequence: Moderate** **Overall rating: High**	• EA conditions for waste management, commensurate to risk of activity • Duty of care requirements under the ACH Act • Waste Management Act	**Likelihood: Unlikely** **Consequence: Moderate** **Overall rating: Medium**	Site specific management, best practice, dependant of soil type and scale of waste generation. Localised, mitigation of this activity should be possible.
6.22	Groundwater and surface water impacts from evaporation of mine voids after completion of operations, including reduced water quality and alteration of overland flow	Natural hydrologic processes Natural water quality Beneficial flooding of land	Natural geomorphic processes Functioning riparian processes Functioning wildlife corridors including springs	**Likelihood: Likely** **Consequence: Major** **Overall rating: Very High**	• Decommissioning and rehabilitation requirements under EA conditions for structures which are dams or levees constructed as part of ERAs, commensurate to risk of activity • RIDA under RPI Act in SEA (as a resource activity under MR Act) – includes land use suitability assessment	**Likelihood: Possible** **Consequence: Major** **Overall rating: High**	Geographic location particularly if located on the floodplain. Auditing and compliance important.

Line no.	Potential impact/ threat to LEB (Qld) river systems	Environmental attributes impacted		Initial risk	Management tool in LEB (Qld)	Residual risk	Panel notes
		Existing attributes	Potential attributes				
					• Prohibition on open-cut mining in designated precinct under RPI Regulation		

Issue 7 – Agricultural practices

Line no.	Potential impact/ threat to LEB (Qld) river systems	Environmental attributes impacted		Initial risk	Management tool in LEB (Qld) (statutory and non-statutory)	Residual risk	Panel notes
		Existing attributes	Potential attributes				
Agricultural practices							
7.1	Groundwater and surface water impacts from water take (through water storage dams), including altered overland flow	Natural hydrologic processes Beneficial flooding of land	Natural geomorphic processes Functioning riparian processes Functioning wildlife corridors including springs	**Likelihood: Almost Certain** **Consequence: Minor** **Overall rating: Medium**	• Exemptions from *Water Act 2000* licencing requirements • Prohibitions on water storage dams under the Regional Planning Interests Regulation (RPI Regulation) that do not meet the domestic water needs of the occupants of the land, and/or water the stock that is usually grazed on the land, and/or water stock that is travelling on a stock route	**Likelihood: Almost Certain** **Consequence: Minor** **Overall rating: Medium**	Irrigation is not authorised in the basin and if it was to be allowed further assessment would be required. Grandfather existing licences for Irrigation in the basin. Use of mining water for use in irrigation.
7.2	Grazing impacts (including moving stock, emergency agistment and long-term grazing of the stock route network) which may include reduced vegetation structure and ground cover along stream banks and trampling of waterholes/springs	Natural hydrologic processes Natural water quality	Natural geomorphic processes Functioning riparian processes Functioning wildlife corridors	**Likelihood: Almost Certain** **Consequence: Moderate** **Overall rating: High**	• Grazing generally not regulated however a series of non-statutory guidance tools are available to support sustainable, opportunistic grazing on floodplains in the LEB (Qld) • Grazing on the Queensland stock route	**Likelihood: Possible** **Consequence: Moderate** **Overall rating: High**	Fencing of permanent waterholes from livestock access water quality due to livestock. Essentially a good strategy provided fencing is not washed away in some stronger flow areas. Need to consider the overall impacts of shifting dispersed cattle impacts on large waterholes to intense impacts at new watering points off-channel.

Line no.	Potential impact/ threat to LEB (Qld) river systems	Environmental attributes impacted		Initial risk	Management tool in LEB (Qld) (statutory and non-statutory)	Residual risk	Panel notes
		Existing attributes	Potential attributes				
	Site Specific/ Local		including springs		requires approval under the Stock Route Management Regulation 2003 and the Stock Route Management System		Lots of discussion about consequence as to if it is minor or Moderate which changes overall risk to be medium high. Location specific and dependant on management processes implemented. Potential for incentives to fence off waterholes. Fencing out waterholes, providing troughs for livestock 5% - 10% Land Condition D degraded (Phelps:2009 Mitchell grass recovery report; Tothill and Gillies 1992). Some disagreed with the 'High" rating given to grazing of riparian areas – whilst acknowledging this could be the case for some banks and waterholes. Given that most waterholes appear to be intact and there is a lack of evidence of long-lasting impacts from over 100 years grazing. But there was agreement to protect specific waterholes of

Line no.	Potential impact/ threat to LEB (Qld) river systems	Environmental attributes impacted		Initial risk	Management tool in LEB (Qld) (statutory and non-statutory)	Residual risk	Panel notes
		Existing attributes	Potential attributes				
							significance (and springs) from direct access by livestock. There could be public benefit from a water-hole fencing scheme and water point relocation to protect chains of waterholes that contribute to ecological values. This is highly dependent of livestock type and density – in many instances stock numbers are low and cause little to no lasting impact by walking down to water level to drink.
7.3	Water quality impacts from use of agricultural chemicals such as pesticides, herbicides, fertilisers and hormones	Natural water quality	Functioning riparian processes Functioning wildlife corridors including springs	**Likelihood: Unlikely** **Consequence: Minor** **Overall rating: Low**	• Prohibition on broadacre cropping within designated precinct under RPI Regulation • Restricted places from historical chemical use or disposal regulated under *Biosecurity Act 2014* for safety of livestock product supply chains • Registration for resource producer and compliance with end of waste code for fertiliser	**Likelihood: Unlikely** **Consequence: Minor** **Overall rating: Low**	Historic use for pesticides for Sheep dipping Intensive agriculture not permitted in the designated precinct. This area does not currently use these chemical/fertiliser. Area is considered clean.

Line no.	Potential impact/ threat to LEB (Qld) river systems	Environmental attributes impacted		Initial risk	Management tool in LEB (Qld) (statutory and non-statutory)	Residual risk	Panel notes
		Existing attributes	Potential attributes				
					wash water and slurry under *Waste Reduction and Recycling Act 2011* (WRR Act) • Exemption in western Queensland from requirements under *Chemicals Distribution Control Act 1966*		
7.4	Increased erosion and water quality impacts from cropping, soil tillage/cultivation, irrigation etc.	Natural hydrologic processes Natural water quality Beneficial flooding of land	Natural geomorphic processes	**Likelihood: Unlikely** **Consequence: Moderate** **Overall rating: Medium**	• Prohibition on broadacre cropping within designated precinct under RPI Regulation	**Likelihood: Rare** **Consequence: Minor** **Overall rating: Low**	Has occurred once it failed and as such operations such as this are prohibited in Designated Precinct. Potential changes in technology may allow future development for irrigation and intensive agriculture viable. Currently Intensive agriculture and broad acre cropping are excluded in Designated Precinct.
7.5	Impacts from aquaculture including water quality impacts from waste, disruption to water flows from artificial structures, and introduction of non-native/endemic	Natural hydrologic processes Natural water quality	Natural geomorphic processes Functioning riparian processes	**Likelihood: Almost Certain** **Consequence: Major** **Overall rating: Very High**	• Environmental authority (EA) under the *Environmental Protection Act 1994* (EP Act) and development approval (DA)/material change of use (MCU) under *Planning Act 2016*	**Likelihood: Unlikely** **Consequence: Minor** **Overall rating: Low**	Failed attempt of Red claw yabby aquaculture. Red claw is a threat to local native blue claw (research in progress, GU). Murray cod stocked in a dam; dam failed.

Line no.	Potential impact/ threat to LEB (Qld) river systems	Environmental attributes impacted		Initial risk	Management tool in LEB (Qld) (statutory and non-statutory)	Residual risk	Panel notes
		Existing attributes	Potential attributes				
	species (noxious fish & non-indigenous fish)	Beneficial flooding of land	Functioning wildlife corridors including springs		for intensive agricultural environmentally relevant activities (ERAs) – smaller scale activities may operate lawfully without this • Development permit under State Development Assessment Provisions (SDAP) code 17 for aquaculture • Registration for resource producer and compliance with end of waste code for associated water under WRR Act (where relevant) • Possession of noxious fish regulated under *Biosecurity Act 2014*		Translocated sleepy cod from northern Australia is already well-distributed in Cooper Creek, must not be enabled to spread, probably adversely interacts with endangered Cooper Creek catfish (Sternberg et al. paper). Other threats due to Mosquito fish *(Gambusia holbrooki*) and pet aquarium fish. Keep Aquaculture out of the floodplain and well away from water courses flowing in. Use endemic LEB species only.
7.6	Impacts from animal husbandry activities including water quality impacts from waste, disruption to water flows from holding structures, increased pest species	Natural hydrologic processes Natural water quality	Natural geomorphic processes Functioning riparian processes	**Likelihood: Possible** **Consequence: Minor** **Overall rating: Medium**	• EA under EP Act and DA/MCU under Planning Act for ERA (intensive activities only – smaller scale activities may operate lawfully without this)	**Likelihood: Unlikely** **Consequence: insignificant** **Overall rating: Low**	Ticks are not an issue, due to biosecurity regulations. Localised scale.

Line no.	Potential impact/ threat to LEB (Qld) river systems	Environmental attributes impacted		Initial risk	Management tool in LEB (Qld) (statutory and non-statutory)	Residual risk	Panel notes
		Existing attributes	Potential attributes				
		Beneficial flooding of land	Functioning wildlife corridors including springs		• Assessment against local government planning scheme • Biosecurity Act		
Other impacts associated agricultural practices (if identified by the panel)							
7.7	Grazing impacts (including moving stock, emergency agistment and long-term grazing of the stock route network) which may include reduced vegetation structure and ground cover along stream banks and trampling of waterholes/springs LANDSCAPE SCALE	Natural hydrologic processes Natural water quality	Natural geomorphic processes Functioning riparian processes Functioning wildlife corridors including springs	**Likelihood: Almost Certain** **Consequence: Minor** **Overall rating: Medium**	• Grazing generally not regulated however a series of non-statutory guidance tools are available to support sustainable, opportunistic grazing on floodplains in the LEB (Qld) Grazing on the Queensland stock route requires approval under the Stock Route Management Regulation 2003 and the Stock Route Management System	**Likelihood: Unlikely** **Consequence: Minor** **Overall rating: Low**	Fencing of permanent waterholes from livestock access Water quality due to livestock. Lots of discussion about consequence as to if it is minor or moderate which changes overall risk to be medium high. Location specific and dependant on management processes implemented. Fencing out waterholes.
7.8	Impacts from increased pest species	Natural hydrologic processes Natural water quality	Natural geomorphic processes Functioning riparian processes	**Likelihood: Almost Certain** **Consequence: Major** **Overall rating: Very High**	• EA under EP Act and DA/MCU under Planning Act for ERA (intensive activities only – smaller scale activities may operate lawfully without this)	**Likelihood: Likely** **Consequence: Major** **Overall rating: Very High**	Weeds are certainly a big issue. Pigs, prickly Acacia, parthenium, goats and camels. These and other species have had big impacts in very remote parts of Australia (Alice Springs

Line no.	Potential impact/ threat to LEB (Qld) river systems	Environmental attributes impacted		Initial risk	Management tool in LEB (Qld) (statutory and non-statutory)	Residual risk	Panel notes
		Existing attributes	Potential attributes				
		Beneficial flooding of land	Functioning wildlife corridors including springs		• Assessment against local government planning scheme • Biosecurity Act		region, Gulf Plains) and we should not therefore be complacent that they won't become big issues out in this pristine river system. The fact that anything can be washed in and/or follow the river system is an added concern. Note risks to springs (IESC report).

Issue 8 – Increased visitor access from tourism

Line no.	Potential impact/ threat to LEB (Qld) river systems	Environmental attributes impacted		Initial risk	Management tool in LEB (Qld) (statutory and non-statutory)	Residual risk	Panel notes
		Existing attributes	Potential attributes				
Increased visitor access from tourism							
8.1	Surface water quality impacts from increased erosion (due to pedestrian/vehicle trampling) and pollution (from littering and other wastes)	Natural hydrologic processes Natural water quality	Natural geomorphic processes Functioning riparian processes Functioning wildlife corridors including springs	**Likelihood: Almost Certain** **Consequence: Moderate** **Overall rating: High**	• Non-statutory control measures such as fencing, signage etc.	**Likelihood: Possible** **Consequence: Moderate** **Overall rating: High**	Restricted to certain areas Highly specific, highly localised. Management of recreation and tourism is required. Possible threat from fishing in waterholes. Use of illegal nets etc. Smaller area of the basin affected. Proximity to towns. Formal areas to camp and park, amenities and facilities. Providing more of this and siting strategically – not necessarily right at the best waterholes – could help in the long term to manage these values.
8.2	Increased pest and weed species from visitors, resulting in	Natural hydrologic processes	Functioning riparian processes	**Likelihood: Likely**	• *Biosecurity Act 2014* requirements	**Likelihood: Possible**	Weeds and pest are difficult to manage once

Line no.	Potential impact/ threat to LEB (Qld) river systems	Environmental attributes impacted		Initial risk	Management tool in LEB (Qld) (statutory and non-statutory)	Residual risk	Panel notes
		Existing attributes	Potential attributes				
	impacts to riparian function (and associated fauna)	Natural water quality	Functioning wildlife corridors including springs	**Consequence: Moderate** **Overall rating: High**	• Non-statutory control measures such as fencing, signage etc. • Non-statutory land and sea ranger program supports land management such as management of pest/weed species	**Consequence: Moderate** **Overall rating: High**	they have taken hold in an area. Management and mitigation measures are impossible to implement over broad scale. Education of tourists and general public (large signage: "You are now entering a near-pristine river basin, one of the last in the world, please do not bring any weeds in mud on your vehicle, release any animals/fish, etc.")
Other impacts associated with tourism (if identified by the panel)							
8.3	Recreational fishing, black market, take, unmanaged fishing			**Likelihood: Almost Certain** **Consequence: Major** **Overall rating: Very High**	Fisheries Act 1995 Education	**Likelihood: Likely** **Consequence: Major** **Overall rating: Very High**	Regulation of fishing. Enforcement and education. Education. Bag limits, ban gill nets, bycatch.
8.4	Impacts from introduction of non-native/endemic	Natural hydrologic processes	Natural geomorphic processes	**Likelihood: Almost Certain**	• Environmental authority (EA) under the *Environmental Protection Act 1994* (EP Act) and development approval	**Likelihood: Likely** **Consequence: Major**	Introduction of these species has significant impact on native species

Line no.	Potential impact/ threat to LEB (Qld) river systems	Environmental attributes impacted		Initial risk	Management tool in LEB (Qld) (statutory and non-statutory)	Residual risk	Panel notes
		Existing attributes	Potential attributes				
	species (noxious alien fish & non-indigenous fish translocated from other catchments)	Natural water quality Beneficial flooding of land	Functioning riparian processes Functioning wildlife corridors including springs	**Consequence: Major** **Overall rating: Very High**	(DA)/material change of use (MCU) under *Planning Act 2016* for intensive agricultural environmentally relevant activities (ERAs) – smaller scale activities may operate lawfully without this • Development permit under State Development Assessment Provisions (SDAP) code 17 for aquaculture • Registration for resource producer and compliance with end of waste code for associated water under WRR Act (where relevant) • Duty of care requirements under the ACH Act Possession of noxious fish regulated under *Biosecurity Act 2014*	**Overall rating: Very High**	and the system. See notes on pest species above. Having seen the impacts of carp and Tilapia, this must be one of the most serious issues, and not limited to caused by tourism. E.g., carp is not yet in LEB, but is in Warrego and other Murray Darling Basin streams.

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