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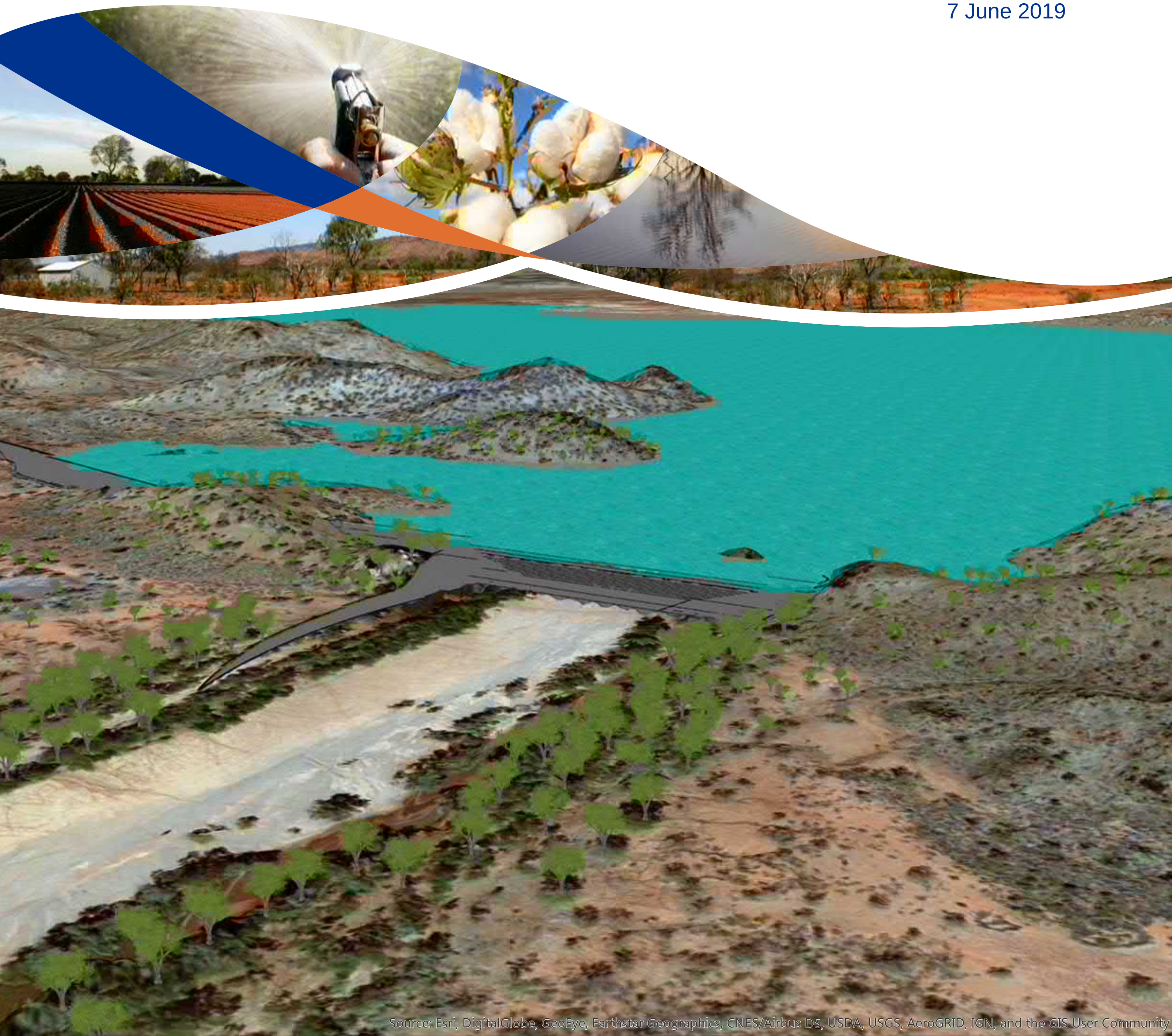
Cloncurry River Dam

Detailed Business Case

For

Mount Isa Townsville Economic Zone Inc (MITEZ)

7 June 2019



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Jacobs Australia Pty Limited

32 Cordelia Street
PO Box 3848
South Brisbane QLD 4101 Australia
T +61 7 3026 7100
F +61 7 3026 7300
www.jacobs.com

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1d	7 June 2019	Updated Final DBC for DNRME	Cameron Smith, Scott Abbey, Leon Hellberg, Russell Paton and Sam Watt	Angus MacDonald	Michelle Watson

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Final Report

1. Executive Summary

Background

This report describes the detailed business case (DBC) of a new dam on the Cloncurry River. The DBC forms part of a strategic investigation into improving the supply of water in north-west Queensland to achieve agricultural development and provide water security for the Mount Isa—Cloncurry Region.

The strategic investigation is supported by funding from the Australian Government National Water Infrastructure Development Fund (NWIDF), an initiative of the Northern Australia and Agricultural Competitiveness White Paper. The Mount Isa to Townsville Economic Zone Inc. (MITEZ) secured the funding and contracted Jacobs to undertake the investigation in accordance with the guidelines prepared by Building Queensland (BQ).

A preliminary business case (PBC) was completed in 2018, which investigated several options to provide water and advance irrigated agriculture in the region. It found that a new dam on the Cloncurry River, at a site called "Cave Hill", was the option most likely to meet the identified service need in the area.

The hypothesis underpinning the second stage of the strategic investigation, the DBC, is that a new large dam on the Cloncurry River will facilitate the development of irrigated agriculture on the fertile soils along the river. This, in turn, will support economic diversification and critically contribute to social prosperity in the region. The dam will contribute significant additional water storage to the Mount Isa—Cloncurry Region and improve water security for urban communities and the mining and mineral processing sectors.

The key objective of the DBC is to explore the opportunity of the dam as a new infrastructure solution to deliver water primarily for irrigation.

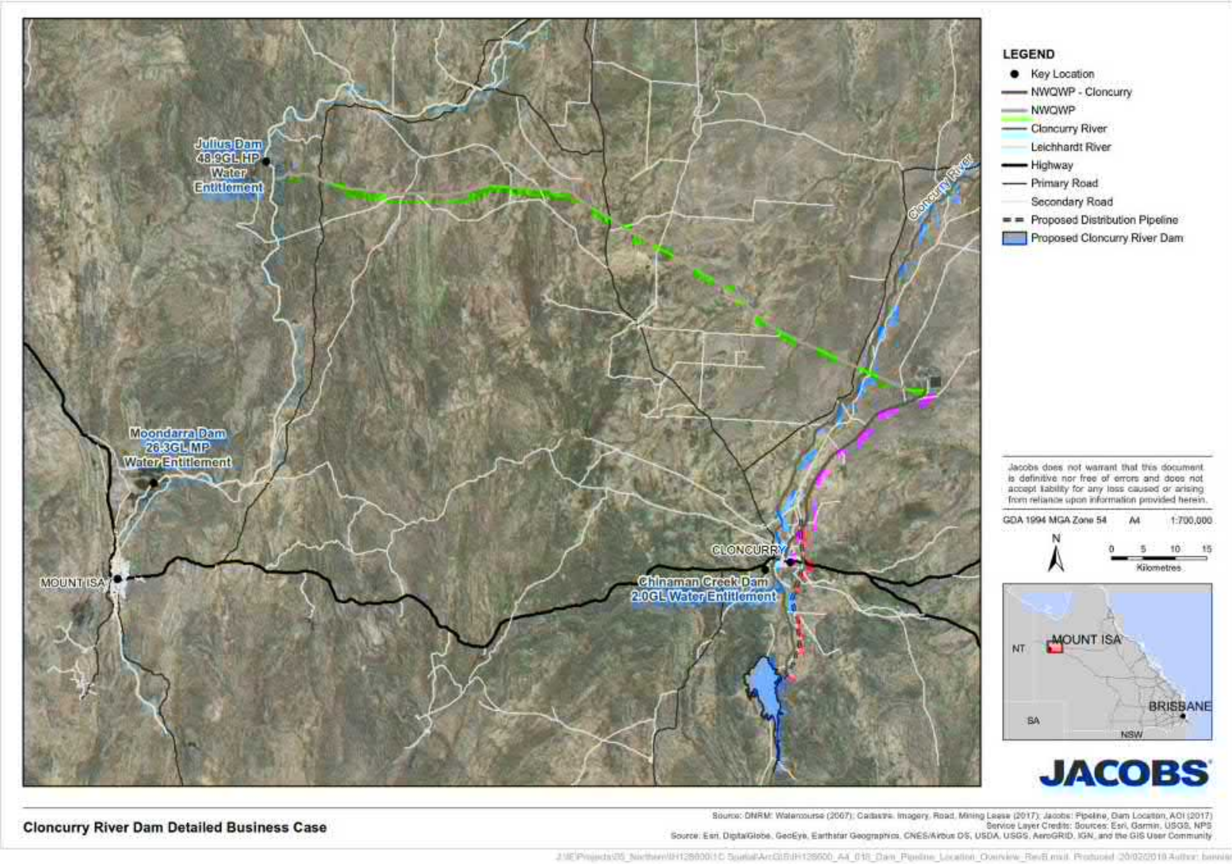
Current major water storages in the Mount Isa-Cloncurry Region include Julius and Moondarra Dams on the Leichhardt River near Mt Isa, and Chinaman Creek Dam near Cloncurry. They have the capacity to deliver 49, 26 and 2 gigalitres (GL) of water per year, respectively. These storages were built decades ago to meet mining, mineral processing and urban water demand in the region. The North West Queensland Water Pipeline (NWQWP) connects the two catchments and supplies water from Julius Dam to clients in the Cloncurry Region.

The Cloncurry River Dam, as conceived in this report, has the capacity to deliver an additional 50 GL at 80% reliability.

This report details technical, financial, economic, social and institutional dimensions of the Cloncurry River Dam. It details challenges that the project faces and, ultimately, identifies the conditions that will result in the Cloncurry River Dam becoming viable in the medium to long term.

Figure 1.1. shows the geographical context of the investigation. It illustrates the location of existing water infrastructure and the proposed new dam and water distribution system.

Figure 1.1 : Study area existing and proposed water infrastructure



The need for a new dam

The supply assessment finds that urban water security of Mount Isa (population approx. 19,000) and Cloncurry (population approx. 3,200) can be provided by existing water supply infrastructure under the predicted modest population growth. This result concurs with findings of previous studies.

A synthesis of forecasts of mining water demand similarly finds that this demand, while variable and difficult to predict, can likely be met from existing storages and alternative sources unless significant unexpected developments emerge.

However, current storages cannot supply sufficiently abundant and affordable water to support irrigated agriculture.

There are extensive areas of land that are available and suitable for irrigation along the Cloncurry River.

Some landholders there can use unsupplemented water for irrigation. Under Queensland water regulations, in particular the Gulf Water Plan, landholders in the Cloncurry Region currently hold 155,000 megalitres (ML) of allocations for unsupplemented water, most of which have been acquired recently.

Of landholders having allocations, few use any water for irrigated agriculture. Key reasons for the low level of usage are that the construction of on-farm water storages is expensive, unsupplemented water is considered unreliable and current landholders are cattle graziers with limited experience with irrigated agriculture. Many landholders may have purchased water rights primarily to add to the asset value of their properties and to have the option to irrigate at some stage in the future or sell water entitlements, rather than for immediate use.

Without the construction of a large water storage a material shift towards irrigated cropping will not occur and low-input cattle grazing will continue to be the major agricultural activity of the region.

Only a new water storage on the Cloncurry River can conceivably deliver sufficiently reliable water to achieve the economies of scale required for the development of a viable irrigation industry. A flourishing irrigation industry will leverage associated services industries and processing infrastructure (e.g. a cotton gin) and generate value-adding opportunities for agricultural sectors, including the use of cotton seed to feed livestock on cattle grazing enterprises.

The expressed demand for water from current land owners exceeds the capacity of the dam to supply water. The owners of all nine properties that be supplied from the Cloncurry River Dam and associated pipeline network participated in the demand assessment. Three additional owners of adjacent properties were also consulted as part of the expression of interest process. Of the 12 properties included in the demand assessment, three stated a demand for water. The combined demand is 62.8 GL of medium reliability water, compared to the Cloncurry River Dam's delivery capacity of 50 GL at 80% reliability.

The project

The Cloncurry River Dam unlocks the opportunity for targeted development of an irrigated agriculture sector in the study area. The project is consistent with contemporary federal and state strategies related to the promotion of high-value agriculture production and the development of northern Australia.

The Cloncurry River Dam will be on Roxmere Station, 20 km south of Cloncurry.

The dam wall will cross the Cloncurry River at a site known as "Cave Hill" and stand approximately 25 metres above the river bed. The dam can store approximately 140,000 ML water and have a footprint of approximately 50 square kilometres. The land which will be inundated is currently used for cattle grazing and nature conservation. The water will be delivered up to 40 km north of the dam (downstream) where black soil suitable for cropping is available. Key details of the project are summarised in Table 1.1.

The main dam and the spillway will be constructed using the roller compacted concrete (RCC) method to minimise construction risk. In contrast to other construction methods, an RCC construction can be overtopped by a flash flood, even when partially built, without being damaged or washed away. This is important as the Cloncurry River is prone to flooding during summer following erratic but heavy rainfalls in the upper catchment.

Other saddle dams are to prevent leakage to the north of the main dam. These dams are significantly smaller and can be earth-embankment constructions. A fuse plug spillway will be included in the saddle dam to the south of the main dam. The main dam includes a water outlet that can supply the pipeline and provide for environmental releases.

The irrigation water distribution network includes a 40 km pipeline, one pump station, and a renewable energy source. The proposed design includes a solar array and associated battery storage to offset a proportion of the annual pumping costs and provide an income stream outside the irrigation season.

Table 1.1 : Characteristics of the project

Characteristic	Metric
Location	"Cave Hill", Roxmere Station, Cloncurry River Latitude: 20.8691 S Longitude: 140.4945 E
Dam name	Cloncurry River Dam (or "Cave Hill Dam")
Dam status	Proposal
Purpose of storage	Irrigation and water supply
Dam type	RCC main embankment incorporating a fixed crest spillway. Fuse plug spillway in a saddle south of the main embankment Three saddle dams, zoned earth fill, north and northwest of the main embankment
Catchment area:	5,107 km^2
Storage at full supply level	140,827 ML
Surface area at full supply level	3,277 ha
Main embankment and spillway height	25 m
Main spillway crest length	240 m
Total length of main embankment	445 m
Distribution Network Length	40 km approximately

Potential benefits and impacts

The major beneficiaries of the project will be downstream landholders along the Cloncurry River who will be able to initiate irrigation projects. It is also conceivable that future mining and mineral processing industries will benefit from an additional, possibly cheaper than the NWQWP, source of water.

Yield modelling confirms that the dam can supply a nominal volume of 50,000 ML per annum with a monthly reliability of between 70 and 90 per cent over a 150-day delivery period and an annual reliability of between 40 and 80 per cent. For our analysis, we have assumed a long-term water use of 76%, corresponding a mean annual diversion of 37,792 ML for the preferred hydrological model.

The project can support 3,150 hectares of new irrigated agriculture near Cloncurry. Assuming cotton is grown on this land, it is estimated this will increase gross agricultural production in the region by $14 million annually.

The project will generate significant employment benefits in the Cloncurry region. During construction, the project is estimated to generate 396 construction full-time equivalent (FTEs) jobs over three years. Once operational, there will be two ongoing operator FTEs and an additional 58 FTE other ongoing jobs, including 37 FTEs directly related to agriculture and 21 FTE jobs indirectly related to agriculture (e.g. jobs in the provision of goods and services to agriculture, including transportation, processing, mechanical services and accountancy).

Through the injection of money into the regional economy and employment, the project will provide important economic impetus and generate social benefits for the community. Jobs will help reverse the recent population decline and rising unemployment experienced in Cloncurry (and Mount Isa). These trends are a result of the recent downturn in the mining and mineral processing sectors—the largest source of employment in the region. Given the diversity of jobs generated, the project will help alleviate the divide between the highly remunerated employed segment of the population and the currently unemployed or people with low remuneration.

Many of the jobs in the construction phase will be taken up by worker from elsewhere, therefore creating demand for accommodation. Based on Cloncurry's ability to accommodate a large long-distance commuting workforce during the mining boom, this demand can be met by existing housing options, including rental housing, motels and short-term accommodation facilities.

An additional water supply, though not deemed necessary to meet urban water needs in the foreseeable future, will add to water security and drought resilience of Cloncurry but also, indirectly, Mount Isa under expected climate change conditions.

A dam will create a large ponded area of water within 20 km of Cloncurry. This has the potential to increase the amenity of the local area by providing opportunities for activities such as fishing, kayaking, water skiing and camping for residents and tourists. Conceivably, tourists may stay longer in Cloncurry thus further enhancing economic benefits generated by the project. The construction of any new dam has environmental impacts. The dam will cause clearing of native vegetation to facilitate construction and, when the dam fills, at least 3,277 hectares will be inundated. Twelve EPBC Act listed threatened fauna species have been identified as occurring in the project area. At this early stage of the project, no offset mechanisms have been considered.

Storing and diverting water from the Cloncurry River will alter environmental flows and consequently downstream habitats, including declared fish habitat areas in the Gulf of Carpentaria. The outlet works and fish passage are in the right abutment of the main dam. To conform to the requirements of the water plan and meet Environmental Flow Objectives (EFO), which hydrological modelling shows are up to 55,000 ML/d, the dam needs to be capable of significant compensatory releases of inflows when the reservoir level is below the spillway level as well as smaller releases to offset the dam's impact on existing water users.

Stakeholder opinion

The notion of a new dam on the Cloncurry River has strong support from the Cloncurry Shire Council, which sees it as critical to the development of irrigated agriculture, which, in turn, will underpin future growth and social prosperity of the town and local government area. The Shire Council also sees benefits for water security long-term and expects possible co-benefits of a dam for liveability and recreation.

There is mixed support from agricultural producers near Cloncurry, with some landholders expressing demand for water while others are not interested in pursuing irrigation agriculture or are outside the delivery radius for water from the dam. There is general support for the implementation of an experimental irrigation farm at Cloncurry, which emerged in the PBC report as the single most important strategy to overcome the lack of experience with irrigated agriculture in the Mount Isa-Cloncurry region.

The mining and mineral processing sectors are supportive of the project and think it may be able to provide an additional water source for new industrial activities at some stage in the future. However, there is no immediate site-specific mining or mineral processing demand for water.

Traditional owner groups consulted are strongly opposed to the project as it will impact on culturally important values (e.g. stories) and physical sites in the inundation area of the dam, upstream and downstream of the dam on the Cloncurry River, and potentially along the pipeline route.

Environmental interest groups are also likely to oppose the project as inundation of 50 km^2 of land some of which is declared nature reserve, will affect ecological values. The carbon footprint of the project can be mitigated to some extent by sourcing local materials and contractors, where available, and using solar power for irrigation pumping.

Project financial and economic assessment

The dam failure impact assessment identifies significant risks as the dam is only 20 km upstream from Cloncurry and much of the town is located on the river flats. If the dam was to fail, this area of town would be inundated with very little warning, and it is estimated that up to 970 persons might be affected. This puts the Cloncurry River Dam in the 'high risk' hazard category. To ensure the dam is safe, in accordance with ANCAP guidelines, it is engineered to have a flood capacity equivalent to the largest rainfall event expected in the catchment above the dam. This means the dam wall is much higher and stronger than would be required for a dam of the same size in a low-risk location. This also means the dam is significantly more expensive to build.

The raw capital cost estimate for the project is $459 million which escalates to $494 million when risk adjustments and contingencies are included. Operating costs are estimated to be $2.4 million per year.

The project will create total economic benefits estimated to be worth $150 million (over thirty years), with a net economic loss of $322 million after subtracting the upfront and ongoing costs of the project.

The project has a benefit–cost ratio (BCR) of 0.3.

Consequently, the project is not economically viable at this time under the assumptions applied in the analysis. For the project to become viable, there must be a significant decrease in the capital and operational costs associated with the project, and/or increased returns from agriculture and/or major new demand from the urban, mining and mineral processing sectors, which are able to pay higher water charges.

Financial analysis of the project assumes that 100% of the dam's water allocation is pre-sold with irrigators paying $1,500 per ML upfront for a total of $75 million. This $/ML amount mirrors the value of medium priority water allocations permanently traded in SunWater schemes in inland Queensland where cotton is grown. The funding shortfall needs to be covered by government grant funding or provision of a (concessional) loan.

Financial modelling shows that only in the scenario where government contributes 86% of costs in the form of a non-repayable capital grant is the project financially viable and results in a high likelihood of affordable water prices for irrigators.

The financial and economic assessments are based on hydrologic modelling that uses historical climate and rainfall data. Climate change may warrant revisiting of the business case in the future. Should there be more frequent and/or longer droughts in the future, this will cause an increase in the value of water for the agricultural industry. Under such a scenario, the reliability of existing water sources could decline. This would be further exacerbated if the demand for water from other water users (including mining and minerals processing) were also to increase. Climate change effects coupled with increased future demand may therefore lead to a situation where the benefits of the project need to be re-evaluated.

The path to realisation

While CSIRO (2013) first explored the option of a dam on the Cloncurry River at Cave Hill, this DBC now confirms the exact locality, provides important clarity around technical and functional design, established a P90 estimate of costs, explores financial and economic benefits, and identifies areas of concern particularly relating to environmental and cultural impacts.

If a proponent for the project is found and pursues its realisation, the exact demand for water will need to be clarified. The project will also require several government approvals before it can proceed, and construction can commence.

The project will need to be referred to the Australian Government for determination whether it is a controlled action under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). An Environmental Impact Statement (EIS) will need to be prepared. The EIS will involve several large-scale detailed studies to anticipate all environmental flow, water quality and flora and fauna impacts.

A Cultural Heritage Management Plan will also need to be developed and approved. This will involve conducting an extensive cultural heritage survey and consulting with the Mitakoodi Mayi Traditional Owners. A Native Title determination over an area including the dam site is pending and, if Native Title is found to exist, a formal agreement with the Native Title holders will need to be negotiated.

Agreement will need to be secured from DNRME, that under the Gulf Water Plan, enough water is available for the project and that downstream environmental flow requirements can be met before the project can proceed.

In the meantime, as per a recommendation of the PBC, establishing an irrigated agriculture trial farm near Cloncurry can provide an important step towards realisation of the project. Demonstrating the success or otherwise of different irrigated crops, varieties and production methods helps reduce the skill and knowledge impediments to the uptake of irrigated agriculture by landholders in the region. In the short term, this may lead to the higher utilisation of existing water allocations, and eventually a higher valuation on potential higher reliability water sources.

CSIRO showed that in the Flinders catchment, which includes the Cloncurry River, large on-farm dams could potentially support up to 20,000 hectares of irrigated crop production seven or eight out of 10 years (CSIRO, 2013). Agriculture developed from on-farm storages could contribute towards a larger development.

If the project is to proceed, a ‘design and construct contracting model’ would be recommended, depending on the expertise of the proponent and the prevailing market conditions at that time. This model has proven successful for several comparable projects, including those successfully developed by Tasmanian Irrigation and in several large projects in the United States. This delivery model – in the case of this project – would likely combine the works for the dam and pipeline into a single package. There is proven capacity within Australian construction companies to construct the Cloncurry River Dam and distribution pipeline.

In summary

The DBC concludes that building a dam on the Cloncurry River is technically feasible and will create significant economic opportunities in the Cloncurry Region, facilitating the development of 3,150 ha of irrigated agriculture. The site at Cave Hill is a short distance upstream from Cloncurry and the dam needs to be engineered to high standards to minimise the risk of failure, making it an expensive piece of infrastructure to build. The project consequently faces significant challenges relating to return on investment. Other impediments are the lack of irrigation and cropping expertise among current landholders, small customer base and uncertain demand, environmental impacts and strong opposition from the Mitakoodi Mayi Traditional Owners.

Circumstances need to change, and these challenges overcome or significantly mitigated, before further development of the Cloncurry River Dam proposal can be considered.

2. Governance

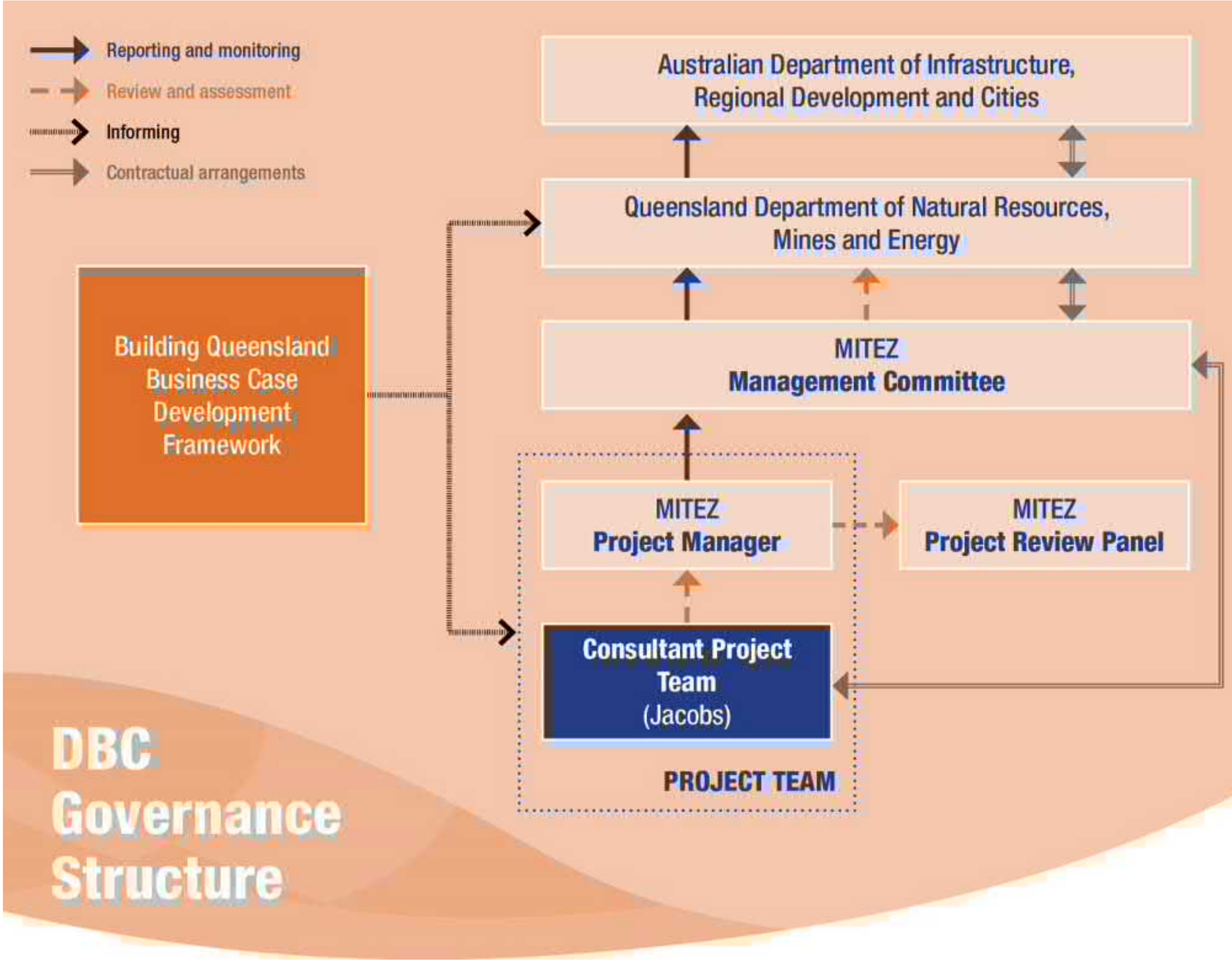
2.1 Key points

- This chapter establishes the governance context for the development of the business case including key roles and responsibilities
- This business case assesses the feasibility of an integrated water storage (Cloncurry River Dam) and associated irrigation infrastructure to service current and future agricultural needs in the Mount Isa—Cloncurry Region.
- The Mount Isa to Townsville Economic Zone Inc. (MITEZ) is the owner of this report.
- MITEZ secured funding from the Australian Government's National Water Infrastructure Development Fund (NWIDF) for this investigation.
- MITEZ contracted Jacobs Consulting (Australia) Pty Ltd (Jacobs), to undertake this detailed business case.
- A project review panel was appointed by the MITEZ Management Committee to peer review materials produced by Jacobs.
- The panel consisted of four professionals with expertise in areas of relevance to the project.
- The Department of Infrastructure, Regional Development and Cities (DIRDC) was the Australian Government agency with responsibility for all feasibility studies funded by the NWIDF.
- The Department of Natural Resources, Mines and Energy (DNRME) was the lead agency for the Queensland Government.

2.2 Project governance

Project governance arrangements are set out in Figure 2.1.

Figure 2.1 : Overview of Cloncurry River Dam DBC governance



Source: Jacobs analysis

2.2.1 Project owner

MITEZ is the project owner. MITEZ had oversight of the Cloncurry River Dam DBC, through the MITEZ Management Committee. MITEZ was instrumental in establishing the need for the feasibility investigation of potential water storage options in the region, submitting the successful application for funding from the NWIDF.

2.2.2 Project manager

MITEZ appointed a project manager, Dr Romy Greiner, who was the lead author of the North West Queensland Water Supply Strategy Investigation (NWQWSSI; Alluvium 2016). Dr Greiner was the key MITEZ contact for this project and was responsible for reporting to the MITEZ Management Committee, working with and guiding the consultant project team and coordinating the review of business case chapters with input by other members of the project review panel.

2.2.3 Project team

MITEZ engaged Jacobs to deliver a PBC and DBC for the project over an 18-month period. Key members of the Jacobs project team are listed in Table 2.1.

Table 2.1 : Jacobs project team

Project review panel members	Expertise
Angus MacDonald—Project Manager	Business case delivery for water infrastructure projects, particularly under Building Queensland and Queensland Government Frameworks. Bulk and distribution irrigation, industrial and urban water pricing. Funding models for water infrastructure. Treatment of capital grants and customer contributions. Economic assessment of water infrastructure in an agricultural context. Financial and commercial analysis. Regulatory economics (specialising in water).
Michelle Watson — Project Director	Project managing multifaceted and complex projects involving multiple sites and teams working under tight timeframes. Delivery of Environmental Impact Assessments/Statements on large and complex projects.
Matt Bradbury—Economics, Financial and Commercial Lead	Bulk and distribution irrigation, industrial and urban water pricing. Funding models for water infrastructure. Financial and economic assessment of water infrastructure, ports, railways and other projects.
Scott Abbey—Civil and Dam Engineering Lead	Management of large, complex engineering projects, including dam upgrades. Leading hydrology/hydraulic assessments for EIS for dam projects in Queensland.

2.2.4 Project review panel

The MITEZ Management Committee appointed a project review panel to independently review the PBC, DBC and other key deliverables on behalf of the MITEZ. Members of the panel are listed in Table 2.2.

Table 2.2 : Project review panel

Project review panel members	Expertise
Dr Romy Greiner (Chair)—natural resource economist	Scientific research; resource economics; sustainable rural and regional development, policy design and program development
Dr Owen Stanley—regional development economist and emeritus professor, Charles Darwin University	Economic development, cost–benefit analysis, environmental economics, with a focus on remote Australia and Indigenous communities
David Stewart—principal engineer, Australian Dams & Water Consultants	Water engineering (geotechnical, dams and distribution systems)
Mr Ross Thompson—commercial, financial and contract specialist	Commercial and financial experience in mining and energy sector, with an extensive knowledge of the study area

The project manager negotiated reviewer input by other members of the review panel in accordance with individual areas of expertise. Panel members were responsible for review of their assigned deliverables, seeking clarification and making recommendations to improve the DBC. The project manager consolidated and communicated reviewer comments to Jacobs, organised meetings of the panel and the Jacobs project team, and guided implementation of reviewer comments into the draft report which was submitted to DNRME for review by Queensland Government agencies.

2.2.5 Australian Government oversight of the DBC

The DIRDC administers the NWIDF on behalf of the Australian Government. DIRDC operates under the auspices of the Minister for Infrastructure and Transport. The Australian Government transferred responsibility for the NWIDF from the Department of Agriculture and Water Resources (DAWR) to DIRDC on 19 December 2017.

The NWIDF reflects the Australian Government's commitment to water infrastructure planning to secure the nation's water supplies and deliver regional economic growth in response to the *Agricultural Competitiveness* and *Developing Northern Australia* White Papers. It was established following a 2013 election commitment from the then Coalition Opposition. The fund is $1.3 billion.

The Cloncurry River Dam Feasibility Investigation (PBC and DBC) is one of 15 feasibility studies funded by the NWIDF in Queensland. A bilateral agreement was negotiated between the Australian and Queensland governments which stipulates milestones for each of the projects and milestone payments.

In addition to capital (grant) funding of $1.3 billion, in May 2017, the Australian Government announced the separate $2 billion NWILF, which:

- was available to provide state and territory governments with concessional loans to co-fund the construction of water infrastructure
- aimed to accelerate the construction of major water infrastructure projects such as dams, weirs, pipelines and managed aquifer recharge projects to provide affordable and secure water supplies to support the growth of regional economies and communities across Australia.

The Australian Government's Regional Investment Corporation will deliver the NWILF. Australian Government grant or loan contributions will not exceed 50 per cent of total project costs. Eligibility for grant and loan funding is restricted to applicants with the written support of the state or territory minister responsible for water.

2.2.6 Queensland Government oversight of the DBC

The Queensland Government manages the 15 Queensland-based feasibility studies funded by the NWIDF under a bilateral agreement between the Australian and Queensland governments. The lead Queensland Government agency for the NWIDF funded feasibility studies, including this project, is DNRME.

DNRME has established a contractual arrangement, in the form of a deed, with each proponents of the NWIDF-funded projects, including MITEZ. The deed stipulates the scope of investigations to be undertaken and articulates delivery and financial milestones. Milestone payments are made by DNRME to MITEZ upon satisfactory completion of milestones. Satisfactory completion means that the investigations are compliant with the relevant Queensland Government frameworks for infrastructure and meet the requirements of the Australian Government, as set out in the bilateral schedule to the National Partnership Agreement for the NWIDF.

DNRME is responsible for liaising with DIRDC on NWIDF project matters. DNRME will update the Australian Government on the delivery of the business case.

The next chapter identifies the key risks involved in developing this business case, how identified risks are to be mitigated and details how key stakeholders in the proposed project were engaged.

3. Risk management and stakeholder engagement methodology

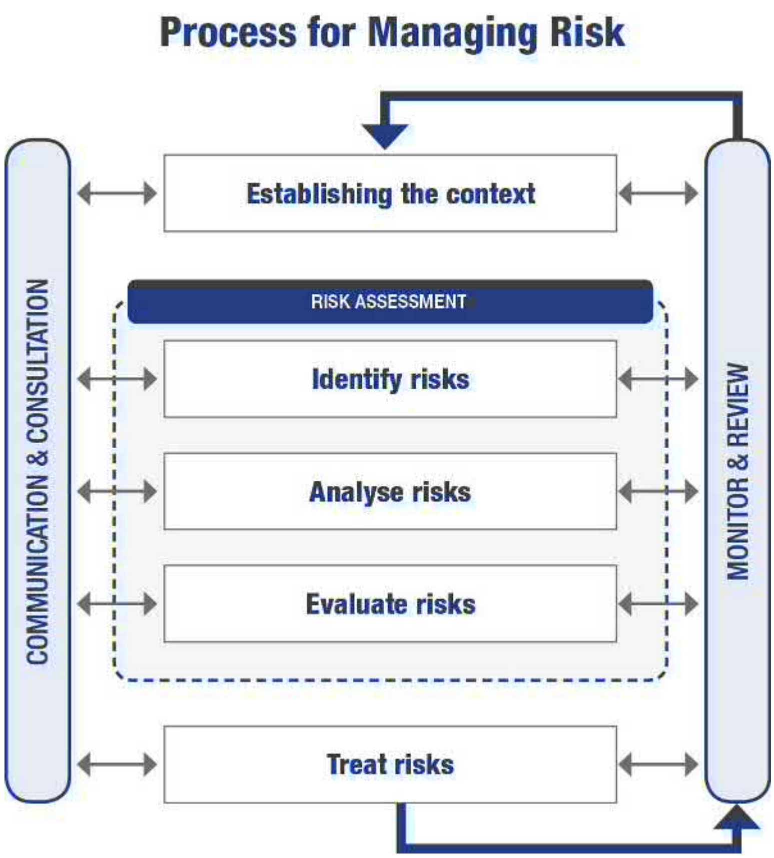
3.1 Key points

- This chapter establishes the methodology for identifying key risks and mitigation strategies relevant to the development of this business case. It also identifies the key stakeholders that need to be engaged as part of the analysis and a plan for accomplishing this.
- The risk management approach is aligned with the Building Queensland framework and other Australian standards.
- Key risks to the business case were identified as significant changes in the identified service need and the strategic financial and political context.
- Other key risks identified included data reliability, accuracy and currency and stakeholder engagement outcomes.
- The full risk register identified through this process is provided as Appendix B.
- Key stakeholders identified for engagement include relevant Government Departments and representatives at all levels, impacted landholders, potential customers and suppliers, environmental and community groups, regional businesses, peak bodies, utility providers and Traditional Owners.

3.1.1 Risk management method

The DBC risk management approach is aligned with the BQ framework (Building Queensland, 2016), DNRME risk matrix and the relevant Australian Standard, AS/NZS ISO 31000:2009 Risk Management—Principles and Guidelines (Figure 3.1).

Figure 3.1 DNRME risk management process adopted for the DBC



Source: (Department of Natural Resources, Mines and Energy, 2017, p. 2).

Several activities were undertaken to manage risk. These are described in Table 3.1

Table 3.1 : Activities to manage risk

Activity	Purpose
Qualitative risk workshops	Establish and update the existing risk register with mitigations, current controls and current risk rating of open risks, future controls and residual risk ratings; monitor the effectiveness of controls; and identify new controls.
Quantitative risk workshops	Quantify material risks identified in the risk register, to inform probabilistic risk analysis.
Monte Carlo simulation and risk model	Run Monte Carlo simulations to map the risk profile of the project and report capex and opex at P90 confidence levels.

3.1.2 Risk identification

Risks were identified using the risk categories in the BQ framework. Proposal risks reflected that the proposal background is subject to changes, including potential changes to the service need, stakeholders, reference project and the strategic and political context. Changes may be caused by developments which impact the project but occur independently of the DBC process. For example, the service need may change if prices for commodities in the region rise or fall.

Methodological risks that were identified relate to the method, assumptions and practices underpinning the assessment of the reference project. Risks concerning data reliability and accuracy fall within this category. Identified process risks relate to stakeholder engagement activities and timing. Additional potential project risks included changes in governance arrangements, funding, delivery and timing.

22 project risks were identified through internal and external workshops (see Appendix B).

3.1.3 Risk analysis and assessment

Risks were analysed and assessed through internal and external workshops. The DNRME Risk Analysis and Scoring Matrix (Table 3.2) was applied to each identified risk during workshops.

Table 3.2 DNRME Risk Analysis and Scoring Matrix

Likelihood / consequence	Insignificant	Minor	Moderate	Major	Catastrophic
Almost certain	Medium (11)	Medium (16)	High (20)	Extreme (23)	Extreme (25)
Likely	Low (7)	Medium (12)	High (17)	High (21)	Extreme (24)
Possible	Low (4)	Medium (8)	Medium (13)	High (18)	High (22)
Unlikely	Low (2)	Low (5)	Medium (9)	Medium (14)	High (19)
Rare	Low (1)	Low (3)	Low (6)	Medium (10)	Medium (15)

Source: (Department of Natural Resources, Mines and Energy, 2017, p. 15)

The process relied on DNRME's description of risk likelihood (Table 3.3), which was used during the risk workshops that were conducted throughout the project.

Table 3.3 DNRME risk likelihood categories

Likelihood	Description	Example to assist stakeholders
Almost certain	The event is expected to occur in most circumstances	May occur once a year or more
Likely	The event will probably occur in many circumstances	May occur once every 3 years
Possible	Identified factors indicate the event could occur at some time	May occur once every 10 years
Unlikely	The event could occur at some time but is not expected	May occur once every 30 years
Rare	The event may occur only in exceptional circumstances	May occur once every 100 years

Source: (Department of Natural Resources, Mines and Energy, 2017, p. 15).

The range from 'yearly' to 'every 100 years' is appropriate for risks relating to water infrastructure, which has a long life.

A simplified version of DNRME's descriptions of consequences of project risks was adopted. Table 3.4 shows how to interpret DNRME's consequences for delivery of the business case; and the realisation of potential project benefits.

Table 3.4 DNRME risk consequences—impact on business case delivery and realisation of benefits

Consequence	Insignificant	Minor	Moderate	Major	Catastrophic
Impact on delivery of this business case	Negligible impact on effective delivery of business case	Minor impact on effective delivery of business case	Moderate impact on effective delivery of business case	Major impact on effective delivery of business case	Catastrophic impact on effective delivery of business case—cannot be done
Impact on realisation of project or option benefits	Negligible impact on realisation of project benefits	Minor impact on realisation of project benefits	Moderate impact on realisation of project benefits	Major impact on realisation of project benefits	Catastrophic impact on realisation of project benefits—cannot be realised

Source: Adapted from (Department of Natural Resources, Mines and Energy, 2017).

DNRME's qualitative guidance was then adjusted to quantify the consequence. This allowed for each risk to be ranked, and appropriately managed. Where a quantifiable risk to project delivery remained, risk adjustments were included in the total project costs. Further details in relation to financial risk adjustments are included in Chapter 16: Financial and Commercial Analysis.

Table 3.5 outlines the quantifiable categories considered as part of this DBC.

Table 3.5 Risk consequences—Financial impact for the project risks

Financial	Insignificant	Minor	Moderate	Major	Catastrophic
Financial consequence for the project	Financial loss can be absorbed	Financial loss requires reprioritisation	Financial loss requires additional customer funding	Financial loss requires significant additional customer funding	Financial loss with severe impacts on the project (e.g. customer capital funding)
Portion of capital cost as risk guide	0–1%	1–2.5%	2.5–5%	5–10%	>10%
Illustrative impact for a dam with capex of $300 million assuming top of range ^	0–$3 million	$3–$7.5 million	$7.5–$15 million	$15–$30 million	>$30 million

Note: ^ The illustrative impacts for the project have been calculated on an individual basis rather than as a combined or aggregated impact.

Source: Adapted from (Department of Natural Resources, Mines and Energy, 2017).

Several workshops were held to identify risks, and each risk was scored in accordance with the above process. Table 3.6 identifies the risk management activities undertaken to identify, analyse and evaluate risks for the Risk Register.

Table 3.6: Risk management activities and timing

Date	Process undertaken	Participants
September 2017 and October 2017	Agency risk identification workshops in Cairns and in Brisbane	Attended by representatives from MITEZ, DNRME, BQ, SunWater, DSD, EHP, DILGP and DAF
September 2017 and October 2017	Two internal risk workshops to identify and refine results of the agency risk workshops	Discipline practice leaders and specialists in economics, finance, engineering, environment, social assessment, cultural heritage and community engagement.
November 2017	Review of the Risk Register	MITEZ Project Review Panel
Early 2018	Review of the Risk Register as part of reviewing the draft PBC	Relevant government agencies

Source: Jacobs analysis

The overall project risk was calculated and compared with the risk tolerance level of the project team to determine the necessary risk treatment.

3.1.4 Risk treatment

Risk treatment occurred after assessment of the project risk. We considered mitigation measures separately for each risk identified. These measures involved tolerating the risk, avoiding the risk, sharing the risk, reducing or controlling the likelihood of the risk or reducing or controlling the consequences of the risk.

If high or extreme risks remained after all practical mitigation measures had been applied, such risks would be continuously monitored. Additional mitigation strategies were developed for this purpose during the project.

Details of risk mitigation measures and retained risks are provided in Appendix B.

After mitigation, of the 22 identified risks, no risks were rated as extreme and the following three risks were rated as high:

- key assumptions (e.g. demand and costs) turn out to be incorrect
- the DBC is completed after NWIDF funding is fully allocated
- a service need is not identified.

3.2 Stakeholder engagement

A structured plan was established during the PBC to guide the consultation process with targeted groups and representatives through in-person meetings, phone calls, workshops, presentations and written communications. Appendix C: Stakeholder Engagement Plan and Register details the plan and the results of consultation.

The DBC included an additional round of stakeholder consultations and demand assessment, which informed the overall demand (Chapter 6: Service need and demand assessment). The responses received were key input to establishing the service need and undertaking the demand assessment.

3.2.1 Stakeholder engagement plan

The starting point for stakeholder engagement was the identification of stakeholders and the development of a stakeholder engagement plan for the project. The engagement plan included for each stakeholder:

- stakeholder name or description
- extent of stakeholder interest
- extent of stakeholder influence
- proposed means of engagement (i.e. inform, consult/interview or active participation in workshops)
- risks of engaging with the stakeholder (or members of the stakeholder group)
- risks of not engaging with the stakeholder (or members of the stakeholder group)
- proposed strategies for mitigating and managing stakeholder risks.

Additional information on the stakeholder engagement plan and register is in Appendix C.

3.2.2 Summary of stakeholder engagement

Stakeholders generally considered the PBC and DBC to be a single integrated process. The engagement with stakeholders was guided by the stakeholder engagement plan (Appendix C) developed during the PBC and updated and reviewed for the DBC.

For the PBC, extensive consultation was undertaken with local and government stakeholders.

Key stakeholders and their relationship to the PBC were identified early in the project through multiple processes, including review of relevant studies, social mapping of the study area, and considering recommendations from stakeholders and agencies.

For the DBC, engagement with stakeholders built upon the extensive work of the PBC with focus on the development of Cloncurry River Dam. The project team engaged with the Australian, Queensland and local governments—including ministers, elected members and senior staff—and maintained contact regularly or as specific issues arose. A full list of consulted parties is included in Appendix C.

Members of the project team met with the single landholder who would be impacted by the construction of the proposed dam in person to outline the process of the project, the potential areas of impact and the proposed scope of future engagement processes once the DBC was completed.

Potential customers were identified and directly contacted by the project team during the service need and demand assessment phase. Channels of communication included emails, phone calls, in-person interviews and expression of interest forms.

The study area’s two Traditional Owner groups were extensively engaged during the PBC and DBC by face-to-face meetings in Cloncurry and Mount Isa and a shared visit to the Cloncurry River Dam site. There was also engagement through their legal representatives.

- the Kalkadoon people, who have made a successful native title claim to land within the Mount Isa and Cloncurry regions
- the Mitakoodi and Mayi people, whose claim to land within the Cloncurry Shire is under consideration.

Native title is relevant to any option including infrastructure built on native title land. Consultation with native title owners or claimants during the project process is an important step in the process of trying to reach an infrastructure solution.

Table 3.6 provides a summary of stakeholders and their interests in the DBC.

Table 3.6 : Analysis of stakeholders’ interest in the DBC

Stakeholder category	Stakeholder	Interest/s
Internal stakeholders		
Project partners	MITEZ Management Committee	Project owner
	Jacobs	Lead consultant for the project (engaged by project owner)
Australian Government		
Departmental Ministers	Minister for Agriculture and Water Resources	• Alignment with federal objectives and plans • Infrastructure that is properly planned and timed • Investment decision/approval • Environmental approvals/ requirements
	Minister for the Environment and Energy	
	Minister for Infrastructure and Transport	
Elected representatives	Federal Member for Kennedy	• Alignment with federal objectives and plans • Infrastructure that is properly planned and timed • Local economic, social and environmental impacts
Australian Government departments and authorities	Department of Infrastructure, Regional Development and Cities	• Administration of the NWIDF • Review of business cases • Alignment with federal objectives and plans
	Infrastructure Australia	
Queensland Government		
Premier and Departmental Ministers	Premier and Minister for Trade	• Investment decision/approval • Alignment with other Queensland Government department objectives and plans • Infrastructure investment that is properly planned and timed
	Queensland Treasurer	
	Minister for State Development, Manufacturing, Infrastructure and Planning	
	Minister for Natural Resources, Mines and Energy	
	Minister for Agricultural Industry Development and Fisheries	
Elected representatives	Queensland Member for Traeger	• Alignment with state objectives and plans • Infrastructure that is properly planned and timed • Local economic, social and environmental impacts

Stakeholder category	Stakeholder	Interest/s
Queensland Government departments, authorities and corporations	Queensland Treasury	• Alignment with other Queensland Government department objectives and plans • Infrastructure investment that is properly planned and timed • Review, input and feedback on the DBC • Ongoing management and delivery activities
	Department of Natural Resources, Mines and Energy	
	Department of State Development, Manufacturing, Infrastructure and Planning (including the Office of the Coordinator-General)	
	Department of Agriculture and Fisheries	
	Department of Environment and Science	
	Department of Local Government, Racing and Multicultural Affairs	
	SunWater	
Local government		
Councils	Cloncurry Shire Council	• Job creation in the region • Impact on environment • Advancing the area's status as an attractive place to invest • Increasing agricultural production
	Mount Isa City Council	
Community and business		
Landholders	Directly affected landholders at the Cloncurry River Dam site, including properties impacted by associated inundation and buffer zone	• Access to and from property • Delivery of land management activities during construction and operations • Property damage, loss, acquisition and compensation
Potential customers	Parties that could receive water from the project, including urban, mining and agriculture	• Up-front capital and ongoing annual cost estimates • Terms and conditions of water delivery • Timing and other impacts of the project
Potential contractors	Parties that could tender for the project if it is approved and funded	• Information on tender process and contract strategy • Promoting innovation, capacity and capability for the construction of the project • Terms and conditions of water delivery • Timing and other impacts of the project
Business and community	MITEZ	• Improved conditions for residents, industry and the agriculture sector • Minimal disruption to the local community and businesses during construction • Advancing economic growth and job creation in the region
Agricultural peak bodies	Flinders Agricultural Precinct	• Improved conditions for the agricultural sector • Advancing the region's status as an attractive place to invest
	Queensland Farmers' Federation	
	Cotton Australia	
Traditional owners / Aboriginal cultural heritage	Kalkadoon people	• Any native title or cultural implications
	Mitakoodi and Mayi people	

The next chapter reviews the findings of the strategic assessment that was completed as a precursor to the detailed business case.

4. Review of preliminary business case

4.1 Key points

- This chapter reviews the key relevant findings of the preliminary business case (PBC) completed as a precursor to the detailed business case (DBC).
- Based on prevailing market conditions and several uncertainties the PBC did not identify a compelling strategy to advance irrigated agriculture in the Mt Isa–Cloncurry region.
- The best option identified to advance irrigated agriculture in the region was Cave Hill Dam.
- The PBC recommended that the Cave Hill Dam proceed to the DBC as the reference project.
- The PBC recommended that the DBC should seek to identify the conditions that may result in the project becoming viable in the medium to long term.
- The PBC concluded that the DBC should seek to add to the enduring relevance (geotechnical, engineering design and yield) of Cave Hill Dam as the most promising option.

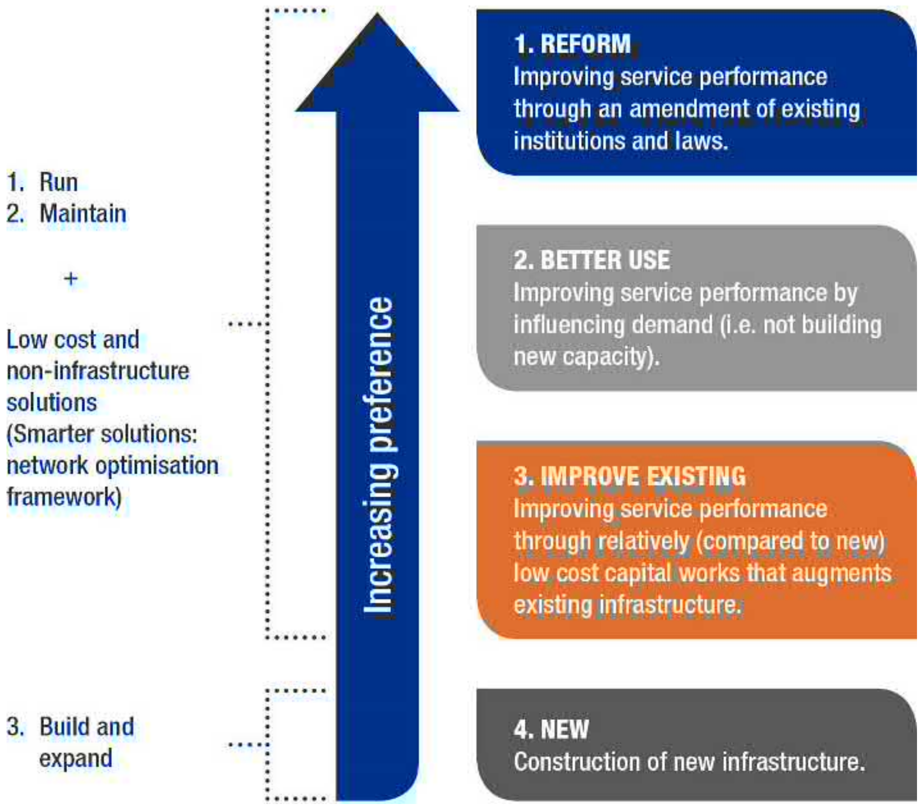
4.1.1 Project location

The study area was defined as the Mt Isa and Cloncurry local government areas (LGAs), principally encompassing the upper Leichhardt and Cloncurry river catchments.

4.1.2 PBC methodology

The key method of the PBC to consider water supply options and solutions was the Queensland Government's State Infrastructure Plan (SIP) Department of Infrastructure, Local Government and Planning (DILGP 2016) hierarchy and its supporting water policy document, the Queensland Bulk Water Opportunities Statement (QBWOS). The method was consistent the Building Queensland business case framework (Figure 4.1).

Figure 4.1: Building Queensland and State Infrastructure Plan (SIP) options assessment approach to infrastructure investment



The SIP and QBWOS prioritise options in the order of (i) reform, (ii) better use of existing water resources, (iii) improving the existing water infrastructure (e.g. limited to moderate capital investments) and (iv) build new (e.g. moderate to major new capital investments). This hierarchy was applied to ensure that the study area makes full use of its existing water entitlements and water infrastructure before any recommendations are made for capital expenditure on infrastructure upgrades or new build projects, such as dams and pipelines.

The PBC identified preferred option/s through a shortlisting process which involved:

1) establishing a clear service need
2) generating options, considering all options that could respond to the service need
3) developing options filters or selection criteria, building on the (BQ, 2016) criteria
4) applying multi-criteria analysis (MCA) to the options longlist
5) shortlisting options to create a shortlist for detailed analysis, based on the outcomes of the MCA.

4.1.3 Existing and future demand for water

To establish whether there was a basis for change, the existing and future demand for water were assessed and compared against existing water supplies. Current water demand from urban, industrial and mining can be met from existing supply sources, for at least the next 30 years (refer Chapter 5: Current situation and base case). Future water demand exceeding current supply can only manifest from agriculture. There is some demand for water from potential irrigators (refer Chapter 6: Service need and demand assessment)

In relation to future demand for water, the PBC found:

1) Current water supply infrastructure is enough to supply the urban demand of Mount Isa and Cloncurry for at least 30 years. Existing mineral processing companies may require small volumes (e.g. <200 ML p.a.) of additional water at Cloncurry in the short term, which can be supplied by existing infrastructure.
2) There *may* be significant demand for water from mining developments in the future, but the exact location, timing and volume of that demand are highly uncertain. This level of uncertainty, in combination with a decentralised development pattern, does not provide a case for a centralised water storage such as a new dam on the Cloncurry River.
3) If mining demand eventuated, it would need to be complemented by significant agricultural demand to underpin the case for a large new dam, as such infrastructure requires an enduring customer base for the 100-year life of a dam. Most local mines have operating lives of 30 years or less. New mining and mineral processing projects, or urban customers, could purchase water from willing agricultural sellers at market prices in the future, if needed.
4) There is currently very limited irrigated cropping in the Mount Isa–Cloncurry area. Principal land use is cattle grazing and very few landholders have expertise with cropping or irrigated agriculture.
5) Demand potentially exists for new water supplies for agricultural production; however, this would need to be confirmed in more detailed demand assessments once a preliminary design and costing for a preferred option are established. Soil suitability and land availability, however, are not constraints. Water is a key constraint on irrigated agricultural production, and several additional barriers to irrigated cropping (e.g. a lack of irrigation expertise, specialist advisors and supply chain capability) need to be addressed if irrigation development is to occur on a significant scale near Cloncurry.
6) The demonstration of successful irrigated farming on the Cloncurry River would be a critical building block towards an irrigated agricultural industry in the study area.

4.1.4 Options to meet possible irrigation demand

The PBC developed a longlist of options that would make additional water available (for irrigated agriculture) through research and consultation with a broad range of stakeholders. The options were assessed regarding their ability to meet the identified service needs and were aimed at increasing productive water use and economic resilience in the study area and north-west Queensland generally.

The longlisted options considered in the PBC aligned with the BQ Framework, the SIP and QBWOS. The options could be grouped into four principal approaches:

1) Reform – reform of existing institutions and laws
2) Better use – better use of existing resources (e.g. education or demand management)
3) Improve existing – investing relatively low capital expenditure to augment existing infrastructure
4) Build new – investing relatively high capital expenditure to construct new infrastructure (e.g. dams).

Each option was assessed on its technical merits and tested on other aspects with the input of stakeholders, including local and state governments, landholders, industry and traditional owner representatives in the area.

In total, 23 options were identified. Of these, six new-build options were excluded from detailed analysis as each had a 'fatal flaw' such as not being technically feasible from an engineering or environmental perspective, or because a site had significant Aboriginal cultural heritage or scientific value. This meant that these six options were principally unsuitable for development. The remaining options were then assessed against criteria that were developed for this project.

Each option was scored out of 100 and ranked. Results showed the three highest-scoring options as:

- Irrigated agriculture demonstration farm (72 points)
- Cave Hill Dam (69 points)
- Business as usual (66 points).

All other options scored less than the business-as-usual option and were not assessed in detail. Consistent with the BQ framework, the business-as-usual-option formed Option 1.

The shortlisted options are listed below.

Option 1: Business as usual

The base case reflected a 'business as usual' option, with no specific new water project, nor construction of new water infrastructure. This, however, was not a 'do nothing' option. Rather, it was a scenario in which the status quo changed over time in a dynamic economy and study area.

This option would not support large-scale irrigated agriculture. Developing irrigated agriculture would require currently unallocated water to be transferred from Lake Julius, via the North West Queensland Water Pipeline (NWQWP), to black-soil country in the Cloncurry area. Water delivered by the NWQWP retails at approximately $3000/ML and, at this cost, would be too expensive for irrigated cropping to make a return. Consequently, this option would not actively address the opportunity to expand irrigation and failed to support development of economic and social resilience beyond mining and mineral processing. It would miss out on the benefits of increased economic activity and employment in the region, which would be attributable to cropping if this sector was developed.

However, this option was likely to meet the urban needs of Mount Isa and Cloncurry for at least 30 years. It would also likely meet the needs of the existing mineral processing companies that may require an additional 85–185 ML per annum of high priority water in the short term.

Option 2: Demonstration farm

Option 2 involved establishing a demonstration farm approximately 7 km north-east of Cloncurry on the town common. The area of land is bounded by Ernest Henry Road (west), Mappley Park Road (east) and the town common property boundary to the north.

This option addressed current knowledge and human capacity constraints, which were considered to impede the development of irrigated agriculture on large-scale farms that already held water entitlements. The rationale stated that without a history of irrigated agriculture in the region, it was uncertain which crops and production practices would be best suited, and what gross margins would be achievable also in the context of distance to market and other challenges. It would be necessary to test the viability of irrigated agriculture before commencing large-scale operations or investing in a large water infrastructure solution such as a dam. Therefore, implementing a substantial 100 to 500-hectare demonstration farm would help to determine or inform the viability of irrigated agriculture in the region.

This option could help unlock the potential of water entitlements that already existed in the region, but which remained unused. Utilising these entitlements would increase employment and might, in time, lead to improvement in land values. Associated negative impacts might include environmental impacts such as reduction in habitat as a result of vegetation clearing, loss of riparian vegetation, changes in surface water and groundwater level and quality due to an increase in agricultural activity, and changes to hydrology as a result of the new water storage and increased irrigated cropping.

The demonstration farm would not require an EIS, but would require state and local government approvals to enable its implementation. Approvals would relate to the new land use on the town common, operational works and vegetation clearing.

The economic analysis considered the economic costs and benefits of the demonstration farm that would accrue in the study area. The benefits of the demonstration farm included the net revenue gained through growing and selling crops. This was measured using gross margins of $900 per hectare for 100 hectares, based on the assumed crop-mix trials that the advising agronomists recommended. The estimated economic benefit, considering the probability that the demonstration farm would provide knowledge that could be used by others on a bigger scale, was $1.0 million. Over 30 years, the estimated total economic benefit was $1.94 million in present value terms.

The total economic costs (including up-front capex to prepare the land and to construct an off-stream storage and pipeline from the Cloncurry River) were $4.8 million over 30 years. In total, the economic NPV was negative $2.9 million and the resulting a BCR of 0.40. This indicates that the direct economic benefits of the demonstration farm would be significantly less than the economic costs.

The financial analysis considered the financial returns that accrue to the infrastructure owner. This was done by measuring the up-front and ongoing costs of building and operating the demonstration farm and subtracting the net revenues. Over 30 years, the estimated risk-adjusted financial NPV was negative $5.6 million.

The economic and financial analysis indicated that this option should not be considered further in the DBC. However, there may be some additional benefits in a broader understanding of the value of a demonstration farm as part of enabling and promoting irrigated agriculture in the North West. Accordingly, the PBC recommended that a demonstration farm proceed before a large dam and distribution network are built to test to the variety of parameters that would inform profitable irrigated agriculture. For example, profitability depends on land preparation costs, water supply infrastructure, pest control, crop selections and yields, pest control and access to specialist services and markets. All such parameters of commercial farming could be tested as part of the demonstration farm, and the learnings shared with local landholders and potential investors from elsewhere.

However, it was not recommended that this option proceed to the DBC, as a project of such modest scale did not warrant a full DBC under the BQ framework. A focused implementation plan would be enough.

Option 3: Cave Hill Dam

Cave Hill Dam was the most promising ‘new build’ dam option, based on new design, costing and yield analysis (building on the CSIRO’s previous assessment), detailed consultation and a multi-criterion shortlisting process. The other dam options either had a fatal flaw, were very expensive per megalitre of yield, were too distant from customers and/or created insufficient benefits. Cave Hill Dam, by contrast, posed no fatal flaws and, of the dams considered, had the largest delivery capacity, lowest capital cost per ML and was closest to customers—generating the most benefit.

This PBC finding endorsed the results of previous studies, CSIRO’s 2013 report into the potential for irrigation development in the Flinders River catchment—the Cloncurry River being a tributary to the Flinders River (Petheram et al., 2013). The PBC Cave Hill Dam analysis was based on more precise data, particularly topographic and geological data. Consequently, there were differences between the PBC and the CSIRO-estimated parameters of a Cave Hill Dam (Table 4.1).

Table 4.1 : Comparison of CSIRO and PBC metrics of Cave Hill Dam

	CSIRO	PBC
Dam type	Zoned earth and rock fill embankment founded on the river bend sands with slurry trench cut-off to bed rock Earth and rock fill embankment saddle dam on the right bank side Diversion conduit and outlet works on the left abutment Unlined spillway with drop structures through a saddle to the west of the dam	Roller compacted concrete (RCC) with central overflow spillway A saddle dam on the right bank side
Full supply level	224 m (based on 5–10 m contour data)	More accurate (1 m) contour data shows that full supply level is 222.5 m
Storage capacity	248,000 ML	140,827 ML based on the lower full supply level (above) and more accurate contour data
Estimated yield	40,000 ML at 85% reliability, or 34,000 ML at 95% reliability.	50,000 ML at 80% reliability (requiring further clarification as this yield may not meet all environmental flow objectives)
Distribution	Releases to river for downstream diversions	40 km pipe network to minimise losses and maximise reliability
Estimated capital cost	Dam: $249 million (2013 dollars) Distribution works: Not included	Dam: $239 million for RCC type dam (2018 dollars) Distribution works: $68 million to deliver supply over 100 days Total: $307 million (2018 dollars)

Progressing to the construction of Cave Hill Dam would:

- put suitable soils on the river flats of the Cloncurry River to use for irrigated cropping, recognising that the limiting factor for agriculture in the study area is water, not land
- yield up to 50,000 ML of medium priority allocations at the dam wall, likely resulting in 4,000–12,000 hectares of irrigated crops, depending on crop selection and water losses (e.g. distribution via pipeline will minimise water losses and maximise cropping areas). This is a limited area of land relative to the size of local grazing properties. Grazing would be able to continue on the relatively large remaining areas of open downs country on local properties
- dramatically expand agriculture in the area
- potentially catalyse additional investment in agriculture by the private and public sector through:
  - attracting further investment in supporting infrastructure and industries such as feedlot/s, abattoirs, biofuels processing and/or a cotton gin in the region
  - generating an increase in support services required by irrigated cropping enterprises (e.g. fertiliser, seed, agronomists, farming machinery and contractors)
  - encouraging development of on-farm off-stream storages on the Cloncurry River (downstream) and potentially the Flinders River, which would be able to take advantage of the scale, infrastructure and services encouraged by a project such as Cave Hill Dam and other initiatives
- supply (future) mining and mineral processing developments south of Cloncurry, due to its location and its yield that would be higher than that of other dam options.

The social opportunity and impact risk analysis indicated that Cave Hill Dam may lead to, or at least support the development of, large new mines (south of Cloncurry) and large greenfield irrigated agricultural sites and supporting infrastructure (predominantly north of Cloncurry).

Cave Hill Dam would require an EIS to identify and assess project environmental impacts. Given the vegetation in the project area, this option is also likely to require assessment by the Australian Government in relation to potential impacts on Matters of National Environmental Significance (MNES). Representatives of the traditional owners in the area, the Mitakoodi and Mayi people, do not support a Cave Hill Dam proposal. Specifically, Mrs Pearl Connelly and Mr Gordon Connelly expressed concern about the potential of a dam being built on the Cloncurry River at this location. During consultation, Mrs Pearl Connelly stated:

> There are a lot of [significant] sites around the area [of the dam site]. There are important women's sites close to the river, near water and in the river—all different and in many places. It is Eagle Hawk dreaming there and men's sites along there too. I am not one to stop progress. This place though, it is highly sensitive. We don't want a dam there. No! (Mrs Pearl Connelly 12 December 2017)

Further, the construction of the Cloncurry River Dam under Option 3 would result in inundation of land currently used for rural purposes. Specific environmental impacts associated with this option include:

- loss of riparian zone and terrestrial habitat and changes in aquatic habitat due to inundation, alteration to flow and/or water quality
- barriers to movement of aquatic fauna as a result of the dam wall
- changes to downstream morphology of the Cloncurry River's bed and banks, which in turn has the potential to change in-stream habitat and allow an increase in invasive species
- impact on benthic substrates and their dependent macroinvertebrate communities, due to changes in sediment loads.

Based on high-level assumptions, the Cave Hill Dam would create $179 million of economic benefits over 30 years but would cost $404 million in equivalent present values (including the capital and operating costs of the project and on-farm) also over 30 years. This results in an economic NPV of *negative* $225 million and a BCR of 0.44 (substantially below a BCR of 1 needed for an economically viable project).

However, sensitivity analysis shows that some scenarios could create an economically and financially viable Cave Hill Dam, and these could be further investigated in the DBC. For example, it may be possible to improve the design or cost estimates associated with the dam and distribution network, which could result in lower capital costs. Further investigation and market testing as part of a DBC would also allow a reduction in the contingency and the risk allowances.

Capital cost required to make Cave Hill Dam economically viable (break-even)

Table 4.2 compares capital costs developed for the PBC with 'target' capital costs that would be required for Cave Hill Dam to be economically viable (i.e. deliver an economic BCR of 1).

Table 4.2 : Cave Hill Dam – Reduction to PBC project capex to achieve target BCR of 1 ($M) (7% real discount rate)

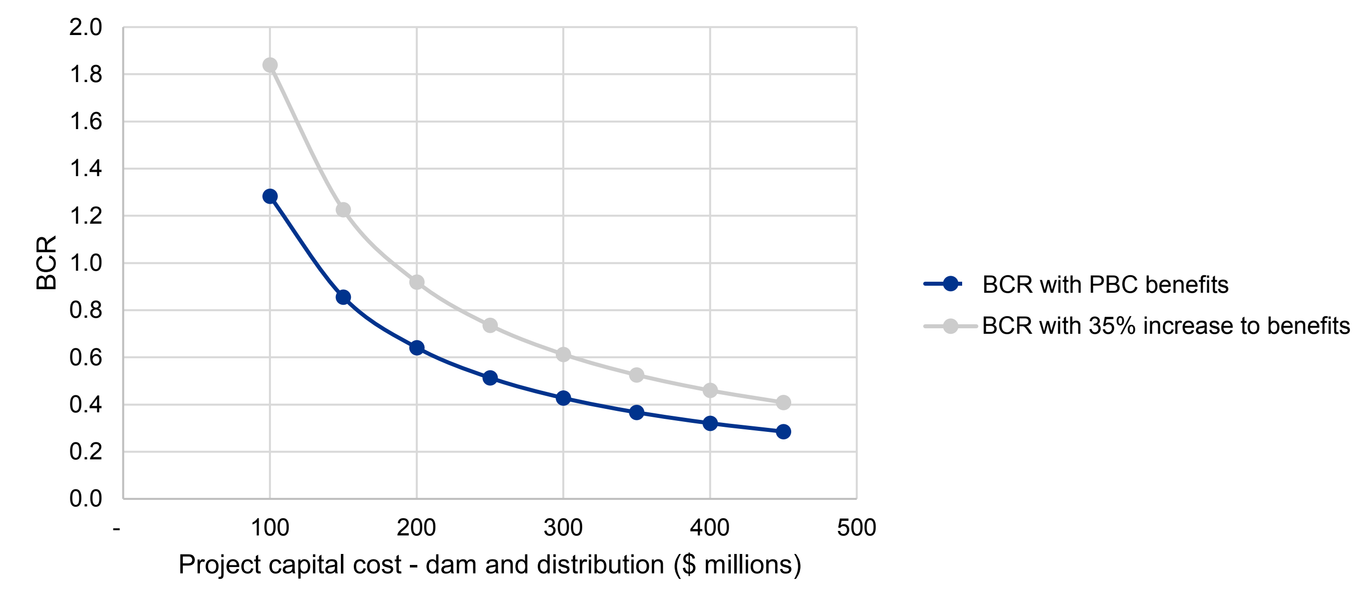
Project capex (dam and distribution only)	Net present value of project capex
PBC capex ($m)	289
Target capex ($m)	128
Reduction from PBC to target ($m)	161
Reduction from PBC to target (%)	56

Table 4.2 shows that the present value of Cave Hill Dam and pipeline capital costs need to be reduced from $289 million to $128 million (a 56% reduction) to achieve a BCR of 1.

Figure 4.2 shows the results of further sensitivity analysis of the BCR based on different capex scenarios holding estimated benefits constant. The BCR curve crosses the value of '1' at project costs of approximately $128 million.

Included in Figure 4.2 is a second frontier which represents a 35% increase in the PBC's assumed gross margin of $900/ha to $1,215/ha, which is a conservative gross margin for cotton. A predominantly cotton growing scenario in the study area is realistic based on extensive consultation (i.e. landholders are interested in growing cotton) and that a number of development proposals in the region include building a cotton gin. Under this scenario, the BCR curve crosses the value of '1' at project costs of approximately $185 million.

Figure 4.2: BCR frontier: sensitivity of BCR to project capital costs given set benefit levels



Source: Jacobs analysis

Additional arguments supporting a feasibility study or DBC being prepared on Cave Hill Dam

Further arguments warranting a DBC for Cave Hill Dam included:

- There is evidence that the willingness to pay (WTP) for water in this area is high—particularly from mining customers, as established mines are paying in the order of $3,000/ML *per annum* to SunWater for water delivered from Lake Julius via the NWQWP.
- The identified Cave Hill Dam location is the best location for a new dam on the Cloncurry River.
- This option is closest to Cloncurry; therefore, access costs for construction and quarry materials are minimised.
- This option has the greatest potential (of the options considered) to enable the development of irrigated agriculture.
- This option is closest to suitable soils for irrigated agriculture in the Cloncurry area, thereby reducing cost and losses.
- Agricultural development would drive associated urban-industrial development and higher water demand by Cloncurry.
- This option may have the benefit of increasing the resilience of the water security for the entire Mount Isa–Cloncurry region, as a geographically diversified system of water capture is preferable in the prevailing spatially and temporally variable rainfall conditions (NWQWSS, 2016).
- This option has potential for co-benefits arising from recreational and tourism use, as it is close to Cloncurry.

The combination of these factors could create an economically viable project.

4.1.5 PBC recommendations

This PBC recommended that:

- Cave Hill Dam on the Cloncurry River should proceed to the DBC as the reference project
- the preferred delivery model (ECI plus a local joint venture) be reviewed as part of the DBC.

4.2 Update of preliminary business case

The final PBC was delivered to the Queensland Government in May 2018. Between then and the delivery of the DBC, there have been no material changes or impacts to project assumptions when the PBC was prepared. Therefore, the analysis and conclusions in the PBC remain current.

The next chapter analyses the demand for additional water supply in the Cloncurry area.

5. Current situation and base case

5.1 Key points

- This chapter assesses future water supply and demand within the Cloncurry and Mount Isa region over the next 30 years if Cloncurry River Dam is not built.
- This represents the base case that the DBC uses as a point of comparison.
- The assessment finds that Cloncurry and Mount Isa have enough water storages to supply urban and mining/industrial demand over the next 30 years.
- Supply is provided by water storages on the Leichhardt River (Lake Moondarra managed by the Mount Isa Water Board and Lake Julius managed by SunWater).
- Mineral processers near Cloncurry may need to increase use of water from Lake Julius by 85–185 ML in the short term. This demand can be met through existing commercial arrangements with SunWater.
- Cloncurry Shire Council will be able to negotiate access to additional water from Lake Julius if required.
- Cloncurry Shire Council may impose water restrictions on Cloncurry to reduce overall water use thereby avoiding the need to access additional water.
- Cloncurry Shire Council may also invest in its local water reticulation network to increase urban water efficiency and reduce network losses.
- Approximately 155,000 ML of water entitlements are currently or soon to be held by landholders that could be used for irrigated agriculture.
- Historically, use of these allocations has been less than ten per cent, on average.
- This water is unsupplemented and considered unreliable.
- The construction of off stream storages would not adequately increase reliability.
- Without access to reliable water there will not be the economies of scale to develop an irrigation industry and the supporting infrastructure such as a cotton gin.
- Without a large water storage, there will not be a material shift towards irrigated agriculture.
- Crop trials will likely continue, but without a large volume of reliable water, the barriers to irrigated cropping remain high.
- Accordingly, the majority of agricultural output (by value) will continue to relate to cattle grazing.
- Irrigated agriculture will remain a small component of the agricultural sector in the absence of a large water storage.

5.2 Assumptions

The base case covers a time period of 30 years. It rests on the following assumptions:

- The base case is not a ‘zero spend’ or static option – it is dynamic and assumes that parties will continue to pursue projects that add value – but without Cloncurry River Dam.
- No large water storage is built within the study area.
- There are no material changes to the water planning framework or changes in the volume or reliability of water. In the recent tender process, the government required that purchasers demonstrate their intention to use water within three years. This provision does not apply retrospectively.
- There are no ‘shocks’ to agricultural and mineral commodity prices and mining activity does not dramatically increase.
- There are no other shocks that would disrupt the social and economic fabric of the study area.

The following key terms are relevant to this chapter:

Key term	Explanation
Water entitlement	Water entitlement is a general term encompassing water allocations, interim water allocations and water licences.
Water allocation	A water allocation is a tradable entitlement that is not linked to land. Rather it is linked to a 'water allocation security objective' (WASO), which defines the reliability and is protected by legislation. Water allocations include both supplemented (created by/linked to infrastructure) and unsupplemented (based on river flow) allocations. Supplemented water allocations typically include in their conditions a priority level (e.g. high or medium). The priority level is applied in determining how the available supplies are shared amongst users annually via the announced allocation process.
Announced allocation	An announced allocation is typically associated only with medium or high priority water allocations, which are created in association with water infrastructure (e.g. weirs or dams). The announced allocation process determines the actual amount of water that will be available under supplemented allocations for a water year. The announcement is made based on actual water in storage and/or predicted flows and is done in accordance with pre-set sharing rules. The process determines the percentage of the nominal volume that is available under different priority groups.
Water licence	An authority granted under the Water Act 2000 to: a) take water; or b) interfere with water. Water licenses are generally tied to land and cannot be traded separately.
Nominal entitlement (supplemented)	Nominal entitlement for a supplemented water allocation is (generally) the nominal volume allowed under a water entitlement. For example, 15 GL of high priority water allocation, with an announced allocation of 100%, allows 15 GL of water use in that year. If the announced allocation is lower (e.g. 50% applied to the nominal volume) water allowable will be lower (e.g. 7.5 GL).
Nominal entitlement (unsupplemented)	Nominal entitlement for an unsupplemented water entitlement is (generally) the average amount of water that the user might expect to receive. In this context it is not a maximum amount. Under some circumstances the user may receive more than 100% of their nominal volume, depending on seasonal availability. Some allocations will have a separate 'cap', which is the maximum amount that can be taken, irrespective of how much water is available that year.
SunWater allocations	These are supplemented water entitlements granted by the Queensland Government to SunWater. SunWater is entitled to use this water for its own purposes or offer it for sale to customers. There are no use specifications associated with this water.

Source: Queensland Competition Authority (2012); Water Act (Qld) 2000.

5.3 Methodology

This chapter discusses the current situation which then informs the base case. This was done by:

- identifying, collating and analysing social and economic data
- land use data
- water supply and demand data.

To describe the base case, generally 30-year forecasts were made of what will happen if Cloncurry River Dam is not constructed. These included that even without the dam there will be a modest increase in irrigated agricultural activity as unallocated water is acquired, likely through the development of off-stream storages.

5.4 Social and economic baseline

5.4.1 Overview

The study area is in North West Queensland and covers an area of 91,431km², which is approximately 5% of the total land area of Queensland (1,734,238 km²). The average daily temperature is 18°C to 32°C. Average rainfall is 425 mm. Broadacre grazing on large scale properties is the dominant land use. Outside of the major population centres of Mount Isa and Cloncurry, the study area is sparsely populated.

The area has had negative population growth in the previous 10 years and population growth is predicted to be lower than for Queensland overall over the next 20 years. The population of the area has a lower median age than the rest of Queensland and includes a large indigenous population. Most housing stock is single dwelling houses, with the rate of home ownership low, compared to Queensland.

Education levels among the population are lower than the rest of Queensland. The major non-school qualifications held are in the Engineering and Related Technologies category.

Mining is the dominant employer, providing nearly one-third of all jobs. Average income in the area is significantly higher than in the rest of Queensland. Social disadvantage is lower than the Queensland average; however, reported offenses against people and property are significantly higher. Despite agriculture being the largest land use, the sector is a minor employer, providing less than 3% of employment.

Unemployment is at 9.0% in Mount Isa and 7.3% in Cloncurry LGAs, (March 2018 quarter[1]), compared with 6.0% across all of Queensland[2].

5.4.2 Population

At June 2017, the estimated resident population of the study area was 22,022. The population growth was slower than for Queensland, with annual average population growth of –2.7% over the five years to June 2017 and –0.8% over the ten years to June 2017.

This is compared to 1.8% and 1.5% growth over the five and ten years to June 2016 respectively for Queensland.

Most of the population (86%) is located within the Mount Isa LGA. Table 5.1 provides a breakdown of population numbers in the study area.

Table 5.1 : Estimated resident population, study area and Queensland, 2007–2017

	2007	2012	2017	% average annual growth 2007–2017	% average annual growth 2012–2017
Cloncurry	3,250	3,356	3,123	-0.4%	-1.4%
Mount Isa	20,711	21,906	18,899	-0.9%	-2.9%
Study area	23,961	25,262	22,022	-0.8%	-2.7%
Queensland	4,111,018	4,569,863	4,928,457	1.8%	1.5%

Source: ABS 3218.0, Regional Population Growth, Australia, various editions

By June 2037, the population of the study area is projected to increase to 30,166 persons, an average annual increase of 0.2% per year for Cloncurry LGA and 0.7% for Mount Isa LGA. (Queensland Treasury, 2017). This is below the average population growth for Queensland over the same period (at 1.7% per year).

5.4.3 Age

The study area has a younger population with a lower median age and a lower proportion of elderly people. Table 5.2 shows the population age distribution and indicates a lower proportion of residents aged 65 years or older (7%) in the study area, compared to the rest of Queensland (14.7%).

[1] https://docs.jobs.gov.au/documents/lga-data-tables-small-area-labour-markets-march-quarter-2018

[2] http://www.ausstats.abs.gov.au/ausstats/meisubs.nsf/0/5B3143B78FAABBE9CA2582730017EE27/$File/62020_mar_2018.pdf

Table 5.2 : Estimated regional population by age

Age bracket (years)	0–14		15–24		25–44		45–64		65+	
	No.	%	No.	%	No.	%	No.	%	No.	%
Cloncurry	645	20.7	366	11.8	1,037	33.3	802	25.8	264	8.5
Mount Isa	4,702	24.3	2,694	13.9	6,349	32.8	4,278	22.1	1,309	6.8
Study area	5,347	23.8	3,060	13.6	7,386	32.9	5,080	22.6	1,573	7.0
Queensland	954,598	19.7	649,335	13.4	1,334,934	27.5	1,196,357	24.7	713,653	14.7

Source: (Australian Bureau of Statistics, 2016)

The median age of the study area in 2016 was 31 years compared to the median age for the rest of Queensland of 37 years. The median age for the study area increased from 29.9 years as at 30 of June 2006 to 31.2 in 2016 compared to an increase in the median age across Queensland from 36 years in 2006 to 37 years in 2016. The median age of the population within the study area is projected to increase to 35.6 years in June 2036 in comparison to the projected median age for Queensland in 2036 of 39.9 years (Queensland Treasury, 2017).

The median age of the population is growing faster than the rest of Queensland – a trend predicted to continue.

5.4.4 Indigenous population

Based on the 2016 Census of Population and Housing, 17.7% of the regional population identifies as Indigenous (with Cloncurry having the largest percentage of Indigenous persons with 22.8% of its population), compared to 4.0% for Queensland (Queensland Treasury, 2017).

5.4.5 Ethnicity and language

Based on the 2016 Census of Population and Housing,15.1% of people in the study area were born overseas in comparison to 21.6% for Queensland overall. Moreover, 8.1% of the population indicated that they spoke a language other than English at home compared to 12% for Queensland overall. The top non-English languages spoken at home were:

- Southeast Asian Austronesian languages (1.8%)
- Indo Aryan languages (0.9%)
- Afrikaans (0.5%)
- Australian Indigenous languages (0.3%)
- Chinese languages (0.3%).

5.4.6 Religion

Consistent with the state average, 55.8% of the population in the study area indicated that they were affiliated with a Christian religion compared to 56% of the Queensland population overall. Table 5.3 provides the religious profile summary for the Cloncurry and Mount Isa LGAs.

Table 5.3 : Religious profile, Cloncurry and Mount Isa LGAs

Religious affiliation	Percentage
Catholic	27.6%
No religion	26.9%
Anglican	11.8%
Uniting Church	4.5%
Presbyterian and Reformed	2.2%

Source: (Australian Bureau of Statistics, 2016)

5.4.7 Families and housing

The number of households within the study area was 7,006. Of these households, 68.1% were a one-family household.

Most of the housing stock (77.1%) was defined as separate houses. The percentage of total occupied private dwellings in the study area that were fully owned was 17.3%, compared to Queensland overall at 28.5% (Queensland Treasury, 2017).

By contrast, 52.6% of dwellings within Cloncurry were rented. Within Cloncurry, 6.4% of private dwellings were classed as caravans compared to 0.8% for Queensland (Queensland Treasury, 2017).

5.4.8 Motor vehicles

Figures for ownership of motor vehicles in the study area show:

- 7.4% of dwellings had no motor vehicles
- 18.3% of dwellings had three or more vehicles

In Cloncurry, 10.4% of households had no motor vehicle, compared to 6.0% for Queensland (Queensland Treasury, 2017).

5.4.9 Internet access

The portion of occupied private dwellings with internet access was 78.5%. Within Cloncurry, however, 25.4% of private dwellings had no access to the internet (Queensland Treasury, 2017).

5.4.10 Department of Social Services payments

In terms of welfare payments, 1,035 residents received the age pension, 445 received the disability support pension, and of the 974 people receiving the Newstart allowance, 848 were located in Mount Isa (Queensland Treasury, 2017).

5.4.11 Education

Education levels in the study area were lower than for the rest of Queensland. Table 5.4 summarises the highest level of schooling achieved.

Table 5.4 : Level of schooling

Area	Did not go to school, or Year 8 or below		Year 9 or 10 or equivalent		Year 11 or 12 or equivalent		Total
	No.	**%**	**No.**	**%**	**No.**	**%**	**No.**
Cloncurry	185	7.8%	684	28.9%	1,112	47.0%	2,364
Mount Isa	684	5.0%	3,790	27.7%	7,285	53.3%	13,677
Total study area	869	5.4%	4,474	27.9%	8,397	52.30%	16,041
Queensland	196,488	5.4%	964,903	26.5%	2,146,809	58.9%	3,3643,834

Source: (Australian Bureau of Statistics, 2016)

In terms of higher education, 12.3% of people held a bachelor's degree or higher compared to 18.3% for the Queensland population. Similarly, 5.4% held an advanced diploma or diploma compared to 8.7% for the Queensland population, while 25.2% held a tertiary certificate in comparison to 21.3% for Queensland overall (Australian Bureau of Statistics, 2016).

Table 5.5 provides a breakdown of the non-school qualifications by field of study for both the study area and Queensland.

Table 5.5 : Non-school qualifications by field of study

Field of study	Study area		Queensland
	No.	**%**	**%**
Engineering and Related Technologies	2,588	26.7%	15.7%
Management and Commerce	1,073	11.1%	17.5%
Health	719	7.4%	9.8%
Education	704	7.3%	7.5%
Society and Culture	652	6.7%	10.7%
Food, Hospitality and Personal Services	435	4.4%	5.5%
Architecture and Building	429	4.4%	6.2%
Agriculture Environment and Related Studies	171	1.8%	1.9%
Natural and Physical Sciences	156	1.6%	2.3%
Creative Arts	110	1.1%	3.0%
Information Technology	89	0.9%	2.2%
Mixed Field Programs	33	0.3%	0.3%
Other	2,534	26%	17%
Total	**9,693**	**100%**	**100%**

Source: (Australian Bureau of Statistics, 2016)

5.4.12 Unemployment

Unemployment is at 9.0% in Mount Isa and 7.3% in Cloncurry LGAs, (March 2018 quarter[3]), compared with 6.0% across all of Queensland[4]. Furthermore, 14% or (264 families) with children under 15 years had no parent in employment, compared to 13.8% for Queensland overall (Queensland Treasury, 2017).

The increase in the unemployment level in the study area can be partially attributed to the downturn in the mining industry. The 2011 Census showed a total of 3,559 persons employed in the mining sector compared to 3,171 in the 2016 Census, representing a decline of 11%. Similarly, employment in the manufacturing sector fell from 570 persons in 2011 to 287 in 2016, representing a decline of 50%. Employment sectors dependent on the mining industry, such as construction and wholesale and retail trade, also suffered significant declines in the same time period adding to regional unemployment overall (Australian Bureau of Statistics, 2011 and 2016).

5.4.13 Employment

Metal ore mining was listed as the top occupational category in the study area at close to 30%. According to the 2016 Census of Population and Housing (2016), the top five occupational groups of employment for residents in the study area were:

5) Metal ore mining (27.6%)
6) Pre-school and school education (7.1%)
7) Public administration (4.3%)
8) Hospitals (4.3%)
9) Food and beverage services (3.7%).

In 2016, mining was the major direct employer in the study area, with employment significantly higher than the Queensland level of employment as an industry. Employment by industry is shown in Table 5.6.

Table 5.6 : Employment by industry, Cloncurry/Mount Isa study area and Queensland

Industry	Study area		Queensland
	No.	%	%
Mining	3,171	29.8%	2.3%
Health care and social assistance	1,080	10.2%	13.0%
Education and training	853	8.0%	9.0%
Retail trade	812	7.6%	9.9%
Public administration and safety	698	6.6%	6.6%
Accommodation and food services	539	5.1%	7.3%
Construction	498	4.7%	9.0%
Transport, postal and warehousing	484	4.6%	5.1%
Administrative and support services	329	3.1%	3.5%
Agriculture, forestry and fishing	305	2.9%	2.8%
Manufacturing	287	2.7%	6.0%
Wholesale trade	198	1.9%	2.6%
Professional, scientific and technical services	169	1.6%	6.3%
Rental, hiring and real-estate services	121	1.1%	2.0%
Electricity, gas, water and waste	103	1.0%	1.1%
Financial and insurance services	80	0.8%	2.5%

[3] https://docs.jobs.gov.au/documents/lga-data-tables-small-area-labour-markets-march-quarter-2018

[4] http://www.ausstats.abs.gov.au/ausstats/meisubs.nsf/0/5B3143B78FAABBE9CA2582730017EE27/$File/62020_mar_2018.pdf

Information, media and telecommunications	63	0.6%	1.2%
Arts and recreation services	55	0.5%	1.6%
Other	401	7.2%	8.2%
Total	**10,246**	**100.0%**	**100.0%**

Source: (Australian Bureau of Statistics, 2016)

5.4.14 Income

Incomes in the study area were higher than those for Queensland overall. Median annual personal income in the study area in 2011 was $52,093, compared to $34,320 for Queensland overall. Continuing this higher-income trend, 20% of the adult population (aged 15 years or older) earned less than $20,000 per annum, compared to 28.4% for Queensland overall (Queensland Treasury, 2017).

Approximately 7.6% of families in the study area were classified as low-income, compared to 9.4% of families for Queensland overall. Median family income in the study area was $122,304 per year, compared to $86,372 for Queensland overall (Queensland Treasury, 2017).

5.4.15 Socio-economic index

Socio-Economic Indices of Areas is a summary measure of the socio-economic condition of geographic areas across Australia. The Index of Relative Socio-Economic Disadvantage generally focuses on low-income earners, with relatively lower education attainment, high unemployment and dwellings without motor vehicles.

In relation to disadvantage, 13.2% of the study area population were in the most disadvantaged quintile, compared to 20% of the Queensland population. In contrast, 6.7% of the population were in the least disadvantaged quintile, compared to 20% of the Queensland population (Queensland Treasury, 2017).

In Cloncurry 36.6% were in the most disadvantaged quintile compared to 9.6% for Mount Isa (Queensland Treasury, 2017).

5.4.16 Reported offences

The study area generally had higher levels of crime, with 26,214 reported offences per 100,000 persons in 2015–2016 (compared to Queensland at 9,856 per 100,000 persons).

Offences against persons were higher in the study area than Queensland overall for the same time period (2,532 offences per 100,000 persons versus 634 offences). Offences against property were higher in the study area than Queensland overall (6,426 per 100,000 persons versus 4,250 offences) (Queensland Treasury, 2017).

5.5 Historical trends and current situation

5.5.1 Existing water infrastructure

The study area has existing water infrastructure, mainly to service urban and mining users shows the geographical location of water storage infrastructure in the study area (Mount Isa and Cloncurry local government areas).

Table 5.7 outlines the capacity of water storages and associated nominal water entitlements in the study area.

Figure 5.1 : Location of water storage infrastructure in the study area

Figure 4-1: Project location map

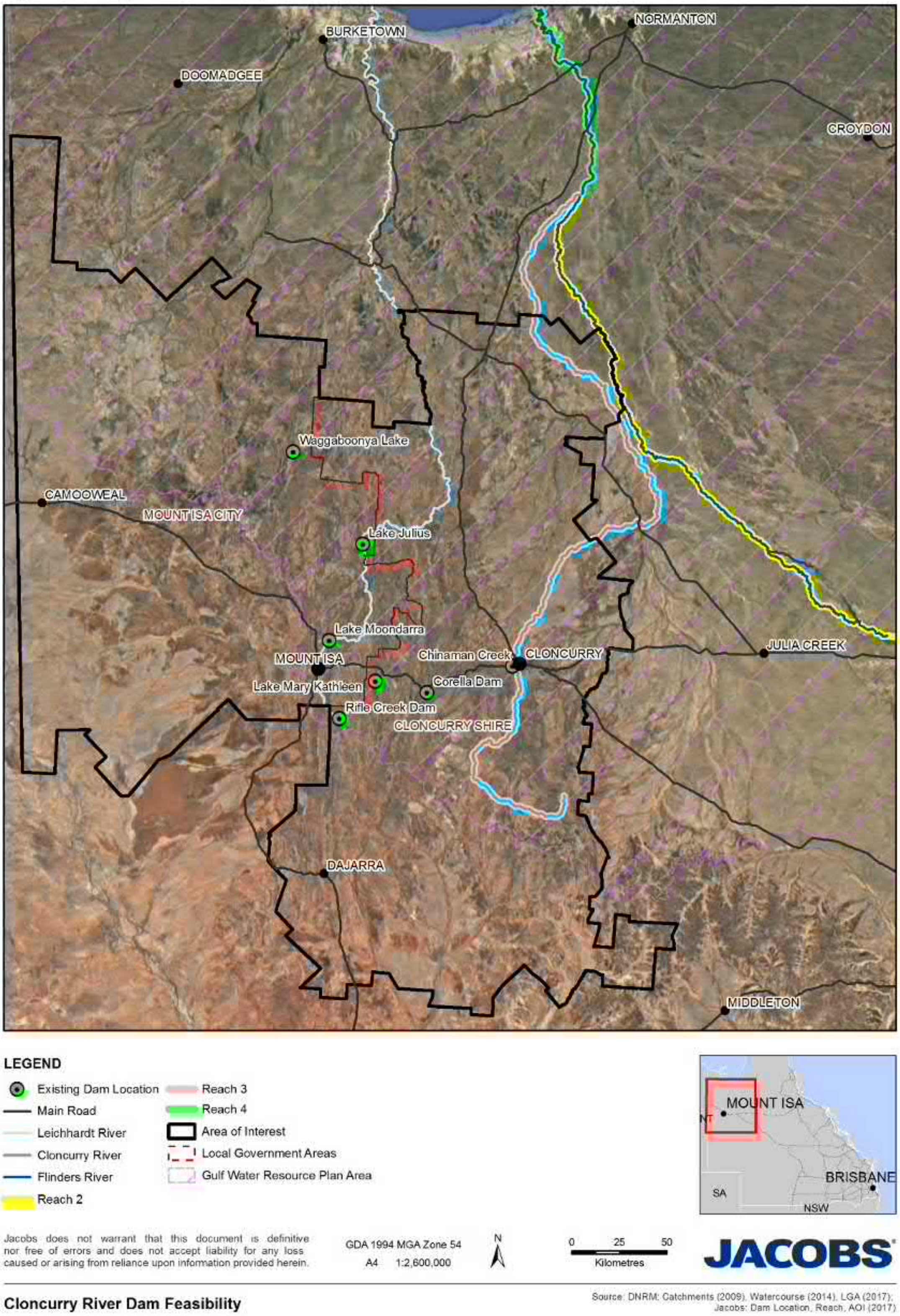


Table 5.7 : Water storages in the study area

Water storage	Capacity (ML)	Nominal water entitlement (ML p.a.) ^
Julius Dam	107,500	48,850
Moondarra Dam	106,833	26,300
Lake Waggaboonya (Greenstone Creek Dam)	13,570	3,953
Lake Mary Kathleen (East Leichhardt Dam)	11,400	1,100*
Rifle Creek Dam	9,488	1,500
Lake Corella (Corella Dam)	10,000	2,500*
Chinaman Creek Dam	2,750	2,000
Total	**261,541**	**82,603**

^ Nominal water entitlement can be viewed as the maximum available water in any one year. Source: (DEWS, 2017); Jacobs analysis.

The entitlements shown in Table 5.7 have varying degrees of reliability, for example, in Julius Dam the high priority allocations are approximately 95 per cent reliable. This means the full nominal entitlement will not always be available. Rather, in 95 per cent of years, the allocation will be less than 100 per cent—down to potentially zero allocation in the driest years. The announced allocation is determined in accordance with the water sharing rules, which consider expected losses throughout the year, including evaporation.

5.5.2 Urban water supply and demand

5.5.2.1 Cloncurry water supply and demand

Cloncurry's urban water treatment plant draws water from four bulk water supply sources, depending on availability and water quality:

- *Chinaman Creek Dam* was constructed in 1993 and is owned and operated by the Cloncurry Regional Council. The dam is located on Chinaman Creek, 600 m upstream from its junction with the Cloncurry River, and has a capacity of 2,750 ML. The council's water licence for extracting water is a maximum of 2,000 ML per annum and the daily volumetric limit is 12 ML (DEWS, 2017).
- *Cloncurry River wells* are located on the banks of the Cloncurry River close to town. They are spears that draw water from the river bed. The council holds a licence to extract up to 1,460 ML per annum from a total of four operational wells (DEWS, 2017).
- *Cloncurry Weir* was completed in February 2014 on the western side of town. The weir maintains Cloncurry River levels for an extended period so that water can be pumped from Cloncurry Weir into the Chinaman Creek Dam for a longer period than would be the case without the weir. The weir secures an additional 700 ML per annum of water in the Cloncurry River,
- In 2010, Cloncurry was linked to the North West Queensland Water Pipeline, after the Queensland Government extended the pipeline from Earnest Henry Mine in response to extreme water shortages experienced by the township. This means, Cloncurry has access to water from Lake Julius. The Cloncurry Shire Council was granted an allocation of 950 ML per annum from the NWQWP. The pipeline can deliver about 100 litres per second or approximately 3 GL per annum. Operationally, Water from the pipeline is used regularly by Cloncurry Shire Council due to its relatively high-water quality and the associated lower overall water treatment costs.

Cloncurry has a combined nominal entitlement of 5,110 ML per annum. Additional capacity could be provided by the NWQWP to Cloncurry – in a drought. Table 5.8 provides details of the Cloncurry urban reticulation network. Table 5.9 provide details of the urban historical water use.

Table 5.8 : Technical and financial parameters of Cloncurry's urban reticulation network

Source	Nominal entitlement (ML p.a.)	Max instantaneous extraction rate (litres/second)	Annual water charge or annual cost of bulk water delivery ($/ML 2016–17)
Chinaman Creek Dam	2,000	140	79
Cloncurry River wells	1,460	TBC	79
Cloncurry Weir	700	740	77
NWQWP^	950	100+	450
Total	**5,110**	**n/a**	**n/a**

Source: Cloncurry Shire Council (2017); Jacobs analysis Note: ^ The cost for NWQWP is paid to SunWater as an annual charge paid for bulk water delivery via the pipeline. The other costs are Cloncurry Shire Council's estimate of the internal cost per ML of water delivery to the town's water treatment plant.

Table 5.9 : Cloncurry's urban water supply, by source, 2013-2016

Year	2013	2014	2015	2016 ^
Chinaman Creek Dam (ML/a)	N/A	303	89	246
River wells (ML/a)	244	371	366	404
NWQWP (ML/a)	1,006	534	866	295
Total (ML/a)	**1,250**	**1,208**	**1,321**	**945**

** No data for Cloncurry weir usage was provided. ^ Cloncurry Shire Council did not provide an explanation for the decline in water use reported in 2016. It is likely that this was driven by a decline in demand coinciding with a downturn in mining, which resulted in higher rates of vacant dwellings in Cloncurry This is consistent with the fall in population. Source: Cloncurry Shire Council (2017) ; Jacobs analysis.*

Over the past four years, water use has been less than 25 per cent of combined water allocations. The forecast population growth for Cloncurry of 0.2 per cent per annum through to 2037 (Queensland Treasury, 2017) means that Cloncurry's population could grow to 3,527. Assuming domestic and urban-industrial demand grow at the same rate, the associated increase in water use will equate to approximately 35 per cent of combined water allocations in 2036.

For the period of the base case assessment, it is therefore concluded that forecast demand for Cloncurry is below available water supplies and that spare water supply capacity remains, when access to the NWQWP is included. This provides access to Lake Julius and provides additional water security which was not available in 2008, when Cloncurry faced critical water shortages.

5.5.2.2 Mount Isa water supply and demand

DNRME assessed the surface water availability for urban, mining and agricultural sectors for Mount Isa LGA. As part of their assessment, they examined the nominal water entitlements as shown in Table 5.10.

Table 5.10 : Mount Isa Local Government Area supplemented water entitlements

	Nominal water entitlement (ML p.a.) ^		
Allocation Holder / type	**Moondarra Dam**	**Julius Dam**	**Total**
Mount Isa City Council (Urban)	12,500	7,900	**20,400**
Mining	12,500	8,850	**21,350**
Distribution losses	1,250	1,250	**2,500**
SunWater	0	10,850	**10,850**
NWQWP	0	15,000	**15,000**
Mount Isa Water Board#	50	5,000	**5,050**
Agriculture	0	0	**0**
Total—all sectors	**26,300**	**48,850**	**75,150**

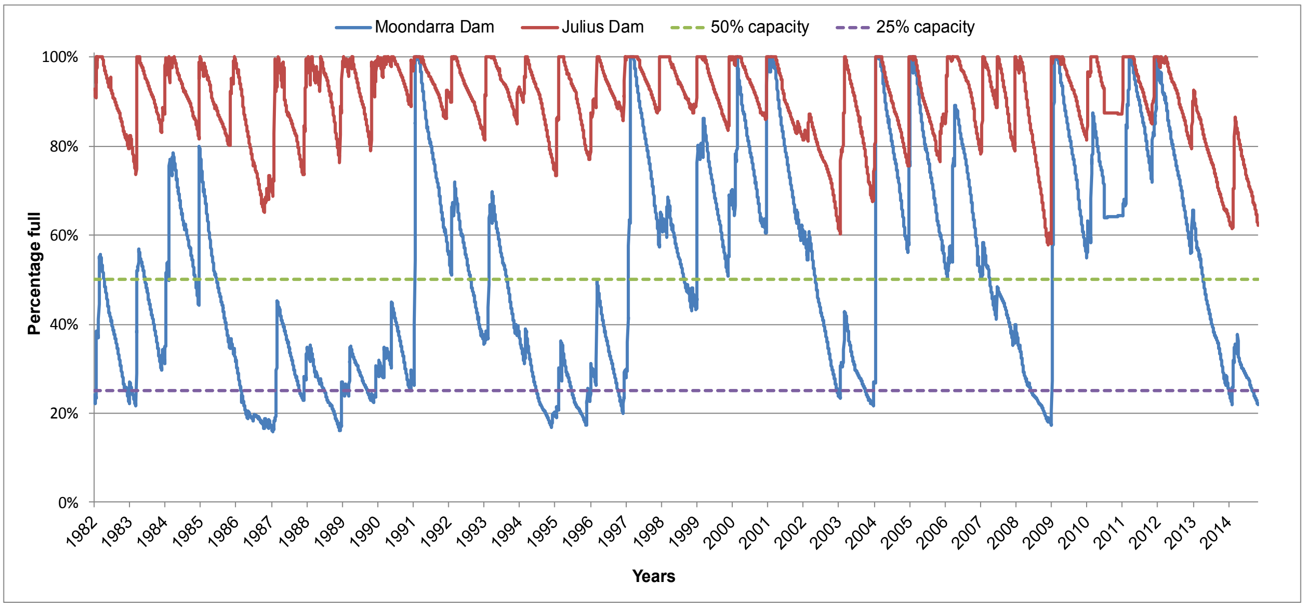
** Entitlements from harvesting overland flows is not included in the assessment. ^ Nominal water entitlement can be viewed as the maximum available water in any one year. # Mount Isa Water Board supplies bulk water to industrial customers and drinking water to Mount Isa City Council.*
Source: DEWS (2017); Jacobs analysis.

Table 5.10 shows that there are approximately 75,000 ML of water allocations associated with the Lake Moondarra and Lake Julius water storages. Of this, approximately 21,000 ML is not currently committed to a customer. This consists of the full SunWater allocation and approximately half of the water allocations held by the NWQWP and Mount Isa Water Board.

As noted above, water entitlements have varying degrees of reliability and full nominal entitlement will not always be available.

Mount Isa's urban water supply is managed by the MICC which holds multiple licences relating to residential bulk water supply. Moondarra and Julius dams are the primary water supply sources for Mount Isa's urban and industrial customers (Figure 5.2).

Figure 5.2 : Dam levels (percentage full) of Moondarra Dam and Julius Dam, 1982-2015



Source: DEWS (2017) *Mount Isa Regional Water Supply Assessment*

The volume of water stored in Moondarra Dam fell below 25% of its total maximum capacity on more than 10 occasions during 1982 to 2015. The volume of water stored in Moondarra Dam fell below 20% of its total maximum capacity on six occasions.

The volume of water stored in Julius Dam remained above 50% of maximum capacity throughout this period. Over the same period, Mount Isa City had Level 1 water restrictions in 30% of years, and Level 2 restrictions in

19% of years. Level 1 water restrictions include limiting the use of sprinklers to alternate days while level two water restrictions also limit the use of hand-held watering to alternate days.

The introduction of water restrictions is a decision based primarily on the relatively higher cost of accessing Lake Julius water (as Lake Julius is at a lower altitude and further away than Moondarra Dam). The other reason for applying water restrictions is that pumping capacity from Lake Julius to Mount Isa is limited (i.e. alone it could not meet Mount Isa's summertime peak daily demand). Accordingly, it is considered prudent to conserve Moondarra Dam water via water restrictions to maintain both sources of supply (and use both pumping capacities) to meet those peak demands.

The Mount Isa RWSSA (2017) concluded that the average urban, mining and industrial water demand is expected to peak at around 30,000 ML/a. The maximum forecast annual demand over 30-years was up to 48,000 ML/a. Based on total allocations of 75,150 ML, the Mount Isa RWSSA concluded that the likelihood of the combined water supply system of Moondarra Dam and Julius Dam failing to meet Mount Isa's urban demand is less than once in 1,000 years, on average.

Considering the State Government's assessment, Mount Isa City Council has confirmed, that it has enough water allocations (i.e. in Moondarra and Julius dams combined) to meet forecast demand in the long term.

On this basis, it is concluded that there is no urban, mining or industrial demand that would warrant additional water storage capacity within the next 30 years.

5.5.2.3 Urban demand and supply base case (next 30 years)

Over the next 30 years, it is expected that Cloncurry and Mount Isa will have enough existing water supply infrastructure to satisfy the forecast demand. This is based on State Government forecasts.

Any short-term water shortages would be addressed through water restrictions and/or drawing on the spare capacity of existing water infrastructure – not new infrastructure.

5.5.3 Mining water supply and demand

5.5.3.1 Current situation

The study area is located centrally in the North West Queensland Mineral Province (NWQMP). The NWQMP contains approximately 75 per cent of Queensland's known base metal minerals, including copper, lead and zinc, as well as major silver and phosphate deposits and rare earth potential (DSD, 2017). Within the province, the mining and mineral processing sector is the central source of employment and a significant contributor to economic growth. Mining and minerals processing operations in the NWQMP also have indirect supply chain impacts on zinc and copper refineries in Townsville as well as the Port of Townsville (DSD, 2017).

There are numerous operational mines in the study area. The Strategic Blueprint for the NWQMP (DSD, 2017) identified a significant opportunity to increase production and expansion within the study area. More efficient utilisation of enabling infrastructure such as transport, power and water was identified as key to promote industrial growth. As part of the stakeholder consultation conducted as part of DBC investigation (full details in Appendix C) Incitec Pivot, Centrex Metals and Great Australian Mine were consulted. This included the companies completing a demand expression of interest form. This written advice supported by several conversations showed that there is an interest in and a requirement for acquiring more stable and cost-effective water access for commercial use.

The NWQWP supplies water to several mines. NWQWP Pty Ltd (a subsidiary of SunWater) has a 15 GL allocation in Julius Dam and supplies water to Cloncurry Shire Council, mines and number of rural and agricultural users through the NWQWP. The current total capacity of the NWQWP is only 7 GL per annum. Table 5.11 provides a breakdown of the allocations from Lake Julius delivered by the NWQWP.

Table 5.11 : Allocations held by NWQWP in Lake Julius

Customer/Category	Nominal Entitlement (ML p.a.)
Mining and industrial	2,875
Cloncurry	950
Rural	59
Total nominal entitlement	**3,884**
Existing excess pipeline capacity	3,116
Total pipeline capacity	**7,000**

Source: Jacobs analysis.

As shown in the above table, the current excess capacity via the NWQWP is about 3 GL, which is the difference between the total pipeline capacity (7,000 ML) and the customer held nominal entitlement (3,884 ML).

5.5.3.2 Mining demand and supply base case (next 30 years)

The development of new mining operations has the potential to increase demand for NWQWP allocations. The Dugald River Mine and the Roseby Copper Mine are two major projects that are within a viable distance of the pipeline (Dugald River is already connected). Demand projections for each project were derived from GHD (2014) and DEWS (2017), which estimated that water demands from Dugald River and Roseby Copper Mine eventually will be 3 GL and 2.2 GL per annum respectively—totalling 5.3 GL – potentially during the next 30-years.

As the NWQWP has spare capacity of 3 GL per year, these mines can be supplied by the NWQWP in the medium term. If both mines require the maximum amount of water, then an additional 2.3 ML would need to be sourced.

The capacity of the NWQWP can be augmented by an additional 8 GL per annum through the upgrade of a central pump station. This upgrade could bring the total available capacity of the pipeline to 15 GL, matching the NWQWP allocation. SunWater estimates the cost to upgrade the pump station to be in the order of $2–$6 million; however, this project is not currently a focus for SunWater, based on its understanding of forecast demand. It is unlikely this 8 GL upgrade will occur without a significant increase in demand for water in the region.

Many mining operations can access sufficient amounts of groundwater. Water is a relatively small cost for miners and is unlikely to be a limiting factor.

Accordingly, we conclude that mining will not be constrained by a lack of water over the next 30 years. This is particularly the case for mines within financially viable reach of the NWQWP or the Mount Isa water supply system.

5.5.4 Mineral processing water supply and demand

5.5.4.1 Current situation

Current mineral processing activities in the study area include copper, lead and zinc concentrating and smelting facilities. Current mineral processing activities are adequately supplied through existing water infrastructure. Zinc and copper ore are transported from the study area to Townsville for processing in regional facilities.

Mineral processing is a large user of water and future processing activities in the study area will be highly dependent on the expansion of mining operations. Rare earth elements, which are currently a focus of exploratory activities, have a much greater mineral processing water footprint than most other metals (Harque, et al., 2014).

The volume of mineral processing depends on the volume of future mining activity. Future demand for additional water for mineral processing is uncertain, in both volume and location, and will be dependent on the scale of current and future mine development, the outcomes of current exploration activities and the commercial decisions of mine developers and operators.

Stakeholder consultation (refer Appendix C) has confirmed the critical role that access to and reliability of water and electricity utilities have on attracting investment in new and expanded facilities, and the preference for seeking water source alternatives to the NWQWP due to the cost of water supply.

5.5.4.2 Mineral processing demand and supply base case (next 30 years)

There is a short- to medium-term water supply deficit in Cloncurry, when the demand of the Great Australian Mining Company and urban water demand are aggregated (this is more fully explained in Chapter 6: Demand Assessment). This results in a demand that exceeds Cloncurry's current water entitlements, of approximately 85 ML by 2020, 185 ML by 2021, and 185 ML by 2022. However, such a demand would not on its own warrant investment in new water infrastructure when the following options are open to the Cloncurry Shire Council:

1. Access more water from the NWQWP from SunWater or via temporary trading with Ernest Henry Mine.
2. Reduce losses in the Cloncurry reticulation system.
3. Reduce urban and industrial water use by imposing water restrictions or equivalent demand management.

The latter two options could see Cloncurry Shire Council supply raw water from its river bores and/or China Creek Dam and consequently increase its demand for NWQWP water, which has the advantage of higher water quality.

Beyond the demand from mineral processing operations adjacent to Cloncurry, the water demand for mining and mineral processing is not centralised, nor does it currently require a major investment in new water infrastructure on the Cloncurry or Leichhardt rivers. Cloncurry's combined demand for mineral processing and urban supply, sees an 85–185 ML shortfall in three to five years. This can be met by the options outlined above.

Accordingly, it was concluded that mineral processing will not be constrained by a lack of access to water over the next 30 years.

5.5.5 Agriculture water demand and supply

5.5.5.1 Current situation

Grazing of cattle for the beef industry on unimproved pastures is the dominant land use in the study area. The study area is dominated by large properties with low carrying capacities. The feed is generally insufficient to fatten cattle for market. Accordingly, cattle are transported to richer pastures in Central Queensland or feedlots outside of the immediate area for fattening. However, local beef production is an integral part of a state-wide supply chain to meet domestic, exported meat and live export market demands.

According to the Queensland Agricultural Land Audit, the potential for grazing in the area is fully realised. Any improvements in productivity will not come from expanding the area but through improved land management and production systems. Fodder production has the potential to expand, which would add value to the study area by helping to maintain productivity in dry seasons. Currently, significant volumes of fodder are brought into the area in dry seasons and stock are transported out of the area to be fed elsewhere prior to being exported live or processed to be sold as meat domestically or overseas.

Table 5.12 shows the breakdown of land use in North West Queensland.

Table 5.12 : Land use in North West Queensland

Land use	Area (ha)	Percentage of region
Grazing	19,591,309	97.7%
Other land use (non-agricultural land)	399,485	2.0%
Grazing (sown pastures)	55,395	0.28%
Broadacre cropping	885	0.004%
Aquaculture	441	0.002%
Total	**20,047,515**	**100.0%**

Source: DAF (2017), *Queensland Agricultural Land Audit Gulf and North West.*

In 2016–17, total annual agricultural production value in the Southern Gulf was estimated at $588 million. Table 5.12 shows that 99 per cent of agricultural production relates to cattle.

Table 5.13 Agricultural production in the Southern Gulf ($ million)

Type	2012–13	2013–14	2014–15	2015–16	2016–17
Cattle	393	364	537	600	582
Other livestock	2	2	1	4	2
Hay	6	3	0	6	5
Crops	–	–	0.03	0.05	–
Total	**401**	**369**	**538**	**610**	**588**

Source: (Australian Bureau of Statistics, 2017), cat. no.7503.0.

DNRME summarised water availability for urban, industrial and agricultural sectors for Cloncurry (Table 5.14). This shows that approximately 97% of water allocations relate to agriculture.

Table 5.14 : Water entitlements in the Cloncurry region

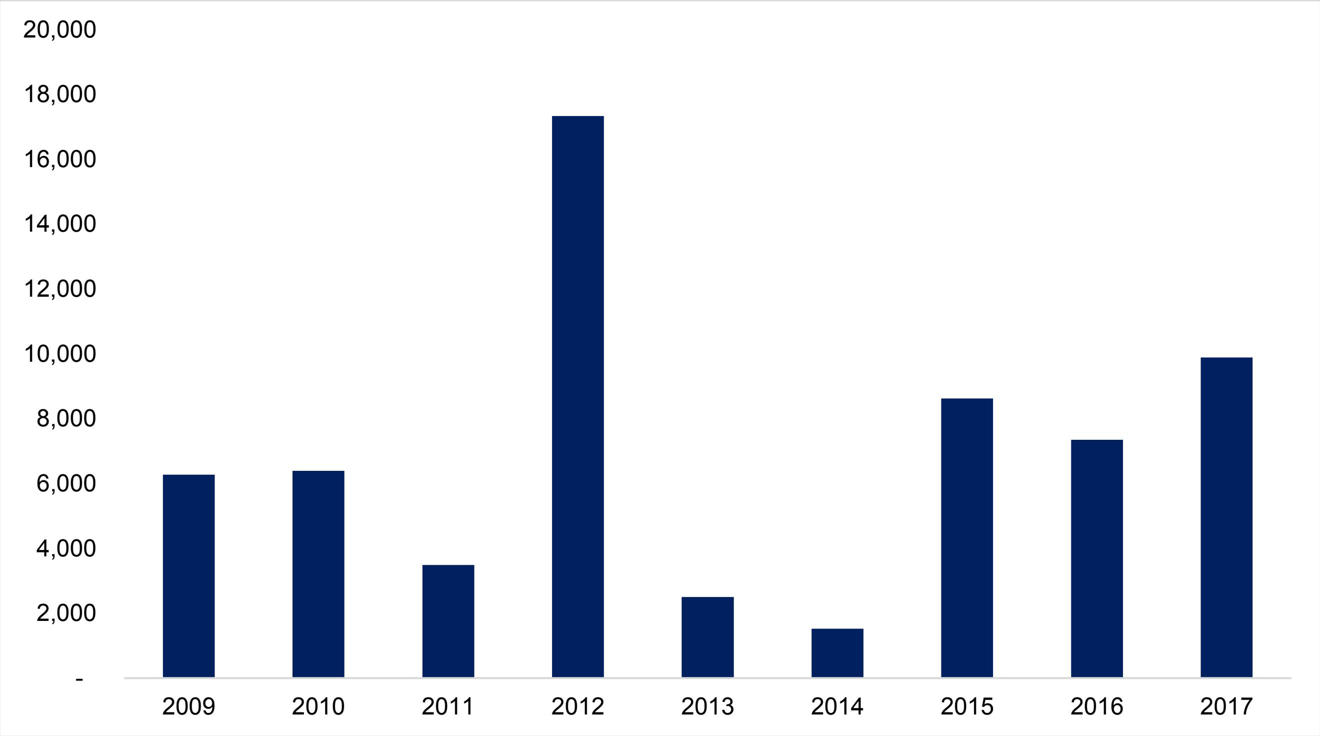
Sector	Water source	Nominal water entitlement (ML p.a.)
Urban	Chinaman Creek Dam	2,000
	Cloncurry River	2,160
	NWQWP (from Julius Dam)	950
Subtotal—Urban[5]		**5,110**
Mining	Cloncurry River upstream (Licence)	18
	Cloncurry River upstream (Permit)	1,272 (excluded from total due to the nature of allocation)
	Coppermine Creek (Licence)	200
Subtotal—Mining		**218**
Agriculture	Cloncurry River (Reach 3) – Product 1	7,500
	Cloncurry River (Reach 3) – Product 2	69,200
	Flinders River (Reaches 1, 2 and 4) – Product 2	77,822
Subtotal—Agriculture		**154,522**
Total—All sectors		**159,850**

Source: DEWS (2017), DNRM (2015)

[5] *Information on urban water usage within the Cloncurry region is based on draft inputs to the Cloncurry RWSSA* (DEWS, 2017).

There are approximately 155,000 ML of water entitlements that are held by land holders. Figure 5.3 shows the historical extraction levels, which are generally 5-10 per cent of total water allocations. The available data does not allow disaggregation into the individual rivers or reaches.

Figure 5.3 : Annual river water extraction in the Flinders and Cloncurry rivers for agricultural use (ML)



Source: ABS, Water Use on Farms, 2008-09 to 2016-17

5.5.5.2 Off stream storages

Without the construction of a large dam, the alternative approach is to build private off stream storages. Under certain flow conditions, water can be pumped out of the river and into the off-stream storage for later use.

The off-stream storages were modelled with the assumptions outlined in Table 5.15

Table 5.15 : Off-Stream Storage Configuration Assumptions

Feature	Downstream of Cloncurry
Storage volume	7 x 7,500 ML = 52,500 ML
Storage surface area	7 x 120 ha = 840 ha
Crop type	Cotton
Usage per area	10 ML/ha/yr
Area	800 ha
Demand distribution	

Feature	Downstream of Cloncurry
Reach Limit and Conditions Source	Product 2: Reach 3; Release of unallocated water in the Gulf: Terms of Sale 2015
Maximum annual volume available (ML)	50,000
Maximum Extraction Rate	14% of annual volume tendered 7000 ML/d
Flow Diversion Threshold (ML/d)	Taking the water is only permitted when the flow in the Cloncurry River at Canobie GS915212A exceeds 10,000 ML/d. Despite this, each time the flow exceeds 10,000 ML/d in the period of 1 January to 31 March, taking water may only commence after the first peak flow passes the gauge. Taking water may then continue until the flow falls below 10,000 ML/d

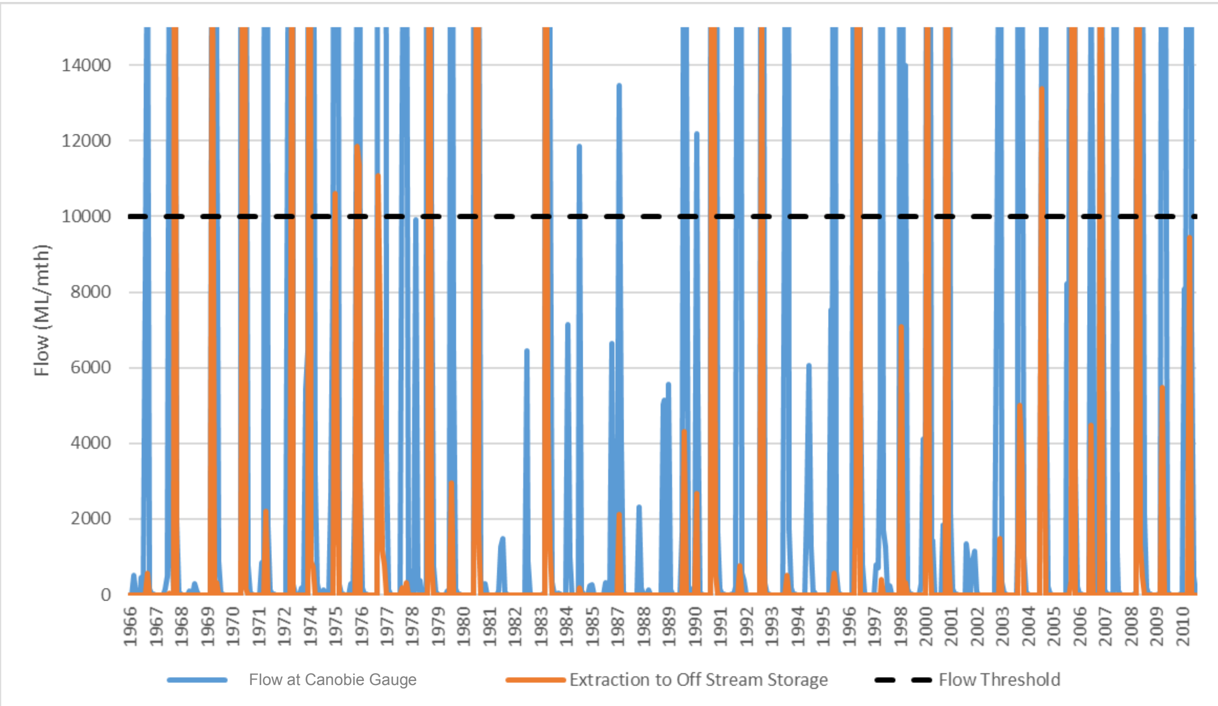
Source: Jacobs analysis

These assumptions were applied to the model with the irrigation demand being modelled as a monthly demand pattern with access to an on-farm storage. An explicit crop model with consideration of incident rainfall was not used. Further refinement of the demand including the crops to be irrigated, the soil type and incident rainfall on the crop will need consideration in further stages of the project.

The maximum extraction rate and diversion threshold were modelled in accordance with the Water Plan. A series of on farm off stream storages were modelled for irrigation of cotton on black soil downstream of Cloncurry. This was based on access to a 50,000ML/yr Product 2 water harvesting allocation. The irrigation demand was modelled as a monthly demand pattern with access to an on-farm storage with the maximum extraction rate and diversion threshold modelled in accordance with the Water Plan (see Table 5.15).

The target reliability was 80%. However, it was not possible to access the full 50,000 ML/yr yield at this reliability. The diversion threshold for Product 2 water harvesting is the limiting factor, as occurrence of flows over 10,000 ML/d at Canobie are so infrequent that a high volume of water was unable to be supplied at the off-stream storage with a reliability of 80%. This is shown in Figure 5.4.

Figure 5.4 : Flow Comparison of Cloncurry River at Canobie Gauge and Extraction to Off-Stream storage



Source: Jacobs analysis

A maximum Monthly Reliability of 53% could be achieved for the 50,000 ML/yr with seven (7) 7,500ML storages. For this scenario, a total of 12,431 ML/yr can be delivered annually.

To identify the maximum potential yield at the target 80% reliability with the same storage configuration, the yield was reduced until the target was met, with a demand of 8,000 ML/yr. However, due to the limiting factor of the infrequency of flows greater than 10,000 ML/day at Canobie, this yield can only be supplied if the full 50,000 ML/yr allocation (with a maximum daily extraction rate 7,000 ML/day) is used to access only 8,000 ML/yr.

Table 5.16 presents the results from these two scenarios.

Table 5.16 : Yield modelling results for two scenarios upstream of Cloncurry

	Scenario 1	Scenario 2
Annual Allocation (ML/yr)	50,000	50,000
Monthly Reliability (%)	80%	53%
Annual Demand (ML/yr)	8,000	50,000
Annual Yield (ML/yr)	5,433	12,431

Source: Jacobs analysis

To establish cropping, there needs to be access to a reliable water supply. Otherwise, the returns will be too volatile to justify investment. The above analysis shows that the conversion from annual allocation to a reliable product reduces the amount of water that can be used by 84%. The off-stream storage would need to be very large, which would increase the establishment costs. The low reliability of water resulting from a combination of low-frequency flooding events and environmental flow requirements is a high barrier of irrigated cropping.

5.5.5.3 Unallocated water

In addition to the available water outlined above, there is a material volume of unallocated water that could be made available in neighbouring LGAs.

Given that the urban and mining sectors do not generally have unmet demand, it was considered likely that unallocated water would be purchased by land holders for potential agricultural purposes. This is consistent with the recent tender process.

In late 2015, the Queensland Government called for water tenders in Gulf catchments, making 264,550 ML of unallocated water available for irrigated agriculture. Two products were made available (Table 5.15).

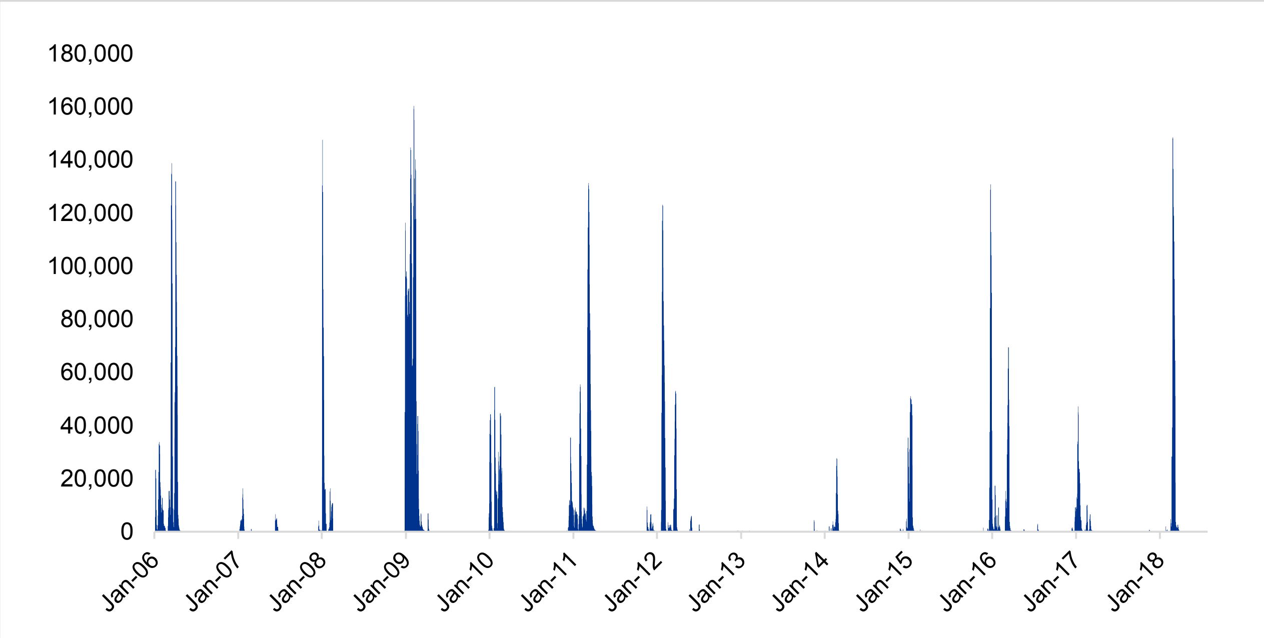
Table 5.17 : Water harvesting product specifications

Feature	Product 1	Product 2
Maximum annual volume available (ML)	7,500	50,000
Maximum daily extraction rate	6% of annual volume (180 ML/d)	14% of annual volume (7,000 ML/d)
Flow diversion threshold (ML/d)	Low flow – Taking water will be permitted when the flow in the Cloncurry River at Canobie GS915212A exceeds 4,000 ML/d	High flow – Taking the water is only permitted when the flow in the Cloncurry River at Canobie GS915212A exceeds 10,000 ML/d. Despite this, each time the flow exceeds 10,000 ML/d in the period from 1 January to 31 March, taking water may only commence after the first peak flow passes the gauge. Taking water may then continue until the flow falls below 10,000 ML/d

Source: DNRME (2015)

Based on the previous 13 years of data (commencing in 2006), the river flow exceeds 4,000 ML/day 11 percent of the time and exceeds 10,000 ML/day 8 per cent of the time. This is presented in Figure 5.5.

Figure 5.5: Maximum flow in the Cloncurry River at Canobie (ML/day)



Source: DNRME Water monitoring information portal

The tender process allocated a total of 100,000 ML of unsupplemented water licences, which were sold to eight parties.

Table 5.18 : Unallocated water entitlements

Catchment or sub-catchment area	Water product	Bid price per ML ($)	Volume purchased (ML)
Gregory River sub-catchment area	General reserve	54.00	2,500
Lower Leichhardt sub-catchment area	General reserve	45.50	5,000
Flinders River catchment area	Product 1 – Reach 1	100.00	6,000
		100.00	12,000
	Product 1 – Reach 2	55.00	4,500
	Product 2 – Reach 4	125.00	12,500
	Product 2 – Reach 3	105.00	50,000
	Product 2 – Reach 4	105.00	7,500
Total		**100.10 (average price)**	**100,000**

Source: (DNRM, 2017).

Reach 3 of the Flinders River catchment area is the Cloncurry River and tributaries from the top of the catchment to the confluence with the Flinders River. This is the reach where Cloncurry River Dam would be located, and it is within the study area.

After the conclusion of the tender process, DNRME announced that further water allocations could be purchased, at a shelf price. However, all lots that were originally made available in the Cloncurry River have now been granted[6].

[6] https://www.business.qld.gov.au/industries/mining-energy-water/water/catchments-planning/unallocated-water/gulf

5.5.5.4 Agricultural demand and supply base case (next 30 years)

Since the 2015 process for release of water commenced in the study area and across the region, no clear evidence emerged of a trend to higher water use or materially increased areas of land under irrigation. The amount of water extracted is related to the annual volume of stream flows.

The development of off-stream storages to increase utilisation of released water allocations is highly uncertain. Discussions with land holders have not indicated concrete time-bound plans to develop their allocated water. As shown above, the reliability of off stream storages is low, or requires that only a small amount (16%) of the annual allocation is used annually.

The historical extraction levels of generally 5-10 percent of total water allocations are, therefore, expected to continue.

Accordingly, without Cloncurry River Dam, we expect that the agricultural sector will remain largely the same. It will be dominated by cattle, with a very small contribution from crops and hay. Agricultural water use will remain low, as the scale to create supplementary infrastructure (such as a cotton gin) does not exist.

Without the construction of a large agricultural dam (such as Cloncurry River Dam), no step change in agricultural water use is expected. Water use will continue to be low due to the unreliable nature of the products. The existing users will continue to grow limited areas of low value crops such as hay and lucerne.

Without scale and reliability, a cotton industry could not support a cotton processing gin, which is a requirement for cost effective production.

The following chapter assesses the agricultural demand for reliable water.

6. Service need and demand assessment

6.1 Key points

- This chapter identifies the service need for additional water provided by the project in the region.
- The analysis assumes that economic activity and associated socio-economic wellbeing within the greater Cloncurry region will be enhanced through the provision of additional water.
- An irrigated agriculture sector in the area has the potential to develop based on the area of suitable land and soil that is available. However, several barriers need to be addressed for this opportunity to be realised.
- Irrigation will increase agricultural output and production value and create the opportunity for agricultural processing to develop.
- All nine property owners that could be supplied from the Reference Project and pipeline network directly participated in the demand assessment for the project.
- Three additional owners of property in the study area, without access to the project, were also consulted as potential investors and included in the expression of interest process.
- Of the 12 properties included in the demand assessment, three stated a demand for water while nine stated they had no interest in water from the Reference Project.
- The combined stated demand was 62,800 ML of medium reliability water.
- The stated demand exceeded the Reference Project's delivery capacity of 50,000 ML by 12,800 ML (26%).
- The small number of potential customers presents challenges for the project.
- There is an increased risk of the available water allocations not reaching full uptake if one of the potential customers defaulted on any future commitment and a weakened case for the project receiving capital funding from government.
- The land owners who did not express an interest in water indicated the barriers to purchase as:
- lack of irrigated agriculture / cropping experience of the property owner/manager
- high up-front cost to purchase water and establish on-farm irrigation infrastructure
- lack of demonstrated success of irrigated agriculture in the region
- lack of support services (e.g. agronomists) and local processing (e.g. a cotton gin)
- additional operating and production risks of irrigated agriculture when compared to existing beef production systems.
- It was concluded that in the mining, mineral processing and urban sectors Cloncurry and Mount Isa will have enough existing water supply infrastructure to satisfy forecast demand over the next 30 years from existing water sources.
- The service need, therefore, is not a problem that needs solving. Rather it is an *opportunity* that could be realised with investment targeted to developing an irrigated agricultural sector in the study area.

6.2 Assumptions

The service need and demand assessments were based on the following assumptions:

- A material increase in irrigated agriculture on the black soils along the Cloncurry River requires a new large water storage on (or near) that river.
- More irrigated agriculture of the scale that could be supported by the Reference Project will provide increased economic activity and associated socio-economic wellbeing and resilience.
- Cloncurry and Mount Isa have enough existing water storages and support infrastructure to supply urban, mining and mineral processing demand over the next 30 years (refer to Chapter 5). However, the construction of an additional large water storage, such as Cloncurry River Dam, would in the longer term (30 years plus) increase regional water supply security across the entire region, as the Mount Isa and Cloncurry water supply systems are connected.

6.3 Methodology

To establish the service need, the main factors considered were current water supply and water security conditions, and the future opportunity for agriculture, mining, mineral processing and regional urban requirements.

The demand assessment engaged potential customers of Cloncurry River Dam who owned land in the region, through a stated demand approach in the form of a formal expression of interest process. Engagement included consultations with landholders of river frontage properties 20–40 km north and south of Cloncurry. The process consisted of an initial telephone discussion with each landholder regarding the Reference Project and their ability and desire to undertake irrigated agriculture in the region. Discussions were semi-structured with responses provided on the landholder's understanding of the Reference Project, current activities on the property, the property's suitability for irrigation, aspiration to purchase water allocations from the Reference Project and barriers and opportunities with irrigated agriculture on their property. Following the initial discussion, a formal expression of interest form was emailed to each landholder, asking them to return their responses.

6.4 Service need

Four specific service needs – relating to the agriculture, mining and mineral processing – were developed to understand future water needs and opportunities in terms of products required (e.g. medium or high priority water allocations), volume (ML) and timing for each of the major sectors in the region (Table 6.1).

The forecast urban demand for Cloncurry and Mount Isa is lower than available water supplies and spare water supply capacity remains (Chapter 5: Current situation and base case). As a result, urban service need was not included in the demand assessment.

Table 6.1 Summary of service needs requiring consideration in the DBC

Service need	Response
1. **Address barriers to the use of existing and future water entitlements for agriculture**. • Until the barriers to agriculture have been addressed and agriculture has proven to be viable at a small and medium scale, a large water source cannot be developed. • Stakeholder consultations during the PBC led to the suggestion that a demonstration farm on the Cloncurry River was an enabling mechanism to irrigated agriculture as it would help overcome several human capacity and knowledge barriers to the adoption of irrigated agriculture.	Investigate further the viability of a demonstration farm in Cloncurry. This investigation is outside the scope of this DBC.
2. **Realise a potentially significant opportunity for irrigated agriculture in the Cloncurry region.** • Generating evidence that agricultural production is viable (e.g. via a demonstration farm) to underpin potential demand for additional water from agriculture exists. • Soil suitability and land availability are not constraints. • Based on experience with agricultural development elsewhere in northern Australia, pest control and management challenges may be significant, including crop damage by native animals and pest insects. • Some landholders indicated they would invest in medium priority water allocations. • The landholder consultations clarified that the yield of the magnitude estimated for Cloncurry River Dam will be necessary to (i) ensure that irrigation water will be affordable for irrigators and a financial case for irrigation at the enterprise level and (ii) maximise economies of scale and the coordination of investment in supporting	Deliver a DBC for the Reference Project. Cave Hill Dam was identified as the most viable large water storage in the PBC, for reasons including its scale and dam constructability.

Service need	Response
agricultural processing capacity and other support services. • It is noted that early adopters of irrigated agriculture will have to transport produce to remote processing facilities, incurring associated transport costs.	
3. **Address future demand for water to support mining development**. • There is significant potential (future) demand for water from mining developments, but locations and volumes are uncertain, thus not immediately supporting the case for a centralised water storage—such as a new dam on the Cloncurry River. • If mining demand eventuated, it would need agricultural demand to underpin the funding of a dam and to provide an enduring customer base for the 100-year life of the dam, particularly as many mines have lives of 30 years or less.	Investigate decentralised on-site surface water capture at mine sites and options for better use of the existing NWQWP to meet water demand for mining development. (decentralised location of potential mining developments and potential level of demand (around 5–6 ML per annum per small mine) (refer to section 5.6.1). Larger demands from known proposed mines of significant scale are likely to be met by the NWQWP.
4. **Address demand for water to support mineral processing**. • Existing mineral processing companies will require additional water at Cloncurry in the short term, but volumes are in the order of 85–185 ML per annum of high priority water in excess of current supply.	Investigate non-build options, such as better use of existing water supplies available to Cloncurry, to meet water demand for mineral processing due to proximity of this known demand to Cloncurry (short-term around 85–185 ML per annum). For other mineral processing demand, investigate other on-site options, due to the decentralised location of potential mineral processing developments and potential level of demand (refer to section 5.7.1).

Source: Jacobs analysis

6.5 Objectives and benefits sought

By addressing the need that exists for the additional water supply, a series of benefits would be realised for each sector (Table 6.2).

Table 6.2 Expected benefits from addressing the need for additional water supply

Sector	Outcomes	Benefit description	Type of benefits	Unit of measurement
Agriculture—production	Development of high value irrigation cropping	The extent to which cropping expertise and water resources can be used to support the development of high value irrigated agricultural production	Quantitative financial	Regional GVP, IVA and gross margins ($)
	Development of irrigated cattle feed growing and feedlot industry	The extent to which additional cropping expertise and water resources can be used to support the development of high value irrigated agricultural production	Quantitative financial	Regional GVP, IVA and gross margins ($)
	Additional employment created through increased agricultural production	The number of additional jobs created in agriculture through development of water resources	Quantitative non-financial	FTEs
Agriculture—processing	Development of innovative agricultural processing	Extent to which additional cropping expertise and water is used to develop agricultural processing industry (abattoir, biofuel refinement, cotton gin etc.)	Quantitative financial	Regional GVP, IVA and gross margins ($)
	Additional employment created through increased agricultural processing	The number of additional jobs created in agricultural processing through development of water resources	Quantitative non-financial	FTEs
Mining	Additional water to support existing mines	Water to support existing mining operations, particularly south of Cloncurry, that have expressed a demand for more reliable water	Quantitative financial	Volume of water sold to mining companies
	Additional water to support new mines	Additional water to support new mines establishing in the Mount Isa–Cloncurry region	Quantitative financial	Volume of water sold to mining companies
	Additional water to reduce pressure on groundwater resources	Groundwater resources in the area are limited. Using additional surface water resources may reduce pressure on groundwater reserves	Quantitative non-financial	ML of groundwater substitution achieved
	Increase in regional employment through water security for existing mines	Additional regional employment created through certainty of water supply for existing mines	Quantitative non-financial	FTEs
	Increase in regional employment through water security for new mines	Additional regional employment created through certainty of water supply for existing mines	Quantitative non-financial	FTEs
	Increase in royalties paid from existing mines using additional water	Amount of additional royalties received by the state government based on certainty of water supply for existing mines	Quantitative financial	Dollars ($)
	Increase in royalties paid from new mines using additional water	Amount of additional royalties received by the state government based on certainty of water supply for new mines	Quantitative financial	Dollars ($)

Sector	Outcomes	Benefit description	Type of benefits	Unit of measurement
Mineral processing	Water to support new mineral processing facility	Additional water to support existing and new mineral processing facility establishing in the Mount Isa–Cloncurry region	Quantitative financial	Volume of water sold to mineral processing companies
	Increase in regional employment through new mineral processing	Additional regional employment created through certainty of water supply for new mineral processing facility	Quantitative non-financial	FTE's
Other—general benefits	Resilient community due to diverse economic production base (sustainable agriculture, mining and mineral processing)	Diversification of sources of economic growth, resulting in long-term social and economic resilience, growth and jobs.	Quantitative non-financial	Population growth and employment statistics

Source: Jacobs analysis.

More detail on the identified benefits appear in Appendix A (Benefits register).

Chapter 5 concluded that additional water storage capacity was not expected to be required to meet urban demand within the next 30 years. However, Cloncurry River Dam would provide capacity to meet any increased water demand from the resident population and industry above the projected growth rates. This provides greater resilience to the impacts of drought and/or a changing climate in the longer term.

6.6 Demand assessment

6.6.1 Agriculture

The study area is in North West Queensland and lies within Australia's tropical savannas which spread across the top of the country. Land use in the study area is dominated by cattle grazing at low densities on large properties, most of which are held in leasehold title. Typical stocking rates in the tropical savannas are two to five head of cattle per square kilometre. According to DAFF in the 2013 Agricultural Land Audit, there is an opportunity in the study area for growth in agriculture in establishing horticulture and intensive livestock practices (DAFF, 2013).

Water is sourced from the Flinders and Leichhardt river catchments and is highly dependent on environmental and natural factors, including climate conditions, evaporation rate and flow. Within the Cloncurry region, agricultural operations have no access to affordable supplemented water (i.e. with a specified reliability), resulting in very few irrigators or crops. Current land use is predominately based on extensive cattle grazing.

High value crops are currently challenging to produce in the study area due to water supply uncertainty and the level of capital expenditure required to establish crops, such as cotton, chickpeas and rice. Other factors/barriers include a critical mass or volume of water being held by willing investors, distance to market, distance to specialised services for irrigated cropping, local climate and wildlife.

Soil suitability and land area are not barriers to irrigated agriculture, as there are large areas of black soils on the Cloncurry River, north of Cloncurry, and red soils, south of Cloncurry, that may be suitable for some irrigated crops.

Future industry growth in the region may be largely driven by Stanbroke Pastoral Company, the Australian Agricultural Company (AACo) and other major pastoralists in the region with an interest in potentially developing irrigated cropping. For example, AACo is a large holder of water entitlements in the Cloncurry Shire with around 70,000 ML of water harvesting licences on the Cloncurry River, 100–200 km north of Cloncurry (i.e. on Dalgonally and Canobie stations).

6.6.1.1 Barriers to irrigated agriculture

Key landholders and producers within the study area indicated their interest in further development of water sources and cropping in the area. The stakeholder consultation process (see Appendix C) for the PBC and DBC process identified some key barriers including:

- the absence of critical supporting processing facilities within the study area leading to higher production and transport costs (e.g. a cotton gin, feedlot or meat works)
- the lack of a critical mass of water held by a single investor (or group of coordinated investors) to provide economies of scale that would be required to generate enough yield to justify large capital investment in enabling infrastructure (e.g. in a cotton gin, feed lot or meat works)
- a lack of demonstrated successful irrigated cropping on the Cloncurry River—irrigated cropping is in its infancy on the Leichhardt River (e.g. Lorraine Station, 250 km north of Cloncurry) and very limited on the Flinders River (e.g. Silver Hills near Richmond 285 km east of Cloncurry); Testing the suitability of a range of crops and irrigation systems, and making the trials accessible to interested landholders would generate experiential and data evidence. Sharing learnings and successes with landholders from a Cloncurry River demonstration farm may encourage further investment in irrigated cropping in the study area
- a focus on / expertise in beef cattle production—some landholders are graziers, not experienced farmers
- distance to market—which could see transport costs jeopardise the viability of irrigated crop outputs
- local pests, including termites and wildlife (e.g. wallabies, pigs, grasshoppers and corellas)—which may threaten crop yields or jeopardise the longevity of tree crops
- a lack of specialised support services for irrigated cropping (e.g. fertiliser, seed, farm machinery and agronomy)—however, due to the mines and grazing business, diesel fitters and contracting services (such as earthmoving) are available in the study area to support farming
- extreme weather conditions—especially in summer, when temperatures can reach 50 degrees Celsius
- difficulty retaining an experienced labour force—it is relatively easy to attract inexperienced labour for one season, but production and labour force efficiencies are made difficult by the barriers to retaining workforce over multiple seasons, partly due to the remote location and partly to the climate.

The study area including Cloncurry is generally well-serviced by road and rail infrastructure. The presence of mines and mineral processing facilities means that supporting service providers are available, such as diesel mechanics, civil contractors, earthmoving, quarrying and other services used by the mines. Cloncurry also has the short- and long-term accommodation options required to support a cyclical mining sector. All these factors could facilitate expansion in agricultural sectors including beef, biofuels and other irrigated crops.

6.6.1.2 Land suitability

There are large expanses of relatively undeveloped land within the region with suitability for irrigation

Soils near Cloncurry are (at least) moderately suitable, as noted by the CSIRO (Petheram, Watson, & Stone, 2013). Jacobs' soil analysis suggested highly suitable black soils on the Cloncurry River flats, starting 15 km north of Cloncurry, which indicated that the soil offers significant cropping potential.

The area of land which is both suitable for irrigation, and within reasonable proximity to the river, was quantified. Figure 6.1 shows land suitability for potential irrigated cropping, based on Queensland Government high level analysis, including:

- Limited crop land – located on immediate Cloncurry River flats (purple on map). Limited crop land may be suitable for cropping with engineering and/or agronomic improvements. The land is all within 4km of the Cloncurry River.
- Pasture land – native pastures forming extensive areas either side of Cloncurry River (green on map). This land is suitable only for improved or native pastures due to limitations which preclude continuous cultivation for crop production. Some areas may tolerate a short period of ground disturbance for pasture establishment.

6.6.1.2.1 Area of suitable land

The area of each of these soil types was identified. The crop land is more suitable for irrigated agriculture and will be used in preference to the pasture land. Pasture land may then be used for fodder and other crops, with land closer to the river to be used first. Accordingly, we have quantified the closest 2km of pasture land to the river, as the land closest to the river is cheaper to transport the water (Table 6.3 and Figure 6.1).

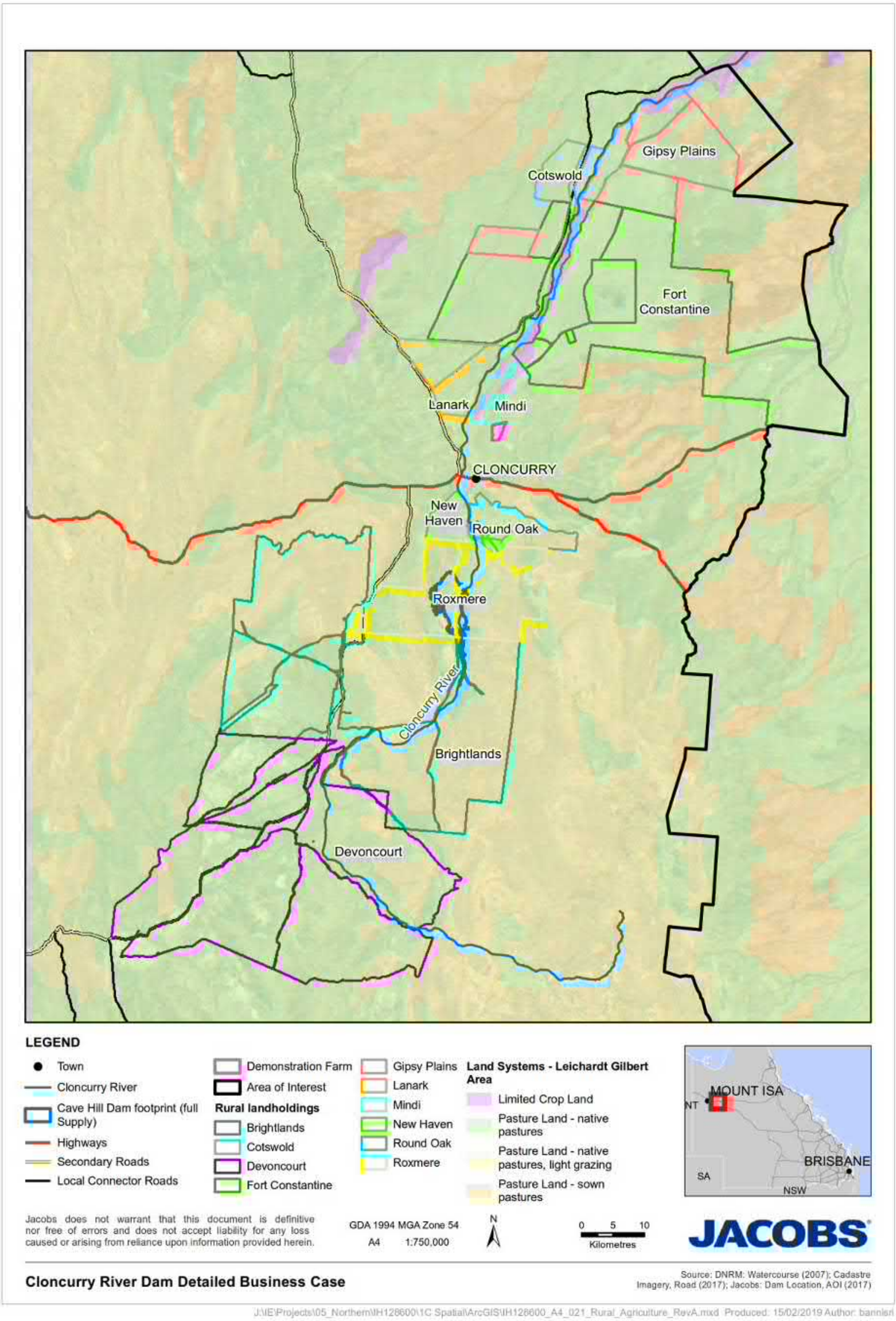
Based on the range of water use applications, the suitable soil could use between 190,000 ML and 473,000 ML of water each year. This is considerably higher than the 50,000 ML yield of Cloncurry River Dam and confirms that land availability is not a limiting factor.

Table 6.3: Upper limit demand for water based on land suitability

Land type	Area within demand assessment properties (ha)	Demand for water (ML) – Conservative / fodder application rate of 4 ML/ha	Demand for water (ML) – Cotton / commercial cropping application rate of 10 ML/ha
Limited crop land	5,160	20,640	51,600
Pasture land (within 2km of river)	42,214	168,856	422,140
Total	**47,374**	**189,496**	**473,740**

Source: Jacobs analysis

Figure 6.1: Potential land use



Source: Jacobs analysis, based on Queensland Government land use categories

6.6.1.2.2 Soil testing

Where extensive areas of land have been mapped at a high-level (i.e. with limited on-ground verification by a State department) it is not uncommon for subsequent on-ground soil testing to reveal land suitability that varies from the high-level land categorisation provided by State mapping.

Preliminary on-site soil testing, conducted by Farmacist for the PBC, was undertaken on selected properties with access to the project (i.e. Roxmere and the demonstration farm). Informal, visual / manual soil testing by an experienced commercial agriculture advisor suggested the suitability of the black soils on Fort Constantine.

The results of the soil testing indicated that the land suitability mapping likely understates the suitability of the properties forming part of the demand assessment. That is, the following high-level categories are conservative:

1) Limited crop land, which is located on the river flats within 4km of the Cloncurry River (purple on map), is very likely to be suitable for cropping with limited engineering and/or agronomic improvements as it includes the black soils on Fort Constantine, which are considered highly suitable for irrigation.
2) Pasture land – native pastures, which was tested was also considered suitable for irrigated cropping (contrary to it definition), as it includes the soils on the Town Common, which are considered suitable for irrigation as part of the PBC's recommended council-led demonstration farm.

Case study

Soil testing done for the PBC indicated, for example, that the demonstration farm (categorised as pasture land) was likely suitable for irrigation. The Farmacist (2017) results are as follows:

- Preliminary investigations of the Cloncurry town common identified suitable soils (soil analysis summary in Appendix H of the PBC)
- The soils of the town common to be included in a demonstration farm are classified as cracking clays with some residual stones (20-30mm diameter). Soil samples taken from 0-20cm show no evidence of salinity and very low levels of Organic Carbon.
- Phosphorus levels as shown by the Colwell analysis are also very low with Sulphur levels similarly low. In contrast, the Potassium levels are very high.
- Zinc levels as shown by the DTPA analysis are extremely low.
- On a more positive note, there appears to be very low levels of sodium as shown by ESP values ranging from 1.07 to 2.48% of cations.
- These soil test values reflect the ancient sediments that have formed these cracking clay soils. The Phosphorus, Sulphur and Zinc levels are extremely low; much lower than witnessed on soils in the Burdekin flood plain soils currently farmed to sugarcane.

Pre-plant applications of Phosphorus, Sulphur and Zinc would be obligatory given the chemical status of these soils, whilst Nitrogen should also be added pre-plant for all non-leguminous plantings (Farmacist 2017).

Testing of red soils south of Cloncurry on Roxmere Station (also categorised as pasture land) indicated suitability for irrigation (Table 6.4) (Farmacist 2017).

Table 6.4: Results of soil testing on Roxmere and Town Common

	Unit	Roxmere 01	Common 3	Common 2	Common 1
Sample Depth	cm	0–20	0–20	0–20	0–20
Soil Texture		Clay Loam	Heavy Clay	Heavy Clay	Heavy Clay
pH (1:5 Water)		6.69	8.28	8.07	8.31
pH CaCl		5.89	7.14	6.97	7.16
ECSE	dS/m	2.236	0.2726	0.2146	0.2958
EC (1:5)		0.26	0.047	0.037	0.051
Chloride	mg/kg	286	4	7	3
Organic Carbon (OC)	%	0.15	0.28	0.36	0.21
Phosphorus (Colwell)	mg/kg	7	5	5	5

	Unit	Roxmere 01	Common 3	Common 2	Common 1
Phosphorus (BSES)	mg/kg	10	30	10	10
PBI-Col		41.7	72.4	63	67.2
Potassium (Amm-acet.)	Meq/100g	0.38	0.66	0.57	0.69
Potassium	%	2.98	1.87	1.57	2.1
Potassium (Nitric K)	Meq/100g				
Available Potassium	mg/kg	150.1	259.8	221.8	271.5
Sulphate Sulphur (MCP)	mg/kg	8.9	1	1.9	1
Cation Exchange Capacity	Meq/100g	12.9	35.5	36.1	33.1
Calcium (Amm-acet.)	Meq/100g	5	28.38	25.23	21.55
Calcium %CEC	%	38.8	79.98	69.98	65.15
Magnesium (Amm-acet.)	Meq/100g	5.86	5.76	9.87	10.01
Magnesium %CEC	%	45.51	16.24	27.38	30.27
Sodium (Amm-acet.)	Meq/100g	1.64	0.68	0.38	0.82
Sodium % of Cations (ESP)	%	12.7	1.91	1.07	2.48
Aluminium (KCl)	mg/kg				
Zinc (HCl)	mg/kg	0.31	0.44	0.45	0.42
Zinc (DTPA)	mg/kg	0.11	0.06	0.07	0.06
Copper (DTPA)	mg/kg	1.58	0.63	0.81	0.75
Iron (DTPA)	mg/kg	7.5	5.8	5.1	6.4
Manganese (DTPA)	mg/kg	22.66	3.51	3.96	3.61
Silicon (BSES)	mg/kg	559	1,471	1,266	1,364

Source: Farmacist (2017)

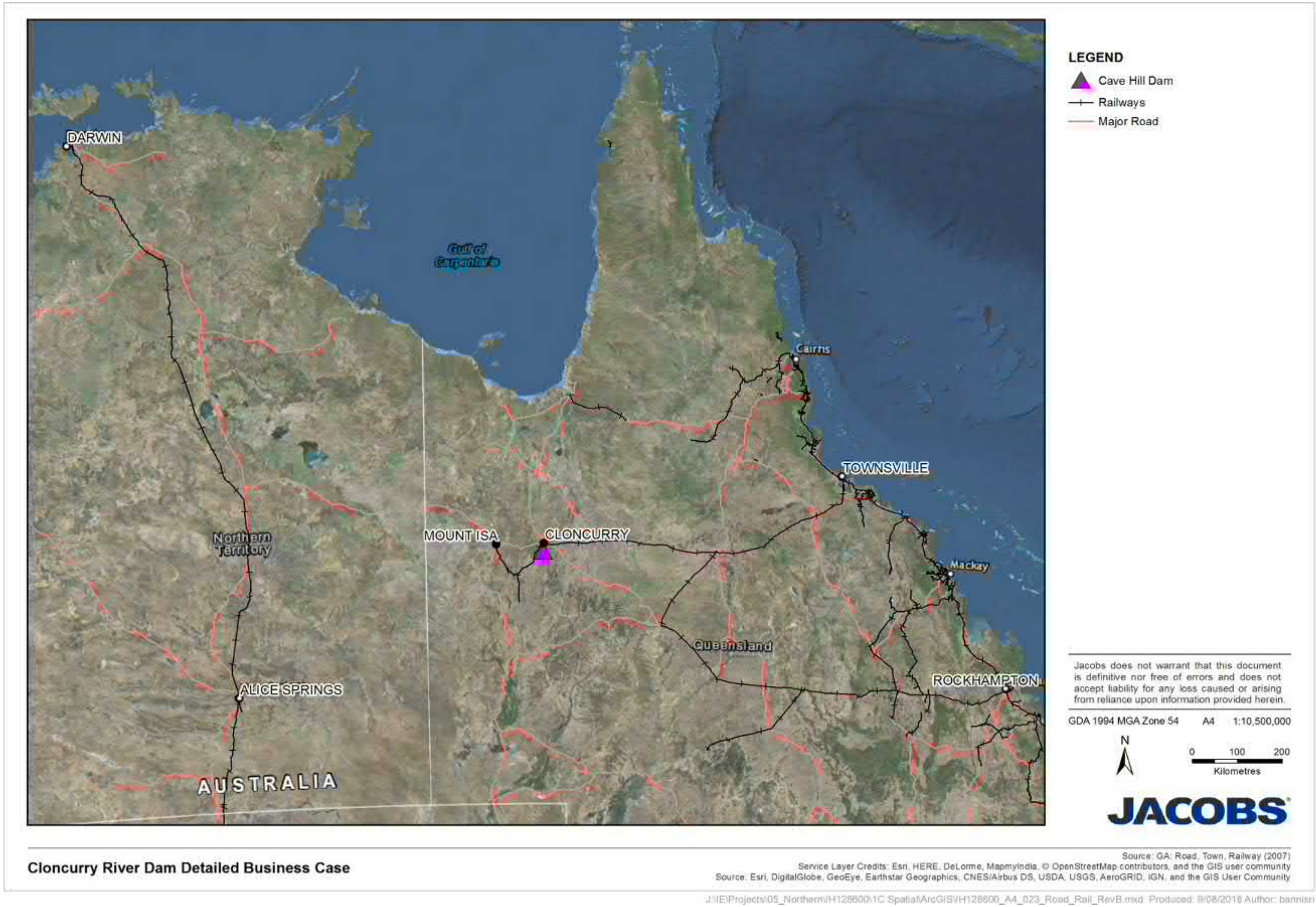
In summary, the soils on the town common are likely to be suitable for irrigated cropping (Farmacist 2017). Based on the soil mapping and the ground truthing, we concluded that there is adequate suitable soil to apply 50,000 ML per year, or more. That is, suitable soil will not limit demand.

6.1.1.1.1 The opportunity

The beef production industry is well-developed, and production can be facilitated on various land types, which allows for multiple grazing options. There is the potential to increase beef and develop irrigated agricultural production with improved water management and availability in the region. Facilitating the development of supporting industries associated with agricultural production (packing, production and processing) would underpin continual economic growth.

The transport infrastructure network of roads and rail already implemented in the study area could allow for ease of transport to the major centres of Townsville, Darwin, Brisbane, Sydney and Melbourne (Figure 6.2). This transport network could expand and increase the amount of agricultural production traffic that could be supplied and exported to other regions of Australia and overseas. For example, the ports at Darwin and Townsville are well situated to export agricultural produce to countries in the northern hemisphere.

Figure 6.2: Transport network connecting Cloncurry to regional cities



While irrigated agriculture is not a significant feature of the region, most landholders consulted were interested in accessing additional water to irrigate crops. This was the case on the Cloncurry River (revealed in consultations with river frontage properties 20–40 km north and south of Cloncurry).

While the skills required for irrigating and marketing crops (and supporting suppliers of business inputs) are not in place locally, potential exists for the development of irrigated agriculture in the study area. Some landholders possess the corporate knowledge to irrigate, having grown irrigated crops elsewhere. These companies include AACo, Stanbroke Pastoral Company and MDH Holdings. Other graziers demonstrated willingness to learn, including Roxmere, Round Oak, New Haven, Lanark, Gipsy Plains and potentially Bendigo Park stations.

In summary, there may be agricultural demand for the development of new water sources in the Cloncurry area, as suitable soils, land areas, business acumen and corporate experience of cropping are in ample supply. What has not been demonstrated, is a successful irrigation farm on the Cloncurry River, which could encourage investment in water and irrigated cropping infrastructure. If the Cloncurry River Dam was constructed, for example, irrigated crops could be grown on Roxmere, Round Oak, New Haven, Fort Constantine, and potentially Lanark stations and several properties heading further north on the river including Gypsy Plains, Dalgonally and Canobie stations. Some of the latter properties have access to the Flinders River and water entitlements purchased in recent DNRME water release processes.

6.6.1.3 Expression of interest process

The demand assessment aimed to establish the volume and location of demand for water from the project. This information informed other aspects of the DBC, including design optimisation of the dam and pipeline network, environmental approvals and financial and economic assessments.

The demand assessment targeted land holders within the region through a formal expression of interest process conducted between June and August 2018, supported by telephone and email discussions.

A key component of the process was the proposed operating conditions under which demand was expressed. The monthly reliability of the water allocation was expected to be greater than 80 per cent. Prospective customers were asked to consider a one-off cost of $1,500/ML for a water allocation, and an annual charge of $50/ML (comprising a fixed charge of $40/ML and an annual water use charge of $10/ML).

An initial contact list was developed of the owners of the nine properties that could be supplied from the Cloncurry River Dam and pipeline network directly. Three additional owners of property in the study area, without access to the project, were also consulted as potential investors and included in the expression of interest process (Table 6.5, Figure 6.3 and Figure 6.4).

Table 6.5: Landholders who participated in the demand assessment

ID	Property / Entity	Contact	Customer access to Reference Project
1	Cloncurry Shire Council - Demonstration Farm	Greg Campbell	Access to Reference Project
2	Cotswold Station	Jacqueline & Robert Curley	Access to Reference Project
3	Fort Constantine	Mark Perkins	Access to Reference Project
4	Gipsy Plains Station	Jacqueline & Robert Curley	Access to Reference Project
5	Lanark Station	Mark McMillan	Access to Reference Project
6	Mindi Station	Bryan & Linda McLeod	Access to Reference Project
7	New Haven Station	Bill Windus	Access to Reference Project
8	Round Oak Station	Colin & Judy Saunders	Access to Reference Project
9	Roxmere Station	Sam Daniels	Access to Reference Project (Cloncurry River Dam site)
10	Australian Agricultural Company	Sam Graham	Outside scheme (potential investor) - downstream
11	Brightlands Station - MDH	Allister McDonald	Outside scheme (potential investor) - upstream
12	Devoncourt Station - MDH	Don McDonald	Outside scheme (potential investor) - upstream

Figure 6.3 : Properties of rural land holders included in demand assessment

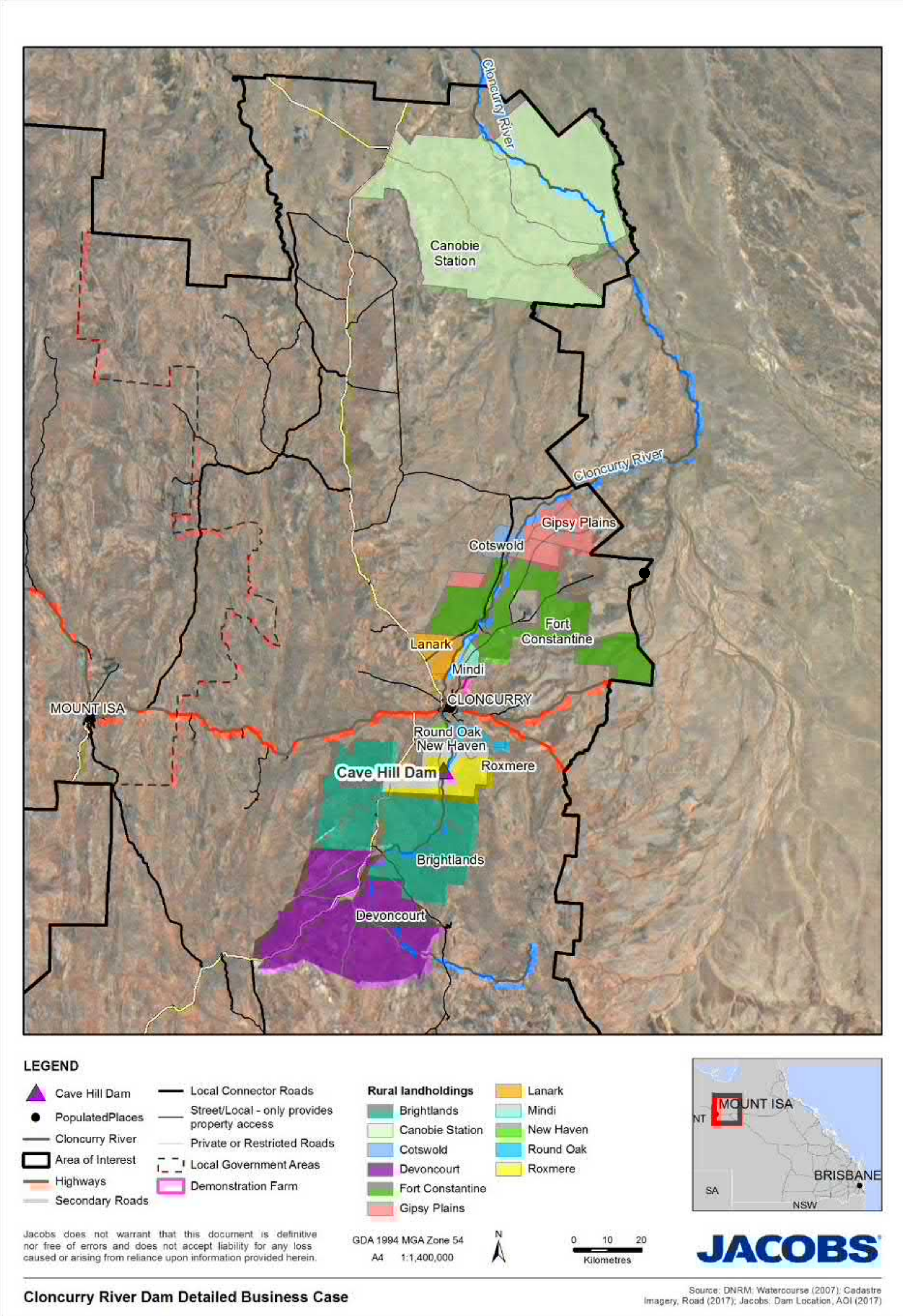


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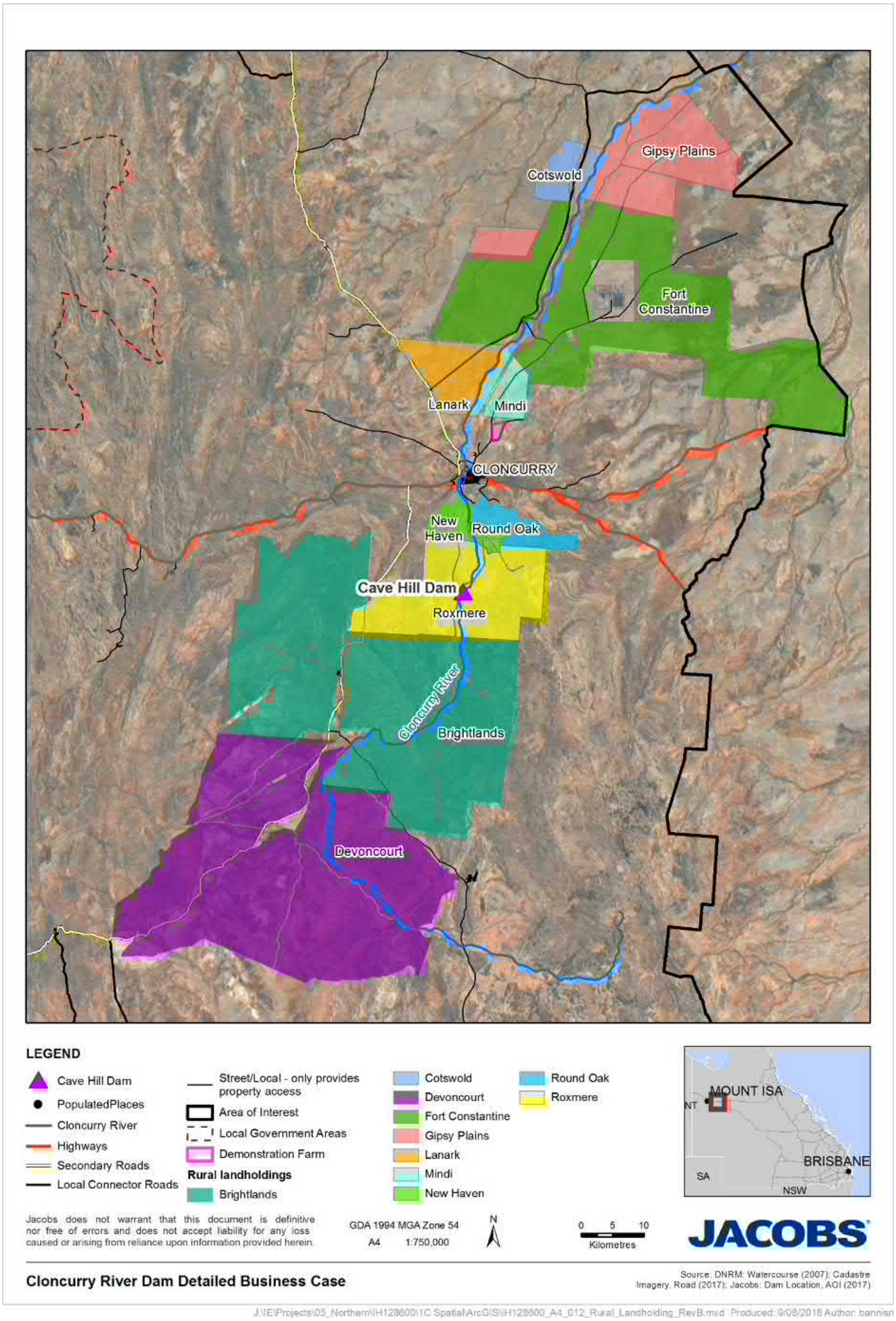
Figure 6.4: Properties of rural land holders included in demand assessment (excl. AA Co's Canobie Station)



6.6.1.3.1 Demand assessment engagement process

An initial phone conversation was held with each land owner on the contact list. The phone calls consisted of an update on the progress of the DBC. Matters that were discussed included project understanding, potential demand for water now that the reference project had been clarified and barriers to purchasing water.

Following an initial contact with a land owner, an expression of interest form was emailed (Appendix E). The forms, once completed, were not legally binding on the customer. Key information collected through the expression of interest included:

- minimum, most likely and maximum water purchase from the project (e.g. ML of medium priority allocations)
- preferred delivery location of additional water
- proposed current and future agricultural production, based on the availability of additional water.

Approximately twelve follow-up discussions occurred via telephone (and in person with the Mayor of Cloncurry) prior to and following the submission of the expression of interest forms with individual land owners, to clarify responses, forecast use of water and further discussion of barriers to irrigation.

Several insights were provided during the expression of interest process, including that most landowners in the region had no or minimal interest in purchasing water from Cloncurry River Dam and distribution network.

Major barriers

The main reasons for the demand assessment responses (raised by most stakeholders) were:

- the prohibitive up-front capital cost for water and on-farm infrastructure (i.e. $1,500/ML)
- a lack of experience with irrigated agriculture
- a lack of demonstrated success of irrigated agriculture in the region
- the perceived risk of irrigated agriculture in the region (e.g. hot and dry climate and, wild life/pests)

Minor barriers

Other reasons for the demand assessment responses (raised by some stakeholders) included:

- absence of processing facilities (e.g. abattoir, biofuels and cotton gin)
- absence of cropping-specific support services (e.g. agronomist and specialised farm machinery)
- the perceived risk of irrigated agriculture in the region (e.g. unskilled labour force and distance to market).

By contrast, due to the mining and infrastructure activity in the region, stakeholders noted that the transport network is generally an advantage and that the availability of earth moving equipment and diesel fitters / mechanics is strength of the study area, including equipment and services available in Cloncurry.

An interviewed land owner within the region, whose property was unable to be directly supplied, expressed enthusiasm for the project. The land owner indicated an intention to purchase water if land became available. The landowner has experience with irrigated agriculture in southern Queensland and was confident of the opportunities presented by the project.

Two large commercial farming businesses with extensive beef production enterprises in the region were interviewed via telephone at length. Each senior manager / owner-operator considered their expression of interest for water from this project. However, neither business submitted an expression of interest form. One business indicated that it had progressed its own on-farm infrastructure solution to improve water availability and security due to the uncertainty of the timing of the development of the Cloncurry River Dam.

The expression of interest process closed on 30 July 2018. Three expressions of interest were received, indicating a stated demand of 62,800 ML from Cloncurry River Dam (Table 6.6). This represents 126 per cent of the dam's 50,000 ML expected annual yield of medium priority water.

Table 6.6: Cloncurry River Dam expressions of interest for water

No. of properties included in expression of interest process	No. of returned expression of interest forms	Expressed demand		
		Minimum (ML)	Likely (ML)	Maximum (ML)
12	3	36,800	62,800	102,800

Existing land owners may not (if the project proceeded to construction) be the final entities to use the water from the dam for irrigated agriculture. Prior to the project commencing construction, alternative operating models should be considered to leverage the increase in water availability from the Cloncurry River Dam, as should the skills, expertise and value chains to take full advantage of the region's potential for irrigated agriculture.

Operating models could investigate long-term leases of the most productive land for irrigated agriculture from existing land owners and match the leases with the purchase of a suitable volume of water from the dam. This model could be marketed towards entities that have demonstrated performance and capability in irrigated agriculture and can leverage existing fixed overhead cost structures, value chains and economies of scale to extract value from the proposed operating model.

6.6.1.4 Summary

The capacity of water allocation available from Cloncurry River Dam is 50,000 ML. The stated *likely demand* from three land owners in the region is 62,800 ML, or 126 per cent, of the capacity of the dam. However, the small number of potential customers presents significant challenges for the project. These challenges include:

- an increased risk of the project not reaching full uptake if ultimately one of the potential customers defaulted on their future commitment to purchase water (noting that, appropriately, no binding commitments have been made as part of this DBC)
- a weak case for the project receiving capital funding from the government to benefit a small number of customers.

Potential mitigations to the above challenges include:

- After the DBC, a project proponent would enter into binding water sales contracts with land owners before the project commences construction. These contracts would include a material deposit (around 10% of total water purchase price) to reduce the likelihood of a customer walking away from the project (i.e. defaulting on any future contract for purchase of water allocations).
- Increasing the number of land owners purchasing water and receiving benefit from the project by:
  - developing a commercially-credible prospectus as a time *when the project seems likely to progress* (e.g. with funding and other support from government)
  - developing alternative operating models, for example, long-term leases of productive land for irrigation and matching leased areas with water requirements from the dam. This model could be marketed towards entities who have demonstrated performance and capability in irrigated agriculture.

6.6.2 Other sectors

For mining, mineral processing and urban sectors, it was concluded that Cloncurry and Mount Isa have enough water supply infrastructure to satisfy the sector's forecast demand over the next 30 years (Chapter 5).

Any short-term water shortages would be addressed through water restrictions and/or drawing on the spare capacity of existing water infrastructure. It would not require the development of new infrastructure, such as the Cloncurry River Dam.

However, if the Cloncurry River Dam were to be constructed mainly for the purpose of supporting increased irrigated agriculture, there may be secondary benefits that could be received by these sectors. An example is the greater resilience of the study area, to the impacts of drought and/or a changing climate for the region's urban and other water requirements, if a large storage such as Cloncurry River Dam were to be built.

The next chapter describes the proposed project and provides the point of reference against which further analysis in the business case is conducted.

7. Reference project

7.1 Key points

- This chapter describes the project objectives and scope, expected outcomes, key stakeholders and recommendations as a point of reference for the project to be assessed against.
- The key objective of the project is to deliver water primarily to be used for irrigated agriculture, as identified in the demand assessment.
- The project involves constructing a dam with a wall approximately 25 m high.
- The dam will store 140,000 ML.
- The water will be delivered through a 40 km pipeline to customer's north of the dam, up to 20 km north of Cloncurry.
- The concept design, costs, hydrology and geotechnical studies are presented in Chapter 14.
- This chapter provides a non-technical overview of the project.

7.2 Objectives, outcomes and benefits

The project objective is to meet predominantly agricultural demand for irrigation water, which has been identified using two rounds of demand assessments. Agricultural demand for water in the Cloncurry area cannot be economically met by pumping more water through the NWQWP from Lake Julius but building a dam on the Cloncurry River upstream from the town of Cloncurry, and an associated supply network. The outcome will be a reliable yield of 50,000 ML, which will enable irrigated agricultural production to be commenced and conducted on approximately 10,000 – 20,000ha of black and red soils—the major benefit of the project.

7.3 Project scope

7.3.1 Project location

Various sites for a dam were considered and investigated during the PBC to select the most suitable dam site. Site selection was informed by LIDAR mapping, aerial photographs, Google Earth maps and site reconnaissance (both aerial and ground). Concept designs for dams at each of the possible locations were undertaken. Each site was compared based on the estimated construction cost (P50), site access, possible environmental and cultural heritage impacts, system yield and location.

Cave Hill was identified as the only suitable dam site. Cloncurry River Dam is consequently the Reference Project.

For the proposed dam site, Cloncurry River, approximately 20 km south (upstream) from Cloncurry (-20.870808, 140.493174) a geotechnical investigation was undertaken to confirm the suitability of the site, identify construction risks and inform dam design.

This site had been examined several times previously, most recently by CSIRO (2013) and Alluvium (2016), but in less detail and has on all occasions been considered the best dam site near Cloncurry. The PBC confirmed the outcome of the earlier studies.

Figure 7.1 shows the dam site and pipeline route relative to the urban centres of Mount Isa and Cloncurry, and existing road, railway, water and power infrastructure.

7.3.2 Dam and spillway infrastructure

Cloncurry River Dam involves a large dam (according to Australian National Committee on Large Dams (ANCOLD) definition with a 25m tall wall), a spillway and three saddle dams.

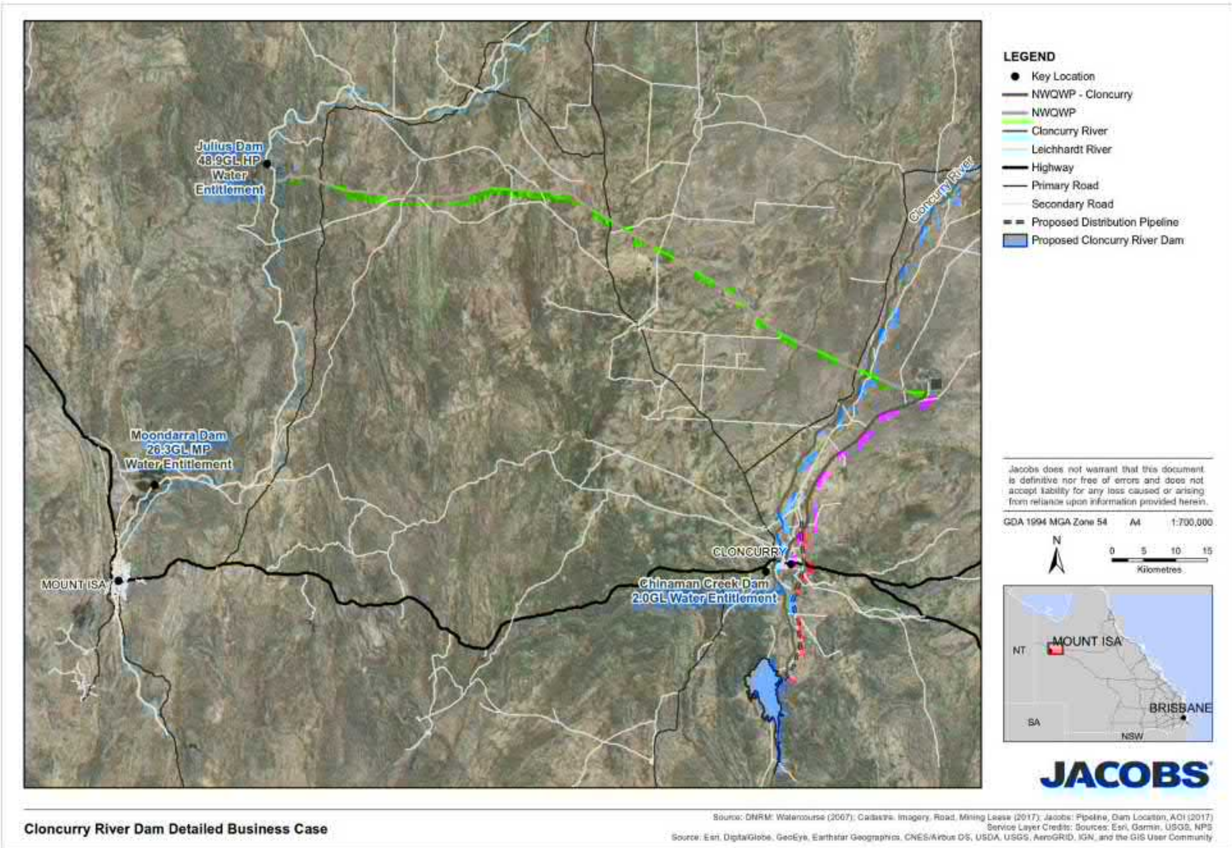
The PBC recommended that the main dam and the spillway should be constructed using the rolled compacted concrete (RCC) method, which reduces the risk of the dam or spillway being washed away during construction, if summer flows are higher than can be accommodated by temporary flood diversion and storage. An RCC construction can be overtopped, even when partially built. Given that Cloncurry can experience extreme wet season rainfalls and the Cloncurry River experiences large flooding events, this approach reduces construction risk compared to other construction methods such as concrete-face-compacted-earth. Further, given the access to concrete locally, it is also the cheapest option.

The main dam includes a water outlet that can supply the pipeline and to provide for environmental releases.

Other saddle dams are to prevent leakage to the north of the main dam. These dams are significantly smaller and can be an earth embankment construction.

Current storages in the area include Julius Dam, Moondarra Dam and Chinaman Creek Dam, with available allocations of 48.9 GL, 26.3 GL and 2.0 GL respectively.

Figure 7.1 : Cloncurry River Dam location



The dam will create an inundation volume of 140,827 ML and an annual yield of approximately 50,000 ML.

The parameters of the Reference Project differ from the parameters published by CSIRO in 2013. (Petheram, et al., 2013). Table 7.1 articulates the parameters and explains the differences.

Table 7.1 : Comparison of CSIRO and DBC Cloncurry River Dam parameters

	CSIRO (2013)	Reference Project
Dam type	Zoned earth and rock fill embankment founded on the river bend sands with slurry trench cut-off to bed rock. Earth and rock fill embankment saddle dam on the right bank side. Diversion conduit and outlet works on the left abutment. Unlined spillway with drop structures through a saddle to the west of the dam.	Roller compacted concrete (RCC) with central overflow spillway and central grout curtain A saddle dam on the right bank side. A secondary spillway is proposed through a saddle off the right abutment. Diversion conduit and outlet works on the left abutment Cheaper and safer construction method.
Full supply level	224 m (based on 5–10m GIS contour data)	More accurate GIS contour data shows that full supply level is 222.5 m.
Storage capacity	248,000 ML	140,827 ML based on the lower full supply level (above) and more accurate contour data
Estimated yield	40,000 ML at 85% reliability, or 34,000 ML at 95% reliability.	50,000 ML at 80% reliability (requiring further clarification as this yield may not meet all environmental flow objectives)
Distribution	Releases to river for downstream diversions	40 km pipe network to minimise losses and maximise reliability
Estimated capital cost	Dam: $249 million (2013 dollars) Distribution works: Not included	Dam: $391 million for RCC type dam (2018 dollars) Distribution works: $68 million to deliver supply over 150 days Total: $459 million (2018 dollars)

7.3.3 Distribution network infrastructure

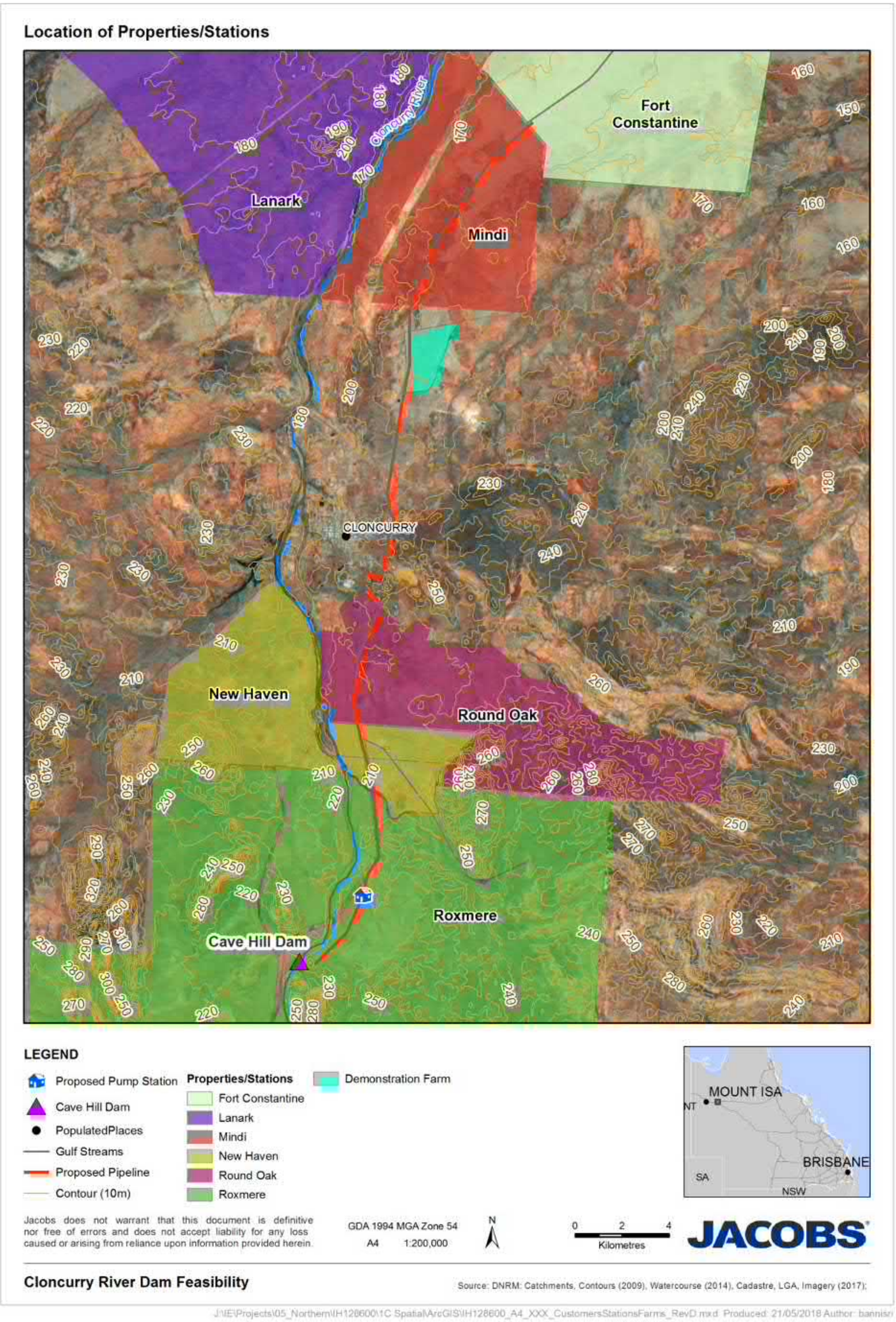
The pipeline is designed to deliver 50,000 ML of water per annum over 150 days. Distributing water via pipeline (rather than the river or open channel) means that very little water is lost during delivery and that the water is delivered with some residual head.

The pipeline will be made from high-density polyethylene as this product has the best cost, durability and pressure characteristics. To deliver the required daily volumes of 333 ML, a single DN1600 pipe is needed.

The pipeline is gravity fed for the first 5 km and then a 1000 kw booster pump is required to maintain the daily flow requirements. A solar array and battery are proposed to power the pump. As pressures are low until the booster pump station, PN4 pipe can be used, which is cheaper but is only suitable for lower pressures. North of the pump station, a higher-graded PN6.3 pipe is needed.

The pipeline can be buried below the natural surface in most places. There are two road crossings, two drain crossings and one rail crossing. The pipeline route extends 40 km from north of the dam to Fort Constantine and falls by approximately 1m/KM, as shown in Figure 7.2.

Figure 7.2 : Pipeline route



7.4 Stakeholders

The key stakeholders include:

- potential customers (especially landholders who want to establish irrigation businesses supplied by water from Cloncurry River Dam)
- landholders by the infrastructure associated with the dam and pipeline infrastructure during construction and operation,
- SunWater
- DNRME
- community of Cloncurry and Mount Isa
- environmental
- traditional owner groups
- local businesses and potential construction contractors
- local, state and federal departments
- Local, State and federal members of parliament.

The stakeholder engagement plan and register are included as Appendix C.

7.5 Implications of not proceeding

Chapter 5: Base case sets out what would happen without the project. In summary, without a large, reliable water storage, an irrigated agricultural industry will not evolve in the region of a scale necessary to transition into higher value crops such as cotton, which require some processing facilities, for example, a cotton gin. Without the dam, cattle grazing will remain the sole significant agricultural industry in the Mount Isa Cloncurry Region with no or little scope for growth of the sector.

The next chapter assesses the extent to which the project aligns with and supports federal, state and local government programs, strategies and policies.

8. Strategic considerations

8.1 Key points

- This chapter assesses the extent to which the project aligns with and supports federal, state and local government programs, strategies and policies and considers changes to the project based on this assessment.
- Twelve critical Australian and Queensland Government plans and strategies were reviewed
- Overall, the Reference Project is consistent with the government's strategic plans, including delivery of water infrastructure solutions.
- The Reference Project supports federal and state objectives related to the promotion of high-value agriculture production through alignment with the Queensland Agriculture and Food Research, Development and Extension 10-Year Roadmap and Action Plan (2018), the State Infrastructure Plan (SIP) and the Advancing North Queensland Plan (2016).

8.2 Strategic alignment and policy issues

Jacobs has identified and reviewed five federal and seven state strategic planning documents, which provide relevant context for the Reference Project. Table 8.1. provides an assessment of the alignment of the Reference Project with each of the documents.

Table 8.1: Strategic alignment—Australian Government

Government plan / strategy	Overview	Project alignment
National Water Initiative (NWI), 2004	The NWI is an intergovernmental agreement that provides the blueprint for national water reform. For the NWI's reforms about Northern Australia, Australian government guidance was that water infrastructure projects should: 1. be in areas where NWI-compliant water planning and entitlement frameworks are or will be put in place 2. demonstrate that costs will be recovered through user fees 3. be economically viable and ecologically sustainable 4. demonstrate that unallocated water will be released for consumptive use through market-based mechanisms.	The project is expected to be consistent with the NWI, on the following basis: 1. An NWI-compliant water plan and entitlement regime is in place for the Queensland Gulf catchment. 2. Apart from a request for an initial capital contribution/concessional loan, all subsequent costs are to be recovered through water use fees. There will be no ongoing government subsidy. The provision of a capital grant (if any) can be considered consistent with the NWI, which provides for transparency in those instances where financial support is required. 3. Ecological sustainability will be demonstrated through compliance with the EIS and the Water Plan. Economic viability was considered through this DBC. 4. Water under the project will be sold to irrigators and other commercial customers via a market-based process, consistent with the demand for water identified through the demand assessment processes conducted during the DBC.
White Paper on Developing Northern Australia	The White Paper (2015) identified the inadequate access to secure and tradeable water rights as a key impediment to economic development and committed $200 million to Northern Australia water projects. Main objectives were to: 1. enhance the knowledge base underpinning water infrastructure planning and decision making 2. undertake the detailed planning required to inform water infrastructure investment decisions 3. expedite the construction of water infrastructure.	The project would secure reliable and tradeable water rights. The project would also significantly expand the knowledge of large-scale irrigated agriculture in Northern Australia. This DBC is consistent with the second objective, by undertaking detailed planning and assessment.

Government plan / strategy	Overview	Project alignment
National Water Infrastructure Development Fund (NWIDF)	• The $1.3 billion fund supports planning and construction of water infrastructure projects. • It is only available to state and territory governments.	The proponent may seek capital grant funding from the NWIDF, working with the Queensland Government, upon completion of the DBC, if the assessment and results warrant such an application.
National Water Infrastructure Loan Facility (NWILF)	• The $2 billion loan facility provides concessional funds to co-fund the construction of water infrastructure, including dams, weirs and pipelines, up to 49% of the cost. • It is only available to state and territory governments. • Projects must be economically viable over the operational life, and resources must be managed in accordance with the principles of the NWI. • It is not available to support urban water projects. • The loan term is currently 15 years. The minimum loan amount of $50 million means projects must have a construction cost of $100 million or more. (Although, discussions with Australian Government representatives—and the fact that this facility has not yet provided funding for any project—have indicated that such rules may change to encourage future applications). • The facility is administered by the Regional Investment Corporation.	The project is consistent with the objectives of the loan facility. However, the current loan term of 15 years is not well suited to long-life water infrastructure, and would: • provide only partial relief from the cost of commercial lending for a period that is short relative to the life of the assets (50 to 200 years). • drive intergenerational inequity by placing the proponent under pressure to recover a disproportionately higher proportion of capital costs (early in the assets' lives), thereby recovering from an early generation of customers more costs than the benefit they receive. A solution would be to extend the period of the loan. The implications of the loan term are discussed in Chapter 16: Financial and commercial analysis. The capacity to access the loan facility will depend on the final cost of the project and support from the Queensland Government in applying for a loan. Changes to the rules of the NWILF would likely be required to accommodate loans for a longer period to improve the project's viability.
Australia Infrastructure Plan 2016	• The plan sets out the infrastructure challenges and opportunities that Australia faces over the next 15 years. • It provides a package of reforms focused on improving investment in, delivery of and use of Australia's infrastructure. • The plan notes that successful irrigated agriculture is dependent on producers having access to reliable and secure water resources. • The plan notes that regional water infrastructure that supports irrigated agriculture faces challenges because of the increasingly variable climate, growing demand and difference in the ability or willingness to pay. • It provides that more detailed catchment-level resource assessments would inform the level of investment needed to increase surface water storage—which could substantially boost broad-scale irrigation in regional Australia. • It recommends that governments commit to increasing information on the feasibility, economic viability and sustainability of new water resource developments and infrastructure in priority catchments.	The project aligns with the plan, by delivering water infrastructure that addresses growing demand and climate variability and is based on assessments of demand and economic viability. This DBC is being prepared in accordance with Infrastructure Australia's Assessment Framework, which sets out the process Infrastructure Australia uses to assess initiatives and projects on its Infrastructure Priority List. This framework has generally been embedded in the BQ framework.

Table 8.2: Strategic alignment—Queensland Government

Government plan/strategy	Overview	Project alignment
North West Queensland Strategic Development Strategy (2014)	The strategy identified that there were significant land and mineral resources in North West Queensland, which were underutilised due to a lack of water storages.	The project would increase the utilisation of available land by providing a reliable water source.
A Strategic Blueprint for Queensland's North West Minerals Province (2017)	Three strategic priorities have been identified as central to securing the future of the Province. 1. Facilitating continued resources sector development. 2. Diversifying the regional economy and creating employment opportunities. 3. Working with businesses and the community to deliver integrated and appropriate services. The diversification component of strategy seeks to leverage and identify development opportunities in key sectors including resources, agriculture, enabling infrastructure, tourism, and business and industry. The Cooperative Research Centre for Developing Northern Australia, currently being established in Townsville, is intended to provide a collaborative research platform to address challenges that have constrained agricultural and broader development in the north and includes a $75 million commitment over 10 years from the federal government.	The project closely aligns with the strategic priorities of the blueprint, particularly priority 2. The project would allow diversification of the local economy into water intensive industries, particularly irrigated agriculture. This would create additional ongoing employment and support agribusiness. The project is consistent with the ongoing research that is seeking to unlock irrigated agriculture in Northern Australia.
The Water Plan (Gulf) 2007 (Qld)	• The current water plan identifies unallocated water that is available for strategic purposes. • The government has recently sold and continues to sell unallocated water through a market-based mechanism.	The project aligns with the water available under the water plan. It is also consistent with the plan's environmental flow and water allocation security objectives. Development of a large storage with a reticulated delivery system will allow trading and sale of entitlements within the scheme over the medium and long term as part of farm development and succession plans. This trading may be independent of land ownership and transfer and thus more readily facilitated.
Queensland bulk water opportunities statement (QBWOS)	• The QBWOS sets out a framework for the Queensland Government to support and contribute to sustainable regional economic development through a hierarchy including policy changes (first), better use of existing water entitlements (second), improvements to existing bulk water infrastructure (third) and investment in new infrastructure (fourth)—consistent with the State Infrastructure Plan (SIP) (further below). • The QBWOS identifies four principles to inform assessment of bulk water infrastructure proposals: 1. Analysis of water demand is informed by direct engagement with potential customers. 2. Estimates of water charges that are presented to potential customers are underpinned by strategic and technical assessments.	The project is consistent with the principles, as follows: 1. The demand assessment has been informed by direct engagement with potential customers. 2. Potential customers have been provided with estimates of water charges, based on an assessment of construction and operation costs.

<table>
<tr><th>Government plan/strategy</th><th>Overview</th><th>Project alignment</th></tr>
<tr><td></td><td>3. There should be secure customer commitment prior to any state government funding being provided.
• If a state government contribution is necessary, the government should be presented with a business case that addresses the above points.</td><td></td></tr>
<tr><td>Queensland Agriculture and Food Research, Development and Extension 10-Year Roadmap and Action Plan (2018)</td><td>• The plan identifies accessing irrigation water as a priority to address climate variability and climate change.
• Strategies include supporting existing sectors to grow.</td><td>The project aligns with the objective of supporting existing agricultural sector to grow. As noted above, the increase in hectares is driven by the 50,000 ML of yield. Agricultural production could expand by up to 8,000 ha.</td></tr>
<tr><td>State Infrastructure Plan (SIP)</td><td>The plan sets out the Queensland Government's strategic direction for the planning, investment and delivery of infrastructure in Queensland. The plan includes the following outcomes related to water:
• Water supply infrastructure is in place or in train where there is a sound business case and water resources are available.
• Appropriate solutions, including demand management, are evaluated and implemented after the water needs of local government have been assessed in partnership with the state.
• Greater use of recycled water has been encouraged by state policies, where it is fit for purpose and economically viable.
• State dams are safe during extreme climate events.
• Water is regarded as a valuable finite resource and the impact on availability and cost of water use behaviours is recognised by Queenslanders.
• The water management and trading framework maximises the efficient use of water and water infrastructure.
The SIP also outlines the hierarchy / preferred progression of options reflected in the QBWOS (further above).</td><td>The project aligns with the plan in the following ways:
• The project will only proceed if this DBC presents a sound proposition, and a successful outcome.
• Water can be made available for the project, subject to the issues identified above.
• Trading of water and delivery rights will be possible, to maximise the efficient use of water.
• The project design will be consistent with the State's dam safety guidelines.
• The DBC aligns with Building Queensland requirements and the Queensland Government's Project Assurance Framework.
The project is consistent with the SIP.</td></tr>
<tr><td>Advancing North Queensland Plan</td><td>The plan was released in June 2016 and highlights several priorities that encourage the potential of the region through leveraging the region's competitive natural advantages.
Water security is one of the priorities under the Advancing North Queensland plan, which acknowledged that water security and water infrastructure are critical to sustain agricultural industries and boost regional development.
The Queensland Government committed to:
• supporting feasibility studies funded under the NWIDF
• securing capital funding from the NWIDF</td><td>The project will advance the plan through:
• Improving water supply security.
• Increasing water availability for urban, mining and agricultural industries.
• Increasing economic activity.
The project is consistent with the Advancing North Queensland Plan.</td></tr>
</table>

Government plan/strategy	Overview	Project alignment
	• Engaging with stakeholders in the region when funding decisions have been made through the NWIDF.	

8.3 Advantages and disadvantages of the project

Table 8.3 interprets the alignment of the Reference Project with the plans, i.e. Does the Reference Project advance the strategic initiatives outlined by governments?

Table 8.3: Summary of advantages and disadvantages arising from the strategic assessment

Government plan/strategy	Relationship of the Reference Project
National Water Initiative 2004	Advantage
White Paper on Developing Northern Australia	Advantage
National Water Infrastructure Development Fund	Advantage
National Water Infrastructure Loan Facility	Advantage
Australia Infrastructure Plan 2016	Advantage
North West Queensland Strategic Development Strategy 2014	Advantage
A Strategic Blueprint for Queensland’s North West Minerals Province 2017	Advantage
Water Plan (Gulf) 2007 (Qld)	Advantage
Queensland bulk water opportunities statement 2018	Advantage
Queensland Agriculture and Food Research, Development and Extension 10-Year Roadmap and Action Plan 2018	Advantage
State Infrastructure Plan	Advantage
Advancing North Queensland Plan	Advantage

8.4 Impact of the strategic alignment assessment

Sections 8.2 and 8.3 identify a state and federal policy and planning environment, which is overall very favourable for the realisation of the Reference Project, provided there is a strong financial and economic case (see Chapter 15: Financial and commercial analysis and Chapter 16: Economic analysis).

This following chapter sets out the key legal and regulatory considerations associated with the project and identifies critical issues.

9. Legal and regulatory considerations

9.1 Key points

- This chapter sets out the key legal and regulatory considerations associated with the project and identifies critical issues.
- The Reference Project—Cave Hill Dam--has not undergone planning development.
- The Project will need referral to the Australian Department of the Environment for determination of whether the project is a controlled action under the *EPBC Act 1999*.
- An EIS will need to be prepared and the Coordinator-General appointed under the *State Development and Public Works Act 1971* (Qld) (State Development Act) will need to evaluate the Reference Project.
- The EIS identifies and comprehensively considers all environmental impacts of the project.
- Sufficient detail is required for the necessary local and state government approvals to be secured as part of the EIS process.
- Additional secondary approvals need to be obtained including approval for construction-related activities such as gravel extraction, construction equipment storage depots and vegetation clearing.
- Acquiring the land that consists the footprint of the Reference Project from the private owner through voluntary acquisition is recommended.
- If this is not possible, then applying for status as a private infrastructure facility under the State Development Act would be necessary.
- Subject to historical tenure investigations being complete, complying with the *Native Title Act 1993* (Cth) (Native Title Act) process is a requirement.
- Applying to the Queensland Minister for Planning for an infrastructure designation, formally known as a community infrastructure designation (CID) under the *Planning Act 2016* (Qld) (Planning Act), would result in the project being an ‘accepted development’ under the Planning Act.
- Such approval would mean no development application is required, either for the state or local government, under the Planning Act except for building works.
- Agreement will need to be secured from the water regulating agency (DNRME) that under the Gulf Water Resource Plan sufficient water is available for the project. That is, downstream environmental flow requirements can be met, and existing water allocations are not impacted by the dam.
- Vegetation clearing is to be dealt with through the EIS process and should align with both Queensland Government and Australian Government legislation.
- The proponent would be required to obtain specialist legal advice at different stages of the project to ensure compliance with the legislative provisions, particularly in relation to public notification of any EIS process, the infrastructure designation application, any compulsory land acquisition and native title processes.

9.2 Methodology

The key legal and regulatory considerations associated with the development, construction and operation of the project were identified, as well as any critical issues that may impact the project and its timelines. The key issues have been grouped as follows:

- water planning and water regulatory issues associated with securing sufficient water for the project
- legal issues associated with securing appropriate land title to the project areas including any native title process that may be required
- regulatory approvals required to construct the project including consideration of the approvals already obtained for the project
- the structure of the project proponent and raising capital for the project from end user investors
- regulatory approvals required to operate and maintain the project.

9.3 Overview

Construction of Cave Hill Dam and associated irrigation infrastructure requires a proponent. The proponent will lead construction and operation of the dam and pipeline.

Conceivably, the proponent can be any of a number of entities, including a private company, a company limited by shares, a company limited by guarantee, a not-for-profit organisation, a shire council, a cooperative or a government corporation.

There are alternative proponent options. The structure of the existing irrigation entities primarily falls in two categories:

- A Corporation Act company limited by shares or limited by guarantee, or
- A dual-structure cooperative, which involves one entity owning the assets and a trading cooperative providing the services. This is commonly referred to as 'local management'.

Given its presence in the region and status as a registered water service provider under the *Water Act 2000,* SunWater (SunWater Limited) is a likely candidate. SunWater was established under the *Government Owned Corporations Act 1993* (Qld). SunWater has developed and manages a regional network of bulk water supply infrastructure that spans across Queensland. The totality of this infrastructure supports approximately 5,000 customers across the mining, power generation, industrial, local government and irrigated agriculture sectors. SunWater operates 19 major dams, 66 weirs and more than 3,000 km of pipelines. SunWater would be well suited to construct and operate the dam.

If SunWater was to own and operate Cave Hill Dam and associated pipeline, it would sell allocations to customers along the pipeline, much as it operates Julius Dam and the NWQWP.

Alternatively, the Cave Hill Dam associated irrigation scheme could be operated under 'local management. Local management of irrigation schemes has been in place in other Australian states for more than 20 years. In Queensland, two schemes (St George and Theodore) have transitioned from government ownership to local management. Two other schemes (Emerald and Eton) are currently being transitioned to local management.

Local management allows for customer ownership and, subject to the corporate structure adopted, the issuing of shares (for a company limited by shares) or granting of membership (for a co-operative or company limited by guarantee). It is a flexible and proven organisational structure, and provides the ability to create a set of governance documents to provide for:

- shareholder/member decision-making thresholds for critical decisions
- shareholder/member interests to align with the number of megalitres held by the shareholder/member in the scheme
- the appointment of a management board made up of both skilled independent directors and shareholder/member directors (and if appropriate, a director nominated by an interested community or government group).

In addition, this structure allows for the constitution to provide "not for profit" status, limiting the payment of dividends/profits.

The key objectives of the Cloncurry River Dam local management could include the following:

- Construct the dam for the benefit of the local community and customers.
- Own, operate and maintain the dam and pipeline.
- Provide efficient and cost-effective water supply services to water allocation holders under long-term water supply contracts, including any emergency urban water requirements.
- Set the price for the supply of water such that the price covers the operation and maintenance costs.

Governance documents typically prevent the income and assets of the company being distributed to the shareholders in the company, except as compensation for services provided, and specify a skills-based and board of directors.

9.3.1 Approval and steps already undertaken in relation to the project

At the time of completion of the DBC, the Reference Project is not at a stage where a proponent will have been identified and no approvals will have been sought.

9.4 Access to water for the project

9.4.1 Overview of the applicable water framework

Water resource management in Queensland is regulated under the *Water Act 2000* (Qld) ('Water Act') and the *Water Regulation 2016* (Qld) ('Water Regulation'), made under the Water Act referred to in combination as 'the water legislation'.

The Water Act establishes a system for the sustainable planning, allocation and use of water. Water Regulation specifies the application of the Water Act in relation to water rights, water planning, water allocations and other matters. Under the water legislation, regionally specific water planning instruments have been established.

The existing instruments relevant to the project area are:

- The Water Plan (Gulf) 2007, which is currently (August 2018) considered for extension by 10 years to September 2028; and
- The Gulf Resource Operations Plan June 2010 (last amended in August 2015)

The EFO and other hydrology issues addressed by these two instruments are discussed in Chapter 15.

The Department of Energy and Water Supply (2017) summarised the water availability for urban, industrial and agricultural sectors for Cloncurry (see Table 9.1).

Table 9.1 : Cloncurry water entitlements, 2018

Sector	Water source	Nominal water entitlement (ML p.a.)
Urban	Chinaman Creek Dam	2,000
..	Cloncurry River	2,160
	NWQWP	950
Subtotal – Urban		5,110
Mining	Cloncurry River upstream (Licence)	18
..	Cloncurry River upstream (Permit)	1,272 (excluded from total due to the nature of allocation)
	Coppermine Creek (Licence)	200
Subtotal – Mining		218
Agriculture	Cloncurry River (Reach 3) – Product 1	7,500
	Cloncurry River (Reach 3) – Product 2	69,200

Source: (Department of Energy and Water Supply, 2017), DNRM (2015)

9.4.2 Unallocated water in the Gulf water management area

Unallocated water reserves are detailed in the Water Plan (Gulf) 2007. In the Release of Unallocated Water in the Gulf: Terms of Sale, the Cloncurry River is identified as 'Reach 3' of the Flinders River, which extends from its headwaters to the confluence with the Flinders and River.

There is a material volume of 157,500 ML of unallocated water in the Flinders River Catchment and 25,000 ML are currently unallocated in the Leichhardt River Catchment (Table 9.2).

Table 9.2 : Unallocated water entitlements in the Leichhardt and Flinders River Catchments, 2017

Location and nature of unallocated water entitlement	Nominal water entitlement (ML p.a.)
Leichhardt River Catchment	
Strategic allocation	15,000
General allocation	10,000
Subtotal	*25,000*
Flinders River Catchment (including Cloncurry River)	
Strategic allocation	17,850
General allocation	139,650
Subtotal	*157,500*
Total – Strategic reserve (across both catchments)	32,850
Total – General reserve (across both catchments)	149,650
Total – All types	182,500

Source: (Department of Energy and Water Supply, 2017); Draft Mount Isa RWSSA and inputs to the draft Cloncurry RWSSA.

With this much unallocated water, there is no significant constraint to the development of further water storages in the region from a water planning perspective. In addition, a significant proportion of the volume of water entitlements which have been released in the study area, including water harvesting licences in the Flinders River and high priority water allocations in Lake Julius Dam remains unused.

The general and strategic reserve in the Flinders River Catchment (Table 9.2) could conceivably support future water developments, including on the Cloncurry River. It is important to consider that these are annual volumetric limits (or maximum annual extraction volumes), as they were developed with water harvesting in mind rather than in-stream infrastructure such as dams. Modelled yields arising from the Reference Project take this into account.

Realisation of the Reference Project would require amendment of the *Water Plan (Gulf) 2007* to regulate the use of the additional water made available. The Cloncurry River is a prescribed watercourse within this plan area; therefore, water in and underneath the watercourse is subject to this plan. The plan regulates the taking of overland flow water and groundwater. Amendments to the plan would likely need to address:

- additional water entitlements to allow the use of water from the Reference Project (either allocations and/or licences)
- water management protocols including operational matters such as water sharing and trading rules applicable to water management areas in the water plan area
- distribution operations licences that detail the roles and responsibilities of scheme operators to achieve the outcomes of the water plan
- the operations manual, including the day-to-day operation rules for the Reference Project.

9.5 Land access and approvals

To proceed to construction of the Reference Project, the proponent would have to secure title to the land which forms the Project footprint, including the inundation area, area for the dam wall and other critical infrastructure, and a buffer area. For the water pipelines, where they are located on privately owned or leasehold land, easements need be secured, or where they are within existing road or rail corridors, appropriate approvals and access are required.

If native title has not been extinguished in the project area, the proponent will need to follow the requirements under the Native Title Act.

9.5.1 Acquisition of land

The Reference Project's footprint area is entirely located within one property, Roxmere Station. The project proponent would need to negotiate the acquisition of the land required for the dam directly with the land owner. Purchase contracts to acquire the land should be in the form of an option, which can be exercised by the proponent (or their nominee) upon the final project approvals and financial close being achieved.

Queensland legislation contains provisions to overcome impasses in the land acquisition process of projects such as the Reference Project. Should these private negotiations fail or become protracted, the project proponent could consider making an application under the State Development Act to the Coordinator-General for approval of the project as a 'private infrastructure facility'. The process may also be followed in relation to land on which native title has not been extinguished. If the project is a 'private infrastructure facility', the Coordinator-General may use its compulsory acquisition powers to acquire the land.

To be eligible to apply for approval as a private infrastructure facility, a number of conditions must be met: the project in question must have been declared a coordinated project, for which an EIS is required under section 26(1)(a); the Coordinator-General must have publicly notified the Coordinator-General's report for the project; the Coordinator-General's report cannot have lapsed; and the area of land identified for the infrastructure facility must be consistent with the land assessed in the EIS for the project.

In addition, for the Governor in Council to approve the application, the proponent needs to satisfy the Governor in Council of a number of criteria[7], including (most relevantly):

- The project has economic or social significance and economic or social benefits to Australia, the State or the region in which the project is to be undertaken.
- The proponent has the financial and technical capability to complete the project.
- The project satisfies an identified need or demand for the services provided by the project.
- The proponent has taken reasonable steps to purchase the land by agreement and negotiated for at least six months with each registered owner of the land.

The documentation required for this process is significant and guidance is provided to a proponent in the Co-ordinator General's Practical Guideline for Private Infrastructure Facilities dated September 2018. Any proposal needs to clearly address the economic benefits of the dam to the region.

The approval must be gazetted and tabled by the Minister within three business days of the gazette notice.

Once the approval has been obtained, the proponent must negotiate one final time and make the registered owner a final unconditional offer to purchase the land.[8] Once all the requirements have been satisfied under these provisions, provided the Coordinator General is satisfied the project will proceed in a timely way, the Coordinator-General may take the relevant land under section 125(1)(f) of the State Development Act, and the process under the *Acquisition of Land Act 1967* (Qld) applies. Prior to taking the land, the Coordinator-General is likely to require a cost compensation agreement from the project proponent that addresses issues such as the payment by the proponent of compensation and costs associated with the proposed acquisition. The Coordinator-General is also likely to require security from the project proponent.[9]

9.5.2 Watercourse land

The land underlying the Cloncurry River is owned by the State and is 'non-tidal watercourse land' for the purposes of the Land Act. The part of the water course which lies within the footprint of the Reference Project would need to be made available to the project.

9.5.3 Roads

There are currently no gazetted State or local roads within the inundation area.

[7] Section 153AC (2) of the State Development Act.
[8] Section 153AE (1) of the State Development Act.
[9] See the Coordinator-General's Practical Guideline in relation to Private Infrastructure Facilities, https://www.statedevelopment.qld.gov.au/resources/guideline/cg/private-infrastructure-facility-guide.pdf.

9.5.4 Electricity

There are currently no known electrical assets identified within the inundation area or immediate surrounds.

9.5.5 Railway land

There are currently no known rail corridors within the inundation area. Should the final pipeline alignment be located within the rail corridor, written approval is required from the ‘railway manager’ (Queensland Rail). This is usually provided in the form of a wayleave agreement requiring the proponent to give Queensland Rail indemnity provisions in relation to any loss or damage associated with the pipeline.

9.6 Native title and cultural heritage

9.6.1 Native title

Since the High Court’s Mabo Decision in 1993, native title has been granted over vast areas of land, particularly in northern Australia. Native title has not been granted over the footprint area of the Reference Project.

In the case of land within the project area that was not the subject of a previous exclusive possession act, native title may still exist. Native title can be considered extinguished if the land has been subject to a ‘previous exclusive possession act’, if prior to 23 December 1996 there was a valid grant of freehold or certain leasehold occurred with respect to land.[10]

A claim for native title cannot be made with respect to land that is the subject of a ‘previous exclusive possession act’.[11] In order to determine whether land in the project area has been subject to a prior ‘exclusive possession act’, an historical tenure analysis is required in relation to all land within the project area. On existing analysis, it is possible that within the inundation area and particularly the watercourse native title may not have been extinguished.[12]

For land required for the project, where either freehold title or title which if granted has the effect of extinguishing native title, the proponent is required to negotiate an Indigenous Land Use Agreement (ILUA) with the native title parties, or alternatively (or in parallel) follow the ‘right to negotiate’ process set out in subdivision P of the Native Title Act.

There are three possible pathways:

- Enter into an Indigenous Land Use Agreement (ILUA) with the native title parties.
- Follow the right to negotiate process set out in Subdivision P of the Native Title Act.
- Follow the compulsory acquisition process under the State Development Act (which could not occur if the proponent has not sought to negotiate an ILUA).

The most common way, which would be subject to specialist legal advice, is to enter into an ILUA with the native title parties. An ILUA may deal with a range of issues including access to the land, compensation, protection of certain areas, and access to water and waterways.

The area proposed for the Cloncurry River Dam is registered as Leasehold Land, which would be subject to Native Title. The Mitakoodi People #5 (QC2015/009) are the active Native Title claimants. Negotiations would be entered into with the registered Native Title claimant group either through an Indigenous ILUA or the Right to Negotiate Process (RTN). This negotiation process would occur in parallel with the EIS process.

9.6.2 Native title claims within the project area

Searches indicate that there is a current native title application covering the project area. The application has been approved for consideration by the Tribunal. No determination has been made yet. The Mitakoodi and Mayi People filed a claim in July 2015 over an area near Cloncurry and Julia Creek, extending northerly from the Selwyn Range along the McKinlay, Fullarton, Cloncurry and Saxby rivers to the Norman River.

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[10] Section 23B of the Native Title Act.
[11] Section 61A of the Native Title Act.
[12] A historical tenure analysis will be required for the project area.

9.6.3 Process—dam and inundation area

Where land will be required as freehold (or other secure long-term tenure, for example a perpetual lease granted under the Land Act) by the project proponent, then the right to negotiate process should be followed in the first instance.

The Queensland Government encourages parties to negotiate an ILUA, which includes an agreement in relation to the future acts that may occur in the ILUA area. It should be noted that the right to negotiate process contains timeframes and a process for determination to be made. The ILUA process does not include timeframes.

The right to negotiate process can take between nine months and one year if negotiations are successful, and a further six months if they become protracted and the Native Title Tribunal is required to make a determination or mediate. The timeframes to negotiate an ILUA are dependent on the negotiation process, but at least 12 to 18 months should be allowed for the process.

9.6.4 State Development Act

The State Development Act does include an ability for the land where native title has not been extinguished to be compulsory acquired, which results in native title being extinguished. The process requires an application to be approved as a private infrastructure facility, as set out above, and the proponent needs to demonstrate it has taken reasonable steps to enter into an ILUA.[13]

9.6.5 Native Title—pipeline easements

In relation to the pipelines, it may be possible to consider the application of section 24KA of the Native Title Act, which allows the construction of low impact facilities, including pipelines, if the ‘act’ does not prevent native title holders from having reasonable access to the area.

9.6.6 Cultural heritage

In Queensland, cultural heritage is protected under the *Queensland Heritage Act 1992* (Qld) and the *Aboriginal Cultural Heritage Act 2003 (*Qld) (Aboriginal Cultural Heritage Act).

The Aboriginal Cultural Heritage Act includes a general duty of care to take all reasonable and practicable measures to ensure the activity does not harm Aboriginal cultural heritage, makes it unlawful to harm Aboriginal cultural heritage and includes a prohibition in relation to the excavation, relocation or taking away of Aboriginal cultural heritage.[14] The duty and other restrictions can be overcome/complied with if the person is acting under an approved Cultural Heritage Management Plan (CHMP).[15] Cultural heritage can also be dealt with in a native title agreement with an Aboriginal party.

9.7 Infrastructure designation

The Planning Act allows an application to be made under section 35 of the Planning Act for a designation of the infrastructure by either a local government or the Queensland Planning Minister.

The effect of an infrastructure designation under the Planning Act is to make that development an ‘accepted development’ under the Planning Act. An ‘accepted development’ does not require a development application, other than for ‘building work’ under the Building Act.

An infrastructure designation would result in a single process being required for the major state and local approvals. The project is of a sufficient size and scale and can demonstrate an economic benefit such that it is appropriate for the proponent to apply for an infrastructure designation for the project.

9.7.1 Infrastructure designation criteria and process

The criteria which must be satisfied for the Planning Minister (or local government) to make the designation are set out in section 36 of the Planning Act. The criteria for making the designation include that the project

[13] Section 153AC(2)(g)(ii) of the State Development Act.
[14] Sections 23, 24 and 25 of the Aboriginal Cultural Heritage Act.
[15] Sections 23(3)(a)(ii), 24(3)(a)(ii) and 25(3)(a)(iii) of the Aboriginal Cultural Heritage Act.

satisfies statutory requirements and there is or will be a need for the infrastructure to be provided in an efficient and timely manner.

To make the designation, the Minister must also be satisfied that adequate environmental assessment, including consultation, has been carried out.[16] The Minister's Guidelines and Rules 2017, made under the Planning Act, provide guidance with respect to making an infrastructure proposal to the Planning Minister. The matters that must be addressed include:

- the site description including the location, any existing uses on the site and existing uses on adjoining sites
- the type of infrastructure
- information about the nature, scale and intensity of the infrastructure and use
- any anticipated impacts on the surrounding infrastructure network (both state and local)
- a list of the applicable state interests as identified by the infrastructure entity and a statement about how they relate to the infrastructure proposal
- a statement about any relevant regional plans and state development areas that are applicable to the site and how they are relevant to the infrastructure proposal
- sufficient information to address the requirements of section 36(1) of the Planning Act
- a proposed consultation strategy for the proposed designation that has considered the level of impact of the infrastructure proposal and that includes a method for consultation with directly affected landowners, adjoining landowners, and identified native title parties, differentiated from general public consultation.

The Reference Project is of sufficient size and scale and can demonstrate economic benefit such that it seems appropriate for the proponent to apply for an infrastructure designation.

9.7.2 Development applications—Planning Act

If the designation for the project is obtained under the Planning Act, a development application will *only be required* with respect to any assessable building works.

However, if a designation is not achieved, a development application will need to be made for at least the following:

- material change of use
- reconfiguration of lot
- operation work that is clearing vegetation
- operation work that is the construction of a dam
- development for removing quarry material from a watercourse or lake
- operational work that involves taking or interfering with water under the Water Act
- operational work that is constructing or raising waterway barrier works.[17]

9.7.3 Environmental authority

The proponent will be required to obtain an environmental authority for any environmental relevant activities (ERAs). This may include but not be limited to ERA 33 Crushing, milling, grinding, screening – for the management of the material removed from the dam and inundation area.

9.7.4 EPBC Act

Key environmental issues relate to the potential impacts of the dam inundation area, the need to build additional infrastructure to support construction and the distribution of water, and the use of additional water made available as a result of this option. Resulting environmental impacts include:

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[16] Section 36(2) of the Planning Act.
[17] Schedule 8, Table 4 of the Planning Regulation.

- changes to in-storage and downstream habitats resulting from changes to stream flows in the Cloncurry River, including declared fish habitat areas in the Gulf of Carpentaria
- loss of vegetation through clearing to enable construction
- changes to surface water and groundwater levels and quality as a result of altered water flows in the Cloncurry River
- changes to the land use pattern as a result of additional water being available (namely clearing of native vegetation which forms part of grazing systems to make way for irrigated agricultural crops)
- changes to the distribution of water allocations in the study area.

The Reference Project would need to be referred to the Australian Government Department of Environment and Energy (DoEE) for determination of whether the project is a controlled action under the EPBC Act. The EPBC Act is the Australian Government's central piece of environmental legislation and considers impacts of developments on MNES, such as threatened species. If the determination was in the affirmative, an assessment of the environmental impacts on MNES would be required.

The Queensland environmental impact assessment processes have been accredited by the Australian Government and are used to assess controlled actions under the EPBC Act. Once a project has thus been assessed, approval by the Minister for the Environment (Australian Government) determines whether the project is a controlled action. If it is not determined to be a controlled action, the Australian Government will not be involved in the environmental approval and assessment process.

Realisation of the Reference Project would require preparation of an EIS to identify and comprehensively consider all environmental impacts of the project. The EIS would provide sufficient detail to enable the necessary local and state government approvals to be secured as part of the EIS process. Additional secondary approvals that would be required include construction-related activities such as gravel extraction, construction equipment storage depots and vegetation clearing.

9.7.5 Vegetation clearing

Desktop analysis of the vegetation types affected by the Reference Project has indicated that the inundation area and pipeline would impact several plant species listed as 'endangered', 'vulnerable' or 'near threatened' under the *Nature Conservation Act 1992* (Qld). A clearing permit is thus required under that Act.

In addition, it is noted that changes have been made recently to the *Vegetation Management Act 1999* (Qld), so that should an infrastructure designation not be obtained, a development permit will be required for the clearing of the endangered and 'of concern' regional ecosystem types identified as being within the project area in the evaluation report on vegetation within the project area.

The clearing of native vegetation in Queensland is regulated by both Australian Government legislation—the *EPBC Act*—and Queensland legislation—the *Nature Conservation Act 1992,* the *Vegetation Management Act 1999*, the *Planning Act 2016* and the State Policy for Vegetation Management and other associated policies and codes. Some local governments also regulate clearing of native vegetation.

Approximately 220 ha of the Ballara Nature Refuge, located within the Cloncurry Shire Council area, would be impacted by the realisation of the Reference Project. The Refuge was gazetted in 2014 under the *Nature Conservation Act (1992)*. and covers an area of 174,916 ha. The inundation area of the dam would require clearing of 0.1 per cent of vegetation within the Ballara Nature Refuge. Clearing would trigger the need to investigate environmental offset requirements.

An offsets strategy that achieves offsets for residual impacts on MNES and Matters of State Environmental Significance (MSES) in accordance with Australian and Queensland government requirements will be developed in conjunction with the project EIS. This strategy will also address the potential impacts to Ballara Nature Refuge and the need to source additional offsets. Further ecological studies and ground truthing are planned to occur as part of the EIS. Based on the outcomes of this work, mitigation measures will be developed and included in the environmental management plan (EMP) and an offsets strategy.

Under the *Nature Conservation Act (1992),* revocation of all or part of a nature refuge would be required through regulation by the Governor in Council after approval by the Legislative Assembly.

9.8 Approvals

Table 9.3 summarises the approvals likely to be required for the realisation of the Reference Project. In particular, it sets out the type of approval required for what action, under what legislation and when. Most approvals are required prior to commencement of construction activity.

Table 9.3 : Approvals likely to be required for the project

Approval required	Legislation	Description/Action	Timing	Responsible authority
Commonwealth				
Controlled action	*Environment Protection & Biodiversity Conservation Act 1999* (Cth)	Refer the project to the Commonwealth DoEE for determination whether the project is a controlled action under the EPBC Act (i.e. there is a significant impact to one or more MNES)—in which case an assessment of the environmental impacts on MNES is required.	Prior to construction	Department of the Environment (Commonwealth)
State approvals				
Declaration as a coordinated project	*State Development and Public Works Organisation Act 1971* (Qld)	Seek declaration by the Coordinator-General that the project is a 'significant project' (now called a coordinated project) for the purposes of section 26(1)(a) of the State Development Act, for which an EIS is required.	Prior to construction	The Coordinator-General under the State Development Act Department of State Development, Manufacturing, Infrastructure and Planning
EIS and Evaluation Report by Coordinator General	*State Development and Public Works Organisation Act 1971* (Qld)	Complete the EIS process and obtain an evaluation report by the Coordinator-General.	Prior to construction	The Coordinator-General under the State Development Act Department of State Development, Manufacturing, Infrastructure and Planning
Application for designation of the infrastructure	*Planning Act 2016* (Qld)	Apply for designation of the project, which, under the Planning Act, will allow the project to proceed without development permits required under the Planning Act, except in relation to any assessable building works.	Once decision to proceed is obtained	Minister for the Department of State Development, Manufacturing, Infrastructure and Planning
Development permits	*Planning Act 2016* (Qld) *Planning Regulation 2017* (Qld) *Vegetation Management Act*	Should the designation not be achieved, make a development application for at least the following: • material change of use • reconfiguration of lot • operation work that is clearing vegetation	Applicable if designation for the Reference Project is not obtained	State Assessment and Referral Agency

Approval required	Legislation	Description/Action	Timing	Responsible authority
	Fisheries Act *Water Supply (Safety and Reliability) Act 2008* (Qld) *Water Act 2000* (Qld) *Nature Conservation Act 1992* (Qld)	• operation work that is the construction of a dam • development for removing quarry material from a watercourse or lake • operational work that involves taking or interfering with water under the Water Act • operational work that is constructing or raising waterway barrier works.[18]		
Environmental Approval for Environmental Relevant Activities (ERAs)	*Environmental Protection Act 1994* (Qld)	Obtain an environmental authority for any environmental relevant activities (ERAs)	Prior to construction	Department of Environment and Science
Clearing permit for the taking of protected plants	*Nature Conservation Act 1992* (Qld)	Apply for a clearing permit, which is required with respect to any plants identified as endangered, vulnerable or near threatened in the project area (these are identified in the evaluation report).	Prior to construction	Department of Environment and Science
Development permit for building works	*Planning Act 2016* (Qld) *Planning Regulation 2017* (Qld) *Building Act 1975* (Qld)	Make a development application, which is required for any assessable building works against the Building Act and the Regional Council Planning Scheme.	Prior to construction	Cloncurry Shire Council
Water permit	*Water Act 2000* (Qld) (section 137)	Apply for a water permit, which is required to take water during construction.	Prior to construction	Department of Natural Resources, Mines and Energy
Riverine protection permit	*Water Act 2000* (Qld) (section 218)	Apply for a riverine protection permit, which is required in order to excavate, place fill or destroy vegetation in a watercourse.	Prior to construction	Department of Natural Resources, Mines and Energy
Disposal permit to remove, treat of dispose of contaminated land	*Environmental Protection Act 1994* (Qld)	Apply for a disposal permit if contaminated soil is to be removed from the site.	Prior to construction	Department of Environment and Science

The following chapter assesses whether the proposed Cloncurry River Dam Project is in the public interest through focusing on its impact on stakeholders, consumer rights, safety and security, privacy, environmental concerns, access or use changes and public access and equity.

[18] Schedule 8, Table 4 of the Planning Regulation

10. Public interest considerations

10.1 Key points

- This chapter assesses the extent to which a dam on the Cloncurry River and associated water infrastructure development to support irrigated agriculture is in the public interest.
- To do this it examines if the project will provide equitable outcomes for stakeholders and impact on consumer rights, safety and security, the environment and access and equity.
- Consultation with potential irrigation water customers and the broader community undertaken as part of the preliminary business case and this detailed business case identified that sectors of the community supported the project.
- The dam had a strong social licence to proceed from agricultural producers downstream of the dam who would benefit from opportunities to expand production.
- The mining and mineral processing industries were supportive of the project as it could provide an additional water source for new mines if they are developed.
- Traditional owner groups consulted were opposed to the project as it would impact on several culturally important sites in the inundation area of the dam and along the Cloncurry river.
- The project may impact on several species of threatened flora and fauna and impact on a small proportion of an existing nature refuge.
- The project will impact on downstream flora and fauna and wetlands.
- The project will increase the water supply in the Cloncurry region by approximately 3 times and increase gross agricultural production by $14 million annually.
- It will add 3,150 hectares of new irrigated agriculture to the Cloncurry region and has the potential to support mining, mineral processing and urban sectors.
- The project will create 58 full-time equivalent (FTE) ongoing jobs. These jobs include on-farm employment (i.e. 37 FTE jobs directly related to agriculture) and jobs in the provision of goods and services to agriculture, including transportation, processing, mechanical services and accountancy (i.e. 21 FTE jobs indirectly related to agriculture).

10.2 Methodology

According to the BQ Guidelines, public interest is defined as: *considerations affecting the good order and functioning of the community and government affairs, for the well-being of citizens*. The assessment of whether the Reference Project is in the public interest needs to consider its impacts on:

- stakeholders
- consumer rights
- safety and security
- privacy
- environmental concerns
- access or use changes
- public access and equity.

10.3 Public interest of stakeholders

10.3.1 Community and stakeholder consultation process

Consultation activities primarily conducted as part of the Preliminary Business Case included one-on-one consultation and site visits. Details of the community and stakeholder engagement processes undertaken as part of the project are documented in the Stakeholder Engagement Plan and outcomes have been reported in the Stakeholder Register.

Both local and government stakeholders were consulted. Engagement with potential irrigation water customers was undertaken through an expression of interest process to establish the demand for water. Stakeholder input into the Cloncurry River Dam project was also a part of developing the business case. The consultation also formed an important part of the analysis of likely local social, environmental and economic impacts.

The following engagement activities have been undertaken and are documented in the Stakeholder Register (see Appendix C):

- one-on-one discussions and workshops with state agencies, including BQ, DAF, DEWS, DILGP, DNRM, DSD and SunWater
- one-on-one discussions and mini-workshops with representatives from Cloncurry Regional Council (Mayor and CEO), Richmond Shire Council (Mayor), Mount Isa City Council (GM Water) and Mount Isa Water Board (Chief Executive)
- two or more one-on-one discussions each with landholders and graziers with river frontage on the Cloncurry River, companies and stations consulted included MDH, Brodie and Co, Stanbroke Pastoral Company, AA Company, New Haven, Round Oak, Lanark and Mindi stations
- meetings with representatives of the Traditional Owners and recognised Native Title holders of the land in the impact zone, the Mitakoodi and Mayi People.
- meetings with existing customers of the NWQWP, including Dugald Mine, Ernest Henry Mine and Cloncurry Shire Council
- meetings with mining and mineral processing companies that are operating in or could potentially operate in the Cloncurry and Mount Isa region, such as Glencore.
- one-on-one meetings with representatives from agricultural interest and producer groups, including Queensland Farmers Federation, Cotton Australia and Flinders River Agricultural Precinct to discuss the potential for cropping in the region.

10.3.2 Social licence status and other matters arising from engagement

A 'social licence to operate' is commonly defined as a project having ongoing approval within the local community and other stakeholders, resulting in broad social acceptance.[19] The stakeholder consultation revealed the level of approval and acceptance for the project but also significant opposition.

The Mitakoodi and Mayi People were opposed to the project. The cultural significance of the dam inundation site and the Cloncurry River was identified. Opposition to the dam was strongly expressed at a site visit, since important men's and women's sites would be impacted.

Most landholders who would be able to access water from the Cloncurry River Dam expressed interest in investing in the development of irrigated cropping on the Cloncurry River. There was strong support for the opportunity to grow crops in the study area and investment in purchasing water allocations to fund part of the Cloncurry River Dam's capital costs.

[19] https://socialicense.com/definition.html.

The Cloncurry Shire Council advised that if mining or mineral processing demand for water increases, the council may need more water to meet the combination of urban and industrial demand from its urban water sources.

Consultation with mining and mineral processing companies in the area revealed that most were using ground water to service their needs, faced significant uncertainty regarding future demand for water, or were constrained by distance and cost from committing to taking large volumes of water from the dam.

Supporters of the project recognised the opportunities for the project to enhance regional development. Direct beneficiaries, such as irrigators within the supply area and other enterprises, strongly supported the project on the basis that it would lead to growth in business, provide drought resilience and improve the viability and sustainability of existing enterprises.

Wider beneficiaries of the project, such as local businesses and accommodation providers, were also supportive. The additional jobs supported by the project are a key feature of the social licence to operate.

Consultation with Queensland Government departments and corporations revealed additional matters relating to the wider implications and distribution of benefits and costs arising from the Reference Project.

Future water demand from the mineral processing sector was recognised as being highly uncertain by government representatives. Processing low grade minerals currently presents significant technical challenges that need to be resolved before it will be economically feasible. However, if these challenges are overcome the mineral processing sector in the Cloncurry region may require large amounts of additional water in excess of the limited groundwater reserves available.

It was highlighted that agriculture generally has a low capacity to pay and funding is required from other sources. In the region there is little diversification and a heavy reliance on beef production and the beef supply chain. Consequently, there is limited supply chain support for other industries. A critical mass needs to be built before industry support can develop.

10.4 Consumer rights

No consumer rights issues (including right to safety and right to be informed) were identified.

10.5 Safety and security

All construction and operational activities associated with the Cloncurry River Dam project will comply with the security, health and safety requirements outlined in the relevant legislation.

Personal information collected by the project team to inform this DBC has been kept securely and has remained confidential.

Procurement will follow the proper process and checks and balances. The risk of corrupt activity potentially in the building and management of the dam would be managed by adhering to strict procurement guidelines and the laws of the State of Queensland.

Dam construction and operations are a highly regulated activity in Australia. Dangers to members of the public downstream from dam failure have been assessed in accordance with ANCOLD guidelines and Queensland's *Water Supply (Safety and Reliability) Act 2008,* which sets the legislative framework for dam safety.

10.6 Environmental concerns

Building of the dam and the associated water delivery infrastructure will result in the loss of native vegetation in the inundation area and along the pipeline routes. Beside vegetation loss Kingsford (2001) identifies that large dams lead to the alienation of floodplain wetlands by reducing the frequency and volume and flow to them.

Large dams alter downstream river flows. They change flooding patterns and affect temperature, channel stability and salinity in downstream reaches. Changes in flow regimes caused by dams affect riverine flora and fauna (Kingsford 2001).

Vegetation communities near the Cave Hill site include *Eucalyptus camaldulensis* (river red gum) and *Lophostemon grandiflorus* (northern swamp box) woodland, which dominates on the channels and floodplain of the Cloncurry River. This latter community includes *Melaleuca leucadendra* (weeping river teatree) and *M. argentea* (silvery weeping river teatree) woodland that typically fringes waterholes and frequently inundated areas of the floodplain, which is classified as a MSES under the *Environmental Offsets Act 2014* (Qld).

The inundation area of the dam would impact regulated vegetation and wetland vegetation, both of which are MSES. Clearing of regulated vegetation and MSES vegetation would require approval.

The inundation area of this option would require clearing of vegetation within the Ballara Nature Refuge which has been designated under the NC Act. The impacted area of refuge would be approximately 1,100 ha, which represents less than 0.5 per cent of the total refuge area. Environmental offset requirements triggered by this vegetation clearing would need to be investigated. Twelve EPBC listed threatened fauna species are listed as potentially present (or suitable habitat present) within the project area.

There would be an impact on benthic substrates and their dependent macroinvertebrate communities due to changes in sediment loads. Changes in flow regimes caused by the damming of the river would change the composition of riverine flora and fauna and could have significant impacts on downstream floodplains.

Construction of the dam would introduce a large water body into an arid landscape which would provide new habitat opportunities for certain species.

10.7 Access or use changes

Construction activities associated with the dam and pipeline will impact on the access of the landholders either temporarily or permanently. The project would require the acquisition of land for the 3,277-hectare inundation area of the dam and any permanent infrastructure outside the inundation area.

Access routes may also necessitate land acquisition or access easements over freehold land.

Water pipelines or channels to transport water from the inundation area to customers may also trigger land acquisition or easement requirements. Any additional on-farm infrastructure required to store and use the water would be the responsibility of the individual landholder.

The footprint of the dam is contained within one property. The affected landholder will lose access to at least 3,277ha of their property which will be in the inundation area of the dam.

Impacts from the project will be resolved through commercial negotiation between the affected landholder and the proponent. Farming enterprises along the Cloncurry river downstream of the dam would be the greatest beneficiaries of the project.

The project will increase the water supply in the Cloncurry region by approximately 3 times and increase gross agricultural production by $14 million annually. It will add 3,150 hectares of new irrigated agriculture to the Cloncurry region and has the potential to support mining, mineral processing and urban sectors.

The project will create 58 full-time equivalent (FTE) ongoing jobs. These jobs include on-farm employment (i.e. 37 FTE jobs directly related to agriculture) and jobs in the provision of goods and services to agriculture, including transportation, processing, mechanical services and accountancy (i.e. 21 FTE jobs indirectly related to agriculture).

The Reference Project could also provide an additional recreational area for use by the general public and generate additional tourism visits. Activities that the community and tourists may undertake and benefit from in the recreation area include camping, rowing and sailing, fishing, eco-tourism, activity areas for schools and picnicking.

The following chapter assesses the sustainability aspects of the project through analysing key governance, environmental, social and economic aspects

11. Sustainability assessment

11.1 Key points

- The purpose of this chapter is to assess the sustainability aspects of a dam and associated water infrastructure on the Cloncurry River.
- The Reference Project is assessed against the sustainability criteria set out in the Building Queensland guidelines.
- The Building Queensland Guidelines requires assessment against a quadruple bottom line of governance, environmental, economic and social aspects.
- Criteria are established for each of the quadruple bottom line aspects and the project has been assessed against each of these.
- Internal expert workshops were used to assess the reference project against the relevant criteria.
- A dam on the Cloncurry River could provide additional water to support agricultural development and improve water security for the urban, mining and mineral processing sectors.
- The level of strategic planning associated with the proposed dam on the Cloncurry River is in its early stages meaning many sustainability assessment aspects are not yet fully explored.
- Sourcing local materials and contractors will reduce the carbon footprint of the project.
- Growing crops locally will reduce the need to import large volumes of feed into the area.
- Additional water supply will add to water reliability and drought resilience in Cloncurry.
- The project will have significant impacts on the hydrology of the Cloncurry River and will potentially impact on downstream users and indigenous stakeholders.
- The Cloncurry River Dam at Cave Hill would result in the inundation of 3,277ha of land at full supply level that is currently used for rural purposes and impact on an area of declared nature refuge.
- Several threatened and rare flora and fauna species are found in the inundation area of the dam and along the Cloncurry River.
- The project will provide a social return through increased employment.
- The area has significant heritage value for Traditional Owners, who strongly oppose building this dam.
- The construction of the dam and its inundation area will all occur on one property.
- The major beneficiaries of the project will be downstream landholders along the Cloncurry River, who will be able to initiate irrigation projects and potentially future mining and mineral processing industries.
- Most externalities identified have been included in the broader analysis.
- Further work to assess and address the sustainability opportunities of the project should be undertaken if the project moves to the next phase

11.2 Methodology

Consistent with the BQ Guidelines, a quadruple bottom-line definition of sustainability is used. The reference project has been assessed against the four identified aspects of sustainability identified by BQ: governance, environmental, social and economic.

Governance sustainability under the BQ Guidelines is the extent to which the project is planned and integrated within the wider system, how the project meets the strategic need identified and leaves a legacy, how a culture of knowledge-sharing and innovation has been incorporated into the project design and how procurement will be undertaken.

The assessment was informed by internal workshops. It is acknowledged that as the reference dam design and project development was at an early stage when this assessment was undertaken further workshops will need to occur to refine the sustainability aspects of the project.

The workshops identified that the most important drivers for change in the future and how the project would respond to these. Key future drivers identified were global demand for metals and minerals, northern Australia irrigation development, climate change and population growth.

11.2.1 Ratings

As per the BQ Guidelines the major issues used to assess sustainability are governance, environmental, social and economic.

A series of sub-principles as outlined in the BQ Guidelines were examined under these major principles and are presented in the text. The level of achievement against each of the principles is rated as either advanced, moderate, basic, compliant or poor. Ratings for each category are described as follows by BQ:

- **Advanced—**Generates significant additional value and new opportunities not previously evident, such as changing a liability into an asset. 'Designs out' the problem upfront rather than relying on managing impacts later. Solutions generate benefits outside the project boundary.
- **Moderate**—Solutions to significant issues result in multiple benefits through economic, social and or environmental outcomes. Meets immediate community and user needs and will be resilient and efficient into the future. Significant innovation and leading practice are incorporated into the project.
- **Basic**—Avoids harm and negative effects. Solutions create project efficiencies. Solutions have an immediate or short-term focus.
- **Compliant**—Meets legislative and regulatory requirements.
- **Poor**— Fails to meet legislative and regulatory standards. Solutions may result in dis-benefits and negative effects.

11.3 Governance

11.3.1 Context

Level of achievement: Advanced

A dam on the Cloncurry River could provide additional water to support agricultural development and improve water security for the urban, mining and mineral processing sectors.

The Cloncurry region has significant natural wealth, including a diversity of mineral resources and high-quality soils. Additional water may help support the development of new mines and associated mineral processing in areas currently without access to affordable water in one of the world's ten richest mineralised zones. Additional water supply would also improve resilience to climate change for the water supply systems in North West Queensland.

The dam would support opportunities for irrigated broad-acre cropping, new agriculture such as cotton farming, and intensification of cattle production. This would result in associated value-add and flow-on economic opportunities, such as meat processing, cotton gins, food transport and packaging. The limiting factor for agriculture intensification and crop production in the region is water, not land. Additional water would take advantage of the extensive areas of soils on the river flats of the Cloncurry River that are suitable for irrigated cropping.

The Cloncurry River Dam would significantly improve the water availability in the region.

11.3.2 Strategic planning

Level of achievement: Basic

The level of strategic planning associated with the proposed dam on the Cloncurry River is in its early stages. The Cloncurry River Dam feasibility investigations commenced in 2017. Prior to this only a high-level water availability assessment (CSIRO 2013) of the Flinders River catchment and a strategic assessment of the water supply situation (Alluvium 2016) had been completed. The Cloncurry River Dam PBC was completed by Jacobs in 2018.

The PBC investigated the Cloncurry River Dam project as part of a broader project that assessed a suite of options to improve water availability in the Mt Isa – Cloncurry Study Area. Options examined included better use of existing resources, reform and new infrastructure. It established that all known and anticipated urban and mining water demand in the study area could be met through existing sources but that existing water sources could not support the development of irrigated agriculture on the Cloncurry River floodplains.

This DBC has assessed the dimensions of the technical, environmental and economic dimensions of the Reference Project, thereby providing certainty of key parameters. This enables the Reference Project to be systematically included in local, regional, state and northern Australia planning processes.

11.3.3 Leadership, knowledge sharing and innovation

Level of achievement: Moderate

National thought leaders in irrigation and dam design have been recruited for the development of this DBC. The project builds on the experience of external consultants working on dam and infrastructure projects across Australia.

Innovation has been sought in making use of the comparative advantages that Cloncurry has in the sourcing of materials for a dam and in maximising the existing local construction and civil contractor capability. The sustainability assessment found that capital expenditure reduction opportunities exist in the Cloncurry area because of large-scale mining activities including:

- very efficient drilling and blasting capability
- low-cost earth and rock moving on a significant scale.

11.3.4 Procurement

Level of achievement: Compliant

Procurement refers to the goods and services used in the construction of the dam. If Federal Government funding for the project is received, then procurement processes will need to follow the sustainable procurement principles outlined in the Australian Government Sustainable Procurement Guide (2013). The core principle underpinning the guide is value for money, which has also been a key consideration for the development of the project. Relevant financial and non-financial costs and benefits have been considered over the entire life of the project (Chapter 15: Financial and commercial analysis and Chapter 16: Economic analysis).

Other procurement practices to enhance sustainability include:

- adopting strategies to avoid unnecessary future water consumption during construction
- minimising environmental impacts over the life of the infrastructure by using materials with low adverse impacts—for example, using locally sourced materials where possible to minimise climate impacts
- fostering innovation in sustainable products and services through the design and construction
- ensuring that fair and ethical sourcing practices are applied and that suppliers are complying with socially responsible practices.

11.4 Environment

11.4.1 Climate change mitigation

Level of achievement: Basic

Sourcing materials from local suppliers would reduce the carbon intensity of the construction activities; furthermore, using the water from the dam to grow cattle feed would reduce the need for trucking feed long distances to Cloncurry. A solar array is included in the engineering design to provide power for irrigation pumping reducing the demand on existing coal fired power plants.

The increased agricultural activities due to increased water availability could result in land clearing and increased use of fossil fuels, which contribute to greenhouse gas emissions. The increase in plant production from the additional agricultural areas, on the other hand, would increase the amount of carbon dioxide absorbed through plant growth.

11.4.2 Water management

Level of achievement: Compliant

The key impact of the dam on surface water relates to changes to flow regimes in the Cloncurry River, specifically in the inundation area and downstream of the dam. The result would be hydrological changes in the Cloncurry River and the Flinders River catchment. The catchment has been minimally modified, primarily through construction of Chinaman Creek Dam near the township of Cloncurry and downstream of the proposed project.

Changes to groundwater levels and quality may occur because of changes to surface water levels and flows in the Cloncurry River. Changes to groundwater levels may result in rising water tables and accelerated aquifer recharge in the Great Artesian Basin groundwater management area. Further assessment of the hydrological impacts of the dam on surface and groundwater would be undertaken as part of the required environmental impact assessment prior to the dam proceeding.

11.4.3 Resource recovery

Level of achievement: Advanced

Material that is excavated from the spillway area may be used in embankment construction if the quality is suitable. Depending on the volumes required for embankment construction, this may make spillway excavation less expensive, and lead to a large shallow auxiliary spillway being preferred. In addition, works which have been used for temporary flood diversion during construction may be able to form part of a permanent spillway system.

All materials that can be recycled would be processed through local recycling facilities, although volumes are expected to be minimal. Waste that could be generated by construction activities during the construction phase include earth, rock, vegetation matter, excess construction materials and oils. Runoff from exposed areas of land may also occur. Volumes of material that will need to be managed will be determined through the Environmental Impact Assessment that will be required if the project moves to the next stage. Waste would be managed in accordance with an approved Environmental Management Plan.

11.4.4 Land selection

Level of achievement: Compliant

Construction of Cave Hill Dam would require the acquisition of land for the inundation area of the dam and any permanent infrastructure outside the inundation area. The inundation area of the dam at full supply level is 3,277ha. The footprint of the dam and inundation area is located on one property. Access routes may also necessitate land acquisition or access easements over freehold land. Water pipelines to transport water from the inundation area to future customers may also trigger land acquisition or easement requirements. The water will be delivered through a 40 km pipeline to customers north of the dam, up to 20 km north of Cloncurry.

Any additional on-farm infrastructure required to store and use the water would be the responsibility of the individual landholder.

11.4.5 Ecology

Level of achievement: Compliant

The Cloncurry River Dam at Cave Hill would result in the inundation of 3,277ha of land at full supply level that is currently used for rural purposes and impact on an area of declared nature refuge.

Construction of the dam will result in the loss of riparian zone and terrestrial habitat and change the aquatic habitat due to inundation, alteration to flow and/or water quality. Barriers to movement of aquatic fauna will occur because of the dam wall. The dam will change the downstream morphology of the Cloncurry River's bed and banks, which in turn will change in-stream habitat and allow an increase in invasive species.

Impact on benthic substrates and their dependent macroinvertebrate communities will occur due to changes in sediment loads.

The key potential impacts of the dam on flora and fauna relate to direct clearing within the footprint of the dam and associated infrastructure, and changes to ecosystems resulting from changes to the surface water and groundwater levels within the inundation area and downstream of it.

Ecosystems and habitat that are dependent on flow regimes and water quality may be present downstream of and within the inundation area. Areas of endangered and 'of concern' regional ecosystems along watercourses, with larger tracts present along the Cloncurry River would be impacted.

Vegetation communities in the Cave Hill Dam area include *Eucalyptus camaldulensis* (river red gum) and *Lophostemon grandiflorus* (northern swamp box) woodland, which dominate the channels and floodplain of the Cloncurry River.

The inundation area of 3,277ha includes *Melaleuca leucadendra* (weeping river teatree) and *M. argentea* (silvery weeping river teatree) woodland that typically fringes waterholes and more frequently inundated areas of the floodplain. These are classified as a MSES.

The inundation area of this option would require clearing of vegetation within the Ballara Nature Refuge, which has been designated under the NC Act. The impacted area of refuge would be approximately 1,100 ha, which represents less than 0.5 per cent of the total refuge area. Environmental offset requirements triggered by this vegetation clearing would need to be investigated.

Twelve EPBC-listed threatened fauna species are potentially present based on existing mapping within the footprint area of the Reference Project. The purple-necked rock-wallaby and painted honeyeater, listed as vulnerable, and the Gouldian finch, listed as endangered, have previously been recorded within the project area.

Further studies of terrestrial and freshwater wetland ecosystems would be required as part of the EIS process to determine if populations of threatened species are likely to be present and to assess the nature and significance of impacts that may occur.

11.4.6 Green infrastructure

Level of achievement: Moderate

Opportunities to replace traditional infrastructure solutions with more environmentally benign technologies have not been examined extensively at this stage of the engineering design. A peer review of the RCC dam design suggested in the Preliminary Business Case has resulted in the following refinements being progressed as part of the DBC dam design development:

- including stepped RCC sections to improve constructability
- including a gallery and associated drainage in the RCC dam
- providing a smooth spillway section to aid downstream fish passage
- including upstream fish passage arrangements
- increasing outlet works sizing to enable release of environmental flows.

11.4.7 Sustainable procurement

Level of achievement: Moderate

The remoteness of the site necessitates that a large proportion of capital expenditure will be spent locally. Minimising the cost of constructing the dam will require the purchasing and transporting of suitable materials, equipment and labour from as close to the site as possible.

The intensive and well-developed mining sector in Cloncurry has significant experience in large construction projects and local capacity in terms of rock drill and blast and earth moving.

11.5 Social

11.5.1 Employees

Level of achievement: Compliant

The Sustainability Assessment section of the BQ Guidelines challenges projects to assess how marginalised and disadvantages groups can be supported. This criterion can be met by the final proponent and construction manager of the dam developing an employment strategy for the construction and operation phase of the project with the aim of ensuring workforce involvement of indigenous people, people with a disability and people from non-English-speaking backgrounds.

11.5.2 Social return

Level of achievement: Moderate

The project will increase the water supply in the Cloncurry region by approximately 3 times and increase gross agricultural production by $14 million annually. It will add 3,150 hectares of new irrigated agriculture to the Cloncurry region and has the potential to support mining, mineral processing and urban sectors.

The project will create 58 full-time equivalent (FTE) ongoing jobs. These jobs include on-farm employment (i.e. 37 FTE jobs directly related to agriculture) and jobs in the provision of goods and services to agriculture, including transportation, processing, mechanical services and accountancy (i.e. 21 FTE jobs indirectly related to agriculture).

The construction of the dam would potentially improve the drought resilience of the region and provide additional water supply certainty for the township of Cloncurry.

Construction of a dam at Cave Hill would lead to a loss of areas of cultural significance for Traditional owners at the dam construction site and inundation area, and in downstream areas of the Cloncurry River.

A social impact assessment (SIA), undertaken as part of the EIS, would identify positive and negative social impacts and provide mitigation strategies.

11.5.3 Community stakeholders

Level of achievement: Moderate

The project team undertook most of the consultation during the development of the Preliminary Business Case. A significant number of one-on-one consultation and site visits were undertaken. The community and stakeholder engagement processes are detailed in the Stakeholder Engagement Plan and documentation of outcomes in the Stakeholder Register.

Key stakeholders and their relationship to the project were identified through multiple processes, including the review of relevant studies, social mapping of the study area, and considering recommendations from stakeholders and agencies.

Local and government stakeholders were consulted. Local and government inputs formed an important part of the analysis of likely local social, environmental and economic impacts.

The following engagement activities were undertaken and are documented in the Stakeholder Engagement Register:

- one-on-one discussions and workshops with state agencies, including BQ, DAF, DEWS, DILGP, DNRM, DSD and SunWater (and their successors)
- workshops with MITEZ and State agencies, including BQ, DAF, DEWS, DILGP, DNRM, DSD, EHP and SunWater (and their successors)
- one-on-one discussions and mini-workshops with representatives from Cloncurry Regional Council (Mayor and CEO), Richmond Shire Council (Mayor), Mount Isa City Council (GM Water) and Mount Isa Water Board (Chief Executive)
- two or more one-on-one discussions each with landholders and graziers with river frontage on the Cloncurry River, including MDH (McDonalds), Brodie and Co (Daniels), Stanbroke Pastoral Company, AA Company, New Haven, Round Oak, Lanark and Mindi stations.
- meetings with representatives of relevant Indigenous groups including:
  - Mitakoodi and Mayi People—the project is likely to be relevant to this group (e.g. much of the Cloncurry River and Cave Hill dam site are in Mitakoodi and Mayi country).
- meetings with customers of the NWQWP, including Dugald Mine, Ernest Henry Mine, Cloncurry Shire Council
- meetings with mining and mineral processing companies which are operating, or could potentially operate in the Cloncurry and Mount Isa region, such as Glencore, based on current mineral deposit knowledge
- one-on-one meetings with representative agricultural groups, including QFF, Cotton Australia and Flinders River Agricultural Precinct, to discuss the potential for cropping in the region, and importantly, the goals, barriers and suggested solutions needed to promote irrigated agriculture.

11.5.4 Heritage

Level of achievement: Poor

In consultation the Mitakoodi and Mayi People indicated that the riverine landscape is important from a cultural heritage perspective and is dotted with cultural sites, particularly within a few hundred metres of the Cloncurry River. They have referred to women's sites along and within the river and men's sites downstream from the proposed dam site. The area of the proposed dam site on the Cloncurry River is known to be Eagle Hawk Dreaming.

The number of Aboriginal cultural sites located within the construction and inundation of the proposed dam is unknown. There are two registered cultural heritage sites located within the Cave Hill Dam inundation area, an open camp site with an artefact scatter and earth oven. The small number of registered sites within inundation area indicates that cultural sites have not been registered rather than them not being present.

Details of cultural sites that are known to be in the area are currently before the Federal Court in the Mitakoodi and Mayi People native title claim and are therefore confidential.

11.6 Economic

11.6.1 Equity

Level of achievement: Compliant

Equity under the BQ Guidelines is defined as the extent to which the share of the benefits and costs is fair and equitable

The economic benefits of the project include additional production and associated labour requirements.

The project may impact on fishing and other important indigenous economic and cultural activities in downstream areas.

A major cost impact relates to the landholder in the inundation area. Only one property would be impacted by the dam wall, the water-inundated area (at full supply level) and the buffer area. Current land use in the impacted area includes cattle grazing and nature conservation. Fair and reasonable compensation would be provided for the impacted landholder. This may be determined as the result of commercial negotiations between the proponent and impacted landholder, or other options may be considered based on project needs.

11.6.2 Whole of life impacts

Level of achievement: Moderate

The structure of water pricing would reflect the long-term maintenance requirements of the assets constructed as part of the project. Whole of life impacts and benefits from the project would be incorporated into the project through the structuring of the company vehicle to be established to manage the project.

11.6.3 Valuing externalities

Level of achievement: Compliant

Effects that are not considered directly in market-place transactions are known as externalities. Externalities typically involve welfare effects on others not involved in the transaction; often have long-term or unknown outcomes upon community well-being and are part of complex cause-effect chains. The purpose of this part of the sustainability assessment is to examine the extent to which externalities have been identified and included in the decision-making process.

The Urban Water Security Research Alliance established in south east Queensland in response to the Millennium Drought identified externalities associated with dam construction and operation (Daniels, et al., 2012). The key externality is the impact of damming a river on the ecosystems and biodiversity of the catchment. A dam impacts the variability, magnitude, frequency, duration, timing and rate of change of a river's natural flow. This natural flow is essential for sustaining ecosystem integrity. Any alterations to the natural flow can result in significant sediment, nutrient, chemical and temperature changes, all of which can have serious ecological and economic consequences (Daniels, et al., 2012). The overall externalities identified are summarised in the following table.

Table 11.1 : Main externalities associated with dams

Impact area	Effect of dam
Upstream catchment and river	Loss of biodiversity, increased agriculture, sedimentation and flooding, changes in river flow regime
Reservoir area	Inundation of land, presence of large man-made reservoir, pollution, changes in mineral content, decaying organic material, pollution, creation of recreation area
Downstream river	Lower water levels, reduced water quality, lack of seasonal variation, loss of biodiversity, including fish and turtles. Sediment migration.
Irrigation areas	Increased water availability and agriculture, water weeds, changes in flow and mineral content, pollution
Construction activities	Migration, informal settlement, sex work, road traffic increase, hazardous construction
Country/regional/global	Reduced fuel imports, improved exports, loss of biodiversity, reallocation of funding, sustainability

(Daniels, et al., 2012)

Most of these externalities have been addressed and included in the decision-making process. The cost of mitigation activities to manage externalities have been included in capital costs.

Compensation for the impacted landholder has been considered in the costing analysis, as have the benefits from additional agricultural production in the area.

11.7 Summary

The following table provides a summary of the sustainability principles and their ratings, for this project.

Table 11.2 : Sustainability principles and ratings

Principle	Rating
Governance	
Context	Advanced
Strategic planning	Basic
Leadership, knowledge sharing and innovation	Moderate
Procurement	Moderate
Environment	
Climate change mitigation	Basic
Water management	Compliant
Resource recovery	Advanced
Land selection	Compliant
Ecology	Basic
Green infrastructure	Moderate
Sustainable procurement	Compliant
Social	
Employees	Compliant
Community stakeholders	Moderate
Heritage	Poor
Economic	
Equity	Compliant
Whole of life	Moderate
Valuing externalities	Compliant

The major opportunities identified in the sustainability assessment revolve around the sourcing of local materials and expertise. The optimisation of volumes of materials and reuse of on-site materials, and sourcing materials, equipment and skills locally would significantly reduce the carbon footprint of the project overall.

The outcomes of the sustainability assessment are incorporated in the financial assessment and the economic cost and benefit analysis of the project.

The assessment of the sustainability aspects of the project preceded the larger body of work regarding dam and pipeline design and detailed economic analysis. Therefore, the analysis is sub-optimal, and it is recommended that a full sustainability analysis workshop be undertaken prior to the project moving to the next phase.

The following chapter conducts an analysis of the social impacts associated with the project.

12. Social impact evaluation

12.1 Key points

- This chapter provides a social baseline and evaluates the potential social impacts of the project.
- Evaluation of the social impacts has been carried out in line with the Building Queensland Guidelines.
- The social impacts of the dam are expected to extend across the Cloncurry and Mount Isa local government areas, which together form the region defined as the study area.
- The baseline assessment shows that within the study area metal ore mining is the largest employer.
- The study area has suffered from negative population growth in the 10 years leading up to 2018 in line with the downturn in the mining industry.
- Slight population increases are predicted to occur in the period to 2036.
- The population is younger than the rest of Queensland with significantly fewer residents aged 65 and over. Accordingly, families with children are the greatest proportion of households.
- High unemployment is apparent in the study area and is indicative of a social divide between the highly remunerated employed sector of the population and the unemployed or lowly remunerated.
- The area around Cloncurry has a large indigenous population. 22.8 per cent of the population identify as indigenous compared to 4 per cent for the rest of Queensland.
- Average and weekly individual and family incomes are higher than for the rest of Queensland.
- Construction of the dam and most of the inundation area will be located on only one property.
- Analysis of the rental market indicates that the additional need for accommodation generated in the construction phase of the dam will be able to be met by existing long term and short-term housing options.
- The major social benefits arising from the implementation of the project relate to additional employment, intensification of agricultural production, enhanced urban water security and additional recreational facilities.
- The major negative impacts of the project include loss of sites of cultural significance to Traditional Owners and increased demands on regional infrastructure such as roads and electricity.
- Mitigation measures have been proposed for many but not all the negative social impacts.
- An environmental impact assessment process will be required if the project moves to the approval stage. This process will need to develop a Cultural Heritage Management Plan and provide an in-depth consideration of the societal impacts on downstream communities from the construction and operation of the dam

12.2 Introduction

A social impact evaluation is important to identify wider social opportunities for the community; enable planning of how to deal with the impacts. A Social impact assessment is widely described as ‘the processes of analysing, monitoring and managing the intended and unintended social consequences, both positive and negative, of planned interventions and any social change processes invoked by those interventions’ (Vanclay, 2003).

This chapter presents the social impacts associated with the Cloncurry River Dam. It includes an overview of the existing social conditions and values in the study area and an assessment of potential benefits and impacts of the dam’s construction and operation. Mitigation measures to manage identified impacts are also outlined.

12.3 Methodology

The social impact evaluation undertaken as part of this detailed business case is in line with the guidelines developed by Building Queensland. It builds on and progresses the analyses that have been undertaken of other components of the detailed business case, such as stakeholders; the service need; strategic, legal and regulatory requirements; the market; public interest; and sustainability considerations. The outputs of the social impact evaluation have in turn informed the economic, financial and environmental analysis.

Further data for the social impact evaluation has been derived from the Australian Bureau of Statistics (ABS), other published reports and previous studies.

Detailed social impacts of the construction and operation of the Cloncurry River Dam will need to be further explored as part of an EIS if the dam moves to the next stage of approval.

12.4 Social baseline

12.4.1 Regional context

Cloncurry River Dam will be located on Roxmere Station, 20 km south of Cloncurry at a site known as Cave Hill. The dam wall will cross the Cloncurry River and inundate approximately 50 square kilometres of land that is currently used for grazing or nature conservation. The water will be delivered up to 40 km north of the dam where black soil suitable for cropping is available.

The region has significant natural wealth, including a diversity of mineral resources and high-quality soils. A key current and future constraint to realising the potential to generate additional prosperity from these resources is securing affordable water.

The social impacts of the Cloncurry River Dam are expected to occur most heavily in the Cloncurry and Mount Isa areas. Therefore, the study area for this social impact evaluation incorporates the local government areas of Cloncurry and Mount Isa.

12.4.2 Existing social environment

12.4.2.1 Overview

The study area is in Far North West Queensland and covers an area of 91,431 square kilometres which is approximately 5 per cent of the total land area of Queensland (1,734,238 km^2). The average daily temperature range is 18.1 °C to 32.3 °C. Average rainfall is 637 mm. Broadacre grazing on large scale properties is the dominant land use in the region.

The study area is classified by the ABS as remote or very remote. Within the study area there are 4 police stations, 5 ambulance stations, 2 fire stations, 18 schools and 4 hospitals. Most of these services are based in Mount Isa, the major regional centre. For example, 15 of the 18 schools in the study area are in Mount Isa.

The area has experienced negative population growth in the previous 10 years and population growth is predicted to be lower than Queensland overall over the next 20 years). The population of the area has a lower median age than the rest of Queensland and has a large indigenous population. Most housing stock is single dwelling houses, with the rate of home ownership being low, compared to Queensland).

Table 12.1: Population and demographic characteristics of communities in the study area, compared to Queensland (2017)

Characteristic	Cloncurry	Mount Isa	Study area	Queensland
Population and growth				
Estimated resident population (ERP) (2017)	3,133	19,192	22,325	4,929,158
Average annual change in ERP (2007–2017) (%)	–0.4	–0.8	–0.7	1.8
Population projection (2036)	3,527	26,369	29,896	6,763,153
Projected annual change in population (2011–2036)	0.2	0.7	0.7	1.7
Age profile				
Median age (years) (2016)	34.0	30.8	31.2	37.0
0–14 years (%)	20.6	24.2	23.7	19.7
15–64 years (%)	70.9	69.1	69.3	65.6
65+ years (%)	8.5	6.7	7.0	14.7
Cultural diversity				
Overseas born (%)	8.7	16.1	15.1	21.6
Speaks language other than English (%)	4.4	8.7	8.1	12.0
Speaks other language at home and speaks English not well or not at all	0.3	0.7	0.7	1.8
Families and households				
Couple family with no children (%)	38.0	35.3	35.6	39.4
Families with children (%)	60.2	63.2	62.8	59.0
Total families	603	4,413	5,016	1,221,148
Housing				
Total private dwellings	922	6,078	7,000	1,656,831
Separate houses (%)	79.1	76.8	77.1	76.6
Fully owned (%)	24.7	16.2	17.3	28.5
Rented (%)	52.6	46.5	47.3	34.2
Median weekly rental costs (3-bedroom house) ($)	300	350		350

Source: Information based on ABS data taken from Queensland Government Statistician's Office (2018), Queensland Regional Profiles: Resident profile for Cloncurry and Mount Isa LGAs).

A comparison between income and employment data for the study area and for Queensland) shows that, from the 2016 Census data, the study area had:

- higher median weekly incomes than in Queensland as a whole
- higher rates of unemployment than Queensland overall.

The high wage, high unemployment situation is indicative of a significant social divide. Construction activities stimulated by the building of the dam have the potential to add to the existing social divide unless managed appropriately. Other projects have implemented targeted employment programs to address such issues. The importance of metal ore mining to the economy of the study area is reflected in the industries of employment for residents in the study area.

Education levels among the population are lower than for the rest of Queensland. The major non-school qualifications held are in the 'engineering and related technologies' category. Social disadvantage is lower than the Queensland average; however, reported offenses against people and property are significantly higher. Average income in the area is significantly higher than in the rest of Queensland. Unemployment, at 9 per cent, is almost 3 per cent higher than the Queensland average. Mining is the dominant employer, providing nearly a third of all jobs. Despite being the largest land use, agriculture is a minor employer in the study area, providing less than 3 per cent of employment.

Table 12.2 outlines the income and employment characteristics of Cloncurry and Mount Isa, compared with Queensland.

Table 12.2: Income and employment in the study area and in Queensland (2016)

Characteristic	Cloncurry	Mount Isa	Study area	Queensland
Income				
Median weekly personal income ($)	1,022	997	1,001	660
Median weekly household income ($)	2,140	2,382	2,352	1,402
Employment				
Total labour force	1,542	9,687	11,229	2,602,760
Unemployment (%)	7.3	9.0	8.8	6.0
Main industries of employment (top 5)			• Metal Ore Mining (27.6%) • Pre-School and School Education (7.1%) • Public Administration (4.3%) • Hospitals (4.3%) • Food and Beverage Services (3.7%)	• Hospitals (except psychiatric hospital) (4.3%) • Primary education (2.5%) • Supermarket and grocery stores (2.4%) • Cafes and restaurants (2.3%) • Takeaway food services (2.0%)

Source: Information based on ABS data taken from Queensland Government Statistician's Office, Queensland Treasury (2018), Queensland Regional Profiles: Resident profile for Cloncurry and Mount Isa LGAs. ABS 2016 Census of Population and Housing, Census QuickStats Social infrastructure, transport and access.

12.4.2.2 Indigenous population

Based on the 2016 Census of Population and Housing, 17.7% of the regional population is identified as Indigenous (with Cloncurry having the largest percentage of Indigenous persons with 22.8%), as compared to 4.0% for Queensland (Queensland Treasury, 2018).

12.4.2.3 Ethnicity and Language

Based on the 2016 Census of Population and Housing,15.1% of people in the region were born overseas in comparison to 21.6% for Queensland overall. 8.1% of the population indicated that they spoke a language other than English at home in comparison to 12% for Queensland overall. The top non-English languages spoken at home were:

- Southeast Asian Austronesian Languages (1.8%)
- Indo Aryan Languages (0.9%)
- Afrikaans (0.5%)
- Australian Indigenous Languages (0.3%)
- Chinese Languages (0.3%)

12.4.2.4 Religion

55.8% of the population in the study area indicated that they were affiliated with a Christian religion compared to 56% of the Queensland population overall.

Table 12.3 provides the religious profile summary for the Cloncurry and Mount Isa regions.

Table 12.3: Cloncurry/Mount Isa study regions - religious profile summary

Religious affiliation	Percentage
Catholic	27.6%
No Religion	26.9%
Anglican	11.8%
Uniting Church	4.5%
Presbyterian and Reformed	2.2%

Source: (Australian Bureau of Statistics, 2016)

12.4.2.5 Families and housing

Within the study area there were 7,006 households. Of these households 68.1% were a one family household.

Most the housing stock (77.1%) was defined as separate houses. The percentage of total occupied private dwellings in the study area that were fully owned was 17.3%, compared to Queensland overall at 28.5 (Queensland Treasury, 2018).

52.6% of dwellings within Cloncurry were rented. Within Cloncurry 6.4% of private dwellings were classed as caravans compared to 0.8% for Queensland (Queensland Treasury, 2018).

12.4.2.6 Motor vehicles

7.4% of dwellings had no motor vehicles. 18.3% of dwellings had 3 or more vehicles. Within Cloncurry 10.4% of households had no motor vehicle compared to 6.0% for Queensland (Queensland Treasury, 2018).

12.4.2.7 Internet access

78.5% of total occupied private dwellings had access to the internet. Within Cloncurry 25.4% of private dwellings had no access to the internet.

12.4.2.8 Department of Social Services Payments

1,007 residents received the age pension. 450 received the disability support pension. Of the 1,103 people who received the Newstart allowance, 973 of these were located in the Mt Isa region (Queensland Treasury, 2018).

12.4.2.9 Education

Education levels in the study area are lower than for the rest of Queensland. Table 12.4 summarises the highest level of schooling achieved.

Table 12.4 : Level of schooling achieved

Area	Did not go to school or Year 8 or below		Year 9 or 10 or equivalent		Year 11 or 12 or equivalent		Total
	number	**%**	**number**	**%**	**number**	**%**	**number**
Cloncurry	185	7.8%	684	28.9%	1,112	47.0%	2,364
Mt Isa	684	5.0%	3,790	27.7%	7,285	53.3%	13,677
Total Region	869	5.4%	4,474	27.9%	8,397	52.30%	16,041
Queensland	196,488	5.4%	964,903	26.5%	2,146,809	58.9%	3,3643,834

Source: (Australian Bureau of Statistics, 2016)

In terms of higher education 12.3% of people aged over 15 held a bachelor's degree or higher compared to 18.3% for the Queensland population. Similarly, 5.4% held an Advanced Diploma or Diploma compared to 8.7% for the Queensland population, while 25.2% held a certificate in comparison to 21.3% for Queensland overall (Australian Bureau of Statistics, 2016).

Table 12.5 provides a breakdown of the non-school qualifications by field of study for both the study region and Queensland.

Table 12.5 : Non School qualifications by field of study

Field of study	Study region		Queensland
	number	**%**	**%**
Natural and Physical Sciences	156	1.6%	2.3%
Information Technology	89	0.9%	2.2%
Engineering and Related Technologies	2,588	26.7%	15.7%
Architecture and Building	429	4.4%	6.2%
Agriculture Environment and Related Studies	171	1.8%	1.9%
Health	719	7.4%	9.8%
Education	704	7.3%	7.5%
Management and Commerce	1,073	11.1%	17.5%
Society and Culture	652	6.7%	10.7%
Creative Arts	110	1.1%	3.0%
Food, Hospitality and Personal Services	435	4.4%	5.5%
Mixed Field Programs	33	0.3%	0.3%
Total	**9,693**	**100%**	**100%**

Source: (Australian Bureau of Statistics, 2016)

12.4.2.10 Socio Economic index of areas

Socio-Economic Indexes of Areas is a summary measure of the socio-economic condition of geographic areas across Australia. The Index of Relative Socio-Economic Disadvantage generally focuses on low-income earners, with relatively lower education attainment, high unemployment and dwellings without motor vehicles.

16.4% of the study area population were in the most disadvantaged quintile compared to 20% of the Queensland population overall. 8.2% of the population were in the least disadvantaged quintile compared to 20% of the Queensland population overall (Queensland Treasury, 2018). In Cloncurry 33.8% were in the most disadvantaged quintile compared to 13.6% for Mt Isa (Queensland Treasury, 2018).

12.4.2.11 Reported offences

The study area generally had higher levels of crime, with 30,067 reported offences per 100,000 persons in 2016-2017 (compared to Queensland at 10,142 per 100,000 persons).

Offences against persons were higher in the study area than Queensland overall for the same time period (3,525 offences per 100,000 persons versus 699 offences). Offences against property were higher in the study area than Queensland overall (10,208 per 100,000 people versus 4,691 offences) (Queensland Treasury, 2018).

12.4.2.12 Income

Incomes in the study area were higher than those for Queensland overall. Median annual personal income in the study area in 2011 was $52,093 compared to $34,320 for Queensland overall. 20% of the population aged 15 years or older earned less than $20,000 per annum compared to 28.4% for Queensland overall (Queensland Treasury, 2018).

Approximately 7.6% of families in the study area were classified as low income compared to 9.4% of families for Queensland overall. Median family income in the region was $122,304 per year compared to $86,372 for Queensland overall (Queensland Treasury, 2018).

12.4.2.13 Unemployment

In the June 2017 quarter, the unemployment rate in the study area was 7.2% (815 unemployed persons), compared to 6% for Queensland.

14.0% -264 families, with children under 15 years had no parent in employment, compared to 13.8% for Queensland overall (Queensland Treasury, 2018).

12.5 Impact identification

Construction of the dam will require the acquisition of land for the inundation area of the dam and any permanent infrastructure outside the inundation area. The footprint of the dam and inundation area is located on one property. Access routes will also necessitate land acquisition or access easements over freehold land.

The pipeline will also trigger land acquisition or easement requirements. Any additional on-farm infrastructure required to store and use the water will be the responsibility of the individual landholder. The current landholder within the inundation area and construction footprint will be disadvantaged. This will be resolved through commercial negotiation between the affected landholders and the proponent. Farming enterprises along the Cloncurry River downstream of the dam will be the greatest beneficiaries of the project.

Potential impacts on property from the construction and operation of the dam and associated pipeline will be described in detail in the subsequent EIS. Given the remoteness of the site, the fact that it is located on a single property, and the low population density of the area, such impacts can be expected to be minimal.

12.5.1 Property impacts

The two main ways property will be affected, are through:

- impact on land uses within the buffer around the full supply level inundation area, including prohibition of farming, livestock and similar activities
- impact on property values, due to amenity impacts from construction activities (e.g. noise, dust, traffic disruptions). Once constructed, it is expected that the land adjacent to the dam will have greater amenity and land values will rise.

12.5.2 Housing and accommodation

During construction, demand for accommodation from the construction workforce will increase. It is expected that most workers will seek accommodation within or close to the town of Cloncurry, which provides access to a range of services and facilities.

Increased demand for rental accommodation during construction could lead to higher rents. In Cloncurry, 485 dwellings (52.6 per cent) of all dwellings are rental properties (Queensland Treasury, 2018).

In the June 2018 quarter, residential rentals in the Cloncurry Council area were classified as ‘weak’, with vacancy rates at 4.1 per cent, up from 2.9 per cent in the March 2018 quarter (REIQ, 2018). Average costs of rental housing have declined significantly in the five years from 2013. Average rental cost for a three-bedroom house in Cloncurry has declined from $450 per week in 2013 to $300 in 2018 (REIQ, 2018).

During operation of the dam, no significant increase in demand for housing and accommodation is expected.

12.5.3 Population and demography

The acquisition of property for the project is not expected to impact significantly on the study area’s population or demography due to the low number of properties with dwellings to be acquired for the project.

The influx of construction workers will result in a small increase in the population of the study area for the duration of the construction phase. This will impact on community services and facilities in the study area, through increased demand for existing services (e.g. health care). Other local community facilities, such as sporting clubs, shops and community organisations, will benefit from an increased population during construction.

Employment and training associated with the project may provide opportunities for young people to remain in Cloncurry and gain skills in the construction industry. The magnitude of this benefit would be dependent on access to appropriate skilling and employment programs prior to construction.

During operation, the project will provide opportunities to develop new agricultural and horticultural businesses and expand existing ones. This will provide new employment opportunities in the study area and help create diversity in employment opportunities.

12.5.4 Employment and training

Where possible, construction workers will be sourced locally to maximise the employment benefits for residents and communities in the study area. However, the availability of appropriately skilled and qualified workers may impact on the ability of workers to be sourced locally and the level of benefit would depend on access to appropriate skilling and employment programs prior to construction. In order to maximise employment, an employment and training strategy will be considered, to identify the skills required for construction and the training required to enable locals to gain the necessary skills.

Indirect employment opportunities are also likely to be created during construction through increased demand for goods and services. This would have positive benefits for residents and workers.

The construction phase of the project is expected to provide a range of opportunities for local contractors and suppliers, which could have direct and indirect employment benefits for residents. Consultation has been undertaken with local contractors and suppliers to identify potential construction-related opportunities and how these can maximise local employment benefits.

Following construction, the dam will be operated by a small workforce.

12.5.5 Community services and facilities

An increase in population during the construction phase will increase demand for medical and health services, potentially impacting on service levels. Consultation will be undertaken with Queensland Health to ensure that potential increases in population and demand for medical and health services can be appropriately managed. It is expected that emergency services and hospitals will have the capacity and capability to respond to most construction-related incidents and emergencies; however, consultation will be undertaken with the hospital and emergency services in the preparation of emergency response procedures.

An increase in the number of children relocating to the study area with construction workers will impact on child care services and local schools, particularly smaller schools. Early consultation will be undertaken with Education Queensland, local schools and child care providers to manage potential impacts. Often regional communities support additional students, as there can be a positive impact on school resources.

Operation of the project is not expected to impact on community services and facilities.

12.5.6 Transport and access

The area is remote, though relatively well serviced by road and rail links, which have been developed to support the extensive mining operations in the area. A detailed assessment of potential impacts on transport and access from the construction and operation of the project will be provided as part of the EIS if the project moves to the next phase of approval.

12.5.7 Social amenity and use

A detailed assessment of potential impacts on social amenity and uses will be provided in the EIS if the project moves to the next phase of approval.

12.6 Impact assessment and mitigation

Table 12.6: Social impact risk assessment

Summary of social benefits and impacts	Project phase	Nature of impact	Receptors	Significance rating	Can the impact be quantified or monetised?	Mitigation measures and strategies	Significance rating after mitigation
Community impacts							
Large long-term increase in regional employment from increases in agricultural and agricultural processing and mining and mineral processing productivity	Operation	Positive	Farmers, local community, labour market participants	Major	Yes	No mitigation required	Major
Significant demands on existing transport networks and electricity infrastructure at the dam site, new mining sites and new irrigation area	Construction	Negative	Infrastructure providers	Major	Yes	Inform relevant organisations of proposed works program and schedule and engage as part of the planning process	Medium
Potential loss of areas of cultural significance—at the dam site, inundation area, downstream areas of the Cloncurry River and waterholes—and impacts on fishing and other important Indigenous economic activities	Construction and operation	Negative	Traditional Owners	Major	No	Consult with native title groups. Undertake cultural heritage survey and incorporate in planning program. Develop Cultural Heritage Management Plan as part of an EIS process	Major
Competition for skilled labour	Construction	Negative	Labour market	Medium	Yes	Undertake workforce skills gap analysis	Low
Urban water security supply	Operation	Positive	Local community	Medium	Yes	No mitigation required	Medium
Additional demands on existing services during construction and operational phases	Construction and operation	Negative	Service providers	Medium	Yes	Inform relevant organisations of the proposed works program and schedule, and engage as part of the planning process	Minor
Demand for worker housing during construction, which may impact on regional housing affordability and supply	Construction	Negative	Regional housing market	Medium	Yes	Undertake housing supply analysis and develop alternative housing arrangements if required	Minor
Cultural impacts							

Summary of social benefits and impacts	Project phase	Nature of impact	Receptors	Significance rating	Can the impact be quantified or monetised?	Mitigation measures and strategies	Significance rating after mitigation
Potential significant impacts on downstream communities through changes in flows impacting important commercial aquatic species in rivers and the Gulf	Operation	Negative	Downstream industries	Major	No	Determine the significance of impacts as part of the EIS process and develop mitigation strategies.	Major
Opposition to a dam on the Cloncurry River by regional, national and international environmental groups undermining social cohesion	Construction	Negative	Regional community	Major	No	Develop a detailed consultation and communication strategy	Medium
Change in land use to crops with a higher value per hectare in suitable areas	Operation	Positive	Land owners	Medium	Yes	No mitigation required	Medium
Large-scale change in land use from broadacre grazing to intensive agriculture, which will change community numbers and composition	Operation	Negative	Regional community	Medium	No	Develop a detailed consultation and communication strategy	Minor
Competition for new water sources and cost of water, which may drive social conflict	Operation	Negative	Regional Community	Medium	No	Develop a detailed consultation and communication strategy	Minor
Temporary influx of construction workers impacting on community cohesion	Construction	Negative	Regional community	Medium	No	Develop a detailed consultation and communication strategy	Minor
Displacement of existing landholders and industry	Operation	Negative	Landholders	Minor	Yes	Develop a detailed consultation and communication strategy	Minor
Personal and property rights							
Quality of life							
Potential impacts on heritage areas from changes in flow regimes and impacts on groundwater tables	Construction and operation	Negative	Traditional Owners	Major	No	Mitigate as part of the EIS process	Major
Acquisition of land in the dam inundation/buffer area	Construction	Negative	Landholder	Medium	Yes	Adequately compensate the landholder	Minor

Summary of social benefits and impacts	Project phase	Nature of impact	Receptors	Significance rating	Can the impact be quantified or monetised?	Mitigation measures and strategies	Significance rating after mitigation
Impacts on current water licence holders	Construction and operation	Negative	Water license holders	Medium	Yes	Adequately compensate landholders	Minor
Opportunities for additional recreation areas surrounding the dam	Construction and operation	Positive	Regional community	Medium	Yes	No mitigation required	Medium
Lifestyle impacts from construction, development of the new irrigation area and supporting infrastructure.	Construction and operation	Negative	Regional community	Medium	No	Develop a detailed consultation and communication strategy	Minor
Temporary impacts during construction on liveability (noise, dust)	Construction	Negative	Regional community	Medium	No	Mitigate as part of the EIS process	Minor
Restriction on land use within the buffer area	Construction and operation	Negative	Landholder	Minor	Yes	Adequately compensate the landholder	Minor

12.7 Conclusion

An assessment of potential social impacts associated with the construction and operation of the Cloncurry River Dam has identified a few social impacts. These would need to be managed through construction management and consultation with key stakeholders.

Possible mitigation measures were also identified to minimise potential social impacts. After implementation of mitigation measures, these impacts are expected to be low.

Major ongoing construction and operation impacts generally relate to sites of cultural heritage for Traditional Owners.

Employment and training opportunities are also likely to have a medium level of impact, including opportunities provided through the construction phase and opportunities associated with future expansion of primary industries.

The following chapter analyses the environmental impacts of the project.

13. Environmental assessment

13.1 Key points

- This chapter assesses the environmental impacts of the project.
- The major predicted environmental impact from the construction and operation of the dam will be on downstream habitats including declared fish habitat areas in the Gulf of Carpentaria
- The project will damage native vegetation through inundation and clearing to facilitate construction of the dam wall and the water delivery infrastructure.
- There will be changes to surface water and groundwater levels and quality as a result of altered water flows in the Cloncurry River
- There will be additional changes to land use patterns as a result of additional water being available.
- The project area is remote, and the amount of background environmental information is limited in comparison to other dam project sites in Queensland.
- There is limited data on surface water quality.
- The project will impact on the Great Artesian Basin.
- The Gulf Water Resource Plan shows that there are significant amounts of unallocated water in the region.
- Climate projections indicate that there will be increasing temperatures and evaporation in the project area.
- Twelve EPBC Act listed threatened fauna species have been identified as occurring in the project area.
- The project will negatively impact on 0.1% of the declared Ballara Nature Refuge.
- An EIS will be required. Including several detailed of water quality and flora and fauna impacts.
- The objective of the EIS is to ensure all potential environmental, social and economic impacts of the project are identified and assessed, as well as how any adverse impacts would be avoided or mitigated.
- The area has significant indigenous cultural heritage that will be impacted by the project.
- Traditional Owners are opposed to the project.
- Significant consultation and planning will need to occur with Traditional Owners as part of the EIS process and broader project implementation activities.

13.2 Purpose

The BQ Guidelines require that the environmental impacts of the Reference Project are clearly identified. In the PBC, the environmental impacts of all options were identified and described; the DBC assessment revisits and updates the work from the PBC, considering any relevant information obtained since the completion of the PBC.

Extensive environmental assessments will need to be undertaken for this project as part of an EIS. Where major environmental investigations are likely to be required, such as water quality, flora and fauna and cultural heritage, the requirements of the EIS process are explicitly identified below. Significant environmental conditions and requirements will be imposed by the Australian and Queensland governments should this project proceed.

13.3 Methodology

The methodology that has been followed for the assessment includes the following steps:

- Identify and review existing environmental assessments, studies and approval documentation.
- Assess how the identified environmental issues may impact the project and identify mitigation measures recommended to manage such impacts.
- Identify further technical investigations required.
- Identify any additional legislation and permits required for the project that are not identified in Chapter 9: Legal and regulatory considerations.

13.4 Identification of environmental impacts

The key environmental issues associated with the construction of the Cloncurry River Dam relate to the potential impacts of the dam inundation and pipeline area, the need to build additional infrastructure to support construction and the distribution of water and the use of additional water made available by this project. The key environmental impacts of this project would include:

- changes to in-storage and downstream habitats resulting from changes to stream flows in the Cloncurry River, including declared fish habitat areas in the Gulf of Carpentaria
- clearing of vegetation to facilitate the project, including all construction activities
- changes to surface water and groundwater levels and quality as a result of altered water flows in the Cloncurry River
- changes to the land use pattern as a result of additional water being available
- changes to the distribution of water allocations in the study area.

13.4.1 Legislation and permit requirements

Construction of the dam will require preparation of an EIS to identify and comprehensively consider all environmental impacts of the project. It would need to provide sufficient detail to enable the necessary local and Queensland Government approvals to be secured as part of the EIS process. Additional secondary approvals required would include construction-related activities such as gravel extraction, construction equipment storage depots and vegetation clearing.

The objective of the EIS is to ensure that all potential environmental, social and economic impacts of the project are identified and assessed, as well as how any adverse impacts would be avoided or mitigated. Direct, indirect and cumulative impacts must be fully examined and addressed in an EIS.

The project would need to be referred to the DoEE for determination whether the project is a controlled action under the EPBC Act. The EIS informs the Commonwealth to determine the extent of potential impacts of the project on MNES in terms of:

- world heritage
- national heritage place
- wetlands of international importance
- listed threatened species and ecological communities
- listed migratory species
- Commonwealth marine areas.

The proponent is required to address the terms of reference for the EIS established by the Queensland Coordinator-General. To date no EIS has been completed for the dam on the Cloncurry River and only preliminary environmental investigations have been undertaken.

13.4.2 Planning and land use

The project falls within the planning area of the North West Regional Plan 2010–2031. The regional plan is a statutory instrument under the *Statutory Instruments Act 1992* and was developed as a planning instrument under the *Sustainable Planning Act 2009* (SPA). The regional plan provides the broad framework for addressing priority issues in the North West region for the next 20 years to ensure that planning decisions do not compromise longer-term planning needs. The objective in relation to water outlined in the regional plan are to 'manage the region's river systems, groundwater, and wetlands for sustainable use by industries and communities, and protect dependent ecosystems and water quality'.

The plan recognises that the region is the source of a few major rivers that flow into the Gulf of Carpentaria and the Lake Eyre Basin and that the characteristics of the water resources in northern Australia are distinctly different from other parts of Australia.

Key strategies in relation to water resource development that are outlined in the regional plan are:

- Actively involve Traditional Owners in water planning and management as part of collaborative management forums and regimes operating in the region or through on-site practices on country.
- Improve catchment management to maintain water quality and the health of the Lake Eyre Basin and the lower Gulf of Carpentaria river catchments.
- Investigate the benefits and impacts of mosaic irrigation.
- Facilitate mapping of land and soil resources at a fine scale to facilitate planning for irrigation.
- Plan, design, construct and operate development in accordance with best practice environmental management principles that meet water quality objectives.
- Consider the impacts of developments on the water quality and health of rivers and streams flowing into the lower Gulf of Carpentaria and the Lake Eyre Basin.
- Adopt demand management principles for the planning, design and construction of water infrastructure.
- Incorporate industry best practice water saving methods and technology in all development.
- Avoid clearing native vegetation or development within a waterway, wetland, riparian area or flood plain using appropriate setbacks and buffer zones, and where unavoidable, mitigate through best practice design, rehabilitation and management.

The Cloncurry Planning Scheme operationalises the regional plan at a local level. The project will need to ensure compatibility with the Cloncurry Shire Council Planning Scheme, which came into effect in February 2016. The Planning Scheme seeks to protect and enhance the environmental values of waterways. Developments must protect and manage in a way to ensure long-term sustainability not only for the region, but also the greater bioregions and water catchments. In terms of water resources, the planning scheme seeks that surface and groundwater resources are utilised sustainably to meet the shire's needs without compromising the ecological health and function of water cycles.

Land use in the project area is broad scale cattle grazing, with a small area of nature refuge to be impacted within the inundation area—that is, 1,100 hectares of the 174,916-hectare Ballara Nature Refuge is anticipated to be impacted.

13.4.2.1 Assessing land use Impacts in the EIS

The EIS will need to describe potential impacts of the proposed land uses, taking into consideration the proposed measures that would be used to avoid or minimise impacts. The impact prediction must address the following matters:

- any changes to the landscape and its associated visual amenity in and around the proposed project area
- any existing or proposed mining tenement under the *Mineral Resources Act 1989*, petroleum authority under the *Petroleum and Gas (Production and Safety) Act 2004*, petroleum tenure under the *Petroleum Act 1923*, geothermal tenure under the *Geothermal Energy Act 2010* and greenhouse gas tenure under the *Greenhouse Gas Storage Act 2009* overlying or adjacent to the proposed project site
- temporary and permanent changes to land uses of the proposed project site and adjacent areas, considering:

- actual and potential agricultural uses
- regional plans and local government planning schemes
- any Key Resource Areas that were identified as containing important extractive resources of state or regional significance which the state considers worthy of protection (Business Queensland, 2017).
- strategic cropping land, priority agricultural areas, priority living area and strategic environmental areas under the *Regional Planning Interests Act 2014* and the trigger map for strategic cropping land (Department of State Development, Infrastructure and Planning, 2015).
- findings of the Agricultural Land Audit (Department of Agriculture, Fisheries and Forestry, 2013).
- constraints to the expansion of existing and potential agricultural land uses

- any existing or proposed incompatible land uses within and adjacent to the site, including the impacts on economic resources and the future availability and viability of the resources; including extraction, processing and transport location to markets
- any infrastructure proposed to be located within, or which may have impacts on, the stock route network associated with the *Land Protection (Pest and Stock Route Management Act) 2002.*

13.4.2.2 Land use impacts

The footprint of the dam will be on one property. The affected landholder will lose access to some or all of their property. The project would require the acquisition of land for the inundation area of the dam and any permanent infrastructure outside the inundation area. Access routes may also necessitate land acquisition or access easements over freehold land. Water pipelines or channels to transport water from the inundation area to customers may also trigger land acquisition or easement requirements. Any additional on-farm infrastructure required to store and use the water would be the responsibility of the individual landholder.

Likely impacts *during construction of the project* will need to be considered as part of the EIS process. At a minimum, the following issues will need to be considered:

- establishment of construction facilities
- construction of the dam wall and associated buildings such as the pump station and pipeline
- construction of access and temporary construction roads
- impacts associated with water distribution (temporary access impacts, vegetation clearing, cultural heritage impacts).

The likely impacts of the project *during the operation phase of the project*, too, will need to be considered as part of the EIS process. At a minimum, they will include:

- the unavoidable loss of land use within the inundation area of the dam
- the impact on land areas that were part of larger lots partially acquired for the project
- restricted land use options in the buffer area around the inundation area
- impacts on downstream land users and water-dependent land-based ecosystems
- potential benefits to properties and businesses in the dam locality resulting from the tourism, and recreation opportunities created by the dam and recreation area
- an increase in irrigated land uses in the region as a result of increased agricultural water security for customers of the dam.

13.4.3 Topography, geology, and soils

The topography is varied across the study area and ranges in elevation from approximately 130 m above sea-level near the Cloncurry and Flinders River plains in the north east, to approximately 620 m on rocky outcrops in the uplands south-west of Corella Dam and on the Selwyn Range. The Barkly Tableland foothills extend across the Northern Territory/Queensland border into the north-west of the study area.

The geology of the study area is characterised by lower Proterozoic aged units forming the basement rocks, which have been heavily intruded by granite rocks and subjected to widespread weathering. The overlying Cambrian aged units and Mesozoic sediments have also been subjected to weathering. Quaternary sediments hosting sand and gravels are deposited in stream channels, with silts and clays splayed over the associated flood plains (Hofmann, 1972).

Soil types vary throughout the study area. Fertile vertisols dominate the western and eastern margins of the study area. Central to the study area, running north–south along the mountainous terrains and drainage sub-basins between Mount Isa and Cloncurry, there is a combination of soil types including rudosols, kandasols and tenosols, which are characterised as soils with low fertility and poor water holding qualities. Also present are clay-rich chromosol soils (Australian Soil Resource Information System (ASRIS), 2014).

Heavy-textured black soils are present across the river plains and along watercourses in the north-east of the study area. These black soils support good quality agricultural land (Class A1 and A2) north of Cloncurry along the Cloncurry River, north of Kajabbi along the Leichhardt River and along the Gregory River in the north-west of the study area. These areas of good quality agricultural land, approximately 5,000 square kilometres in area, are generally suitable for a wide range of crops and pasture. Good quality agricultural land adjacent to the Cloncurry River is also defined as an Important Agricultural Area, which is defined as 'land that has all of the requirements for agriculture to be successful and sustainable, is part of a critical mass of land with similar characteristics and is strategically significant to this region of the state' (Department of Agriculture, Fisheries and Forestry, 2013). This represents approximately 3,400 square kilometres of the study area.

A more detailed study of the topography, geology and soils would need to be undertaken as part of the EIS.

13.4.4 Water quality

13.4.4.1 Surface water

Environmental values and water quality objectives are yet to be determined for the Cloncurry River and only limited data on surface water quality is publicly available. The most recent water quality monitoring data is from the 1990s, so it is difficult to determine whether water sampled at gauging stations would currently meet the Australian and New Zealand Environment Conservation Council guidelines for drinking water or ecosystem health.

13.4.4.2 Groundwater

Groundwater is generally suitable for stock and domestic purposes. An extensive network of artesian bores exists across the study area. A limited desktop study of registered bore database shows that water supplies from these bores are typically of good quality.

A dam on the Cloncurry River has the potential to impact on the Great Artesian Basin.

13.4.4.3 Assessing water quality Impacts in the EIS

The impact of the project on surface and groundwater quality impacts would form a major part of the EIS. The EIS at a minimum would need to cover the following key areas:

- Identify the environmental values of surface waters within the proposed project area and immediately downstream that may be affected by the proposed project, including any human uses and cultural values of water.
- Define the relevant water quality objectives applicable to the environmental values and demonstrate how these will be met by the proposed project during construction and operation. Where water quality objectives are not available, they should be derived according to the Queensland water quality guidelines, and include any semi-permanent or permanent pools, including stock water (Department of Environment and Heritage Protection, 2009).
- Detail the chemical, physical and biological characteristics of surface waters and groundwater within the area that may be affected by the proposed project and at suitable reference locations using enough data to define natural variation, including seasonal variation.
- Describe the quantity, quality, location, duration and timing of all potential and/or proposed releases of contaminants. Releases may include controlled water discharges to surface water streams, uncontrolled discharges when the design capacity of storages is exceeded, spills of products during loading or transportation, contaminated run-off from operational areas of the site (including seepage from waste rock dumps), or run-off from disturbed acid sulfate soils.
- Assess the potential impact of any releases from point or diffuse sources on all relevant environmental values and water quality objectives of the receiving environment. The impact assessment should consider the resultant quality and hydrology of receiving waters and the assimilative capacity of the receiving environment.
- Describe how water quality objectives would be achieved and environmental impacts would be avoided or minimised through the implementation of management strategies that comply with the management

hierarchy and management intent of the Environmental Protection (Water) Policy 2009. Appropriate management strategies may include the use of erosion and sediment control practices.

- Describe how monitoring would demonstrate that objectives were being assessed, audited and met. Propose corrective actions if objectives are not likely to be met.
- Describe the quality, quantity and significance of groundwater in the proposed project area and any surrounding area potentially affected by the proposed project's activities. Include the following:
- Characterise the nature, type, geology/stratigraphy and depth to and thickness of the aquifers; their transmissivity; and value as water supply sources.
- Analyse the movement of underground water to and from the aquifer(s), including how the aquifer(s) interacts with other aquifers and surface water.
- Characterise the quality and volume of the groundwater including seasonal variations of groundwater levels.
- Provide surveys of existing groundwater supply facilities (e.g. bores, wells or excavations).
- Provide a description of the proposed project's impacts at the local scale and in a regional context, including:
- changes in flow regimes from diversions, water take and discharges
- groundwater draw-down and recharge
- alterations to riparian vegetation and bank and channel morphology
- direct and indirect impacts arising from the development.
- Specifically address whether the proposed project would take water from, or affect recharge to, aquifers of the Great Artesian Basin. Identify any approval or allocation that would be needed under the Water Act 2000.
- Describe the practices and procedures that would be used to avoid or minimise impacts on water resources.
- Describe how 'make good' provisions would apply to any water users that may be adversely affected by the proposed project. Propose a network of groundwater monitoring bores before and after the commencement of the proposed project that would be suitable for the purposes of monitoring groundwater quality, and hydrology impacts that may occur as a result of the resource activity.
- Describe watercourse diversion design, operation and monitoring based on current engineering practice and the Department of Natural Resources and Mines' (2014) guideline on watercourse diversions.
- Describe the proposed supply of potable water for the proposed project, including temporary demands during the construction period. Also describe on-site storage and treatment requirements for wastewater from accommodation and/or offices and workshops.

13.4.5 Hydrology

Water use and allocation is managed through the Water Plan (Gulf, 2007). Rivers in these catchments flow north and north-west into the Gulf of Carpentaria.

NRME gauging stations are located on a few the major watercourses in the study area, including the Cloncurry, Gregory and Leichhardt rivers. Streamflow data for the Cloncurry River, at open gauging stations near Cloncurry and Canobie, reveal varied flow volumes, with the greatest flow volumes measured between December and March/April. The greatest flow volumes have also been measured in the Leichardt River at gauging stations near Doughboy Creek and Miranda Creek downstream of Mount Isa. Flow volumes are significantly less outside these months (Queensland Government, 2017).

The EIS prepared for the project would need to describe the history of flooding on-site and in proximity to the site. It would have to describe current flood risk for a range of annual exceedance probabilities up to the probable maximum flood for the proposed project site and use flood modelling to assess how the project will change flooding and run-off characteristics on-site and both upstream and downstream of the site. The assessment will have to consider all infrastructure associated with the proposed project including levees, roads, and linear infrastructure, and all proposed measures to avoid or minimise impacts.

The EIS will need to assess the project's vulnerabilities to climate change (e.g. changing patterns of rainfall, hydrology, temperature and extreme weather events) and describe possible adaptation strategies (preferred and alternative) based on climate change projections for the proposed project site.

13.4.5.1 Water resource plan

The Water Act establishes a system for sustainable planning, allocation and use of water. Under the water legislation, a process for creating water planning instruments has been established. The existing instruments relevant to the dam on the Cloncurry river are:

- the Water Plan (Gulf) 2007
- the Gulf Resource Operations Plan June 2010 (last amended in August 2015)

The then Department of Energy and Water Supply (2017) summarised water availability for urban, industrial and agricultural sectors for Cloncurry (Table 13.1).

Table 13.1: Cloncurry River water entitlements

Sector	Water source	Nominal water entitlement (ML per annum)
Urban	Chinaman Creek Dam	2,000
	Cloncurry River	2,160
	NWQWP	950
Subtotal—Urban		**5,110**
Mining	Cloncurry River upstream (Licence)	18
	Cloncurry River upstream (Permit)	1,272 (excluded from the total due to the nature of allocation)
	Coppermine Creek (Licence)	200
Subtotal—Mining		**218**
Agriculture	Cloncurry River (Reach 3)—Product 1 (release pending)	7,500
	Cloncurry River (Reach 3)—Product 2	69,200
	Flinders River (Reaches 1, 2 and 4)—Product 2	77,822
Subtotal—Agriculture		**154,522**
Total—All sectors		**159,850**

Source: Department of Energy and Water Supply (2017).

13.4.6 Unallocated water in the Gulf water management area

Within the Gulf area is the Cloncurry River or 'Reach 3', which extends from its headwaters to the confluence of the Flinders and Cloncurry rivers. The Cloncurry River was assessed in the NWQ WSSI as being suitable for a new major water storage (Alluvium, 2016).

There is a material volume of unallocated water in the Flinders River catchment (in which the Cloncurry River is located). There is no significant constraint in the water planning regulatory framework to the development of further water storages in the region. Significant volumes of water entitlements have been released in the study area, and the water harvesting licences in the Flinders and high priority water allocations in Lake Julius Dam are generally underutilised.

In the Flinders sub-catchment, significant volumes of potential water entitlements are also held in the general and strategic reserve as part of the Gulf Water Plan (i.e. 157,500 ML). These volumes could support future water developments including on the Cloncurry River; notably, these are to be viewed as annual volumetric limits (or maximum annual extraction volumes), as they were developed with water harvesting in mind (not in-stream infrastructure such as dams). Modelled yields arising from a Cloncurry River Dam take this into account.

Construction of the dam would require amendment of the *Water Plan (Gulf) 2007* to regulate the use of the additional water made available. The Cloncurry River is a prescribed watercourse within this plan area; therefore, water in and underneath the watercourse is subject to this plan. The plan regulates the taking of overland flow water and groundwater. Amendments to the plan would likely need to address:

- additional water entitlements to allow the use of water from the project (either allocations and/or licences)
- water management protocols including operational matters such as water sharing and trading rules applicable to water management areas in the water plan area
- distribution of operations licences that detail the roles and responsibilities of scheme operators to achieve the outcomes of the water plan
- the operations manual, including the day-to-day operation rules for the scheme.

13.4.7 Climate

Longer-term projections for the North West Queensland region include an overall decline in rainfall with increasing temperature, evaporation and an increase intensity of rainfall events. This will result in more extreme climate events, such as flooding, drought, bushfire and cyclonic weather. Management of the region's agriculture and industry activities are likely to be adversely affected by the projected increases in temperature and changing rainfall patterns.

The EIS developed for the project would need to:

- describe the proposed project area's climate patterns that are relevant to the environmental impact assessment
- assess the vulnerability of the area to natural and induced hazards, including floods, bushfires and cyclones. The relative frequency and magnitude of these events should be considered, together with the risk they pose to the construction, operation and decommissioning of the proposed project, as well as the rehabilitation of the site. Measures that would be taken to minimise the risks of these events should be described
- assess the proposed project's vulnerabilities to climate change (e.g. changing patterns of rainfall, hydrology, temperature and extreme weather events). Possible preferred and alternative adaptation strategies should be described, based on climate change projections for the region to minimise the risk of impacts from climate change to the proposed project.

Table 13.2: Specific climate change projections for the North West region

Variable	Season	1971–2000	2030	2070
Temperature, centigrade (C°)	Annual	25.2	+1.1	+ 3.4
Rainfall	Annual	534 mm	-2%	-5%
Potential evaporation	Annual	2,775 mm	+3%	+9%

Source: Commonwealth Scientific and Industrial Research Organisation 2007; Bureau of Meteorology 2008. Regional summaries prepared by Queensland Climate Change Centre of Excellence.

13.4.8 Flora and fauna

Construction of the dam will result in the loss of riparian zone and terrestrial habitat and changes in aquatic habitat due to inundation, and alteration to flow and water quality. Barriers to movement of aquatic fauna will occur as a result of the dam. The dam will change downstream morphology of Cloncurry River's bed and banks, which in turn has the potential to change in-stream habitat and allow an increase in invasive species.

Impact on benthic substrates and their dependent macroinvertebrate communities due to changes in sediment loads are also likely to occur. The key potential impacts of the dam and pipeline on flora and fauna relate to direct clearing within the footprint of the dam and associated infrastructure and changes to ecosystems resulting from changes to the surface water and groundwater levels within the inundation area and downstream of it.

Ecosystems and habitat may be present downstream of and within the inundation area that are dependent on flow regimes and water quality. Areas of ‘endangered’ and ‘of concern’ regional ecosystems along watercourses, with larger tracts mapped along the Cloncurry River, would be impacted.

Vegetation communities in the Cave Hill dam area include *Eucalyptus camaldulensis* (River Red Gum) and *Lophostemon grandiflorus* (Northern Swamp Box) woodland, which dominate the channels and floodplain of the Cloncurry River. It also includes *Melaleuca leucadendra* (weeping river teatree) and *M. argentea* (silvery weeping river teatree) woodland that typically fringes waterholes and more frequently inundated areas of the floodplain. These are classified as matters of state environmental significance (MSES).

Twelve EPBC-listed threatened fauna species are potentially present within the project area. The purple-necked rock-wallaby and painted honeyeater, listed as vulnerable, and the Gouldian finch, listed as endangered, have previously been recorded within the project area.

Figure 13.1: Cave Hill Dam, regional ecosystems

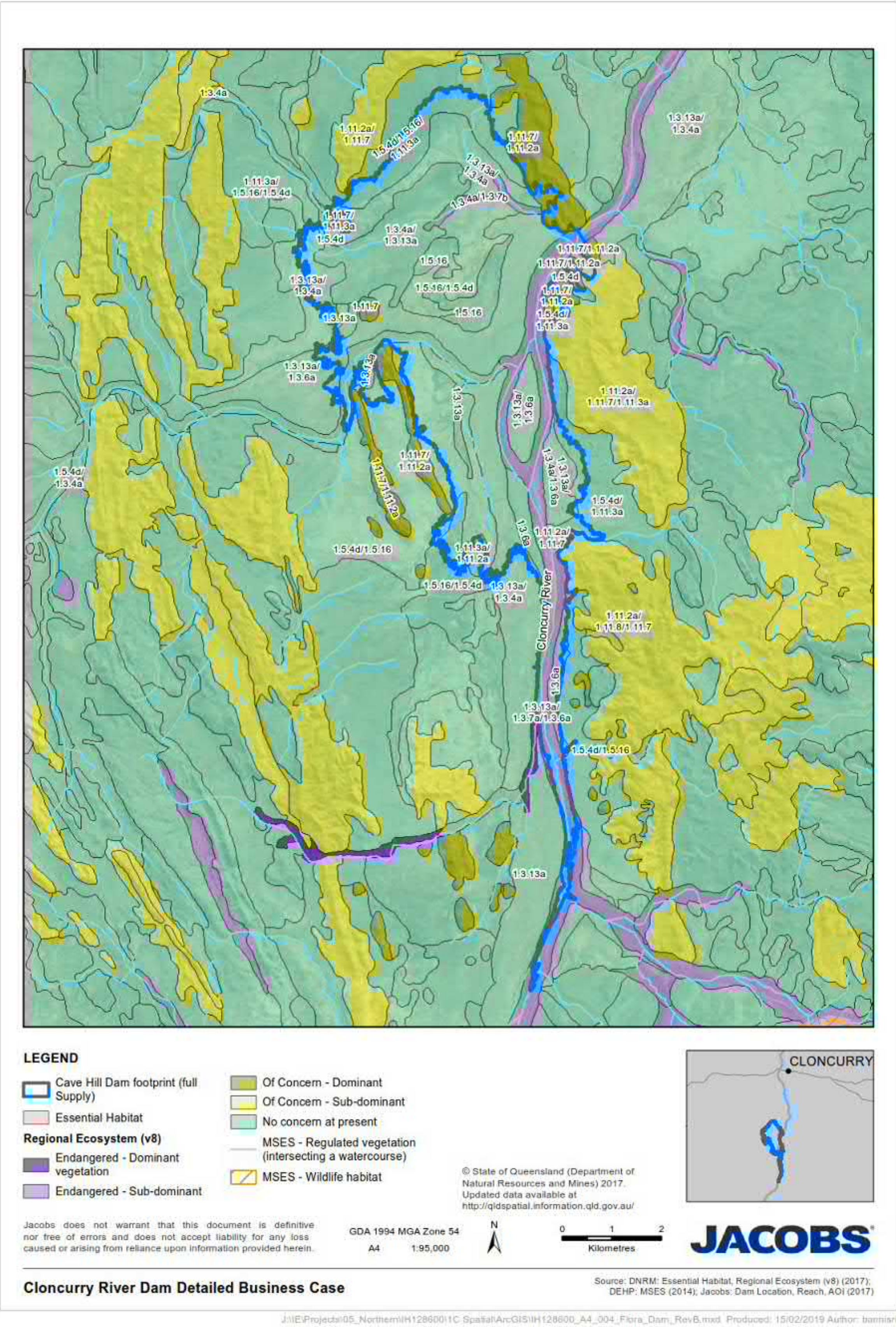

Figure 13.2: Cave Hill Dam pipeline regional ecosystems

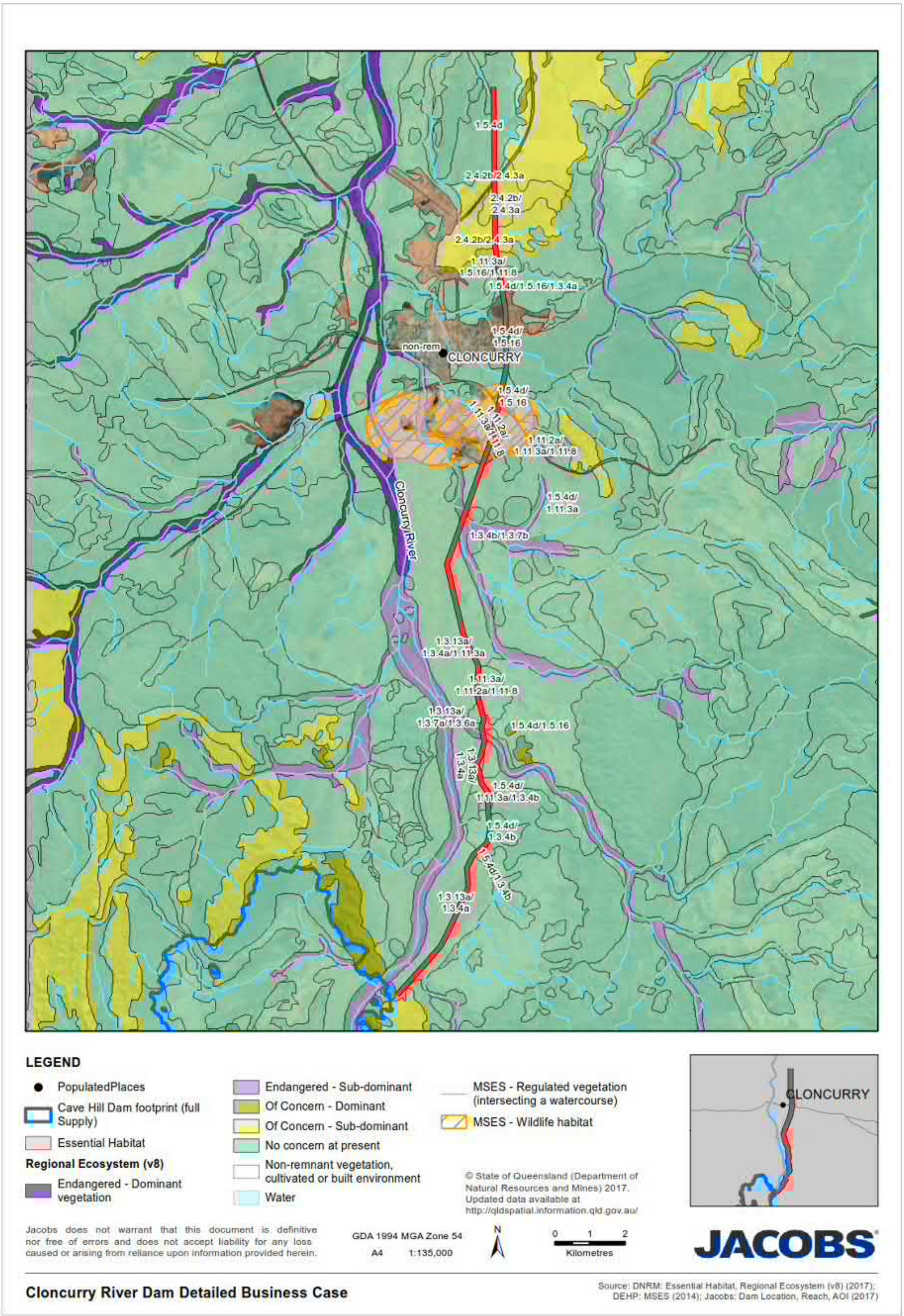

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Table 13.3 lists the vegetation communities in the Cloncurry River Dam area

Table 13.3: Cave Hill Dam mapped regional ecosystems (REs)

Regional ecosystem	Description	VMA class	State biodiversity status	Location within study area
1.3.4a	*Acacia cambagei* low open woodland to woodland on alluvium	Least concern	No concern at present	Alluvial plains adjacent to Cloncurry River in southern portion of the Cloncurry River Dam inundation area
1.3.6a	*Corymbia aparrerinja*, *Corymbia terminalis* open woodland on sandy levees	Of concern	Of concern	Sandy levees adjacent to Cloncurry River in the Cloncurry River Dam inundation area
1.3.7a	Riverine wetland or fringing riverine wetland. With *Eucalyptus camaldulensis +/- Lophostemon grandiflorus +/- Melaleuca leucadendra +/- M. argentea*	Least concern	Endangered	Main channel and more frequently inundated wetlands of the Cloncurry River in the Cloncurry River Dam inundation area
1.3.13a	Mixed woodland of *Eucalyptus leucophylla / Corymbia terminalis / Acacia cambagei* over *Triodia spp.* Hummock grassland and mixed tussock grass species.	Least concern	No concern at present	Recent floodplain levees of the Cloncurry River in the Cloncurry River Dam inundation area
1.5.4d	Shallow red earth and skeletal soil plains and valleys with *Eucalyptus leucophylla / Corymbia terminalis* low open woodland to low woodland, over annual grasses with areas of *Triodia spp*.	Least concern	No concern at present	Valleys and plains in the northern portion of the Cloncurry River Dam inundation area
1.5.16	*Acacia cambagei* low woodland over sparse *Triodia longiceps* +/- tussock grasses.	Least concern	No concern at present	Areas of older alluvium in the northern portion of Cloncurry River Dam inundation area
1.11.2a	Low open woodland of *Eucalyptus leucophloia* often with *Corymbia terminalis*, *Corymbia capricornia, Terminalia aridicola* and *Eucalyptus leucophylla* with shrub layer of *Acacia spp.* and ground layer of *Triodia spp*. Occurs on steep hills and strike ridges.	Least concern	No concern at present	Sub-dominant RE on the low hills south-east of the Cloncurry River Dam site and ridges in the central western portion of the inundation area
1.11.7	*Acacia cambagei* low woodland on metamorphic hills	Least concern	Of Concern	Dominant RE on the low hills south-east of Cloncurry River Dam and ridges in the central western portion of the inundation area
1.11.3a	Low open woodland of *Corymbia terminalis* and/or *Eucalyptus leucophylla* with *Acacia spp*. dominated shrub layer and ground layer of *Triodia spp.* and/or tussock grasses. Includes areas of *Acacia spp.* shrubland and *Triodia spp.* grassland. Occurs on broad low hills.	Least concern	No concern at present	Broad low hills along pipeline alignment
2.4.3a	*Acacia cambagei* low woodland. A shrub layer dominated by *A. cambagei* commonly occurs. The ground layer is sparse tussock grasses, including *Aristida latifolia, Enneapogon spp*. and *Sporobolus australasicus*.	Least concern	Of concern	Undulating alluvial clay deposits along pipeline alignment
1.3.4b/1.3.7b	*Acacia cambagei* low open woodland to woodland on alluvium, sometimes with *Eucalyptus leucophylla*	Least concern	No concern at present	
1.11.8	*Terminalia aridicola* and/or *Corymbia aspera* low open woodland to low woodland, usually with vine-scrub species, on rock outcrops	Least concern	No concern at present	Rocky outcrops along pipeline alignment

EPBC-listed threatened fauna species are potentially present (or suitable habitat present) within the area, including a 20 km buffer. EPBC-listed threatened species and the likelihood of occurrence based on the preliminary desktop study appear in Table 13.4.

Table 13.4: Cave Hill Dam— APBC Act listed threatened fauna

Species	Common name	EPBC Act[1]	Likelihood of occurrence	Comment
Birds				
Calidris ferruginea	Curlew Sandpiper	CE	Unlikely	Preferred tidal wetland habitat not identified in RE mapping
Erythrotriorchis radiatus	Red Goshawk	V	Possible	Preferred taller Eucalypt woodland or open forest habitat may be present on Cloncurry River floodplain
Erythrura gouldiae	Gouldian Finch	E	Likely	Preferred Eucalypt open woodland and tussock grassland habitat may be present
Grantiella picta	Painted Honeyeater	V	Likely	Preferred Eucalypt open woodland identified in RE mapping
Numenius madagascariensis	Eastern Curlew	CE	Possible	Preferred freshwater wetland habitat identified in RE mapping
Pezoporus occidentalis	Night Parrot	EN	Possible	Preferred hummock grassland may be present
Rostratula australis	Australian Painted-snipe	EN	Possible	Preferred wetland habitat identified in RE mapping
Mammals				
Macroderma gigas	Ghost Bat	V	Possible	Roosting cave habitat may be present
Macrotis lagotis	Greater Bilby	V	Possible	Preferred hummock grassland / tussock grassland habitat identified in RE mapping
Pseudantechinus mimulus	Carpentaria Antechinus	V	Possible	Preferred rocky escarpment habitat identified in RE mapping
Sminthopsis douglasi	Julia Creek Dunnart	V	Unlikely	No preferred cracking clay tussock grassland habitat identified in RE mapping
Reptiles				
Acanthophis hawkei	Plains Death Adder	V	Unlikely	No preferred cracking clay tussock grassland habitat identified in RE mapping

Desktop analysis has indicated several plants listed as 'endangered', 'vulnerable' or 'near threatened' in the project area under the *Nature Conservation Act 1992* (Qld). A clearing permit for the taking of these plants will be required under that Act.

The clearing of native vegetation in Queensland is regulated by both Australian Government legislation— the *APBC Act*— and Queensland legislation—the *Nature Conservation Act 1992,* the *Vegetation Management Act 1999*, the *Planning Act 2016* and the State Policy for Vegetation Management and other associated policies and codes.

The Ballara Nature Refuge will be impacted by the construction of the dam. The nature refuge, which was gazetted in May 2014, is located within the Cloncurry Shire Council area. It covers an area of 174,916 hectares over part of Lot 427 on SW805054, and part of lot 2547 on SP255326 in the county of Selwyn. The inundation area of the dam would require clearing of vegetation within the nature refuge, which has been designated under the *Nature Conservation Act (1992)*. The impacted area of refuge would be approximately 220 hectares, which represents less than 0.1 per cent of the total refuge area. Refer to Figure 13.2. Environmental offset requirements triggered by this vegetation clearing would need to be investigated and would be covered under the EIS process and offset strategy and also through the Coordinator-General's conditioning of the project.

Under the *Nature Conservation Act (1992),* revocation of all or part of a nature refuge would be required through regulation by the Governor in Council after approval by the Legislative Assembly.

Further studies of terrestrial and freshwater wetland ecosystems will be required as part of the EIS process to determine if populations of threatened species are likely to be present and to assess the nature and significance of impacts that may occur. This will include assessment of the impacts on the Bynoe River fish habitat in the Morning Inlet in the Gulf of Carpentaria.

13.4.8.1 Assessing flora and fauna impacts in the EIS

The EIS to be prepared for the dam on the Cloncurry River will need to describe the potential direct and indirect impacts on the biodiversity and natural environmental values of affected areas impacted by the construction, operation and decommissioning of the proposed project. It will need to consider any proposed avoidance and/or mitigation measures.

The assessment will have to include the following key elements which will be informed by ecological surveys:

- identification of all significant species and ecological communities, including MSES and MNES, listed flora and fauna species, and regional ecosystems, both on the project's site and in its vicinity
- terrestrial and aquatic ecosystems (including groundwater dependent ecosystems and subterranean fauna, such as stygofauna) and their interactions
- biological diversity
- the integrity of ecological processes, including habitats of listed threatened, near threatened or special least concern species
- connectivity of habitats and ecosystems
- the integrity of landscapes and places, including wilderness and similar natural places
- direct and indirect impacts on terrestrial and aquatic species and ecosystems whether due to vegetation clearing; hydrological changes; discharges of contaminants to water, air or land; noise; or other relevant matters.
- impacts of waterway barriers on fish passage.

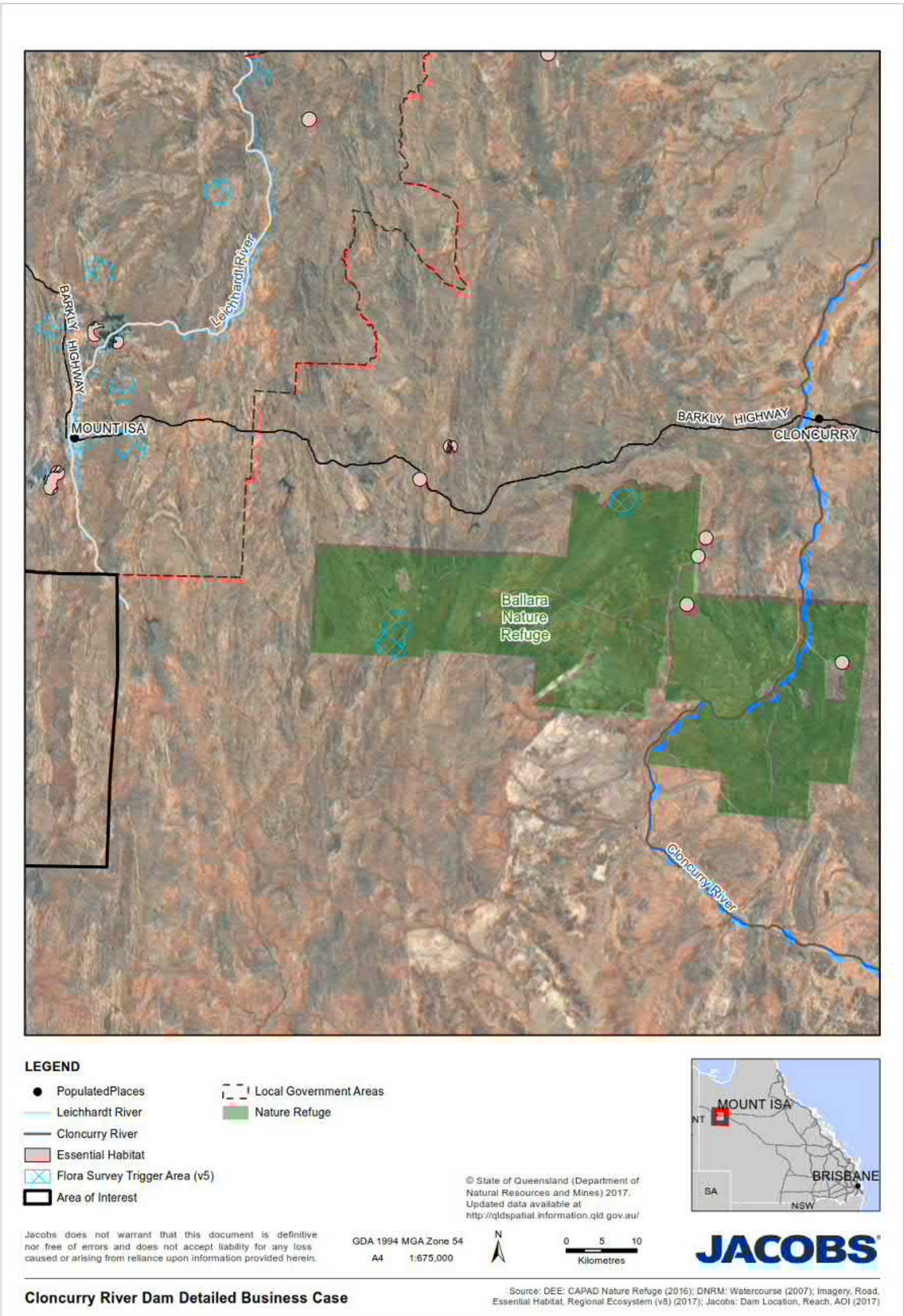
The EIS will have to describe any actions of the proposed project that require an authority under the *Nature Conservation Act 1992*, and those that would be assessable development for the purposes of the *Vegetation Management Act 1999*, the *Regional Planning Interests Act 2014,* the *Fisheries Act 1994* and the *Planning Act 2016*. The EIS must propose practical measures to avoid, minimise, mitigate and/or offset direct or indirect impacts on ecological environmental values. The EIS needs to address measures to protect or preserve any listed threatened, near threatened or special least concern species.

The EIS will need to assess the need for buffer zones and the retention, rehabilitation or planting of movement corridors. It will also be necessary to propose rehabilitation success criteria, in relation to natural values, that would be used to measure the progressive rehabilitation of disturbed areas. A monitoring and auditing program will need to be developed.

Any obligations imposed by State or Commonwealth legislation or policy or international treaty obligations, such as the China–Australia Migratory Bird Agreement, Japan–Australia Migratory Bird Agreement, or Republic of Korea–Australia Migratory Bird Agreement would need to be addressed.

Significant residual impacts would need to be managed through proposing offsets that are consistent with the requirements as set out in applicable Australian and Queensland legislation and policies.

Figure 13.3: Other key environmental features



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13.4.9 Climate change and emissions

Sourcing materials from local suppliers will reduce the carbon intensity of the construction activities. Delivery of water to downstream users will be through a combination of gravity feed and low head pumping, reducing the need for energy intensive pumping activities. Feed for cattle produced in irrigated areas will reduce the need for trucking feed long distances to Cloncurry.

The increased agricultural activities that will be generated as a result of water availability from the project are likely to result in land clearing and increased use of fossil fuels, which are greenhouse gas emissions. The increase in plant production from the additional agricultural areas will increase the amount of carbon dioxide absorbed through plant growth.

As the proposed inundation area will impact on threatened flora species and part of a declared nature refuge, significant vegetation offsets are likely to be required. These will act to store significant amounts of carbon.

The EIS will need to further assess the potential impacts of operations within the proposed project area on the state and national greenhouse gas inventories and propose greenhouse gas abatement measures, including:

- a description of the proposed preferred and alternative measures to avoid and/or minimise greenhouse gas emissions directly resulting from activities of the proposed project, including such activities as transportation of products and consumables, and energy use by the proposed project
- an assessment of how the preferred measures minimise emissions and achieve energy efficiency
- a comparison of the preferred measures for emission controls and energy consumption with best practice environmental management in the relevant sector of industry
- a description of any opportunities for further offsetting of greenhouse gas emissions through indirect means.

Construction activities associated with the project have the potential to generate short-term air quality impacts stemming from activities such as earthworks and land clearing, establishment of supporting infrastructure and construction of access routes. These activities may result in increased dust from exposed surfaces generated by construction vehicle movements as well as wind.

The nearest sensitive receptor (i.e. residential dwelling) is located approximately 4.5 km north-east of the project area. This separation distance will result in air quality impacts being minimal at this receptor.

13.4.10 Noise and vibration

Noise and vibration will be generated by construction activities associated with the construction of a dam on the Cloncurry River. The distance from the project area to the nearest sensitive receptor will result in minimal noise and vibration impacts being experienced at this dwelling.

No noise and vibration impacts are likely to be generated during the operation phase of the dam. Intensification of agricultural activities resulting from the project would generate noise that is consistent with other agricultural activities in the area. In terms of noise and vibration, the EIS will need to:

- fully describe the sources and characteristics of noise and vibration that would be emitted during the construction, commissioning, operation, upset conditions, and closure of the proposed project
- conduct a noise and vibration impact assessment in accordance with the latest version of the department's *EIS information guideline—Noise and vibration* (Department of Environment and Science, 2018)
- demonstrate that the proposed project can meet the environmental objectives and performance outcomes in Schedule 5 of the EP Regulation
- describe how the proposed activity would be managed to be consistent with best practice environmental management, including the control of background creep in noise as outlined in the *Environmental Protection (Noise) Policy 2009*. The EIS must address the compatibility of the proposed project's noise emissions with existing or potential land uses in surrounding areas.
- describe how the environmental management objectives for noise and vibrations would be achieved, monitored, audited and reported, and how corrective actions would be managed.

13.4.11 Landscape and visual amenity

Intensification of agricultural uses as a result of this option would be consistent with the overall landscape character of the study area, which is described as rural land. The dam wall and associated infrastructure would introduce newly built elements into the landscape, which would be visible from elevated areas surrounding and near the project site. The inundation area would also be a larger water feature compared to the unmodified sections of the Cloncurry River. These elements of the project are unlikely to detract from the overall visual amenity and landscape of the area. The inundation area has potential to become an important recreational asset for the local population.

13.4.12 Cultural heritage

13.4.12.1 Indigenous heritage

The Preliminary Business Case indicated that if a dam at Cave Hill was to be moved forward as the preferred option into a Detailed Business Case a Cultural Heritage Management Plan would need to be prepared. Further analysis and consultation have indicated that this requirement is more suitably addressed as part of the EIS process.

The EIS will be required to conduct an impact assessment in accordance with the latest version of the *EIS information guideline—Indigenous cultural heritage* (Department of Environment and Science, 2018)

The proponent must develop a Cultural Heritage Management Plan in accordance with the requirements of Part 7 of the *Aboriginal Cultural Heritage Act 2003*.

The landscape features in the immediate vicinity of the dam site are suitable for choice as a campsite location, including the igneous outcrop and semi-permanent waterhole, mature vegetation and a variety of readily available raw material for stone tool production in the riverbed nearby. The site is therefore assumed to have archaeological potential.

The immediate area around the outcrop was inspected for signs of Aboriginal cultural heritage. None were definitively identified during this inspection; however, the site was observed to contain a significant amount of alluvium on adjacent terraces that could have covered archaeological features.

A field visit was made to the potential Cave Hill dam site in 2017 in the company of the Senior Cultural Sites Officer of the Mitakoodi and Mayi People. This field visit followed a meeting the previous day with the principal Mitakoodi elder and native title claimant. Elders expressed concern about the potential of a dam being built on the Cloncurry River at this location:

> There are a lot of [significant] sites around the area [of the dam site]. There are important women's sites close to the river, near water and in the river – all different and in many places. It is Eagle Hawk dreaming there and men's sites along there too. I am not one to stop progress, but weirs would be better. White fellas never listen to us; they just take what they want. This place though, it is highly sensitive. We don't want a dam there. No!' (Mrs Pearl Connelly, 12 December 2017)

The database and register of cultural heritage sites are established and maintained in accordance with Part 5 of the Aboriginal Cultural Heritage Act. There are currently two known cultural heritage sites located within the Cloncurry River Dam inundation area comprising an open camp site with an artefact scatter and earth oven (refer to Table 13.5). Another three registered sites are located within a few hundred metres of the inundation area (Table 13.6).

Table 13.5: Registered sites located within the Cave Hill dam site inundation area

Site Name	Site type	Location	Aboriginal party
BJ00000431	Artefact Scatter	-20.87 S 140.53 E	Mitakoodi and Mayi People #5
BJ00000431	Hearth/Oven(s)	-20.87 S 140.53 E	Mitakoodi and Mayi People #5

Table 13.6: Registered sites located within a few hundred metres of the Cloncurry River Dam inundation area

Site Name	Site type	Location	Aboriginal party
BJ00000434	Artefact Scatter	-20.93 S 140.50 E	Mitakoodi and Mayi People #5
BJ00000432	Artefact Scatter	-20.97 S 140.50 E	Mitakoodi and Mayi People #5
BJ00000433	Artefact Scatter)	-20.97 S 140.50 E	Mitakoodi and Mayi People #5

It is not currently known how many Aboriginal cultural sites are located within the potential Cave Hill Dam site and inundation area. The fact that there are so few registered sites within the Cave Hill Dam inundation area points more to the fact that cultural sites have not been registered than it does to their absence. This can be because the Cave Hill Dam site is located on pastoral properties to which Aboriginal people have historically been denied access. Details of cultural sites that are known to be in the area are currently before the Federal Court in the Mitakoodi and Mayi People native title claim (Mitakoodi and Mayi People #5: QC2015/009) and are therefore confidential.

Mitakoodi and Mayi People have indicated that the landscape is highly sensitive from a cultural heritage perspective and is dotted with cultural sites, particularly within a few hundred metres of the Cloncurry River. They have referred to women's sites along and within the River and men's sites downstream near Top Camp (also referred to as Black Fort). The general area of the Cloncurry River is known to be Eagle Hawk dreaming.

The potential for cultural heritage sites being in the area of the dam site on the Cloncurry River can be informed by a survey of cultural heritage undertaken north of Cloncurry. This area north of Cloncurry has been extensively surveyed for cultural heritage sites by archaeologists and Mitakoodi site officers. A total of 115 sites are recorded on the Department of Aboriginal and Torres Strait Islander Partnerships (DATSIP) site register in this 100 square kilometres survey area between Cloncurry and Fort Constantine Station along the Cloncurry River. Given the similar landscape features, it is possible that cultural heritage sites may occur with similar frequency in the potential inundation area of the dam. The survey findings suggest the possibility of more than 500 cultural heritage sites within the potential inundation area (at least 50 km^2).

The wide variety of site types indicated by other areas of the Cloncurry River that have been surveyed (Table 13.7) and testimony of the Mitakoodi and Mayi elders' points to the sensitivity of the cultural landscape at Cave Hill Dam site and the high social significance it possesses, providing direct evidence of the use of the area by Aboriginal people and tangible links between contemporary Mitakoodi and Mayi People and their ancestors.

A search of the Aboriginal and Torres Strait Islander cultural heritage database and register was undertaken on 30 November 2017. A total of 115 sites Aboriginal cultural heritage sites are located within a 10 km radius of Cave Hill Dam with a detailed breakdown shown below in Table 13.7.

Table 13.7 Aboriginal cultural heritage sites types located along the Cloncurry River

Cultural heritage site type	Number of sites located along Cloncurry River
Artefact scatters	47
Isolated finds	25
Quarry sites	13
Hearth/oven sites	15
Cultural sites	4
Landscape feature	4
Stone arrangements	2
Engraving sites	2
Well	1
Story place	1
Burial	1

If the dam on the Cloncurry River is to proceed beyond the detailed business case phase, a cultural heritage assessment in accordance with the Aboriginal Cultural Heritage Act needs to be undertaken, which will involve further in-depth consultation with the Mitakoodi and Mayi People in respect to the significance of these cultural places. It is clear, however, that the native title applicants consulted for this area (i.e. its Traditional Owners) do not support a dam being built at Cave Hill.

13.4.13 Waste management

Waste may be generated by construction activities during the construction phase. Waste may include earth, rock, vegetation matter, excess construction materials and oils. Runoff from exposed areas of land may also occur. Waste would be managed in accordance with an approved Environmental Management Plan for each of the phases.

13.5 Conclusion

There are significant information gaps in relation to the environmental impacts of the proposed dam site on the Cloncurry River. A detailed large study in terms of an EIS will need to be completed and approved before the project can proceed.

The project will potentially have a significant impact on the downstream habitats and species of the Cloncurry river including the Gulf of Carpentaria. The extent of these impacts is at this stage unknown and will require extensive scientific, monitoring and modelling studies. The inundation area of the dam will impact on vegetation communities and potentially a few threatened species of flora and fauna. The EIS will need to be informed by a detailed flora and fauna assessment. Significant environmental offsets to account for impacts on vegetation, including riparian vegetation are likely to be required if the project is to proceed.

The area is of cultural significance to Traditional Owners, and detailed consultation and planning will be required as a prerequisite to the project proceeding.

The following chapter provides the reference engineering design for the dam and the geotechnical assessment of the site.

14. Engineering design

14.1 Key points

- This chapter presents the engineering design aspects of the proposed storage and irrigation infrastructure and provides a raw cost estimate for the project.
- The purpose of the project is to deliver water primarily to be used for irrigated agriculture, as identified in the demand assessment. This involves constructing a dam with the main wall approximately 25 m high and creating a reservoir of approximately 140,000 ML at full supply level.
- The water will be delivered through a 40 km pipeline to customers north of the dam, up to 20 km north of Cloncurry.
- Yield modelling confirmed that the dam can supply a nominal volume of 50,000 ML per annum in compliance with the Water Plan (Gulf) 2007, with a monthly reliability between 70 and 90 per cent and an annual reliability between 40 and 80 per cent.
- To be compliant with the requirements of the Water Plan, the dam needs to be capable of, at times, passing significant environmental flows (up to 55,000 ML/d) when the reservoir level is below the spillway level and smaller releases to offset the dam's impact on existing water users.
- The dam hazard category is 'High A'. This category requires the dam to have a flood capacity of the probable maximum precipitation flood (PMPF), the largest rainfall event ever expected in the catchment above the dam. This requirement applies because the dam failure impact assessment undertaken identified an incremental population at risk (PAR) of 966 and the severity of damage or loss, based on the cost to replace the dam being in the range of $100-500 million, being considered as Major.
- This preliminary design is based on the spillway and abutment sections being constructed of roller compacted concrete. A fuse plug spillway is in a saddle to the south of the dam. Three saddle dams comprised of zoned earthfill are located to the north and north west of the dam. The non-overflow abutments and saddle dam crests are set at 235 m AHD which corresponds to the PMPF level plus an allowance for freeboard.
- The outlet works and fish passage are in the right abutment of the main dam. The outlet provides for irrigation, environmental and emergency releases.
- The distribution network includes a 40 km pipeline, one pump station, and a renewable energy source.
- The design includes a solar array and associated battery storage to offset a proportion of the annual pumping costs and provide an income stream outside of the irrigation season.
- The current 'Medium' raw capital cost estimate for the project is $459.3 million including contingency.
- The annual operational costs were estimated at $2.4 million per year.

14.2 Project overview

This project will result in the construction of a new dam on the Cloncurry River with a wall approximately 25 m high and creating a reservoir of approximately 140,000 ML at full supply level. The dam will be able to supply a nominal volume of 50,000 ML per annum of medium priority water that will be delivered through a 40 km pipeline to customers north of the dam, up to 20 km north of Cloncurry. A summary of the key design characteristics of the project is provided in the following table:

Table 14.1 : Project key design characteristics

Characteristic	Project configuration
Dam	
Location	Cloncurry River at Cave Hill Latitude: 20.8691 S Longitude: 140.4945 E
Dam name	Cave Hill Dam
Dam status	Proposed dam
Purpose of storage	Irrigation and water supply
Dam type	Roller compacted concrete (RCC) main embankment incorporating a fixed crest spillway Fuse plug spillway in a saddle south of the main embankment Three saddle dams, zoned earth fill, north and northwest of the main embankment
Catchment area:	5,107 km^2
Full supply level	222.5 m AHD
Storage at full supply level	140,827 ML
Surface area at full supply level	3,277 ha
Dead storage level	210.0 m AHD
Dead storage volume	470 ML
Hazard category	High A
Acceptable flood capacity	PMPF
Main embankment and spillway	
Dam type	RCC
Crest elevation	235.0 m AHD
Maximum dam height	25 m
Spillway crest elevation	222.5 m AHD
Spillway type	Ungated ogee crest with smooth concrete chute
Spillway crest length	240 m
Total length of embankment	445 m
Spillway capacity	22,592 m^3/s
Fuse plug embankment / spillway	
Dam type	Zoned earth and rock fill embankment
Crest elevation	235.0 m AHD
Maximum dam height	16 m
Spillway crest elevation	231.0 m AHD (1 in 10,000 AEP lake level)
Spillway type	Four bay fuse plug on concrete ogee sill set at dam full supply level (222.5 m AHD)
Spillway crest length	400 m
Total length of embankment	600 m
Spillway capacity	33,588 m^3/s
Saddle Dam 1	
Dam type	Zoned earth and rock fill embankment
Crest elevation	235.0 m AHD
Maximum dam height	12.5 m
Total length of embankment	208 m
Saddle Dam 2	

Characteristic	Project configuration
Dam type	Zoned earth and rock fill embankment
Crest elevation	235.0 m AHD
Maximum dam height	9.0 m
Total length of embankment	924 m
Saddle Dam 3	
Dam type	Zoned earth and rock fill embankment
Crest elevation	235.0 m AHD
Maximum dam height	3.0 m
Total length of embankment	632 m
Design life	100 years
'Normal operations' design capacity	1 in 1000 AEP (assumes no damage to spillway, outlet works and river immediately downstream of the dam)
Outlet works	
Environmental releases	
Location	Adjacent to right abutment
Intake elevation	Variable 210 m AHD to 225 m AHD based on water quality
Control	4 x radial gates and fixed wheel gate
Capacity	Up to 55,000 ML/d
Irrigation releases	
Location	Adjacent to right abutment
Intake elevation	210 m AHD
Outlet conduit size	1 x 1,600 mm mild steel cement lined (MSCL) pipe
Mechanical asset design life	Nominal 35 years
Electrical asset design life	Nominal 25 years
Distribution network	
Length	40 km approximately
Pipe size	1 x 1,600 mm high density polyethylene (HDPE)
Pipe class	PN 4 to PN 6.3
Maximum flowrate	333 ML/d (3.85 m^3/s) Annual entitlement delivered evenly over set 150-day irrigation season
Minimum on-farm pressure	3 m residual pressure
Civil asset design life	50–100 years
Mechanical asset design life	Nominal 35 years
Electrical asset design life	Nominal 25 years

14.3 Project location

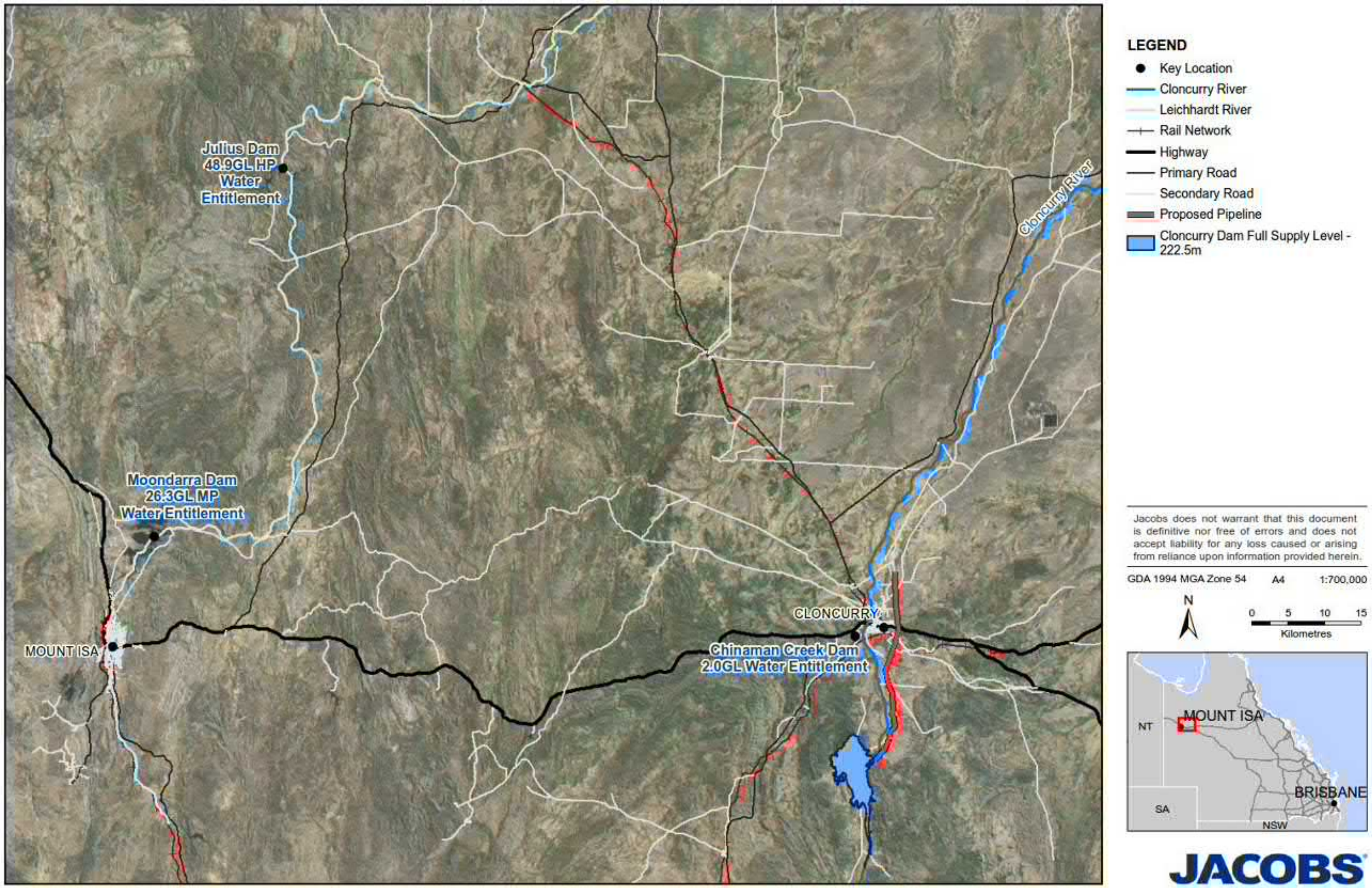
Various sites and dam types were considered and investigated to select the most suitable dam site and dam wall type. Site selection was informed by LIDAR mapping, aerial photographs, adequate geotechnical information and site reconnaissance (both aerial and ground).

Dam sites were compared according to construction cost, site access, and possible environmental and cultural heritage impacts. For the proposed dam site, a feasibility-level geotechnical investigation was undertaken, centring on a detailed review of the substantial previous site investigation, combined with additional geological mapping and geophysical surveys. The available and collated data was used to confirm the suitability of the site, availability of construction materials and construction risks.

The previous geotechnical scope of works coupled with the project specific investigations and interpretations have provided sufficient information for a practical and technically viable design for the proposed selected dam site and associated ancillary structures.

This site has been examined several times previously and has generally been the best dam site near Cloncurry. This was confirmed in the PBC. Based on these inputs, a dam site at Cave Hill, 20 km south of Cloncurry, has been selected. Figure 14.1 shows the dam site and pipeline route relative to Cloncurry, Mt Isa and existing water infrastructure.

Figure 14.1 : Cloncurry River Dam and pipeline location



Cloncurry River Dam Detailed Business Case

Source: DNRM: Watercourse (2007); Cadastre. Imagery, Road, Mining Lease (2017); Jacobs: Pipeline, Dam Location, AOI (2017)
Service Layer Credits: Sources: Esri, Garmin, USGS, NPS
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

14.4 Demand assessment

The demand assessment undertaken as part of the PBC identified that it would be reasonable to design a dam with a yield of at least 40,000 ML medium priority water, but potentially for a demand as high as 80,000 ML. The assessment undertaken for the DBC (Chapter 6) resulted in expressions of interest indicating a potential demand of 62,800 ML from Cave Hill Dam. This represents 126 per cent of the dam's 50,000 ML expected annual yield of medium priority water identified in the PBC.

14.5 Yield analysis

A yield assessment was undertaken as part of the PBC, which showed that a nominal volume of 50,000 ML per annum could likely be supplied from Cave Hill Dam, with a monthly reliability of between 70 and 90 per cent and an annual reliability of between 40 and 80 per cent. This assessment focused on providing the same yield identified in the PBC for Cave Hill Dam, while meeting environmental flow requirements, mitigating downstream impacts and improving reliability.

To achieve this, further investigation of the ideal range for compensatory releases was undertaken as part of the yield assessment. Reliability and yield depended on the compensatory releases required to mitigate impacts on downstream users and meet environmental flows. Full details of the analysis are provided in the report presented in Appendix D.

The study area, comprising the Cloncurry and Mt Isa local government areas, is located within the area covered by the *Water Plan (Gulf) 2007* (the Gulf WP). The Gulf WP is subordinate legislation under the *Water Act 2000* and provides the strategic framework for the allocation and sustainable management of water for the Gulf area.

The Gulf WP covers eight catchment areas including the Flinders River catchment area, in which the proposed Cave Hill Dam site lies. The plan establishes performance indicators for both water supply security and the environment.

No water allocation security objectives (WASOs) are currently specified for the Flinders catchment, as there are no existing water supply schemes within the catchment.

The Gulf WP specifies the use of the Department of Science, Information Technology and Innovation (DSITI) Flinders catchment Source model for the assessment of water resource development within the Flinders River catchment area. Using this model, the following conclusions were drawn:

- The project can yield a total nominal volume of around 50,000 ML with a monthly reliability between 70-90%, depending on the requirements for compensatory releases for downstream users and the environment.
- With no compensatory releases, the dam complies with only four of the seven mandatory EFO's set out in the Gulf WP.
- Compliance with all EFOs is possible with environmental flows from the dam. The dam needs to be capable of, at times, passing flows of up to 55,000 ML/d when the reservoir is below full supply level. The outlet works of the dam need to be sized accordingly to allow the dam to pass these flows over a large range of reservoir operating levels.
- There is the potential for the dam to impact on existing downstream water entitlement holders. These impacts can be mitigated by compensatory releases from the dam or provision of a supplementary allocation from dam.
- Reliabilities are sensitive to the operational parameters, such as size of release and range of operating levels in the dam, applied to the environmental release strategy required for Gulf WP compliance.

This assessment considered the best available stage-storage, dam design and demand profile available at the time. The modelling has included consideration of the impact of compensatory releases for downstream users and environmental compliance on the yield. The requirement to be able to release up to 55,000 ML/d means that the outlet works of the dam will need to include adequate gates or valves to achieve this.

14.6 Geotechnical considerations

A geotechnical investigation was undertaken as part of this DBC to support the development of the reference design and cost estimate. Full details of the investigation can be found in the report provided in Appendix D. A summary of the key features of the investigation is set out below.

The methodology adopted to provide input data to and for undertaking the required geotechnical assessments to inform the concept design of the proposed dam included:

- Geotechnical desk study including review of previous site-specific geotechnical investigations and the collation of all public domain sources (including the DTMR quarry database);
- Aerial photography/satellite imagery interpretation (including potential construction material sourcing sites within and around the proposed dam site);
- Walkover survey and geological mapping exercise (including specific visits to existing quarries and borrow pits within the vicinity of the Cave Hill dam site);
- Definition of a preliminary geotechnical/geological model for the site and from which the site-specific geotechnical investigation was designed;
- Interpretation of outcomes of the geotechnical investigation able to be completed and updating the preliminary ground model; and
- Concept design geotechnical assessments of the dam elements, and identification of potential risks and related mitigation measures.

The following key findings were determined based on the geotechnical work undertaken for the DBC:

- The Cave Hill dam site is composed of a variable melange of metasedimentary rockmasses which have been seemingly intruded by a later phase igneous intrusion. The site and its immediate adjacent zones are cross cut by at least three main faults, with the main river channel fault interpreted at the present time to have a potential significant impact on the proposed Main Dam/Primary Spillway alignment. In addition, from geological mapping potential other minor faulting may be apparent traversing the proposed dam and spillway alignments;
- The Cloncurry River Channel is composed of a thick alluvial sequence of interbedded granular and cohesively dominated soils, with an interpreted deep infilled palaeo-channel;
- Stability of an RCC dam is achievable to acceptable Factors of Safety; permanent and temporary cuttings may require a variety of support measures, dewatering and possibly ground treatments;
- Adequate basal bearing capacity for a dam can be provided;
- Piping failure may be a plausible risk, occurring through the alluvial deposits, the interpreted river channel fault and the void filled quartzite bedrock. To alleviate these potential seepage paths, it is suggested that a grout curtain be installed below the RCC dam incorporating the faulted ground and the void filled quartzite rockmass, as well as 5m below the dam foundation level to accommodate possible permeable sheeting joints;
- For the RCC dam creating a stable and dry significant excavation within the existing river channel is a substantial challenge considering the interpreted ground conditions and high groundwater, as well as the possible physical constraints; a clear idea of the stratigraphy, consistency and permeability of the inherent ground conditions will be necessary, as well as the undertaking of associated stability and dewatering analysis to confirm that the excavation is possible in itself and offering a suitable FoS;
- Saddle dam foundations and abutment stabilisation are not currently seen as significant engineering risks although this will need to be confirmed at later stages of this project; and
- Various potential construction material sources are interpreted to be available in enough quantities near the dam alignment, however these may require secondary processing to meet specifications; an offsite good hard rock source has been identified which could be practically used for aggregates for the project.

14.7 Dam design and cost estimate

Jacobs and Water Resources Pty Ltd worked collaboratively to develop a preliminary design and associated cost estimate for the Cave Hill Dam for this DBC. Appendix D contains supporting technical documents including yield assessment, failure impact assessment, geotechnical report, general arrangement drawings and Water Resources Pty Ltd preliminary design and cost report. A summary of the key features of the design is set out below.

14.7.1 Previous studies

A number of previous studies have been completed. The CSIRO recently investigated the Cave Hill dam site (Petheram, 2013). A comparison of the findings is below.

Table 14.2 : Comparison of CSIRO and DBC metrics

	CSIRO	DBC
Dam type	Zoned earth and rock fill embankment founded on the river bend sands with slurry trench cut-off to bed rock. Earth and rock fill embankment saddle dam on the right bank side. Diversion conduit and outlet works on the left abutment. Unlined spillway with drop structures through a saddle to the west of the dam.	Roller compacted concrete RCC main embankment incorporating a central overflow fixed crest spillway with grout curtain into bed rock. Concept level costings suggested that, for a scenario comprising embankment of maximum height 18m, the earthfill dam option was estimated to cost $165 million (direct costs excl. contingency), while RCC was estimated at $175 million. Note these costs are not to be considered as total out turn costs. Due to a substantially different construction risk profile, the RCC option was selected for further development. RCC construction offers significant advantages over earthfill dams during construction, as the latter are more vulnerable to flood damage when partially constructed. The decision to proceed with RCC was thus largely driven by a more favourable construction risk profile with for similar capital costs. Fuse plug spillway in a saddle south of the main embankment Three zoned earthfill saddle dams north and northwest of the main embankment Diversion conduit and outlet works on the right abutment including gates/valves for environmental releases Fish/turtle passage
Full supply level	224 m (based on inaccurate 5–10 m GIS contour data)	222.5 m (based on more accurate GIS contour data)
Storage capacity	248,000 ML	140,827 ML, based on the lower full supply level (above) and more accurate contour data.
Estimated yield	40,000 ML at 85% reliability, or 34,000 ML at 95% reliability.	50,000 ML at 79% monthly reliability, 51% annual reliability, or 20,000 ML at 92% monthly reliability, 81% annual reliability
Distribution	Releases to river for downstream diversions	40 km pipe network to minimise losses and maximise reliability
Estimated capital cost	Dam: $249 million (2013 dollars) Distribution works: not included	Dam: $391 million (2018 dollars) Distribution works: $68 million to deliver supply over 150 days Total: $459 million (2018 dollars)

14.7.2 Full supply level

The refinement of the full supply level, described in the PBC report, was based on analysis of additional AW3D Standard DSM contour data available at the time. This was the best information readily available at the time of this study. The previous information used by CSIRO was based on a 30 m grid cell. The new information was based on a 5m grid cell. This provided 36 times better resolution of the terrain in the area. Given the sparse nature of the vegetation in this area, the relative accuracy between points in the terrain model is expected to be good. This data indicated that an additional saddle dam is needed to contain a reservoir between the contours of 222 m and 223 m. On this basis, a full supply level of 222.5 m was adopted, while acknowledging that embankments will be required to comply with dam safety requirements.

14.7.3 Dam consequence assessment

A high-level Failure Impact Assessment (FIA) has been completed to support the development of the DBC concept design for the proposed dam. This assessment has been undertaken in accordance with the Guidelines on Failure Impact Assessment of Water Dams (DEWS, 2012). Should the project proceed to further phases, the FIA will need to be updated based on the current guidelines at the time of assessment

This involved the following tasks:

- Development of a hydrologic model (RORB) of the Cloncurry River catchment in accordance with the requirements of Australian Rainfall and Runoff (Ball, et al., 2016).
- Development of hydrology for dam inflows and coincident tributary flows.
- Development of a two-dimensional hydrodynamic model (TUFLOW) to simulate the effects of dambreak on the downstream floodplain.
- Modelling of failure and no-failure scenarios.
- Estimation of the Population at Risk (PAR).

Outcomes of this assessment were used to determine the dam consequence hazard category which determined the spillway and embankment requirements for the dam. Full details of the analysis are provided in the report presented in Appendix D. A summary of the findings of this report follows.

In determining the hazard category of the dam, the following failure modes were considered:

- Instantaneous failure of the RCC dam section in the Sunny Day Failure (SDF) event; and
- Flood-induced instantaneous failure of the RCC dam section in the Probable Maximum Flood (PMF) event.

The PAR was estimated from the number and type of buildings in the area subject to incremental flooding following dam failure, and the number of occupants expected to be within those buildings before warning and evacuation begins. The occupancy of these buildings was estimated based on the guidance in the Guidelines on Failure Impact Assessment of Water Dams (DEWS, 2012). The estimated PAR in the model area downstream of Cave Hill Dam is presented in Table 14.3. Details are provided for Sunny Day Failure (SDF), Probable Maximum Flood Failure (PMFF)and Probable Maximum Flood No Failure (PMFNF) scenarios.

Table 14.3 : Population at Risk

PAR	SDF	PMFF	PMFNF
Total PAR	378	3,573	2,607
Incremental PAR	378	966	

The PMFF has the highest estimated total PAR at 3,573 and the highest incremental PAR at 966.

The Hazard Category rating and Acceptable Flood Capacity for the dam have been assessed based on the Fallback Option detailed in the *Guidelines for Acceptable Flood Capacity for Water Dams* (DEWS, 2017) and with reference to the *Guidelines on the Consequence Categories of Dams* (ANCOLD, 2012).

The maximum incremental PAR has been identified as 966 for the PMF. The severity of damage or loss based on the cost to replace the dam of $100-500 million is considered Major.

Based on the estimated incremental PAR of 966, a Consequence Category or Hazard Category of High A has been applied. Accordingly, the Acceptable Flood Capacity for the dam has been identified as the Probable Maximum Precipitation Flood (PMPF) event.

No Potential Loss of Life analysis has been undertaken. Given the large PAR, this would be recommended for future phases of the project. A summary of the estimated values is provided in Table 14.4.

Table 14.4 : Hazard category

Category	Value
Maximum Incremental PAR	966
Failure Impact Assessment Category	Category 2
Severity of Damage and Loss	Major
Hazard Category	High A
AEP of Acceptable Flood Capacity for Existing PAR	PMPF

Following flooding in the Cloncurry district in February 2019 the Council sought clarification of the Population at Risk adopted for the consequences assessment and the magnitude of flooding used in the assessment. The clarification identified that the size of flood that would be associated with a dam failure would have flows more than 10 times the flows that have been experienced in the history of records at Cloncurry and a peak flood level in the township around seven metres above the highest recorded level. It was also noted that for a project at this stage of development it was prudent to use the relevant Queensland and national guidelines and practices for compiling the PAR, and even if a bespoke detailed analysis of individual properties were undertaken the resulting PAR is unlikely to be low enough to alter the required dam hazard category and the associated design parameters. Full details are provided in the Project Note in Appendix D.

14.7.4 Dam overview

The discharge capacity of the dam is determined based on the consequence category of the dam. The Cave Hill dam site is assessed as being in consequence category High A. For this category, The Hazard Category rating and Acceptable Flood Capacity for the dam have been assessed based on the Fallback Option detailed in the Guidelines for Acceptable Flood Capacity for Water Dams (DEWS, 2017) and with reference to the Guidelines on the Consequence Categories of Dams (ANCOLD, 2012). Accordingly, the Acceptable Flood Capacity for the dam has been identified as the Probable Maximum Precipitation Flood (PMPF) event.

The dam’s overall flood capacity, spillway size and freeboard are determined to accommodate outflows of up to the PMPF, with an appropriate level of safety of the dam, community and environment.

General arrangement drawings of the dam configuration are presented in Appendix D. The proposed Cave Hill dam site is located on the Cloncurry River 20 km south of the town of Cloncurry. A locality plan is shown as Drawing SKT-0001, and site plan of the dam as SKT-002 in Appendix D.

The fixed crest spillway level at 222.5 m AHD is approximately 13 metres above the river bed level and provides a storage capacity of 140,800 ML. The spillway width has been set at 240 m which is the maximum practical width of the river channel.

This preliminary design is based on the spillway and abutment sections being constructed of roller compacted concrete. A fuse plug spillway is in a saddle to the south of the dam. Three saddle dams comprised of zoned earthfill are located to the north and north west of the dam. The non-overflow abutments and saddle dam crests are set at 235 m AHD which corresponds to the Probable Maximum Precipitation Flood Level plus an allowance for freeboard.

The outlet works and fishway are in the right abutment of the dam. The outlet provides for irrigation, environmental and emergency releases.

Irrigation releases can be made through a separate outlet which consists of a 1600mm mild steel cement mortar lined pipe which bifurcates upstream of the fish passage. Environmental flows and emergency releases of up to 13,750 ML/day can be made through each of four outlets which are controlled by separate hydraulically operated radial gates. Environmental flows discharge to the spillway apron downstream of the dam face. The total discharge capacity is 55,000 ML/day; the maximum required release rate.

14.7.5 Design Inflows

The peak design inflows derived from revision of the flood hydrology as part of the DBC are presented in Table 14.5.

Table 14.5 : Peak design inflows

Annual Exceedance Probability (AEP 1 in Y)	Peak inflow (m^3/s)
1,000	9,013
10,000	16,300
50,000	29,988
100,000	40,684
PMPF (Probable Maximum Precipitation Flood)	60,816
PMF (Probable Maximum Flood)	66,710

14.7.6 Dam elements

The key elements of the dam include:

- RCC main dam with 240m wide spillway with a conventional section.
- A 400m wide fuse plug which commences operation at the 1 in 10,000 AEP event and has a concrete control at full supply level.
- Three saddle dams of zoned earthfill construction.
- An outlet works which comprises four radial gated conduits with two inlet structures like Burdekin Falls Dams (note Burdekin only has three conduits) to meet the Gulf Water Plan EFO's.

Details of the key elements are provided in the following sections

14.7.7 Roller compacted concrete section

A typical RCC cross-section has been adopted in accordance with similar recent designs. This approach is considered reasonable for the purposes of the preliminary design. The adopted cross-section has a vertical upstream face and an assumed downstream face slope of 0.75 horizontal to 1.0 vertical. Drawing No. SKT-0004, Appendix D shows the adopted cross-section.

14.7.7.1 Freeboard and crest elevation

The minimum freeboard is the vertical distance between the crest of the dam and the maximum reservoir water surface that results from routing the inflow design flood through the reservoir. The proposed dam type is RCC and therefore it can tolerate the increased loading associated with some overtopping and as such, may not require positive freeboard. For the purposes of the preliminary design the proposed non-overflow crest elevations has been set at 235 m AHD which provides about 1 m freeboard for the PMPF event.

14.7.7.2 Gallery and drainage

The gallery is part of a drainage system, an important component of a gravity dam on rock. Drainage holes into the foundation increase stability by decreasing uplift pressures. Ceiling drains have also been included as pore pressures may develop within the body of the dam, in poor construction joints, in cracks and in unsound concrete. The gallery also provides ease of maintenance of the drainage holes, future access for grouting if required and access for surveillance and monitoring of dam performance.

The gallery elevation should consider tailwater elevations, stability analysis and access. As stability analysis has not been completed a notional gallery elevation has been proposed as shown on Drawing SKT-0004. As the tailwater level will be above the gallery level sump pumps will be required to remove water entering the drainage system. The entrances to the gallery would be located above the PMPF tailwater elevation.

The further upstream the gallery and drains are placed, the more effective uplift reduction is, resulting in increased stability. The gallery has been set 8.0 metres downstream of the upstream face of the structure, to facilitate the economic placement of RCC. The dimension of the gallery has been taken as that required for access; 1.8m wide, 2.2 m high with a 0.3m x 0.3m floor drain. A precast roof and second stage concrete floor, with a zone of 400mm thick grout enriched RCC surround has been assumed. This arrangement would require the walls to be formed, seen as preferable to precast units so that the lift joints can be inspected from within the gallery.

14.7.7.3 RCC Material properties

Grout-Enriched RCC (GE-RCC) has been specified to provide a dense, uniform, durable outer facing to the RCC along the upstream and downstream faces and gallery walls, and as a surround to waterstops. The extent of the bedding mortar on RCC lift surfaces has been taken as the minimum of one-third the width of the section (to reduce permeability along the lift surface), or the width that is necessary to achieve the required factors of safety for sliding stability.

14.7.7.4 Stability

The proposed RCC section is based on typical dimensions. It is anticipated that Cave Hill Dam will be stable with the section shown on Drawing No. SKT-0004. As such no stability assessment has been carried out as part of this investigation. A stability assessment of the RCC section should be completed in subsequent studies.

14.7.8 Saddle dams

Drawing No. SKT-0001 shows three saddle dams located north and north west of the main dam. The lowest elevation of these saddles is approximately 220 mA HD which is below the predicted water surface elevations for extreme flood events of 234 m AHD. The proposed saddle dam section is based on typical dimensions from recent projects. It is anticipated that the section shown on Drawing No. SKT-0004 will be stable.

If post-development flows are allowed through the saddle during extreme events, then uncontrolled flooding would occur downstream of the saddle. Therefore, a zoned earth saddle dam is proposed as shown on Drawing No. SKT-0004. The crest elevation of the saddle dam has been set at a nominal one metre above the peak water surface elevation for the PMPF to allow for wind set-up, wave run-up, future settlement and some residual freeboard. This provides a notional freeboard for the PMPF event to reduce the risk of the saddle dam eroding and failing during extreme events.

14.7.9 Spillway

The function of the spillway (and fuse plug) is to safely pass the design flood. A controlled spillway crest (gated spillway) should be avoided if possible as operations and maintenance are important issues associated with controlled crests. An uncontrolled spillway crest has been proposed. The spillway has been designed to pass the PMPF without crest overtopping. The spillway arrangement is shown on Drawing Nos SKT-0003 and SKT-0004, Appendix D. A stepped spillway may dissipate energy for relatively low flows. However, concerns have been raised by stakeholders about the potential for damage to fish which are swept down the spillway. Therefore, a smooth spillway has been adopted for the preliminary design. Model testing of the spillway arrangement will be essential at the detailed design stage.

14.7.9.1 Length

The spillway length of 240 metres is proposed as shown on Drawing No. SKT-0003. The choice of spillway length has been based on a qualitative assessment of the following issues:

- Alignment with the existing river;
- Limiting erosion risk;
- Limiting downstream river protection works; and
- Limiting the extent of the apron.

14.7.9.2 Crest profile

The crest ogee profile was based on standard United States Bureau of Reclamation profiles (USBR, 1973) with the design head, HD, equal to 11.5 metres corresponding to 75% of the head over the spillway for the PMPF. The ogee profile is based on the principles outline in Design of Small Dams (USBR, 1987). The downstream quadrant of the crest ogee profile is based on a formula that conforms to the shape of the lower nappe of a flow over a sharp crested weir.

14.7.9.3 Stability

The proposed spillway section is based upon similar dams. It is anticipated that Cave Hill Dam will be stable with the spillway section shown on Drawing No. SKT-0004. No spillway stability assessment has been carried out as part of this investigation.

A stability assessment of the spillway section should be completed in subsequent studies.

14.7.9.4 Apron and energy dissipator

The spillway flow energy will require dissipation to reduce the flow velocity downstream of the spillway and to reduce the risk of scouring the riverbed and undermining the downstream toe of the dam. Given the tailwater levels predicted a horizontal apron was analysed, with the details presented in Table 14.6. Two flows were analysed being the 1 in 1,000 AEP and 1 in 10,000 AEP flood events. Note that the fuse plug commences operation at the 1 in 10,000 AEP events. As the calculated Froude number is greater than 4.5 and the incoming velocity is greater than 18 m/s a type II dissipator has been adopted.

Table 14.6 : Hydraulic jump characteristics

Parameter	1 in 10,000 AEP flow	1 in 1,000 AEP flow
Approx. Peak Discharge (m^3/s)	16,300	9,013
Unit Discharge (m^3/s/m)	67.9	37.6
Reservoir Water Level (m AHD)	231.0	226.4
Tailwater Level (m AHD)	216.0	213.6
Velocity head at basin level (m)	31.0	26.4
Velocity at basin level (m/s)	24.7	22.8
Flow depth at basin level (m)	2.75	1.65
Froude number	4.7	5.7
Type II Stilling Basin Length (m)	**73.8**	**53.3**

As the basin would need to be extended considerably to contain the hydraulic jump for the 1 in 10,000 AEP event the apron has been sized to contain the 1 in 1,000 AEP event and taken to be 55m in length. These dimensions should be investigated further with physical hydraulic modelling within the detailed design stage.

Drawing No. SK-0003 shows a plan view of the stilling basin and a section is shown on Drawing No. SK-0004.

The preliminary design provides for conventional concrete training walls to contain the spillway and stilling basin flow. It is proposed that stilling basin walls are constructed as gravity retaining walls. The spillway training walls are assumed to be cantilever walls anchored to the downstream face of the RCC dam.

The stilling basin walls extend downstream of the spillway to contain the area of turbulent flow within the stilling basin. The elevation of the top of the stilling basin walls downstream of the sloping face of the spillway has been set at 215 m AHD which is just above the tailwater level for the 1 in 1,000 AEP events. The required length and height of the training walls should be investigated by physical hydraulic modelling of the spillway arrangement during detailed design.

14.7.10 Fuse plug

In order to safely pass all floods up to the design flood it is proposed to construct an auxiliary spillway consisting of a secondary, four bay fuse plug, some 500m south east of the proposed dam. The following outcomes have been considered for the design of the fuse plug:

- To allow Cave Hill Dam to safely pass the latest estimate of the Probable Maximum Precipitation Flood (PMPF);
- To ensure that outflows are less than inflows for all flood events;
- To limit the frequency of operation of the auxiliary spillway to reduce downstream damage; and
- To minimize capital cost.

14.7.10.1 Auxiliary spillway configuration

The auxiliary spillway works will consist of a four-bay fuse plug spillway. Details of the auxiliary spillway are provided in Table 14.7.

Table 14.7 : Fuse plug details

Fuse plug number	Spillway Control Crest Type	Spillway Crest Width (m)	Spillway Crest Level (m AHD)	Fuse Plug Pilot Channel Crest Level (m AHD)
1	Ogee	100	222.5	230.5
2	Ogee	100	222.5	231.0
3	Ogee	100	222.5	231.5
4	Ogee	100	222.5	232.0

Initiation of Fuse Plug 1 occurs at about the 1 in 10,000 AEP events.

14.7.10.2 Concept of controlled fuse plug spillway

Drawing SKT-0003, Appendix D shows a cross section of a typical fuse plug embankment. It is effectively a zoned earth and rock fill embankment that is constructed on a non-erosive sill or weir. The embankment is designed to erode in a controlled manner when the lake water level reaches a pre-determined level. Below this level, the embankment impounds water in the same manner as a typical zoned earth and rock fill embankment.

The upstream face of the embankment consists of a riprap layer to protect against wave action. Consecutive layers consist of coarse rock followed by a coarse filter and then the impermeable clay core that are laid on a similar slope to the riprap. Downstream of the sloping clay core are more layers of filters that lie on compacted rock fill, which extends to the downstream slope of the embankment.

The controlled erosion is initiated at a low point, or pilot channel located in the embankment crest. A narrow vertical slot of coarse filter is located immediately downstream of the pilot channel that extends to the downstream slope of the dam and replaces the compacted rock fill. As the lake water level rises above the pilot channel crest to a depth of about 0.1 m, fast flowing water starts to erode the coarse filter in the vertical slot, which removes the material supporting the sloping clay core eventually causing it to collapse. The material adjacent to the slot is then exposed to the fast-flowing water initiating lateral erosion.

It is noted that the current interpreted geological model at the proposed fuse plug location would suggest there may be up to 10m of residual soil above the competent metasediments. Whilst tailwater levels will be elevated (which would have the effect of suppressing the extent of erosion that may occur) when the fuse plug operates subsequent investigations may conclude there is insufficient erosion resistance to prevent undermining the concrete ogee. If later detailed geotechnical and hydraulic studies conclude this is the case the fuse plug may need to be relocated to one of the other three saddle dam locations.

14.7.10.3 Fuse plug reconstruction

Fuse plug embankments can generally be reconstructed within three months of an initiation event provided sufficient material is available. The initiation of the first fuse plug occurs at an annual exceedance probability of the 1 in 10,000 AEP events. It is not practical to stockpile material for such a rare event. To ensure sufficient material is available at the time of an initiation event, the owner would need to identify sources of replacement material, should it be needed, as part of the Dam Safety Inspections undertaken every 10 to 15 years.

14.7.11 Outlet works

The proposed outlet works arrangement and principal components are shown on Drawing Nos. 231491 to SKT-0005. No liaison has been conducted with the Queensland Department of Primary Industries and Fisheries and it has been assumed that fish passage facilities will be required. This assumption should be confirmed during future investigations.

The outlet works (and fish passage facilities) are located on the non-overflow portion of the dam wall on the right side of the river. The outlet facilities proposed for preliminary design comprise an intake structure located adjacent to the upstream face of the dam, four conduits passing through the dam each controlled by a radial gate and able to be isolated by a fixed wheel gate. Irrigation releases can be made through a separate outlet which consists of a 1600mm mild steel cement mortar lined pipe which bifurcates upstream of the fish passage. Environmental flows and emergency release of up to 13,750 ML/day can be made through each of four outlets which are controlled by separate hydraulically operated radial gates. Environmental flows discharge to the spillway apron downstream of the dam face. The total discharge capacity is 55,000 ML/day; the maximum required release rate.

A fish trap and truck arrangement are proposed for upstream migration. A branch pipeline from the irrigation pipeline supplies the fishway with an attraction water supply. The design of the outlet works is heavily dependent upon the design and operating requirements of the upstream and downstream fish passages and in particular in assisting in attracting fish to these facilities. The development of fish passage systems for dams in Australia is in its infancy. The concept designs included for the proposed fish passages at Cave Hill Dam are likely to change during detailed design. The outlet works arrangement may also change depending on the finally adopted fish passage arrangements.

14.7.11.1 Environmental releases and reservoir evacuation

The environmental flow requirements to meet the 1.5-year ARI EFO of the Gulf Water Plan requires the dam to be able to release up to 55,000 ML/day through the outlet works. This is a considerable flow and four outlets, have been provided to meet this requirement. Each outlet is controlled by one 4m x 2m, high pressure radial gate raised by a hydraulic cylinder. The gate seal is fixed to the outlet conduit and the gate lead is pressed onto it by a second cylinder turning an eccentric trunnion support shaft. Before the gate is moved this cylinder retracts the gate from the seal and after the required opening is attained the gate is pressed back onto the seal.

The control gates can be readily removed or installed by the main gantry crane via access shafts provided over each gate. While each gate will weigh about 8 tonnes, the leaf and arm assemblies will be installed separately. There is one winch-operated wheeled guard gate to serve the four control gates. A travelling gantry situated in a gate chamber under deck level will enable the gate to be lowered into any one of the four conduits.

A steel baulk would be provided to enable the upstream end of the outlet conduit to be sealed off for maintenance. This baulk can only be positioned in still water after the flow has been stopped by either the control gate or the emergency guard gate. It will be handled by a 15 tonne main gantry crane which travels along the top of the deck. The baulk will be housed in a chamber attached to the upstream face of the dam.

In terms of evacuation of the storage, the evacuation time to lower the reservoir to 10% storage capacity is expected to be much less than 100 days which has been commonly used to assess what might be termed “reasonable”.

14.7.11.2 Location

The outlet works and fish passage facilities have to be located in the same area to ensure effective operation of the fish passage facilities. It is also logical that these facilities be collocated to facilitate connection to water and power supplies and for convenience in operation and servicing. The proposed location adopted for the concept design is on the right bank. This location was selected having regard to the fact that primary access to the site is likely to be via the right bank and the geology on that side suggests a more competent rock strata at higher levels. The generally higher foundation levels on the right bank would allow the various works to be located closer to each other and the downstream river channel.

14.7.11.3 Intake structure

The two intake structures consist of a framework of semicircular beams and vertical columns attached to the upstream face of the dam. Trashracks are housed in the outer slots in the columns forming the entry bays and selective withdrawal baulks are housed in the inner slots. The purpose of the baulks is to allow the withdrawal of the better-quality water from the storage by altering the draw off level.

There are three types of baulks; open frames to allow water entry, closed baulks to prevent entry, and collapsible baulks which have a door that will automatically open when the head differential exceeds 4m. These collapsible baulks will protect the concrete intake structure and closed baulks from damage in the event of operational mistakes.

14.7.11.4 Fish passage provisions

It has been assumed for the purpose of preliminary design that provision will have to be made for the passage of fish in the upstream direction. The need for fish passage should be reassessed as part of future studies. It is proposed to provide a fish trap and truck generally similar design to that recently installed at Hinze Dam and as shown on the concept design Drawing Nos. SKT-0005. The fish passage will be located on the river side of the outlet works and comprise a downstream entrance points, a system for providing attraction flows, a fish trap and hopper chamber, and hoisting equipment. The entrance is located to cater for upstream fish migration during the passage of minor floods over the spillway and during the major proportion of the time when the spillway is not operating. Attraction flow for the fish passage will be sourced from the outlet works conduit and will be passed through the trap/hopper chamber and the fishway entrance. A separate valve chamber has been provided to accommodate attraction flow valves and associated equipment. The attraction flow will be supplemented by normal operational releases through the outlet works.

14.7.12 River diversion during construction

During construction base flows will have to be passed through the site without interruption to the work. Also, all flood events will have to be either passed around the works or safely through the works so as to minimise the risk of serious damage or dam failure. The major advantages of RCC dams during the construction phase are twofold. Firstly, being a concrete dam the partially completed structure can be overtopped safely by flood waters with minimal risk of damage. Secondly, the shortened construction phase associated with RCC construction compared to alternate embankment dam construction significantly reduces the time the partially completed works are exposed to flood risk. The main advantage of a concrete gravity dam as proposed in this concept design, regardless of the construction method, is its extremely low risk of failure during construction as a consequence of flood loading. Having regard to all of these factors the following diversion arrangements and associated construction sequence have been developed for the purpose of preliminary design.

The concrete dam can safely pass major floods even though it may only be partially complete. Therefore, the major diversion requirement is during foundation excavation and preparation for the central spillway section of the dam and subsequent construction of the work below river level. Once the concrete construction in this portion of the dam rises above river bed level the potential for major delays and damage to the diversion works begins to reduce significantly.

Accordingly work below river bed level should be targeted for the historically drier winter and spring months of the year. Having regard to the flood hydrology, topography, dam layout and geotechnical conditions at the site, it is considered likely that the capacity of the proposed environmental release conduits will be sufficient to provide a reasonable immunity to the works.

This discharge could be conveyed along the right abutment in a diversion channel with an invert level at about bed level in conjunction with modestly sized upstream and downstream cofferdams.

Further review and refinement of the diversion channel capacity will be required during the next phase of design when a more accurate tailwater curve is derived and more rigorous analysis of dry and wet season streamflow is carried out. It will again be reviewed by the constructor when the detailed construction methodology and program are established.

14.7.13 Sediment management

The Cave Hill Dam has been documented as having a substantial mobile bed sediment load (Alluvium 2016). The sediment supply to the river was considered to be high due to the geology of the catchment, high variability in climatic conditions in the catchment and agricultural land use. Detailed modelling would be required to quantify the potential sediment load which is outside the scope of the DBC design development. To address the risks associated with the uncertainties regarding sedimentation, the design of the dam has incorporated several features that will provide opportunities to manage this issue.

The invert of the environmental release gates is set low in the dam at 210.0 m AHD. However, the invert level is about 3 m above the invert of the channel. This provides a dead storage volume of 470 ML or 470,000 m^3 that can contain sediment entering the dam without impacting on the outlet works. The environmental release gates can also be actively operated to pass sediment through the dam in times of significant flows in the catchment. The gates are designed to safely pass flows of up to 55,000 ML/d (636 m^3/s) at relatively low reservoir levels and with low water levels downstream of the dam. These gates can be opened when the dam is full, and the spillways are overtopping. The head available to the gates under this scenario will generate velocities that will mobilise sediment in the storage and pass it downstream combined with spillway overflows. The resulting sediment transport will be similar in nature to natural flood flows, reducing the risk of clear water scour downstream of the dam. While the current design provides opportunities to manage sediment at the dam, the quantum of the sediment expected at the dam, and design responses commensurate with the risk should be investigated during detailed design of the dam.

14.7.14 Cost estimation

14.7.14.1 Upfront capital cost estimation

The methodology adopted for cost estimation was developed to provide as reliable an estimate at the feasibility stage as possible. After the structure was designed and sketches developed, quantities were estimated for all items and a bill of quantities was developed.

Based on recent experience, variability in rates used in the estimate will likely be due to one or more of the following:

- risk apportionment—risk should lie with those who can manage it best.
- contracting model— whether it is design and construct, schedule of rates or other
- design development focus— additional work/investigations should provide information that reduces risks/unknowns for contractors pricing, for example geotechnical investigations, borrow areas and survey information.

In addition to rates, there is also potential for variability in quantities for which the project has been costed. Quantity variations typically arise because of:

- variations made to the design—alternative design options
- risk tolerability of designers
- assumptions made during early stages of design.

With these factors in mind, a raw cost estimate was developed for the current dam design. The cost estimate has been broken down into the major components of dam construction, with each component having an adopted rate and quantity (medium cost) based on the preliminary design and the best available cost information. Lower and upper bound estimates of quantities and rates were then identified and used to develop lower and upper bound cost estimates to provide an indication of the potential range and sensitivity of costs.

The raw cost estimate is summarised in Table 14.8. Full details are presented in Appendix D.

Table 14.8 Dam raw cost estimate

Item Number	Description	Capital cost ($)		
		Lower bound	Medium cost	Upper bound
	Direct costs			
1	Environmental controls	2,440,778	3,050,973	3,661,168
2	Clear site and inundated area	1,947,444	3,477,579	6,120,538
3	Site access road construction and maintenance	4,046,423	8,030,604	15,158,664
4	Construction and maintenance of site haul roads	1,302,261	2,362,053	4,437,752
5	Conventional concrete plant operations	267,424	334,281	367,709
6	Diversion and care of river	2,689,526	4,711,764	6,667,782
7	Dewatering of foundation areas	175,000	350,000	385,000
8	Foundation excavation and preparation	9,393,133	14,676,770	22,602,227
9	Foundation grouting	1,146,075	1,790,742	2,568,645
10	RCC dam	31,138,684	48,604,193	64,113,535
11	Conventional concrete to spillway	26,526,617	41,447,838	54,711,147
12	Outlet works concrete structures	8,359,141	13,061,158	17,240,729
13	Outlet works metalwork	940,450	1,469,453	1,939,678
14	Fish passage	403,914	575,994	711,804
15	Fuse plug spillway	30,962,609	48,379,076	63,860,380
16	Saddle dam 1	3,398,448	5,310,075	7,009,299
17	Saddle dam 2	7,783,462	12,161,660	16,053,391
18	Saddle dam 3	2,487,464	3,886,663	5,130,395
19	Instrumentation	424,483	530,604	583,664
20	Permanent site services (power, water, coms, office, workshop)	1,627,893	2,790,977	3,070,075
	Subtotal	**137,461,229**	**217,002,456**	**296,393,583**
	Indirect costs			
	Contractors overheads & profit	32,990,695	65,100,737	106,701,690
	Construction camp	4,835,925	7,768,043	10,435,919
	Design	6,007,829	12,571,860	22,104,408
	Owners costs	4,398,759	8,680,098	14,226,892
	Environmental requirements	9,040,255	12,550,318	13,805,350
	Land purchase	3,932,400	9,831,000	15,336,360
	Other owner costs	2,128,616	3,304,527	4,457,074
	Subtotal	**63,334,479**	**119,806,582**	**187,067,693**
	Direct and Indirect Costs Subtotal	**200,795,708**	**336,809,039**	**483,461,276**
	Contingency	42,659,918	54,398,349	108,297,772
	Total	**243,455,625**	**391,207,387**	**591,759,048**

The raw cost estimate for the dam will be further developed as part of the financial and commercial analysis. The variability in rates and quantities will be used to develop a risk-adjusted capital expenditure estimate through the quantification of intrinsic and contingent risks. This process will develop a P50 cost estimate (the value at which there is a 50 per cent chance of the project coming in above this cost and a 50 per cent chance of it coming in below this cost) and a P90 cost estimate (the value at which there is a 90 per cent chance of the project coming in at a lower cost).

14.7.14.2 Operational cost estimation

To operate the dam one full-time and one part-time employee (1.5 FTE) will be needed. Power will be required to operate the gates, valves and fish/turtle passage. Other costs include surveillance and monitoring of the dam, grounds maintenance, other routine maintenance, meeting ongoing EIS conditions, land tax and council rates, land management costs, insurances and refurbishment costs. Annual operating costs are summarised in Table 14.9.

Table 14.9 : Annual dam operating costs

Operating costs	Annual costs ($)
Operations and maintenance	500,000
Operation of Fish Trap and Haul	200,000
Ongoing EIS conditions	300,000
Land tax	100,000
Council rates	150,000
Land management costs	400,000
Insurance	300,000
Total Operating Costs	**1,950,000**

14.8 Distribution network design and cost estimate

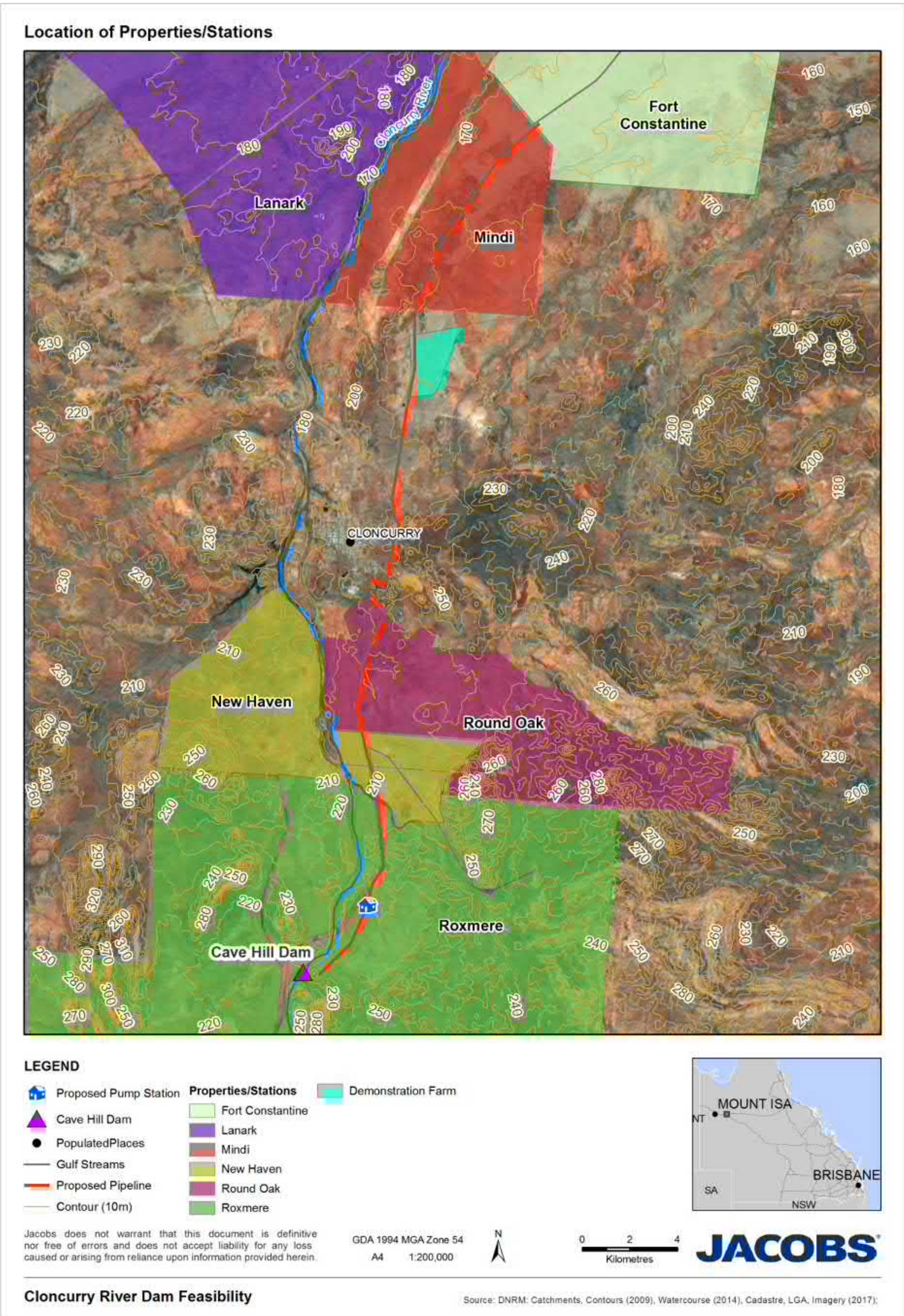
14.8.1 Inputs

The distribution pipeline route was selected following field reconnaissance through the proposed irrigation area. There are limitations on routing around the Cloncurry Township due to irregular topography. The proposed alignment is shown in Figure 14.2.

The following assumptions were made regarding the extent of the irrigation area:

- The possible area and demand for each property have been estimated based on the demand assessment.
- The irrigation water is supplied up to the boundary of Fort Constantine.
- Gipsy plains and Carsland properties are not included.
- The pipeline can deliver a total of 333 ML/d (50,000 ML over 150 days).
- The elevation at the start of the distribution system is 209 m AHD (as per the dam design).
- The minimum operating level of the dam is 215 m AHD.
- The total length of the distribution system is 40 km.

Figure 14.2 : Pipeline route



14.8.2 Pipeline network overview

To minimise water loss from the system and operating costs, a low head pipeline system has been adopted to transport irrigation water from the dam to customers. High density polyethylene (HDPE) pipes were considered suitable for this application.

Up to 50,000 ML per annum will be available to customers of the network. The network has been designed to supply this water over a 150-day irrigation season. The resulting peak capacity of the network is 333 ML/d.

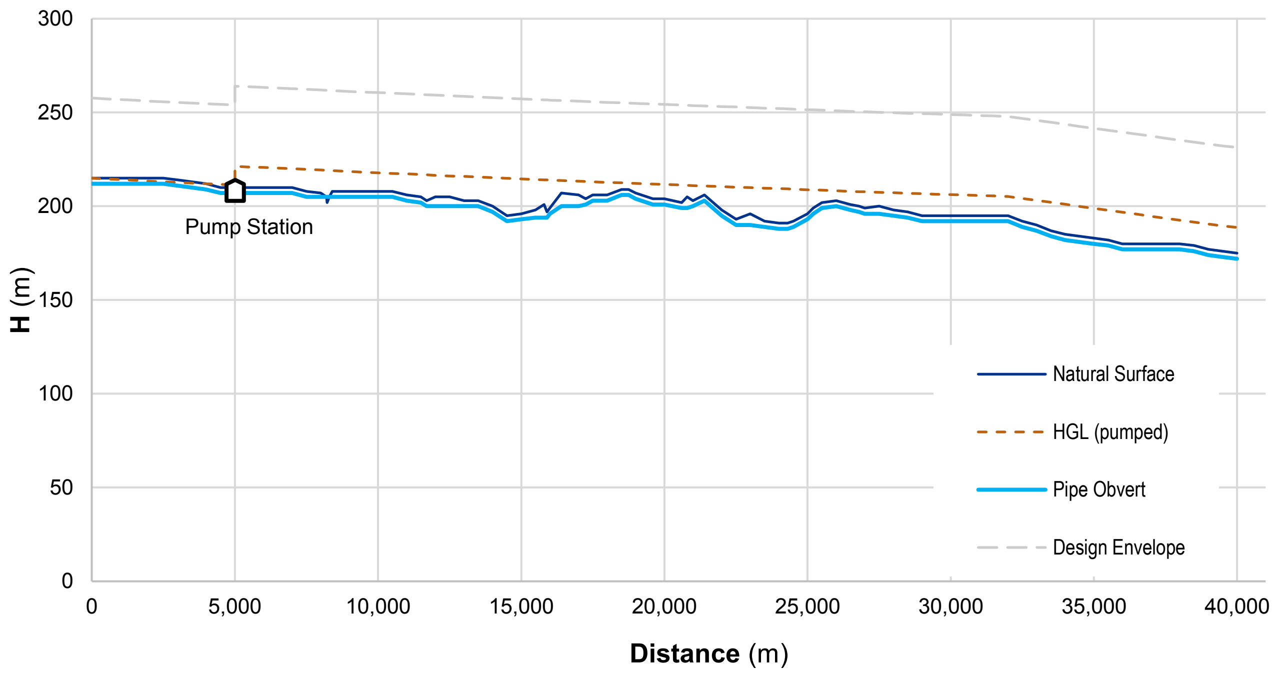
To deliver the required daily volumes, a single DN1600 (1,600 mm nominal diameter) pipe will be utilised.

The network will be gravity-fed directly from the dam for the first 5 km. A booster pump station at this location will be required to maintain the daily flow requirements for the remainder of the network. To offset pumping electricity costs, the network includes a solar array and battery storage system adjacent to the pump station.

As pipeline pressures are relatively low in the section upstream of the booster pump station, pipe with a pressure rating of PN4 can be used. Downstream of the pump station, a higher-rated PN6.3 pipe will be required. For most of the route, the pipeline can be buried below the natural surface. There are two major road crossings, two drain crossings and one rail crossing.

A longitudinal section of the pipeline route illustrating pipe invert levels relative to natural surface levels is presented in Figure 14.3.

Figure 14.3 : Pipeline longitudinal section



Specific design parameters for the network are summarised in Table 14.10.

Table 14.10 Pipeline network design parameters

Parameter		Adopted standard	Comment
Scheme reliability		Approx. 80% monthly reliability	Subject to reliability of dam yield
Flowrate		Annual entitlement delivered evenly over set 150-day irrigation season	
Pipeline	Diameter	DN 1600	
	Material	HDPE	
	Max velocity	1.9 m/s	
	Pressure Rating	PN4 and PN6.3	
Pumping Station	Design Flow Rate	3.85 m^3/s	
	Design Head	10m	
	Shaft Power	630kW	Based on η=0.6
On-farm pressure		Minimum 3 m residual pressure	
Civil asset design life		50–100 years	Typical concrete structures
Mechanical asset design life		Nominal 35 years	
Electrical asset design life		Nominal 25 years	

14.8.3 Cost estimation

14.8.3.1 Upfront capital cost estimation

The cost of the pipeline network infrastructure required for this project has been estimated at approximately $68 million (Table 14.11).

The costs have been estimated using rates for Cloncurry to cater for:

- working in undulating terrain and irregular topography
- the cost of hiring contractors and personnel in north-west Queensland
- the cost and cartage distance for suitable pipe bedding material.

DN1600 pipe is not a regularly produced pipe size; however, Iplex pipes has confirmed that it can be produced on demand, although supply would have a relatively long lead time. This would need to be considered in the programming of construction of the network.

Table 14.11 : Pipeline network cost estimate

Item	Unit	Quantity	Rate ($/unit)	Total ($)
Design	Item	1	350,000	350,000
Approvals	Item	1	100,000	100,000
Design and approvals subtotal				**450,000**
Pipe supply				
DN1600 PN 4	m	5,000	650	3,250,000
DN1600 PN 6.3	m	35,475	980	34,765,500
Fittings supply	10% of pipe costs			3,801,550
Fittings supply subtotal				**41,817,050**
Construction				
DN 1600 PN 4	m	5,000	170	850,000
DN 1600 PN 6.3	m	34,475	200	6,895,000
Inlet connection	Item	1	75,000	75,000
Road crossing	no.	2	10,000	20,000
Drain crossing	no.	2	12,000	24,000
Rail crossing	no.	1	20,000	20,000
Pressure test	Item	1		50,000
Site establishment	Item	1		300,000
Site clean-up	Item	1		220,000
Demobilisation	Item	1		50,000
Construction subtotal				**8,504,000**
Pump station				
Pump station (1000 kw)	Item	1	3,000,000	3,000,000
Solar array and battery	Item	1	3,000,000	3,000,000
Pump station subtotal				**6,000,000**
Contingency	20% of costs			11,354,210
Total				**68,125,260**

14.8.3.2 Operational cost estimation

To operate the pipeline one part-time employee (0.5 FTE) will be needed. The booster pump station was estimated to cost approximately $5/ML to operate, accounting for the offsets provided by the solar array. A small amount of materials and consumables will also be required. Annual operating costs are summarised in Table 14.12.

Table 14.12 : Annual pipeline network operating costs

Operating costs	Annual costs ($)
Labour	40,000
Net Electricity	267,300
Materials and consumables	20,000
Total	**327,300**

15. Financial analysis

15.1 Key points

- The purpose of this chapter is to assess the financial viability of the Cloncurry River Dam and irrigation network project.
- The financial viability of the project directly relates to the amount of Government funding that is received.
- Government funding determines ongoing debt levels and water charges.
- Three funding scenarios have been modelled.
- Scenario 1—High government funding: A 50 per cent Australian Government grant, for example through the NWIDF and a further 36 per cent from an alternative government source.
- Under this scenario, annual water charges are $65 per ML. At this price, there is enough demand for the full 50,000 ML nominal volume of the reference project.
- This scenario results in the high likelihood of affordable prices and a financially viable ongoing water business (with only construction finance required).
- Scenario 2—Medium government funding: A 50 per cent Australian Government grant only and no Queensland Government grant.
- Under this scenario the annual water charges are $214 per ML. This is about four times the price used during the demand assessment and would place downward pressure on demand.
- Under this scenario the water business could remain in debt for 50 years.
- Scenario 3—No government grant funding.
- Under this scenario annual water charges are $414 per ML, eight times the price used for the demand assessment and would place downward pressure on demand.
- Under this scenario, the project is not likely to be viable.
- In each of the scenarios it is assumed that irrigators contribute $1,500 per ML upfront for a total of $75 million (based on 50,000 ML) with 100% of water allocations are pre-sold in all scenarios.
- Government funding is needed for this project to be financially viable.
- Under Scenario 1 or 2, an Australian Government grant of 50 per cent would support the project's affordability and financial viability.
- A further upfront contribution of up to $187.3 million from an alternative government source would substantially increase the probability that demand of 50,000 ML can be realised.

15.2 Inputs and assumptions

The key assumptions used for the financial assessment relate to the timing and value of revenues and costs, including financing costs such as the cost of debt.

15.2.1 Timing assumptions

The financial NPV considers the timing of the cash flows. Accordingly, the modelling of costs and revenues accounts for timing. Table 15.1 outlines assumptions about the timing of cash flows.

Table 15.1 : Timing assumptions

Component	Assumptions/inputs
Model start date	1 July 2019
Model evaluation period	• 30 years in total • 3 years for design and construction: starting 1 July 2019 and finishing 30 June 2022 • 27 years for commissioning and operations: starting 1 July 2022 and finishing 30 June 2049
Base date for escalating real construction and upfront capital cost forecasts	30 June 2018, as the cost estimates were developed in 2017–18 based on prevailing costs
Base date for escalating real ongoing operating cost forecasts	30 June 2018, as the cost estimates were developed in 2017–18 based on prevailing costs
Upfront customer contributions	• 2% is paid when agreeing to purchase (assumed to be 1 July 2019) • 8% is paid when all the conditions have been met for construction to begin (1 January 2020) • 90% is paid when the scheme is commissioned (1 July 2022)
Ongoing customer charges	Charges will be collected mid-year (on average), commencing in 2022–23.
Discount date—base date applied to discount cash flows to determine the NPV	1 July 2019

15.2.2 Financial assumptions

The financial assumptions include escalation and discount rates that have been applied in the financial model.

Table 15.2 : Financial assumptions

Component	Assumptions/inputs
Assessment	• All references to real dollars in this report refer to FY19 dollars. NPV figures are discounted to 30 June 2019 • An evaluation period of 30 years has been adopted for the financial analysis, to align with BQ guidelines
Escalations	• Where nominal costs are provided: – capital and implementation costs are escalated at 2.26%, the 10-year average annual increase of the ABS Producer Price Index for other heavy and civil engineering construction from FY08 to FY18 – other real costs (including operating costs) have been escalated by 2.5% per annum. This rate has been determined to reflect the midpoint of the RBA's target interest rate range
Discount rate	• 6% based on the cost of debt (nominal rate, distinctly different to the real discount rates of 4%, 7% and 10% used in the Economics chapter).
Capital costs	• The financial analysis undertaken for the project is based on the raw capital costs presented in Chapter 15 (Engineering design and costs). These raw capital cost estimates have been further developed into minimum, maximum and most likely real unit prices and quantities for each key capital item and form the basis of the Monte Carlo analysis • The estimated cost of acquiring water allocations from the Queensland Government has been included • A range of probable estimates have been prepared based on this analysis
Operating costs	• The operations and maintenance cost assumptions are based on assumed unit quantities and real annual price distribution ranges • The unit price and quantity distribution ranges specify a minimum, maximum and most likely annual real unit price for each key operational and maintenance cost item and form the basis of the Monte Carlo analysis • A range of probable estimates have been prepared based on this analysis • The key items comprising the ongoing real operations and maintenance cost assumptions include staff, electricity, materials and consumables, vehicles, insurance and dam inspections
Demand	• Irrigation demand is assumed to be 50,000 ML per year (refer demand assessment) • 100% of water allocations are pre-sold in all scenarios. This reflects that the scheme will not be built unless the water is pre-sold

Component	Assumptions/inputs
	• A 2% deposit is paid when agreeing to purchase; a further 8% is paid when all the conditions have been met for construction to begin; and the final 90% is paid when the scheme is commissioned. This payment schedule requires the business to obtain a construction loan, and to pay interest during construction
Pricing	• The annual fixed charge will comprise of: – fixed operating costs – a renewal annuity – interest and debt repayments[20] • The variable charge will comprise of variable operating costs • Prices will be calculated to increase at a constant rate to recover costs over a 30-year period. Fixed prices will start at $61/ML and variable charges will start at $4/ML
Funding	• It is assumed that irrigators contribute $1,500 per ML upfront for a total of $75 million (based on 50,000 ML). • The quantum of government funding is not yet known. Therefore, three scenarios have been adopted: – Scenario 1: The Australian Government contributes 50% of the upfront capital expenditure ($262.3 million) and the Queensland Government contributes the balance of $187.3 million – Scenario 2: The Australian Government contributes 50% of the upfront capital expenditure ($273.3 million) and the balance of $198.3 million is sourced from a commercial loan – Scenario 3: No grant funding: The Australian Government loans 50% of the upfront capital expenditure ($283.0 million) through the concessional loan facility (NWIDF), and the balance of $208.0 million is sourced from a commercial loan. These assumptions are outlined in Table 15.3

Table 15.3 : Capital cost funding contributions ($ million nominal)

Funding source	Scenario 1	Scenario 2	Scenario 3
Customer contribution	75.0	75.0	75.0
Australian Government	262.3	273.3	-
Queensland Government	187.3	-	-
NWIDF loan	-	-	283.0
Commercial loan	-	198.3	208.0
Total P90 capex, including escalation and interest during construction	**524.6**	**546.6**	**565.9**

Note: All scenarios assume that 100% of water allocations are pre-sold. This reflects that the project will not proceed unless the water is pre-sold. The amount of interest incurred during construction varies in accordance with the timing and amount of external funding. Therefore, the total capex varies under each funding scenario.

15.3 Raw capital and operating costs

The financial model includes all capital costs, risks, ongoing costs and residual value. By calculating the net cash flow balances in each year over the evaluation period and discounting these at an appropriate rate, a risk adjusted financial NPV has been produced.

15.3.1 Raw capital costs

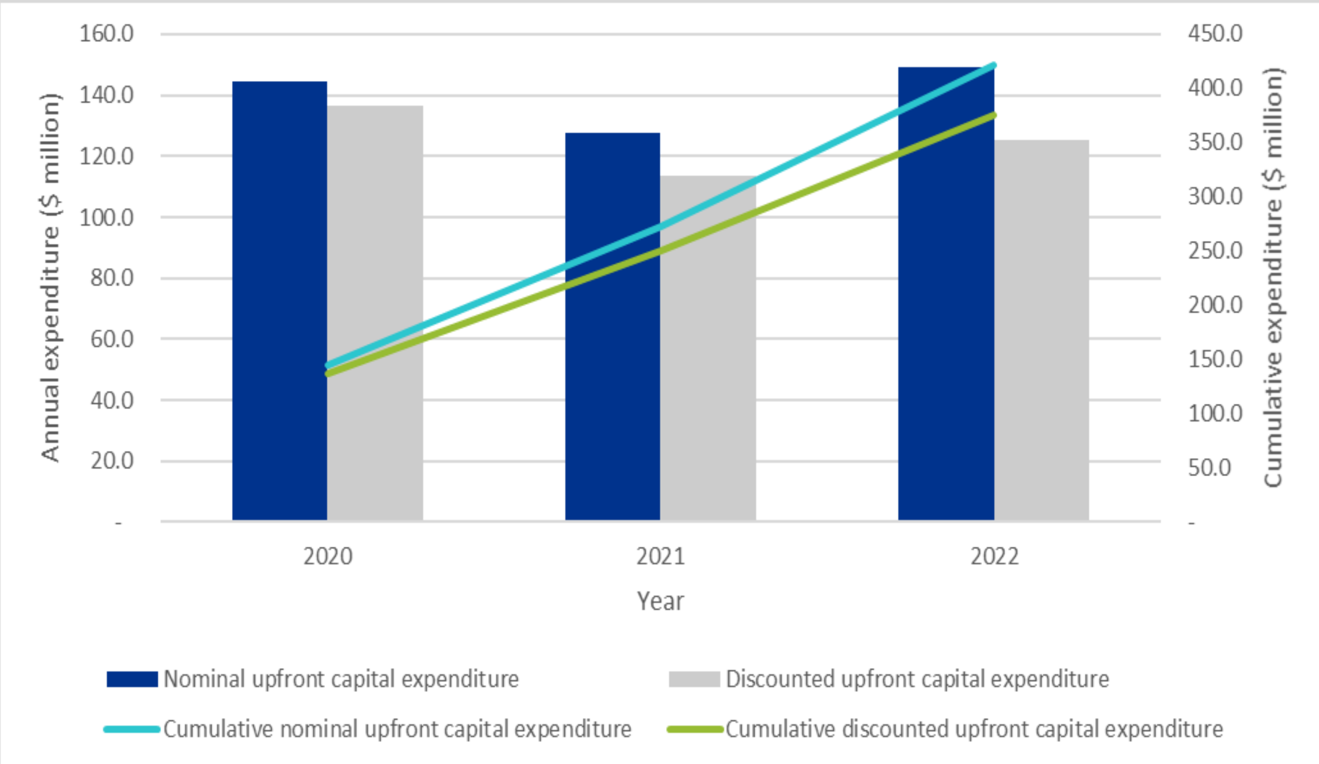
Capital costs are described in Chapter 14 (Detailed engineering design and costs). All options include the cost of purchasing water allocations. The upfront capex is summarised in Table 15.4.

Table 15.4 : Raw upfront capital costs ($ million)

Capex element	Nominal	Real	NPV
Dam design, construction and delivery capex	351.9	336.8	314.6
Pipeline and pump design, construction and delivery	60.2	56.8	51.8
Purchase of water allocations (9.7, 9.4, 9.1)	9.7	9.4	9.1
Total (351.9, 336.8, 314.6)	**421.7**	**403.0**	**375.6**

This capital will be spent progressively over three years throughout the design and construction period. As shown in Figure 15.1, expenditure will increase over time as the activity on-the-ground becomes more intense and more advanced.

Figure 15.1 : Raw capital cost cash flow profile



There will also be a requirement for ongoing capex, as infrastructure will need to be replaced. Some of the distribution costs (e.g. electrical components) will need to be replaced within 30 years. Ongoing capital costs are recovered through a rolling 30-year renewals annuity that is paid into a sinking fund. The ongoing capital costs are presented in Table 15.5.

Table 15.5 : Raw ongoing capital costs over 30 years

Capex element	Nominal ($ million)	Real ($ million)	NPV ($ million)
Dam ongoing capital costs	1.0	0.5	0.2
Pipeline, pump and solar array ongoing capital costs	4.6	3.1	1.6
Total	**5.6**	**3.6**	**1.8**

15.3.2 Raw operating costs

The annual costs required to maintain and operate the scheme for the first year of operation is estimated to be $2.38 million. It is comprised of overhead and operating costs which are detailed in Table 15.15.

Table 15.6 : Overhead costs

Item	Total ($ per annum)
Overheads / administration	100,000
Total	**100,000**

Table 15.7 : Dam operating costs

Item	Total ($ per annum)
Operations and maintenance	500,000
Operation of Fish Trap and Haul	200,000
Ongoing EIS conditions	300,000
Land tax	100,000
Council rates	150,000
Land management costs	400,000
Insurance	300,000
Total	**1,950,000**

Table 15.8 : Distribution operating costs

Item	Total ($ per annum)
Labour	40,000
Materials and consumables	20,000
Total	**60,000**

Electricity for the project will be supplied by Ergon, which is the sole supplier in north-west Queensland. Ergon's tariffs are made up of the following charges:

- fixed charges, including:
  - a flat daily connection charge
  - a demand charge based on the maximum amount of power used in each month above a demand threshold, measured in kVA
- variable charges, including:
  - a usage charge based on the amount of energy used, measured in kWh.

The pump station's tariff is determined by the maximum power usage of the pump. The charges in Table 15.9 are from the Queensland Competition Authority's most recent annual determination on retail tariffs[21].

[21] QCA, *Regulated retail electricity prices for 2018–19*, final determination, May 2018, http://www.qca.org.au/Electricity/Regional-consumers/Reg-Electricity-Prices/Final-Report/Regulated-Electricity-Prices-2018-19#finalpos.

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Table 15.9: Electricity tariff

Pump station	Tariff	Supply charge ($ per day)	Demand threshold (kW)	Demand charge ($/kVA per month)	Usage charge ($/kWh)
Booster pump station	Tariff 46	439	400	24	0.16

The tariff and power requirements of the pump station result in the fixed charges for electricity shown in Table 15.10. The supply charge is based on the daily rate for the tariff. The demand charge is calculated monthly based on the total power requirement (minus the demand threshold). It is assumed that there is a need for mains power between November and March (150-day delivery).

Table 15.10: Fixed electricity costs

Pump station	Supply charge ($ per annum)	Power requirement (kVA)	Demand charge ($ per annum)	Total ($ per annum)
Booster pump station	160,312	531	15,678	**175,991**

The amount of electricity required by the pump station depends on the pressure the water needs to overcome, known as head. Moving 50,000 ML of water through the distribution pipes in 150 days requires 1.9 million kWh of electricity. Refer Table 15.11 and Table 15.12.

Table 15.11 : Electricity requirement

Pump station	Pumping head requirement (m)	Electricity per metre of head (kWh/m/ML)	Pumped water (ML)	Total electricity requirement (kWh)
Booster pump station	10	3.87	50,000	1,987,439

Table 15.12: Variable electricity costs

Pump station	Energy demand (kWh)	Variable costs with no solar supply ($)	Variable costs with solar supply ($)	Variable cost reduction through solar energy supply ($)
Booster pump station	1,937,439	311,327	189,216	122,112

When the solar array is not supplying electricity directly to the pump stations, solar energy can be sold into the electricity grid. We have used the feed in tariff of $0.09/kWh set by the Queensland Competition Authority[22].

The pump stations will also earn Large-scale Renewable Energy Certificates while generating electricity. These can then be sold to retailers. Due to the uncertainty in the Large-scale Renewable Energy Certificate Market, we have used the 2022 forward price of $0.1/kWh[23].

Table 15.13 shows the revenue from solar feed-in and Large-scale Renewable Energy Certificates sales is used to reduce the annual fixed charge.

Table 15.13: Solar array revenue

Item	Available electricity (kWh)	Price ($/kWh)	Revenue ($)
Excess solar energy sold to the electricity grid	827,680	0.09	77,545
Large-scale Renewable Energy Certificate sales	1,587,600	0.01	20,361
Total revenue from solar array	**n/a**	**n/a**	**97,906**

[22] QCA, *2018–19 Solar feed-in tariff*, determination, May 2018, 2http://www.qca.org.au/getattachment/28553074-402e-415b-bc38-e84d326dde93/Report%E2%80%942018%E2%80%9319-Solar-Feed-in-tariff-for-regional-Q.aspx.
[23] Mercari, LGC Closing Rates. 2018, http://lgc.mercari.com.au/.

Table 15.14 shows that the net electricity costs are $267,300 in the first year of operation.

Table 15.14 : Electricity costs

Item	Cost ($)
Electricity for pumping—fixed	175,991
Electricity for pumping—variable	189,216
Revenue from solar array	-97,906
Net electricity costs	**267,300**

Table 15.15 shows that the operation costs of the dam and pipeline are $2.38 million annually, in 2018–19 dollars.

Table 15.15: Total annual operating costs ($2018–19)

Opex item	Cost ($ per annum)
Overhead	100,000
Dam operation	1,950,000
Distribution operation	60,000
Net electricity	267,300
Total	**2,377,300**

Any cost associated with new infrastructure required to connect to Ergon's network has not been included.

The costs over 30 years are shown in Table 15.16.

Table 15.16 : Raw ongoing operating costs over 30 years ($2018–19 million)

Opex element	Nominal	Real	NPV
Overhead	4.2	2.7	1.6
Dam	81.6	52.7	30.8
Pipeline, pump & solar array	2.5	1.6	0.9
Electricity	11.2	7.2	4.2
Total	**99.5**	**64.2**	**37.5**

15.4 Risk adjusted capital and operating costs

Forecasting costs includes some uncertainty. A DBC requirement is for raw costs to be risk adjusted to a P90 estimate. This means that there is a 90 per cent probability that a P90 cost estimate will *not* be exceeded (or a 10 per cent probability that it will be exceeded).

There are two risk adjustments:

- intrinsic risk, based on the range of price and quantities of each line item
- contingent risk based on risks from the risk register that may affect the cost.

The major cost categories are shown below, along with high, most likely and low-cost estimates. Monte Carlo simulation then runs 10,000 simulations to determine a P90 estimate.

15.4.1 Risk adjusted capital costs

To establish the range of price and quantity for each cost line item, Jacobs convened a workshop of engineers experienced in the delivery of water infrastructure projects. This is shown in Table 15.17.

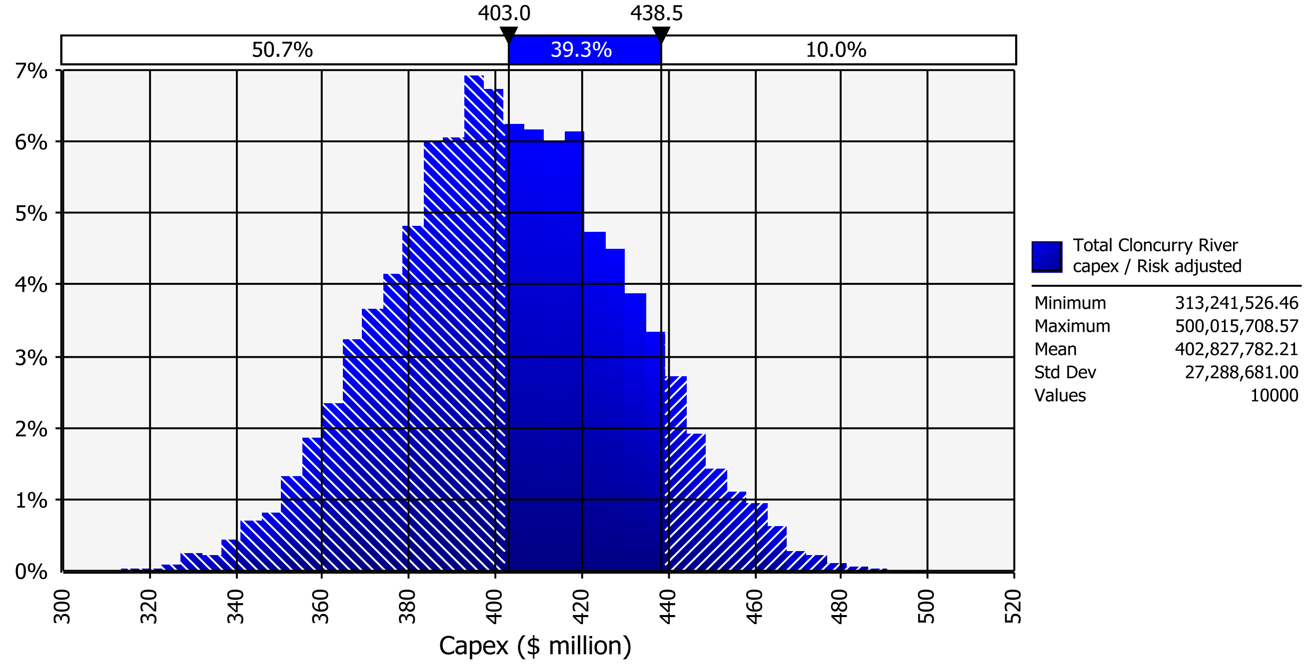
The low-cost estimate represents the best-case scenario where all aspects of construction proceed perfectly well; the high cost estimate is the worst-case scenario where everything goes badly; and the most likely estimate is the cost estimate most likely to be correct, based on engineering judgement.

Table 15.17 : Intrinsic risk associated with upfront capital costs ($ million)

Capex element	Low cost estimate	Most likely cost estimate	High cost estimate
Dam design, construction and delivery capex	200.8	336.8	483.5
Pipeline and pumps design, construction and delivery	39.6	56.8	65.0
Purchase of water allocations	-	9.4	18.9
Total	**240.4**	**403.0**	**567.4**

A Monte Carlo simulation was undertaken to provide a risk-based capex estimate. This method runs 10,000 simulations to determine a cost profile (Figure 15.2). This shows that the 90 per cent of capex estimates are below $438.5 million. Accordingly, the intrinsic risk is $35.5 million, which is the gap between the most likely and the P90 estimate, as shown in Figure 15.2.

Figure 15.2 : Risk adjusted capex



Several contingent risks were included in the simulations (Table 15.18), as reflected in the risk register. The likelihood of any of the risks manifesting and the associated cost impact (low, medium, high) if the event does occur are shown. These factors were then each assessed separately to estimate a total contingent risk and to adjust the capital cost estimate.

Table 15.18: Upfront capital cost contingent risks

Risk description	Likelihood of occurrence	Low cost ($ million)	Medium cost ($ million)	High cost ($ million)
Dam foundation major level change—increased foundation	50%	7.0	9.9	12.9
Dam foundation major level change—decreased foundation	40%	14.6	20.9	27.1
Survey error—increased dam and spillway height	30%	1.7	2.9	4.3
Survey error—decreased dam and spillway height	40%	4.0	5.0	5.5
Fractured foundation under dam alignment	20%	2.3	4.7	7.5

Risk description	Likelihood of occurrence	Low cost ($ million)	Medium cost ($ million)	High cost ($ million)
Rock sourced close to the dam site (i.e. Roxmere) is unsuitable for rockfill source	40%	2.0	4.0	6.4
Quality rock source close to dam site (i.e. Roxmere)	10%	12.0	20.0	30.0

A Monte Carlo simulation was performed to convert these estimates into a P90 estimate. This means that the P90 contingent risk allowance is $55.9 million. The upfront capital costs for the three scenarios is shown in Table 15.19.

Table 15.19: Total upfront capital costs ($ million)

Capital expenditure element	Scenario 1: High government funding (core scenario)	Scenario 2: Medium government funding	Scenario 3: No government funding
Base capital expenditure	403.0	403.0	403.0
Intrinsic risk allowance	35.5	35.5	35.5
Contingent risk allowance	55.9	55.9	55.9
P90 capital expenditure	**494.4**	**494.4**	**494.4**
Working capital	0.6	0.6	0.6
Escalation during construction	23.0	23.0	23.0
Interest during construction	6.6	28.6	47.9
Total capital expenditure	**524.6**	**546.6**	**565.9**

The next 30 years of capex has been assessed to determine a range of estimates, as shown in Table 15.20

Table 15.20 : Risk adjusted ongoing capital costs ($ million, present value)

Capex element	Low cost estimate	Most likely cost estimate	High cost estimate
Dam ongoing capital costs	0.2	0.2	0.3
Pipeline and pump ongoing capital costs	1.6	1.9	2.4
Total	**1.8**	**2.1**	**2.7**

15.4.2 Risk adjusted operating costs

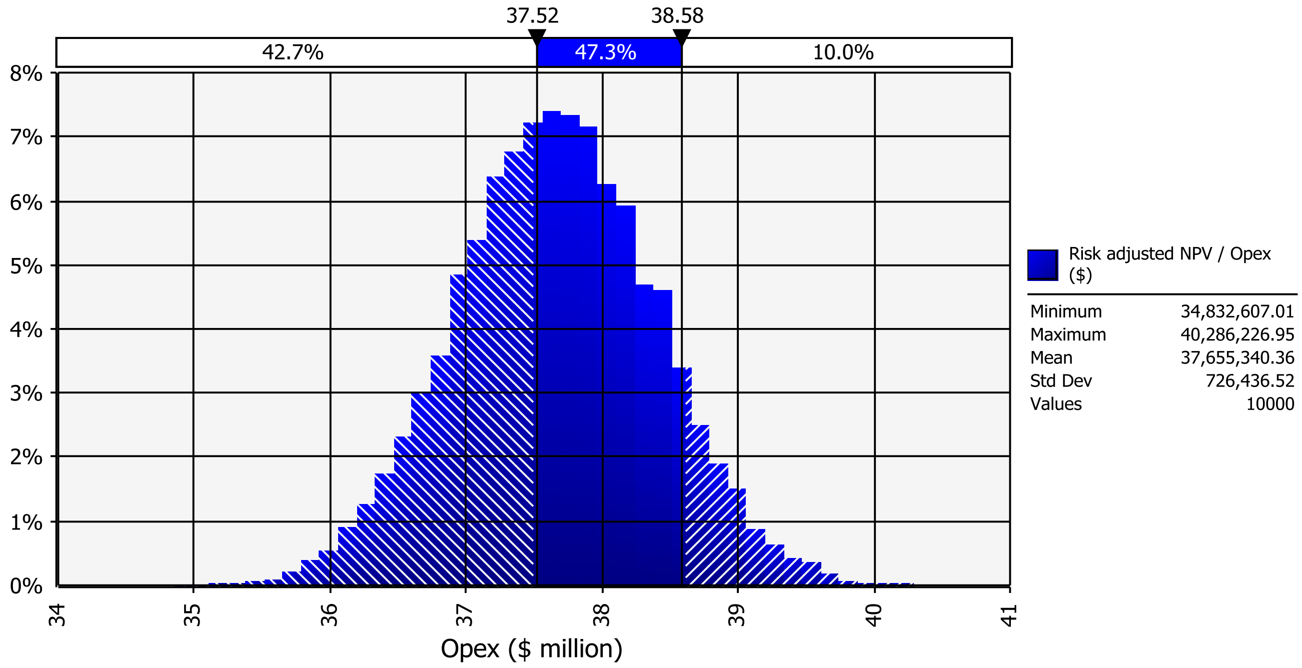
The risk adjusted costs over 30 years is shown in Table 15.21.

Table 15.21 : Risk adjusted ongoing operating costs ($ million, present value)

	Low cost estimate	Most likely cost estimate	High cost estimate
Opex costs	**28.1**	**37.5**	**47.7**

A Monte Carlo simulation was undertaken to provide a risk-based estimate. This method runs 10,000 simulations to determine a cost profile (Figure 15.3).

Figure 15.3: Risk adjusted opex



Several contingent risks have been included and are shown in Table 15.22. These reflect risks in the risk register that may have an impact on operating costs but are not reflected in the intrinsic risks. These risks are not covered by insurance.

Table 15.22: Contingent risk associated with operating costs ($ million)

Risk description	Likelihood of occurrence	Low consequence	Medium consequence	High consequence
Recreation incident	1.00%	–	0.5	2.0
Sunny day failure[24]	0.001%	5.0	50.0	300.0
Seepage	1.00%	-	0.2	1.0
Erosion of spillway	2.00%	1.0	5.0	10.0

15.5 Revenues

The scheme will receive revenues through upfront capital contributions by customers, ongoing annual charges (fixed and variable) and government grants, if received.

The status of any grants from the Australian or Queensland governments is currently uncertain. Accordingly, a range of possible scenarios have been considered. The core scenario assumes that these governments contribute $449.6 million. Other scenarios are set out in Table 15.23.

[24] A Sunny day failure is the term used to describe the failure of a dam for reasons not related to a flood event. For example, an earthquake.

Table 15.23: Capital cost funding contributions ($m nominal)

Funding source	Scenario 1: High government funding (core scenario)	Scenario 2: Medium government funding	Scenario 3: No government funding
Customer contribution	75.0	75.0	75.0
Australian Government	262.3	273.3	-
Queensland Government	187.3	-	-
NWIDF loan	-	-	283.0
Commercial loan	-	198.3	208.0
Total (incl. escalation and interest during construction)	**524.6**	**546.6**	**565.9**

Starting prices have been set at the amount necessary to recover costs in the first year. The prices will recover operating costs, ongoing capital costs (through a renewals annuity), and principal and interest costs (if any). There will be a fixed charge set to recover fixed costs, and a variable charge, set to recover costs that vary with water deliveries (e.g. pumping costs).

15.5.1 Operating costs

The BQ Guidelines suggest that DBC costs be estimated to a P90 level. Accordingly, costs are based on P90 costs, shown in Table 15.24.

Table 15.24 : Operating costs ($2018–19 million)

Opex element	Opex (P90)
Dam operation	1.95
Pipeline and pump operation	0.14
Overhead costs	0.10
Total fixed costs	**2.19**
Dam variable costs	-
Pipeline and pump variable costs	0.19
Total variable costs	**0.19**
Intrinsic risk allowance	0.07
Contingent risk allowance	0.39
Total operating costs	**2.83**

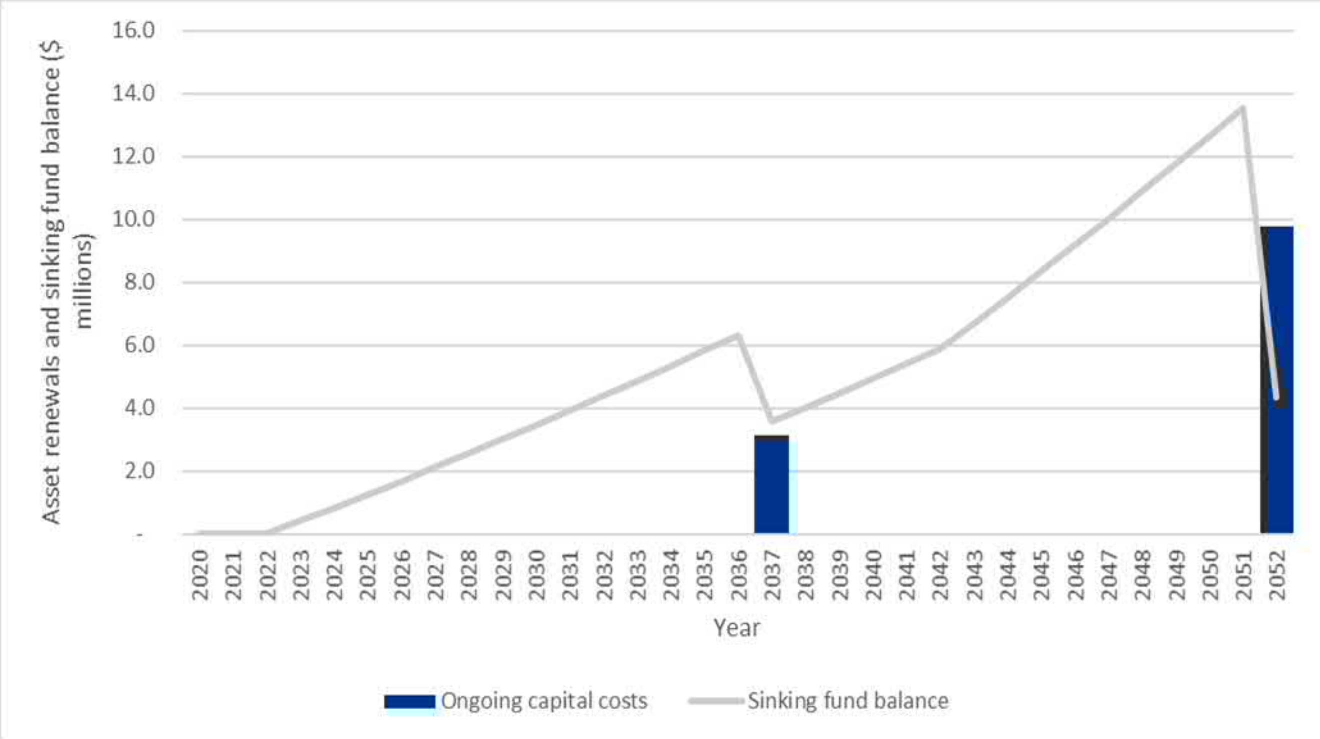
15.5.2 Ongoing capital costs

Over time, the major assets of the scheme will need to be replaced. A common mechanism to fund asset replacement in irrigation schemes is a renewals annuity. A renewals annuity is an amount collected annually in charges to fund ongoing capex. It is a way of putting funds aside for major asset refurbishments and replacements. This approach recognises that a privately-owned not-for-profit scheme will generally prefer to fund asset replacement in advance, rather than fund it through additional debt. A renewals fund is also referred to as a sinking fund.

To estimate the renewals annuity, the future capex needs of the business need to be established. For this purpose, the life of each asset type and its likely replacement cost over the first 30 years was estimated. This is shown in Figure 15.4 along with the balance of the annuity fund. Fully funding capex over 30 years requires an annual contribution of $8/ML, growing at 2.5 per cent per annum. Most irrigation schemes review their capital cost profile every five years and adjust the annuity.

The major renewal costs are associated with the distribution system, with solar arrays renewed 15 and 30 years after construction ($3.0 million in 2018–19 dollars), fittings renewed 30 years after construction ($3.9 million in 2018–19 dollars) and pump stations renewed 30 years after construction ($3.0 million in 2018–19 dollars).

Figure 15.4 : Ongoing capital costs and sinking fund balance ($ million, real)



15.5.3 Interest

If debt is required to fund the upfront or ongoing capex, interest costs will be incurred. The amount of debt and the resulting interest depend heavily on the amount of grant funding.

It is assumed that a NWIDF loan charges interest of 3.2 per cent and a commercial loan has interest of 6 per cent. It is assumed:

- NWIDF loans have a maximum term of 15 years, with a maximum of 5 years interest only during construction and a maximum of 10 years of principal and interest payments following construction.
- Commercial loans have a term of 15 years, with debt rolled over into new loans and a payback period for all debt of 50 years.
- Charges to recover debt are escalated at 2.5 per cent per annum.

The share of principal and interest will change over the term of the loan. It is assumed that commercial loans can be redrawn. Escalating charges mean commercial loans still have a maximum payback period of 50 years.

The principal of the NWIDF loan begins to draw down immediately, as the NWIDF loan has a fixed principal and interest payback period of 10 years after construction.

The Principal and interest payable in the first year of operation is shown in Table 15.25.

Table 15.25 : Principal and interest payable in the first year of operation ($ million)

	Scenario 1: High government funding (core scenario)	Scenario 2: Medium government funding	Scenario 3: No government funding
NWIDF loan principal	-	-	283.0
NWIDF loan interest	-	-	9.3
NWIDF loan drawdown	-	-	1.8
NWIDF debt funding charge (2022–23 $)	**-**	**-**	**11.1**
NWIDF debt funding charge (2018–19 $)	**-**	**-**	**10.1**
Commercial loan principal	-	198.3	208.0
Commercial loan interest	-	11.9	12.5
Commercial loan re-draw	-	-3.7	-4.3
Commercial loan debt funding charge (2022–23 $)	**-**	**8.2**	**8.2**
Commercial loan debt funding charge (2018–19 $)	**-**	**7.5**	**7.4**
Total debt funding charge (2018–19 $)	**-**	**7.5**	**17.4**

15.5.4 Cost-reflective prices ($)

Cost-reflective prices are based on the actual costs, as shown in Table 15.26. The fixed charge is the total fixed costs divided by the volume of water allocations (50,000 ML). Variable costs have been calculated under the assumption that water use will be 79 per cent of 50,000 ML, to reflect average reliability. Accordingly, variable costs are divided by 39,500 ML to obtain the variable charge.

Table 15.26 : Forecast ongoing costs and resulting charges

Charge component	Scenario 1: High government funding	Scenario 2: Medium government funding	Scenario 3: No government funding
Fixed costs			
Fixed operating costs	2,644,146	2,644,146	2,644,146
Renewals annuity	418,488	418,488	418,488
Debt principal and interest	0	7,467,264	17,444,523
Total fixed costs	3,062,634	10,529,898	20,507,158
Water allocations (ML)	50,000	50,000	50,000
Fixed charge ($/ML)	**61**	**211**	**410**
Variable costs	-	-	-
Bulk variable costs	-	-	-
Pumping costs	149,480	149,480	149,480
Total variable costs	**149,480**	**149,480**	**149,480**
Forecast water use (ML)	39,500	39,500	39,500
Variable charge ($/ML)	**4**	**4**	**4**
Total revenue collected	**3,212,115**	**10,679,379**	**20,656,638**
Total charge ($/ML)	**65**	**214**	**414**

If a water allocation was offered at a higher reliability, the one-off capital and annual charges would be adjusted based on the conversion factor from converting to a higher reliability allocation. For example, if a customer required an allocation with a reliability of greater than 80 per cent, a hydrology assessment would determine a conversion factor to improve the reliability, say 95 per cent. This scenario may require a conversion factor of 3 to 1 (e.g. 3 ML of 80 per cent reliable water allocation to 1 ML of 95 per cent reliable water allocation). Because of the conversion, the one-off purchase price would increase three times ($1,500/ML to $4,500/ML) as would the annual water charge ($65/ML to $195/ML under the high government funding scenario). The conversion would reduce the total yield of the dam and have no net impact on the financial position of the project.

Furthermore, it would be necessary to consider the upfront capital cost paid by non-agriculture customers (urban and mining) for a water allocation if the project received the benefit of government grants.

Fixed and variable prices are payable separately for the dam (bulk) and distribution system as shown in 15.27.

Table 15.27 : Fixed and variable prices

Charge type	Scenario 1: High government funding	Scenario 2: Medium government funding	Scenario 3: No government funding
Part A— bulk fixed charge ($/ML water allocation)	49	177	348
Part B—bulk variable charge ($/ML water use)	-	-	-
Part C—distribution fixed charge ($/ML water allocation)	12	34	62
Part D—distribution variable charge ($/ML water use)	4	4	4
Total	**65**	**214**	**414**

Chapter 6 (Service Need and Demand Assessment) outlines the demand assessment of potential customers. The one-off purchase price would be $1,500 per ML from a water allocation with a reliability of around 80 per cent.

In the demand assessment, annual water charges were estimated at $50/ML, based on the charges paid in comparable schemes. Potential customers expressed a likely demand of 62,800 ML representing 126 per cent of capacity of the project.

Annual charges are $65/ML when Australian and Queensland government funding is provided, potentially leading to full uptake of water from the scheme. The Intergovernmental Agreement on the National Water Initiative (NWI) allows government support for rural schemes if the support is reported publicly.

The medium government funding and no government funding scenarios generate annual water charges of $214/ML and $414/ML respectively. No explicit demand assessment was conducted for these price points. However, based on the expected returns of the potential irrigated enterprises, these annual water charges are unlikely to be affordable. They would significantly reduce demand to well below 50 per cent of the capacity of the project and impact the likelihood of achieving full uptake of water allocations.

It is therefore clear that government funding is needed for this project to be financially viable. Specifically, an Australian Government grant of 50 per cent and an additional Queensland Government contribution of $187.3 million would substantially increase the probability that annual charges would be affordable to customers and that demand of 50,000 ML could be realised.

15.6 Net cash position

Figure 15.5 shows that funding under each of the three scenarios involves very different cash positions over time.

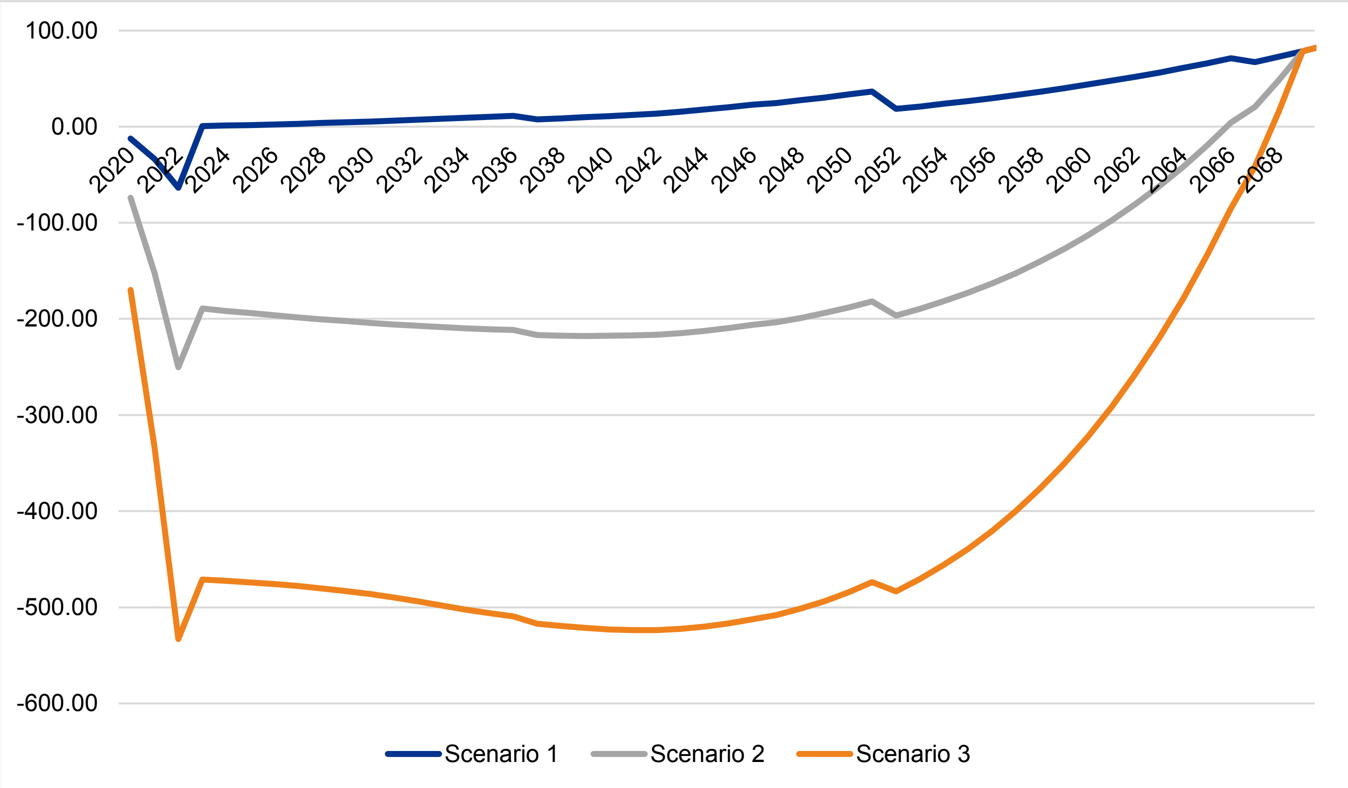
In Scenario 1, the cash balance is positive, except for a short period during construction. The cash position returns to balance when the final customer contribution is made. Over this time, the interest payable is $6.6 million.

In Scenario 2, debt peaks at $250.0 million and does not reach a positive balance until year 47. Over this time, the total interest payable is $553.1 million.

In Scenario 3, debt peaks at $533.0 million and does not reach a positive balance until year 49. Over this time, the total interest payable is $1,164.5 million.

For all three scenarios, it is assumed that the debt principal is repaid in year 50. The positive balance at this time reflects the funds set aside for future asset replacement.

Figure 15.5 : Cash balance of the Cloncurry River Dam project including annuity fund ($ million)



15.7 Cash flow analysis

Table 15.28 shows the cash flow analysis that has been undertaken. This modelling assumes that the principal and interest will be repaid over 50 years, with the repayment increasing by 2.5 per cent, at the same rate as charges. In this way, the absolute size of the debt increases for approximately 30 years.

Table 15.28 : Free cash flow

	Scenario 1: High government funding	Scenario 2: Medium government funding	Scenario 3: No government funding
Allocations (ML)	50,000	50,000	50,000
Average water use (ML)	39,500	39,500	39,500
Allocation price (2024 $)	68	232	453
Water use price (2024 $)	4	4	4
Revenue ($)	3,545,573	11,788,036	22,801,063
Opex ($)	3,083,640	3,083,640	3,083,640
Annuity payment ($)	461,933	461,933	461,933
Free cash flow ($)	**0**	**8,242,462**	**19,255,490**
Average interest rate	0.0%	6.0%	5.8%
Charge escalation	2.5%	2.5%	2.5%
Payback period (years)	50	50	50
Debt that can be serviced ($)	**0**	**196,344,905**	**474,057,604**

15.8 Value capture

The Cloncurry River Dam could provide a recreational benefit for residents and tourist of Cloncurry. This could provide two value capture opportunities:

- A levy through rates due to increased land value
- A direct charge on visitors to the dam.

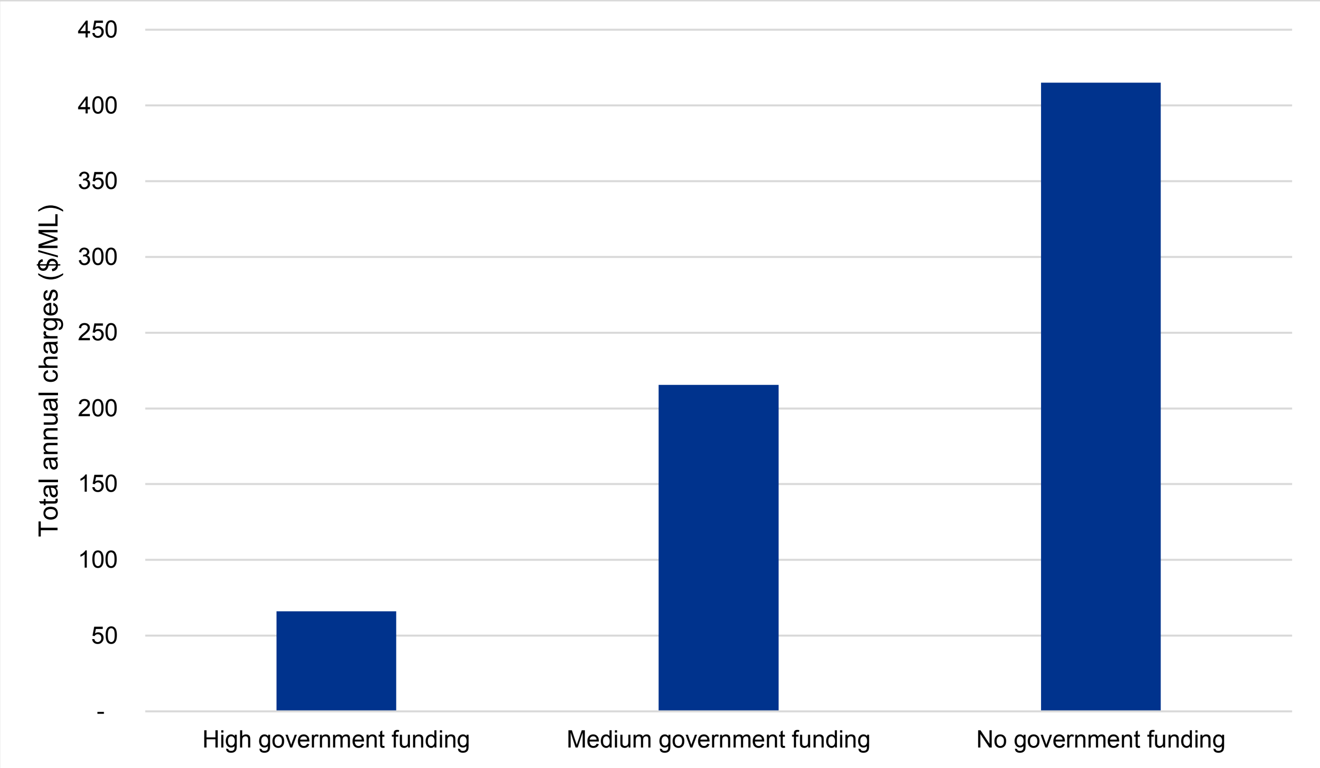
The dam will be surrounded by private property. Furthermore, costs for recreational facilities have not been included in the capex.

If the landholder arranged for access to the dam, these value capture changes could be considered.

15.9 Conclusions

The annual water charges per ML for the project relate to funding, as reflected in Figure 15.6.

Figure 15.6 : Annual water prices ($/ML) for different levels of government funding



Scenario 1—High government funding: With a 50 per cent Australian Government grant ($262.3 million) and a Queensland Government grant ($187.3 million), the annual water charges would be $65 per ML. At this price, there is enough demand for the full 50,000 ML nominal volume of the reference project dam.

Scenario 2—Medium government funding: With a 50 per cent Australian Government grant ($273.3 million) and no Queensland Government grant, the annual water charges would be $214 per ML. This is about three times the price used during the demand assessment. It would likely reduce demand to below 50,000 ML.

Scenario 3—No government grant funding: Without a government grant (but with a low interest NWIDF loan), the annual water charges would be up to almost $414 per ML. Under Scenario 3, demand is likely to be significantly less than 50,000 ML.

The overall conclusion is that Scenario 1 (High government funding) results in the high likelihood of affordable prices and a financially viable ongoing water business. Scenarios 2 and 3 are unlikely to result in affordable prices and a financially viable ongoing water business.

The following chapter presents an economic analysis of the project.

16. Economic analysis

16.1 Key points

- This chapter establishes the economic benefits and costs of the project.
- The economic assessment of the Cloncurry River Dam indicates that the project has economic challenges.
- For the project to be economically viable, significant changes to the assumptions of the project would be necessary—that is, a decrease in capex and opex, and an increase in returns from agriculture.
- The project has a benefit–cost ratio (BCR) of between 0.21 and 0.50 and an economic net present value of between –$248 million and –$338 million.
- The project will increase the water supply in the Cloncurry region by approximately 3 times and increase gross agricultural production by $14 million annually. It will add 3,150 hectares of new irrigated agriculture to the Cloncurry region and has the potential to support mining, mineral processing and urban sectors.
- The project will create 58 full-time equivalent (FTE) ongoing jobs. These jobs include on-farm employment (i.e. 37 FTE jobs directly related to agriculture) and jobs in the provision of goods and services to agriculture, including transportation, processing, mechanical services and accountancy (i.e. 21 FTE jobs indirectly related to agriculture).
- In addition, the project will generate 396 construction FTEs over three years, and 2 ongoing FTEs.
- The project will create total economic benefits of $150 million, with a net economic loss of $322 million after subtracting the upfront and ongoing cost of the project.
- This results in a BCR of 0.30, meaning that for every dollar invested by farmers and government, there is a return of $0.30 to the community.

16.2 Approach and assumptions

16.2.1 Approach

The main steps of the economic analysis were to:

- quantify cash flows (inflows and outflows) that ensue from the base case, including the costs to be incurred in meeting water requirements in the Cloncurry region over the study period
- identify all cash flows related to the project
- quantify the economic benefits and costs (i.e. net cash flows) of the project relative to the base case, where economic impacts are material and quantifiable
- estimate the net economic impact, in terms of both the BCR and NPV of the project relative to the base case.

The economic costs and benefits were considered independently of the financing option and the interest paid. That is, the source of project funds does not impact the assessment of economic costs and benefits.

The economic assessment measures the economic benefit over time, and then converts it to today's dollars using a range of discount rates.

16.2.2 Assumptions

The modelling assumptions set out in Chapter 15 (Financial analysis) also apply to this analysis. The key assumptions for this economic analysis are consistent with those in the Building Queensland DBC Guidelines:

- a real discount rate of 7 per cent, with sensitivity analysis to be conducted at 4 and 10 per cent. The financial discount rate used represents the cost of funds.
- a study period of 30 years, with a residual value beyond 30 years
- commencement of the project on 1 July 2019.

16.3 Base case

The base case is fully described in Chapter 6. This chapter concludes:

- Without the construction of a large agricultural dam (such as the Cloncurry River Dam at Cave Hill), no step change in agricultural water use is expected on the Cloncurry River. Water use will continue to be low due to the unreliable nature of unsupplemented water. The existing users, including recent purchasers of unallocated water, will continue to grow limited areas of low value crops such as hay and lucerne.
- Mining operations and mineral processing will not be constrained by a lack of access to water over the next 30 years, especially those who can cost-effectively use water of the NWQWP or the Mount Isa water supply system.
- Cloncurry and Mount Isa are expected to have enough existing water supply infrastructure to satisfy the forecast demand—over the next 30 years—based on Queensland Government forecasts.

16.3.1 Current economic activity

In 2016, the mining industry was the major direct employer in the study area, with employment significantly higher than the Queensland level of employment as an industry. Employment by industry is shown in Table 16.1.

Table 16.1: Employment by industry, Cloncurry/Mount Isa study area and Queensland

Industry	Study area		Queensland
	FTE	%	%
Mining	3,171	29.8%	2.3%
Health care and social assistance	1,080	10.2%	13.0%
Education and training	853	8.0%	9.0%
Retail trade	812	7.6%	9.9%
Public administration and safety	698	6.6%	6.6%
Accommodation and food services	539	5.1%	7.3%
Construction	498	4.7%	9.0%
Transport, postal and warehousing	484	4.6%	5.1%
Administrative and support services	329	3.1%	3.5%
Agriculture, forestry and fishing	305	2.9%	2.8%
Manufacturing	287	2.7%	6.0%
Wholesale trade	198	1.9%	2.6%
Professional, scientific and technical services	169	1.6%	6.3%
Rental, hiring and real-estate services	121	1.1%	2.0%
Electricity, gas, water and waste	103	1.0%	1.1%
Financial and insurance services	80	0.8%	2.5%
Information, media and telecommunications	63	0.6%	1.2%
Arts and recreation services	55	0.5%	1.6%
Other	401	7.2%	8.2%
Total	**10,246**	**100.0%**	**100.0%**

Source: (Australian Bureau of Statistics, 2016)

Cloncurry's total annual agricultural production value was estimated at $136 million (Table 16.2) by the ABS.

Table 16.2: Agricultural production in Cloncurry and surrounding region

Crop type	Gross value of agricultural production ($ millions)	Total area (ha)	Gross Value of Agricultural Production/ha ($/ha)
Cattle and other livestock	136.2	4,231,362	32
Broadacre cropping, including hay and wheat	0.2	589	399
Total	136.4	4,231,951	32

Source: (Australian Bureau of Statistics, 2017).

16.3.2 Current and future water supply

16.3.2.1 Urban

Annual water use by Cloncurry ranged from approximately 945 ML to 1,321 ML between 2013 and 2016. This is approximately 25 per cent of the volume of water allocations held. The forecast population growth for Cloncurry of 0.2 per cent per annum through to 2037 (Queensland Treasury, 2017) means that Cloncurry's population could grow to 3,527.

16.3.2.2 Mining

NWQWP Pty Ltd (a subsidiary of SunWater) has a 15 GL allocation in Julius Dam and supplies water to Cloncurry Shire Council, mines and number of rural and agricultural users through the NWQWP. The annual total capacity of the NWQWP is only 7 GL per annum as shown in Table 16.3 which provides a breakdown of the allocations from Lake Julius delivered by the NWQWP.

Table 16.3: Allocations held by NWQWP in Lake Julius

Customer/Category	Nominal Entitlement (ML p.a.)
Mining and industrial	2,875
Cloncurry	950
Rural	59
Total nominal entitlement	**3,884**
Existing excess pipeline capacity	3,116
Maximum annual pipeline capacity	**7,000**

Source: Jacobs analysis.

The current excess capacity via the NWQWP is about 3 GL. This is the difference between the total annual pipeline capacity (7,000 ML) and the customer held nominal entitlement (3,884 ML).

The development of new mining operations has the potential to increase demand for water from the NWQWP. The Dugald River Mine and the Roseby Copper Mine are two major projects that are within a viable distance of the pipeline (Dugald River is already connected). Demand projections for each project were derived from GHD (2014) and DEWS (2017), which estimated that water demands from Dugald River and Roseby Copper Mine eventually will be 3,000 ML and 2,200 ML per annum respectively—totalling 5,300 ML—potentially during the next 30-years.

As the NWQWP has spare capacity of 3,000 ML per year, these mines can be supplied by the NWQWP in the medium term. If both mines require the maximum amount of water, then an additional 2,300 ML would need to be sourced.

The capacity of the NWQWP can be augmented by an additional 8 GL per annum through the upgrade of the central pump station. This upgrade could bring the total available capacity of the pipeline to 15 GL, matching the NWQWP allocation. SunWater estimates the cost to upgrade the pump station to be in the order of $2–$6 million; however, this project is not currently a focus for SunWater, based on its understanding of forecast demand. It is unlikely this 8 GL upgrade will occur without a significant increase in demand for water in the region.

Many mining operations can access groundwater, capture surface water runoff on-site and use mine de-watering to meet water demand. As outlined in the PBC, water is a relatively small cost for miners and is unlikely to be a limiting factor.

Accordingly, we conclude that mining will not be constrained by a lack of water over the next 30 years. This is particularly the case for mines within financially viable reach of the NWQWP or the Mount Isa water supply system.

16.3.2.3 Agriculture

Since the 2015 process for release of water commenced, no clear trend to higher water agricultural water use has emerged. The amount of water extracted is related to the annual volume of stream flows.

The development of off-stream storages to increase utilisation of released water allocations is highly uncertain. Discussions with land holders have not indicated concrete time-bound plans to develop their allocated water. The reliability of off stream storages in the region is low. Higher reliabilities require that only a small amount (16%) of the annual allocation is used annually.

The historical extraction levels of generally 5-10 percent of total water allocations are, therefore, expected to continue.

16.4 Economic benefits

Several economic benefits are associated with the construction of the project. These can be broadly attributed to the following four sectors:

- Agriculture
- Urban
- Mineral processing
- Mining.

The project is designed to provide 50,000 ML medium priority water with a reliability of around 79 per cent. However, some potential users may require a high level of security for their needs—such as those in the mineral processing and mining sectors—and require a reliability of close to 100 per cent. To achieve this, medium priority allocations would need to be converted to high priority allocations by applying a conversion factor. The conversion factor is typically between 2 and 3. Therefore, for the DBC, a conversion factor of 2.5 is reasonable. However, additional modelling would be required to confirm this figure during further analysis.

Table 16.4 outlines the expected water demand by industry sector. It has been converted to a medium priority equivalent where high priority water is required.

Table 16 4: Forecast water demand from Cloncurry River Dam, by industry sector

Water use	Medium priority demand (ML)	High priority demand (ML)	Medium priority equivalent (ML)
Agriculture	41,675	–	41,675
Urban	675	–	675
Mineral processing	–	185	463
Mining	–	2,875	7,188
Total	**42,350**	**3,060**	**50,000**

16.4.1 Agricultural sector

The use of water for agricultural purposes will materially increase the economic value of production. This benefit has been calculated specifically for the region around the project's location.

The water will mainly be used to expand agricultural production onto land that currently is not used for crops but is perhaps used for unimproved grazing.

The DBC considers that for the project to be proven viable, a base (or dominate) crop would have to be grown in the region to ensure scale and skills are established. The volume of and expertise in irrigated agriculture in the region are low. Establishing a dominate crop in the region will encourage the development of specific skills and support services and will establish scale, which will create efficiencies in the enterprises value chain. This will allow for an early uptake of significant volumes of water allocations, which will strengthen the early benefits of the project and improve its economic performance.

Cotton is the most likely dominate crop to be developed for the region. Cotton was chosen based on detailed assessments by agronomist Farmacist (2017), which indicated that cotton had the best gross margin of the crops that could be grown at a large scale. Farmacist examined which enterprises would be suited to the region, considering the soil and climate. There is a trend towards cotton become more insect resistant, which is important in Cloncurry.

Furthermore, local landowners have expressed interest during the demand assessment in growing cotton. Cotton—produced at scale—is an enterprise that can benefit from value adding through processing at a cotton gin. Cotton gins are factories that complete the first stage of processing cotton—separating the lint from the seed—and are typically located locally to avoid costly transport.

Cotton gins benefit from increasing returns to scale. A large dam will maximise the potential yield of cotton, increasing the viability of developing a cotton gin.

The local availability if cotton seed meal could allow for additional cattle to be fattened locally.

Nevertheless, the project also provides the opportunity for diversification into alternative crops—other than cotton—which may be more profitable in the future. Alternative crops could include rice, lucerne, maize, soybeans and chickpeas.

The economic benefit was calculated in four main steps:

- Determine the amount of water likely to be used for agriculture by the remaining allocations after the needs of the mining, mineral processing and urban sectors have been met (see Table 16.4)
- Consider a regional water application for cotton, based on industry averages and advice from Farmacist (see Table 16.5) as all water allocations for agriculture are assumed to be used for cotton only
- Determine the net margin of cotton (per ML) based on public sources and industry experience (Table 16.6).
- Multiply the amount of water by the net margin to obtain the annual economic benefit and convert the annual benefits to a single net present value. The total economic benefit is determined by multiplying the amount of water by the net margin to obtain the annual economic benefit and converting the annual benefit to a single net present value (Table 16.7).

16.4.1.1 Water demand—agriculture

The volume of water that agriculture uses from the project is based on the remaining allocations after the needs of the mining, mineral processing and urban sectors have been met (see Table 16.5). All water allocations for agriculture from the project is assumed to be used for cotton.

Table 16.5: Cotton—water demand indicator

	Cotton
Total water demand (ML per annum)	41,675
Water application rate (ML/ha per annum)	10
Water security factor (%)	24
Water required per hectare (ML/ha per annum)	13.2
Total area (ha)	3,150

Source: Farmacist (2017), Jacobs analysis

An area of 3,150 hectares of cotton is expected to be grown from 41,675 ML of water allocations from the project. Consideration has been given to the application rates for cotton and the reliability of the medium priority allocations and a long-term average extraction of 37,792 ML.

16.4.1.2 Net margins

Farmacist (2017) cotton margins are drawn from the Australian Cotton Comparative Analysis Report. We have updated the interim 2017 average with the 2017 average[25].

We have used the combination of gross margin over the previous two years, 2016 and 2017, with 2017 weighted more heavily (65 per cent) as it is more reflective of industry averages over the long-term. This is shown in Table 16.6.

Table 16.6: Cotton—net margin per hectare and per ML

Net margin	Cotton 2016 (High GM)	Cotton 2017 (Low GM)	Weighted average (35% 2016 65% 2017)
Net margin per hectare ($/ha)	2,016	1,802	1,876
Net margin per ML ($/ML)	**152**	**136**	**140**

Source: Farmacist (2017), Jacobs analysis

16.4.1.3 Total economic benefit

Table 16.7 sets out the total economic benefit is determined by multiplying the amount of water proposed to be used from the project, by the net margin per ML to obtain the annual economic benefit.

Table 16.7: Economic benefit related to cotton ($ million, NPV 30 years plus residual)

	Cotton
Total economic benefit	63.3

Source: Farmacist (2017), Jacobs analysis.

16.4.2 Urban sector

Over the past four years, Cloncurry has sourced an average of 675 ML from the NWQWP at a total fixed and variable annual cost of approximately $303,000. If the Cave Hill Dam was built, then Cloncurry could source additional water from this dam and save the variable charge ($317/ML) that it pays to the NWQWP. This is a possible additional annual economic benefit up to approximately $214,000.

[25] https://www.crdc.com.au/sites/default/files/pdf/2017%20Australian%20Cotton%20Comparative%20Analysis%20Report.pdf

Cloncurry and Mount Isa are expected to have enough existing water supply infrastructure to satisfy the forecast demand—over the next 30 years—based on Queensland Government forecasts (as outlined in Chapter 6 – Current situation and base case). Therefore, no additional benefits—in additional substitution of existing water supply—are considered in this assessment.

16.4.3 Mining and mineral processing sector

Mining operations and mineral processing will not be constrained by a lack of access to water over the next 30 years, as explained in Chapter 5 (Current situation and base case). This is especially the case for those users within reach of the NWQWP or the Mount Isa water supply system.

However, there may be demand for 185 ML of high priority water allocations from the reference project – refer Chapter 5 (Current situation and base case).

An economic benefit could also be derived from the project supplying the 2,875 ML of water annually, which is currently supplied by the NWQWP to the Ernest Henry Mine. The project could supply this more cheaply through high priority water allocations via the dam and distribution network. Users of the NWQWP are paying approximately $3,000/ML for high priority water. The estimated cost-reflective charge for high priority Cloncurry River Dam water is $354/ML. Therefore, the total annual saving could amount to $7.6 million. This is a significant saving to the mine. However, this benefit will not be realised if the mine life is not extended. Accordingly, we have run a sensitivity scenario that removes this benefit, below.

This economic benefit could result in an economic cost to SunWater. However, SunWater, acting in accordance with its commercial mandate, would seek new customers for the NWQWP and recover a portion of the forgone fixed revenues over time. This demand could be met by the spare capacity created by Ernest Henry Mine switching to Cloncurry River Dam.

Consistent with the approaches of the QCA and ACCC in their determinations on termination fees—which allowed 10 years for water service providers to find alternative customers when fixed demand exited a distribution scheme—we have assumed that the demand is replaced evenly over 10 years.

In this scenario, the mining benefit is reduced by 30 per cent, which is the extent to which SunWater's revenue is likely to be temporarily reduced, as well as the extent to which its fixed costs are not fully recovered for a period. Losses from reduced revenue are defrayed to an extent by a reduction in the variable operating costs that SunWater incurs (e.g. a reduction in pumping costs).

This approach reflects a cost-reflective and economically efficient market response, including mines seeking the cheapest source of water and SunWater seeking new customers and planning to sell all its spare capacity and water allocations over time. Existing contracts need to be honoured.

16.5 Economic costs

The economic costs include all the direct costs that are incurred to realise the economic benefits.

Economic costs include all the direct and indirect costs, opportunity costs and externalities arising from the reference project. Direct costs are the most obvious and are associated with the construction of the project. Opportunity costs arise from the loss of currently productive land to infrastructure but are likely to be small (see Table 16.2 indicating $32/ha agricultural revenue from grazing). Externalities arise from e.g. loss of cultural values to Traditional Owners; increased traffic and noise pollution generated by construction of the project. Stated preference methods are required to estimate the value of externalities.

The net margin for new crops considers establishment costs (i.e. it amounts to revenue minus fixed and variable costs for each enterprise). Project capex and opex estimates respectively consider the cost of establishing the dam's recreational facilities and maintaining them perpetually. The project capex and opex costs, summarised below, are detailed in Chapter 16 (Financial analysis).

16.5.1 Upfront capex

The P90 estimate of capex is $524.4 million (in 2018–19 dollars). This includes risk and contingency allowances of $91.3 million. Table 16.8 outlines Jacobs' assessment which also allows for construction cost escalation ($21.4 million) and interest during construction and working capital ($30.2 million) for the period 2019–20 to 2021–22.

Table 16.8: Capex items

Item	Expenditure ($ million)	Portion of total capex
Dam wall and spillway	336.8	64%
Subtotal (bulk)	**336.8**	**64%**
Pipeline to farm gate	50.8	10%
Pump stations	3.0	1%
Solar and battery	3.0	1%
Sub-total (distribution)	**56.8**	**11%**
Purchase of water allocations	9.4	2%
Contingency and risk adjustments	91.3	17%
Total capex	**494.4**	**94%**
Construction cost index (Nominal capex during construction 2019-20 to 2021-22)	23.0	4%
Interest during construction and working capital	7.2	1%
Total capex (Nominal and IDC)	**524.6**	**100%**

The discounted project construction cost (using a 7% real discount rate) is $431.4 million. This is based on a risk-adjusted P90 construction cost of $494.4 million in $2018–19 or $524.6 in nominal terms, including cost escalation and interest during construction. The former estimate has informed Jacobs' estimated economic NPV of costs and the BCRs.

16.5.2 Ongoing opex

Opex is estimated to be $2.8 million annually, or $18.6 million over 30 years in NPV terms.

16.5.3 Ongoing capex (renewals)

Ongoing capex (renewals) is estimated to be $0.9 million over 30 years in NPV terms.

16.5.4 Base case—opportunity cost

As part of its assessment of the base case, Jacobs estimated that in a situation without the project, land would continue to be used for grazing cattle, generating a revenue of $32/ha. The NPV of the benefit from that base case scenario is $1.0 million.

If the project proceeds, however, the base case benefit will be foregone as the land will be used for irrigated cotton. The economic assessment of the project must deduct the forgone benefit of the base case (see opportunity cost in Table 16.9).

16.5.5 Total economic costs

Most of the economic costs relate to capex and opex. However, net economic benefits that accrue under the base case are also set out in Table 16.9.

Table 16.9: Economic costs ($ million)

Category	Low economic discount rate (real rate: 4%)	Medium economic discount rate (real rate: 7%)	High economic discount rate (real rate:10%)
Ongoing opex	-41.1	-27.7	-19.7
Upfront capex	-456.1	-431.4	-408.8
Ongoing capex (renewals)	-1.5	-0.9	-0.5
Base case opportunity cost	-1.4	-1.0	-0.7
Total costs	**-500.1**	**-460.9**	**-429.7**

16.6 Total NPV and benefit–cost ratio

Table 16.10 shows that the NPV is –$321.8 million, based on a real 7 per cent discount rate with a BCR of 0.30. The BCR remains below 1.0 even with a low discount rate. This indicates that the project has a few economic challenges.

Table 16.10: Economic costs and benefits—NPV and BCR ($ million, including residual value)

Category	Low economic discount rate (real rate: 4%)	Medium economic discount rate (real rate: 7%)	High economic discount rate (real rate:10%)
Total benefits	296.78	150.17	94.93
Total costs	-500.11	-460.93	-429.72
Net benefits NPV	-248.48	-321.78	-338.14
BCR	**0.50**	**0.30**	**0.21**

The benefits include an economic residual value (economic benefits minus costs over the remaining useful life of assets built in the study period) of $16.1 million.

16.7 Sensitivity of the economic results

Table 16.11 outlines the key parameters that were varied to understand the sensitivity of the inputs to the overall results. Under all scenarios the NPV rate remains negative.

Table 16.11: Sensitivities—economic NPV ($ million)

Sensitivity	Low economic discount rate (real rate: 4%)	Medium economic discount rate (real rate: 7%)	High economic discount rate (real rate: 10%)
Central case	**-248**	**-322**	**-338**
Capital expenditure—increase by 10%	-295	-365	-379
Capital expenditure—decrease by 10%	-202	-278	-297
Operating and maintenance costs ($ per annum)—increase by 10%	-255	-325	-340
Operating and maintenance costs ($ per annum)—decrease by 10%	-242	-318	-336
Benefits ($/ML)—increase by 10%	-221	-307	-329
Benefits ($/ML)—decrease by 10%	-276	-336	-348
Water allocation sales—decreases by 10%	-276	-336	-348
'Downside case'—capital expenditure and operating and maintenance costs each increase by 10%; benefits ($/ML) and water allocation sales (ML) each decrease by 10%	-354	-396	-399
'Upside case'—capital expenditure and operating and maintenance costs each decrease by 10%; benefits ($/ML) increase by 10%	-168	-261	-286

Likewise, Table 16.12 outlines the BCRs that have been calculated for the same range of scenarios.

Table 16.12: Sensitivities—economic BCR

Sensitivity	Low economic discount rate (real rate: 4%)	Medium economic discount rate (real rate: 7%)	High economic discount rate (real rate: 10%)
Central case	**0.50**	**0.30**	**0.21**
Capital expenditure—increase by 10%	0.46	0.28	0.19
Capital expenditure—decrease by 10%	0.55	0.33	0.24
Operating and maintenance costs ($ per annum)—increase by 10%	0.49	0.30	0.21
Operating and maintenance costs ($ per annum—decrease by 10%	0.51	0.30	0.21
Benefits ($/ML)—increase by 10%	0.56	0.33	0.23
Benefits ($/ML)—decrease by 10%	0.45	0.27	0.19
Water allocation sales—decreases by 10%	0.45	0.27	0.19
'Downside case'—capital expenditure and operating and maintenance costs each increase by 10%; benefits ($/ML) and water allocation sales (ML) each decrease by 10%	0.36	0.22	0.16
"Upside case'—capital expenditure and operating and maintenance costs each decrease by 10%; benefits ($/ML) increase by 10%	0.63	0.37	0.26

The NPV of the project is between –$168 million and –$399 million and the BCR is between 0.16 and 0.63 under the central case. The project has a negative economic net benefit under all 30 scenarios.

Further analysis has been undertaken to consider the future conditions that need to be met for the project to be economically viable. These conditions relate to reduced capex, including risk and contingency, and increased agricultural benefits from utilising the water from the project.

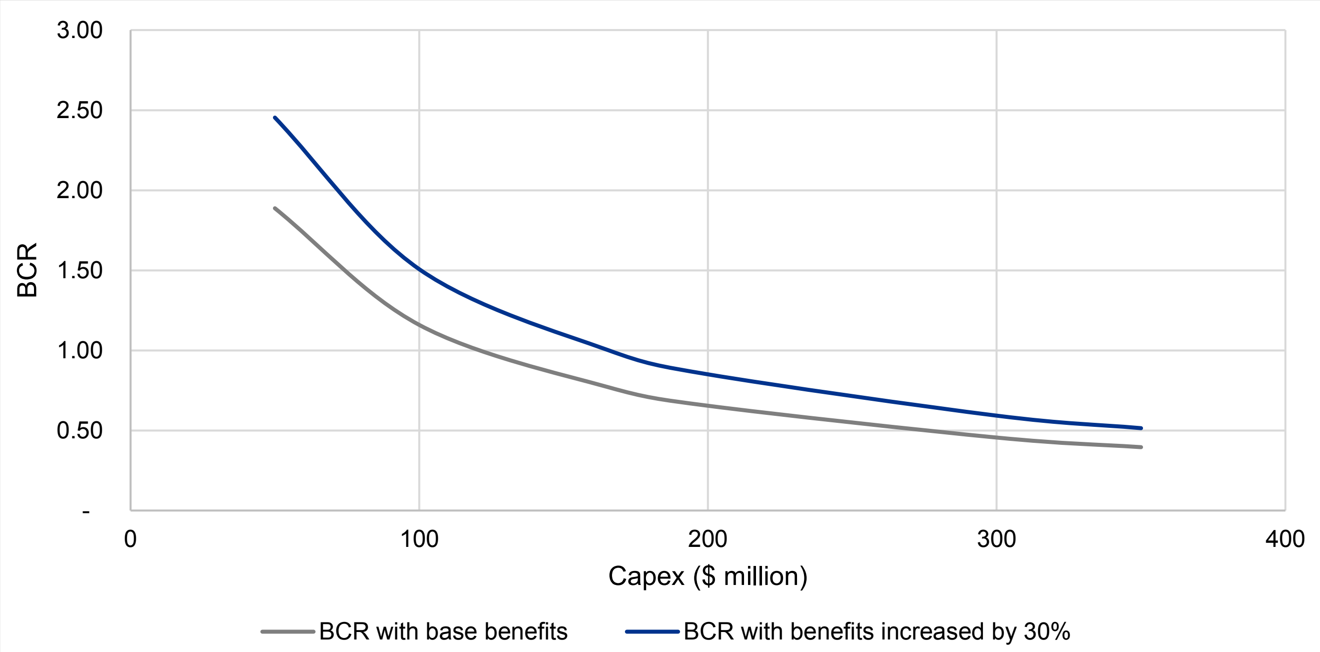
Table 16.13 compares capital costs developed for the DBC with 'target' capital costs that would be required for Cloncurry River Dam to be economically viable (i.e. deliver an economic BCR of 1). The table shows that the present value of Cloncurry River Dam and pipeline capital costs need to be reduced from a present value of $431 million to a present value of $121 million (a 72% reduction) to achieve a BCR of 1.

Table 16.13: Break-even capex values

	Low economic discount rate	Medium economic discount rate	High economic discount rate
DBC capex ($ million)	456	431	409
Break-even capex ($ million)	253	121	74
Reduction ($ million)	**203**	**311**	**335**
Reduction (%)	**45%**	**72%**	**82%**

Figure 16.1 shows the results of the sensitivity analysis of the BCR based on different capex scenarios ceteris paribus (i.e. holding estimated benefits constant). The BCR curve crosses the value of 1 at capex of approximately $121 million.

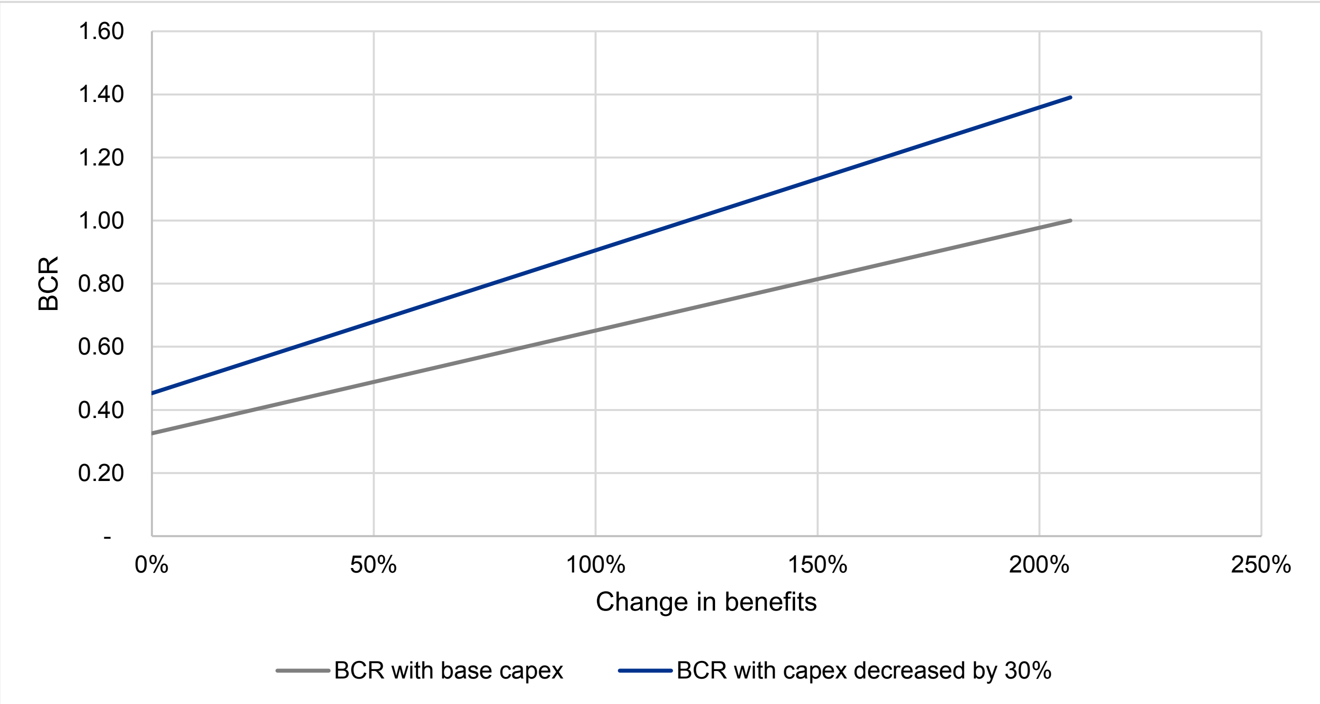
Figure 16.1: Capex BCR frontier



Included in Figure 16.1 is a second frontier, which represents a 30 per cent increase in the DBC's assumed net margin of $1,876/ha to $2,439/ha. The BCR curve crosses the value of 1 at capex of approximately $166 million under this sensitivity.

Figure 16.2 shows the results of further sensitivity analysis of the BCR based on different benefit scenarios, ceteris paribus (i.e. holding estimated project costs constant). The BCR curve crosses the value of 1 at with benefits increasing approximately 207 per cent. A decrease in capex by 30 per cent would require an increase of benefits of 121 per cent to return a BCR of 1.

Figure 16.2: Benefit BCR frontier



16.8 Economic impact assessment

This economic assessment would not be complete without also identifying, in addition to the core economic assessment, those costs and benefits that would be delivered in a broader economic context. The significant benefits presented below are excluded from the NPVs or BCRs set out in the preceding sections.

16.8.1 New jobs

Under full production, the project will lead to 58 new full-time equivalent (FTE) positions, including:

- 37 new jobs directly related to agriculture
- 21 new jobs indirectly related to agriculture, in support industries such as farm input supplies (e.g. fertilizer, seedlings, pesticides, packaging and fuel) and services (e.g. transportation, refrigeration, mechanical services, food, accommodation and accountancy)
- 2 new jobs to operate and maintain the dam and pipeline.

The number of new FTE jobs has been estimated by examining the input–output tables produced by the ABS. This has been extrapolated from current levels of production and employment to the expected levels of production. The assumption was that jobs are created in accordance with the current ratios.

The inability of input-output multipliers to model effects such as transfer of jobs from other sectors of the economy means these results must be interpreted with caution.

16.8.2 Increased agricultural production

This project will lead to additional gross agricultural production of $14.2 million per annum. Based on economic multipliers, we expect that this would support an additional $13.0 million of activity in the local economy, including $7.9 million of direct activity and $5.1 million of indirect activity, every year.

16.8.3 Increased recreation and tourism use

The project could also provide an additional recreational area for use by the public and generate additional tourism visits. Activities that the community and tourists may undertake and benefit from in the recreation area include camping, rowing and sailing, fishing, eco-tourism, activity areas for schools and picnicking. Recreational sites at water storages are increasingly recognised for their potential to encourage outdoor activities.

Unless access to the dam is restricted, recreation and tourism benefits will not be marketable. For example, if fishers bring their own boat, no money will be spent at the dam. However, the economic and recreation benefits of fishing will be reflected in the wider economy. The monetary value of amenity and recreation benefits have been calculated based on an estimate of willingness to pay per visit and number of visitors to the area.

The value to the community of having access to a new recreational facility has been estimated using a benefit transfer approach which 'transfers' willingness to pay values from more detailed studies (i.e. surveys) at other sites that have similar or transferable characteristics to the proposed project site. Benefit transfer is the most common valuation approach due to the high costs associated with undertaking site-specific surveys. The accuracy of benefit transfer depends on the degree of similarity between the study and the project area and the accuracy of the initial study.

Willingness to pay for fishing is based on the Stocked Impoundment Permit Scheme study that assessed the willingness to pay for recreational fishing and annual visitation rates for 31 different dams in Queensland (Gregg and Rolfe, 2013). The study used an online survey to collect information on willingness to pay during the Stocked Impoundment Permit application process. $206 per day ($2018–19) was the resulting average willingness to pay.

Using the same average length of stay as Mt Isa published by Tourism Research Australia[26], 6 days per visit, the willingness to pay per visit for recreational fishers is $1,234.

[26] https://www.tra.gov.au/Regional/local-government-area-profiles

Other recreation and amenity benefits such as the value placed on improved access to walking tracks, picnic areas, swimming and potential camping grounds were grouped together. These values were based on studies that considered willingness to pay for visits to state and national parks in Victoria and NSW.

Table 17.14: Recreation willingness to pay studies

Study	Willingness to pay per visit ($)
Dorrigo National Park (Bennett, 1995)	59
Minnamurra Rainforest Centre, Budderoo National Park (Gillespie, 1997)	64
Grampians National Park (Read, Sturgess and Associates, 1994)	60
Valuing Victoria's Parks (Parks Victoria, 2015)	21
Gibraltar Range National Park (Bennett, 1995)	33
Average	**47**

Visitor information from Tourism Research Australia[27] and the Stocked Impoundment Permit Scheme study was used to estimate the number of recreational fishers visiting the dam.

To estimate the total number of tourist visits for the entire Cloncurry Shire Council region, the same ratio of tourists to population as neighbouring Mt Isa published by Tourism Research Australia[28] was used. This is 6 tourist visits for each resident.

Table 16.15: Tourist to population ratio

Council area	Mt Isa	Cloncurry
Population	19,192	3,133
Tourist visits	145,000	23,671
Ratio	8	8

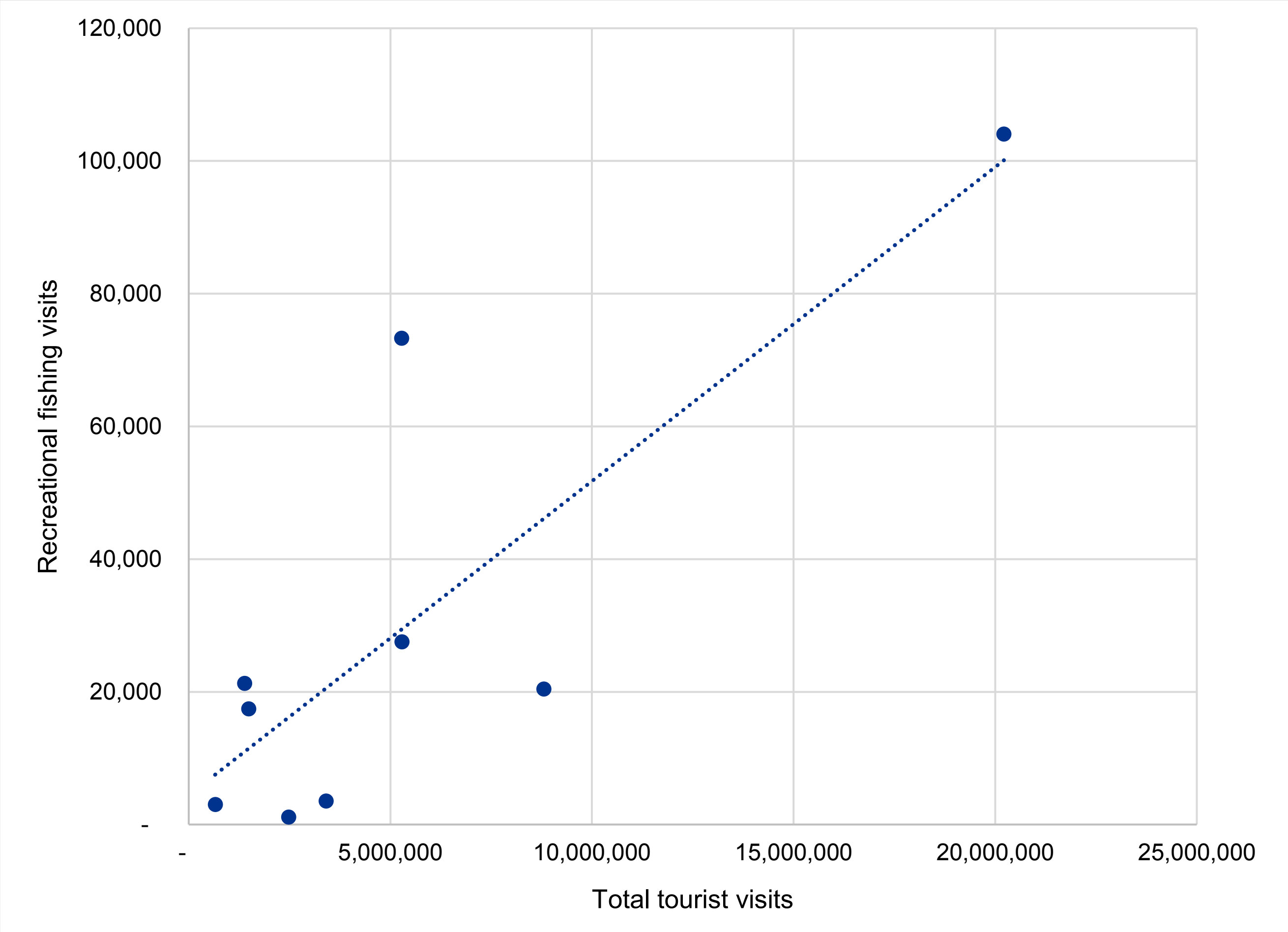
The number of recreational fishing visits was plotted against the number of tourist visits for each tourist region in Queensland. A linear regression of against total number of tourist visits shows recreational fishing visits made up 0.5% of total tourist visits.

Table 16.16: Total and recreational fishing visits by tourist region

Region	Total tourist visits	Recreational fishing visits
Brisbane	20,216,000	104,021
Darling Downs	5,275,000	73,249
Tropical North Queensland	5,281,000	27,503
Bundaberg	1,382,000	21,240
Sunshine Coast	8,803,000	20,422
Mackay	1,484,000	17,427
Central Queensland	3,401,000	3,540
Whitsundays	655,000	2,995
Northern Queensland	2,475,000	1,089

[27] https://www.tra.gov.au/tra/2016/Tourism_Region_Profiles/Region_profiles/index.html
[28] https://www.tra.gov.au/Regional/local-government-area-profiles

Figure 16.3: Total and recreational fishing visits



Recreational fishing visits are assumed to comprise 8% of total visits to the dam. This results in 1,401 total visits, with 112 recreational fishing visits and 1,289 visits for other recreational purposes, such as picnicking or camping.

Table 16.17: Annual dam recreational visits

Visitor category	Annual visits
Tourist visits to Cloncurry	23,671
Recreation fishing visits as a portion of tourist visits	0.5%
New recreational fisher visits pa	**112**
Recreational fisher visits portion of total visits	8%
New annual visitors to Cloncurry River Dam	**1,401**
New annual visitors to Cloncurry River Dam for other recreational benefits	**1,289**

Recreational fishing and other benefits are valued at $0.20 million per annum, with a present value over 30 years of $2.48 million.

Table 17.18: Recreational benefits

Category	Annual visits	Willingness to pay per visit ($)	Annual recreational benefit ($ pa)	Present value of recreational benefits ($PV 30 years)
Recreational fishing	112	1,234	138,237	1,718,386
Other recreational benefits	1,289	47	61,123	766,326
Total	**1,401**	**n/a**	**199,361**	**2,484,712**

16.9 Climate variability and change

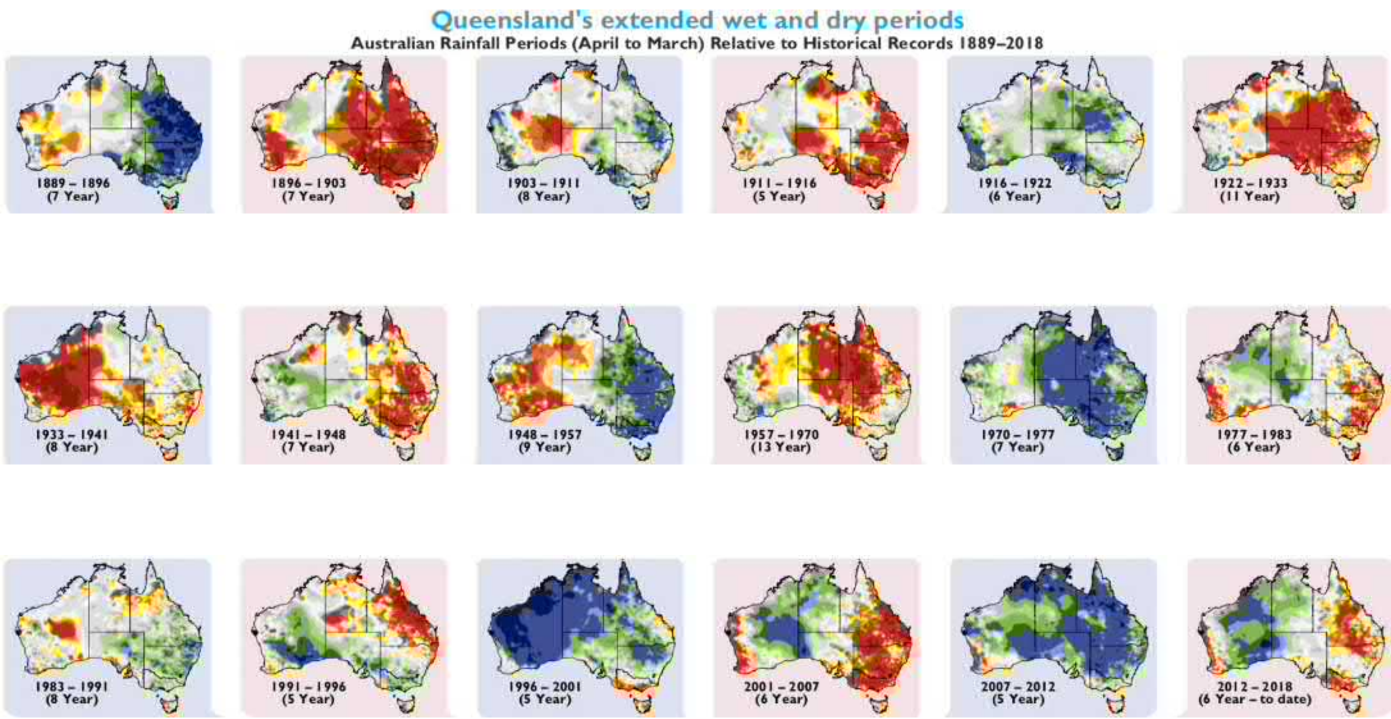
Mean annual and seasonal climate change measures should be considered along-side natural climate variability – both spatially and temporally – which is an important feature of Queensland's climate. Understanding both climate variability and likely future climate change is therefore crucial for adaptation and preparedness (Queensland Government (a), 2019).

16.9.1 Climate variability

Queensland is typically impacted with episodic droughts, floods and tropical cyclones with droughts potentially persisting for several years. Rainfall variability occurs at interannual, quasi-decadal, multi-decadal and centennial time scales (Queensland Government (b), 2019).

Australia's historical climate variability is illustrated in Figure 1. This illustrates how rainfall totals that are well-below average have been experienced in North-West Queensland over durations spanning up to over a decade (e.g. 1922 to 1933).

Figure 16.4: Queensland's extended wet and dry periods relative to historical records 1889 – 2018



Source: Queensland Government (a) (2019)

16.9.2 Climate change

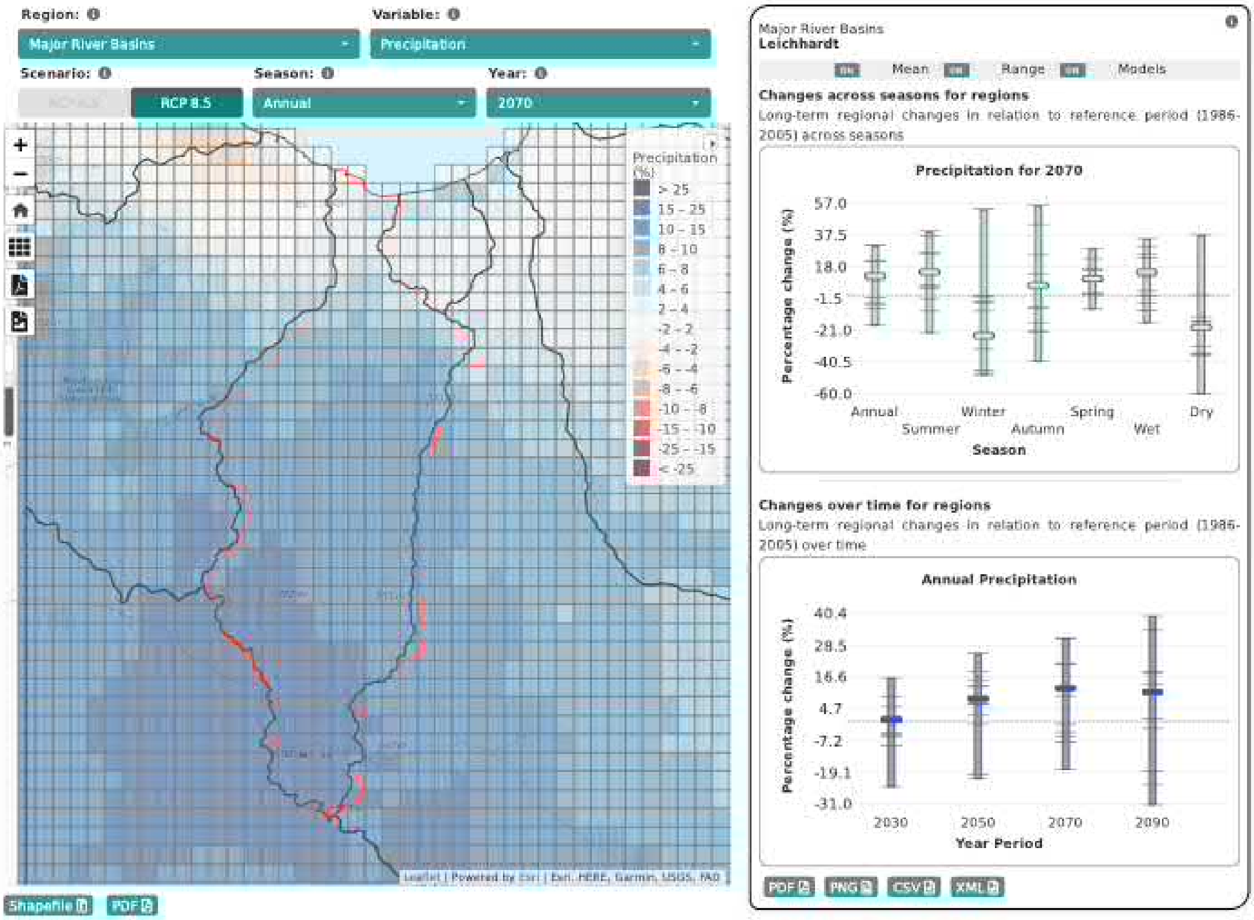
An inter-active “Queensland Future Climate Dashboard” is produced by the Queensland Government and “summarises information of 11 state-of-the-art climate models with regional scale simulations until the end of the current century”.

The Dashboard includes a range of climate metrics including, for example, precipitation (rainfall), temperature and pan evaporation (Queensland Government (a), 2019).

Figures 2 and 3 present the projected mean annual and seasonal projected precipitation for the Leichhardt and Flinders Rivers catchments. These indicate that, based on these metrics, the future mean climate in 2070 in North-West Queensland may be described as becoming:

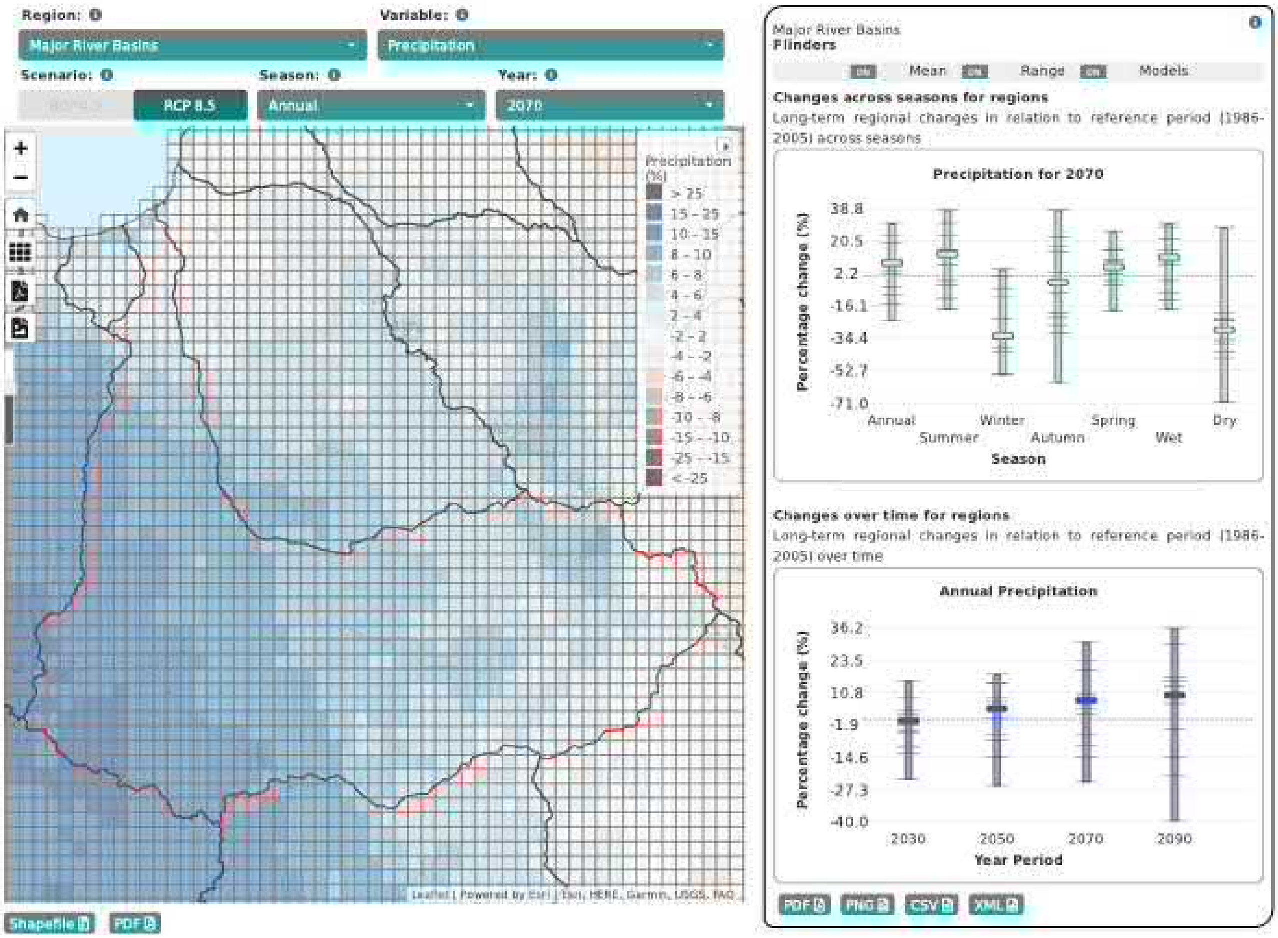
- Hotter in each season (summer, autumn, winter and spring) and around 3 per cent hotter annually
- Higher evaporation throughout the year (around 18 per cent more pan evaporation annually)
- Less rainfall in winter offset by more rainfall in the other seasons resulting in around 8 to 12% more rainfall annually on average.

Figure 16.5: Projected changes in average annual and seasonal precipitation for the Leichhardt River catchment



Source: Queensland Government (a) (2019)

Figure 16.6: Projected changes in average annual and seasonal precipitation for the Flinders River catchment



Source: Queensland Government (a) (2019)

The above data and figures suggest that drought response measures, including proposals for new water infrastructure such as the Cloncurry River Dam, are likely to be triggered by the emergence (or updated assessments) of the increased threat of prolonged extreme drought events such as those that have occurred in the recent past.

The emergence of extended droughts may warrant revisiting of this business case in the future. Extended droughts would increase the value of water for the agricultural industry. Demand for water may also increase from other water users, including mining and minerals processing, as the reliability of existing water sources drops. These effects would increase the benefits of proceeding with the project.

17. Market delivery assessment

17.1 Key points

- This chapter determines the appropriate contracting approach and assesses whether there is enough contractor capacity to deliver the project.
- A design and construct (D&C) contracting model is recommended. It combines the works for the dam and pipeline in a single package. This approach has been successful for several comparable projects.
- There is capacity within Australian construction companies to construct the Cloncurry River Dam and distribution pipeline, particularly in the medium to long term.
- Two tier one contractors that were directly approached were positive about being able to construct the project.
- These contractors have limited interest in the project at present due to uncertainty of project funding.
- Material risks are associated with the below-ground uncertainties and the management of large flows associated with high rainfall events during construction.
- A large risk premium would be included in a tendered price if these risks were the primary responsibility of the contractor.
- The construction market in North West Queensland is currently resource-constrained.
- Both Queensland tier one contractors indicated that there is a strong flow of work in pipeline in the short to medium term.
- Therefore, proceeding with the Cloncurry River Dam project within the next two to six years is likely to result in a higher price, compared with average market conditions.

17.2 Assumptions

The market delivery analysis is based on the following assumptions:

- There was significant uncertainty about the likelihood of funding and on the timing of the development of the Cloncurry River Dam, as no Government funding has been committed.
- Tier one construction contractors can build the dam and associated delivery network. A tier one contractor would assemble a project team with the relevant experience and technical capacity to deliver the project. Usually, a construction contractor will either partner with or engage a design consulting team that can supply the appropriate professional personnel.
- Enough dam and delivery network engineering expertise are accessible in the Australian construction market, for potential contractors to form credible bid teams for this project.
- Further consideration and analysis of additional delivery risks would be required if a non-traditional delivery approach was to be explored further.

17.3 Methodology

This DBC draws on the assessment undertaken during the PBC. The PBC analysis considered the full range of delivery models applicable to this project with reference to relevant projects of similar complexity, scale and conditions.

Market sounding was undertaken with two companies to test the assumptions and understanding of the market. The sounding was conducted with the Queensland office of two national tier one contractors, Fulton Hogan and John Holland Group (JHG). Discussions were conducted over the telephone, and the contents of the discussion was confirmed via email. The construction market sounding was conducted by approaching appropriately skilled and experienced tier one contractors and discussing with them the project scope, delivery plan and timing. Only information that was publicly available on the project was discussed. Discussions were held with each contractor early in August 2018. As the PBC was on the public record, it was sent to each company beforehand. No information that was not on the public record was shared with either contractor.

Fulton Hogan has just completed the 11 GL Arraw Dam for Rio Tinto near Weipa under the supervision of Bechtel as part of the Amrum bauxite project, at a cost approaching $70 million. The company is presently constructing two smaller dams in northern Australia.

JHG represents one of the leading construction firms in Australia and is actively building in-house capacity to position itself as a key player in dam building and dam upgrades in Queensland.

The key risks for the project reside with the dam construction. There are construction risks associated with the types of rainfall events that occur in the region and the capacity of the operational bypass flows. The uncertainty of below-ground conditions always accompanies dam construction, notwithstanding the amount of geotechnical investigation conducted.

17.4 Delivery model assessment

The choice of an optimal model depends on various factors, including complexity and scope of the project, level of innovation required, timeframes, cost certainty, risk, and more (Table 17.1).

Table 17.1: Assessment of delivery models

Delivery model	Characteristics
Traditional delivery model options	
Construct only The proponent retains full responsibility for design and documentation (via engaging a design consultant) and tenders for construction contractors. Example: • Keepit Dam Safety Upgrades, NSW	• The project scope and works are routine, uncomplicated, and of a small to medium size and duration. • The project content is well defined through a consolidated/peer reviewed design process. • The timeframe for project delivery is not compressed, allowing the design and construction to be conducted sequentially. • Construction innovation is not considered a priority. • The proponent is willing to retain design risk as it relates to the construction, as well as most other risks. • A high degree of cost certainty at the time of award is desirable but design omissions and changes are mostly the responsibility of the proponent and tend to be priced highly by the contractor. • The proponent has suitably skilled and experienced resources to manage the project delivery.
Early tenderer involvement (ETI) As a subset of the Construct Only delivery model, this model involves selecting shortlisted competing contractors to participate in value engineering and refinement of a client's preliminary designs. Examples: • Shannon Creek Dam, Clarence Valley Council • Mt Crosby East Bank Water Treatment Plant, Centrifuge Upgrade Project, Seqwater	In addition to the points noted under 'Construct only': • A relationship (not adversarial) contracting environment is desirable. • The scope is well defined. • Involving the contractor early helps to identify the most effective method to procure and manage the construction. • There is scope for value engineering / refinement of existing design documentation. • There is market interest and scope for competition.
Design and construct (D&C) The proponent contracts with a single entity that is responsible for both design and construction of the project. Examples: • Tasmanian Irrigation's Tranches one and two irrigation schemes, Tasmania • Meander Dam Construction Project, Tasmania • Bootawa Dam Water Treatment Plant, NSW • Folsom Dam Joint Federal Project, USA • Calveras Dam Replacement Project, USA • Olivenhain Dam, USA • Glencorse Water Treatment Works, Scotland	• The project scope and works are routine, uncomplicated, and well-defined. • It is desirable to fast-track the project timeframe, by undertaking design and construction activities partially in parallel. • A degree of innovation in the design is desirable. • A high degree of cost certainty at the time of award is desirable. • The proponent has suitably skilled and experienced resources to manage the project delivery. • There is a preference to have a single point of responsibility for design and construction. • There is an opportunity to realise benefits by combining the design and construction.

<table>
<tr><th>Delivery model</th><th>Characteristics</th></tr>
<tr><td></td><td>There can be opportunity for variations, particularly due to design omissions or errors.
Building is undertaken at a predetermined price.</td></tr>
<tr><td>Early contractor involvement (ECI)
As a subset of the D&C delivery model, this model involves engaging a construction contractor prior to commencing a project to work in collaboration with the project sponsor.</td><td>In addition to the points noted under D&C:
There is a perceived benefit of involving the contractor early to assist with scoping the project and outcomes.
A relationship (not adversarial) contracting environment is desirable.</td></tr>
<tr><td>Design, construct, maintain and operate (DCMO)
The proponent contracts with a single entity that is responsible for design and construction of the project, as well as the operations and maintenance components. Examples:
Adelaide Desalination Plant, SA
Kurnell Desalination Plant, NSW
Tampa Bay Seawater Desalination Plant, USA</td><td>In addition to the points noted under D&C:
There is a desire to have a single point of responsibility for the design, construction, operations and maintenance phases.
There is an opportunity to realise benefits by combining design, construction, operations and maintenance into one package.
Innovation across the whole-of-life of the facility or infrastructure is desirable and achievable.
There is a desire/opportunity to realise efficiencies in the ongoing operations and maintenance components of an asset and associated service/s.</td></tr>
<tr><td>Alliance
The proponent enters into a transparent ‘open book’ co-operative contracting arrangement with the private sector wherein unforeseen risks and benefits are essentially shared.
Examples:
Wyaralong Dam, Queensland
Logan River Catchment Project, Queensland
Burnett Water Project, Queensland
Hinze Dam Stage 3 Construction, Queensland
Eildon Weir Improvement Works, Victoria
Thames Water Desalination Plant, UK</td><td>The project is complex or high-risk.
The scope is unclear, and the risks are unpredictable.
A high level of innovation is required, particularly in resolving technical challenges or maximising operating efficiencies and performance.
A transparent relationship is possible and desirable.
A flexible schedule is desirable.
A knowledge transfer between parties is highly desirable.
Risks are best managed collectively and collaboratively.
Close involvement of the owner can add value.
There is sufficient capacity and capability to resource the alliance.</td></tr>
<tr><td>Managing contractor
The proponent engages a head contractor to coordinate, engage and manage the design, procurement, and construction, while retaining the ability to directly influence the design development. Often delivered under a negotiated capped price (guaranteed construction sum or CGS).</td><td>The project is complex or high-risk.
The scope is unclear, and the risks are unpredictable.
There may be significant time constraints, necessitating bundled delivery.
A high level of innovation is required, particularly in resolving technical challenges or maximising operating efficiencies and performance.
A transparent relationship is possible and desirable.
Delivery is essential, but a flexible schedule is desirable.
A knowledge transfer between parties is desirable.
Risks are best managed collectively and collaboratively.
Close involvement of the owner can add value.
There is sufficient capacity and capability to resource the process.</td></tr>
<tr><td colspan="2">Partnership delivery model options</td></tr>
<tr><td>Availability payment public private partnership (PPP)
A Special Purpose Vehicle (SPV) receives a guaranteed fixed payment from the proponent in return for delivering a project on behalf of the public sector (i.e. an availability payment).
Examples:
Mundaring Weir Water Treatment Plant, WA</td><td>There is a major and complex capital investment program, requiring effective management of risks associated with construction, operations and maintenance.
The private sector has the expertise to deliver the project and there is good reason to think it will offer value for money.
The public sector can clearly define its needs as service outputs that can be adequately measured and contracted in a way that ensures</td></tr>
</table>

Delivery model	Characteristics
• Tuaspring Desalination and Integrated Power Plant, Singapore	effective, equitable and accountable delivery of public services in the long term, and risk allocation between public and private sectors can be clearly made and enforced. • The assets and services identified as part of the partnership scheme are capable of being costed on a whole-of-life long-term basis and there is scope for innovation. • The value of the project is sufficiently large to ensure that procurement costs are not disproportionate. • The technology and other aspects of the sector are stable and not susceptible to fast-paced change. Or, if the technology relevant to the project is subject to rapid change, the private sector can allow for an appropriate technology refresh without impacting service requirements and/or introducing significant pricing uncertainty. • Long-term planning horizons apply, with assets used far into the future.
Build, own, operate/transfer (BOO/T) A SPV builds, owns and operates an asset for a specified period, during which time the SPV is entitled to collect user charges. Examples: • Prospect Water Filtration Plant (NSW) • Macarthur Water Filtration Plant (NSW)	In addition to the points noted under 'Availability payment PPP': • An element of demand/revenue risk is transferred to the private sector. • Project returns depend in part on the user charges expected to be collected during the operations phase. • The state may be required to make capital contributions during the construction phase to help fund the project. • The state may be required to underwrite a minimum level of demand for the project (usually only sufficient to cover the debt obligations of the SPV). • It is applicable to greenfield or brownfield projects (but most commonly used for brownfield projects in the current environment). • Residual risk may be transferred to the private sector under BOO.

Source: Adapted from BQ (2018).

17.4.1 Work packages

For this project, it is recommended that the work be tendered as a single package. This is because it is important that the contractor has the flexibility to switch resources between the dam construction and the pipeline construction, and thereby leverage efficiency gains. There is much overlap of equipment and the skilled personnel required for each of these tasks; therefore, if an area of work is delayed, the resources can be redeployed to other areas. The contract is also more attractive due to its larger value. A single work package also eliminates the need to negotiate two construction contracts.

17.4.2 Delivery model assessment

The delivery model would be developed in a way that allocates the construction risk to the contractor and payment would be conditional on the Queensland dam safety regulation requirements and ANCOLD guidelines being met for the construction of the dam. The following simplified evaluation criteria were applied to assess the models of delivery (Table 17.2):

1) willingness of contractors to be involved

2) likelihood of producing a final contract price under the economic viability price ceiling

3) not having to pay contractors to participate in the tendering process.

The delivery models were rated on a scale of 1 to 10 for likelihood of success, with 10 representing the highest likelihood of success (Table 17.2).

Table 17.2: Assessment of delivery models

Delivery model	Evaluation criteria*			Likelihood of success	Comments
	1	2	3		
Construct only	3	2	8	Very unlikely	The contractors would like this approach, as they are likely to do well through variations. The tender prices are likely to be low, but the final price is not. The tender prices are not likely to be low enough to make the project viable.
Early tenderer involvement (ETI)	3	5	4	Unlikely	This option provides engagement with local contractors and businesses to reduce the capital budget estimate, due to regional knowledge, experience and construction efficiencies. Tenderers may accept a lower construction margin, due to reduced construction risk and flexibility to manage the construction schedule. Not recommended, as the implied multiple-party involvement would require the parties to be paid for their involvement because of the reduced likelihood of reward.
Design and construct (D&C)	4	4	8	Moderate	This option is very good at building to a predetermined price if good tendering, contract formation and administration are used diligently.
Early contractor involvement (ECI)	4	4	4	Unlikely	ECI could certainly bring innovation and construction experience to the table. The budget constraints would dampen the enthusiasm and the contractor would require a substantial payment before they undergo the process.
Design, construct, maintain and operate (DCMO)	2	2	4	Very unlikely	The option lacks the margin required for broad contractor support and interest, due to the limited capital expenditure budget to meet funding and development thresholds, and the lack of allocated funds. The risks associated with maintenance and operation would require significant margins. Conflict arising from government grants and a private operator earning a return on their invested capital would have to be resolved.
Alliance	3	2	3	Very unlikely	The option lacks the margin required for contractor support and interest, due to the limited capital expenditure budget to meet funding and development thresholds and the lack of allocated funds.
Managing contractor	3	3	4	Very unlikely	The option could be used as a variation to ECI, with the same strengths and weaknesses, but with the risk carried by a different party. Alternatively, it could be used to deliver ETI but would thereby share its weaknesses. A managing contractor adds another layer of overhead costs, which makes this option like using a tier one contractor.

Delivery model	Evaluation criteria*			Likelihood of success	Comments
	1	2	3		
Competitive alliance	2	2	1	Very unlikely	The option lacks the margin required for contractor support and interest due to the limited capital expenditure budget to meet funding and development thresholds and the lack of allocated funds.
Availability payment public private partnership (PPP)	3	2	4	Very unlikely	There is no capacity for the irrigation scheme to pay the return required for a PPP consortium to get a reasonable return on funds. An irrigation scheme has never been developed in Australia in this way.
Build, own, operate/transfer (BOO/T)	3	2	4	Very unlikely	There is no capacity for the irrigation scheme to pay the return required for a BOO/T consortium to get a reasonable return on funds. An irrigation scheme has never been developed in Australia in this way.

Source: Jacobs analysis.

**Note: The three evaluation criteria are: 1) willingness of contractors to be involved 2) likelihood of producing a final contract price under the economic viability price ceiling 3) not having to pay contractors to participate in the tendering process.*

17.4.3 Recommendation of delivery analysis

Should funding for this project be secured, it is recommended that a design and construct (D&C) contracting model be adopted, using a single works package for the dam and pipeline. If there is a cap on the funding in line with the economic return for the project, it may be necessary to declare this to the prospective tenderers before tendering starts.

A prerequisite of this option is that the proponent has access to suitably skilled and experienced resources to manage the project delivery, to ensure they are contractually and technically well informed. In addition, an experienced facilitator should be engaged to run a competitive tender process, oversee the contract formation and set up the contract administration. This approach has worked well for Tasmanian Irrigation.

17.5 Contracting tiers

Market sounding was conducted on the basis that it is likely that it will take tier one contractors to manage a project of this value and risk profile.

There is no definitive classification for each tier of company—tiers are specific to a region and/or market—but tiers can generally be identified by some typical features (Table 17.3). The tier of a construction company reflects the company's capacity to take on certain projects; its capacity in turn typically depends on its size, resources, experience and financial position.

Financing cash flow during construction (particularly with retentions and liquidated damages) is a significant part of a contractor's willingness to tender.

Table 17.3: Features of tier one, two and three construction companies

Tier 1	Tier 2	Tier 3
Tier one contractors are typically the largest and most experienced and have a substantial financial position. This tier typically is engaged on large commercial projects, such as motorways, railways and hospitals, with contract values ranging from hundreds of millions of dollars to billions of dollars. They have the expertise, resources, and finances to deliver large-scale projects. John Holland and CPB Contractors are examples of tier one contractors in Australia.	Tier two companies typically secure work that is under the threshold of a tier one company. Tier two companies can take advantage of smaller overheads and administrative functions, and therefore tend to be more competitive on a medium-sized project than a tier one contractor. For large contracts undertaken by a tier one company, a tier two company may be engaged as a subcontractor. Tier two companies usually take on medium projects, up to $35 million in capital costs. Tier two contractors can be more cost-competitive than tier one contractors, as they do not have the additional costs of management, higher margins, corporate offices and overheads. They usually own plant and equipment and have access to experienced machine operators.	Tier three companies usually take on small projects, up to $5 million. They may also support tier one and two companies on a larger project under a subcontractor, where specific expertise and/or additional resources are required. It is considered that local tier three companies could support the successful tier two companies. Tier three contractors can be more cost-competitive than tier one contractors, as they do not have the additional costs of management, higher margins and overheads. They also usually own plant and equipment and have access to experienced machine operators.

To increase the attractiveness of the project to contractors, the tender design and specifications need to be carefully crafted. This can be done by reducing negative cash flows (i.e. improving cash flow conditions) faced by the tendering companies (e.g. using upfront and monthly payments), identifying and reducing risk and providing all parties with complete information and site access. At the same time, a rigid fixed price approach will be maintained. That will minimise the risk of contractors bidding low with a plan to recoup money through variations and resulting in a project overspend, and therefore ensure value is preserved for the project.

17.5.1 Tendering process

The market needs to be informed of the project progression through public notices well before tenders are released. The tender process should be open to all civil construction companies, in accordance with sound probity and procurement practices. The assessment criteria should be clearly stated in the conditions of tender so that each contractor will be able to assess the cost of tendering.

An open tender process is preferred, because an individual contractor's ability to perform and need to be competitive depend on the company's forecast capacity. Each company's capacity will vary according to its equipment purchases and disposals, staff movements and the availability of subcontractors on which the company relies. The open tender process in effect lets the civil construction market self-assess the value of spending money on tendering.

This also allows the up-and-coming—and usually younger—contractors to prove their competence in assembling the resources for a competitive bid.

The alternative is a two-staged process in which companies undergo a process of providing evidence of capability, experience and capacity, so that a prequalified limited bid list can be compiled. Companies on the prequalified list are then offered the opportunity to tender. This requires very careful real-time analysis of each company's resources and work commitments. Companies are reluctant to declare all the information required to keep such an assessment current. A fully open tender process is therefore recommended.

17.5.2 Risk management

Within the contracting plan, each risk will be allocated to the party best able to manage that risk. A risk management plan will be developed and updated by the proponent if the project proceeds to tendering.

Where appropriate, risk will be transferred to the contractor. To ensure that this does not increase the contractor's risk margin and increase prices more than necessary, all relevant information should be shared, and the pre-tender investigation should be as comprehensive as reasonably practicable. Additional geotechnical investigations could be undertaken by the proponent prior to the release of tender documents and provided to potential bidders to reduce the uncertainty associated with below ground conditions. The contractors may provide a lower quote as a result of less uncertainty. For example, details of below-ground geotechnical investigations and the identified source of construction materials should be provided, but great care should be taken not to provide interpretation of the data. This is consistent with the successful approach adopted by Tasmanian Irrigation.

The recommended approach provides the opportunity for each tenderer to innovatively modify the detailed design of the dam and pipeline to incorporate changes that add value to the project and improve their competitive offering. This transfer of risk (from proponent to contractor) also requires a tendering procedure that gives the contractors ample access to the site to make any further investigations they deem necessary. To facilitate this process, a tendering duration of six to eight weeks is necessary.

Another risk and cost for the contractors will be cash flow. This will need to be carefully addressed in the contract documents, as the contract sums involved are large and will cause significant additions to the tendered sums if not planned, to reduce the quantum of financing needed by the contractors and the risk that accompanies large expenditures that cannot be claimed immediately.

A significant part of maintaining the rigid fixed price contract is to ensure that as many project approval conditions as possible have been included as conditions in the tendering documents, so that they are priced by the contractors before award.

This tendering and contracting methodology has been used successfully more than 12 times by Tasmanian Irrigation, with no overspends. This performance-based approach allowed the contractor maximum opportunity to apply the advantages of their specific plant and equipment and their experience to maximum effect, along with any design opportunities they can identify, principally in constructability.

This approach is now well-proven in the context of irrigation development nationally and results in a high likelihood of building a project to specification and within budget.

17.6 Market sounding objectives

The main objective of the market sounding process was to assess the capability and appetite of construction companies for involvement in the project, given the contracting methodology adopted.

Feedback was also solicited from the contractors on their view of the contracting method chosen and how to make the project more attractive to contractors.

There is a limit to the frequency that contracting companies can be engaged on such projects. Construction companies are generally unwilling to devote time and resources to considering a project unless they believe that it will proceed. Generally, Government support for a project is required before significant resources will be expended. As this project is not considered likely to proceed in the short term, testing the depth of the market and assessing the market risk appetite and the availability of interested contractors was of limited value because these factors vary over time. Extrapolating to make an assessment on these issues was not credible due to the uncertainty surrounding the funding and timing of the project.

17.7 Market sounding approach

The results of market sounding are influenced by whether contractors believe a project is likely to be funded and developed in a reasonable timeframe. The Building Queensland Guidelines state that 'care must be taken to ensure participants' expectations regarding project implementation and options are managed appropriately and with due regard for probity'. To give the impression that a project is more likely to be funded than is the case will distort the contractor market against the best interests of the contractor. This risk is especially challenging for this DBC, as the modelled economic benefits are not greater than the economic costs. This is generally a required to justify the government funding (discussed in Chapter 16: Economic Analysis).

Contractors and other private sector entities have limited resources to investigate and bid for projects. They dedicate these limited budgets towards projects that are more likely to be built and projects for which they believe they can deliver a competitive proposal.

Estimating and bidding for a job is expensive for a contractor, who needs to apply enough resources to properly quantify and manage risks. Where risks cannot be adequately quantified with the resources available, the cost estimates increase as the risk cost allocation for each risk increases. The risks associated with building a large dam in an area where tropical rainfall intensities occur are particularly challenging, as the bypass flows during construction and operation must be managed. This coupled with the below-ground risks of the Cloncurry River Dam, create a project which contractors will approach with caution.

This project requires the involvement of tier one contractors, due to the magnitude of the risks, and the complexity and value of the project.

Both contractors understood that the Cloncurry River Dam was unlikely to be funded and constructed in the short to medium term under current project conditions and assumptions.

If project funding was secured, a more comprehensive market sounding process would be recommended and would likely be successful in positively engaging suitable contractors. This process would support the development of the procurement strategy and delivery model.

17.8 Market feedback

The Strategic Development Manager for Fulton Hogan Queensland and Business Development Manager of Infrastructure for JHG Queensland were interviewed. These companies were chosen as they are considered capable of undertaking the required construction, and were likely to be interested, given their involvement in similar jobs. Their feedback included:

- Both companies were positioning themselves as significant dam builders. Fulton Hogan had just completed an 11 GL dam near Weipa for Rio Tinto and was building two more smaller dams in the far north. As a priority, JHG was actively ‘pulling together a dam building team’. JHG mentioned the Burdekin and Paradise Dams and the Rookwood Weir as work in which it was interested. JHG also has interest in more than a dozen other dams and dam upgrades.
- Both companies were prepared to take on the inherit risks associated with constructing large dams, including below-ground conditions, managing the diversion of existing water courses and sourcing suitable construction material.
- The remote location was not seen as a problem.
- The proposed contracting approach of transferring the below-ground risk and the risk of inundation to the contractor did not cause concern with either contractor; they saw this as business as usual, particularly if the geotechnical investigation was rigorous. They were both comfortable with contracting the dam construction under a design and construct contract and one said that it ‘really loves that approach’.
- JHG said that it had a strong appetite for building dams, and in particular RCC dams. The Cloncurry River Dam ‘ticked all the boxes’ for them.
- They were both prepared to contribute to ECI if the proponent provided payment for the time involved.
- They identify which projects they are likely to tender for two years in advance and then target their limited project procurement budgets mainly on those projects selected.
- Both contractors indicated that there was a strong flow of construction work in the short- to medium-term for them in Queensland. However, the contractors still had ‘some interest’ in the project as a potential longer-term opportunity for when the current work had been completed. As a result, the contractors were generally supportive but reticent to commit resources presently. Other future projects that were mentioned included substantial road infrastructure, inland rail, 20 dam projects over 20 years, WA iron ore, coal and oil and gas projects. They said they believed they would be resource- constrained for two to six years.

17.9 Assessment of market capability

The capability exists in the market to deliver the Cloncurry River Dam and associated infrastructure. Typically, this capacity would reside with a tier one contractor with a proven track record and capacity to deliver projects of this scale, risk profile and complexity. Tier one contractors are the largest and most experienced and have a substantial financial position. These contractors typically are engaged on large, commercial projects such as motorways, railways and hospitals, with contract values ranging from hundreds of millions of dollars to billions of dollars. They have the expertise, resources, and finances to deliver large-scale projects. JHG, Fulton Hogan and CPB Contractors are examples of tier one contractors in Australia.

In addition, to apply for Australian Government funding, federal safety accreditation must be held by the contractor. This accreditation is typically held by tier one contractors, and some tier two contractors. The cost of maintaining accreditation limits the number of contractors with accreditation. For a contractor with federal safety accreditation, the systems and processors must be utilised on all work that the contractor performs, irrespective of a requirement for them to be held on any job.

The project offers the opportunity for a head contractor to engage several small construction contractors with local experience in the mining industry. For example, a head contractor could sub-contract efficient rock drill and blast, and earth and rock moving rates from smaller local subcontractors with intensive and well-developed experience in mining activities in the Cloncurry area. The availability of such subcontractors depends on whether they are committed to mining projects during the proposed construction period.

However, there is limited interest from contractors at present, because it is not certain how funding will be obtained.

If the project receives funding, significant consideration would need to be given to the allocation of project risk and the conditions of a construction contract to ensure an effective and efficient delivery model is adopted.

In conclusion, the market sounding has found that there is capability, but the construction market is likely to be capacity-constrained over the next two to six years. Proceeding within this timeframe is likely to result in higher than expected tender pricing.

The following chapter provides the public sector comparator.

18. Public sector comparator

18.1 Key points

- The BQ Guidelines describe the Public Sector Comparator (PSC) as a financial model that estimates the risk-adjusted, whole-of-life cost of a project to the government using a traditional delivery method (i.e. public sector delivery).
- The PSC represents the most likely and efficient form of public sector delivery of the reference project.
- The PSC provides a benchmark against which decision makers can compare private sector bids for projects when delivered under a public private partnership (PPP) delivery.
- A public sector comparator is only required should a PPP be included in the considerations.
- According to Queensland Treasury (2015) the PSC is a hypothetical model that estimates the risk-adjusted, whole of-life cost to the Government if the reference project was to be delivered via a traditional public sector delivery method.
- It is not a necessary requirement for a detailed business case where there is no case for comparison between private sector and public sector delivery.
- The detailed business case for the Lower Fitzroy River Infrastructure Project (BQ, 2017), for example, did not include an assessment of a PSC—as that assessment is only required under a PPP model, which the business case had ruled out.
- In the case of the Cloncurry River Dam, a PPP model is not being considered. (Ref. Chapter 17: Market Delivery Assessment Tables 17.1 and 17.2. Therefore, a comparison with a public sector entity is not required.

19. Affordability analysis

19.1 Key points

- This chapter examines the affordability of the Cloncurry River Dam to the Government of Queensland.
- Without any funding from either the Australian or Queensland governments, annual charges for customers would be $414 per ML based on estimates for capital and operating costs.
- This would significantly compromise the viability of the project, as it would then be unlikely that customers could afford to purchase water allocations from the project.
- It is assumed that customers pay $1,500 per ML or $75 million upfront for 50,000 ML of water allocations.
- The resulting project funding shortfall could be funded from a combination of Australian Government grant funding, Queensland Government grant funding concessional and/or commercial loans (repaid by customers through increased annual charges).
- This affordability analysis demonstrates that the project requires the support of grant funding from the Australian Government and Queensland Government to fund the gap between the capital cost of the project and the proposed funding contribution from customers.
- For the Queensland Government, a contribution of $187.3 million as envisaged under Scenario 1 indicates a level of affordability that can be described as 'very low' (i.e. over $100 million).
- Under current assumptions, the project will not deliver positive economic performance.
- Therefore, the case for Queensland Government funding support is weak.

19.2 Affordability assessment

19.2.1 Queensland Government

One of the funding scenarios described in Chapter 15 (Financial analysis) is Scenario 1: High government funding. Under that scenario, a grant of $187.3 million from the Queensland Government is required, representing 32 per cent of the project's capital cost. The Queensland Government grant amount is based on the gap between the project's P90 capital cost less contributions from customers and a 50 per cent contribution from the Australian Government. It may be lower if compliant tenders are received from the design and construction market after the DBC is complete.

The funding request to the Queensland Government has been based on a risk-adjusted (P90) estimate and the assumption of customers purchasing of 50,000 ML of water allocations at $1,500 per ML by customers. It would be prudent to confirm this purchase of water allocations through binding water sales prior to the construction of the project to provide certainty about the Queensland Government contribution.

The BQ Guidelines describe the affordability analysis as assessing the net financial cost to the State of Queensland. An affordability assessment in isolation would not be the only metric on which a funding decision is based. Consideration would be given to other aspects of the DBC, such as environmental and social impacts, NPV economic benefits and costs, and construction and operating licences and approvals.

19.2.2 Other funding sources

19.2.2.1 Customers

Under all three funding scenarios outlined in Chapter 15, customers will contribute $75 million towards the project by purchasing 50,000 ML of water allocations at $1,500 per ML, meet repayments of loans required to fund any capital shortfalls (if required) and fund all operating expenditure through annual charges.

The one-off capital cost—$1,500 per ML for a water allocation from the project—has been developed through extensive engagement with potential customers and other key stakeholders, including local agribusinesses and consultants. A key consideration was a customer's capacity to pay, based on the customer's expected margins for enterprises to be irrigated and experience with irrigated agriculture. This figure is consistent with the demand assessments undertaken as part of this DBC.

Chapter 6 (Service Need and Demand Assessment) outlines the interest potential customers expressed in purchasing water allocations. The one-off purchase price would be $1,500 per ML for a water allocation with an average monthly reliability of about 80 per cent. In the demand assessment, annual water charges were estimated at $50 per ML. These estimates were based on the most up-to-date information at the time.

Potential customers expressed a likely demand of 62,800 ML, representing 126 per cent of capacity of the project. However, this response was received from only three potential customers, which presents a challenge for the project. It implies the risk of not reaching full uptake if one of the potential customers defaulted on any future commitment to purchase water, and a weakened case for the project receiving capital funding from government to benefit a small number of water users.

If the purchase of 50,000 ML of water allocations is not secured before the commencement of construction, a further loan would be required, and its repayments would be matched to future water sales. Alternatively, additional grant funding would be required.

19.2.2.2 Australian Government

An Australian Government contribution of $262.3 million, or 50 per cent of the project's capital cost of the project, is outlined under funding scenario 1 in Chapter 15.

In May 2016, the Australian Government allocated $1.06 million under the NWIDF's feasibility component for the Queensland Government to complete a preliminary business case on the feasibility and economic viability of the preferred option to provide additional water supply and security for the Cloncurry/Mt Isa region. However, this funding does not guarantee that a project will receive capital funding from the Australian Government.

At present, there is no commitment for the capital component of the Australian Government's NWIDF to assist in funding the project. Nevertheless, the DBC has considered the objectives and criteria of the capital component of the NWIDF (see Table 19.1).

Table 19.1: NWIDF criteria and potential implications

Criteria and relevant considerations	Implications/issues
Only state and territory governments may apply for funding	No issues
Only projects ready to progress to construction are to be eligible for funding	It is estimated that the project could begin construction within 18 months of signing a bilateral schedule between the Australian Government and Queensland Government It is noted that the implementation activities and conditions set out in the recommendations of this DBC will require some additional work on behalf of the proponent prior to any formalisation of the bilateral schedule
Applications must have the support of the Minister responsible for water	Ministerial approval will be sought upon finalisation of the DBC
State/territory governments must commit to the implementation of water management arrangements in the relevant catchment that are consistent with the NWI	No current known issues
Australian Government contributions from all sources will not exceed 50 per cent of the total project cost	All scenarios that consider Australian Government funding do not exceed 50 per cent of the total project cost
Projects must be completed by 30 June 2025	Assuming the construction of the project commences no later than January 2023, the project will commence operations before 30 June 2025

The Cloncurry River Dam project and the NWIDF capital component guidelines are strongly aligned. Specifically, the project:

- is consistent with the objectives and intended outcomes of the NWIDF, in that it promotes long-term regional economic growth and development in the Cloncurry region by providing secure and affordable water
- will be managed in accordance with the principles of the National Water Initiative
- is consistent with many related Australian Government's policies, plans and strategies, including the White Paper on Developing Northern Australia, the Northern Australia Audit, and the Australian Infrastructure Plan
- is unlikely to proceed, at least in the foreseeable future, without the provision of financial assistance from the government
- has undergone a robust DBC process.

However, under current assumptions, the Cloncurry River Dam is not economically viable. A key criterion of the NWIDF capital component is for projects to be economically viable—demonstrated by a benefit–cost ratio (BCR) of greater than 1. The DBC's BCR for the Cloncurry River Dam is 0.30.

19.3 Conclusion

This affordability analysis demonstrates that the project requires the support of grant funding from the Australian Government and Queensland Government to fund the gap between the capital cost of the project and the proposed $75 million funding contribution from customers.

For the Queensland Government, a contribution of $187.3 million as envisaged under Scenario 1 indicates a level of affordability that can be described as 'very low' (i.e. over $100 million).

Under current assumptions, the project will not deliver positive economic performance. Therefore, the case for Queensland Government funding support is weak.

Annual charges payable by customers are expected to be around $414 per ML if no government grant/s were received. At this price (i.e. $1,500 per ML upfront plus this annual charge), water allocations would be unaffordable to most agricultural producers in the Cloncurry region and the project would not proceed.

The following chapter presents the assurance framework used during the development of the business case.

20. Assurance

20.1 Key points

- This chapter outlines the assurance framework adopted by the project.
- The Business Case was developed in consideration of the key assurance objectives articulated in the Building Queensland Business Case Development Framework.
- To ensure an independent review process of all aspects of the DBC, MITEZ established a Project Review Panel with expert skills in key DBC elements, including economics, financial and commercial assessment, risk and technical design.
- Each BQ control point deliverable was peer reviewed by the Project Review Panel. The Project Review Panel provided written comments and participated in meeting with the Jacobs team to discuss issues and agree on pathways forward. DBC chapters were updated as required as part of this process.

There are no outstanding issues.

20.2 Overview

This DBC has been developed in consideration of the key assurance objectives.

- The DBC is complete and has been developed under the BQ and Infrastructure Australia guidelines.
- All baseline assumptions for the assessment of the Project have been assessed as reliable and reasonable. The formulation of the DBC has leveraged existing standards and guidelines including:
  - Financial Analysis: Discount rate advice and financial model in accordance with BQ Guidelines
  - Risk assessment
  - ANCOLD
- The DBC built on and leveraged work conducted by Jacobs during the Preliminary Business Case (PBC), which was completed in May 2018. The DBC is comparable in the methodologies and metrics previously used in relation to water infrastructure projects and prepared in line with the Infrastructure Australia and the BCDF guidelines.
- Detailed cost and risk estimates have been transparently articulated. They were reviewed internally by Jacobs and peer reviewed by the Project Review Panel.

20.3 Independent assurance

To ensure an independent review process of all aspects of the DBC, MITEZ established a Project Review Panel with expert skills in key DBC elements, including economics, financial and commercial assessment, risk and technical design. Members of the Project Review Panel were engaged based on their professional expertise and experience. The Independent Review Group was comprised of:

Adjunct Professor Romy Greiner PhD. Currently Managing Director of River Consulting Pty Ltd and Adjunct Professor at the Cairns Institute of James Cook University. Romy project manages the North West Queensland Strategic Water Investigation (aka Cloncurry River Dam Feasibility Study) on behalf of MITEZ and chairs the Project Review Panel. Romy is a natural resource economist and has previously held a professorial appointment at Charles Darwin University and research leadership positions with the CSIRO and ABARES. She has published extensively in the international literature and remains an active peer reviewer for numerous international scientific journals and the Australian Research Council. She has extensive experience working with Aboriginal people. Romy has previously served as chair of review panels, in particular the NT Water Resources Review Panel, as economic expert on scientific advisory panels and as non-executive director on not-for-profit boards. She led the strategic investigation into north-west Queensland water demand and supply in 2016.

Mr. David Stewart GAICD BE(Hons) FIEAust, CPEng. Currently Managing Director of Australian Dams and Water Consultants Pty Ltd, currently Director SunWater Limited, and Principal Dam Safety Engineer, Tasmanian Irrigation Pty Ltd. David has significant experience in designing Dams, infrastructure and Irrigation systems; dam safety management systems and emergency planning; dam operational management, maintenance and remedial work. David has been a Director and past Chairman of ANCOLD.

Emeritus Professor Owen Stanley BE(Hons) PhD. Currently Adjunct Professor with the School for the Environment at Charles Darwin University. Previous roles included Professor and Head of School (Business and Economics) at James Cook University. Owen is a regional economic development economist with a long track record of research and engagement across northern Australia, which has included reviews of Indigenous Land Use agreements, government employment programs and enterprise development. In addition to being an academic, Owen has also worked on projects overseas, with particular emphasis on China, and published extensively.

Mr. Ross Thompson. Currently Managing Director Soren Consulting. Ross has extensive business experience including in engineering and commercial management. A significant portion of this experience has been gained in north-west Queensland with particular focus on the strategic development of infrastructure to meet the evolving needs of the regional mining operations and communities. Ross was involved in the operations, maintenance and commercial structures, including water supply involving Lake Julius and Lake Moondarra systems, representing MIM on the Mount Isa Water Board. Ross' experience extends large-scale project management, commercial negotiations, joint ventures, board representation, international marketing and personnel management, and government relations.

Each BCDF Control Point deliverable was peer reviewed by the Project Review Panel. The Project Review Panel provided written comments on each chapter of the DBC, identifying issues and suggesting actions required. Meetings were held between the Project Review Panel and the Jacobs team to discuss issues and agree on pathways forward. DBC chapters were updated as required as part of the Independent Review process and key chapters were re-reviewed.

Meetings between the Project Review Panel and Jacobs team were held on:

- Control Points 1,2: 16 August 2018
- Control Point 3: 15 October 2018
- Control Points 4-6: 27 November 2018.

21. Conclusions, implementation plan and recommendation

This report describes the DBC for a new dam on the Cloncurry River at a site called “Cave Hill”. The report forms the second part of a strategic investigation into improving the supply of water in north-west Queensland to achieve agricultural development and provide water security for the Mount Isa—Cloncurry Region in north-west Queensland. The first part of the investigation had identified this new water infrastructure option as the most promising alternative for achieving the first goal.

The hypothesis underpinning the DBC is that a new large dam on the Cloncurry River would facilitate the development of irrigated agriculture on the fertile soils along the river. This, in turn, would support economic diversification and, importantly, contribute to social prosperity in the region. The dam would contribute significant additional water storage to the Mount Isa—Cloncurry Region and potentially improve long-term water security for urban communities and the mining and mineral processing sectors.

The DBC found that the site at “Cave Hill” on Roxmere Station is suitable for construction of the Cloncurry River Dam. The DBC provides a preliminary technical design for the dam and associated infrastructure.

Another key finding is that the project can indeed technically deliver on the promise of irrigation development. The project can support approximately 3,150 ha of irrigation agriculture in the Cloncurry region, based on a dam that yields approximately 50,000 ML of water allocations with monthly reliability of about 80%. There is demand, albeit requiring confirmation, for this water from landholders.

Irrigation, of a size necessary to achieve economies of scale in this remote region is highly unlikely to emerge in the absence of a major dam. However, the new water infrastructure is not necessary, in the near to medium future, from the perspective of water security for the urban centres of Mount Isa and Cloncurry, and from the perspective of the mining and mineral processing sectors.

A new large water storage can create many opportunities. It can generate an additional $14.2 million of agricultural production per year. This helps the local economy grow by $13.0 million every year, of which $7.9 million is direct activity and $5.1 million indirect activity. This scale of irrigation will diversify agricultural production, which is currently primarily focussed on cattle grazing. The project would provide opportunities for irrigation-based enterprises and supporting industries to emerge.

The project generates 58 FTE new jobs in agriculture:

- 37 new jobs directly related to agriculture
- 21 new jobs indirectly related to agriculture, in support industries such as farm input suppliers (e.g. fertilizer, seedlings, pesticides, packaging and fuel) and services (e.g. transportation, refrigeration, mechanical services, food, accommodation and accountancy).

Additional employment benefits generated by the project include:

- 396 FTE construction jobs over 3 years
- 2 new FTE ongoing jobs to operate and maintain the dam and pipeline.

A dam will create a large ponded area of water within 20 km of Cloncurry. This has the potential to increase the amenity of the local area by providing additional recreation opportunities for activities such as fishing, kayaking, water skiing and camping for residents and tourists. Conceivably, tourists may stay longer in Cloncurry thus further enhancing economic benefits generated by the project.

The project aligns with key Australian and Queensland Government strategies and policies regarding economic development, renewable energy, water infrastructure, food security and drought resilience. However, despite the obvious benefits, the Project does not provide a straight-forward proposition.

The dam is an expensive piece of water infrastructure particularly because it must be engineered to be a safe dam for the people living in Cloncurry, which is located just 20 km downstream and lies partially on the river flats. This means that the financial case for the dam is commercially weak, at least under the assumptions applied for the DBC modelling. Consequently, realisation of the project requires strong government financial support, in the form of grant funding, to achieve water prices that are viable for irrigators.

Alternatively, the project would require higher crop yields and commodity prices than are currently forecast, so that irrigators can fund the dam through higher water prices.

The project is estimated to create total economic benefits of $150 million, with a net economic impact of negative $322 million after subtracting the upfront and ongoing project costs. This results in a benefit–cost ratio of 0.30, which means that for every dollar invested by farmers and government, there is a return of $0.30 to the community. The outcomes of the project would not normally warrant government investment. However, many social benefits of the project have not been monetised in the economic model, consistent with Building Queensland's guidelines.

In most cases, government funding will not be provided to projects with a BCR below one. To equal or exceed a BCR of one, a material change is required for this project in:

- The construction cost of the dam and the pipeline—the cost estimates in the DBC reflect the expected market conditions; should the construction market soften, perhaps due to a sharp mining-related downturn, the capital cost estimate could decrease. However, capital costs would need to decrease from the current estimated range of approximately $450 to 500 million to $121 million, which is the level required to achieve a BCR of 1.0 with the current level of estimated benefits.
- Crop yields or returns would need to increase significantly—a demonstration farm would provide data on the opportunities for higher value crops in the study area. However, forecast benefits include the returns available from cotton. Without significant commodity price changes, there are no other suitable crops that have been identified for this area that would reliably generate equivalent or higher economic benefits.
- Non-agricultural demand—should additional urban or mining demand materialise, the economic benefits could rapidly increase. However, the prospect of significant additional urban demand materialising has been assessed as unlikely given the spare capacity that exists in Mt Isa's storages and the NWQWP. New mining and mineral processing demand that would access this project has been challenging to identify.

If the project is revisited in the future, the demand for irrigation water will need to be confirmed. The DBC demand estimates are based on the nominal expressions of interest from the 12 landholders who can conceivably receive water from the project. While total stated demand exceeds the capacity of the dam to deliver water, the market is thin with only three landholders expressing a demand for water. Real demand will have to be ascertained in a two-part process incorporating, first, an expression-of-interest phase and then a binding water sales process. Establishing real demand for water matching or exceeding dam capacity will be a necessary condition for the project proceeding beyond technical reports and being able to attract funding.

From a Queensland Government perspective, a new dam is considered a new build option under the State Infrastructure Plan and the Queensland Bulk Water Opportunity Statement (QBWOS) (DNRME 2017). Under the government's framework, preference is giving to options that make better use of existing water infrastructure, which leads to the question whether the spare capacity that exists in NWQWP could be utilised first. The spare capacity, however, does not support a similar scale of irrigation development. The QBWOS also prefers that underutilised water entitlements in the region be put to better use, for example, through development of on-farm storages to facilitate irrigated agriculture at the property-level.

There are also several non-financial barriers associated with building the project, including environmental and cultural. Environmental impacts can often be mitigated, e.g. provisions can be built in to facilitate the movement of fish across the dam, gates in the dam can be engineered to ensure environmental flow requirements are met and off-sets can be arranged to ensure there is a positive net outcome from the immediate impact of the project on sensitive ecosystems and species.

If a proponent for the Project is found and the dam on the Cloncurry River is to proceed beyond the DBC phase, however, the project will likely encounter strong opposition from the Mitakoodi and Mayi People. The Mitakoodi and Mayi People have indicated that the landscape is highly sensitive from a cultural heritage perspective, being replete with cultural sites and cultural significance (including stories of profound import to these Traditional Owners). This is particularly the case within a few hundred metres of the Cloncurry River banks, on both sides, extending beyond the construction zone, to both downstream and upstream of the dam wall including the extensive inundation area.

The archaeological assessment and consultation with the Traditional Owners referred to women's sites along and within the river and men's sites near Top Camp (also referred to as Black Fort). The general area of the Cloncurry River is known to be Eagle Hawk dreaming.

The area north of Cloncurry (over 20km downstream of the dam site) has been extensively surveyed for cultural heritage sites by archaeologists and Mitakoodi site officers. A total of 115 sites are recorded on the DATSIP site register in the 100 square kilometre survey area between Cloncurry and Fort Constantine Station along the Cloncurry River – this is where part of the distribution system would be located.

Based on an extrapolation of previous survey findings, it has been suggested that more than 500 cultural heritage sites may be found within the potential inundation area (at least 50 km2) upstream of Cloncurry River Dam. Additional sites would be expected particularly along the Cloncurry River in the approximately 20 km between the dam site and Cloncurry.

Protracted Native Title negotiations will likely ensue. There are five known cultural heritage sites within and near the inundation zone. A cultural heritage assessment in accordance with the Aboriginal Cultural Heritage Act 2003 needs to be undertaken, which will involve further in-depth consultation with the Traditional Owners of the land affected by the Project, Mitakoodi and Mayi People, regarding the significance of these cultural places. The proponent will be required to develop a Cultural Heritage Management Plan in accordance with the requirements of part 7 of the Aboriginal Cultural Heritage Act.

An EIS will need to conduct an impact assessment in accordance with the latest version of the EIS information guideline—Indigenous cultural heritage (Department of Environment and Science, 2018).

Construction of the dam would require amendment of the Water Plan (Gulf) 2007 to regulate the use of the additional water made available. The Cloncurry River is a prescribed watercourse within this plan area; therefore, water in and underneath the watercourse is subject to this plan. The plan regulates the taking of overland flow water and groundwater. Amendments to the plan would likely need to address:

- additional water entitlements to allow the use of water from the project
- water management protocols including operational matters such as water sharing and trading rules applicable to water management areas in the water plan area
- distribution of operations licences that detail the roles and responsibilities of scheme operators to achieve the outcomes of the water plan
- the operations manual, including the day-to-day operation rules for the scheme.

Several plants listed as 'endangered', 'vulnerable' or 'near threatened' are in the project area. Under the Nature Conservation Act 1992 (Qld), a clearing permit for these plants will be required. Environmental offset requirements triggered by any vegetation clearing would need to be investigated under the EIS process and offset strategy and through the Coordinator-General's conditioning of the project.

Further studies of terrestrial and freshwater wetland ecosystems will be required as part of the EIS to determine if threatened species are present and to assess the significance of impacts that may occur. This will include assessment of the impacts on the Bynoe River fish habitat in the Morning Inlet in the Gulf of Carpentaria.

The EIS must propose practical measures to avoid, minimise, mitigate and/or offset direct or indirect impacts on ecological environmental values. It will need to assess the need for buffer zones and the retention, rehabilitation or planting of movement corridors. A monitoring and auditing program will need to be developed. Significant residual impacts would need to be managed using offsets that are consistent with the requirements of applicable Australian and Queensland legislation and policies.

In conclusion, while the benefits of the Project would have a significant positive economic and social impact in the region – including 60 ongoing new full-time jobs, almost 400 jobs during construction and an extensive lake for use by the community and tourists – the costs appear prohibitively high now. Nevertheless, this Project has regional economic development and social merit and would be a game-changing development for the Cloncurry Region in north-west Queensland. It is recommended that there be periodic updates of the assessment, to test whether the underlying conditions have changed sufficiently to warrant additional consideration of the project in the medium to long term.

22. Glossary

Abbreviation/term	Meaning
AACo	Australian Agricultural Company
ABS	Australian Bureau of Statistics
Abutment	That part of the valley side against which the dam is constructed. The left and right abutments of dams are defined with the observer viewing the dam looking in the downstream direction.
ACCC	Australian Competition and Consumer Commission
AEP	Annual Exceedance Probability
AHD	Australian Height Datum
alluvial	Sediment deposited by flowing water, such as in a riverbed
ANCOLD	Australian National Committee on Large Dams
Announced allocation	An announced allocation is typically associated only with medium or high priority water allocations, which are created in association with water infrastructure (e.g. weirs or dams). The announced allocation process determines the actual amount of water that will be available under supplemented allocations for a water year. The announcement is made based on actual water in storage and/or predicted flows and is done in accordance with pre-set sharing rules. The process determines the percentage of the nominal volume that is available under different priority groups.
aquifer	A geologic formation(s) that is capable of yielding water in enough quantity to constitute a usable supply for people's uses
ARI EFO	Annual Recurrence Interval Environmental Flow Objectives
AS/NZS ISO 31000:2009	Australian and New Zealand risk management standard
Annual volumetric limit	– volume of water in ML that can be extracted from a catchment consistent, for example, with the general and strategic reserves set aside in the Gulf Water Plan
BQ Guidelines	Building Queensland Business Case Development Framework
BCR	Benefit–cost ratio (if greater than 1, the economic benefits exceed the economic costs)
borrow area	The area from which natural materials, such as rock, gravel or soil, used for construction purposes is excavated
BQ	Building Queensland – established under the *Building Queensland Act 2015* to provide independent expert advice to the Queensland Government about infrastructure
capex	Capital expenditure
CHMP	Cultural Heritage Management Plan
CID	Community infrastructure designation
CSIRO	The Commonwealth Scientific and Industrial Research Organisation – an independent agency of the Australian Federal Government responsible for scientific research in Australia
DAF	Department of Agriculture and Fisheries (Queensland)
DAFF	The Australian Government Department of Agriculture, Fisheries and Forestry, now Department of Agriculture and Water Resources
dam	An artificial barrier that can impound water for the purpose of storage or control of bulk water. A dam comprises the barrier or wall, spillway, outlets and other appurtenant structures
DATSIP	Department of Aboriginal and Torres Strait Islander Partnerships (Queensland)
DAWR	The Australian Government Department of Agriculture and Water Resources
DBC	Detailed Business Case – assists agencies to select the most appropriate response to a service need (problem) or opportunity. It supports a detailed assessment of all components of the project and includes contemporary considerations such as social impact and sustainability assessments.
DEWS	Department of Energy and Water Supply (Queensland)
DILGP	Department of Infrastructure, Local Government and Planning (Queensland)

Abbreviation/term	Meaning
DIRDC	Department of Infrastructure, Regional Development and Cities - the Australian Government agency with responsibility for all feasibility studies funded by the NWID
DNRM	Department of Natural Resources and Mines (Queensland), now DNRME
DNRME	Department of Natural Resources, Mines and Energy
DoEE	Department of Environment and Energy (Commonwealth)
DSD	Department of State Development (Queensland)
DSITI	Department of Science, Information Technology and Innovation (Queensland)
DTMR	Department of Transport and Main Roads
DTPA	Diethylene Triamine Pentaacetic Acid
ECI	Early Contractor Involvement – a delivery model method
EFO	Environmental Flow Objectives – as outlined in the relevant Water Plan (e.g. Gulf Water Plan 2007)
EHP	Department of Environment and Heritage Protection (Queensland)
EIS	Environmental Impact Statement
EMR	Environmental Management Register, which is administered by EHP (Queensland), lists sites that are currently, or were previously, used for notifiable activities or if the land is contaminated. Land may not be contaminated to be included on this register, but its use may indicate that the land is likely to be contaminated
EPBC Act	The *Environment, Protection and Biodiversity Conservation Act 1999* – the primary Commonwealth legislation to protect and manage nationally and internationally important flora, fauna, ecological communities and heritage places that are defined ass matters of national environmental significance
ERA	Environmental Relevant Activities
ETI	Early Tenderer Involvement – a delivery model method.
feasibility study	Detailed Business Case
FIA	Failure Impact Assessment
FNPV	The Financial Net Present Value – a measure of the profitability and success of an investment. The FNPV uses financial cash inflows and outflows and a discount rate (usually the WACC) to determine the net financial impact of the investment
Full supply level	The full supply level – the normal maximum operating water level of a water storage when not affected by floods. This water level corresponds to 100% capacity.
FTE	full-time equivalent ongoing jobs
geological science	Earth science concerned with the physical structure of rocks and land forms and the processes which have affected them over time
geotechnical engineering	A specialised area of civil engineering concerned with the analysis, design and construction of systems that are made of or are supported by soil and rock
GE-RCC	Grout-Enriched roller compacted concrete
GIS	Geographic Information System – a framework for gathering, managing and analysing data
GL	Gigalitre = 1000 ML
GM and NM	Gross margin (GM) – refers to the total income derived from an enterprise less the variable costs incurred. Expressed as a percentage, GM represents the portion of each dollar of revenue that the enterprise retains as gross profit. GM is a potential measure of economic benefit and includes: payments to capital – or earnings before interest, tax, depreciation and amortisation (i.e. EBITDA) fixed costs (including taxes less subsidies on production) Net margin (NM) – a measure of profitability after all operating expenses (fixed and variable) have been deducted from a company's total revenue. NM considers earnings after depreciation and amortisation is removed (includes it as an operating expense within the calculation). The key difference between these two is the treatment of expenses in each calculation. GM excludes the variable costs associated with production; NM excludes total fixed and variable operating costs associated with production.

Abbreviation/term	Meaning
GVP	Gross value of production – measures the actual production output of an organisation. It also calculates the value of goods and services produced in an area, industry or sector of an economy. GVP is measured at the price the producer receives, or prices at the farm gate, not the price the consumer pays. It excludes transport, wholesale and retail margins.
ha	Hectare
HDPE	High density polyethylene
Hydrology	Earth science concerned with the properties of the earth's water and especially its movement in relation to land
ILUA	Indigenous Land Use Agreement
Inundation Area	The upstream watercourse and area of land (beyond the river banks) that floods with water impounded by a dam
IVA	Industry value added – the value added by an industry after deducting the cost of inputs (or goods and services) used in the process of production. It is the contribution of a private industry or government sector to overall GDP. IVA is used to breakdown the total value added by each sector (e.g. agriculture). IVA is a potential measure of economic benefit and includes: payments to capital – or earnings before interest, tax, depreciation and amortisation (i.e. EBITDA) taxes less subsidies on production payments to labour, e.g. wages and salaries
LGA	Local government area
LIDAR mapping	Light Detection and Ranging - is a surveying method that measures distance to a target by illuminating the target with pulsed laser light and measuring the reflected pulses with a sensor.
MCA	Multi-criteria analysis
MICC	Mt Isa City Council?
MIM	Mt Isa Mines – one of Australia's largest mining operations, located near Mt Isa
MITEZ	Mount Isa Townsville Economic Zone Inc.
ML	Megalitres (one million litres)
ML/a	Megalitres per annum
MNES	Matters of national environmental significance
MP	Medium priority water allocation (e.g. 70–88% reliable on annual basis)
MSES	Matters of State Environmental Significance
NC Act	The *Nature Conservation Act 1992* (Queensland) – provides for the legislative protection of Queensland's threatened biota
Nominal entitlement (supplemented)	Nominal entitlement for a supplemented water allocation is (generally) the nominal volume allowed under a water entitlement. For example, 15 GL of high priority water allocation, with an announced allocation of 100%, allows 15 GL of water use in that year. If the announced allocation is lower (e.g. 50% applied to the nominal volume) the take may be lower (e.g. 7.5 GL).
Nominal entitlement (unsupplemented)	Nominal entitlement for an unsupplemented water entitlement is (generally) the average amount of water that the user might expect to receive. In this context it is not a maximum amount. Under some circumstances the user may receive more than 100% of their nominal volume, depending on seasonal availability. Some allocations will have a separate 'cap', which is the maximum amount that can be taken, irrespective of how much water is available that year.
NPV	Net present value – generally, the difference between benefits and costs expressed in today's dollars (e.g. FY2017–18). Building on the economic cost benefit analysis (above) the net present value is, for example, the difference between the economic benefits (e.g. $100 million) and the economics costs (e.g. $80 million) – expressed in today's dollars – resulting in an NPV for an option (e.g. $20 million).
NWI	National Water Initiative
NWIDF	National Water Infrastructure Development Fund
NWILF	National Water Infrastructure Loan Facility
NWQMP	North West Queensland Mineral Province

Abbreviation/term	Meaning
NWQWP	North West Queensland Water Pipeline
NWQ WSSI	North West Queensland Water Supply Strategy Investigation
opex	Operating expenditure
p.a.	Per annum
PAR	Population at risk
PBC	Preliminary Business Case – supports the identification and assessment of potential options to respond to the identified service need. The development of a PBC aligns to the preliminary evaluation stage of the PAF and is consistent with Stage 3 (Options Assessment) of Infrastructure Australia's Assessment Framework.
Plan Area	The area as defined within a WRP
Planning Act	The *Planning Act 2016* (Queensland) – provides a statutory framework for the assessment of development in Queensland
Planning Scheme	The Cloncurry Shire Planning Scheme – the primary planning document used by Cloncurry Shire Council to guide land use and development across the Shire
PMF	Probable Maximum Flood
PMPF	Probable maximum precipitation flood
PPP	Public Private Partnership
QBWOS	Queensland Bulk Water Opportunity Statement (DEWS, 2017) – Supports implementation of the SIP in Queensland's bulk water sector.
QCA	Queensland Competition Authority
RCC	A roller compacted concrete dam is constructed from a dry mixture of concrete, which is spread in thin layers and compacted into place using rollers.
Regional Plan	The North West Regional Plan 2010–2031 – provides the statutory regional planning framework to guide and manage change and growth in the North West region from 2010 to 2031 that achieves a prosperous and sustainable economy, which is serviced by well-planned infrastructure and services
RORB	Hydrologic model
RTN	Right to Negotiate
RWSSA	Regional Water Supply Security Assessment
SDF	Sunny Day Failure
SIA	Social Impact Assessment
SIP	State Infrastructure Plan (Queensland Government, 2016), which provides a hierarchy for the development of options: (1) Reform; (2) Better use; (3) Improve existing; and (4) Build new
sub-catchment area	A part of the plan area, as defined within a WRP
SunWater	SunWater Limited (A Queensland Government Owned Corporation)
SunWater allocations	These are water entitlements granted to SunWater with no specific purpose of use and for which no customer contract has been entered. SunWater is entitled to use this water for its own purposes or offer it for sale to a customer.
supplemented water	Water supplied under an interim resource operations licence, resource operations licence or other authority to operate water infrastructure
SPA	Sustainable Planning Act 2009
TUFLOW	two-dimensional hydrodynamic model
unallocated water	Water available for allocation in the plan area (i.e. yet to be allocated to an end user by DNRM)
USBR	United States Bureau of Reclamation
WASO	A water allocation security objective, as defined in the Water Act 2000 – an objective that may be expressed as a performance indicator and is stated in a water resource plan for the protection of the probability of being able to obtain water in accordance with a water allocation

Abbreviation/term	Meaning
water allocation	A water allocation is a tradable entitlement that is not linked to land. Rather it is linked to a 'water allocation security objective' (WASO), which defines the reliability and is protected by the legislation. Water allocations include both supplemented (created by/linked to infrastructure) and unsupplemented (based on river flow) allocations. Supplemented water allocations typically also include in their conditions a priority level. (e.g. high or medium). The priority level is applied in determining how the available supplies are shared amongst users via the announced allocation process.
water entitlement	Water entitlement is a general term encompassing water allocations, interim water allocations and water licences.
water licence	An authority granted under the *Water Act 2000* to: a) take water; or b) interfere with water. Water licenses are generally tied to land and cannot be traded separately.
WSS	Water supply scheme – a discrete water supply scheme including water infrastructure (e.g. dams and/or weirs) that is generally associated with the provision of supplemented water allocations to meet demand for water from urban, mining, industrial and/or agricultural sectors
Willingness to pay	–A demand assessment or an assessment of customer's willingness to pay, for example in this study, for water allocations including information on the volume required in ML and price, given specified monthly reliability and delivery locations. Pricing should include upfront capital investment and/or lease options to acquire the entitlements and guidance on annual water charges.

23. References

ANCOLD, 2012. *Guidelines on the Consequence Categories of Dams.* s.l.:s.n.

Australian Bureau of Statistics, 2016. *3218.0 Regional Population Growth Australia,* Canberra: ABS.

Australian Bureau of Statistics, 2016. *3235.0 Population by Age and Sex regions of Australia,* Canberra: ABS.

Australian Bureau of Statistics, 2016. *ABS Census of Population and Housing 2016,* Canberra: ABS.

Australian Bureau of Statistics, 2017. *Value of Agricultural Commodities Produced, Australia 2015-16 cat. no. 75030DO005.* Canberra: Australian Government.

Australian Soil Resource Information System (ASRIS), 2014. *Australian Soil Classification Soil Order Layer,* Canberra: Australian Soil Resource Information System (ASRIS).

Business Queensland, 2017. *Key Resource Areas in Queensland,* Brisbane: Queensland Government.

Cloncurry Shire Council, 2017. *Cloncurry Water Source Data.* Cloncurry: s.n.

CSIRO, 2013. *Flinders and Gilbert Agricultural Resource Assessment: key findings,* Canberra: CSIRO.

DAF, 2017. *Queensland Agricultural Land Audit Annual Addendum 2017,* Brisbane: Queensland Government.

Daniels, P., Porter, M., Bodsworth, P. & Coleman, S., 2012. *Externalities in Sustainable Regional Water Strategies: A Compendium of Externality Impacts and Valuations. Urban Water Security Research Alliance Technical Report No. 42.,* s.l.: s.n.

Department of Agriculture and Fisheries, 2018. *10-Year Roadmap and Action Plan,* Brisbane: Department of Agriculture and Fisheries.

Department of Agriculture, Fisheries and Forestry, 2013. *Queensland Agricultural Land Audit,* Brisbane: Queensland Government.

Department of Energy and Water Supply, 2017. *Draft Cloncurry Regional Water Supply Assessment,* Brisbane: Queensland Government.

Department of Energy and Water Supply, 2017. *Mount Isa Regional Water Supply Assessment,* Brisbane: Queensland Government.

Department of Environment and Heritage Protection, 2009. *Queensland Water Quality Guidelines, Version 3,* Brisbane : Queensland Government .

Department of Environment and Science, 2018. *Environmental Impact Assessment Guidelines,* Brisbane : Queensland Government .

Department of Natural Resources, Mines and Energy, 2017. *Risk Management Policy and Procedure,* Brisbane: Queensland Government .

Department of State Development, Infrastructure and Planning, 2015. *Mining and extractive resources ,* Brisbane : Queensland Government .

Department of Sustainability, Environment, Water, Population and Communities, 2013. *Sustainable Procurement Guide,* Canberra: Australian Government.

DEWS, 2017. *Acceptable Flood Capacity for Water Dams.* s.l.:s.n.

DEWS, 2017. *Draft Cloncurry Regional Water Supply Assessment,* Brisbane: Queensland Government.

DEWS, 2017. *Mount Isa Regional Water Supply Assessment ,* Brisbane : Queensland Government .

DNRM, 2015. *Release of unallocated water in the Gulf Water Resource Plan area—Flinders, Norman, Nicholson, Gregory and Leichhardt catchments: Terms of Sale,* Brisbane: Queensland Government.

DNRM, 2017. *Sale of general reserve unallocated water,* Brisbane: DNRM.

DSD, 2017. *A Strategic Blueprint for Queensland's North West Minerals Province ,* Brisbane : Queensland Government .

Harque, N., Hughes, A., Lim, S. & Vernon, C., 2014. Rare Earth Elements: Overview of Mining, Mineralogy, Uses, Sustainability and Environmental Impact, Resources. Volume 3, pp. 614 - 635.

Petheram, C., Watson, I. & Stone, P., 2013. *Agricultural resource assessment for the Flinders catchment ,* Australia: CSIRO.

Queensland Government (a), 2019. *Queensland Future Climate Dashboard.* [Online]
Available at: https://app.longpaddock.qld.gov.au/dashboard/#responseTab1

Queensland Government (b), 2019. *Australia's Variable Rainfall.* [Online]
Available at: https://www.longpaddock.qld.gov.au/other-products/australias-variable-rainfall/

Queensland Treasury, 2017. *Queensland Regional Profiles - Cloncurry and Mt Isa Local Government Area,* Brisbane: Queensland Government Statisticians Office.

Queensland Treasury, 2017. *Queensland Regional Profiles: Resident Profile for Cloncurry/Mount Isa Region,* Brisbane: Queensland Government Statisticians Office.

Queensland Treasury, 2018. *Queensland Regional Profiles: Resident Profile for Cloncurry/Mount Isa Region,* Brisbane: Queensland Government Statisticians Office.

Queensland Treasury, 2018. *Queensland Regional Profiles: Resident Profile for Cloncurry/Mount Isa Region,* Brisbane: Queensland Government Statisticians Office.

Queensland Treasury, 2018. *Queensland Regional Profiles: Resident Profile for Cloncurry/Mount Isa Region,* Brisbane: Queensland Government Statisticians Office.

Vanclay, F., 2003. International principles for social impact assessment. *Impact Assessment and Project Appraisal,* 21(1), pp. 5-12.

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