



NW Queensland Water Supply Strategy Investigation

Final Consultant Report

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Abbreviations and glossary

CSS	Cloncurry Shire Council
EHM	Ernest Henry Mine, Cloncurry
GL	Gigalitre = 1000 ML
MAUT	Multi-attribute utility theory
MCDA	Multiple criteria decision analysis is a sub-discipline of operations research that explicitly considers multiple criteria in decision-making environments. It is ideally suited to providing a structured and transparent way of analysing complex issues and selecting between competing options. Criteria represent different dimensions of the decision making space and are captured as indicators. Indicators can be qualitative or quantitative, and include technical, physical, social and other dimensions, and aspects of risk and uncertainty. MCDA is particularly suited to including stakeholder knowledge in the analysis and facilitates a transparent choice or ranking process.
MICC	Mount Isa City Council
MIM	Mount Isa Mines
MIWB	Mount Isa Water Board
MITEZ	Mount Isa Townsville Economic Zone Inc
ML	Megalitre = 1,000,000 litres
NRM	Natural Resources Management
NWQWP	North West Queensland Pipeline Inc
TOR	Terms of reference

Executive Summary

An investigation was conducted into potential new and additional water storages and supply options in the Mount Isa—Cloncurry region in light of past water shortages and likely increased future water demand associated with irrigated agriculture development and new mining activity. The purpose of the investigation was to identify the best alternative for additional water storage(s) to provide water supply and security. Specific objectives were:

- Provision of a precise overview and assessment of the current water storage situation, including the vulnerability of community and industries to failure of water supply during prolonged drought;
- Assessment of potential options for new and additional water storage infrastructure on the basis of technical, hydrological, risk/uncertainty, social, economic and environmental dimensions; and
- Identification of preferred alternative(s) in terms of suitability to address current and anticipated future demands within the regulatory environment and a changing climate.

The investigation revisited, consolidated and built on recent investigations into water in the region, with particular emphasis on GHD's 2014 North West Minerals Province Water Demand & Supply Assessment (GHD 2014), CSIRO's 2013 assessment of irrigation water development in the Flinders River Catchment (Petheram, Watson et al. 2013), CSIRO's 2009 NAWA report (CSIRO 2009) as well as the Regional Water Supply Security Assessment conducted by the Queensland Department of Energy and Water Supply for Mount Isa (DEWS 2015). In addition, local expertise and knowledge was harnessed and integrated to develop a comprehensive model of water demand, infrastructure, supply and security in the region.

The information was consolidated into a multiple criteria decision analysis (MCDA) model, designed to identify the best water supply alternative(s) in a transparent and robust manner, based on a set of quantitative and qualitative evaluation criteria. Evaluation criteria included:

- Additional effective water storage generated
- Reliability of water
- Contribution to building resilience of regional water supply
- Connectivity and proximity to water users
- Sedimentation and likely lifespan of infrastructure
- Absence of regulatory issues
- Likely cost, and
- Uncertainty associated with the geotechnical and other aspects of the alternative.

Nine water infrastructure alternatives were considered:

- Dams on the upper Cloncurry River at 'Cave Hill', 'Black Fort' and 'Painted Rock', and a dam at 'Slaty Creek'—a tributary to the Cloncurry River
- A combination of two dams, one at 'Black Fort' and the other at 'Slaty Creek'
- Increasing water storage on the Leichhardt River by raising the height of Julius Dam or building an additional dam just upstream from Lake Julius; and
- Connecting existing but currently unused water storages of Corella Dam and Lake Mary Kathleen.

After consolidating available information into the MCDA model, a final ranking of alternatives was obtained in consultation with regional stakeholders so as to reflect a whole-of-region perspective.

Based on the input parameters and the criteria weighting agreed on by regional stakeholders 'Cave Hill Dam' was found to be the highest ranked water infrastructure alternative for increasing water supply and security of supply in the Mount Isa—Cloncurry region. Its large effective storage, contribution to resilience of regional water supply and potential to support irrigated agriculture and tourism were particular strengths.

A funding proposal was consequently developed for a detailed feasibility study of 'Cave Hill Dam' and submitted to the Australian Government.

1 Introduction

Alluvium Consulting Australia Pty Ltd (Alluvium) was commissioned by the North West Queensland Strategic Plan Water Sub-committee to conduct a desktop investigation into potential new/additional water storages and supply options in the Mount Isa—Cloncurry Region in light of future water demand.

The purpose of the investigation was to identify the best option for additional water storage(s) to provide supply and security of water for the Mount Isa—Cloncurry Region. This would include:

- Provision of a precise overview and assessment of the current water storage situation, including the vulnerability of community and industries to failure of water supply during prolonged drought;
- Assessment of potential options for new and additional water storage infrastructure on the basis of technical, hydrological, risk/uncertainty, social, economic and environmental dimensions; and
- Identification of preferred option(s) in terms of suitability to address current and anticipated future demands within the regulatory environment and a changing climate.

A key objective of the investigation was to revisit, consolidate and build on recent investigations into water in the region, with particular emphasis on:

- GHD's 2014 North West Minerals Province Water Demand and Supply Assessment (GHD 2014),
- CSIRO's 2013 assessment of irrigation water development in the Flinders River Catchment (Petheram, Watson et al. 2013),
- CSIRO's 2009 NASY report (CSIRO 2009),
- the Regional Water Supply Security Assessment conducted by the Queensland Department of Energy and Water Supply for Mount Isa (DEWS 2015), as well as
- historical investigations into potential dam sites.

In addition, local expertise and knowledge was to be harnessed and integrated to develop a comprehensive model of water demand, infrastructure, supply and security in the region.

The information was to be consolidated into a multiple criteria decision analysis (MCDA) model, designed to identify the best water supply option(s) in a transparent and robust manner, based on a set of evaluation criteria. These criteria would reflect key considerations in a choice situation and be informed by the science contained in the previous studies, supported by additional investigative elements. Criteria would include technical, geo-hydrological, social, economic and environmental considerations and risk. After consolidating available information into the MCDA architecture, a final ranking of alternatives would be obtained in consultation with regional stakeholders so as to reflect a whole-of-region perspective. A funding proposal would be submitted to the Australian Government to seek funding for a feasibility study for the resulting "preferred alternative".

Section 2 of this report outlines the rationale and details of methods employed. Section 3 details regional demand for water, including considerations for future demand, and vulnerability to water shortage. Section 4 illustrates the water supply alternatives considered in the study and their translation into the MCDA metric. Section 5 details the implementation of results of the MCDA.

2 Methodology

2.1 Geographic scope and relevant regional characteristics

The investigation focussed on the Mount Isa—Cloncurry Region, which encompasses the upper parts of the Leichhardt and Cloncurry River catchments. These catchments provide the surface water resources that support the urban centres of Mount Isa and Cloncurry, and the mining and processing industries that operate in their vicinity. Thus, the Study Area represents the very south-western corner of the Southern Gulf Catchments area, as illustrated in Figure 1.

Figure 1: Study Area: Upper Cloncurry and Leichhardt River catchments



(Original map taken from Southern Gulf Catchment (www.sgc.com.au))

The Study Area lies within the semi-arid parts of northern Australia's tropical savannas. Rocky ranges dominate the region's topography and the vegetation is open steppe, dominated by spinifex grasses with few trees, and with soft grassy vegetation confined to creek and river floodplains. Mean annual rainfall is around 400-500mm and mean annual evapotranspiration is approximately 2800mm (BOM 2015).

Rainfall is highly variable. During the year, most rain tends to fall during summer months while winter months are dry. Rainfall also varies between years: Across the Study Area, the coefficient of variation of annual rainfall is around 1.1 to 1.3, indicating that the standard deviation of rainfall received exceeds mean rainfall. Coefficients of variation above "1" indicate that rainfall is characterised by extremes and not generally dependable. Rainfall also tends to be spatially variable, with patchy rain delivering better conditions in some areas than others.

Mean annual runoff reaching the waterways and contributing to river flow is approximately 10% of annual rainfall, with a higher proportion of rainfall converting to surface water in wet years and a smaller proportion in dry years.

The region comprises major parts of two local government areas, Mount Isa City Council and Cloncurry Shire Council. In 2011, Mount Isa City had a resident population of approximately 22,091 while the resident population of Cloncurry Shire was 3428 (OESR 2012), of which approximately 2500 live in Cloncurry. Average household size in both localities is 2.7 persons. Both towns also host a relatively large population of non-resident people, consisting mainly of a fly-in—fly-out mining workforce and tourists during the winter months. Non-resident workers made up 11% of Mount Isa's total population in 2007 while in Cloncurry almost 900 non-resident workers were present at 30 September 2007, boosting the town's population by more than one third. The population in both council areas has been declining over the past 10 years, though some predictions see this trend reversed over the next two decades.

Surrounding Mount Isa and Cloncurry is the North West Queensland Minerals Province, which produced more than 71% of the value of metalliferous minerals recovered in Queensland, amounting to approximately \$7.6 billion during 2010-11. The base metals mined in the Mount Isa – Cloncurry vicinity include lead, silver, zinc, copper and gold. There are also rare earths and the potential for uranium mining.

2.2 Situation and vulnerability analysis

A review of existing literature was undertaken and complemented with stakeholder and expert interviews to ascertain the current situation in the Study Area with respect to water supply and demand. There were situations in the recent past when dramatic measures were considered in response to water shortages, in particular the evacuation of Cloncurry, when the town's main water supply reached 15% capacity early in 2014 (Figure 2) and emergency planning considered evacuation as the final option (Calligeros 2014).

Figure 2: Chinaman Creek Dam at 15 % capacity in February 2014



(Photo: Penny Timms/ABC News)

Similarly, Mount Isa experienced a ‘water crisis’ in May 2013 when its main water supply, Lake Moondarra, reached low levels following the lowest rainfall conditions since 1967 (ABC-Splash 2013) and again in May 2013, when the main water filtration system failed (Northwest Star 2015).

Vulnerability is the degree to which a system (natural or human) is susceptible to, and unable to cope with, adverse effects of—in this case—insufficient and uncertain water supply. There are three components to vulnerability: exposure, sensitivity and adaptive capacity. In the context of the Consultant Study, vulnerability is a function of the magnitude and likelihood of water shortage, and the communities and industry’s sensitivity and adaptive capacity. Vulnerability assessment identifies, assesses and understands the vulnerability of the Cloncurry and Mount Isa communities and nearby industries to water shortage and uncertainty of supply. Vulnerability assessment in this case is the process of identifying and quantifying biophysical and socio-economic vulnerabilities in a system and assessing their inter-connectivity.

Systematic stakeholder consultations were conducted to complement the literature review. Means of consultations included telephone, email and face-to-face meetings. Table 1 provides an overview of stakeholders and experts consulted.

Table 1: Stakeholders and experts consulted for the Study

Local Government
Cr Tony McGrady, Mayor, Mount Isa City Council, 28 January 2016, face-to-face
Cr Andrew Daniels, Mayor, Cloncurry Shire Council, 2 February 2016, telephone
Cr Jane McMillan, Acting Mayor, Cloncurry Shire Council, 16 December 2015 and February 2016, face-to-face
David Neeves, CEO, Cloncurry Shire Council, 28 January 2016, face-to-face
Peter Fidget, Senior Engineer, Cloncurry Shire Council, 28 January 2016, face-to-face
Water managers
Stephen Farrelly, CEO, Mount Isa Water Board, 28 January 2016, face-to-face
Robert Lewis, Manager Service Delivery, SunWater, 5 February 2016, telephone
Darren Thompson, Department of Energy and Water Supply, 18 February 2016
Graham Jones, Asset Manager IP, Sunwater, 18 February 2016, email and telephone
Heather Sparks, Department of Natural Resources and Mines, 19 February 2016, email
Local experts
Rex Whitehead, Member MITEZ, 21 December 2015, telephone
Bob McDonald, Landholder, 22 December 2015, telephone
Don McDonald, Landholder, 22 December 2015, telephone
Paul Woodhouse, Chairman, RDA Townsville and NW Queensland, 23 December 2015, telephone
Michael Crisp, Station Manager, Lorraine Station, 13 January 2016, telephone
Don Pollock, Consultant, 8 February 2016, telephone
Scientists
Dr Ian Watson, CSIRO, 23 December 2015, telephone
Dr Peter Stone, CSIRO, 3 February 2016, presentation to AARES, and 8 February 2016, email
Mines: Managers and Environmental officers
Keith Fisher, Utilities Manager, Glencore Mount Isa Mines, 9 January 2016, email; 10 February 2016, telephone
Alex Sexton, Environmental Officer, Glencore Ernest Henry Mine, 9 February 2016, telephone, email
Mark Roberts, General Manager, CuDECO Rockland Copper Project, 9 February 2016, telephone, email
Trevor Gray, Glencore—Mount Isa Mines, 17 February 2016, telephone

2.3 Multi criteria decision analysis

2.3.1 The principles of multi criteria decision making

For the assessment of water storage options, a multiple criteria decision analysis (MCDA) was adopted. The methodological and process standards recommended by the World Commission on Dams (Sutherland and Fenn 2000) for the assessment of water supply options was utilised to guide the MCDA.

MCDA is a tool which provides a structured and transparent way of analysing complex issues and selecting between competing options (Annandale and Lantzke 2000). MCDA can be combined with probability theory and scenario planning to deliver sound environmental decision support (Reichert, Langhans et al. 2015). MCDA is thus ideally suited to assessing the suitability of different water storage options in the context of delivering water security for the Cloncurry-Mount Isa region. MCDA can handle a large number of diverse assessment criteria, including criteria that deal with the diverse facets of water security and water supply.

MCDA is grounded in multi-attribute utility theory (MAUT), which says that, from a set of alternatives, a decision maker will choose the alternative which delivers the highest utility (Ishizaka and Nemery 2013). Utility represents the decision maker's suite of preferences.

The purpose of the MCDA is to identify the best alternative in a complex situation. In the case of selecting a preferred water supply option complexity arises because of the need to integrate technical, hydrological, geographical, risk/uncertainty, social, economic and environmental dimensions; data uncertainty; and competing values. MCDA offers a systematic decision-making process and justification of the resulting decision.

MCDA disaggregates the problem into a number of criteria, and each alternative is scored in terms of its achievement against the optimum level in each criterion. Preferences can be encapsulated by assessment criteria, and each criterion receives a relative weighting to reflect its importance in the decision finding process. The sum of criteria weightings is always one. Each alternative receives a score against each criterion, and by adding the criteria scores, the utility score of each alternative is established. Alternatives are then ranked based on their utility score, revealing the best alternative. This process is illustrated in Table 2.

Table 2: The principle of finding the best alternative using MCDA

	Criteria				Utility	Rank
	A	B	...	N		
Criteria Weights	ω_A	ω_A		ω_A	1	
Alternative 1	X_{1A}	X_{1B}	...	X_{1N}	Σ_{X1}	1...n
Alternative 2	X_{2A}	X_{2B}	...	X_{2N}	Σ_{X2}	
...					...	
Alternative n	X_{nA}	X_{nB}	...	X_{2nN}	Σ_{Xn}	

MCDA is an established method in environmental decision support (Reichert, Langhans et al. 2015). It relies on the availability of quantitative scientific knowledge but also requires that societal preferences can be described and elicited. The latter is implemented through the specification of criteria, weights and scoring functions as input parameters.

In the evaluation of alternatives, parameter values are first transformed into marginal utility contributions before the marginal utility scores are then aggregated with a weighted sum (Ishizaka and Nemery 2013). The weights represent trade-offs, meaning the amount of unit of criteria the decision maker is willing to sacrifice in order to gain one unit on another criterion. Generally, the marginal utility function of any given criterion is such that the best alternative on that criterion has a marginal utility score of 1, and the worst alternative on the same criterion a score of 0. If the weights are normalised, the utility score of all alternatives is always between 0 and 1, with the highest score representing the overall most preferable alternative. The shape of the marginal utility function reflects different risk attitude and preferences.

When implementing a MCDA, quantification of the criteria weights needs to reflect stakeholder preferences and values. To that effect, a stakeholder consultation meeting was organised by Mount Isa Townsville Economic Zone Inc. (MITEZ) on 19 February 2016 in Cloncurry as an extraordinary meeting of the NW Water Sub-committee. Attendees are shown in Table 3. The meeting was facilitated by the lead consultant of the Consultant Study. Meeting objectives were to:

- (i) report findings and create shared understanding of meeting participants of water demand, infrastructure and supply situation and projections in the region,
- (ii) review, and if necessary, revise the structure of data foundation of the MCDA framework, and
- (iii) implement agreed criteria weightings to arrive at a consensus decision about the preferred water infrastructure alternative. Table 3 lists the attendees of the meeting.

Table 3: Attendees of meeting held 19 February 2016, Cloncurry

Regional organisations
Paul Woodhouse, Chairman RDA Townsville and NW Queensland
David Glasson, Chair MITEZ
Glen Grahm, CEO MITEZ
Local Government
Cr Tony McGrady, Mayor Mount Isa City Council
Cr Jane McMillan, Acting Mayor Cloncurry Shire Council
David Neeves, CEO Cloncurry Shire Council
Water managers
Jim Mummary, SunWater, Manager Bulkwater
Queensland Government
Greg Palm, Department of State Development
Local experts
Rex Whitehead, Expert
Mines: Managers and Environmental officers
Keith Fisher, Glencore-Mount Isa Mines
Peter Schmidt, Glencore-Mount Isa Mines

2.3.2 Quantitative criteria

When assessing water storage options, obvious considerations refer to the amount of water that can be stored and the reliability with which water can be delivered to users. For the purpose of the MCDA, two quantitative criteria were developed:

- Size of effective storage
- Efficiency and reliability

When considering effective storage, it is important to consider whether and how frequently the reservoir fills and water losses during storage and transport of water to end users. Availability of water in a storage or dam is determined by its capacity to capture water and is reduced by evaporation and leakage (and water which is inaccessible i.e. “dead water”).

The size of effective storage was determined from a multi-step process:

1. Determination of the increased storage volume created by each option (either new storage, or increased storage in the case of an upgrade to an existing asset).
2. Determination of the surface area of dam when full.
3. Calculation of the evaporation over two years (assuming the storage starts full) and assuming 2.18m evaporation per year (Petheram et al. 2013).
4. The effective storage is then determined as a ratio of the volume of water remaining at the end of 2 years divided by the largest volume remaining from any of the options.

The efficiency and reliability of each option was determined through a process which considered the residual water remaining after a two year period assuming no additional inflow. The following process was used:

1. Starting with a full storage, two years of evaporation is applied (without additional inflow) to determine a residual storage volume, which is then divided by the full storage volume to determine the evaporation efficiency percentage.
2. The reliability is then calculated by dividing the evaporation efficiency by the highest evaporation efficiency determined for any option. The resulting ratio is used to rank the storage reliability of each option.

While some water supply options have been explored in detail in the literature, in particular by CSIRO and GHD (Petheram, Watson et al. 2013; GHD 2014), others have not. For these other options, key hydrological indicators were estimated using catchment modelling. Catchment delineation and subdivision was undertaken using the CatchmentSIM software program which delineates catchments and sub-catchments from a Digital Terrain Model (DTM) and calculates their properties and creates output data suitable for input to other modelling process. For this project, the 1 arcsecond NASA SRTM 30m DEM grid data was obtained from Geosciences Australia’s National Elevation Data Framework Portal. The data is of a coarse resolution however it covered the entire area of interest, was free to access and provided a suitable level of detail to compare the options considered in this study.

Twenty-four years of simultaneous rainfall and flow gauging data (1968 – 1992) from the Cloncurry River catchment was used to determine annual runoff volumes relative to catchment area. Data was used from the following sites:

- Flow gauging station #915203A, Cloncurry River at Cloncurry. This station has a catchment area of 5,975km².
- Flow gauging station #915204A, Cloncurry River at Damsite, This station, located at the Black Fort dam location, has a catchment area of 4,240 km².
- Bureau of Meteorology daily rainfall gauge #29008, Cloncurry McIlwraith Street.
- Bureau of Meteorology daily rainfall gauge #29129, Devoncourt Station.

The percentage conversion of rainfall to runoff averaged around 10% per annum though varied from as little as 1% in dryer years to 38% in wetter years. For each storage option, the potential annual runoff was calculated based on the catchment area upstream. In recognition of the coarse process used to derive these annual volume estimates the values were validated against the 85% reliability yield estimates derived by Petheram et al. 2013 to provide comparable estimates.

2.3.3 Qualitative criteria

There are other important criteria relating to the performance of water storage and infrastructure options, which could not be derived by modelling. These criteria are listed and explained below.

Alternatives were scored against qualitative criteria on a scale from 1 to 5 with “1” indicating poor performance and “5” indicating very good performance.

- Added regional resilience

Resilience describes the capacity of a community or a system to bounce back after an external shock or impact. In a planning context, there are a number of design principles which contribute to making regional communities more resilient (resilientcity.org). These principles were translated into the context of regional water supply and security.

A key element of building resilience is increasing diversity of water storages. Reliance on a single storage increases the risk associated with the failure of that single storage. Having multiple storages reduces risk and increases resilience, e.g. as is already the case with Moondarra and Julius dams. However, both dams are in the Leichhardt River catchment and harvest water from the same catchment area.

In addition to having high inter-annual variability of rainfall, Northern Australia also experiences high spatial variability of rainfall. Spatial variability is associated with patchy heavy showers and thunderstorms. Consequently, harvesting water from different catchments increases the likelihood of securing water supply compared to relying on runoff from one catchment only.

Water infrastructure alternatives which increased an existing storage received a “1” rating against this criterion while alternatives which provided storage(s) on as yet undammed waterways received a high rating.

- Proximity and connectivity

As has been shown in the case of Lake Julius, distance between water supply and water users is a key contributor to the cost of water delivery and consequently the cost of water to users. In the instance of Lake Julius, distance is compounded by the fact that water has to be pumped uphill for delivery to Mount Isa in particular. Even if a storage is upstream from water users, water delivery requires delivery infrastructure such as pipelines, which are expensive to build—the pipeline connecting Cloncurry to the North West Queensland Pipeline cost more than \$1 million/km—and to maintain. It is therefore preferable for water storages to be both upstream from and in close proximity to water users.

New water infrastructure alternatives which were geographically distant from water users received a low rating against this criterion while alternatives in close proximity received a high criteria rating. Alternatives which could use existing water infrastructure also received higher ratings.

- Sedimentation / Likely lifespan of the infrastructure

The geomorphological suitability of water storage options relates to sediment supply and transport relationships in the waterway on which the storage is built and the nature of the strata that will be within the impounded footprint. If the waterway has high sediment supply and that sediment would be prone to

deposition under the backwater conditions of an impoundment, the effective storage area will reduce over time. This may necessitate substantial maintenance to retain effective storage volumes. Should the strata within the impoundment be subject to mobilisation under impounded conditions, this also has the potential to reduce capacity of the storage in drier years by infilling of the lower parts of the impoundment profile.

Finer sediments (silt and clay) are likely to be transported through the impoundment options in larger flow events, with deposition in smaller flow events and upon recession of flow. Coarser sediments (sand and greater) are likely to deposit in the impoundments in most flow events. Supply and transport capacity of the waterway upstream of the impoundment footprint determine the risk to effectiveness.

Sites with lower potential for sedimentation consequently achieved a higher rating and sites with higher potential for sedimentation a lower rating for this criteria.

An aerial inspection of the potential water storage (impoundment) locations and the waterway characteristics overall was undertaken. The Cloncurry River was noted to have a substantial mobile bed sediment load. The sediment transport capacity is not known and would require detailed modelling for quantification. Sediment supply to the river is likely to be high due to the geologic characteristics of the catchment, the high variability in climate conditions and the agricultural use of the land.

Slaty Creek was noted to have a relatively low mobile bed sediment load than the Cloncurry River at the potential dam sites inspected. This does not mean sediment supply conditions may be substantially different to the Cloncurry River but could mean that transport capacity is different (for example, higher energy conditions that transport sediment through the confined valley locations suitable for a dam and/or deposition of that sediment further upstream along the waterway).

The sediment transport dynamics of the waterway will also play an important role in the form and function of the waterway downstream of any impoundment. Significant channel erosion is a common occurrence downstream of impoundments should the channel boundaries not be robust. This erosion then contributes to sedimentation further down the waterway that may impact on its environmental performance and utility for industries such as agriculture (pumping suitability, infilling of stock watering holes, etc).

- Absence of regulatory issues

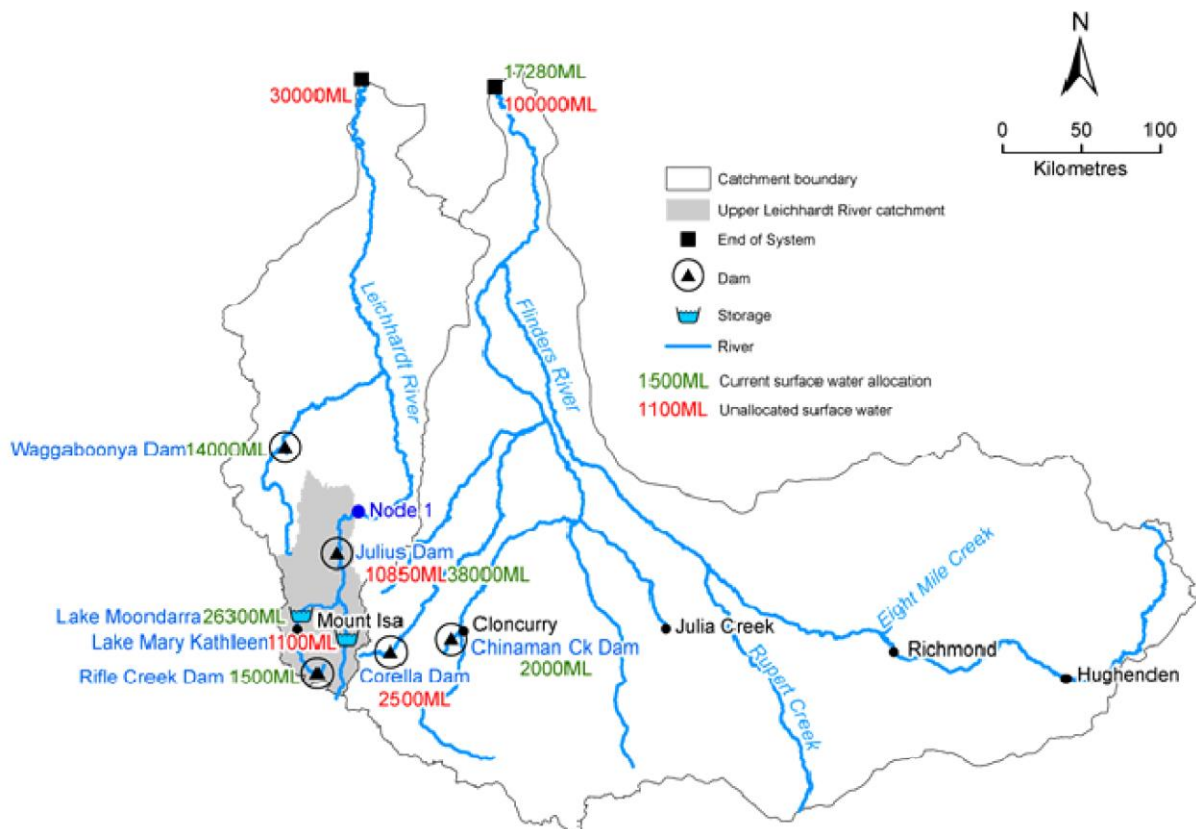
Any water infrastructure, its planning, implementation and management must comply with applicable regulations, policies, plans, criteria and guidelines. Regulatory considerations critically affect planning, realisation and operation of water infrastructure. In any State, there are a raft of legislative requirements that relate to the legitimate and safe construction and operation of dams.

In Queensland, water use and management is principally governed by the *Water Act 2000* (QG 2013). Its contents are interpreted for the Gulf region by the Water Resource (Gulf) Plan 2007 and an associated Operations Plan (DNRM 2007; DERM 2015).

Additional surface water abstraction and use requires water licence applications to be made and allocations to be approved. Figure 3 shows allocations and unallocated surface water as per 2009. Recently, unallocated water was offered for sale (DNRM 2015).

General advice was received from the Queensland Department of Natural Resources and Mines in regards to a query. This advice is shown in Appendix 6.1.

Figure 3: Surface water allocations and unallocated surface water in 2009



(after Water Resource (Gulf) Plan (DNRW, 2007), Source: CSIRO, 2009, p. 213)

Water resource development is also subject to a cultural heritage duty of care and must comply with the Aboriginal Cultural Heritage Act (Queensland) 2003.

At the national level, the Australian Government is responsible for protecting matters of national environmental significance listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). These matters include, for example, listed threatened special and ecological communities, National Heritage places and migratory species. The EPBC Act was amended in 2013 to include water resources as a matter of national environmental significance. Proposed water infrastructure projects such as dams can trigger the EPBC Act. This was the case, for example, with the Traveston Crossing Dam.

Water infrastructure and its management and operation also need to be seen in the context of the National Water Policy and the National Water Initiative.

Some water infrastructure alternatives may be able to be more easily accommodated than others under the current regulatory framework. Each water infrastructure alternative was assessed as to whether it was more or less likely to incur regulatory obstacles. For example, alternatives which were known to affect Aboriginal cultural heritage were given a lower rating than alternatives which simply sought to increase current reservoir capacity.

- Likely cost

Costing of a water storage infrastructure project is a complex matter and very little information was available with regards to likely cost of the alternatives under consideration. The cost of the recently completed Cloncurry Pipeline was known, as was the cost estimate provided for Cave Hill Dam by Petheram et al. (2013), which included many caveats. The capital cost of Cave Hill Dam was anticipated to be \$249 million, with an equivalent annual unit cost of \$432/ML/year.

Water storage infrastructure options were rated relative to Cave Hill Dam, which received a “1”=very expensive, taking into consideration the size of the dam structure, need for road construction to the dam site, extent of pipe infrastructure required and power connectivity.

- Uncertainty of the alternative with respect to geotechnical and other elements of the project

Among the water infrastructure alternatives considered, Cave Hill Dam was the best researched new dam alternative, yet it still had large geological uncertainties associated with the proposed location (Petheram et al. 2013).

Water storage infrastructure options were rated as less uncertain (ie. received a higher value) if dams already existed and required only pipe infrastructure (e.g. Mary Kathleen), and as highly uncertain if neither geological nor technical analysis existed (e.g. Painted Rock).

- Water quality

Water quality was considered as a potential criterion for the evaluation of water storage alternatives. In particular, it was thought that the legacy of past mining activity upstream from some project locations may constitute a water quality hazard and could conceivably constrain use of water originating from some areas. However, no evidence was found that would allow alternatives to be differentiated on the basis of water quality and consequently ‘water quality’ was not included as a criterion in the MCDA.

3 Situation analysis: Water demand and supply

3.1 Overview

The analysis draws principally on the Regional Water Supply Security Assessment Mount Isa (DEWS 2015) and GHD (2014). It portrays historical and current data and summarises the projections done by these studies. Stakeholder and expert consultations were conducted to provide additional context and explanation.

Key water storages in the Mount Isa – Cloncurry region are Moondarra and Julius dams, both located on the Leichhardt River, downstream from Mount Isa (Figure 4). Moondarra Dam was built by Mount Isa Mines (MIM) and completed in 1958. It has a reservoir capacity of 106,833 mega litres (ML). Further downstream, approximately 70km north of Mount Isa, is Lake Julius, the water reservoir cause by Julius Dam. Julius Dam was built by SunWater and completed in 1979. It has a storage capacity of 107,500ML. The capacity level of Lake Julius has only once, in later 2008, dropped below 60 percent¹.

Lake Moondarra is connected to Mount Isa via an underground water pipeline, which is operated by Mount Isa Water Board (MIWB). Lake Moondarra is downstream of Mount Isa with the altitude difference being approximately 30m. Consequently, water needs to be pumped. MIWB also operates the underground pipeline which connects Lake Julius to Lake Moondarra. Altitude of Lake Julius is approximately 100m below Lake Moondarra, resulting in significant pumping charges to cover both distance and altitude difference. The pipelines are shown in red in Figure 4.

Julius Dam is owned and operated by SunWater. Water from Lake Julius is transported east via the North West Queensland Pipeline, which is shown as black dotted line in Figure 4. The pipeline is owned and managed by the North West Queensland Pipeline Pty Ltd (NWQWP), a wholly owned subsidiary of SunWater. NWQWP delivers bulk water supplies to its customers as its core operation. Its primary assets include low-left and high-left pump stations, the 113km North West Queensland Pipeline and control systems, plus the 38.7km long Cloncurry Pipeline and its two balancing storages and pump station.

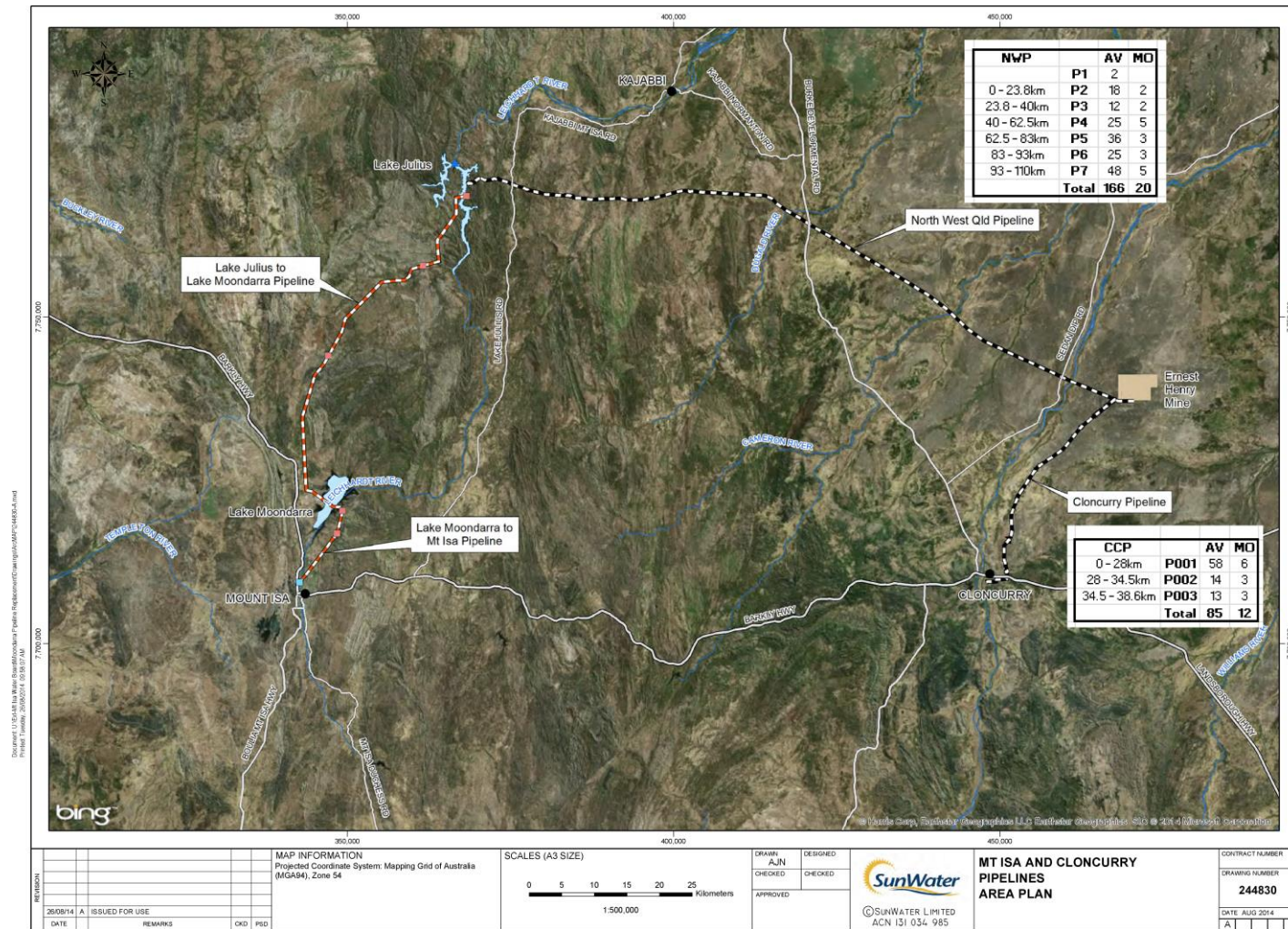
GHD (2014, p. 30) gives technical details of the North West Queensland Pipeline. At kilometre 48, the diameter of the pipeline narrows from initially 660mm to 500mm. In 2014, the “Cloncurry Pipeline” was added, which runs from west of the EHM terminal storage to a 50ML Balancing Storage and Town Water Supply Pump Station at Cloncurry, at a total length of 38km with 450mm diameter.

Lake Julius has a surface elevation of 224m and is therefore higher than Cloncurry, at 186m elevation above sea level. However, due to the terrain, water needs to be lifted before it can be gravity fed east through the North West Queensland Pipeline (G. Jones 18/2/16). Lifting is done by a low-lift pump, which floats on Lake Julius and pumps water into a holding tank, from where it is further lifted by a high-lift pump. Consequently, the pipeline is unidirectional.

The pumping capacity is 290 litres/second. The pumps operate a maximum 16 hours/day to make use of off-peak electricity tariffs, giving a daily pumping capacity of 16.7ML, or 6.1GL/year (G. Jones 18/2/16). Current contracted volume of water to be delivered by NWQWP is 4.66GL/year (3.65GL mining, 0.95GL urban, 0.06GL rural). Assuming all customers use their full entitlements, this leaves a spare capacity of 1.44GL when pumps are operating during standard hours only. Throughput capacity could be increased by up to 50% of current if pumps operated 24 hours/day.

¹ The lowest capacity level recorded was 57.9% on 25 November 2008 (<http://www.mountisawater.qld.gov.au/opendata/>)

Figure 4: Water supply infrastructure in the Mount Isa – Cloncurry Region



(Image courtesy of SunWater, supplied by R. Lewis, 5/2/2016)

Reliability of water supply by NWQWP is dependent on the energy supply to the pumps. Power supply is provided by the MIWB. Power outages can be caused by a number of adverse impacts, including lightning strikes. During 2015, there were 15 power outages with a combined duration of 104.5 hours. In January 2016, 5 power outages were experienced over a total of 207 hours (G. Jones 18/2/2016). To mitigate the risk associated with temporary water delivery problems for customers, SunWater installed a 10ML water storage facility at the pump station in Cloncurry, which has the capacity to store seven days' town water supply (R. Lewis 5/02/2016). Similarly, EHM terminal storage holds 10 days' water demand, while Dougald River Mine has no such risk management strategy.

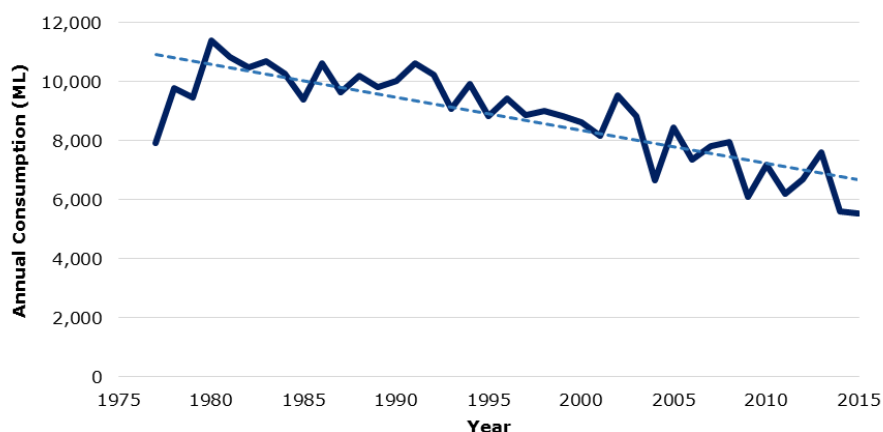
3.2 Urban water demand and supply

3.2.1 Mount Isa

The residential populations of Mount Isa and Cloncurry are approximately 22,000 and 2500, respectively. In the recent past, residential populations have been declining. This, in combination with water saving measures, is reflected in declining residential water demand. In 2015, Mount Isa City Council's (MICC's) water demand was approximately 5.5GL/year (S. Farrelly 28/1/2016), or approximately half of MICC's peak demand of around 11GL/year in the early 1980s (Figure 5).

Residential water use in Mount Isa and Cloncurry is approximately 950 litres per residential connection per day. In Mount Isa, this translates to residential water consumption of approximately 2.8GL/year, or half of MICC usage. The remainder is municipal and light industrial/commercial usage, and leakage. It is estimated that up to 35% of water delivered to MICC may be lost to leakage due to old water infrastructure (S. Farrelly 28/1/2016).

Figure 5: Annual water usage by Mount Isa City Council for years 1975-2015



(Data kindly provided by S. Farrelly, 15/2/2016)

Some population projections see the resident population of Mount Isa increase by up to 20% over the next two decades (e.g. Queensland Government Statistician's Office). The associated increase in water demand to approximately 10GL/year (DEWS 2015) could be met within current storage and infrastructure capacity,

particularly as water demand by the mining sector in the area is likely to decline within two decades (GHD 2014).

MIWB is the bulk water provider for MICC. MICC, in turn, supplies residential and commercial customers. Commercial customers do not include mines. MIM Glencore has its own water supply, though the infrastructure is operated by MIWB.

MIWB uses both Moondarra and Julius Dams for supplying water to MICC—as well as MIM Glencore and other commercial customers. MIWB draws water preferentially from Moondarra Dam due to much lower pumping costs. Take from Julius Dam is triggered typically when Moondarra Dam is below 25% storage capacity. The MIWB operated pump in Lake Julius can safely draw to 8% of that lake’s capacity (S. Farrelly 28/1/2016).

Water supplied by MIWB to MICC is treated to meet potable water standards. After the failure of the biological water filtering system, which caused a severe water shortage in Mount Isa in 2013, a permanent water treatment plant was built in 2014. It has a peak capacity of 25ML/day (S. Farrelly 28/1/2016) and an estimated annual capacity of approximately 9.13GL.

3.2.2 Cloncurry

Cloncurry Shire Council (CSC) operates a local water reticulation network in the town of Cloncurry. CSC draws water principally from Chinaman Creek Dam, just upstream from town, and also operates wells to extract water from the alluvial sands in the Cloncurry River. When full, Chinaman Dam holds 2.8GL—though the dam is shallow consequently much of this water evaporates and is not available for consumption—and the alluvial sands have an estimated annual capacity of 450ML (D. Neeves 28/1/2016).

In 2014, SunWater completed a 37 km extension of the North West Queensland Pipeline from Ernest Henry Mine (EHM) to Cloncurry, at a cost of \$43 million, to drought proof the town. Sunwater supplies up to 950 ML water from Lake Julius to CSC. Sunwater can take water to 17% of Lake Julius’ capacity (R. Lewis 5/2/2016).

While water from Lake Julius is intended to be used by CSC only when local water sources are unable to meet local water demand, CSC draws, on average, 20 litres/second to supplement local water, the reason being the better quality of water from Lake Julius, resulting in reduced repair and maintenance cost of the water treatment infrastructure (D. Neeves 28/1/2016). At this rate, CSC uses 1.73ML of Lake Julius water per day or 631ML/year.

Assuming similar residential water use by Cloncurry households as in Mount Isa, residential water use is approximately 360ML/year. Assuming that municipal and urban-industrial water use is twice residential use, then total annual water demand of CSC is approximately 1GL.

Cloncurry has ambitions for economic development around cropping along the Cloncurry River, e.g. cotton, and agricultural trade and processing, e.g. through the construction and operation of an abattoir. Abattoirs require secure access to a vast amount of potable water. Considerable quantities are required to maintain strict food safety standards. Water is used for washing of livestock and products, and cleaning and sanitising of plant and equipment. Raw water usage is approximately 10.6kL per tonne of carcase weight, or approximately 1500L per head of cattle slaughtered (MLA 2007). If a new abattoir had half the capacity of the new AACo abattoir near Darwin and could process 500 animals per day, the abattoir would require 0.75ML/day, or approximately 200ML/year. Such an abattoir could conceivably employ 150 people and attract families and more businesses into Cloncurry. If, as a result of such economic development, Cloncurry’s resident population was to grow by 250 or 10%, water supply from current sources would still be able to reliably meet demand.

This assessment matches that by CSIRO (Petheram et al. 2013, p.73), which stated that “development of the Chinaman Creek Dam and of the pipeline extension from EHM ensures that urban water supply demands in Cloncurry will be reliably met for the foreseeable future”.

3.3 Mining and mineral processing water demand and supply

3.3.1 Mount Isa precinct

In the Upper Leichhardt Sub-catchment (GHD 2014), key mining water users include MIM-(both Copper and Lead/Zinc/Silver- Glencore), with an expected production life to 2033, George Fisher (Glencore), with a similar lifespan, and Incitec Pivot, with an operating lifetime to 2016. There is one operation in project stage, Barbara, with an expected lifetime from 2015-2020.

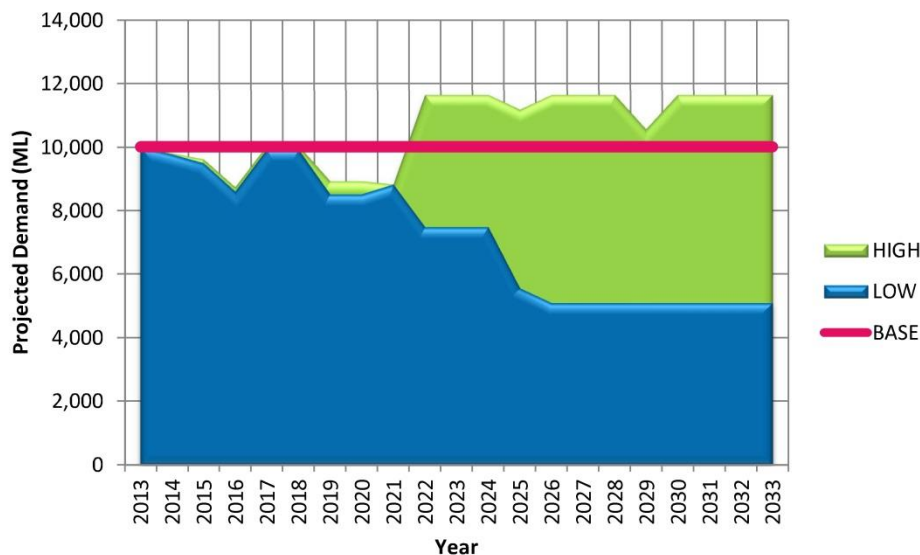
MIM holds a 12.5GL/year water allocation from Moondarra Dam along with an 8.85GL/year water allocation from Julius Dam. Average water use in recent years was approximately 45ML/day, or approximately 16.5GL/year. MIM has introduced water recycling and 80% of water is now being recycled (T. Gray 17/2/2016). There is also infrastructure on-site to capture water, which supplies approximately 1ML/day (S. Farrelly 28/1/2016).

Water demand by Incitec Pivot Acid Plant ranges from 3-5ML/day and amounts to approximately 1.5GL/year (S. Farrelly 28/1/2016).

Valhalla Uranium is currently not in operation.

GHD (2014) estimated that total annual water demand by these operations could either increase from a base level of 10GL/year to approximately 11.5GL/year under a 'high volume' scenario, or could decline from present usage to approximately 5GL/year over the next ten years and then remain at this level until MIM operations cease sometime between 2033 and 2036 (Figure 6).

Figure 6: Projected water demand for mining and processing in the Mount Isa precinct



(Source: GHD 2014, p.23)

Water supply under either scenario is able to be met from current water storages and infrastructure. However, “no one knows what’s around the corner” in terms of new resources identified or viability of currently unviable stock. Either way, “there is no appetite [by MIM] to invest in water infrastructure” (T. Gray 12/2/2016).

3.3.2 Cloncurry precinct

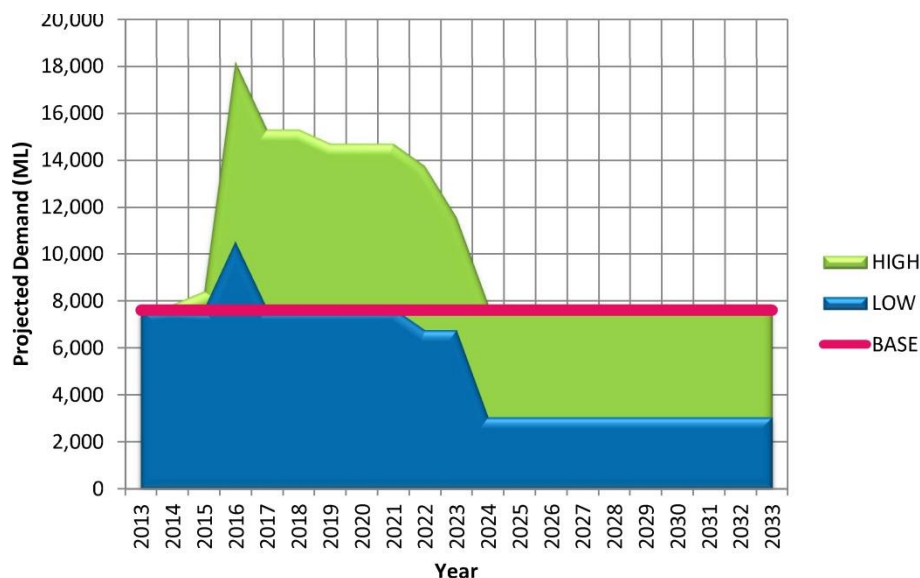
SunWater, via its NWQWP subsidiary, holds a 15GL/year high-priority water allocation in Lake Julius, which it uses to supply customers, predominantly mines, through the North West Queensland Pipeline. The low and high-lift pumps at the Lake Julius end of the North West Queensland Pipeline have a maximum annual capacity (assuming 24 hour operation, no outages) of pumping approximately 9GL/year. At an annual water use by NWQWP of approximately 5.3GL/year, the pipeline is currently “nowhere near capacity” (R. Lewis 5/2/2016).

Ernest Henry Mine (EHM) has a “take-or-pay” agreement with SunWater. Until the anticipated end of the mine’s lifetime in 2026, the allocation will gradually reduce from currently (approximately) 3GL/year. Actual water consumption of EHM has halved from previous levels and is less than half of allocation (A Sexton 9/2/2016). EHM gains approximately 10ML/day (3.6GL/year) from mine de-watering, and re-uses more than half of water used from the tailings dam. It also captures surface water in some on-site dams. EHM has a temporary storage pond for Lake Julius water, at the terminal of the North West Queensland Pipeline, which holds about 10ML.

CuDECO’s Rocklands Project, west of Cloncurry, is set to start production in mid-2016 and has an anticipated life span of 10 years. It anticipates that it will require approximately 1.15GL of “new” water in 2016, increasing to 1.65GL/year in subsequent years (M. Roberts 9/2/2016). “New” water is being supplied from mine de-watering, surface water harvest in the on-site dam (1.5GL capacity), and recycle water supplied by Cloncurry Shire Council. CuDECO has built a pipeline from Cloncurry to the mine site and is in the process of negotiating volume of water supply, terms and price. “New” water is approximately one quarter of the mine’s total water demand, most of which will be met from recovery of water from slurry after processing.

GHD (2014) forecast that water demand of mines in the vicinity of Cloncurry, under a ‘high volume’ scenario, could temporarily double to 15GL/year from a base of 7.8GL/year for a period of ten years—with a short peak of up to 18GL, before returning to current levels after 2025. Alternatively, under a ‘low volume’ scenario, water demand is likely to remain at current levels for the next decade, and then decline to approximately 3GL/year (Figure 7).

Figure 7: Projected water demand for mining and processing in the Cloncurry area



(Source: GHD 2014, p. 25)

Water supply under each of these scenarios can be accommodated with current water supply from Lake Julius and current pipeline infrastructure, which is able to supply 15GL/year of high security water. Peak demand would require additional water sources, which are likely to be found on-site, from de-watering, water recycling and on-site surface water abstraction.

3.4 Agriculture

There is a small, 60ML/year water allocation currently held by agricultural users along the North West Queensland Pipeline. This provides for stock water to pastoralists whose land the pipeline traverses.

There are some pastoralists who have micro irrigation systems downstream from Lake Julius on the Leichhardt River and who opportunistically produce irrigated fodder crops such as sorghum to boost beef production. Michael and Hannah Crisp, managers of Lorraine Station, have been harvesting and storing water from the Leichhardt River in high-flow years and growing hay and silage on approximately 900 hectares of the property. The dry matter yield from irrigated sorghum is approximately 10tonnes/ha using 10ML/ha of irrigation water (M. Crisp 13/1/2016).

CSIRO (Petheram et al. 2013) identified that some pastoralists in the Cloncurry River catchment, particularly downstream from Cloncurry, have moderately suitable soils for small-scale irrigation developments and some have larger areas that are sufficiently large for scheme-scale irrigation (Grice et al. 2013).

Investigations into irrigation in the area have focussed on irrigating pasture. Grice et al. (2013) provided appropriate forage crops are planted, could improve quantity, quality and reliability of on-property production of forage and consequently change beef production enterprises and improve their financial positions. Irrigated forage generates a substantive increase in beef production from the same area of land. There is already mosaic irrigation of pasture happening. Based on this local experience with micro irrigation, demand for water of approximately 10ML/year can be expected to yield production of approximately 15-20 tonnes of dry matter per ha. In the north of Western Australia, the integration of irrigation units for forage production into cattle production systems is already widely recognised (Chilcott 2009). Beef enterprises with integrated irrigated forage production can reach turn-off weights sooner, meet markets with higher specifications and gain price premiums by turning off animals at times of the year when prices are higher.

Grice et al (2013, p.10) estimated that “16 ha of irrigated forage could be used to feed one hundred 30-month-old 450-kg Brahman steers in order to have them reach 560 kg live-weight in three months. This yields an average net return of approximately \$16,000/yr or a marginal annual return of approximately 12% on capital investment.” A net return of \$1000/ha/yr of irrigated pasture is approximately 20-30 fold the net return on un-irrigated native pasture in this region (Greiner, Bliemer et al. 2014). The remarkable increase in net return is reflective of much improved carrying capacity of irrigated pasture compared to native pasture, resulting in higher beef production from the same area. It is also reflective of higher quality cattle being produced and turned off more rapidly.

If the required associated infrastructure investment could be realised² and irrigated forage production was to become a feature in the proximity of Cloncurry, this could conceivably result in more cattle of better quality being produced in the area. This, in turn, would strengthen the business case of the abattoir proposed for Cloncurry. It could also generate animal welfare benefits by reducing the need for long-distance transport of cattle south for finishing and/or slaughter.

² Grice et al (2013, p.11) estimate the initial capital outlay for a 100 ha irrigation unit to be in the vicinity of \$700,000 to several million dollars, including design and survey, land clearing and preparation, water supply and purchase of machinery. Running costs are also said to be ‘substantial’.

The climate and some soils in the lower Cloncurry River catchment are potentially also suited to a wider range of irrigated crops (Webster et al. 2013). Suitable horticultural and broad-acre crops are those produced in the Ord River Irrigation area. Crops grown could conceivably include cotton, sorghum, rice, maize and peanuts (Wittwer and Banerjee 2015). In 2010, the Ord River Irrigation Area produced \$24 million worth of produce on 8500 hectares, which equates to approximately \$2800 of output per hectare (ABS 2012; ABS 2012). While financial output depends on many factors and it is unknown whether similar returns may be expected in the Cloncurry area.

It is unlikely, however, that a new irrigation enterprise will make a profit in the first five years of operation and “a 15-year cash flow budget would be a very good idea before starting development, to ensure that one was still solvent when the business was able to make a profit” (P. Stone 8/2/2016).

Stone (8/2/2016) also points out that the micro-irrigation from on-farm water storage tends to be more cost efficient in places like northern Australia that exhibit very high rainfall variability and have little suitable in-stream storage options. In terms of order of magnitude, it would “cost \$40,000/ha for large in-stream dam, water delivery and land development [while a] scaled land-water development for off-stream storage is of the order of \$10,000/ha.”

3.5 Uncommitted water

At the time when the Consultant Study was conducted, there were approximately 10GL/year of high priority water available for purchase/lease from Lake Julius. Sunwater holds this allocation (Figure 3). MIWB also had approximately 2.35GL/year of its water allocation available for sale or lease.

Uncommitted and consequently unused water remaining in Lake Julius effectively improves water security for existing water users.

GHD (2014) asserts that “currently” uncommitted water could service all “high scenario” water demand futures investigated in that report.

3.6 Projected demand and water security

DEWS (2015) conducted water demand and security modelling under different growth scenarios. Under the high-growth scenario, water demand was predicated to grow to approximately 33.1GL/year by 2033. Under the low-growth scenario, total water demand would increase to 32.1GL/year by 2023 and then decline to around 26.6GL/year by 2033.

The DEWS modelling (DEWS 2015) estimated that the physical capability of the combined Lake Moondarra and Julius water supply system could conceivably meet total annual demands of up to 48GL/year with a failure likelihood of less than one in 1000. Assuming total water demand of 25GL/year, industry level 3 water restrictions would likely occur once in 770 years, on average, and if demand was 39.45GL/year, estimated frequency of restrictions would likely increase to once in 110 years on average.

As indicated earlier (Section 2.2), Mount Isa has experienced water shortages in the past. However, these were due to reasons other than shortage of water supply in Lake Julius. When water restrictions are imposed by MICC, it is mostly for economic reasons: Pumping water from Lake Julius is expensive and thus it is prudent that MICC as well as mining and industrial water users have water restriction regimes in place to reduce water demand during periods of low water availability, i.e. when Lake Moondarra is low.

3.7 Vulnerability to water shortages

As relates to vulnerability of water users in the Mount Isa—Cloncurry Region to water shortages, the findings of the situation analysis can be interpreted to the following effect:

- The exposure of existing water users in the Study Area to water shortages is low given current (January 2016) level of physical supply, level of unused water allocations, and infrastructure to meet existing water demand.
If irrigated agriculture was to be part of the regional economy, agriculture would likely have the lowest security of water and would therefore have the highest exposure to water shortages.
- Sensitivity to potential water shortage is high, particularly for the mining sector as processing would be most immediately affected if water demand could not be met. Despite increasing focus on water recycling and on-site capture of surface and groundwater, all mining operations rely on additional water from external sources for full operation.
For urban/residential water users, quality of life would be severely affected if harsh water saving measures had to be implemented, e.g. if parks and gardens could not be watered or if swimming pools had to be closed because of physical water shortage. Evacuation would be a real option in extreme circumstances.
Irrigated agricultural development in the region would need to be undertaken to minimise sensitivity to potential water shortages, e.g. by focussing on annual crops.
- Adaptive capacity is low. The mining sector has already implemented strategies of diversified sourcing and water recycling to limit dependence on external water sources. A sudden increase in new mines activity will require additional water even if some existing mines are winding back activity.
Urban populations are quite small and urban water use is consequently relatively small. For urban/residential water users, there is scope for reducing water consumption, however quality of life may be severely affected.

Overall, aggregating aspects of exposure, sensitivity and adaptive capacity, it can be concluded that social and economic functioning with Mount Isa—Cloncurry Region is vulnerable to a shortage of water supply.

4 Water infrastructure alternatives

The core purpose of this investigation was to identify and review water infrastructure alternatives, both new storages and upgrades to existing infrastructure, which would increase the availability and security of water in the Mount Isa – Cloncurry area.

Starting point for consideration were the options contained in GHD (2014), Petheram et al. (2013) and CSIRO (2009). Alternatives which were located downstream from Lake Julius on the Leichhardt River and downstream from Cloncurry on the Cloncurry River were not considered. Regional stakeholder consultations revealed additional options.

Table 4 lists the water storage and infrastructure alternatives considered in this Study. It provides geo-references for the position of the proposed (or existing) dam, which are more accurate than in-stream references ('AMTD'). In cases where multiple locality definitions existed in the literature, the exact location was determined by GIS modelling and aerial survey. Catchment size and mean annual rainfall in the catchment are also shown. The alternatives are further illustrated in their geographical context in Figure 8.

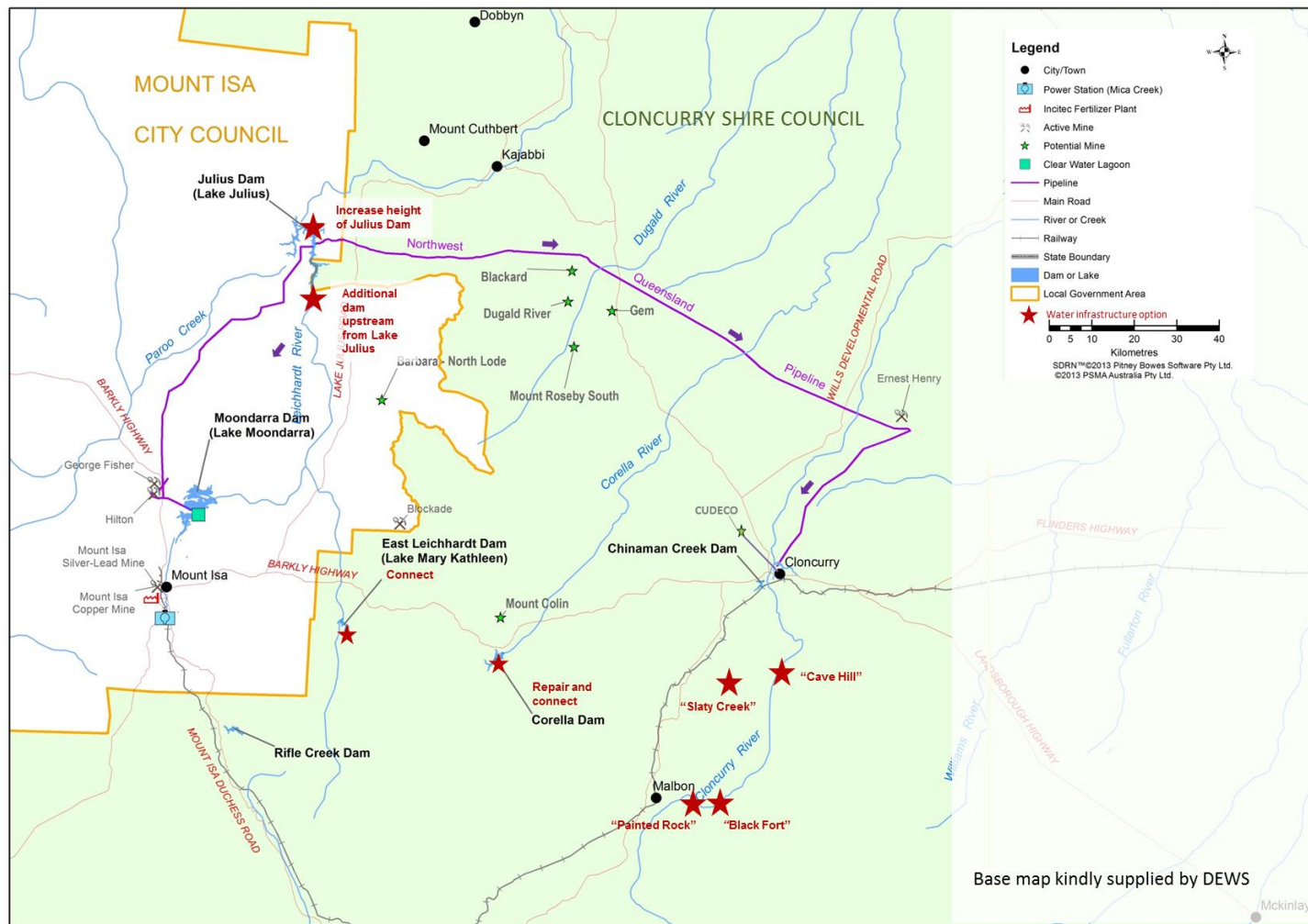
Table 4: Water storage and infrastructure alternatives considered

Alternatives	Dam georeferences		Catchment description			Rainfall
	Latitude dam outlet	Longitude dam outlet	Catchment area (km ²)	Latitude catchment centroid	Longitude catchment centroid	Mean rainfall (mm/year)
Cloncurry River - Single Storage						
Cave Hill	-20.87	140.49	5265	-21.18	140.32	412
Black Fort	-21.08	140.42	4245	-21.22	140.29	408
Painted Rock	-21.08	140.37	4167	-21.23	140.29	408
Slaty Creek	-20.90	140.41	305	-20.88	140.30	458
Cloncurry River - Multiple Storages						
Black Fort AND Slaty Creek	refer to above		4550			430
Leichhardt River						
Julius Dam--increase capacity	-20.14	139.73	4743	-20.59	139.64	443
New dam upstream from Lake Julius	-20.25	139.74	4743	-20.68	139.66	443
Existing unused dams						
Corella--repair, connect	-20.84	140.04	335	-20.85	139.96	493
Mary Kathleen--connect	-20.79	139.78	363	-20.76	139.51	457

Alternatives were grouped based on catchment location, and whether they are existing or new infrastructure.

Two water storages are already in existence but water is not currently being used, these being Corella Dam and Mary Kathleen Dam (East Leichhardt Dam). These would require pipelines installed to make the water available to current water users.

Figure 8: Geographical illustration of water infrastructure alternatives



There are four dam alternatives considered in the upper Cloncurry River catchments, three on the main stream and one in the Slaty Creek sub-catchments. Combinations of dams in that catchment were also considered, with the combination of Black Fort and Slaty Creek locations sought to warrant further investigation.

On the Leichhardt River, the option of increasing the height of Julius Dam and therefore the capacity of Lake Julius was included, as was the option of building an additional dam just upstream from Lake Julius.

4.1 New water storage in the upper Cloncurry River catchment

4.1.1 Cave Hill Dam

‘Cave Hill’ is located some 18km south of Cloncurry. It the only site within the Cloncurry River catchment shortlisted in a CSIRO report (Petheram, Watson et al. 2013) as a “promising site” for a dam, one of three in the entire Flinders River catchment. The report noted, however, that “none of these three [...] options was considered to stand out as particularly well suited for development” (p.xi) and noted uncertainty about the physical foundation. A detailed description of Cave Hill Dam is provided in Petheram et al (2013, pp 70-79) with key parameters repeated here.

The Cave Hill Dam would be capable of storing 248GL of water with a yield of 40GL per year at 80% annual time reliability. It had a projected height of spillway of 16m above the riverbed (FSL 224) and would be over 700m in length. An artistic impression of the dam is given in Figure 9. An additional saddle dam to the west, some 900m long and up to 5m high, would be required to contain flood rises in the reservoir. The reservoir surface area, when full, was an estimated 50km² (see Figure 10) and resulting in a shallow lake with high evaporation losses (at a rate of 6.0mm/day).

Figure 9: Artist’s impression of possible Cave Hill Dam



(Source: Petheram et al. 2013, p.74)

Despite being in a topographically unfavourable location for a dam and known geological difficulties of the site, Cave Hill Dam was nominated by CSIRO as a 'preferred site' because it could supply about 40GL of water in 85% of years and because of its proximity to Cloncurry and some land downstream of the dam that was "moderately suitable" for irrigated agriculture. The report emphasised that the viability of the proposal was dependent on favourable assumptions about the foundation to be correct (p. 72), which was unlikely to be the case, and stated that that "the economic viability of a Cave Hill Dam based proposal would [...] be solely dependent on irrigated agricultural production" (p.75).

Cave Hill Dam was considered by the Joint Select Committee of Northern Australia in 2014 and put forward for further consideration on the basis that it provided a way of increasing supply of town water to Cloncurry, thereby supporting potential development for a feed lot and abattoir, and expansion of mining and industry (JSCNA 2014). An investigation by the Department of Agriculture found that Cave Hill Dam, along with other water infrastructure options in the region, required more information from state and territory government to inform categorisation (DA 2014).

Of the alternatives, Cave Hill Dam has the largest reservoir capacity. It also has a large footprint and would inundate large areas of floodplain, having a surface area at full capacity of approximately 49km². The reservoir would have shallow water storage depths. One year's evaporation (2.19m) results in estimated water loss equivalent to 39% of storage. It is close to Cloncurry and the closest project to areas that have been identified as having potential for irrigated agriculture. Due to its proximity to major roads, it also has potential to support regional tourist activity.

Figure 10: Cave Hill Dam footprint (full supply level)



4.1.2 Black Fort Dam

In the literature, multiple locations are referred to as “Black Fort”. Petheram et al (2013) put it at AMTD 415.8 on the Cloncurry River and made reference to “Black Fort” and “Painted Rock”, while QWRD (1980) put the location at AMTD 371.1. Aerial inspection identified the location given in Table 4 as most likely to be best suited for construction of a dam. Further detail is available in Petheram et al (2013, pp.194-202).

The option provides the potential to have water diverted north (to Cloncurry) or be pumped south to Duchess area. Water could be released downstream however this would result in river conveyance losses.

It has been identified that this option has potential leakage issues associated with the site’s underlying geology.

The site has a catchment area of 4240km² and has a full supply level (assuming a 16m wall height) of 152GL. The surface area of the full dam would be approximately 26km² (see Figure 11). Evaporation has been estimated to lower the storage by 33% to 102GL in the first year, and then to 65GL in the second year (assuming a full dam at the start and no inflow over the two years).

Figure 11: Black Fort Dam footprint (full supply level)



There is an Aboriginal historical site located in the Cloncurry River at GPS UTM, coordinates 54K 0435114 – 7667769. It would appear, that the art site falls within the footprint of the Black Fort storage area (R. Whitehead 29/2/2016).

4.1.3 Painted Rock Dam

This site is located approximately 6.5km upstream of the Black Fort site. The site is named after the painted rock which is located in the river channel. It is an Aboriginal cultural site and likely to be below the dam wall and therefore outside the dam footprint (R. Whitehead 29/2/2016).

The site has a catchment area of 4167km² and has a full supply level (assuming a 16m wall height) of 200GL. The surface area of the full dam would be approximately 49km² (see Figure 12). Evaporation has been estimated to lower the storage by 42% to 117GL in the first year, and then to 63GL in the second year (assuming a full dam at the start and no inflow over the two years).

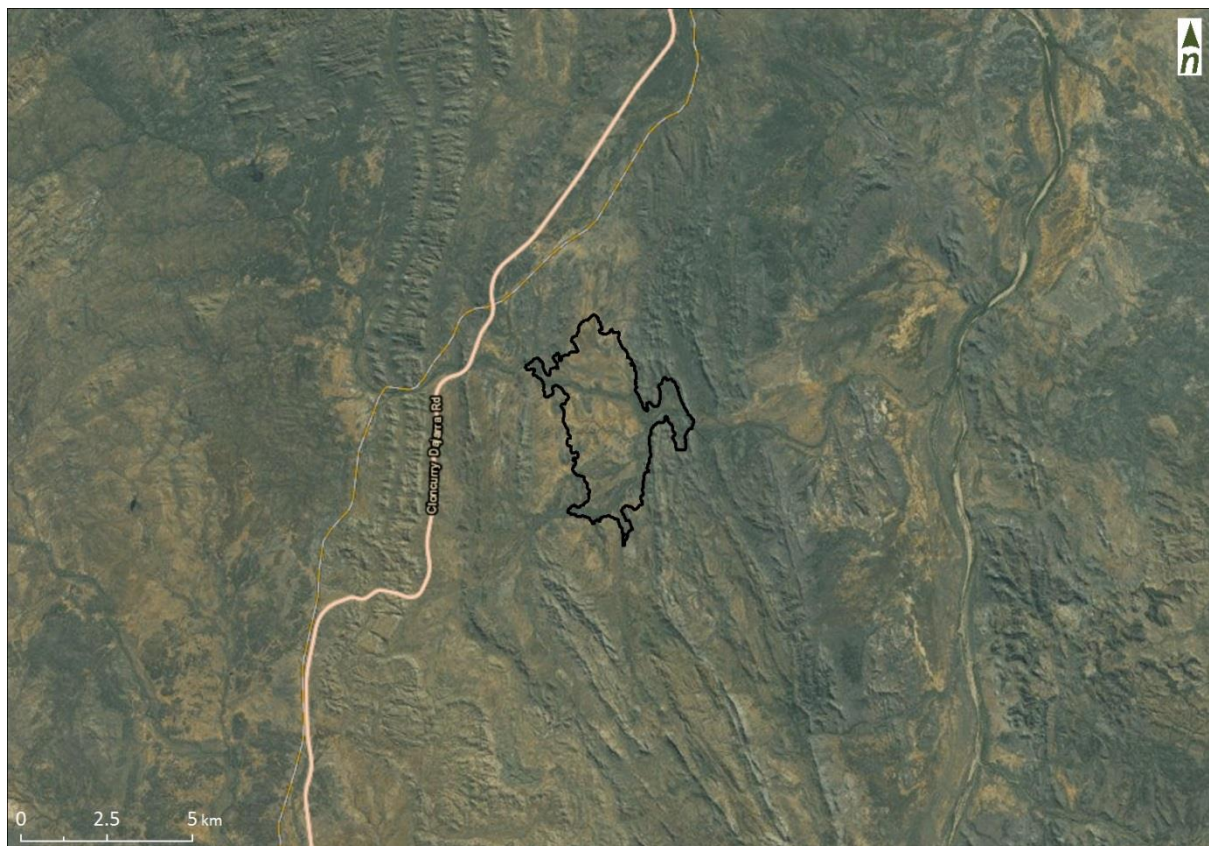
Figure 12: Painted Rock Dam footprint (full supply level)



4.1.4 Slaty Creek

This dam site is located on Slaty Creek, approximately 6.5km downstream of the Cloncurry Dajarra Road crossing. The dam wall can be constructed to approximately 15m high before the full supply level would interfere with the road upstream, however given the relatively smaller upstream catchment area the structure has been assessed on an assumed 10m wall height.. The catchment area is approximately 305km² with a full volume of 45GL. The surface area of the dam has been estimated to be approximately 13km² (see Figure 13). Evaporation has been estimated to lower the dam by 53% to 21GL in the first year and 8GL in the second year (assuming a full dam at the start and no inflow over the two years).

Figure 13: Slaty Creek Dam footprint (full supply level)



4.1.5 Combination of Black Fort Dam and Slaty Creek

This option consists of the direct combination of Slaty Creek and Black Fort Dam. Refer to sections 4.1.2 and 4.1.4 for further details.

The rationale for considering this combination alternative is that it would capture surface water from the main Cloncurry River channel as well as that of the Slaty Creek, which is a tributary to the Cloncurry River. That combination would give a similar volume of flow to Cave Hill Dam. In comparison to Cave Hill, the alternative would have the advantages of firstly, requiring two very much smaller dam structures and, secondly, offering the possibility of working on either dam without the entire storage capacity being affected.

4.2 Increasing the capacity of the Lake Julius water supply

Lake Julius has a maximum depth of 25.2m and an average depth of 8.9m. The reservoir capacity is 107.5GL and the surface area, when full is 12.5km². The dam is unique in Queensland and is a concrete multiple arch and buttress type structure, with the spillway discharging over the tops of the arches. The spillway crest is 18.3m above bed level. The arch barrels, founded on a triangular arch base, are constructed in independent arch rings and are hinged at buttress springing lines. The spillway is a precast superstructure and the dissipation slab at ground level is post tensioned to the foundation rock (Wikipedia.org).

The relief and geology of the Leichhardt River catchment in the vicinity of Lake Julius lends itself to the idea of increasing water storage capacity here, as the gorge provides relatively deep water storage and therefore limits evaporation losses.

Conceivably, based on the terrain, it would be possible to raise Julius Dam and increase the storage capacity of Lake Julius. Benefits of this option include existing road access to the site and electricity infrastructure to site. There haven't been any previous studies undertaken into raising Julius Dam (G. Jones 18/2/2016). The nature of the original dam construction does not lend itself to easily being raised as it is constructed in segments rather than as a continuously structure. If the dam could be raised by 5m —or if a new dam was to be constructed to an equivalent height-- (see Figure 14), the storage volume of Lake Julius could be increased by 62GL. Additional evaporation losses due to the larger footprint would only be 9% of additional storage created—which is a small percentage relative to the other options, making this alternative the most reliable of all the options.

Figure 14: Increased footprint after raising Julius dam (full supply level)



It may also be possible to build an additional dam on the Leichhardt River, just upstream from Lake Julius, which would have similarly beneficial topographic characteristics, and could be used to top up Lake Julius, with water being able to be distributed through current distribution infrastructure.

The site has a catchment area of 3714 km² and has a full supply level (assuming a 18m wall height) of 64GL. The surface area of the full dam would be approximately 8.5km² (see Figure 15). Evaporation has been estimated to lower the storage to 46GL in the first year, and then to 32GL in the second year (assuming a full dam at the start and no inflow over the two years).

Figure 15: New dam upstream of Lake Julius footprint (full supply level)



4.3 Utilising currently unused water storage infrastructure

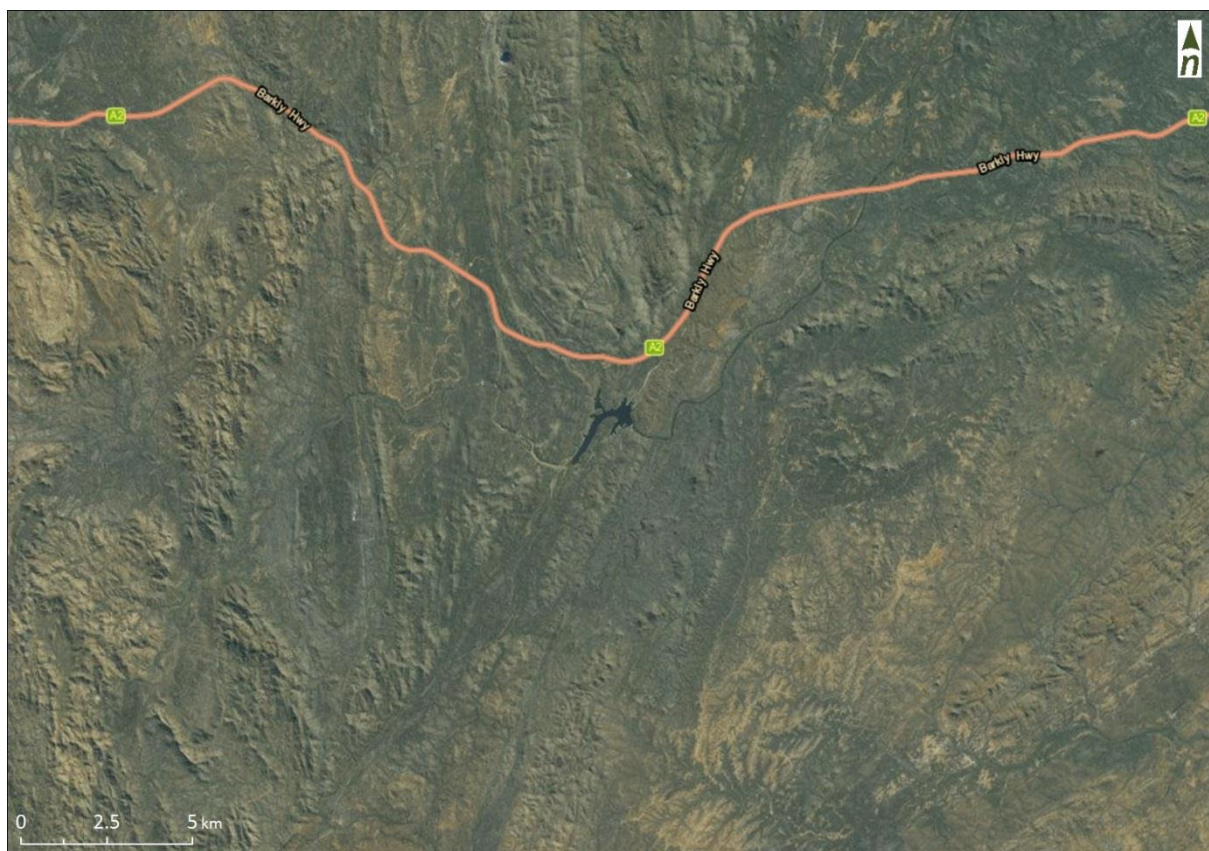
There are two nearby dam storages which are unutilised for water supply and have been considered in this study.

4.3.1 Corella Dam

The dam (see Figure 16) was constructed in the 1950s to supply water to the Mary Kathleen Uranium township and mine. It has a catchment area of 335km² with a full supply level of 10GL (approximately). The dam is owned by the Queensland State Government and managed by DEWS.

There is a 2500ML allocation of surface water, which is unused, and available for purchase or leasing.

Figure 16: Corella Dam footprint



4.3.2 Lake Mary Kathleen

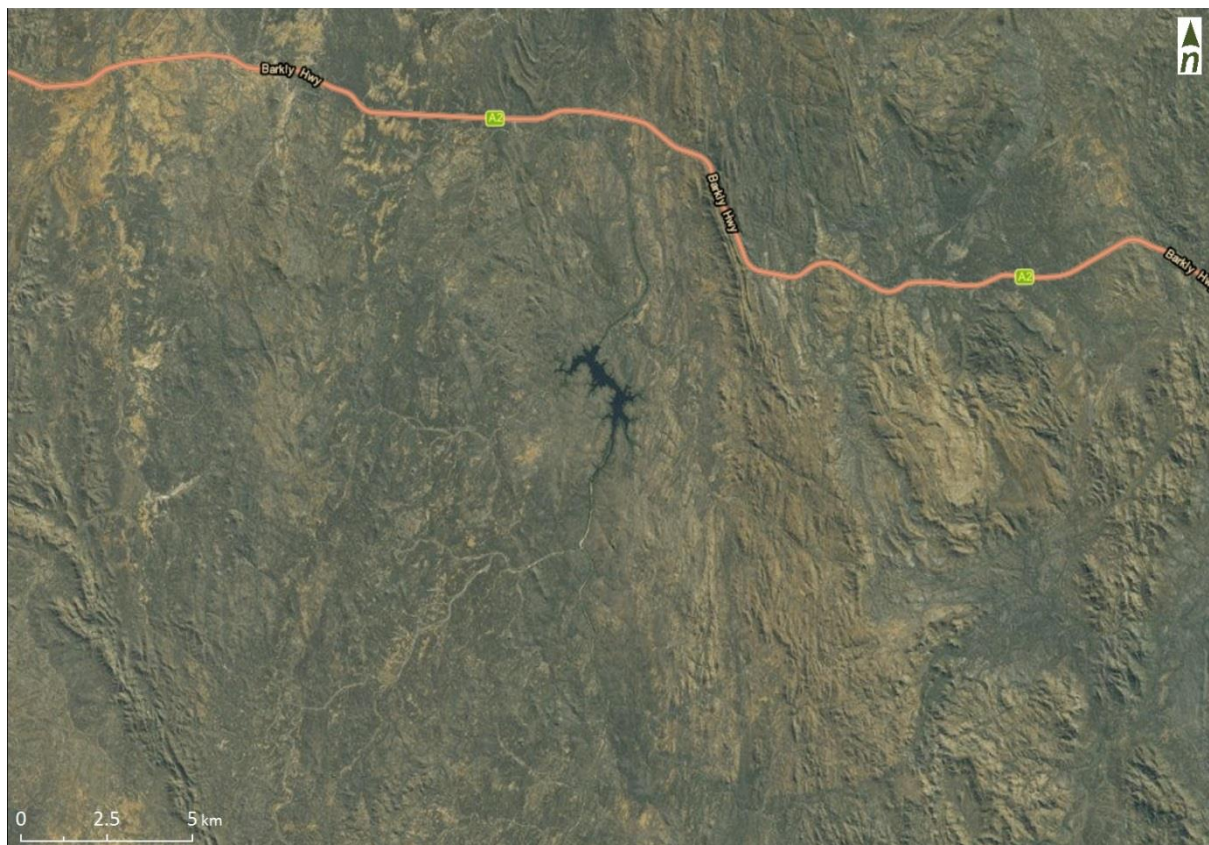
Lake Mary Kathleen is the water body impounded by the East Leichhardt Dam (Figure 17). East Leichhardt Dam was built in 1961 to provide emergency water supply for Mary Kathleen Uranium but the water was not needed.

The dam is owned by the Queensland State Government and managed by DEWS. When full, Lake Mary Kathleen's capacity is approximately 12 GL. There is a 1100ML surface water allocation, which is unused and currently available for purchase or leasing.

Given its location only 25km east of Mount Isa and elevation approximately 100m above that of Mount Isa, it is conceivably easy and relatively cheap to construct a pipeline and make this water available for use in Mount Isa, even if some low-lift pumping would be involved.

No evidence has been found of any water quality concerns associated with this alternative.

Figure 17: Lake Mary Kathleen footprint



5 Ranking of water infrastructure alternatives using MCDA

5.1 Parameterisation

Each of the nine water infrastructure alternatives (Section 4) was assessed against each of the MCDA criteria (Section 2.3). Assessment of alternatives against the qualitative criteria was initially conducted by the project team, then reviewed during the stakeholder meeting convened on 19 February 2016 (Table 3). Thus, parameter values for the qualitative MCDA criteria represent consensus opinion.

Tables 5 and 6 show the modelled parameter estimates used to assess performance of the alternatives. Table 7 shows the qualitative assessments.

Table 5: Evaluation of effective additional water supply provided by infrastructure option

	Existing storage capacity	Dam height (spillway)	Reservoir Capacity Added	Surface Area Added	Evaporation losses y1+2	Remaining volume 2y with no rain	Storage efficiency
	GL	m	GL	km2	GL	GL	(%)
Cloncurry River - Single Storage							
Cave Hill	0	16	241	49	162	79	33%
Black Fort	0	16	152	26	88	64	42%
Painted Rock	0	16	200	49	138	62	31%
Slaty Creek	0	10	45	13	37	8	18%
Cloncurry River - Multiple Storages							
Black Fort + Slaty Creek	0	16+10	197	39	125	72	37%
Leichhardt River options							
Julius Dam--increase capacity	107	5	62	4.6	12	50	81%
New dam just upstream from Lake Jul	0	16	64	8.5	32	32	50%
Currently unused existing infrastructure							
Corella--repair, connect	10	23	10	0	0	5	50%
Mary Kathleen--connect	12	20	12	0	0	6	50%
Min						5	18%
Max						79	81%

Table 6: Evaluation of reliability of supply provided by infrastructure option

	Yield at 85% reliability GL
Cloncurry River - Single Storage	
Cave Hill	40
Black Fort	32
Painted Rock	31
Slaty Creek	4
Cloncurry River - Multiple Storages	
BF+SC	36
Leichhardt River	
Julius Dam--increase capacity	50
New dam just upstream from Lake Jul	16
Currently unused existing infrastructure	
Corella--repair, connect	3
Mary Kathleen--connect	3
Min	3
Max	50

Table 7: Qualitative assessment of water infrastructure options against qualitative criteria

Qualitative assessments against criteria: 1="very poor" to 5="very good"	Added resilience	Proximity / Connectivity	Additional uses	Sedimen- tation	Potential compliance issues	Likely cost	Uncertainty around site
	1=same sources; 5=new source/ redundancy	1=long way away; 5=close/ connected	1=none; 5=good for agriculture + tourism	1=high, 5=very little	1=(almost) certain, 5=highly unlikely	1=Very high, 5=very low	1=very high, 5=very low
Cloncurry River - Single Storage							
Cave Hill	5	3	5	1	3	1	3
Black Fort	3	2	5	1	1	1	2
Painted Rock	3	2	5	1	2	1	1
Slaty Creek	2	2.5	5	3	4	4	2
Cloncurry River - Multiple Storages							
BF+SC	4.5	2	5	2	3	1	2
Leichhardt River							
Julius Dam--increase capacity	3	3	2	5	3	3	4
New dam just upstream from Lake Jul	3	3	2	5	4	3	3
Currently unused existing infrastructure							
Corella--repair, connect	2	1	2	2	5	4	5
Mary Kathleen--connect	2	2	1	2	5	5	5
Min	2	1	1	1	1	1	1
Max	5	3	5	5	5	5	5

5.2 Criteria weighting and results of the MCDA

Stakeholder consensus on criteria weights was achieved in the facilitated meeting on 19 February 2016 (Table 3).

Among criteria, the alternatives' contribution to the resilience of the regional water supply system was deemed the most important criterion (weighting 0.3), followed by the reliability of water storage (weighting 0.2). Size of storage and suitability of the infrastructure to support agricultural development and tourism were both weighted at 0.15. Other criteria had minor weighting or no weighting (cost).

Table 8 gives the resulting MCDA matrix, aggregate scores of alternatives, and ranking of alternatives.

Thus, on the basis of the alternative performance and assessment and criteria weighting, the Cave Hill Dam alternative emerges as the preferred water infrastructure alternative.

Given the chosen criteria weighting, Cave Hill Dam was the superior alternative principally because of its location on the Cloncurry River helps to build water supply resilience in the region, its large storage volume, and because its locality upstream from areas that have potential for irrigated agriculture development.

The 2nd ranked alternative is the combination of two dams at Black Fort and Slaty Creek which shares similar benefits though further upstream, and has the added bonus of adding more resilience due to being two separate dams.

Table 8: MCDA matrix, criteria weightings and resulting ranking of water infrastructure alternatives

CRITERIA	C1 Size of Effective Storage	C2 Reliability	C3 Added regional resilience	C4 Proximity / Connectivity	C5 Suitable for agriculture + tourism	C6 Sedimenta tion / Lifespan	C7 Absence of regulatory issues	C8 Likely cost	C9 Uncertainty around proposal	Aggregate Score (max=10)	Rank
Criteria weights	0.15	0.20	0.30	0.05	0.15	0.05	0.05	0.00	0.05	1.00	Note: model is good
ALTERNATIVES											
Cloncurry River - Single Storage											
Cave Hill	1.00	0.41	1.00	1.00	1.00	0.20	0.60	0.20	0.60	8.0	1
Black Fort	0.81	0.52	0.67	0.67	1.00	0.20	0.40	0.20	0.40	6.6	4
Painted Rock	0.78	0.38	0.67	0.67	1.00	0.20	0.20	0.20	0.20	6.1	6
Slaty Creek	0.10	0.22	0.44	0.83	1.00	0.60	0.80	0.80	0.40	4.7	7
Cloncurry River - Multiple Storages											
Black Fort AND Slaty Creek	0.91	0.45	1.00	0.67	1.00	0.40	0.60	0.20	0.40	7.8	2
Leichhardt River											
Julius Dam--increase capacity	0.63	1.00	0.67	1.00	0.40	1.00	0.60	0.60	0.80	7.2	3
New dam just upstream from Lake Ju	0.41	0.62	0.67	1.00	0.40	1.00	0.80	0.60	0.60	6.1	5
Currently unused existing infrastructure											
Corella--repair, connect	0.06	0.62	0.44	0.33	0.40	0.40	1.00	0.80	1.00	4.6	8
Mary Kathleen--connect	0.08	0.62	0.44	0.67	0.20	0.40	1.00	1.00	1.00	4.5	9

5.3 Sensitivity testing

The results of any MCDA are sensitive to the criteria weights that are applied.

Because there are so many criteria used in the assessment of water infrastructure alternatives and because the majority of these criteria are qualitative, a structured sensitivity analysis does not offer a suitable approach. Instead, a series of alternative options for criteria weightings were explored for illustration purposes, to show whether and how a different set of priorities would affect the resulting preferred alternative.

Table 9 and 10 illustrates that the ranking of alternatives, and the resulting preferred alternative, is entirely sensitive to which criteria are included and the weighting of these criteria. This highlights that each water infrastructure alternative has different strengths and weaknesses and that there is no alternative that delivers best on all criteria.

For example, focussing on likely cost with equal consideration of size, reliability and likely lifespan of the dam, and its contribution to regional water supply resilience, results in an upgrade of Julius Dam emerging as the highest ranked alternative.

Or, focussing on regulatory matters and cost rather than dam size results in connecting East Leichhardt Dam (Lake Mary Kathleen) to current Mount Isa water supply being the highest ranked alternative. Accessing water from Lake Mary Kathleen has been previously explored as an option to help drought-proof Mount Isa (Xstrata_MIM 2013).

Table 9: Alternative MCDA result achieved with different criteria weights—focus on cost, size, reliability, resilience, lifespan and considering uncertainty

CRITERIA	C1 Size of Effective Storage	C2 Reliability	C3 Added regional resilience	C4 Proximity / Connectivity	C5 Suitable for agriculture + tourism	C6 Sedimenta tion / Lifespan	C7 Absence of regulatory issues	C8 Likely cost	C9 Uncertainty around proposal	Aggregate Score (max=10)	Rank
Criteria weights	0.15	0.15	0.15	0.00	0.00	0.15	0.00	0.30	0.10	1.00	Note: model is good
ALTERNATIVES											
Cloncurry River - Single Storage											
Cave Hill	1.00	0.41	1.00	1.00	1.00	0.20	0.60	0.20	0.60	5.1	6
Black Fort	0.81	0.52	0.67	0.67	1.00	0.20	0.40	0.20	0.40	4.3	8
Painted Rock	0.78	0.38	0.67	0.67	1.00	0.20	0.20	0.20	0.20	3.9	9
Slaty Creek	0.10	0.22	0.44	0.83	1.00	0.60	0.80	0.80	0.40	4.8	7
Cloncurry River - Multiple Storages											
Black Fort AND Slaty Creek	0.91	0.45	1.00	0.67	1.00	0.40	0.60	0.20	0.40	5.1	5
Leichhardt River											
Julius Dam--increase capacity	0.63	1.00	0.67	1.00	0.40	1.00	0.60	0.60	0.80	7.5	1
New dam just upstream from Lake Ju	0.41	0.62	0.67	1.00	0.40	1.00	0.80	0.60	0.60	6.4	2
Currently unused existing infrastructure											
Corella--repair, connect	0.06	0.62	0.44	0.33	0.40	0.40	1.00	0.80	1.00	5.7	4
Mary Kathleen--connect	0.08	0.62	0.44	0.67	0.20	0.40	1.00	1.00	1.00	6.3	3

Table 10: Alternative MCDA result achieved with different criteria weights—focus on cost and regulatory ease, reliability, lifespan and size

CRITERIA	C1 Size of Effective Storage	C2 Reliability	C3 Added regional resilience	C4 Proximity / Connectivity	C5 Suitable for agriculture + tourism	C6 Sedimenta tion / Lifespan	C7 Absence of regulatory issues	C8 Likely cost	C9 Uncertainty around proposal	Aggregate Score (max=10)	Rank
Criteria weights	0.10	0.20	0.00	0.00	0.00	0.10	0.30	0.30	0.00	1.00	Note: model is good
ALTERNATIVES											
Cloncurry River - Single Storage											
Cave Hill	1.00	0.41	1.00	1.00	1.00	0.20	0.60	0.20	0.60	4.4	7
Black Fort	0.81	0.52	0.67	0.67	1.00	0.20	0.40	0.20	0.40	3.9	8
Painted Rock	0.78	0.38	0.67	0.67	1.00	0.20	0.20	0.20	0.20	3.0	9
Slaty Creek	0.10	0.22	0.44	0.83	1.00	0.60	0.80	0.80	0.40	5.9	5
Cloncurry River - Multiple Storages											
Black Fort AND Slaty Creek	0.91	0.45	1.00	0.67	1.00	0.40	0.60	0.20	0.40	4.6	6
Leichhardt River											
Julius Dam--increase capacity	0.63	1.00	0.67	1.00	0.40	1.00	0.60	0.60	0.80	7.2	2
New dam just upstream from Lake Ju	0.41	0.62	0.67	1.00	0.40	1.00	0.80	0.60	0.60	6.8	4
Currently unused existing infrastructure											
Corella--repair, connect	0.06	0.62	0.44	0.33	0.40	0.40	1.00	0.80	1.00	7.1	3
Mary Kathleen--connect	0.08	0.62	0.44	0.67	0.20	0.40	1.00	1.00	1.00	7.7	1

6 Conclusions

A desktop investigation was conducted into potential new/additional water storages and supply options in the Mount Isa—Cloncurry Region with the purpose of determining the best alternative for additional water storage(s) to provide supply and security of water in the face of increasing water demand. Such demand was likely to arise from irrigated agricultural development, new mining activity, and associated urban/industrial development.

The reason for identifying a ‘best alternative’ was to subject that alternative to a full feasibility study. Only a feasibility study can determine the actual construction site, detail all required infrastructure, appraise technical feasibility and design, analyse in detail the project cost and risks involved, appraise regulatory and other legal dimensions, conduct the necessary community and stakeholder consultations, appraise operating models and ultimately develop a final business case.

To identify the ‘best alternative’, the investigation reported here conducted (i) systematic assessment of the current regional water supply system and (ii) a comprehensive evaluation of nine water infrastructure alternatives and their relative merits using a multi criteria decision analysis.

The current water supply system is principally centred around two water storages on the Leichhardt River—Lake Moondara and Lake Julius—both downstream from Mount Isa. Water pipelines connect Lake Moondara to Mount Isa and Lake Julius to Lake Moondara. There is also a pipeline running east from Lake Julius, whereby water is initially lifted but then gravity feeds to Ernest Henry Mine and, since 2014, to Cloncurry.

Water infrastructure alternatives investigated included several potential dam sites on the upper Cloncurry River, adding water storage capacity to or upstream of Lake Julius, and connecting currently unused water storages which had been built to support the now defunct Mary Kathleen Mine.

Key water needs in the region arise, in Mount Isa, from high cost of water supply and, in the Cloncurry precinct, from increasing physical demand for water supply primarily from the agricultural sector.

In the Mount Isa precinct, future water demand from both mining and urban/industrial users is more likely to decline than increase in the future and water security is consequently less of an issue. However, pumping water from Lake Julius to Mount Isa is expensive because it involves overcoming an altitude difference of over 100m. To manage cost—and not because of physical water shortage—water restrictions apply in Mount Isa when the water level in Lake Moondara becomes low. This problem may be alleviated by building a relatively short and gravity-neutral pipeline from the existing East Leichhardt Dam (Lake Mary Kathleen) to Mount Isa. While this is a relatively small dam, a water allocation exists, and—pending suitability of water quality and cost efficiency of the pipeline—this source could prove locally valuable particularly in drought times. This option does not address water needs in the Cloncurry precinct.

In the Cloncurry precinct, a number of potential future developments have the potential result of a large increase in water demand. Development of irrigated agriculture would be the principal driver of increased demand. A series of mining proposals may also be realised, pending favourable commodity conditions, and would then look to secure water supply. Additionally, urban-industrial development associated in particular with agriculture would result in higher water demand by Cloncurry. With the recent completion of the Cloncurry extension of the NW Queensland Water Pipeline, water supply for Cloncurry is assured from existing sources even if the town grows. Increasing mine water demand can likely be met through the NW Queensland Water Pipeline particularly in light of currently available allocations from Lake Julius—though cost of water is an issue.

Irrigated agricultural development in the Cloncurry River catchment would require significant new water supply. This investigation was predicated on the assumptions that, firstly, irrigated agricultural development in the lower Cloncurry River was to occur, and secondly, that water was to be provided from a large irrigation scheme rather than a series of on-farm off-stream water storages. Even if the 10GL unallocated Sunwater entitlement in Lake Julius were to entirely be used to support such agricultural development, this would only provide a partial solution. Firstly, the capacity of the current pipeline and pumping infrastructure would act as a constraint to water delivery. Secondly, assuming crop water demand of 10ML/ha/yr, the water volume would irrigate 10,000 hectares at best—about one eighth of the size of Ord Stage 2. Cost of supply would likely also be an issue.

A large storage on the upper Cloncurry River could gravity feed water of sufficient quantity and security to new irrigation enterprises downstream, and could possibly supply water to mines and to Cloncurry more cheaply than current options. Thus, from a regional perspective and to entertain the agricultural development paradigm, the upper Cloncurry River presents the best location for supporting water infrastructure. Water resource development on the Cloncurry River would also have the benefit of increasing the resilience of the water supply and security in the whole Mount Isa—Cloncurry region: A more geographically diversified system of water capture is preferable in the prevailing spatially and temporally variable rainfall conditions. .

Among the alternative sites for a dam on the upper Cloncurry River, Cave Hill is the preferred alternative. It is likely to give the largest effective yield. It is also closest to Cloncurry, meaning access costs will be relatively lower compared to other sites and increasing its potential to positively impact on tourism activity. Despite Cave Hill being the best researched site among the alternatives, there are remaining geological and geomorphological concerns about the best locality to construct the dam. On that basis, the 2nd rated combination of dams at the “Black Fort” and “Slaty Creek” sites should not be ruled out at this stage.

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8 Appendix: Overview information received from DNRM

Email received by Romy Greiner from Heather Sparks, DNRM, on 19 February 2016 in response to:

Request for telephone conversation in relation to Upper Leichhardt and Cloncurry Rivers

Good afternoon,

An officer of the Department has tried to call several times this afternoon in regards to your enquiry, with the view to seek clarity on the information you would like, prior to writing this response; however in the absence of further information, we will do our best to provide a brief overview.

Specifically the department's jurisdiction, under the *Water Act 2000*, is limited to water related activities, such as the take, interference (such as weir wall) or storage (such as dam) of surface water (including lakes or springs), groundwater and overland flow water. As such I am able to comment on the take interference, and storage of both surface water and overland flow water, which I feel may be relevant to your enquiry.

Matters relating to the physical 'structures' of dams, weirs etc. are not within our jurisdiction, therefore I can only comment on the interaction between relevant legislation specified within the Gulf Water Resource Plan; and highlight other possible regulatory requirements.

Firstly, pursuant to the Gulf Resource Operations Plan (Gulf ROP), any application for a water licence that would increase the take or interference with surface water must be refused; with the (relevant) exception of interferences with the purposes specified within s.43 of the Gulf Water Resource Plan (Gulf WRP). These purposes are:

- a) to store water for stock or domestic purposes; or
- b) to provide a pumping pool to enable water to be taken under an authorisation (up to 10ML); or
- c) to store water for a purpose not related to the taking of water under a water entitlement (up to 250ML); or
[Examples of a purpose for subsection (2)(c)— community landscaping or retaining water for flood mitigation purposes]
- d) related to the granting of unallocated water under the process stated in the Water Regulation 2002, part 2, division 1C; or
- e) to provide improved security for town water supplies.

Furthermore pursuant to s.78 of the Gulf WRP a person may not take overland flow water other than:

- (a) for stock or domestic purposes; or
- (b) for any purpose using works that allow the taking of overland flow water and have a capacity of not more than 250ML; or
- (c) under a water licence; or
- (d) overland flow water of not more than the amount necessary to satisfy the requirements of –
 - (i) an environmental authority issued under the *Environmental Protection Act 1994*; or
 - (ii) a development permit for carrying out an environmentally relevant activity, other than a mining or petroleum activity, under the *Environmental Protection Act 1994*; or
- (e) overland flow water that is contaminated agricultural run-off water; or
- (f) under an authority under section 79 [related to: Taking water using particular existing overland flow works authorised]

Therefore the only water that is foreseen to be available (for larger scale projects) within this region would be associated with the release of unallocated water.

In regards to unallocated water, as stated within the Gulf WRP there are three types of unallocated water reserves:

- **General reserve:** water that may be granted for any purpose;
- **Strategic or state reserve:** water that may be granted for projects that the chief executive considers are of regional significance for the plan area or have been declared to be coordinated projects under the *State Development and Public Works Organisation Act 1971*;
- **Indigenous reserve:** water that may be granted for projects that advance the social and economic aspirations of indigenous people.

The projected nature of the proposed projects would therefore influence which water may be applied for, as all may be potentially relevant to infrastructure / storage proposals. The requirements to make application for such water would be advertised.

In relation to 'structures' the Gulf WRP only makes reference to works for the take of overland flow water – therefore not seen to be relevant to your enquiry.

Interference structures would be subject to normal assessment under the *Sustainable Planning Act 2009* with the State Assessment Referral Agency (SARA) setting appropriate conditions to satisfy the requirements of the planning scheme and state interests respectively.

It is noted however that a Water Licence issued under the *Water Act 2000* to interfere with water can contain conditions which, if adhered to, result in works being self-assessable and therefore not requiring further authorisation.

In addition, separate approvals may be required:

- Removal of vegetation to construct a dam would require approval for vegetation clearing pursuant to the *Vegetation Management Act 1999* (unless the water storage is designated as community infrastructure under the Sustainable Planning Regulation 2009) and DNRM would provide technical advice to assist the SARA in making their decision.
- Inundating native vegetation with the construction of the proposed dam and impacts on fish passage may require mitigation measures including the provision of an environmental offset (*Environmental Offsets Act 2014*), which may be a significant cost for the proposal.
- Approval may be required under the *Land Act 1994* to facilitate the development as the land impacted by the proposed dam could be a mixture of freehold, leasehold, reserve (for various purposes) and unallocated state land tenures. Native title would need to be addressed on non-freehold land parcels.

Under the provisions of the Water Supply (Safety and Reliability) Act 2008 the chief executive of Department of Energy and Water Supply (DEWS) is responsible for the regulation of water dams that would, in the event of failure, put two or more people at risk. Such dams are called 'referable' dams in that Act.



Heather Sparks

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