APPENDIX E

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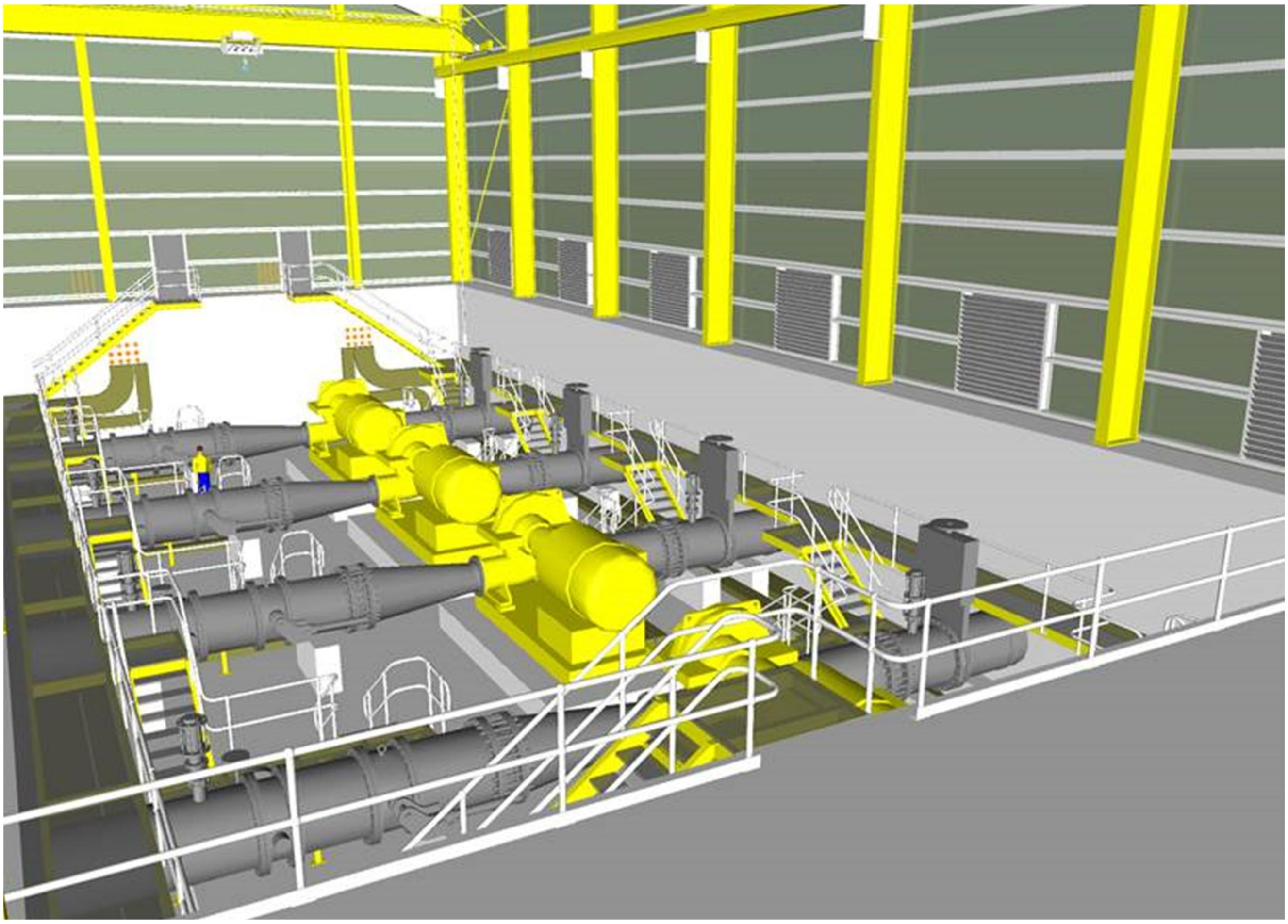
Haughton Pipeline Stage 2 Detailed Business Case

Department of Infrastructure, Regional Development and Cities

Appendix E - Engineering Design and Cost Estimate

IH175200-Appendix E | 0

29 May 2019



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Haughton Pipeline Stage 2 Detailed Business Case

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Contents

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The sole purpose of this report and the associated services performed by Jacobs is to develop a reference design for the proposed Stage 2 Haughton pipeline between Clare and Haughton.

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Acronyms and Abbreviations

Acronym/Abbreviation	Meaning
AS	Australian Standards
BOD	Basis of Design
CCTV	Closed Circuit Television
CML	Cement Mortar Lined
CP	Cathodic Protection
CSG	Coal Seam Gas
DBB	Double Block and Bleed
DI	Ductile Iron
DBC	Detailed Business Case
DICL	Ductile Iron Cement Lined
DINL	Ductile Iron Nylon Lined
DN	Nominal Diameter
EA	Environmental Authority
EC	Engineering Consultant
EPCM	Engineering, Procurement, Construction Management
FEED	Front End Engineering Design
GRE	Glass Reinforced Epoxy
GRP	Glass Reinforced Polymer
HDPE	High Density Polyethylene
HGL	Hydraulic Grade Line
HSSE	Health Safety Security Environment
M	Million or Mega
MAOP	Maximum Allowable Operating Pressure
MAP	Maximum Allowable Pressure
ML/d	Megalitres/day
MMF	Multi-media filtration
MOC	Management of Change
MOL	Maximum Operating Level
MS	Mild Steel
MSCL	Mild Steel Cement Lined
MSEL	Mild Steel Epoxy Lined
MSPE	Mild Steel PE Lined
OD	Outer Diameter
OHS	Occupational Health and Safety
PE	Polyethylene
PEX	Cross-Linked Polyethylene
PFD	Process Flow Diagram
PLC	Programmable Logic Controller
PN	Pressure Number

PP	Polypropylene
ppm	Part Per Million by Mass
PREN	Pitting Resistance Equivalent Number
PTP	Pre-Treatment Plant
PVC	Polyvinyl Chloride
RAPS	Remote Area Power Supply
REV	Revision
RO	Reverse Osmosis
RRJ	Rubber Ring Joint
RTU	Remote Terminal Units
SBB	Single Block and Bleed
SCADA	Supervisory Control and Data Acquisition
SG	Specific Gravity
SSR	Selective Salt Recovery
TBC	To Be Confirmed
TDS	Total Dissolved Solids
TSS	Total Suspended Solids
TW	Treated Water
VSD	Variable Speed Drive
WTP	Water Treatment Plant

E.1. Introduction

E.1.1 Background

Jacobs was commissioned by the Department of Infrastructure, Regional Development and Cities (DIRDC) to prepare a Detailed Business Case (DBC) for Stage 2 of the Haughton Pipeline project, located in North Queensland.

The key objective of this project will be to deliver additional water to the city of Townsville to augment existing water supplies. It will replace an existing (low capacity) pipeline which transfers water from the Haughton Irrigation Area to Ross River Dam.

Stage 1 of the Haughton pipeline project will draw water from a side channel of the Haughton main channel at a location on the southern side of the Haughton River and pump it 35km to a discharge at Toonpan into the Ross River Dam. The base case includes works on the Haughton main channel to remove bottle-necks, particularly in siphon crossings of watercourses, which restrict its capacity.

Stage 2 of the Haughton pipeline project will draw water from Clare Weir on the Burdekin River, pumping it approximately 35km and connecting to the southern end of the Stage 1 Pipeline.

The Stage 1 pipeline is currently being constructed, and at the time of writing the Stage 1 pump station was being tendered. The reference project presented in this report considers two scenarios:

- the Stage 2 pipeline and associated works are constructed immediately, connecting directly to the Stage 1 pipeline and pumping 70km from Clare to Toonpan (i.e.: removing the Stage 1 pump station from the project);
- the Stage 2 pipeline and associated works are implemented in the future, as required by Townsville's growing water demand.

E.1.2 This Report

This report presents an assessment of options for the configuration of the Stage 2 Haughton pipeline, reports on the major technical engineering alternatives considered for the project, and presents the Basis of Design adopted for the development of the reference design.

A summary of the reference project is contained in Chapter 9 of the DBC.

E.2. Pipeline Alignment Evaluation

E.2.1 Overview

Three alignment options for the Haughton Stage 2 pipeline have been considered in this assessment:

- Option 1 – Haughton main channel (HMC) Alignment
- Option 2 – Woodhouse Road Alignment
- Option 3 – Mitchell/Stockham Roads Alignment

These alignments are presented in **Figure E - 4**, and their key features are discussed in the following sections.

E.2.2 Alignments

E.2.2.1 Alignment Option 1 – Haughton main channel (HMC) Alignment

Alignment Option 1 is similar to Option 1-3C1 (Clare Weir to Haughton Pump Station from the GHD Milestone 4 report (GHD, 2018). It follows the Haughton main channel (the "HMC" - the primary irrigation channel for the Burdekin Irrigation Area which runs along the western side of the scheme).

The alignment is 33.5 km in length and runs along a general downward grade from south to north with a total elevation difference of about 7m at the ends (refer alignment profile in **Figure E - 1**). There is a small "peak" (about 8m above the local "grade" level) at about CH17.5km (about 3.5km north of the Ayr-Ravenswood Road crossing).

Ideally, the pipeline would be located within the reserve for the HMC however there is limited space available within the reserve on both sides of the channel. Generally, there is about 10-15m available on both sides. In many locations it appears (based on observations made on site) that this area inside the reserve boundary is waterlogged, presumably as a result of seepage from the HMC. Due to the waterlogging and the fact that a 30-40m wide construction corridor will be required to install the pipeline, it is considered that the most appropriate alignment for a pipeline along the HMC corridor would be just outside the fence line of the HMC reserve.

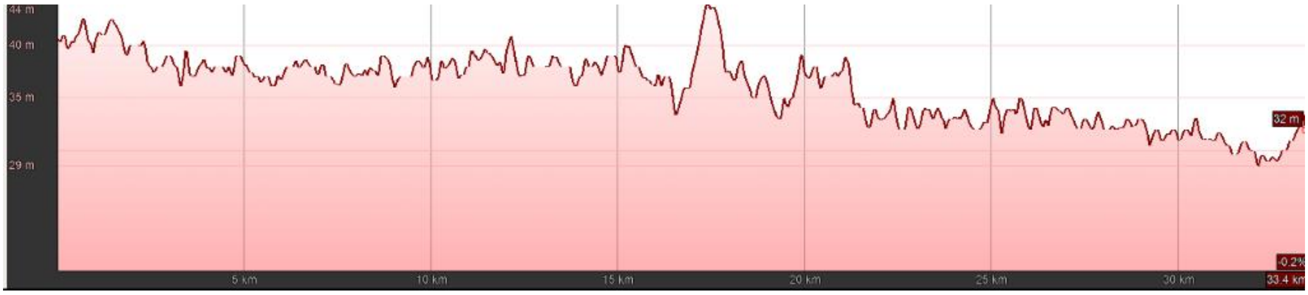
Based on a preliminary assessment, it appears that alignment of the pipeline along the western side of the HMC would be preferable to aligning it along the eastern side of the HMC, for the following reasons:

- There are several dams and large waterlogged areas on the eastern side of the corridor, whereas there are few on the western side.
- Three side irrigation supply channels connect to the HMC on its eastern side; these would need to be crossed by the new pipeline. There are no side channels on the HMC's western side.
- In some locations (particularly at the southern end), the topography on the western side of the HMC is flatter, which will make construction easier and cheaper.
- There are several more irrigation farms abutting the HMC corridor on its eastern side than its western side. Aligning the pipeline along the western side of the HMC would therefore be a little less disruptive than aligning it along the eastern side.
- There are fewer landowners on the western side of the HMC, so negotiating access easements for the new pipeline would be simplified (although the risk of not securing agreement for easements would be unchanged).

Based on these considerations, it has been assumed for this assessment that the Option 1 alignment would locate the pipeline on the western side of the HMC corridor.

The "western" HMC alignment crosses no irrigation side-channels (off the HMC). It crosses significant roads (which vary from formed gravel roads to formed and sealed primary rural roads) in only two locations. It also crosses seven watercourse which vary from minor gullies to incised named creeks. All of the creeks are ephemeral. None of the watercourse or road crossings are considered to be "major" undertakings.

Figure E - 1 Vertical Section - Alignment Option 1



E.2.2.2 Alignment Option 2 – Woodhouse Road Alignment

Alignment Option 2 is the most direct route between the existing Clare Weir and Haughton pump stations and is the shortest of the three alignment options at 30.5km in length. For most of its length, it follows publicly-owned property (generally road reserves and public infrastructure easements).

The alignment is the same as Option 1 for the southern 6km, following the Haughton main channel alignment. It could be aligned either side of the HMC in this section.

Between CH6 – 14km (roughly between Mitchell Road and Ayr-Ravenswood Road), the alignment follows Woodhouse Road and an HV powerline easement. This section is within a very flat, wide drainage line which runs north and discharges into Scotts Creek at approximate pipeline chainage 15km.

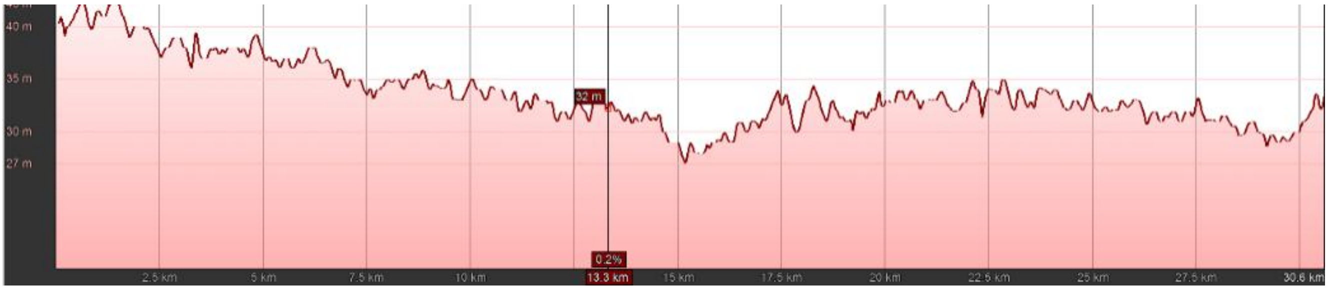
Between CH14 – 20km (roughly between Ayr-Ravenswood Road and Baratta Creek), the alignment follows an HV powerline easement then re-joins the Haughton main channel alignment between CH 20 and 30.5km.

The vertical grade of the alignment undulates slightly, falling from south at the Clare PS to north at Scotts Creek (at CH 15km), then rising again before falling toward the Haughton River. The total elevation difference between the pipeline ends is about 7m with the outlet being lower (refer alignment profile in **Figure E - 2**).

The pipeline on this alignment may be able to be constructed in road reserve and/or HV powerline reserve for about one half of its length (between Mitchell Road and Barratt Creek). It is likely that the remainder of the pipeline would be located in private property adjacent to the HMC. Easements would be required for all sections of the alignment in private property and powerline reserves.

The alignment crosses irrigation channels (including the HMC) in three locations, and crosses roads (which vary from formed gravel roads to formed and sealed primary rural roads) in two locations. It also features six watercourse crossings which vary from minor gullies to incised named creeks. None of the watercourse or road crossings are considered "major" undertakings.

Figure E - 2 Vertical Section - Alignment Option 2



E.2.2.3 Alignment Option 3 – Mitchell/Stockham Roads Alignment

Alignment Option 3 follows major roads wherever possible. Its length is 33.5km. For most of its length, it follows publicly-owned property (generally road reserves and public infrastructure easements).

The alignment is the same as Option 1 for the southern 6km, following the Haughton main channel Alignment. It could be aligned either side of the HMC in this section.

Between CH6 – 14km (roughly between Mitchell Road and Ayr-Ravenswood Road), the alignment follows Woodhouse Road and an HV powerline easement. This section is also within a very flat, wide drainage line which runs north and discharges into Scotts Creek at approximate pipeline chainage 15km.

Between CH14 – 20km (roughly between Ayr-Ravenswood Road and Baratta Creek), the alignment follows an HV powerline easement then re-joins the Haughton main channel alignment between CH 20 and 30.5km.

The vertical grade of the alignment undulates slightly, falling from south at the Clare PS to north at Scotts Creek (at CH 15km), then rising again before falling toward the Haughton River. The total elevation difference between the pipeline ends is about 7m at the ends with the outlet being lower (refer alignment profile in Error! Reference source not found.).

The pipeline on this alignment may be able to be constructed in road reserve and/or HV powerline reserve for about one half of its length (between Mitchell Road and Barratt Creek). It is likely that the remainder of the pipeline would be located in private property adjacent to the HMC. Easements would be required for all sections of the alignment in private property and powerline reserves.

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Figure E - 3 Vertical Section - Alignment Option 3

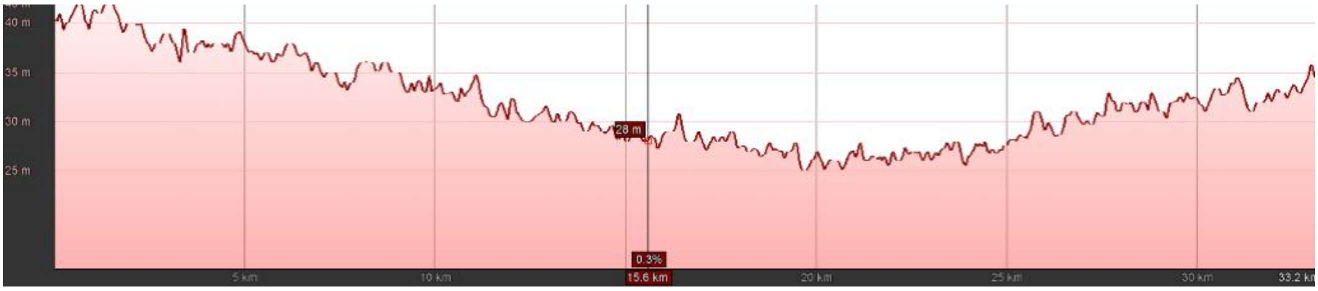
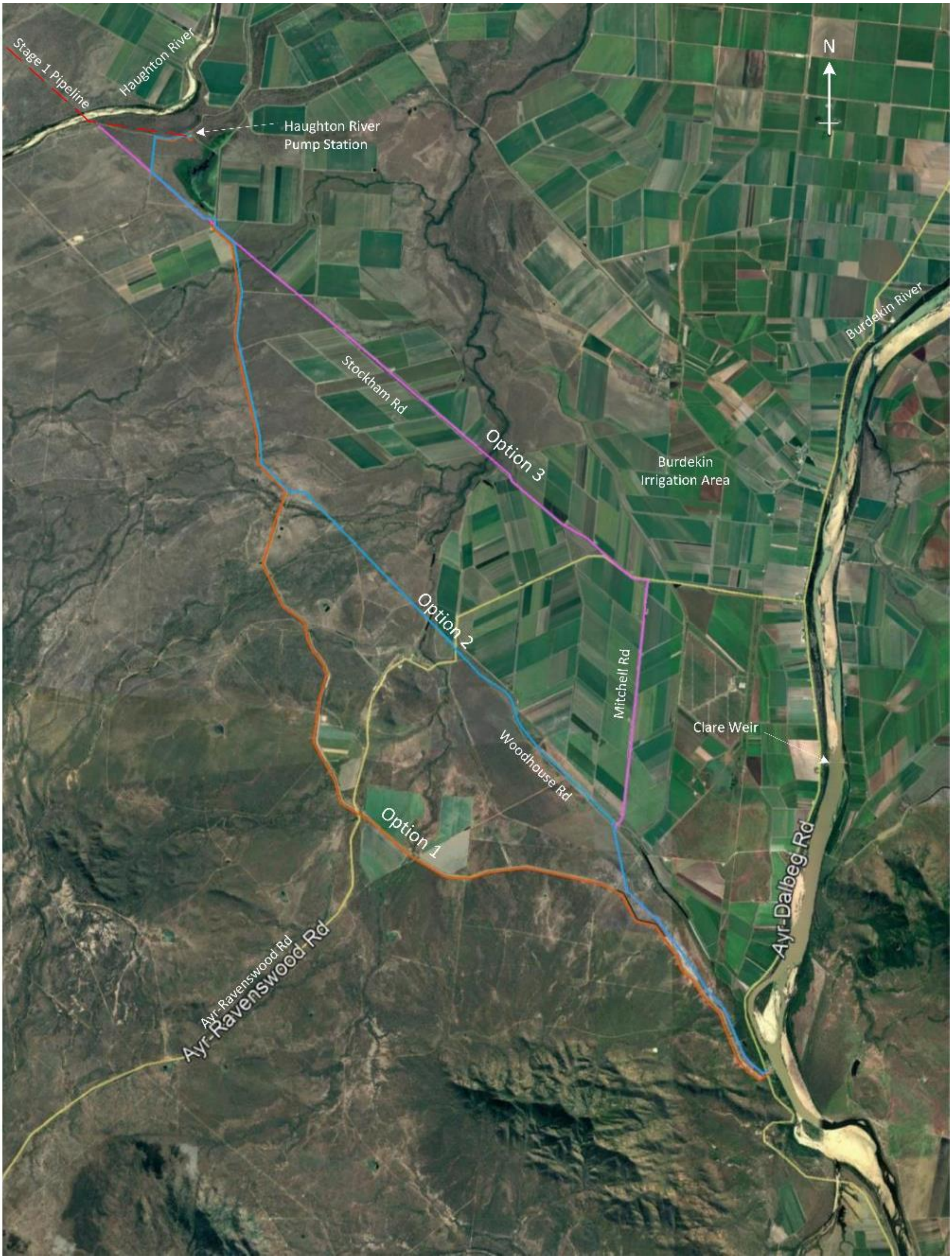


Figure E - 4 Pipeline Alignment Options



E.2.3 Technical Assessment

E.2.3.1 Ground Conditions

The proposed pipeline alignments traverse through a wide floodplain of both the Burdekin and Haughton River systems, encompassing the Oaky, Sandy, Scotts & Barratta creeks (see **Figure E - 4**)

The floodplain is nearly flat, with elevations varying between approximately 30 and 35 mAHD. The only two significant topographical rises are located near Millaroo close to the Burdekin River where the existing Sunwater Main Channel cuts through low granitic hills (at approximately 50mAHD), as well as another granitic hill where the Main Channel cuts through at 40 mAHD.

The Option 1 pipeline alignment (adjacent to the existing Sunwater Main Channel) skirts the edge floodplain and passes through the aforementioned low granitic hill.

The soils along the proposed pipeline alignments are presented in **Figure E - 5**. These soils can be subdivided into sand rich soils (colluvial/residual) derived from the low hills close to the Burdekin River, potentially reactive clays occurring over significant portions of the Option 3 alignment, as well as close to the Haughton River (although site specific investigations show no significant evidence for these types of soils), but generally over much of Option 1 and 2 pipelines consist of variable composed Alluvial soils. It is likely due to the wide floodplain morphology that both the Burdekin and Haughton Rivers have meandered across this floodplain and therefore a number of previous channels and levees may have been reworked. Potential numerous abandoned channels may be seen in **Figure E - 7**. **Figure E - 6** indicates that the presence of Acid Sulphate Soils over the pipeline alignments is unlikely, which is supported by the elevation being above the 20 mAHD upper threshold levels for these types of soils, and project specific laboratory testing undertaken.

Observations during walkover surveys and the site-specific geotechnical investigations indicate that in some areas erosive/dispersive soils may be apparent and are especially associated with residual soils of the low granitic hills. This is somewhat supported by laboratory testing undertaken for the project.

Limited site-specific chemical laboratory testing of recovered soil samples from the project specific geotechnical investigation indicate no aggressive conditions for steel, and buried concrete and reinforcement.

Groundwater for much of the alignments is interpreted to be high and within approximately 1-2 m of present ground levels, but especially during the wet season. For the unlined existing Sunwater Main Channel, in many areas this has been constructed above the original ground level, and seepages from the channel base and sides could be occurring as evidenced by the encountering of “boggy” ground and water lying on the surface immediately at the western toe for significant sections.

In terms of bedrock (see **Figure E - 8**) only the low granitic hills of the Option 1 alignment encounter extremely to highly weathered Granodiorite, whilst a potential NW-SE trending photolineament may also cross this Option in its southern extremity (see **Figure E - 9**).

Deep soil profiles may exist for proposed pumping & pigging stations, as well as the water storage facilities.

Figure E - 5 Soils Along the Pipeline Alignment Options

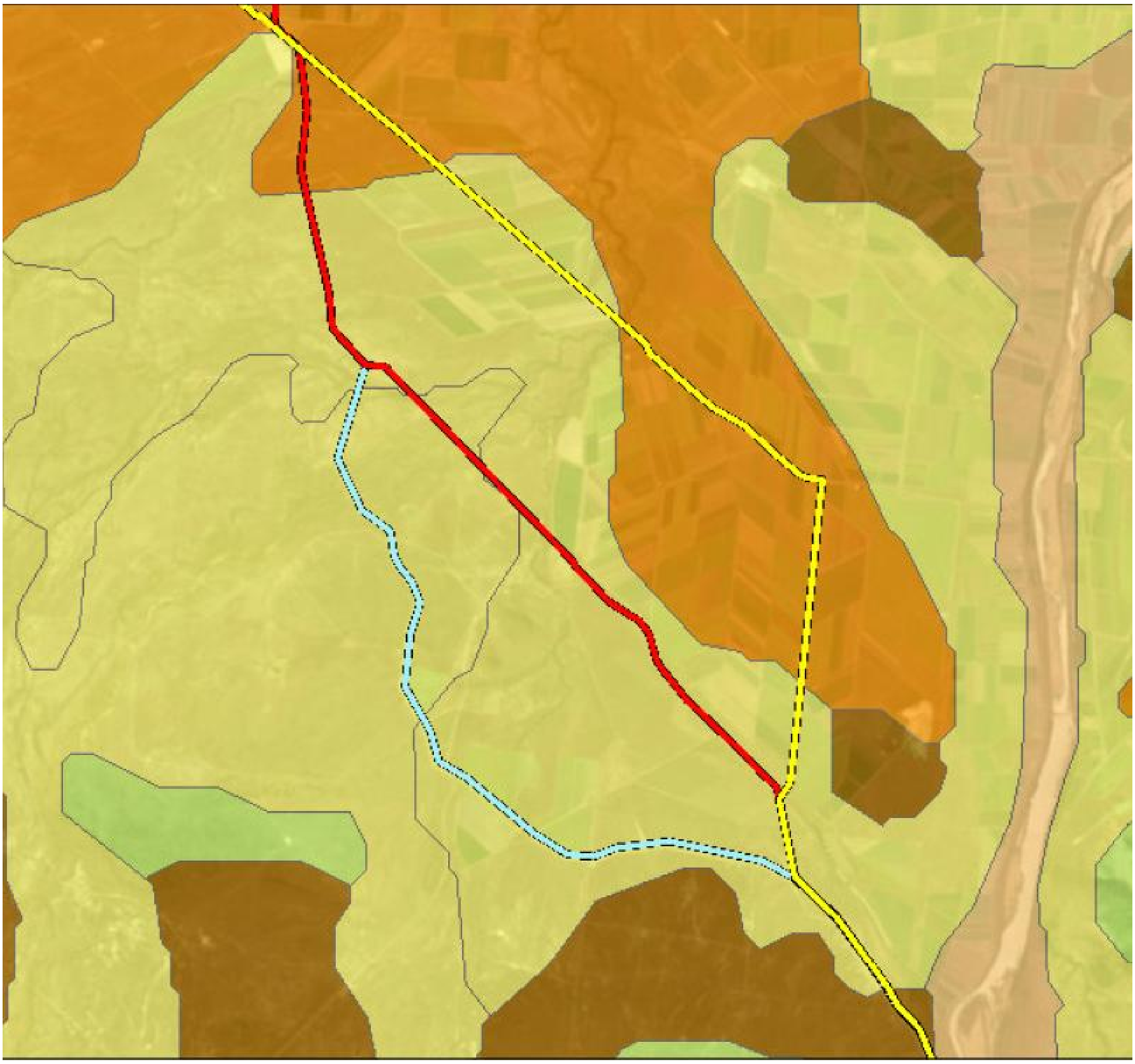


Figure E - 6 Acid Sulphate Soils Along the Pipeline Alignment Options

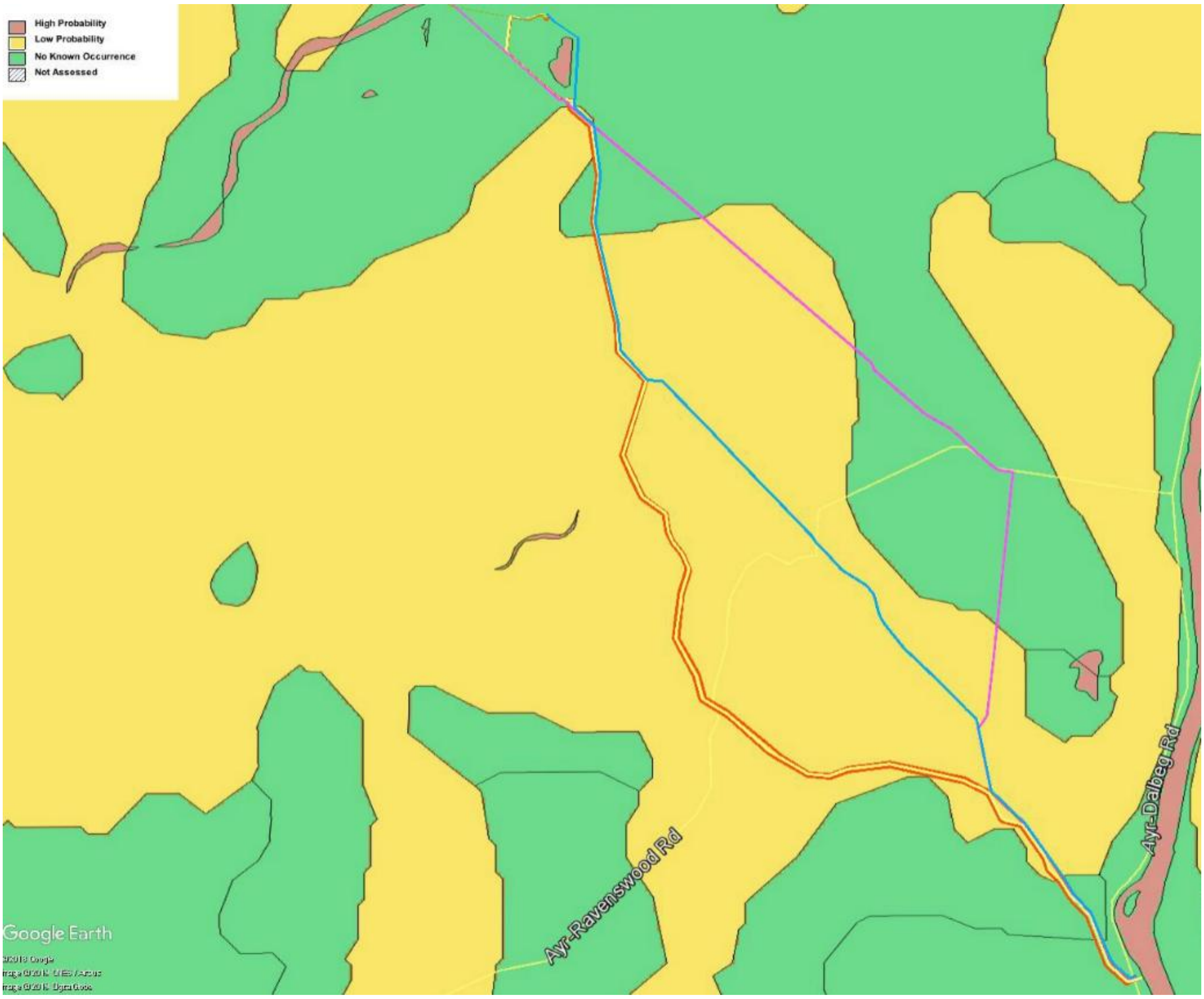


Figure E - 7 Geomorphology Along the Pipeline Alignment Options (1969 Aerial Photography)

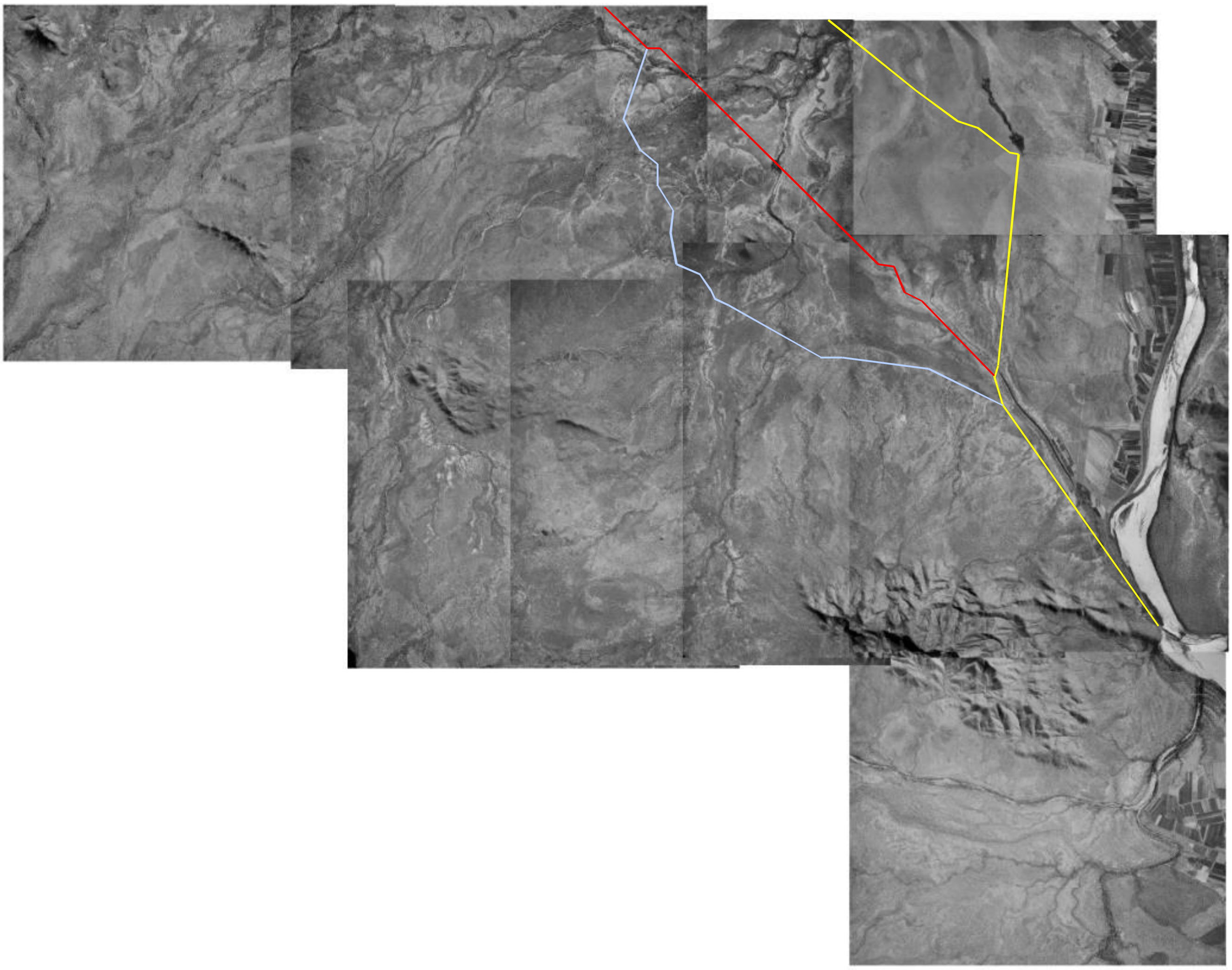


Figure E - 8 Surface Geology Along the Pipeline Alignment Options

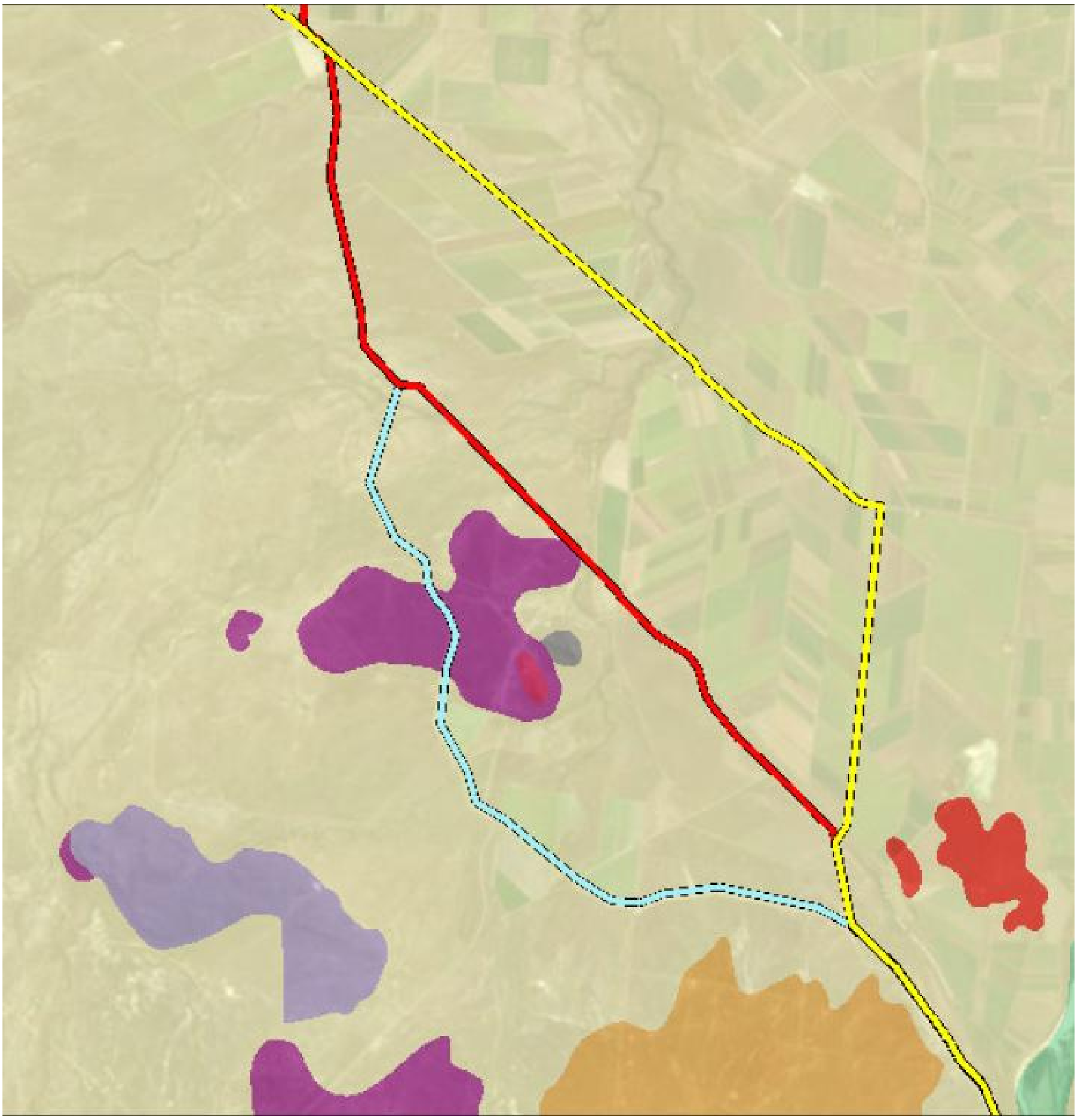
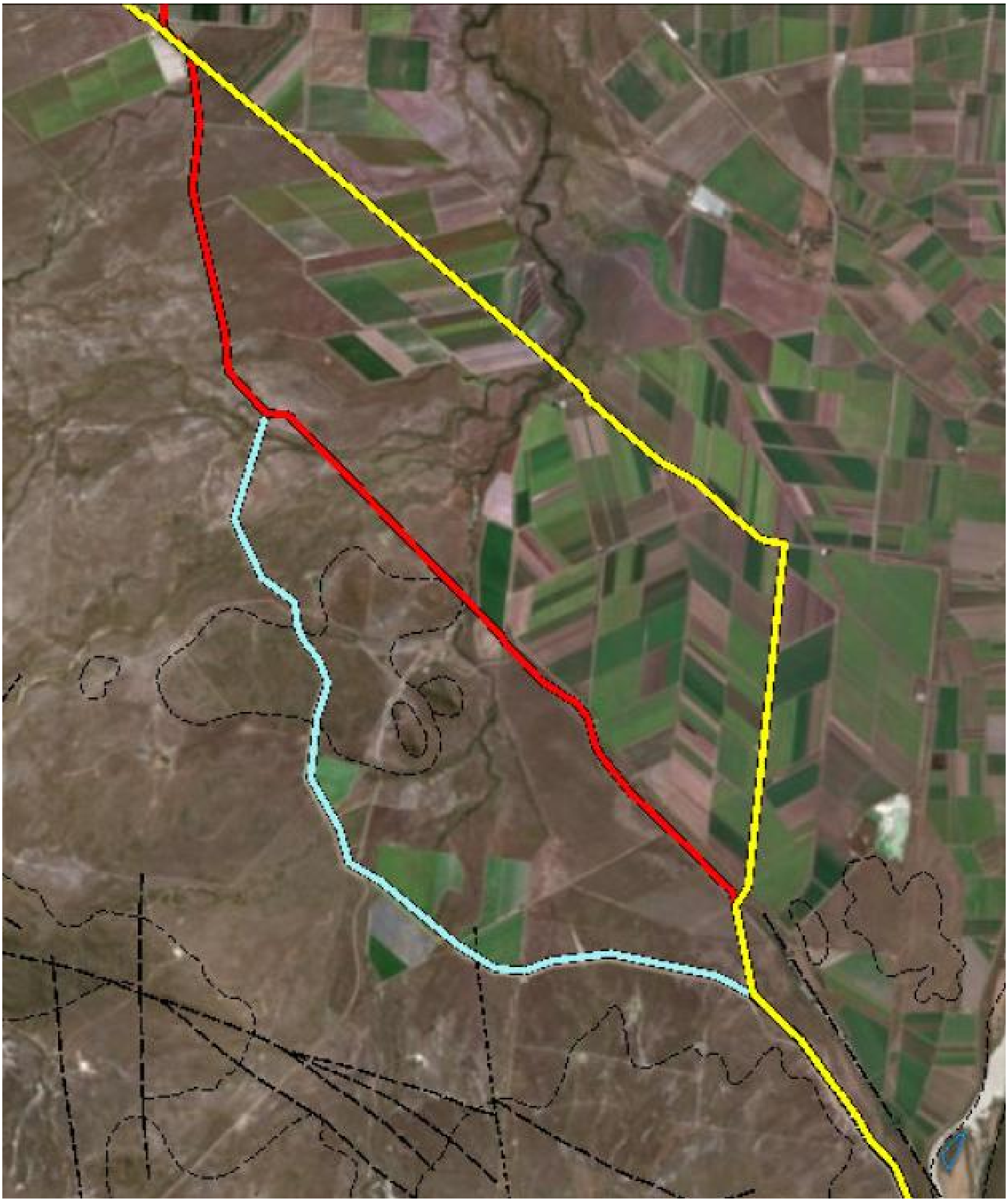


Figure E - 9 Structural Geology Along the Pipeline Alignment Options



E.2.3.2 Environment

General ecological description

The pipeline alignment options are located within the Brigalow Belt North bioregion and comprises of a mixture of non-remnant, remnant and riparian vegetation. The project area and surrounding landscape predominantly comprises disturbed areas associated with irrigated cropping, native vegetation grazing and transport corridors. Biodiversity connectivity along the project options is limited, with remaining vegetation fragmented due to a combination of agricultural practices, commercial development and the existing transport infrastructure. Vegetation corridors which are present along the pipeline alignment options are mainly associated with either watercourses or major waterways.

Of importance is an area associated with the Haughton Balancing Station Aggregation (HBSA) wetland, which is present within the northern section of each option's alignment. This wetland is noted to provide habitat for a diverse assemblage of flora and fauna species.

The biodiversity assessment is based on desktop review only and no field verification or investigations have been undertaken

Threatened ecological communities and regional ecosystems

A review of the regulated vegetation management mapping identified that the all three alignments transect through Category vegetated areas (remnant vegetation) and Category R (reef regrowth vegetation adjoining Barratta Creek). These areas of Category B remnant vegetation comprise mainly regional ecosystems (REs) 11.3.4/11.3.25/11.3.13 and 11.3.25b, while the Category R areas consist of mainly 11.3.35/11.3.9/11.3.13 or 11.3.4/11.3.25/11.3.13/11.3.25b. Of importance, both Category B and R vegetation areas have been identified as potentially containing REs 11.3.13 and 11.3.25b, which have a biodiversity status of 'endangered'.

All three Alignment Options were identified as traversing differing total qualities of Category B and R vegetation containing both 'Not Of Concern' and 'Of Concern' REs. Alignment Options 1 and 2 have the highest potential area of impact due to transecting through an increased number of waterways and watercourse area, while Alignment Option 3 predominately follows road reserves and existing easements.

Initial desktop assessment indicates that Alignment Options 2 and 3 have the least restrictions in terms of vegetation clearing, with the "Of Concern" vegetation identified along the alignment of Option 1 requiring further assessment and studies to understand the potential management measures and permits or approvals.

Waterways

A desktop review of the project's Alignment three Options has identified that all three Options intersect the waterways and watercourses, one watercourse identified under the Water Act 2000 (Water Act), intersected by each Alignment Option and 21 waterways . **Table E - 1** shows the number of impact locations associated with each Alignment Option.

Under the Department of Agriculture and Fisheries (DAF) waterway classification, these waterway zones are colour-coded: in purple, red, amber and green. The colour indicates the risk of adverse impacts from instream barriers on fish movements (DAF, 2016) (**Table E - 1**).

Table E - 1 Watercourse and waterways intersected by the pipeline alignment

Name	Identification	Number of impact locations			DAF classification	Risk rating	Stream Order
		Alignment Option 1	Alignment Option 2	Alignment Option 3			
Deep Creek	Waterway	1			Red	High	4
Scott Creek	Waterway	1			Red	High	4
Woodhouse Creek	Waterway	1	1		Red	High	4
Barratta Creek	Watercourse	1		1	Purple	Major	6
Horse Camp Creek	Waterway	1	1	1	Purple	Major	5
Lagoon Creek	Waterway	1	1	1	Orange	Moderate	3
Oaky Creek	Waterway	1	1	1	Purple	Major	6
Unnamed tributary of Deep Creek	Waterway	1			Green	Low	2
Unnamed tributary of Gladys Lagoon	Waterway	1			Red	High	4
Unnamed tributaries of Woodhouse Creek	Waterway	3			Orange	Moderate	3
Unnamed tributaries of Scott Creek	Waterway	5	1		Orange	Moderate	3
Unnamed tributary of Scott Creek	Waterway	2			Green	Low	2
Unnamed tributary of Barratta Creek	Waterway	2	1		Orange	Moderate	3
Totals		**21**	**7**	**4**			

Source: Department of Agriculture and Fisheries, 2013.

The identified waterways and watercourse are ephemeral in nature, meaning that flow occurs within this system during and following a period of rainfall typically during summer months of October to February.

These identified waterways and watercourse are all fringed to a varying extent by riparian vegetation. The current construction proposal for creek crossings is for a progressively cleared 40 m right of way for the length alignment, utilising a battered open trenching method.

Therefore, the construction disturbance will need to be reduced within the riparian zone to a maximum width of 20m. Construction methods which minimise the disturbance to the riparian vegetation area of intersected waterways or watercourses should also be considered (e.g.: using sheet pile trench shoring to minimise the trench excavation width, or bored pipeline installation).

Some protection works will be required over the pipeline at creek crossings to reduce the risk of erosion of the overlying material during flow events. The protection measures proposed are to increase the pipeline depth (to 2m for the larger watercourses), and to install a rock fill/rip rap layer over the pipe.

Wetlands

The desktop assessment indicates that none of the Alignment Options are within close proximity of any known Ramsar-listed wetlands, with the closest Ramsar wetland identified as Bowling Green Bay approximately 10 to 20 km downstream. Two nationally important wetlands identified as the Barratta Channels Aggregation (BCA) and Haughton Balancing Storage Aggregation (HBSA) have been identified within 2 km of the proposed alignment.

Alignment Option 1 skirts around the HBSA wetland, while Alignment Options 2 and 3 intersect the BCA at Barratta Creek.

Groundwater Resources

A review of relevant geospatial data via the Queensland Globe online mapping tool indicates no groundwater dependent ecosystem (GDE) resources or springs relevant to the project's Alignment Options.

A review of the DNRME registered bore database indicates that approximately 24 bores are located within a 500m buffer of the project's Alignment Options.

Endangered, vulnerable and near threatened species

Flora species: The Environmental Protection and Biodiversity Conservation (EPBC) Protected Matter Search Tool (PMST) report identified four endangered, vulnerable and near threatened (EVNT) species with the potential to occur, or with habitat likely to occur, within 10 km of the project's Alignment Options and associated infrastructure. Further to this, a search of the Queensland database Wildlife Online identified 175 records of terrestrial and aquatic flora species within 10 km of the project's preferred pipeline alignment and associated infrastructure. Four species are listed as Vulnerable under both the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act) and the *Nature Conservation Act 1992* (NC Act).

Fauna species: The EPBC PMST report identified 15 threatened fauna species and 17 migratory species, including 2 critically endangered, 4 endangered and 9 vulnerable species that, within the project area, are either known, have the potential to occur, or are identified as having a habitat. A further search of the Queensland database, Wildlife Online, identified 134 records of terrestrial fauna species within the study area, including one vulnerable species under the NC Act.

Neither terrestrial nor aquatic surveys have been undertaken for the project, However, based on the Haughton Pipeline Duplication Stage 1 ecological assessment, the black ironbox (listed as vulnerable) and Southern black-throated finch (listed as endangered) has the greatest probability of occurrence within the project area.

E.2.3.3 Approvals

The identification of regulatory approvals required for the project has been undertaken based on desktop investigations. No environmental surveys have been undertaken for the project. Given that there are known potential impacts to areas mapped as containing remnant vegetation and endangered species (in the general area), flora and fauna surveys should be undertaken to inform approvals relating to vegetation and habitat impacts. These surveys are expected to take a minimum of 3 months to complete.

The approvals required will depend on the adopted alignment for the pipeline and the outcomes of the flora and fauna field work. The time to obtain approvals could range from 6-12 months. If MNES species are identified, an EPBC referral will also be required and approvals could take up to 18 months.

Overall, an allowance of 9-18 should be assumed to obtain the approvals required for this project.

Given that lack of site-specific information currently available, it is not possible to differentiate between the Alignment Options in terms of approval complexity and timeframes.

E.2.3.4 Land Use

The Project is situated in an established rural production region where the predominant uses consist of irrigated cropping and native vegetation grazing. With all three Alignment Options transecting through irrigated cropping or native vegetation grazing areas.

Each Alignment Option differs in their level of impact to either irrigated cropping or grazing areas. Alignment Option 1 and 2 predominately pass through areas used for grazing, with two areas of irrigated cropping around Ayr Ravenswood Road and toward the northern end of the alignment in the vicinity of Keith Venables Road.

Approximately two-thirds of Option 3 is within cultivated areas, and the remainder is within grazing land.

E.2.3.5 Land Acquisition

All of the pipeline options would require some level of land acquisition. The pipeline infrastructure, including access rights to it, could be secured either by purchasing the pipeline corridor or by securing permanent easements. DNRME have advised that permanent above-ground assets should be on freehold land. This is applicable particularly to the sedimentation pond and substation in the vicinity of the Burdekin River.A minimum corridor width of 40m would be required for construction, except in waterway corridors where it will be reduced. This width could be reduced to 20m post-construction; however, this would necessitate negotiating access agreements from adjacent land owners (to provide adequate working space) to undertake most work requiring excavation on the pipeline during the operational phase.

Alignment Option 1 would be almost entirely located on private property (except where it crosses roads and creeks), so land would need to be purchased (or easements acquired) along the entire alignment length. Given the majority of this alignment is grazing land, and there are only a small number of property owners, this acquisition is considered to be feasible.

Alignment Option 2 has a similar land acquisition situation as Alignment Option 1, except about one third of the alignment is within a power transmission and/or road corridor. Acquiring easements for a major pipeline in this corridor could be problematic. If this became a significant impediment, the alignment could be moved to run outside but adjacent the power transmission corridor through this section. A greater number of property acquisitions would be required compared with Alignment Option 1, which could increase the complexity of negotiations and increase the risk of either delay and/or failure to acquire the required property access rights for the pipeline project. Alignment Option 2 is still however considered to be a feasible option with regard to property acquisition.

Much of Alignment Option 3 traverses the Haughton Irrigation Area. Similar to Alignment Option 2, there is the possibility of locating the pipeline within power transmission and/or road corridors, however the feasibility of this option needs to be evaluated in more detail to be confirmed. There is a significant possibility that the pipeline would need to traverse private property which is used for irrigated crop cultivation. Farming operations could continue over the pipeline after it is installed but would be temporarily disrupted. Purchasing this property or acquiring easements over them is likely to be significantly more difficult and costlier than acquiring the grazing land traversed by the other options.

At this stage, it is unclear whether the property required for the pipeline could be secured by compulsory acquisition via the Queensland Co-ordinator General's office. Given the significance of the project, it's possible that this option may be available, but ideally all reasonable avenues of acquiring the properties by standard negotiation means would need to be exhausted first.

In summary, property acquisition for Alignment Option 1 is expected to be reasonably straightforward. Alignment Option 2 could be similar, but if the alignment is located within road reserves and the power transmission corridors this would become more complicated (a situation which could be mitigated by moving the pipeline out of these corridors). Alignment Option 3 presents appreciable challenges in terms of land acquisition.

E.2.3.6 Pipeline Hydraulics

The topography traversed by all the alignment options is similar. All the options start and terminate at the same locations, so their overall elevation differential is identical (they fall by 5m from end to end). Option 1 has a slight rise in the middle of the alignment which is not present for the other options, although this would have a modest 4 m impact on overall head.

All of the options would require pumps to deliver the required flowrate. All of the alignment Options could be configured to flow by gravity, however the fall along the pipeline is very low (only 0.01%), so the pipeline would need to be much larger than the proposed DN1800 size to deliver the design flow through a pressurized conduit. Piped gravity flow would significantly increase the capital cost and is therefore not considered to be feasible.

Given these factors, pipeline hydraulics will be nearly identical for all of the Alignment Options and is therefore not a differentiating factor.

E.2.3.7 Flooding

Limited flood data is available in the public domain for the proposed pipeline alignments. The major sources of flooding within the project area are the Burdekin River and the Haughton River.

Limited resolution flood data is available for the Burdekin River. It indicates that approximately the southern-most 6 km of all of the proposed alignments is subject to flooding in a 0.01 AEP event. The area around the Clare pump stations will also flood more frequently; the data indicates that this area could be inundated by 0.02 AEP events.

No data is available for the Haughton River, although it is believed that the area along the northern section of the proposed Stage 2 pipeline (along Black Road and at the Haughton pump station site) could be subjected to infrequent flooding.

Local flooding is also likely to occur in creeks and gullies, and surrounding areas may also be periodically flooded after larger rain events.

While flooding will be a consideration for the design, construction and operation of the pipeline, it is not considered to be a significant impediment to the project. It is not possible to differentiate between the Alignment Options with respect to flooding at this stage.

E.2.3.8 Alignment Options comparative summary

The key conclusions regarding the comparison of the Alignment Options in preceding sections are summarised in **Table E - 2**.

Table E - 2 Alignment Options Comparative Summary

Key Feature	Alignment Option 1 HMC Alignment	Alignment Option 2 Woodhouse Road Alignment	Alignment Option 3 Mitchell/Stockham Roads Alignment
Infrastructure			
Route length	33.5km	30.5km	33.5km
Channel crossings	0	3	3
Road crossings	1	2	2
Watercourse/waterway (creek) crossings	21	7	4
Environmental			
Acid sulfate soils	TBC[1]	TBC	TBC
Watercourses	1	1	1
Waterways	20	6	3
Wetlands	Intersects the HBSA	Intersects the BCA and HBSA	Intersects the BCA and HBSA
Groundwater dependent ecosystems	no	no	no
Impact to Category B and R vegetation	yes	yes	yes
Vegetation clearance	Of concern vegetation present	Of concern vegetation not present	Of concern vegetation not present
EVNT	yes	yes	yse
Planning			
Approvals	required	required	required
Land use	Grazing	Grazing and Cropping	Grazing and Cropping
Land acquisition	Entirely located on private property	Private property and road and power reserves.	Private property and road and power reserves.
Pipeline hydraulics	Similar	Similar	Similar
Flooding	Local only	Yes	Yes

Notes:

1) Awaiting laboratory results.

E.2.4 Cost

The estimated capital, operating and NPV cost of the Alignment Options are summarised in **Table E - 3**.

It is noted that the estimates contained in Table E - 3 are at a very high level only. They are based on an initial appraisal of the scope of the project are intended to be used only for the purpose of differentiating between the alignment options considered in this assessment. They are not suitable for budgeting purposes, and they are not directly comparable to the detailed cost estimates derived for the DBC on the basis of the adopted Reference Design.

Table E - 3 Alignment Option Cost Comparison

Alignment Option		Capital Cost $m	Operating Cost $m	NPV Cost[1] $m
Option 1	HMC Alignment	237	5.0	310
Option 2	Woodhouse Road Alignment	218	4.6	286
Option 3	Mitchell/Stockham Roads Alignment	238	5.0	311

Notes:

1) NPV cost calculated over 30 years with a 6% pa discount rate.
2) Estimated costs are for alignment options comparison only and are not for budgeting purposes and are not comparable to the detailed cost estimate produced for the DBC.

This information indicates that there is little cost differential between the Alignment Options. Cost is therefore not considered to be a differentiating factor in terms of alignment selection.

E.2.5 Multicriteria Analysis

A simple multicritera analysis has been undertaken to evaluate the three alignment options based on the information presented in this assessment. The results are summarised in **Table E - 4**.

The assessment evaluated included property acquisition, ground conditions, construction corridor obstructions, construction accessibility, operational accessibility, flooding, safety impact, potential for environmental impact, environmental + planning approval difficulty, community and stakeholder perception (including political), visual amenity impact, future proofing and capital cost.

Table E - 4 Alignment Option Multi-Criteria Analysis Scores

Alignment Option		Excl Cost		Incl Cost	
		Score	Rank	Score	Rank
Option 1	HMC Alignment	79	1	64	1
Option 2	Woodhouse Road Alignment	68	=2	58	2
Option 3	Mitchell/Stockham Roads Alignment	68	=2	55	3

Based on this analysis, Alignment Option 1 (HMC Alignment) scored clearly higher both when cost was included and excluded from the assessment.

E.2.6 Reference Case Selection

Based on the assessments undertaken Option 1 (HMC Alignment) was considered to be the most favourable and was adopted for development as the reference project for the detailed business case.

This alignment has been selected because it:

- Comparable capital cost to the other options.
- Relatively straightforward land acquisition
- Pipeline installation rate is likely to be better than for the other options because it does not have the constraints of working within or around road and power corridors.
- Risk of delays to the project starting time is lower.
- Involves no appreciable technical deficiencies compared with the alternatives.

E.3. Design

E.3.1 Context

The design basis has been considered in terms of the implementation of Pipeline Alignment Option 1 (as selected in **Chapter E.2**), but because the configuration of the pipeline would be much the same for all of the alignment, the technical assessment evaluations are also generally applicable to the other options.

E.3.2 System Configuration

The pipeline system configuration options considered in the detailed business case are set out in **Figure E - 10.** General information about each option is presented in **Table E - 5.**

The Base Case option utilises the existing Haughton main channel (HMC) to transfer water from Clare to the Haughton River, and the Stage 1 pipeline will transfer water from Haughton to the Ross River Dam at Toonpan. Upgrades to the HMC are required to achieve this; these upgrades consist of works to remove capacity restrictions on the channel. The Stage 1 pump station will need to be augmented in the future to provide additional capacity. This option relies on the HMC system in perpetuity.

Option 1 makes the Haughton Pipeline completely independent of the HMC by installing the Stage 2 pipeline. The Stage 1 and Stage 2 pipelines would connect at the Haughton River; the Stage 1 pump station would not be required and the Stage 2 pump station would pump water over 70 km to the Ross River Dam. The pump stations at Clare will need to be augmented in the future to provide additional capacity.

Option 2 is initially identical to the base case, with the difference that at a future date the Stage 2 pipeline and pump stations would be installed to transfer water from Clare to the Haughton PS. When the Stage 2 pipeline is installed, the system would become independent of the HMC system.

Option 3 involves applying demand management strategies at Townsville to reduce demand. These demand management measures are expected to defer but not necessarily remove the need to augment Townsville's water supply in the future. Option 3 is therefore not directly comparable to the other business case options in terms of infrastructure requirements.

The system components required for the three business case alternatives are summarised in **Table E - 6**.

Table E - 5 Business Case Options – Key Features

Business Case Option		Stage 1			Stage 2	
		Pipeline	Pump Station	HMC Upgrades	Pipeline	Pump Station
General Description		DN1800 Haughton PS to Toonpan (as per current design).	Transfer PS at Haughton PS site	Remove restrictions (mainly creek crossing improvements).	DN1800 Clare to Haughton PS.	River PS + Transfer PS, both at Clare site.
Base Case	Scope	I	I	I	NR	NR
	Timing	Under construction.	Now + Future Upgrade	Now	-	-
Option 1	Scope	Modified (reduced length) south of Haughton River.	NR	NR [1]	Black Road to Haughton PS section removed.	River PS + Transfer PS
	Timing	Under construction.	-	-	Now	Now + Future Upgrade
Option 2	Scope	I	I	I	I	I
	Timing	Under construction.	Now + Future Upgrade	Now	Future	Future
Option 3	Scope	I	I	I	NR	NR
	Timing	Under construction.	Now + Future Upgrade	Now	-	-

Notes:

1) HMC upgrades are not required for the Haughton Pipeline, but may be otherwise required for the SunWater operation of the Haughton Irrigation Area.

Figure E - 10 System Configuration Options

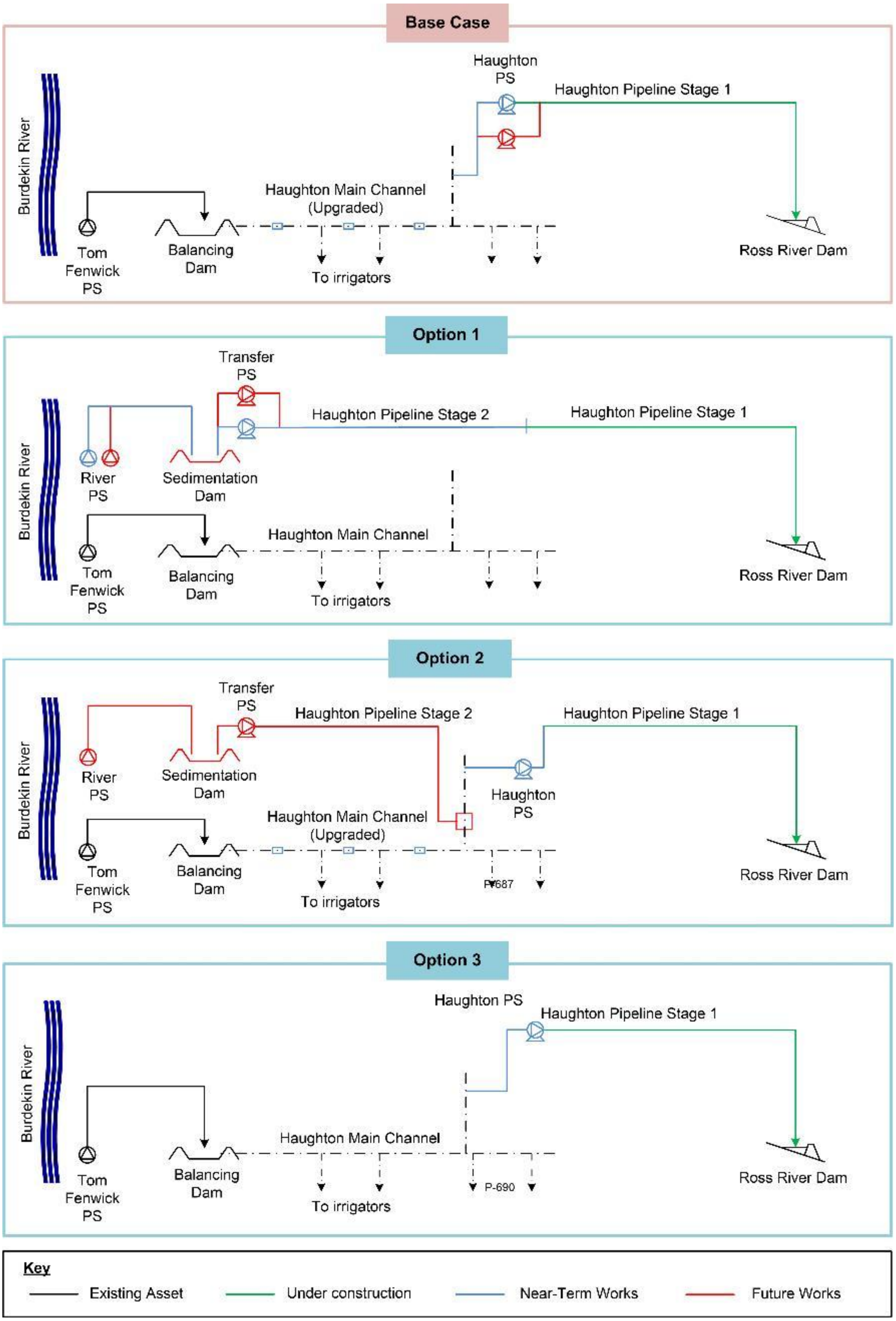


Table E - 6 System Components – Business Case Scenarios

System Element	Infrastructure Description	Base Case	Option 1	Option 2
Stage 1				
Pipeline - Haughton to Toonpan	DN1800 GRP pipeline	l	l	l
Haughton Pump Station – Phase 1	Submersible pump station on HMC - Capacity 234 ML/d	l	-	l
Haughton Pump Station – Phase 2	Upgrade pumps to 364 ML/d	l	-	l
Haughton main channel Augmentation	Modifications to remove capacity constraints, mainly pipe siphons upgrades at creek and road crossings.	l	-	l
Stage 2				
River Pump Station – Phase 1	Pump station tower in bank of Burdekin River	-	l	l
Pipeline - River PS to Sedimentation Dam	1829 MSCL x 500m pipeline Flowmeter	-	l	l
Sedimentation Dam	90ML earth-fill ring dam	-	l	l
Pipeline SunWater Dam – Sedimentation Dam	Optional feature to enable sedimentation dam to be fed from SunWater system if required.	-	Optional	Optional
Transfer Pump Station – Phase 1		-	l	l
Transfer Pump Station – Phase 2	Upgrade pumps to 364 ML/d	-	l	l
Pipeline – Clare Haughton River	1829 MSCL x 33,000m pipeline	-	l	l
Pipeline – Haughton River to Haughton PS	1829 MSCL x 2,000m pipeline	-	-	l
Modified Intake – Haughton PS	Concrete structure built across branch from Haughton main channel branch supplying the Haughton pump station. Concrete structure incorporating: · gates to control flow from HMC, · intake/discharge from Stage 2 pipeline	-	-	l
Power Supply - Mains Power	Capacity to provide full power demand of the system.	-	l	l
Power Supply – Solar Power	Capacity to provide power for 6 hours/day of pump operation.	-	l	l

E.3.3 Design Inputs

E.3.3.1 Geotechnical Conditions

The following sections provide a summary of the major geotechnical considerations for the proposed works.

Pipeline Installations

Trench Profiles & Excavatability

The proposed pipeline will be for the most part be installed by an open trench excavation method, by the use of large excavation plant; significant creek, rail and road crossing will also be installed by trenching, but with the use of sheet piling

The assumption has been that trenches will be excavated by means of excavators (as is the case for the majority of the Stage 1 pipeline). Based on desktop and site-specific investigations undertaken to date, the following conditions are expected:

- Free digging totally within alluvium—18,300 m, or approximately 51 per cent of the proposed pipeline alignment
- Hard digging, then ripping required residual soils/extremely weathered rock overlying competent bedrock—2,700 m, or approximately 9 per cent of the proposed pipeline alignment
- Free digging, then hard digging required for alluvial deposits overlying residual soils/extremely weathered rock (with or without corestones)—10,600 m, or approximately 31 per cent of the proposed pipeline alignment
- Free digging, and then ripping required for alluvial deposits overlying competent bedrock—2,900 m, or approximately 9 per cent.

Groundwater & Trench Stability

The terrain and ground conditions suggest that ground water levels will be high and extensive water management during construction will be required. Soils are likely to be saturated in the vicinity of creek crossings and poorly drained terrain. The proximity of the Haughton main channel, which is understood to lose much water to seepage, will probably exacerbate the situation.

The stability of the pipeline trenches, along with constructability aspects, will probably require dewatering by use of probable well point systems; discharge of pumped water is presently considered to be back into surface water courses via settlement tanks.

Reuse of Excavated Materials

Reuse of excavated materials may be limited due to its variable nature both vertically and horizontally, its inherent characteristics, high moisture contents, lack of space for stockpiling and reprocessing and high groundwater tables. In this respect significant volumes of imported granular backfill materials sourced from offsite commercial quarries or licensed sand extraction locations will be required. The spoiled material will be required to be removed offsite to a suitable receiving location.

No specific treatment of spoiled material is presently considered necessary for disposal to offsite locations/facilities.

Scour & Buoyancy

Scour and buoyancy issues associated with the extensive floodplains can be suitably dealt with (in part with the use of steel pipe), with appropriate designs and options including the use of rock armour, concrete linings, sand bagging and geotextiles.

Impacts on the Existing Haughton Main Channel

Significant sensitivity analysis by use of multiple potential ground profiles, as well as worst case scenarios of surcharge loading and hydraulic conditions, indicates that construction of the proposed Stage 2 pipeline will have no detrimental impacts on the existing Haughton Main Channel.

Other issues

Investigations and site observations suggest that excavated faces and bare soil areas may have a sodic nature. These can be dealt with by a variety of appropriate control measures including:

- Additional drainage control measures;
- Using a non-reactive covering over the surface of the pipeline;
- For cohesive dominated backfill soils treat the upper 300-500mm by mixing with potentially between 2 to 5% by weight of gypsum - the calcium will replace the sodium minerals and improve soil permeability and allow water to pass through this layer without erosion occurring – in addition the mixed zone needs to be carefully compacted;
- For granular dominated backfill soils install a geotextile 300-500mm below ground surface and then replace with the excavated soil – the geotextile will act as a barrier in this case; and
- Installing sand blocks or barriers across/around proven tunnel prone area

The presence of reactive and ASS soils, as indicated in the published data has not been confirmed by the Jacobs investigations and as such no special precautions have been deemed to be required for these ground conditions.

Limited site specific aggressivity testing suggests non-aggressive conditions for the steel pipe and associated buried concrete and reinforcement.

It is recommended that all assumptions on ground conditions and their impacts on the pipeline installations should be further confirmed by additional appropriate investigations during the detailed design phase.

Water Retaining Structures

The Burdekin Sedimentation Dam & Haughton Balancing Storage embankments will be composed of either suitable clay materials from the pipeline or dam excavations but will not include potential sodic or high shrink-swell clays. On the basis that the embankment will be constructed in no greater than 300mm lift heights with suitably compacted low permeability clays, no global stability issues are envisaged for these proposed retaining embankments. Based on the recent site-specific geotechnical investigations a significant thickness of very stiff to hard low plasticity clay was encountered over the footprint of the Burdekin Sedimentation Dam. It is suggested that the dam base is of appropriate character to not require a PE liner to be installed for leakage purposes. No investigations were possible for the Haughton Balancing Storage and in this case, it is suggested that an allowance for a PE liner should be made.

Structural Foundations

Due to the probable existence of deep soil profiles, driven pile foundations have been defined for the proposed pumping station foundations, as well as the associated Intake Structure for the Burdekin Transfer Pumping Station.

A concrete raft support by shallow driven pile foundations have been designed for the pigging stations.

As indicated previously based on limited data it is interpreted that non-aggressive ground conditions may be apparent for structural foundations.

E.3.3.2 Flood Levels

Very limited flood information is available. Based on low resolution flood mapping for the Burdekin River, a 0.01 AEP flood level for the Clare site of RL 39.0m has been assumed for this design.

No flood level data is available for the Haughton PS site.

The pipeline alignment can be subjected to occasional short-term flooding in creeks of up to about 4m depth. The southern 5km of pipeline will occasionally be inundated with surcharge from the Burdekin River. The data is insufficiently detailed to estimate the depth of flooding, but it seems likely that it could be up to about 1-2m deep in some places in a 0.01 AEP event.

E.3.3.3 Bushfire Protection

Bushfire is expected to be a periodic hazard to the pipeline. However, the majority of the pipeline infrastructure will be buried, so any bushfire damage will be limited to surface appurtenances such as air valves and scours.

The pump stations and the discharge structure at Haughton will be above-ground and therefore at risk of bushfire damage. This risk will be mitigated by clearing the area around the structures of vegetation to provide a fire break. It is not considered that fire sprinkler systems are required, however this should be considered in more detail during detailed design.

E.3.3.4 Durability

Based on available site-specific laboratory testing, non-aggressive subsurface ground conditions have been interpreted for steel pipes and buried concrete & reinforcement.

The overall service life assumed for the system is 80 years. The service life required for system components is assumed to be as follows:

- Civil works — 80 years
- Structures — 50 years
- Mechanical — 30 years
- Electrical — 30 years
- Instrumentation and Controls — 20 years

E.3.4 Hydraulics

E.3.4.1 Steady State Hydraulics

The steady state hydraulic characteristics of both the River Pump Station and the Transfer Pump Station and pipelines have been evaluated using spreadsheet analysis.

The steady state analysis for both systems has determined duty flow and pressure ranges between the initial (Phase 1) and ultimate (Phase 2) cases, and also covering varying static head levels, temperature and viscosity, pipe roughness and fouling. Preliminary pump selections were made, ensuring acceptable VSD, motor and pump speeds covering all required operating ranges. Checks were also made for Minimum Continuous Stable Flow (MCSF), inlet submergence and NPSH. Motor rated power and absorbed electrical power values were also derived from these calculations.

The tables below give duty points for both the River Pump Station and Transfer Pump Station pumps.

Table E - 7 River Pump Duty Points

Alignment Option		Pipe Diameter mm	Flow Velocity m/s	Flow		Max. Duty Head m	Pump No. & Power Rating kW
				ML/day	L/s		
Option 1 & Option 2	Phase 1	DN1800	1.21	234	2,955	18.14	2 x 400
	Phase 2		1.88	364	4,595	19.23	3 x 400

Notes:

1) Instantaneous flow calculated based on 22 hr/day operation.

Table E - 8 Transfer Pump Duty Points

Alignment Option		Pipe Diameter mm	Flow Velocity m/s	Flow		Max. Duty Head m	Pump No. & Power Rating kW
				ML/day	kW		
Option 1	Phase 1	DN1800	1.21	234	2,955	66	2 x 1400
	Phase 2		1.88	364	4,595	131	4 x 2600
Option 2	Phase 1		1.21	234	2,955	27	2 x 500
	Phase 2		1.88	364	4,595	63	2 x 1700

Notes:

1) Instantaneous flow calculated based on 22 hr/day operation.

E.3.4.2 Dynamic Hydraulics

Preliminary dynamic hydraulic modelling has been undertaken using Bentley Hammer software package. The Option 1 (combined 70km Stage 1+2 pipeline) and Option 2 (35km Stage 2 pipeline) ultimate configurations were evaluated for the following failure scenarios:

Pump shutdown (power failure):

For the pump power failure case, maximum surge pressures for both Option 1 and Option 2 were no greater than the maximum operating HGL pressures in both the MSCL (Stage 2) and GRP (Stage 1) pipe sections and are thus considered not of concern. Some air valves were modelled in this case to mitigate undue negative pressures and to allow cushioning of water column return. Further transient modelling in the design phase will be required to confirm all required air valve locations and capacities.

Rapid valve closure:

Various valve closure profiles were modelled for both Option 1 and Option 2, and with the pumps running. Valve closure for Option 2 was found suitable within 120 seconds without exceeding the pipeline Maximum Allowable Pressure (MAP). Valve closure for Option 1 required a closure profile of approximately ten minutes in order to avoid the proposed hydrostatic test pressure of the Stage 1 GRP pipeline (1750kPa test, ref. Stage 1 drawing 42-20452-W500). For both options, a detailed transient analysis of the final proposed design will need to be performed to inform and mitigate these cases.

The results (see table below) generally indicate that closure of pipeline valves whilst pumps are running and/or before pipeline transients have settled is not an acceptable operating case is considered an accident condition only. Pipeline valves will need to be locked in the open position, possibly also including a secondary locking device to halt valve closure at say 80% open position. Valve spindle gear boxes and portable actuators should be designed to avoid accidental rapid valve closure. Normal operating procedures must ensure pumps are shut–down and isolated, and with say ten minutes delay time for transients to settle prior to valve closure.

Table E - 9 Preliminary Transient Analysis Results

Alignment Option	Transient Case	MSCL Pipe Max Surge Pressure (kPa)	GRP Pipe Max Surge Pressure (kPa)	Approximate Time Until Transients Settle (Seconds)	Comments
Option 1	Sudden pump stop (power blackout)	1265	829	3000 (+/- 200kPa)	Max pressure is no greater than steady state HGL
	Rapid valve closure (find critical closure time)	1617	1735	1000 (+/-100kPa)	Using last section valve in Stage 1 design 75%@60sec, 90%@120sec, 100%@600sec
Option 2	Sudden pump stop (power blackout)	598	N/A	800 (+/- 100kPa)	Max pressure is no greater than steady state HGL
	Rapid valve closure (find critical closure time)	1896	N/A	3500 (+/-100kPa)	Using isolation valve 100 metres prior to break dam 90%@60sec, 100%@120sec

Generally, this analysis indicated that no special control devices are required on the pipeline apart from air valves. Non-return valves for both the river pump station and transfer pump station have been designed as a non-slam tilting disc type, with counter weight and end of travel slow closure damper.

E.3.5 Pipeline

E.3.5.1 Pressure Rating

Based on the assessment of static and dynamic system hydraulics, the following nominal pressure ratings have been adopted for the pipeline:

- Burdekin River to Sedimentation Dam (Clare) PN10
- Clare to Haughton PN20

E.3.5.2 Pipe Material

Pipe of 1800mm diameter is available at the required pressure ratings in Glass Reinforced Plastic (GRP) and Mild Steel Cement Lined (MSCL) materials.

GRP offers some advantages in terms of being lighter (making handling easier) and having a lower cost of plain pipe (but not necessarily of fittings or special items). The pipe is installed with flexible joints (usually rubber ring collars) which facilitates quick installation. It has the disadvantages of being especially susceptible to damage and requiring large and expensive thrust blocks at each change in direction.

MSCL is a proven, robust material which has extensively been used for large pipelines. It is easily modified on site and is available with rubber ring joints to facilitate rapid installation. Pipe segments can also be welded together which means that the pipeline can be made to be structurally continuous, enabling it to bridge across areas of poor ground, and largely eliminating the need for concrete thrust blocks because thrust forces can be restrained using pipe skin friction. MSCL material cost for plain pipe can be higher than for GRP, but the overall cost of installation is often comparable to other materials when all factors are considered.

Based on these factors, MSCL has been adopted for this DBC design.

E.3.5.3 Channel, Road and Watercourse Crossings

All channel, road and watercourse crossings for the project have been assumed to be trenched.

The pipeline crosses the Haughton main channel in only one location – at the southern end of the channel where three pipes connect the Clare balancing dam to the channel. Trenching under these pipes will necessitate them being supported across the excavation. Only limited information about the pipe has been made available, so it has not been possible to confirm the feasibility of doing this. Alternative solutions would be to remove the HMC pipes at the crossing point during the installation of the new Haughton pipeline, and replace them afterward, install the new pipeline by boring, or bridge over the top of the existing HMC pipes. These options should be considered during detailed design.

The roads crossed by the new pipeline are all relatively minor rural roads, and trenching across them will be quick, cost effective and can be completed with minimal disruption to traffic.

Minor waterway crossings can also be crossed by trenching and reinstated to minimise impact on drainage.

The five major creek crossings are all listed as significant watercourses, so the method of installing the pipeline across them needs to minimise environmental impact of the works. The installation method across these creeks will require approval by the environmental authorities, however we have assumed for this design that trenched installation will be acceptable provided the footprint of the works is constrained. To achieve this, we have assumed that the trench sides will be supported by sheet piling to reduce the excavation width. Together with a modified construction work method, this would enable the construction corridor to be reduced from 40m to 20m through these areas.

Consideration was also given to installing these crossings by boring methods. Pipeline jacking installation by either auger boring or jacked microtunnelling would be feasible for the road and channel crossings. The major creek crossings will be significantly longer than the feasible maximum for auger bores, but jacked microtunnelling would be feasible.

Horizontal Directional Drilling (HDD) would only be feasible if multiple small-diameter pipes were installed at each crossing. Usually HDD is used to install PE pipe, but this would not meet the pressure rating requirements of this pipeline. In any case, the cost of drilling multiple pipes and connecting them with manifolds at each end of the crossing is unlikely to be cost effective. HDD installation is not considered to be viable for this project.

E.3.5.4 Thrust Restraint

Pipeline thrust at bends has been restrained using pipe embedment. This is method of restraint is significantly more cost effective than passive thrust blocks for large diameter pipelines (assuming equal pipe materials and installation costs).

The relatively poor bearing capacity of the ground along the Stage 2 pipeline alignment also means that passive thrust blocks would be very large, and therefore somewhat impractical and expensive to construct.

E.3.5.5 Pigging Stations

The Burdekin River has a particularly high entrained sediment load, and it is very likely that significant sediment will be extracted by the River Pump Station. With some means of controlling the sediment in the pipeline, it is probable that it would become fouled over time. A full investigation of sediment characteristics could not be completed at this time. For this DBC design, it has been assumed that sediment fouling will need to be managed, and the following approach has been adopted to achieve this:

- Sedimentation Basin at Clare – remove most of the sediment before it enters the pipeline.
- Pipeline pigging stations – periodically remove any residual sediment that enters the pipeline.

Extracting this material in the sedimentation dam will greatly reduce the amount of sediment entering the pipeline, and therefore greatly reduce the rate of fouling of the pipeline. It is likely that it will still be necessary to periodically scour the pipeline of accumulated sediment by pigging. Pigging stations have been specified at pipeline chainages 15km and 35km to accommodate this.

A detailed assessment of sediment loads and the management of sediment accumulation in the pipeline should be undertaken before commencing detailed design.

E.3.6 Clare Site

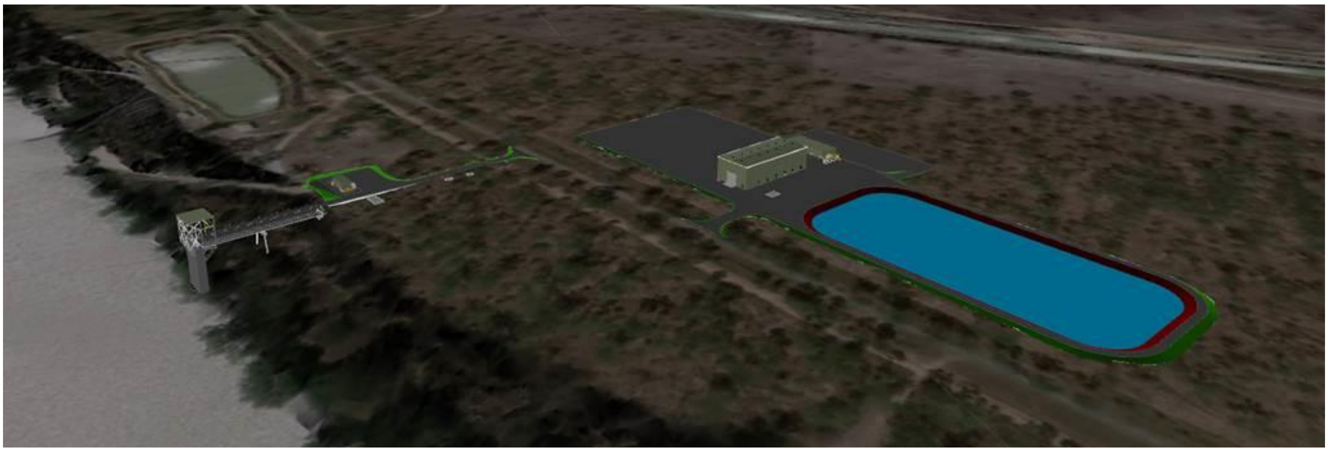
E.3.6.1 Overview

The system at the Clare site includes a low lift pump station on the river, a sedimentation dam and a transfer pump station.

The characteristics of the pumps suitable for the river pump station means that it is not feasible for these to serve the dual purpose of transferring flow from the river to the outlet at Toonpan or Haughton. The silt load in the Burdekin River is also very high, so it will be highly desirable to remove as much silt as possible by passing it through a sedimentation dam before it enters the pipeline.

For these reasons, the two-stage pumping arrangement has been adopted for the pumping system at Clare. A perspective view of the two pump stations and the sedimentation dam at the Clare site beside the existing Tom Fenwick pump station facility is presented in **Figure E - 11**.

Figure E - 11 Clare Site Perspective View

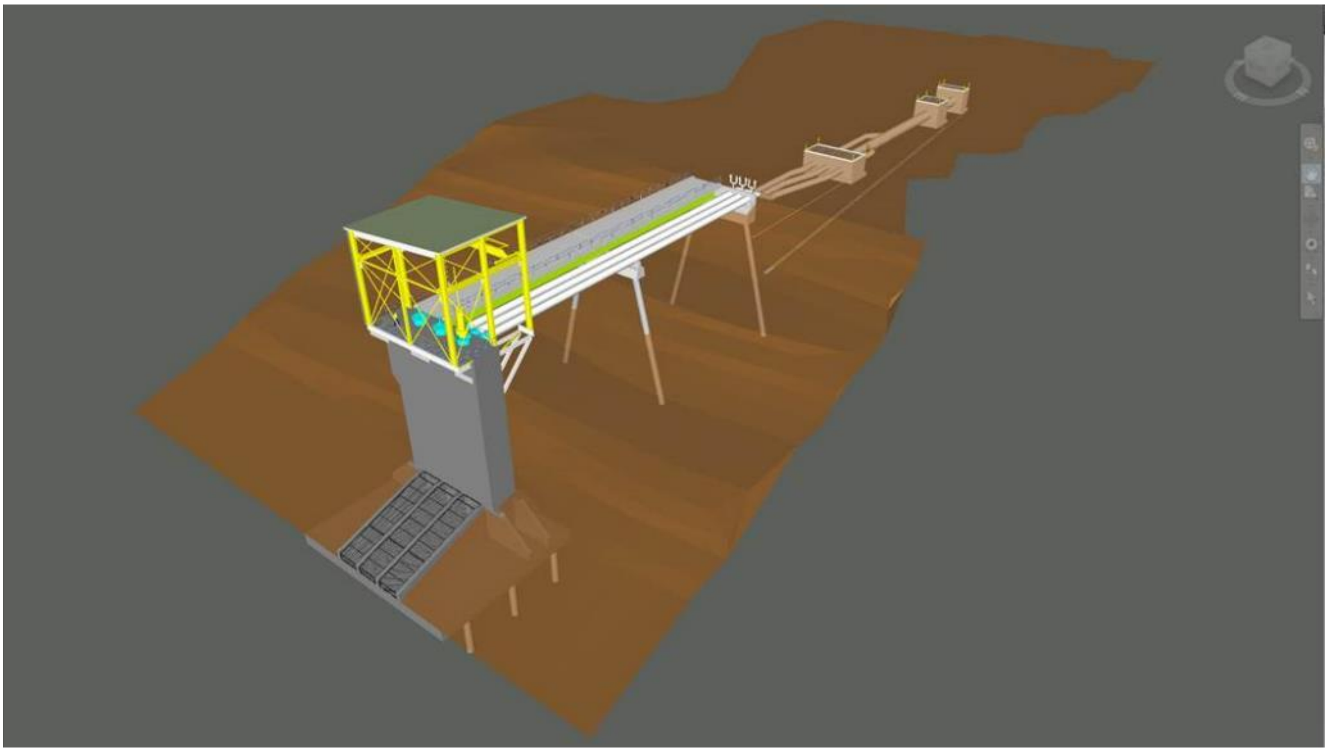


E.3.6.2 River Pump Station

The river pump station has been located adjacent to the existing Tom Fenwick Pump Station (which extracts water from the Burdekin River to supply the Haughton main channel).

A rendered view of the River Pump Station design adopted for the DBC is presented in **Figure E - 12**.

Figure E - 12 River Pump Station Perspective View



For this DBC design, a tower pump station has been adopted. This configuration is built around three submersible centrifugal column pumps of 1400 mm diameter. The tower would be a concrete structure with a footprint of approximately 13 m x 13 m at the river bed level with a 3 m x 13 m x 20 m high mass concrete tower above. A gantry crane would be installed at the top of the tower to enable removal of the pumps. A bridge would span approximately 50 m between the top of bank and the pump tower; the bridge would accommodate the three discharge pipes from the three pumps and a 5 m-wide access road suitable for a heavy rigid vehicle to gain access to the tower.

The foundations of the structure and the bridge would be piled.

The three discharge pipelines from the intake tower would be directed through a pit on the river bank housing non-return and isolation valves for each line before being manifolded into a single 1829 MSCL line. A flowmeter would be installed on the pipeline downstream of the manifold. The discharge pipeline would discharge into the sedimentation dam on the northern side of the Ayr-Ravenswood Road.

Power would be supplied to the site via an 11kV underground power line from a proposed switchyard adjacent to the Transfer Pump Station site on the western side of Ayr-Ravenswood Road. A transformer and switch room would be installed on the river bank adjacent to the tower access bridge. The switchrooms would be elevated above the assumed design flood level of RL39.3m. The switchroom has been designed as a modular unit which can be fully assembled off site, minimising the installation work required on site.

The motors are supplied via low harmonic variable speed drives to limit the harmonic effects on the rest of the power supply.

It is important to note that determining the configuration of a large river abstraction pump station requires evaluation of a complex and challenging operating environment. This design has been developed to serve purpose of cost estimation and has been prepared under significant time constraints and with limited primary data. A full review of the pump station siting, configuration, and details should therefore be undertaken prior to commencing detailed design.

E.3.6.3 Sedimentation Dam

The sedimentation dam has been configured to provide two hours of detention time. While the sediment load within raw water will vary, this time should be sufficient to remove a large portion of the entrained sediment extracted from the Burdekin River by the river pump station.

An earth ring dam has been proposed. The top of the wall has been set at RL39.3m, providing immunity from the assumed 0.01 AEP flood level of RL39.0m, and matching the pad level for the adjacent transfer pump station and 66kV switchyard.

Water would be discharged to the dam from the river pump station via a concrete inlet chamber and discharged to the Transfer pump station via a second chamber located at the opposite end of the dam.

A morning-glory overflow inlet has been provided to enable overfilling of the dam to be discharged from the structure safely to the adjacent gully. This overflow has been sized to accommodate the full rate of pumped inflow (4,600 L/s) A sacrificial crest has been specified on the dam wall to provide a controlled breaching of the dam in the unlikely event that the overflow becomes blocked.

Water level in the dam would be actively monitored (and integrated into the control system) via an ultrasonic water level senor mounted in a standpipe on the pump station suction line.

E.3.6.4 Transfer Pump Station

The Transfer pump station is a conventional pump station which houses horizontal split case pumps.

For Option 2, the pump station would house two pumps for both the short-term and long-term flow scenarios. For Option 1, the pump station would house two pumps for the initial design capacity, and an additional two pumps would be added when it is upgraded to accommodate the ultimate capacity. The footprint shown on the design drawings is for the four-pump configuration.

A rendered view of the Transfer Pump Station exterior design adopted for the DBC is presented in **Figure E - 13**, and a rendered view of the interior is presented in **Figure E - 14**.

Figure E - 13 Transfer Pump Station External Perspective View

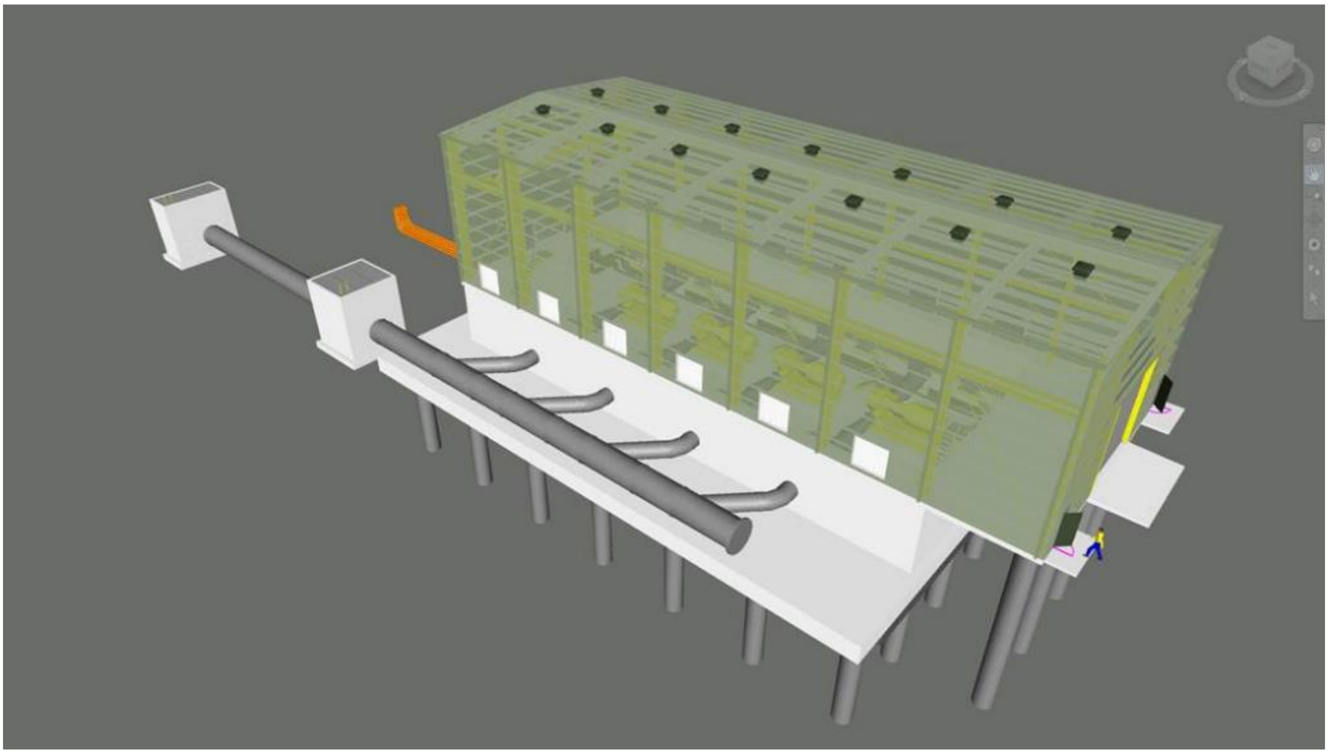
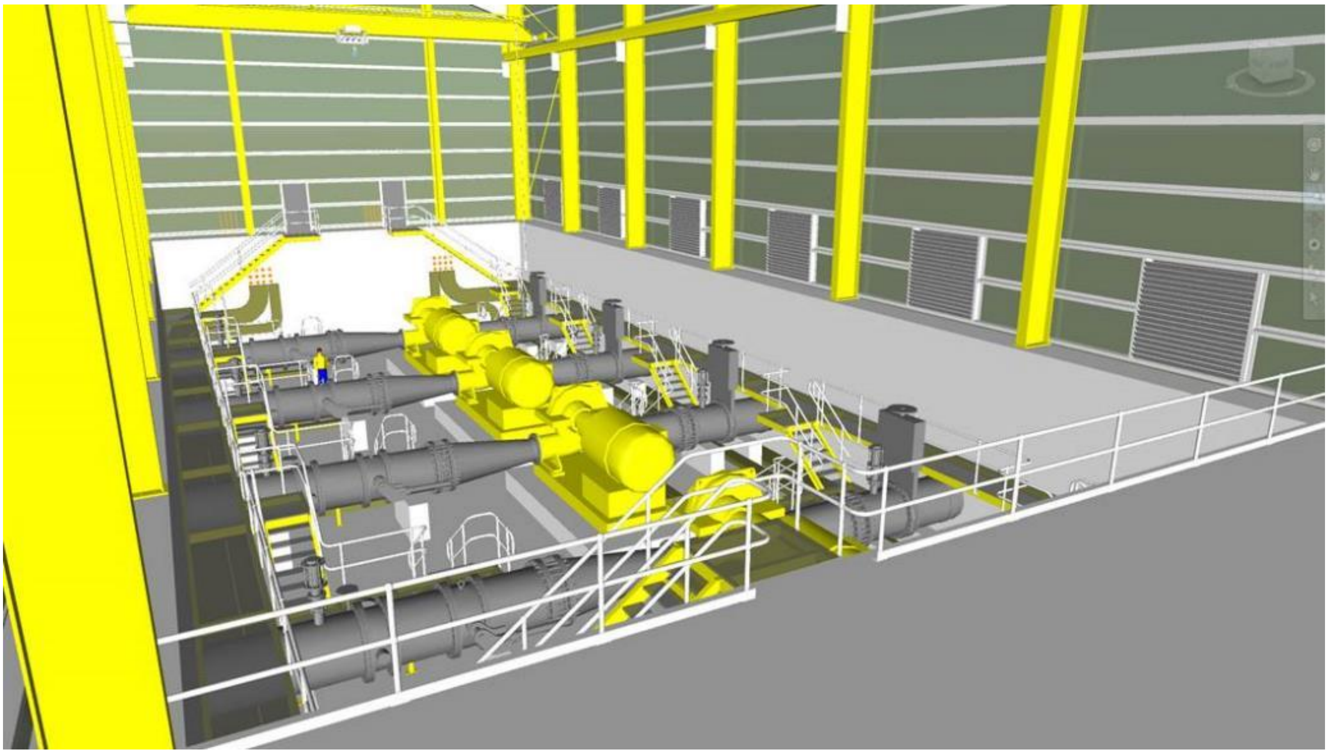


Figure E - 14 Transfer Pump Station Internal View



The pump station would be installed on an earthworks pad with a finished surface level of RL39.3m, located above the adopted 0.01 AEP flood level of RL39.0m. This pad will require filling to raising the existing ground level on the site by about 1.3m.

The pump house floor would be approximately 5m below the pad level. It was necessary to lower the pumps to this level to accommodate the NPSH limitations of the pumps and the water level variability in the sedimentation dam. The sub-surface structure of the pump house would be cast-in place reinforced concrete. The superstructure would be a portal frame steel shed. A gantry crane would be incorporated into the portal frame structure. The foundations of the structure would be piled.

Each pump will be fitted with isolation valves on both sides of the pumps and a non-return valve on the discharge side. The discharge side isolation valve will also function as a start-up control valve, with the pumps being started against a closed valve and protected against high flow motor overload and cavitation conditions. A flowmeter has been provided in a pit outside of the pump house and downstream of the discharge manifold.

Power would be supplied to the site via an 11kV underground cable from the proposed adjacent 66/11kVswitchyard. A transformer and switch room would be installed on the western end of the Transfer Pump Station pump house. The switchrooms would be elevated, providing space underneath for cable marshalling. A building would be installed adjacent to the switch room which will serve multiple purposes as a control room, personnel amenities and site office. The switch rooms and control room building have been designed as pre-assembled modular units which can be fully assembled off site, minimising the installation work required on site.

The motors are supplied via low harmonic variable speed drives to limit the harmonic effects on the rest of the power supply.

E.3.7 Haughton Site

The simplest means of connecting the Stage 2 pipeline to the stage 1 system would be to connect the pipeline directly to the intake of the pump station. Unfortunately, the existing design of the Stage 1 pump station does not facilitate readily accommodate this. The pump station is a structure housing submersible pumps built into a side channel of the Haughton main channel. It is not possible to connect the Stage 2 pipeline to the pump station without significant modifications.

To accommodate this connection, either the Stage 1 pump station would need to be redesigned (which seems unlikely considering that construction tenders have already been called), or an alternative means of feeding the Stage 2 pipeline flow into the Stage 1 pump station would need to be installed.

For this DBC design, it has been assumed that the Stage 1 pump station will be installed as per the design. The proposed Haughton pump station draws water from a side branch of the Haughton main channel. The Stage 2 pipeline will discharge into a new structure built across the HMC side channel which will serve the dual purpose of accepting discharge from the pipeline and controlling the balance of flow between the pumping pool created by the structure and the Haughton main channel.

The structure has been designed with a pipeline outlet control chamber built into a controlled weir across the channel. This effectively creates a controlled pumping pool which can accept water from either the HMC, or the Stage 2 pipeline or both at once. It also enables the Haughton pipeline to be isolated from the HMC so that it can continue to operate when the HMC is not in service.

Flow between the pump pool and the HMC channel is regulated by means of sluice gates installed in the control structure. Overfilling of the pump pool is prevented by means of a weir built into the structure which will enable the pump pool to overtop into the HMC channel, even if the control gates are closed.

The structure will be constructed in reinforced concrete.

Water level in the dam would be actively monitored (and integrated into the control system) via an ultrasonic water level senor mounted in a standpipe on the pump station suction line.

E.3.8 Power Supply

E.3.8.1 Clare Site

Power Demand

Power for the Stage 2 pipeline is predominantly required at the Clare site, due to the presence of two major new pump stations at this location.

The estimated power demand for the Clare site is presented in **Table E - 10**. This data estimates initial power demand rising from 4.9MW initially to 12 MW when full capacity is reached for Option 1 (which involves pumping 70km from Clare to Toonpan with no intermediate (“Stage 1”) pump station). For the Option 2 scenario (under which the Stage 2 pump station only pumps 35km from Clare to Haughton), initial power demand is much lower at 2MW, and rises to 4.7MW ultimately.

Table E - 10 Power Demand Estimate – Clare Site

Facility	Initial				Ultimate			
	Pump Details	Motor Rating kW	Qty No.	Power Demand kW	Pump Details	Motor Rating kW	Qty No.	Power Demand kW
Option 1 (70km Transfer)								
River PS	"Model 3" Pumps	400	2	851	"Model 3" Pumps	400	3	1,200
Transfer PS	Pump Model-600LNN1200	1,400	3	3,723	Add one pump and new motors on all four pumps.	2,600	4	10,400
Auxiliary Load	-			250	-			400
Total (Peak Load)				**4,900**				**12,000**
Option 2 (35km Transfer)								
River PS	"Model 3" Pumps	400	2	851	"Model 3" Pumps	400	3	1,277
Transfer PS	Pump Model-600LNN950	500	2	958	Add one pump and new motors on both pumps.	1700	2	3413
Auxiliary Load	-			150	-			200
Total (Peak Load)				**2,000**				**4,700**

Power Source Options

Two power source options have been considered for the Clare site:

- Grid Power.
- Solar Power.

<u>Grid Power</u>

Grid power is available from a 66kV transmission line which runs past the site. Ergon data available indicates that there is sufficient available capacity in this existing 66kV line to service the power demand for the proposed new pump stations facilities at Clare.

<u>Solar Power</u>

Local solar power generation using photovoltaic (PV) cells has been considered as an optional power source for the project. The project brief was not specific about the design basis expected for the solar power source, however previous options assessment work proposed that a PV generating system would have sufficient capacity to supply all of the power demand for the Stage 1 pump stations.

The solar system adopted is based on a concentrated fixed "PEG" system which requires significantly less land area to the conventional solar systems.

For a PV system to exclusively supply the pump stations, battery storage will be needed to balance the continuous power use (24 hours per day) with the diurnal variation in available sunlight. Generally, sufficient sunlight is available to effectively generate power for 6 hours per day. The batteries will therefore supply the power for 18 hours per day, and for the size daylight hours, the PVs will both supply the power demand and recharge the batteries. The need to provide PV capacity for battery recharge means that the PV surface area for a 24-hour solar system is much greater than for a PV system which only operates for 6 daylight hours per day.

The additional PV capacity plus the battery storage means required for a 24h/d PV system makes it considerably costlier than a system design to operate for 6h/d. The difference in system capacity, footprint and cots is set out in **Table E - 11**.

Table E - 11 Solar Farm Size and Comparative Capital Cost

Item	Unit	Option 1		Option 2	
		Initial	Ultimate	Initial	Ultimate
Total Load	kW	4.9	12.0	2.0	4.7
Solar Farm - 6 Hour/Day Supply					
Solar Farm Size to Supply Pump Station	MWp	12.3	30.0	5.0	11.8
Solar Farm panel Area	Ha	7.3	17.9	3.0	7.0
Indicative Capital Cost	$m	14.7	36.0	6.0	14.1
Solar Farm – 24 Hour/Day Supply					
Battery size	MWh	131	320	53	125
Solar Farm Generating Capacity to Recharge Battery	MWp	32.7	80.0	13.3	31.3
Solar Farm panel Area	ha	19.5	47.7	8.0	18.7
Battery storage area	ha	0.6	1.5	0.3	0.6
Total solar system area	ha	20.1	49.3	8.2	19.3
Indicative Capital Cost	$m	190.6	467.2	77.8	182.9

For the “ultimate” pump capacity (i.e.: 364 ML/d) for Option 1 (pumping 70km from Clare to Toonpan) the solar panel footprint of the 6 h/d solar farm would be 17.9ha, and its indicative cost would be $36m. For this same scenario, but with solar power being used for 24 h/d, the solar panel footprint would be 49.3 ha, and its indicative capital cost would be $467m.

A grid power connection is required for the 6 h/d solar option regardless, which would increase the cost of this option to about $46m. (Arguably, a grid power connection is also needed for the 24 h/d solar generating option to provide a back-up source.)

There is sufficient land available (subject to landowners being willing to sell it) near the Clare site to build a solar farm with sufficient capacity to accommodate any of these scenarios. Cost and reliability are therefore the major factors influencing the feasibility of installing solar power generation capacity for this project.

Because of its very high capital cost, providing 24 h/d solar generating capacity is not considered to be feasible for the project. Providing 6 h/d solar generating capacity is feasible, but still adds significantly to the cost of providing power for the project.

Adopted Power Supply Configuration

For this DBC design it has been assumed that baseload power to accommodate the full power demand will be sourced from the grid. This power proposed to be taken from a new connection to existing 66kV overhead transmission lines which run adjacent to the Transfer PS site. A new 66kV switchyard is proposed beside the Transfer PS which will supply 11kV power to the Transfer Pump Station. The River Pump Station will be supplied via an 11kV underground power supply cable from the Transfer Pump Station switch-room.

It has also been assumed that solar power generating capacity capable of running the Clare site for 6 hours per day will be provided. The solar farm will be located on the western side of the Haughton Main Channel adjacent to the Transfer Pump Station site. It will connect to the Transfer pump station via an 11kV supply cable.

E.3.8.2 Haughton Site

Auxiliary power requirements for the Stage 2 pipeline at the Haughton site are expected to be very low. It has been assumed that low voltage power outlets will be provided for portable valve actuators and for the scour dam pump from the switch-room for the proposed Stage 1 pump station.

E.3.8.3 Other Sites

Section valves and pigging stations along the pipeline will require power for valve actuators and for local instrumentation.

It has been assumed that valve actuators will be portable electric units which will be powered by portable generator, removing the need to provide mains power or generators at these sites.

Instrumentation and local control panels at these sites will be powered by batteries charged by solar panels mounted on the top of the control panels.

E.3.9 Control System

The pipeline and pumping system will be automatically controlled from a PLC/SCADA system installed in the Transfer Pump Station at Clare. SCADA supervisory monitoring and control override will be available locally at the Transfer Pump Station Control Room, from the Townsville City Council control room or from another location nominated by Townsville City Council.

The control system components will communicate via a fibre optic communications cable link. This cable will be installed in a conduit in the pipeline trench between Clare and Haughton sites and connection will be provided at each of the control sites along the route (i.e.: at the River PS, the Transfer PS, the intermediate and outlet pigging stations and the discharge at Haughton. Back-up communications will be provided by radio telemetry along the pipeline noting that a radio-telemetry survey would need to be completed to confirm the viability of this).

The Haughton Pipeline is a back-up water supply system, so it will only operate for part of the time when required by Townsville City Council.

Option 1 Operation

In the DBC Option 1 scenario, the Stage 2 pump station will pump directly to Toonpan (i.e.: the stage 1 pump station will not be required).

When it is operating, the Stage 1 pipeline system run continuously until it is either stopped manually, or after an operator-set time has elapsed. Given the very large capacity of Ross River Dam (the receiving storage) relative to the pipeline flowrate, real-time monitoring of the level in Ross River Dam is not considered to be necessary, however this control functionality could be provided if it thought to be needed.

Under normal operating conditions, the River Pump Station will operate to maintain a flow set point equal to the set point for the Transfer Pump Station. The River PS will modulate using the VSDs to accommodate varying hydraulic conditions in the river. Water levels in the sedimentation/balancing dam at Clare will be monitored and if it moves outside a certain tolerance around the level set point, the pump flow would either be modulated using VSDs, or the pumps would be shut down (if the deviation threatens to cause the receiving dam to over-fill).

Flow meter, flow switch and pressure sensor monitoring of the pipeline will also be used as secondary control inputs, mainly to detect non-standard operating conditions and trigger system shutdown.

Option 2 Operation

In the DBC Option 2 scenario, the Stage 2 pipeline will pump to a “balancing dam” at Haughton (the ponded area behind the control structure on the irrigation supply side channel), then be re-pumped to Toonpan via the Stage 1 pipeline by the Stage 1 pump station.

When operating, the Stage 1 pipeline system will be controlled by the water level in the balancing dam at Haughton. Given that the Stage 2 pipeline will only be operated when the Stage 1 pipeline is also operating, operation of the two pump stations should also be interlocked. This interlock would need to allow the flexibility for either pump station to be operated in isolation of the other for short periods (for example when the Haughton balance storage needs to be filled or emptied.

Under normal operating conditions, the Transfer Pump Station will operate to maintain a flow set point equal to the set point for the Stage 1 pump station. The River Pump Station will operate at the same flow setpoint but will modulate using the VSDs to accommodate varying hydraulic conditions in the river. Water levels in the balancing dam at Haughton and the sedimentation/balancing dam at Clare will be monitored and if it moves outside a certain tolerance around the level set point, the pump flow would either be modulated using VSDs, or the pumps would be shut down (if the deviation threatens to cause the receiving dam to over-fill).

Flow meter, flow switch and pressure sensor monitoring of the pipeline will also be used as secondary control inputs, mainly to detect non-standard operating conditions and trigger system shutdown.

E.4. Basis of Cost Estimate

E.4.1 General

E.4.1.1 Purpose

The purpose of this Basis of Estimate is to provide clear understanding of the processes used in the establishment of the Cost Estimates (CE) prepared by Jacobs. The Estimates have been systematically developed, reviewed and presented with a targeted accuracy range of -15% to +25% in relation to the scope of work, in accordance with the American Association of Cost Engineering (AACE) guidelines for a Class 3 estimate.

E.4.1.2 Estimate Limitations

Jacobs has used its best endeavours within the context of a generally accepted definition of a study of this nature to determine current pricing and equipment lead times for items within this estimate. However, Jacobs cannot warrant the accuracy of this estimate to points in time significantly beyond the date at which this report has been prepared.

It is advised that before applying the estimate provided herein, the user determines current market rates/prices at that point in time (including any foreign exchange variations), to capture any price/rate movements that have occurred since the production of this report. This process ensures that the currency and accuracy of this estimate are maintained.

E.4.1.3 Base Date

The base date for the estimate is Q2 2019.

E.4.1.4 Accuracy of Estimate

The expected accuracy range for AACE Class 3 Estimate is within an accuracy of – 15% to + 25% based on a defined Scope of Work.

Table A.1: Level of Engineering Effort Complete

Discipline	Level of Engineering Effort Complete (%)
Civil	25%
Structural Steel	10%
Mechanical	20%
Pipelines	20%
EIC	10%
Electrical	10%

The level of Engineering Effort Complete, when provided in % complete, relates to the completion of the current scope of work and changes to scope are not considered.

E.4.1.5 Scope of Physical Works for Estimate

Refer to **Chapter E.3** for details of the physical scope of work adopted for this estimate.

A high-level summary of scope of work is:

- River pump station.
- Sedimentation/Balancing Dam.
- Transfer Pump Station.
- Pipeline (brine pipeline network is approximately 35 km long) including provision for future pigging and flushing infrastructure
- Pipeline crossings of watercourses, roads and cane train lines
- Scour dams at pigging stations.
- Discharge/control structure on the channel at the Stage 1 pump station.
- Grid power supply.
- Solar power supply.
- Electrical, Telemetry, Instrumentation and Control System.

E.4.1.6 Work Breakdown Structure (WBS)

Refer to **Attachment C** for the work breakdown structure. The WBS has been developed from PIDs developed for the project.

E.4.1.7 Estimate Currency

The estimate is reported in Australian Dollars. Exchange rate fluctuations are excluded from the estimate.

E.4.1.8 Execution Strategy

It has been assumed that the works will be designed, then delivered via a construction contract.

E.4.1.9 Estimating Software

The estimate was prepared using a combination of MS Excel and Expert Estimator, a commercially available estimating software package from Pronamics, which utilises a detailed resource library and quantity take-offs. It provides estimating functionality supporting "bottom up" estimating methodologies and uses a flexible coding system that enables the project estimate to be sorted and reported in a range of outputs.

The outputs from Success Estimator for Capital Cost are shown in **Attachment C**.

E.4.2 Estimate Methodology

The following sections outline the methodology generally adopted in building up the cost estimate.

E.4.2.1 Major Equipment and Products

Vendor information and budget pricing have been sourced from the following suppliers:

- Switchboards – ABB and Schneider
- Transformers – ABB
- Pump Station Fittings – Steelmains
- Pumps – Flowserve and Grundfos
- Pipelines - MSCL - Steelmains
- Valves – Challenger and AVK

E.4.2.2 Earthworks

Material take-offs (MTOs) for bulk earthworks and civil works have been quantified with the use of design sketches.

A provision of 12% of excavated material within the pipe trench has been made for rock.

Unit rates are based on pricing applicable to other similar projects and current data for the region.

E.4.2.3 Concrete

Quantities have been based on MTOs taken from design sketches for major structures and also on specific designs from previous similar projects for minor footings.

The rates have been built up in the estimate and include detailed excavation, blinding or bedding, formwork, reinforcing steel, concrete and placement, grouped together to form a total concrete rate.

Ready mixed concrete supply pricing was provided from in-house database pricing and allowed at the rate of $\$255/m^3$. Reinforcing supply pricing was supplied from Jacobs' in-house database. Labour hours have been assessed in line with the classification of each category of work.

E.4.2.4 Structural

Material take-offs (MTOs) for structural steel has been quantified with the use of design sketches.

Unit rates are based upon recent budget pricing for the supply, fabrication and delivery of structural steel. Minor items priced using in-house pricing applicable to other similar projects and current data for the region.

E.4.2.5 Architectural

Architectural input for buildings works has been based on quantities derived from preliminary design drawings and details.

Pricing is based on historical pricing.

E.4.2.6 Mechanical

Quantities have been established from P&IDs and general arrangement drawings.

Pricing is based on budget quotations for major equipment, including pumps, pipe fittings, valves and pipe joints.

At pump stations, mechanical drawings have been prepared to detail pipe fittings. Detailed material schedules have been produced and used to quantify for the estimates.

E.4.2.7 Pipelines

Quantities have been provided at a detailed commodity level based on MTO's taken from design drawings and sketches for major structures.

The Long Section and Plan View drawings were used to determine the quantities for air valves, scours, section valves, wet joints, standard gravel access tracks, all-weather gravel access tracks, railway crossings, road crossings, watercourse crossings, foreign utility crossings, low level causeway crossings, flow metering and pond discharge locations.

Typical pipeline detailed drawings were used to build up a detailed breakdown of the main components shown on the Long Section and Plan View drawings.

Key assumptions for pipelines are listed below:

- **Pipeline Alignment** – alignment option 1 has been adopted for the cost estimate.
- **Watercourse Crossings -** crossing of all watercourses was assumed to be by trenching.
- **Road Crossings** - pipeline will be direct laid MSCL with no enveloper pipe (by way of open trench excavation).
- **Low Lying Causeways** – low lying causeways to allow vehicular crossing of minor watercourses were costed based on the assumption that rock crossings will be sufficient (as opposed to concrete or culvert crossings). Rock crossings are deemed more appropriate for western sandy creeks which are prone to washout as the rock is more cost effective and practical to replace.
- **Clearing and Grubbing of the Service Corridor** – it is assumed that a 40m cleared strip will be required to lay the pipeline, but this will be reduced to 25m when crossing significant creeks.
- **Weather** will have an impact on the construction schedule, a provision of 13% of construction days has been allocated for inclement weather disruptions.

E.4.2.8 Electrical, Protection, Communication, and Controls

MTOs were established from single line diagrams (SLDs), data sheets, and drawings (**Attachment C**) and conveyed to the estimator via a delivery process for input into the estimate.

Pricing is based on budget quotations for major equipment. For minor equipment, additional quotes and budgets were obtained to supplement Jacobs' in-house database information.

E.4.2.9 Quantity and Pricing Accuracy

The levels of design used to develop this estimate are summarised by cost and as a proportion of overall costs.

Table A.1: Level of Design Accuracy

Level of Engineering Completed	Percentage of Estimate Value
From Equipment List	30.3%
Preliminary (20%) engineering	69.7%

The levels of pricing used to develop this estimate expressed in costs and as a proportion to overall direct costs are:

Table A.2: Level of Pricing Accuracy

Basis of Estimated Value	Percentage of Estimate Valve
Budget	43.1%
Historical – escalated	56.9%

E.4.2.10 Freight, Duties and Taxes

Pricing for all materials and equipment items included in the direct cost estimate are based on delivery to store on site.

Charges for custom clearance, freight forwarding, import taxes and duties have been included in the prices supplied by the equipment manufacturers and no further allowances were included in the estimate for these items.

Where delivery was not included in the budget quotation, shipping allowances have been made for and specifically identified in the estimate.

All taxes, including Sales and Goods and Services Taxes, are excluded unless otherwise stated.

E.4.2.11 Accommodation for Construction Personnel

Construction of accommodation facilities (e.g. a construction camp) does not form part of the scope of work for this project. It is assumed that construction personnel will be local.

E.4.2.12 Construction Contracts

No specific productivity allowances to the work hours been included in terms of productivity impacts.

The labour rate used in this estimate is based on local personnel on a typical working week.

Contractor Distributable Costs – are calculated as a percentage of the direct labour cost based on historical data for similar projects, both from scope and location aspects.

The Contractor distributable includes items such as:

- Small tools and consumables;
- Contractor's site facilities;
- Indirect labour;

- Supervision;
- Project management;
- Tool box and safety meetings;
- Safety and quality management;
- Mobilisation and demobilisation; and
- Contractor's overheads and profit (for labour hour and distributable costs only).

This is expressed as a percentage mark-up of the base labour rate. It does not include fly-in/fly-out costs or accommodation and messing costs. The percentage mark-ups used in the derivation of the estimate are from our assessment for the likely requirements for each category of work.

Construction Equipment - is included in the contractor distributables.

E.4.2.13 Engineering Services & Management

Costs for Engineering Services associated with detailed design and other Project Management and Construction Management activities have been included in the estimate.

E.4.2.14 Owner's Costs

Owner's costs are included in the cost estimate. The Owner's Budget estimate should include but is not limited to land acquisition, general management, additional consultants and service providers, insurance and fees, legal services, bonds and licences, office overheads, land acquisition, power supply and contingency. The owner should satisfy themselves that the allowance made is enough for their intended delivery method.

E.4.2.15 Growth

Growth is treated as an integral part of the base estimate. It is a provision for that part of the defined scope which is not fully known, specified or measurable at this time. It is not to be confused with contingency which is considered separately.

Growth upper and lower ranges have been nominated against each line item in the estimate based on the assessment of two variables – level of engineering and cost data source.

The combination of these dictates the growth provision as a percentage to be applied to the line item.

E.4.2.16 Escalation

The base date for the estimate is the Q2 2019, with all pricing in the estimate current to this date. No allowance has been made in the estimate for escalation of pricing from this date; however, for project approvals and budgets the Owner must make an allowance for escalation costs.

The Owner should review the estimate on a cash flow commodity basis and derive escalation factors which are applied to the cash flowed commodities to determine the escalation.

E.4.2.17 Contingency

No allowance for contingency has been made in the base cost estimates. For details of the contingency allowance which has been added to these base cost estimate to determine a nominal P90 cost for the project please refer to the Detailed Business Case report.

E.4.3 Qualifications, Assumptions and Exclusions

E.4.3.1 Exclusions

- Residual value of temporary equipment and facilities;
- Residual value of any redundant equipment;
- Residual value of any downtime;
- Cost to Client of any downtime;
- Cost to Client of any isolation and de-isolation of plant and equipment;
- Permits and the like;
- Performance bond premiums;
- All taxes and duties including sales taxes and GST, import duties (except those nominated in vendor quotations);
- Costs associated with further studies;
- Levies such as Portable Long Service Leave; Workplace Health & Safety Levy; and Building and Construction Industry Training Levy.
- Escalation after the estimate base date;
- Project Risk Allowance;
- Unexpected & unidentified site conditions;
- Labour disputes;
- Force Majeure;
- Cost of operational disruptions;
- Loss of production and or extended commissioning period;
- End of life costs including removal of infrastructure and site rehabilitation;
- Allowance for any variation to scope from that described in the study;
- Does not include commissioning costs beyond engineering support;
- Foreign Exchange Allowances;

- Community consultation and engagement allowances;
- Public relations allowances;
- Compliance allowances;
- Insurance Costs;
- Further studies;
- Extreme Weather interruptions to project works;
- Extreme events;
- Acts of God;
- Costs for multiple mobilisation and demobilisation during project delivery;

E.4.3.2 Qualifications

- It has been assumed that the works will be designed, then delivered via a construction contract.
- It is assumed that the pipes and fittings for the pipeline would be free-issued to the contractor (i.e. no contractor overhead or margin has been applied to the value of the pipe and fitting supply costs.
- This estimate is a Project Costs Estimate including allowance for growth, and risk of price adjustment and scope of work uncertainty.
- The estimate includes costs indirect costs such as Engineering Project and Construction Management, common distributable costs, and client costs;

E.4.3.3 Assumptions

Specific Assumptions:

- All construction work is based on day shift work with local labour.
- Geotechnical design information was not available for every site, the CCE allowance for foundations and footings were therefore based on general ground profile available for other sources, and from preliminary site inspections undertaken during the DBC development.
- It has been assumed that pipe crossings of creeks will be performed during dry seasons. A nominal allowance for dewatering and protection has been included in the estimate.
- All construction work is based on a continuous flow of work and any disruption may require changes to the programme and/or additional costs; and
- It has been assumed that sufficient labour resources would be available to perform the works.
- Power and water for the contractor are made available to the contractor at no additional cost.
- A suitable area is made available for contractor facilities;

- Scope of infrastructure would be awarded to a single contractor through a competitive tender.

Attachment A. Cost Estimates - Alignment Options Comparison

Option 1 - HMC Alignment
Cost Estimate
IH175200 Ahughton Pipeline Stage 2 DBC

Revision	A
Revision Date	13/03/2019
Print Date	31/05/2019 7:40

Capital Cost

Item	Description	Details	Unit	Qty	Rate *$/unit)*	Amount *AUD*
1	**River Pump Station**					
1.1	Pump mount/structure		LS	1	9,500,000	9,500,000
1.2	River bank protection works		LS	1	1,000,000	1,000,000
1.3	Pumps		Ea	3	273,000	819,000
1.4	Pipework	Incl valves etc	LS	1	2,500,000	2,500,000
1.5	Switch board & electrical	Incl switch room	LS	1	1,000,000	1,000,000
1.6	Instrumentation and Controls		LS	1	150,000	150,000
1.7	Power supply		LS	1	200,000	200,000
1.8	Access & general civil works		LS	1	1,000,000	1,000,000
1.9	Pipe to settling basin		m	100	5,000	500,000
	Item Sub-Total					**16,669,000**
2	**Settling Basin/Balance Tank (Ring Dam)**					
2.1	Clear, grub and strip		m2	15,090	3	45,271
2.2	Earthworks		m3	29,401	40	1,176,052
2.3	Liner		m2	9,917	40	396,697
2.4	Overflow		LS	1	750,000	750,000
2.5	Inlet		LS	1	400,000	400,000
2.6	Outlet		LS	1	350,000	350,000
2.7	Instrumentation and Controls		LS	1	75,000	75,000
	Item Sub-Total					**3,193,020**
3	**Transfer Pump Station**					
3.1	Building		m2	714	1,250	892,500
3.3	Pumps		Ea	4	673,000	2,692,000
3.4	Pipework	Incl valves etc	LS	1	3,000,000	3,000,000
3.5	Switch board & electrical		3	1	3,000,000	3,000,000
3.6	Instrumentation and Controls		LS	1	350,000	350,000
3.7	Power supply		LS	1	4,000,000	4,000,000
3.8	Access & general civil works		LS	1	300,000	300,000
	Item Sub-Total					**13,934,500**
4	**Pipeline**					
4.1	Pipeline		m	34,000	3,500	119,000,000
4.2	Creek crossings		Ea	7	600,000	4,200,000
4.3	Road crossings		Ea	2	250,000	500,000
4.4	Channel crossings		Ea	0	750,000	0
4.5	Scour outlets		Ea	46	20,000	920,000
4.6	Air valves		Ea	46	15,000	690,000
4.7	Pigging Stations		Ea	2	4,000,000	8,000,000
4.8	Section valves		Ea	3	250,000	750,000
	Item Sub-Total					**134,060,000**
5	**Haughton Discharge Structure**					
5.1	Receiving structure/weir		LS	1	5,000,000	5,000,000
5.2	Pipework		LS	1	500,000	500,000
5.3	Instrumentation and control		LS	1	100,000	100,000
	Item Sub-Total					**5,600,000**
7	**Property**					
7.1	Property easements - grazing land		ha	136.0	500	68,000
7.2	Property easements - irrigated cropland		ha	0.0	3,000	0
	Item Sub-Total					**68,000**
	Sub-Total					**157,005,520**
	Survey, Geotech and approvals				3.0%	4,710,166
	Design				7.5%	11,775,414
	Project Management				10%	15,700,552
	Contingency				30%	47,101,656
	Total					**236,293,307**
	Estimated Capital Cost					**237,000,000**

Notes:

1) Estimates are based on early concept assessment. Numbers are broadly indicative only.

Option 2 - Woodhouse Road Alignment
Cost Estimate
IH175200 Ahughton Pipeline Stage 2 DBC

Revision	A
Revision Date	13/03/2019
Print Date	31/05/2019 7:40

Capital Cost

Item	Description	Details	Unit	Qty	Rate $/unit)	Amount AUD
1	**River Pump Station**					
1.1	Pump mount/structure		LS	1	9,500,000	9,500,000
1.2	River bank protection works		LS	1	1,000,000	1,000,000
1.3	Pumps		Ea	3	273,000	819,000
1.4	Pipework	Incl valves etc	LS	1	2,500,000	2,500,000
1.5	Switch board & electrical	Incl switch room	LS	1	1,000,000	1,000,000
1.6	Instrumentation and Controls		LS	1	150,000	150,000
1.7	Power supply		LS	1	200,000	200,000
1.8	Access & general civil works		LS	1	1,000,000	1,000,000
1.9	Pipe to settling basin		m	100	5,000	500,000
	Item Sub-Total					**16,669,000**
2	**Settling Basin/Balance Tank (Ring Dam)**					
2.1	Clear, grub and strip		m2	15,090	3	45,271
2.2	Earthworks		m3	29,401	40	1,176,052
2.3	Liner		m2	9,917	40	396,697
2.4	Overflow		LS	1	750,000	750,000
2.5	Inlet		LS	1	400,000	400,000
2.6	Outlet		LS	1	350,000	350,000
2.7	Instrumentation and Controls		LS	1	75,000	75,000
	Item Sub-Total					**3,193,020**
3	**Transfer Pump Station**					
3.1	Building		m2	714	1,250	892,500
3.3	Pumps		Ea	4	673,000	2,692,000
3.4	Pipework	Incl valves etc	LS	1	3,000,000	3,000,000
3.5	Switch board & electrical		LS	1	3,000,000	3,000,000
3.6	Instrumentation and Controls		LS	1	350,000	350,000
3.7	Power supply		LS	1	4,000,000	4,000,000
3.8	Access & general civil works		LS	1	300,000	300,000
	Item Sub-Total					**13,934,500**
4	**Pipeline**					
4.1	Pipeline		3	30,500	3,500	106,750,000
4.2	Creek crossings		Ea	3	600,000	1,800,000
4.3	Road crossings		Ea	2	250,000	500,000
4.4	Channel crossings		Ea	3	750,000	2,250,000
4.5	Scour outlets		Ea	41	20,000	820,000
4.6	Air valves		Ea	41	15,000	615,000
4.7	Pigging Stations		Ea	2	4,000,000	8,000,000
4.8	Section valves		Ea	3	250,000	750,000
	Item Sub-Total					**121,485,000**
5	**Haughton Discharge Structure**					
5.1	Receiving structure/weir		LS	1	5,000,000	5,000,000
5.2	Pipework		LS	1	500,000	500,000
5.3	Instrumentation and control		LS	1	100,000	100,000
	Item Sub-Total					**5,600,000**
7	**Property**					
7.1	Property easements - grazing land		ha	122.0	500	61,000
7.2	Property easements - irrigated cropland		ha	0.0	3,000	0
	Item Sub-Total					**61,000**
	Sub-Total					**144,423,520**
	Survey, Geotech and approvals				3.0%	4,332,706
	Design				7.5%	10,831,764
	Project Management				10%	14,442,352
	Contingency				30%	43,327,056
	Total					**217,357,397**
	Estimated Capital Cost					**218,000,000**

Notes:

1) Estimates are based on early concept assessment. Numbers are broadly indicative only.

Option 2 - Woodhouse Road Alignment
Cost Estimate
IH175200 Ahughton Pipeline Stage 2 DBC

Revision	A
Revision Date	13/03/2019
Print Date	31/05/2019 7:40

Capital Cost

Item	Description	Details	Unit	Qty	Rate *$/unit)*	Amount *AUD*
1	**River Pump Station**					
1.1	Pump mount/structure		LS	1	9,500,000	9,500,000
1.2	River bank protection works		LS	1	1,000,000	1,000,000
1.3	Pumps		Ea	3	273,000	819,000
1.4	Pipework	Incl valves etc	LS	1	2,500,000	2,500,000
1.5	Switch board & electrical	Incl switch room	LS	1	1,000,000	1,000,000
1.6	Instrumentation and Controls		LS	1	150,000	150,000
1.7	Power supply		LS	1	200,000	200,000
1.8	Access & general civil works		LS	1	1,000,000	1,000,000
1.9	Pipe to settling basin		m	100	5,000	500,000
	Item Sub-Total					**16,669,000**
2	**Settling Basin/Balance Tank (Ring Dam)**					
2.1	Clear, grub and strip		m2	15,090	3	45,271
2.2	Earthworks		m3	29,401	40	1,176,052
2.3	Liner		m2	9,917	40	396,697
2.4	Overflow		LS	1	750,000	750,000
2.5	Inlet		LS	1	400,000	400,000
2.6	Outlet		LS	1	350,000	350,000
2.7	Instrumentation and Controls		LS	1	75,000	75,000
	Item Sub-Total					**3,193,020**
3	**Transfer Pump Station**					
3.1	Building		m2	714	1,250	892,500
3.3	Pumps		Ea	4	673,000	2,692,000
3.4	Pipework	Incl valves etc	LS	1	3,000,000	3,000,000
3.5	Switch board & electrical		LS	1	3,000,000	3,000,000
3.6	Instrumentation and Controls		LS	1	350,000	350,000
3.7	Power supply		LS	1	4,000,000	4,000,000
3.8	Access & general civil works		LS	1	300,000	300,000
	Item Sub-Total					**13,934,500**
4	**Pipeline**					
4.1	Pipeline		3	33,200	3,500	116,200,000
4.2	Creek crossings		Ea	2	600,000	1,200,000
4.3	Road crossings		Ea	5	250,000	1,250,000
4.4	Channel crossings		Ea	8	750,000	6,000,000
4.5	Scour outlets		Ea	45	20,000	900,000
4.6	Air valves		Ea	45	15,000	675,000
4.7	Pigging Stations		Ea	2	4,000,000	8,000,000
4.8	Section valves		Ea	3	250,000	750,000
	Item Sub-Total					**134,975,000**
5	**Haughton Discharge Structure**					
5.1	Receiving structure/weir		LS	1	5,000,000	5,000,000
5.2	Pipework		LS	1	500,000	500,000
5.3	Instrumentation and control		LS	1	100,000	100,000
	Item Sub-Total					**5,600,000**
7	**Property**					
7.1	Property easements - grazing land		ha	90.0	500	45,000
7.2	Property easements - irrigated cropland		ha	42.8	3,000	128,400
	Item Sub-Total					**173,400**
	Sub-Total					**158,025,920**
	Survey, Geotech and approvals				3.0%	4,740,778
	Design				7.5%	11,851,944
	Project Management				10%	15,802,592
	Contingency				30%	47,407,776
	Total					**237,829,009**
	Estimated Capital Cost					**238,000,000**

Notes:
1) Estimates are based on early concept assessment. Numbers are broadly indicative only.

Attachment B. Basis of Design

Attachment B.1 Reference Documents

The following Australian Codes and Standards, International Codes and Standards and Queensland Acts and Regulations are referenced in this document and will be applied to this project.

Document	Description
Nickel Institute Publication 11021	High Performance Stainless Steels
Nickel Institute Publication 11026	Fabricating Stainless Steel for the Water Industry
Sandvik SAF 2507 Bulletin	Stress Corrosion Cracking properties of SAF 2507 alloy
Sandvik SAF 2205 Bulletin	Stress Corrosion Cracking properties of SAF 2205 alloy
C-276 Hastelloy Properties	http://www.haynesintl.com/hastelloyc276alloy/HASTELLOYC276AlloyACD.htm
AS2129	Flanges for Pipes, Valves and Fittings
AS/NZS 2566.1	Buried Flexible Pipelines – Structural Design
AS/NZS 2566.2	Buried Flexible Pipelines – Installation
AS2638.1	Gate Valves for Waterworks Purposes – Metal Seated
AS2638.2	Gate Valves for Waterworks Purposes – Resilient Seated
AS3780	The Storage and Handling of Corrosive Substances
AS3833	The Storage and Handling of Mixed Classes of Dangerous Goods in Packages and Intermediate Bulk Containers
AS4087	Metallic Flanges for Waterworks Purposes
AS/NZS 4130	Polyethylene Pipes for Pressure Application
AS4158	Thermal Bonded Polymeric Coating on Valves and Fittings for Water Industry Purposes
AS4795	Butterfly Valves for Waterworks Purposes
AS4956	Air Valves for Water Supply
AS5081	Hydraulic Operated Automated Control Valves for Waterwork Purposes

Attachment B.2 Basis of Design

Attachment B.2.1 Design Flow

Design flows to be adopted for this project are summarised in Table 3.

Table 3 Design Flows

Timeframe	Unit	Now	Future
Annual	GL/yr	78	122
Daily	ML/d	234	364
Instantaneous	L/s	2955	4595

Notes:

1) Annual Flow rate based on pumping daily rate for 48 weeks per year.
2) Instantaneous Flow Rate based on pumping for 22 hours per day.

Attachment B.2.2 Pipelines and Pipework

Item	Design Basis
General Pipelines and Pipework	
Design Flow Rates	Refer **Section** Error! Reference source not found..
Minimum Pipeline Velocity	1.1 m/s
Maximum Pipeline Velocity	2.0 m/s
Pipe Material	Below ground generally: Mild Steel Cement Lined 12mm wall ("MSCL") Below ground at high pressure areas: Mild Steel Cement Lined 12mm wall ("MSCL") Below ground at water crossings: Mild Steel Cement Lined 12mm wall ("MSCL")) Above ground generally: Mild Steel Cement Lined 12mm wall ("MSCL")
Maximum Allowable Operating Pressure (MAOP) **Maximum Allowable Pressure (MAP)**	Dependent on pipeline material. Calculate in accordance with relevant codes and manufacturer's recommendations. APIA code will be used for PE pipe. MAOP is the maximum head which can be sustained by the pipeline for extended periods of time under normal operating conditions. Such conditions include: · Normal steady state operation · Pump dead head operation (against a closed valve). MAP is the maximum head which can be sustained by the pipeline for occasional short periods of time of up to a few minutes duration (i.e.: under abnormal operating conditions). Such conditions include: · Pressure surge events · Pipeline pressure acceptance testing.
Air Valves	50 mm to 100 mm double acting air valves located at maximum 800 m spacing and at all high points and significant changes in vertical alignment. Additional air valves are likely to be required in some locations to mitigate vacuum conditions in the pipeline under some surge conditions. *To be confirmed by surge modelling during detailed design.* All Air Valves of Classes 150 and 300 to have Single Block and Bleed ball valve for isolation to enable replacement while main pipeline is on-line. *[Note: it is assumed that the pipeline will not be operating while any work is undertaken on it].*
Surge mitigation facilities	*Size, type and location of surge mitigation facilities to be confirmed by surge modelling with final pump and pipe selections during detailed design.* A surge vessels may be required at Haughton River (discharge) end of the pipeline. Air valves required.
Section Valves	Butterfly valves. Manual actuated with gearbox. (Operable with a portable electric actuator power by generator). Generally located at 5 km intervals. Installed in a closed concrete pit Provide extended spindle to enable operation from the surface with handwheel and gear box above ground.
Scour Valves	Gate valves. Scours to have camlock coupling complete with cap.
Design life	80 years
Design Temperature (pipe)	Above ground: –10 to +80°C Below ground: +8 to +40°C

Availability	98% notional reliability, includes: 0% scheduled maintenance outage allowance (maintenance will occur during the annual 4-week shutdown) 2% unplanned outage allowance (4 days per year)
Pipeline Field Test Pressure	1250 kPa
Effective Roughness (k_s):	Dirty pipe (with slime and scale build-up): 0.5 mm
Minimum Depth of Cover	1.2 m
Pipeline Standards:	Buried: AS/NZS 2566 Above ground: TBC
Valve Standards:	Gate Valves: AS 2638 Butterfly Valves: AS 4795 Ball Valves: ASME B16.34 Air Valves: AS 4956 Check Valves: AS 2845
Flanges:	Up to PN16 Pipe: AS 2129 Up to PN25 Pipe: ISO 1092
Cathodic Protection.	Cathodic protection required for continuously welded buried steel pipes in locations where induced currents are possible (e.g.: near HV power lines).
Pigging Station	
Locations	Provide pigging stations at the following locations: · At Clare transfer PS · At Haughton River · At 5km intermediate intervals (approximately)
Configuration	Pigging pipework partially above ground in pit (enables easy access for maintenance and removes confined spaces). Non-bunded (under pig launcher and retrieval openings only, pumped out into containment dam in case of spillage into bund) with manual drain valve to allow rainwater to drain away when pigging station is not in use. Concrete slab under pipework Security fence around perimeter Unroofed.
Discharge Water Containment	Water contained in a ring dam storage size to accept 150% of the volume of the adjacent section of pipeline (based on 5km sections and DN1800 pipe, the dam would notionally have a capacity of 19 ML. Dam to be designed for periodic desilting. Dam to be drained (by pumping) to the Haughton Main Channel. Provide permanent dewatering pipeline from the containment dam to the HMC. Provide for connection of float-mounted drain pump to the dewatering pipe.
Flow meters	Nil
Pressure Sensors	Manual gauges.
Controls	Upstream pump station to be de-energised before pigging operations. Valve position indicators are interlocked with pump stations to prevent inadvertent pump start-up during pigging operations when valves are incorrectly configured. Communications for controls based on underground fibre network between pump station and pigging stations

Flushing Water Receptacle	No flushing tank on site. Flush water is discharged to tanker truck. Truck connects to flushing point on pig receiver via a camlock connection to receive pigging dirty water.
Sampling Points	DN50 sampling drain under above-ground section of pipe. Locked to prevent inadvertent opening when pipeline is under pressure.
Power Supply	Nil mains power. Local solar power for controls only Control system powered by solar/battery RAPS.
Signaller Transmitter Cabinet	Pig proximity switches. Valve limit switches.
Ring Dam Connections	
Locations	· Clare PS Sedimentation Balancing Dam · Haughton Ps Balancing Dam · Pigging Containment Dams.
Pond Embankment Crossing	Containment Dams: Pipe enters dam over the wall crest. Balancing Dams: Pipe enters dam under wall.
Outlet screens	Trash rack. With 25mm openings.
Overflow	Provide emergency overflow for flow up to the pumped inflow rate. Provide sacrificial crest for emergency dam overtopping control.
Discharge	Concrete lined sump in dam invert. Outlet pipe through dam wall.
Pipe	MSCL

Attachment B.2.3 Pump Stations

Item	Design Basis			
General				
Pump Head and Duty Point	**ID**	**Location/Description**	**Now**	**Future**
		River Pump Station	2955 L/s @ 19-28mH	4596 L/s @ 20-29mH
	Base Case Alt	Transfer Pump Station (to Haughton)	2955 L/s @ 19mH 2955 L/s @ 62-65mH	4596 L/s @ 42mH 4596 L/s @ 108-113mH
Pump Material (Impeller, casing, seals etc.)	Refer **Section** Error! Reference source not found..			
Maximum Operating Pressure	PN12 (Base Case – pump to Haughton) PN16 (Alt Case – pump to Toonpan)			
Operation Regime	Maximum pumping: 24 hours/day. Average pumping: 22 hours/day. Pump station availability is notionally 24 hours per day except for outages.			
Reliability	98% notional reliability, includes: · 1% scheduled maintenance outage allowance (4 days per year) · 1% unplanned outage allowance (4 days per year).			

<table>
<tr><th>Item</th><th colspan="3">Design Basis</th></tr>
<tr><td>Pumped Fluid Temperature Envelope</td><td colspan="3">8 to 45°C</td></tr>
<tr><td>Pump Station Housing</td><td colspan="3">Permanent steel portal frame building designed to appropriate Australian standards.
Building foundations to be designed for 100kPa allowable soil bearing capacity.
Office and toilet facilities required at Clare transfer pump station .
Switchroom incorporated into blockwork pump house.
Non-bunded.</td></tr>
<tr><td rowspan="3">Flood Levels</td><td>ID</td><td>Location/Description</td><td>Design Floor Level</td></tr>
<tr><td></td><td>River Pump Station</td><td>Pump station will be founded in river below flood level.</td></tr>
<tr><td></td><td>Transfer Pump Station</td><td>Minimum of 500 mm above bank level of nearest drain or waterway or established 0.01 AEP flood level, whichever is higher.</td></tr>
<tr><td>Noise Attenuation</td><td colspan="3">No particular noise attenuation required.
Pump house building will provide noise attenuation.</td></tr>
<tr><td>Access within Pump Station Site</td><td colspan="3">Permanent gravelled road access. Turning circles to allow for interim construction traffic and maintenance truck (articulated semi-trailer to be allowed for).
Access to all parts of the site provided for light 4WD vehicle (e.g. Toyota Hilux).
Access adjacent to pump station provided for heavy rigid vehicle (HVR) – AS 2890.2-2002.
Vehicles drive in and drive out via a ring road configuration.</td></tr>
<tr><td>Crane Access</td><td colspan="3">Provide access to all crane setup points for a mobile crane (50 t).</td></tr>
<tr><td>Hardstand</td><td colspan="3">Concrete pad outside pump house main access door.</td></tr>
<tr><td>Vehicle Parking Areas</td><td colspan="3">Nil designated parking.</td></tr>
<tr><td>Security</td><td colspan="3">· Fencing – perimeter man-proof 2100 mm security fence to Australian standard with 8 m wide main gate.
· Key entry on gates.
· Emergency lighting.
· Provision made in PLC for future connection of security sensors.
· No swipe card or keypad access.
· External lighting turned off under normal circumstances.</td></tr>
<tr><td>Earthworks</td><td colspan="3">· In situ topsoil and unsuitable material removed to depth required by geotechnical engineer (minimum 1 m depth below main structures only).
· Foundation: select engineered fill backfill.
· Battered slopes max 1V:2.0H.
· No retaining walls.
· No piles.</td></tr>
<tr><td>Design Life</td><td colspan="3">Civil and Structural 80+ years
Mechanical 30 years
Electrical 30 years
Instrumentation and Controls 20 years</td></tr>
<tr><td>Fire Fighting</td><td colspan="3">As per Australian Codes.
Fire extinguishers only.
No sprinkler system.</td></tr>
</table>

Item	Design Basis
Drainage – External	Open table drains divert upstream flow around pump station site. Minimise drainage structures such as culverts and pipes.
Drainage – Internal	· Provide open table drains within site to divert surface water to a sedimentation basin · Sedimentation basin to be earth lined and sized for a 1 in 10 year event 72 hour duration · Sedimentation basin to include DN300 RCP outlet pipe and headwall, gross pollutant trap and concrete spillway
Landscaping	Nil
Mechanical	
Pipework	· Pipework within pump station facility (both above and below ground) – MSCL. · Pump pipework extends through pump station floor and connects to manifold outside pump house. · Discharge flowmeter located external to pump house.
Valves	Refer “Pipelines.
Pressure Gauges	Provide mechanical gauges and electronic gauges.
Air Management	Double acting air valve located on pump discharge.
Craneage	Permanent overhead gantry crane for pump and equipment removal.
Ventilation	Building to accommodate fixed wall ventilation louvres and roof-mounted ventilators
Pumps	· · Centrifugal pump units, type to suit duty. · Electric motor drives. · Two pumps – 100% duty + 100% standby. · Dry mounted on concrete plinths.
Number of Pumps	· Two to three duty pumps to pump 234 ML/d. · Provide for one to three additional pumps to be added in the future to accommodate 364 ML/d capacity. · No hot standby pump required. · Provide cold standby pump in storage (one duty pump to be swapped out and refurbished each year).
Pump Cooling	· Preferably air cooled. · Water jacketed if required (filtration system required to prepare raw water to suitable spec).
Pump Acoustics	· None required.
Filtering/ Strainers	Nil on pumped line. Provide trash rack in dam.
Flow Control	Isolation valves upstream and downstream of pumps. Check valves (wafer) on discharge side of pumps.
Surge Vessels	No surge vessels required.
Pump Flywheels	No flywheels required.
Structural and Architectural	
Pump Room Floor	· Reinforced concrete slab. · To fall to in-floor sumps to be directed to external gully (ie: no containment).
HVAC Floor	Concrete slab on ground – no subflooring.
Pump Plinths	Concrete
Electrical Panel Plinths	Concrete 150mm high.

<table>
<tr><th>Item</th><th>Design Basis</th></tr>
<tr><td>Building Structure</td><td>Permanent steel portal frame building designed to appropriate Australian with design importance level 3. Building foundations to be designed for 100kPa allowable soil bearing capacity.</td></tr>
<tr><td>Access</td><td>5.0 m high and 5.0 m wide roller shutter on pump building.
Personnel door.</td></tr>
<tr><td>Acoustics/Noise Management</td><td>· Walls on building to provide acoustic attenuation.
· Equipment acoustic enclosures not required.</td></tr>
<tr><td>Air Conditioning</td><td>Air conditioning for switchrooms to limit inside temperature to 30°C. on an N+1 basis</td></tr>
<tr><td>Switchroom</td><td>Incorporated into pump building.</td></tr>
<tr><td>Generator Room</td><td>Concrete slab.
No building.</td></tr>
<tr><td>Elevated Platforms</td><td>Nil.</td></tr>
<tr><td>Access to Heights</td><td>NA</td></tr>
<tr><td>Personnel Amenities</td><td>Unisex toilet facility.</td></tr>
<tr><td>Offices/Staff Facilities</td><td>Office/lunch room.</td></tr>
<tr><td>Barriers/ Bollards</td><td>Bollards to be provided where necessary to protect infrastructure from vehicle movements.</td></tr>
<tr><td colspan="2">Electrical</td></tr>
<tr><td>Site Lighting.</td><td>· Flood lights – normally off with switch at main gate.
· Automated site lighting (night sensor) with manual over-ride switch located within pump housing.
· Emergency site egress lighting. Power by internal backup battery supply.</td></tr>
<tr><td>Power Supply</td><td><table>
<tr><th>ID</th><th>Location/ Description</th><th>Primary Power Supply</th><th>Supplementary Power Supply</th><th>Backup Power Supply</th></tr>
<tr><td></td><td>River PS</td><td rowspan="2">Mains power – From Suitable local network 66kV or 11kV</td><td rowspan="2">Solar power array</td><td rowspan="2">Provision for relocatable diesel generator to supply full load.</td></tr>
<tr><td></td><td>Transfer PS</td></tr>
</table></td></tr>
<tr><td>Power Reticulation</td><td>Under-slab conduits.</td></tr>
<tr><td>Metering</td><td>Meter box on site boundary fence (lockable).</td></tr>
<tr><td>Outdoor Kiosks</td><td>Substation/transformer external to pump house.</td></tr>
<tr><td>Switchboards</td><td>Modular pre-faricated type</td></tr>
<tr><td>UPS/Power conditioning</td><td>Provided for all instrumentation and control system only.
Mains powered battery charger and batteries, with solar panel power backup provided for control and Instrumentation supply.</td></tr>
<tr><td>Voltage</td><td>· Motors to be 400/690 VAC < 800kW.
· HV motors > 800kW @11kV
· Distribution voltage is 11kV
· 24 V DC for PLC/RTU/communications
· 24 V DC for motor starter controls.</td></tr>
<tr><td>Pump Starter Type</td><td>VSD</td></tr>
<tr><td>Redundancy of Drives</td><td>Duty only for all drives (no standby).</td></tr>
<tr><td>Standards for Switchgear</td><td>Australian standards.</td></tr>
<tr><td>Security System</td><td>Provision made in PLC for future connection of security sensors. Provide PTZ web cameras, POE, outdoor housing.</td></tr>
<tr><td>Lightning Protection</td><td>Surge protection on incoming power cables to switchboards. Surge protection provided on incoming instrument cabling to PLC/RTU.</td></tr>
<tr><td>Fire System</td><td>Provide VESDA VLF-250 in switchrooms/kiosks.</td></tr>
</table>

Item	Design Basis
Instrumentation & Control	
Pump Pressure	Remotely monitored PIT discharge side pressure switches, and mechanical gauge to be provided.
Pump Control	VSD
Flow metering	· Single magflow (on above ground tank inlet and monitoring station and on discharge of pumps external to building). · Flow switch cross-checking.
Local Control	· Human manual interface in control panel enables full control of pump station operation. · Switchable off-manual-auto selection for all systems. · Provide for local operation via wireless laptop, and manual plug in point.
SCADA	Local PLC linked to SCADA at centralised data and control centre in Townsville via radio telemetry system.
Data Logging	Local data logging of pump operating parameters, alarms and flow. DNP3 protocol to be used
Standards of Control Systems	As required.
Standards for Instrumentation	As required.
Control System	As required.
Communication Links	Connect to fibre optic cable laid in pipeline trench. Provide for radio connection backup at each site.
Hazardous Substances Management	
Chemical Storage	Nil
Chemical Handling	Nil
Fuel Storage	Diesel – to be self-bunded. Double skin tanks. No additional fuel bunding required. Permanent tanks not required – will be hired if a temporary mobile generated is installed.
Fuel Handling	Manual filling of diesel tanks by tanker. Refuelling operations to be handled by refueller, including containment and spill control.
Pump House Containment	Nil.
Generators	Self-contained bund around generator.

Attachment B.2.4 Storages (Earth Ring Dams)

Item	Design Basis			
General				
Capacity	**ID**	**Location**	**Effective Capacity (ML)**	
			Now	**Future**
		Clare PS	22	33
		Haughton PS	22	33
Nominal Detention Time	Clare PS: 2 hours Haughton PS: 2 hours			
Freeboard	Full Supply Level to Max Operating Level: 500mm Max Operating Level to Sacrificial Spillway Level: 250mm Full Supply Level to Wall Crest: 1500mm			
Dam Configuration	Single containment area.			

Item	Design Basis
	Baffled to prevent short-circuiting between inlet and outlet.
Walls	Homogenous earthfill ring dam. Wall batters 1V:2.5H. Crest Width 3m.
Lining	Imported clay fill. Armour with 150mm rock.
Connections	· Inlet and outlet pipework connections below ground and dam wall. · No isolation valves on all connections outside dam wall. Butterfly valve in a pit.
Primary Overflow	Morning glory spillway overflow discharging to adjacent drainage line. Spillway and outlet concrete. Discharge pipe GRP, RCP or MSCL.
Emergency Overflow	Lowered section of crest (sacrificial spillway).
Water Temperature	Typically: 10 to 30°C. Design range: 8 to 45°C.
Site Lighting	Nil. Temporary lighting will be used if required.
Design Life	80+ years
Reliability	98% notional reliability, includes: · 1% scheduled maintenance outage allowance (4 days per year) · 1% unplanned outage allowance (4 days per year).
Mechanical	
Pipework	All pipe penetrations through/under wall.
Valves	Manually actuated butterfly valve on outlet pipe.
Level Gauge	Full height ball and float mechanical type gauge.
Dam Personnel Egress	Provide rope/chain ladder on each side of the dam at approx. 50m intervals.
Electrical	
External Lighting	As per facility site lighting.
Power Supply	As per facility power supply.
Power Reticulation	Nil
Metering	As per facility metering.
Electrical Panels	Nil
UPS/Power Conditioning	As per facility UPS/power conditioning.
Instrumentation & Control	
Level Sensors	Ultrasonic level transmitter and Mechanical float sensor mounted on gantry.
External Communications	Via facility comms system.
Internal Communications	Via facility comms system
PLCs	As per facility controls.
SCADA	As per facility controls.
Data Logging	As per facility controls.

Attachment B.2.5 Power Supply

Item	Design Basis
Mains Power Supply	
Hierarchy	Secondary/baseload power source.
Power cables	Direct buried cable. Overhead power supply acceptable only if site circumstances make buried power supply infeasible.
Reliability	98% notional reliability, includes: 1% scheduled maintenance outage allowance (4 days per year). 1% unplanned outage allowance (4 days per year). Note: Pump stations considered non-critical load. Power supply restoration within 8 hours acceptable. Allowance for plug-in generation to be made.
Ambient Design Temperature	–10 to +45°C (Air temperature).
Supply Voltage	66kV, 11 kV, or 400V depending on transmission distance.
Power Transformers	Oil type outdoor units in a switchyard. Installed in a concrete bund without a roof or building.
Distribution Transformers	Pad-mounted outdoor dry type units in 250 kVA steps. Installed on a concrete slab without a roof or building.
Generators	Provide for temporary generators to be connected if required. Max noise rating 87 dBA at 1 m. Status monitored via SCADA. Generators to be trailer-mounter containerised. Provide for parking on a concrete slab. Allow for fuel storage area. Fuel storage to be self bunded tanks installed on gravel pad.
SCADA	System status monitored via SCADA.
Power Supply Fail Over	Manual switch over to local diesel generators upon mains power failure.
Solar Power Supply	
Hierarchy	Primary power source.
Cabling	Direct buried cable. Overhead power supply acceptable only if site circumstances make buried power supply infeasible.
Reliability	90% notional reliability, includes: 5% scheduled maintenance outage allowance (18 days per year). 5% unplanned outage allowance (18 days per year).
Sizing Requirements	Output to match estimated load for min 6hrs
Ambient Design Temperature	–10 to +45°C (Air temperature).
Solar Arrays	Fixed base. Post mounted. Concentrated PEG system 385W Solar panels
Storage	Battery system sized for 24hr operation independent of the main power grid
Supply Voltage	11 kV depending on transmission distance.
Transformers	Pad-mounted units in 250 kVA steps. Installed on a concrete slab without a roof or building.
SCADA	System status monitored via SCADA.

Item	Design Basis
Power Supply Fail Over	Permanently connected to power grid with automatic switch over to mains power based on voltage drop or failure.

Attachment B.2.6 Roads

Item	Design Basis
General	
Design Ambient Temperature	–10 to +45°C
Applicable Standards	Queensland Department of Transport and Main Roads and Australian Standards.
Pump Station Access	
Pavement	Single-lane gravel road 4.0 m wide.
Design Vehicle Type	Minimum access suitable for articulated vehicle (AV) – AS 2890.2-2002.
Design Speed	15 km/h
Drainage	Culverts under road. Concrete causeways (with culvert) where required to prevent erosion through low areas (not permanent standing water although subject to high flow). Table drains on both sides of road.
Flood Immunity	Minimum 500 mm above 10 year AEP flood (where flood data is available). Otherwise 500 mm above upper bank of local drainage lines.
Watercourse Crossings	Concrete causeways where required to prevent erosion through low areas (not permanent standing water). No bridges.
Intersections with Public Roads	Locked gate access at property boundary/fence. At-grade intersection with table drain culvert. No turning lane.
Pipeline Access	
Pavement	Single lane formed gravel road
Design Vehicle Type	Minimum access suitable for heavy rigid vehicle (HVR) – AS 2890.2-2002
Design Speed	15 km/h
Drainage	Concrete causeways provided at low points. No culverts. Table drains on both sides of road.
Flood Immunity	Running surface flush with in situ ground level.
Watercourse Crossings	Concrete causeway crossing for small, ephemeral watercourses No bridges.
Intersections with Public Roads	Locked gate access at property boundary/fence. At-grade gravelled intersection with table drain culvert. No turning lane.
Section Valves	Widening of gravel access road to site around facility.
Pigging Stations	Widening of gravel access road to site around facility.

Item	Design Basis
Monitoring Stations	Widening of gravel access road to site around facility.
Scour Valves	Widening of gravel access road to site around facility.

Attachment B.2.7 Communications & Control

Item	Design Basis
Hard Wire Communications	Fibre optic cable running parallel to the pipeline in the same trench. Installed in a conduit.
Radio Telemetry	Backup communications system. Assumed that no RT repeater stations are required – radio telemetry survey will need to be undertaken to confirm this during design.
Local Control	· Each facility in the system will operate under local control. · Each facility will receive signals from instrumentation (where required) from remote facilities via fibre optic cable communication. · Human manual interface in control panel enables full control of pump station operation. · Switchable off-manual-auto selection for all systems. · Provide for local operation via wireless laptop, and manual plug in point.
SCADA	Local PLC linked to SCADA at centralised data and control centre in Townsville via radio telemetry system. Adjustment of system operating parameters and full supervisory control of facilities will be possible from TCC's control room. Generally, it is expected that remote system control will be occasional, and most system operation will occur by automated local controls.
Flow metering	Single magflow (on above ground tank inlet and monitoring station and on discharge of pumps external to building). Flow switch cross-checking.
Pump Control	VSD
Pump Pressure	Remotely monitored PIT discharge side pressure switches, and mechanical gauge to be provided.
Standards of Control Systems	As required.
Standards for Instrumentation	As required.
Control System	As required.

Attachment B.2.8 Pipework/Equipment Isolation and Containment

Facility Type	Facility Site Containment Provided	Isolation Method
Air Valves	Nil	SB
Scour Valves	Nil	SB
Pigging Stations	Nil	SBB
Pipeline Section Valves	Nil	Nil
Pumps	Nil	SBB

Key:
SB = single block, SBB = single block and bleed, DBB=double block and bleed, SPB = spectacle blinds, Opt=if required.

The above isolation philosophy requires any and all associated equipment to be de-energised and locked out prior to isolation or maintenance works.

Attachment B.3 Materials

Attachment B.3.1 Applicable Materials Standards

Material	Short Name	Specification
Ni Resist Cast Iron	NiR CI	ASTM A571 Type D-2
Wrought Nickel Alloy 625 or Hastelloy C	NiA	ASTM B446 grade N06265 or N10276
Cast Nickel Alloy 625 or Hastelloy C	CNiA	ASTM A494 grade N26265 or N30002
Duplex Stainless Steel	DSS	UNS Grade S32205
Cast Duplex Stainless Steel	CDSS	ASTM A995/995M Grade 4A
Super Duplex Stainless Steel	SDSS	UNS Grade S32750
Cast Super Duplex Stainless Steel	CSDSS	ASTM A995/995M Grade 5A
Hot Dipped Galvanised	HDG	Hot Dipped Galvanised to AS 4680
316 Stainless Steel (Wrought)	316 SSW	UNS grade S31603 (316L wrought)
316 Stainless Steel (Cast)	316 SSC	ASTM A351 Grade CF3M (316 L cast)
Ductile Cast Iron	DCI	AS 1831 grade ISO1083/JS/450–10/S
Phosphor Bronze	PB	AS 1565 Grade C90250
Fusion Bonded Nylon	FBN	AS/NZS 4158
Polyvinyl Chloride	PVC	AS/NZS 4765 or AS/NZS 4441
EPDM	EPDM	AS/NZS 1646
Carbon Steel	CS	AS/NZS 3678
Glass Reinforced Epoxy	GRE	API 15 LR or HR
Polyethylene Pipe	PE	AS/NZS 4130
Mild Steel PE Lined Pipe	MSPE	AS1579/AS4321
Mild Steel Cement Lined Pipe	MSCL	AS1579/AS1281

Attachment B.3.2 General Materials Requirements

Component	Applicable Standard	Raw Water		
		Material/Fluid	Coating	
			Internal	External
Water Quality				
Pumping Temperature (°C)		10–45	-	-
Chloride Concentration (mg/kg)		<500	-	-

Component	Applicable Standard	Raw Water		
		Material/Fluid	Coating	
			Internal	External
Total Dissolved Solids (mg/kg)		<1,000	-	-
pH		6–8	-	-
Pumps				
Casing		NiR CI	–	Epoxy-based Coating
Impeller		PB	–	–
Shaft		316 SS	–	–
Shaft Sleeve		316 SS	–	–
Impeller Wear Ring		316 SS	–	–
Case Wear Ring		316 SS	–	–
Casing Gasket		EPDM	–	–
Baseplate		CS	HDG	HDG
Coupling		CS	-	HDG
Coupling Guard		CS	HDG	
Casing Bolting		316 SS	–	–
Mechanical Seal Body		316 SS	–	–
Mechanical Seal Face		Silicon Carbide	–	–
Air Valves	**AS 4956**			
Body		DCI	FBN	FBN
Seat and other stainless components		316 SS	–	–
Wafer Type Check Valves	**AS 2845**			
Body		DCI	FBN	FBN
Disc, shaft and pins		316 SS	–	–
Seals		EPDM	–	–
Gate Valves	**AS 2638**			
Body		DCI	FBN	FBN
Shaft		316 SS	–	–
Wedge		EPDM	–	–
Butterfly Valves	**AS 4795**			
Body		DCI	FBN	FBN
Shaft		316 SS	–	–
Plate		316 SS	–	–
Seat		EPDM	–	–

Component	Applicable Standard	Raw Water		
		Material/Fluid	Coating	
			Internal	External
Ball Valves				
Body	AS 5830.1 (metal)	PE100 DCI (alt)	– FBN	– FBN
Shaft	AS 5830.29 (plastic)	316 SS	–	–
Ball		316 SS	–	–
Spectacle Blinds				
Plate	ASME B16.48	316SS	–	–
Flanges		DCI	FBN	FBN
Pipework				
Above ground		MS	Cement	PE
Below ground		MS or GRP	–	–
Tanks				
Walls		PE	–	–
Bolts		NA	–	–
Roof		PE	–	–

Attachment C. Cost Estimate – Summary

Haughton Stage 2 pipeline – base cost estimate

Item		Base cost estimate	
		Option 1	Option 2
1	**River pump station**		
1.1	Temporary works	2,609,274	2,609,274
1.2	Earthworks	155,160	155,160
1.3	Roadworks	52,754	52,754
1.4	Structural	5,343,407	5,343,407
1.5	Building	494,896	494,896
1.6	Mechanical	4,630,283	4,630,283
1.7	Pipework installation	1,296,879	1,296,879
1.8	Valve pit	703,726	703,726
1.9	Flowmeter pit	410,792	410,792
1.10	Pump station electrical infrastructure	7,929,328	7,929,328
1.11	Low lift pump station switch room	281,485	281,485
1.12	Low lift pump house	52,573	52,573
	Item subtotal	**23,960,556**	**23,960,556**
2	**Settling basin/balance tank (ring dam)**		
2.1	Balance dam fence and gates	143,743	143,743
2.2	Clear, cut and fill	178,236	178,236
2.3	Pipework below embankments	856,296	856,296
2.4	Concrete chambers	331,683	331,683
2.5	Outlet valve chamber	274,367	274,367
2.6	Embankment	985,846	985,846
2.7	PE liner	0	0
2.8	Spillway	191,477	191,477
2.9	Overflow outlet structure	180,402	180,402
2.10	Access road	59,801	59,801
2.11	Buried pipework	1,015,158	1,015,158
	Item subtotal	**4,217,007**	**4,217,007**
3	**Transfer pump station**		
3.1	Earthworks	1,693,339	1,693,339
3.2	Structural	9,422,142	9,422,142
3.3	Access platforms for pumps	203,531	203,531
3.4	Access platforms around perimeter	233,632	233,632
3.5	Mechanical (including pigging station)	8,582,487	7,943,998

Item		Base cost estimate	
		Option 1	Option 2
3.6	Transfer pump station pig launching station	89,993	89,993
3.7	Flowmeter chamber	156,041	156,041
3.8	High lift pump station switch room	863,260	863,260
3.9	High lift pump house	480,392	480,392
	Item subtotal	**21,724,816**	**21,086,328**
4	**Pipeline**		
4.1	Site clearing and access	6,335,288	6,335,288
4.2	Type A open trenched 1.8m Ø RRJ	133,064,114	133,064,114
4.3	Type A open trenched 1.8m Ø SLW	15,564,716	15,564,716
4.4	Type B sheet piled trench 1.8m Ø SLW	1,003,334	1,003,334
4.5	Type C sheet piled trench 1.8m Ø SLW with rip rap overlay	4,711,170	4,711,170
4.6	Type D sheet piled trench 1.8m Ø SLW at creek crossings	5,964,839	5,964,839
4.7	Bends	3,001,950	3,001,950
4.8	Conduits and pits	778,347	778,347
4.9	Rehabilitation	4,203,075	4,203,075
4.10	Air valves	7,858,471	7,858,471
4.11	Scour valves	4,259,126	4,259,126
4.12	Section valves	2,513,549	2,513,549
4.13	Pig launcher and receiver	3,808,265	3,808,265
4.14	Launcher civil	82,881	82,881
4.15	Receiver civil	82,881	82,881
4.16	Scour dam	420,225	420,225
4.17	Fence	61,030	61,030
4.18	Pipework	66,299	66,299
4.19	Generator slab	1,293	1,293
4.20	Outlet structure	158,315	158,315
4.21	Pig receiver mechanical	1,646,343	1,646,343
4.22	Concrete works	70,598	70,598
4.23	Pig launchers and receivers electrical, instrumentation and controls	305,471	305,471
	Item subtotal	**195,961,583**	**195,961,583**
5	**Haughton pump station connection**		
5.1	Earthworks	209,161	209,161
5.2	Polyethylene liner including sand layer beneath	395,188	395,188
5.3	Pipework below embankments	856,296	856,296
5.4	Concrete chambers	261,422	261,422
5.5	Outlet valve chamber 1800mm ø single	173,279	173,279

Item		Base cost estimate	
		Option 1	Option 2
5.6	Temporary works in Haughton channel	534,009	534,009
5.7	Bulk excavation	41,505	41,505
5.8	Foundation	45,840	45,840
5.9	Concrete works	580,040	580,040
5.10	Backfill	26,067	26,067
5.11	Surface treatments	50,044	50,044
5.12	Spillway bridge	93,743	93,743
5.13	Control gates	687,876	687,876
5.14	Discharge structure electrical, instrumentation and controls	52,573	52,573
	Item subtotal	**4,007,044**	**4,007,044**
6	**Indirect costs**		
	Commissioning	4,999,255	4,986,325
	Survey, geotechnical and approvals	1,258,350	1,258,350
	Design	6,291,750	6,291,750
	Land acquisition	2,815,599	2,815,599
	Project management	15,100,200	15,100,200
7	**Stage 1 avoided costs**		
	Stage 1 avoided costs	-54,875,000	-
8	**Haughton pump station augmentation**		
8.1	Pumps	–	650,000
8.2	Pipework	–	1,100,000
8.3	Civil and structural	–	2,700,000
	Item subtotal	**–**	**4,450,000**
	TOTAL	**225,470,000**	**284,140,000**

Solar farm – base cost estimate

Item		Base cost estimate	
		Option 1	Option 2
7	**Solar installation**		
7.1	Solar farm	34,587,750	19,201,050
7.2	Design	1,001,700	556,200
7.3	Land acquisition	100,000	100,000
7.4	Project management	2,003,400	1,112,400
	Item subtotal	**37,692,850**	**20,969,650**
	TOTAL	**$37,700,000**	**$20,970,000**

Attachment D. Engineering Drawings

The following drawings are included as supporting documentation for the reference design:

Drawing Number	Description
PIPELINE	
IH175200-0000-CI-DRG-0001	CLARE - HAUGHTON PIPELINE LOCALITY PLAN AND DRAWING INDEX
IH175200-0000-CI-DRG-0002	PIPING AND INSTRUMENTATION DIAGRAM SHEET 1 OF 2
IH175200-0000-CI-DRG-0003	PIPING AND INSTRUMENTATION DIAGRAM SHEET 2 OF 2
IH175200-0000-CI-DRG-1002	CLARE - HAUGHTON PIPELINE COMPILATION PLAN & NOTES
IH175200-0000-CI-DRG-1005	CLARE - HAUGHTON PIPELINE PLAN AND LONGITUDINAL SECTION SHEET 1 OF 21
IH175200-0000-CI-DRG-1006	CLARE - HAUGHTON PIPELINE PLAN AND LONGITUDINAL SECTION SHEET 2 OF 21
IH175200-0000-CI-DRG-1007	CLARE - HAUGHTON PIPELINE PLAN AND LONGITUDINAL SECTION SHEET 3 OF 21
IH175200-0000-CI-DRG-1008	CLARE - HAUGHTON PIPELINE PLAN AND LONGITUDINAL SECTION SHEET 4 OF 21
IH175200-0000-CI-DRG-1009	CLARE - HAUGHTON PIPELINE PLAN AND LONGITUDINAL SECTION SHEET 5 OF 21
IH175200-0000-CI-DRG-1010	CLARE - HAUGHTON PIPELINE PLAN AND LONGITUDINAL SECTION SHEET 6 OF 21
IH175200-0000-CI-DRG-1011	CLARE - HAUGHTON PIPELINE PLAN AND LONGITUDINAL SECTION SHEET 7 OF 21
IH175200-0000-CI-DRG-1012	CLARE - HAUGHTON PIPELINE PLAN AND LONGITUDINAL SECTION SHEET 8 OF 21
IH175200-0000-CI-DRG-1013	CLARE - HAUGHTON PIPELINE PLAN AND LONGITUDINAL SECTION SHEET 9 OF 21
IH175200-0000-CI-DRG-1014	CLARE - HAUGHTON PIPELINE PLAN AND LONGITUDINAL SECTION SHEET 10 OF 21
IH175200-0000-CI-DRG-1015	CLARE - HAUGHTON PIPELINE PLAN AND LONGITUDINAL SECTION SHEET 11 OF 21
IH175200-0000-CI-DRG-1016	CLARE - HAUGHTON PIPELINE PLAN AND LONGITUDINAL SECTION SHEET 12 OF 21
IH175200-0000-CI-DRG-1017	CLARE - HAUGHTON PIPELINE PLAN AND LONGITUDINAL SECTION SHEET 13 OF 21
IH175200-0000-CI-DRG-1018	CLARE - HAUGHTON PIPELINE PLAN AND LONGITUDINAL SECTION SHEET 14 OF 21
IH175200-0000-CI-DRG-1019	CLARE - HAUGHTON PIPELINE PLAN AND LONGITUDINAL SECTION SHEET 15 OF 21
IH175200-0000-CI-DRG-1020	CLARE - HAUGHTON PIPELINE PLAN AND LONGITUDINAL SECTION SHEET 16 OF 21
IH175200-0000-CI-DRG-1021	CLARE - HAUGHTON PIPELINE PLAN AND LONGITUDINAL SECTION SHEET 17 OF 21
IH175200-0000-CI-DRG-1022	CLARE - HAUGHTON PIPELINE PLAN AND LONGITUDINAL SECTION SHEET 18 OF 21
IH175200-0000-CI-DRG-1023	CLARE - HAUGHTON PIPELINE PLAN AND LONGITUDINAL SECTION SHEET 19 OF 21
IH175200-0000-CI-DRG-1024	CLARE - HAUGHTON PIPELINE PLAN AND LONGITUDINAL SECTION SHEET 20 OF 21
IH175200-0000-CI-DRG-1025	CLARE - HAUGHTON PIPELINE PLAN AND LONGITUDINAL SECTION SHEET 21 OF 21
IH175200-0000-CI-DRG-1040	CLARE - HAUGHTON PIPELINE TRENCH DETAILS
IH175200-0000-CI-DRG-1041	CLARE - HAUGHTON PIPELINE PIPE SUPPORTS
IH175200-0000-CI-DRG-1045	CLARE - HAUGHTON PIPELINE TYPICAL DETAILS - AIR VALVE
IH175200-0000-CI-DRG-1046	CLARE - HAUGHTON PIPELINE TYPICAL DETAILS - SCOUR OUTLET
IH175200-0000-CI-DRG-1047	CLARE - HAUGHTON PIPELINE TYPICAL DETAILS - SECTION VALVE
IH175200-0000-CI-DRG-1050	CLARE - HAUGHTON PIPELINE PIGGING STATION AND SCOUR DAM
IH175200-0000-CI-DRG-1051	CLARE - HAUGHTON PIPELINE PIGGING STATION DETAILS
IH175200-0000-CI-DRG-1052	CLARE - HAUGHTON PIPELINE PIGGING LAUNCHER

Drawing Number	Description
IH175200-0000-CI-DRG-1053	CLARE - HAUGHTON PIPELINE PIGGING RECEIVER
IH175200-0000-CI-DRG-1061	CLARE - HAUGHTON PIPELINE CHANNEL DISCHARGE STRUCTURE
IH175200-0000-CI-DRG-1062	CLARE - HAUGHTON PIPELINE CHANNEL DISCHARGE STRUCTURE PICTORIAL
CLARE SITE	
IH175200-0000-CI-DRG-2002	CLARE SITE PUMP STATIONS SITE - CLARE PUMP STATION SITE PLAN
IH175200-0000-CI-DRG-2005	CLARE SITE PUMP STATIONS SITE - RIVER PUMP STATION TO BALANCE DAM PIPELINE
RIVER PUMP STATION	
IH175200-0000-CI-DRG-2100	CLARE PUMP STATION RIVER PUMP STATION GENERAL ARRANGEMENT
IH175200-0000-CI-DRG-2101	CLARE PUMP STATION RIVER PUMP STATION SITE SECTION – PLAN – PUMP STATION TOWER & CHAMBER
IH175200-0000-CI-DRG-2102	CLARE PUMP STATION RIVER PUMP STATION SITE SECTION – PLAN – TYPICAL SECTION
IH175200-0000-CI-DRG-2103	CLARE PUMP STATION RIVER PUMP STATION SITE – ELEVATION
IH175200-0000-CI-DRG-2104	CLARE PUMP STATION RIVER PUMP STATION SITE – PICTORICAL
IH175200-0000-CI-DRG-2105	CLARE PUMP STATION RIVER PUMP STATION STEEL MARKING GENERAL ARRANGEMENT
IH175200-0000-CI-DRG-2106	CLARE PUMP STATION RIVER PUMP STATION STEEL VALVE PIT DETAILS
SEDIMENTATION DAM	
IH175200-0000-CI-DRG-2200	SEDIMENTATION DAM GENERAL ARRANGEMENT
IH175200-0000-CI-DRG-2201	SEDIMENTATION DAM TYPICAL SECTION
IH175200-0000-CI-DRG-2202	SEDIMENTATION DAM OVERFLOW DETAILS
IH175200-0000-CI-DRG-2203	SEDIMENTATION DAM INLET AND OUTLET STRUCTURE
TRANSFER PUMP STATION	
IH175200-0000-CI-DRG-2300	CLARE PUMP STATION TRANSFER PUMP STATION GENERAL ARRANGEMENT
IH175200-0000-CI-DRG-2301	CLARE PUMP STATION TRANSFER PUMP STATION ELEVATIONS - SHEET 1
IH175200-0000-CI-DRG-2302	CLARE PUMP STATION TRANSFER PUMP STATION ELEVATIONS - SHEET 2
IH175200-0000-CI-DRG-2303	CLARE PUMP STATION TRANSFER PUMP STATION SECTIONS - SHEET 1
IH175200-0000-CI-DRG-2304	CLARE PUMP STATION TRANSFER PUMP STATION SECTIONS - SHEET 2
IH175200-0000-CI-DRG-2305	CLARE PUMP STATION TRANSFER PUMP STATION DETAILS - SHEET 1
IH175200-0000-CI-DRG-2306	CLARE PUMP STATION TRANSFER PUMP STATION PICTORIAL
IH175200-0000-CI-DRG-2307	CLARE PUMP STATION TRANSFER PUMP STATION SLAB AND FOOTING GENERAL ARRANGEMENT
IH175200-0000-CI-DRG-2308	CLARE PUMP STATION TRANSFER PUMP STATION STEEL MARKING GENERAL ARRANGEMENT
IH175200-0000-CI-DRG-2309	CLARE PUMP STATION TRANSFER PUMP STATION STEELWORK TYPICAL SECTION
ELECTRICAL DRAWINGS	
IH175200-052-EE-DRG-001	OPTION 1 SOLAR FARM - INITIAL AND ULTIMATE - GENERAL ARANGEMENT
IH175200-052-EE-DRG-002	OPTION 2 SOLAR FARM - INITIAL AND ULTIMATE - GENERAL ARANGEMENT
IH175200-052-EE-DRG-201	OPTION 1 PUMP STATION – INITIAL AND ULTIMATE SINGLE LINE DIAGRAM