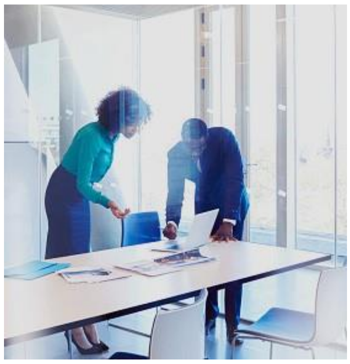
GHD Advisory



End-of-life costs for Directlink Interconnector

Directlink

9 December 2019

Contents

Figures

Tables

1. Summary of GHD's cost estimate

GHD Advisory has estimated the closure cost of Directlink's assets to be $15 million (Dec 2019 dollars).

Directlink has engaged GHD Advisory to estimate the closure cost for its electricity interconnector assets. The Directlink assets consist of three parallel high voltage direct current (HVDC) transmission lines, each approximately 63 kilometres long, with two converter stations at the New South Wales cities of Bungalora and Mullumbimby.

Directlink's assets have a finite technical life, and closure is expected to occur in FY2041-42. It is important for Directlink to be aware of, and prepared for, the closure obligations and costs that will arise around this timeframe. Directlink is subject to economic regulation by the Australian Energy Regulator (AER). As part of its 2020-25 revenue submission to the AER, Directlink proposed to annually recover, through prices, a forecast of the end-of-life closure costs for its assets. GHD Advisory's report forms parts of Directlink's response submission to the AER's draft decision.

Closure activities involve planning, decommissioning, demolition, disposal, remediation, rehabilitation and post-completion maintenance/monitoring. Directlink's obligations for these activities, including how the obligations should be appropriately met, are informed by the environmental legislation it is subject to. The obligations are informed also by deeds of licences and easement agreements that Directlink has entered into with government agencies and other entities.

Table 1 summarises GHD Advisory's estimate of the Directlink closure cost. GHD Advisory has estimated the closure cost of Directlink's assets to be $15 million (Dec 2019 dollars).

Table 1: Summary of GHD Advisory's cost estimate for closure of Directlink assets

Directlink's assets	Cost (December 2019, $M)
Above-ground direct-current cable assets	2.653
Below-ground direct-current cable assets	9.322
Alternating current cable assets	1.452
Converter stations	1.582
Total	**15.009**

Determining an indicative cost of closure for the assets has required GHD Advisory to make assumptions for the analysis and to simplify the demolition/rehabilitation approach for closure. GHD Advisory's closure method, assumptions and cost estimate are detailed in Section 5 of this report. These assumptions are conservative, and there remains a possibility that the actual closure cost will be greater than the indicative cost estimate that this report provides.

Disclaimer

This report has been prepared by GHD for Directlink and may only be used and relied on by Directlink for the purpose agreed between GHD and the Directlink as set out in section 2 of this report. GHD otherwise disclaims responsibility to any person other than Directlink arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report. The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared. The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report. GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by Directlink and others who provided information to GHD (including Government authorities), which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report that were caused by errors or omissions in that information.

GHD has prepared the preliminary cost estimate set out in section 5 of this report ("Cost Estimate") using information reasonably available to the GHD employee(s) who prepared this report, and is based on assumptions and judgments made by GHD. The Cost Estimate has been prepared for the purpose of Directlink's response submission to the Australian Energy Regulator and must not be used for any other purpose.

The Cost Estimate is an indicative estimate only. Actual prices, costs and other variables may be different to those used to prepare the Cost Estimate and may change. Unless as otherwise specified in this report, no detailed quotation has been obtained for actions identified in this report. GHD does not represent, warrant or guarantee that the works can or will be undertaken at a cost that is the same or less than the Cost Estimate.

Where estimates of potential costs are provided with an indicated level of confidence, notwithstanding the conservatism of the level of confidence selected as the planning level, there remains a chance that the cost will be greater than the planning estimate, and any funding would not be adequate. The confidence level considered to be most appropriate for planning purposes will vary depending on the conservatism of the user and the nature of the project. The user should therefore select appropriate confidence levels to suit their particular risk profile.

2. Introduction

2.1 Background

Directlink delivers electricity between the New South Wales (NSW) and Queensland National Electricity Market regions. The Directlink assets consist of three parallel high voltage direct current (HVDC) transmission lines, each approximately 63 kilometres long, with two converter stations at the NSW cities of Bungalora and Mullumbimby.[1]

Directlink's assets have a finite technical life, and closure is expected to occur in FY2041-42. It is important for Directlink to be aware of, and prepared for, the closure obligations and costs that will arise around this timeframe. Directlink is subject to economic regulation by the Australian Energy Regulator (AER). As part of its 2020-25 revenue submission to the AER, Directlink proposed to annually recover, through prices, a forecast of the end-of-life closure costs for its assets.

In forming its draft decision on Directlink's proposal, the AER stated that Directlink needed to provide, among other things, further explanations for and justifications on the basis of estimation for the closure costs.[2] The AER also said that Directlink's estimation approach needed to demonstrate that prudent and efficient costs would be incurred.[3]

2.2 Purpose of GHD's report

To address the AER's comments, Directlink has engaged us to estimate the closure cost for its assets.

Closure activities involve planning, decommissioning, demolition, disposal, remediation, rehabilitation and post-completion maintenance/monitoring. Directlink's obligations for these activities, including how the obligations should be appropriately met, are informed by the environmental legislation (e.g. environmental licences and authorities) it is subject to. They are informed also by deeds of licences and easement agreements that Directlink has entered into with government agencies and other entities for leased corridors.

The scope of Directlink's closure obligations, and the way in which Directlink is allowed to meet these obligations, affects the selection of closure methods (e.g. the way in which the converter stations can be demolished) and the associated cost estimate. We have prepared a report that:

- articulates Directlink's closure obligations for the assets comprising its infrastructure
- explains the nature and sequence of closure activities that need to occur to meet Directlink's obligations, including descriptions of closure methods that satisfy legal and environmental considerations
- provides a closure cost estimate is consistent with points 1 and 2 above.

[1] See https://www.apa.com.au/our-services/other-energy-services/electricity-transmission-interconnectors

[2] The AER referred to these as 'land rectification and restoration' costs.

[3] AER Draft Decision, Attachment 5, Capital expenditure, p. 20

2.3 GHD's qualifications and track record in asset closure

GHD has over 25 years' experience in decommissioning, closure and rehabilitation projects and has delivered successful outcomes for significant sites throughout Australia, North America and the UK. Our globally connected teams provide a multidisciplinary service to clients to assist them through each phase of the asset life cycle, from concept/pre-feasibility through operations to suspended operations and closure, and eventual repurposing and/or rehabilitation.

GHD has developed a standardised process for conducting decommissioning assessments and planning asset decommissioning, renovation, closure, and/or demolition. This process can be applied to any industry, type of asset or location and has been used to support facility closure, demolition, mothball, strip-out, renovation and repurposing projects. GHD's services include:

- Closure planning development
- Demolition assessment
- Environment, engineering and project management services
- Biological surveys - terrestrial and aquatic
- Owner's engineer/agent
- Planning and approvals
- Regulatory interpretation for business provisions
- Scoping
- Technical review and methodology assessment.

Most recent projects include the:

- Rehabilitation plan and rehabilitation cost estimate for Dalrymple Bay Coal Terminal (https://www.qca.org.au/wp-content/uploads/2019/05/2019-dau-submission-appendix-1-ghd-rehabilitation-plan-2018.pdf)
- Closure cost estimates for Synergy. GHD was engaged to provide closure and rehabilitation estimates for various Synergy sites. The purpose of the estimates was to allow Synergy to plan and budget for their closure obligations.
- Closure Studies for various miners. GHD was engaged to complete a selection phase study, including demolition, disposal and execution options to remove the redundant infrastructure from various mine site and processing plants in the Pilbara Region of Western Australia.

2.4 Structure of GHD's report

Our report is structured as follows:

- Asset overview (section 3)
- Closure objective (section 4)
- Closure method and cost estimate (section 5).

3. Asset overview

The Directlink interconnector is a 63 kilometre HVDC link between NSW and Queensland, using ABB HVDC Light technology. The system has three 65 MVA Voltage Source Converters at converter stations at Mullumbimby and Bungalora, connected by three pairs of transmission cables. Each pair of cables operates at +/-80 kV and transmits 60 MW. Directlink owns the land that the two converter stations are located on, and there are no known contaminants at either of the converter station sites.

In NSW, the Directlink system is connected to a 132 kV alternating current (AC) transmission grid and in Queensland to 110 kV AC transmission grid. The total rating of the interconnector is 180 MW. Each cable is a 630 mm^2 Aluminium XLPE cable with a HDPE insulating jacket that weighs 4.5 kg/m.

Several different techniques were applied to install the cables, including: open-cut-and-fill; direct burial by cable plough; galvanized steel troughing; and directional drilling. The route is an aggregate 39 kilometre below ground, and 24 kilometre above ground.

4. Closure objective and final landform

Directlink's assets can be broadly divided into: cables; and converter stations. Directlink's closure-related obligations for the cables are different from those of the converter stations.

4.1 Cables

Directlink's cables assets are subject to a 'deed of licence' that the State Rail Authority of New South Wales issued when the assets were being constructed. Under clause 12(b) of the deed, Directlink is obliged to

… remove all of its cables or other wires, hardware, equipment, fixtures and fittings and restore the Premises to the condition they were in at the commencement of this Licence…

Given this requirement, we consider that the closure objectives are to provide a final land use that is representative of the land use prior to installation and operation of the cables and consistent with the current adjacent land uses. The landform is to be stable and non-polluting.

4.2 Converter stations

The converter stations are situated on land that Directlink owns. Directlink is not subject to any rehabilitation conditions for the land, requiring the sites to be returned to a specific condition or land use. We consider that the closure objectives are to provide a final land use and landform that does not impede any other future uses of the land and is consistent with the current adjacent land use. The landform is also to be stable and non-polluting.

5. Closure method and cost estimate

Asset closure involves decommissioning, demolition, disposal, remediation, rehabilitation and post-closure maintenance/monitoring activities. Overarching the closure requirements is the need to make the sites on which the infrastructure sits, safe, stable and non-polluting.

The way in which the closure work is to be performed needs to be consistent with safework practices (e.g. fatigue-management laws) and public safety (e.g. using appropriate traffic management control to prevent access to open trenches), such that human safety is preserved. The closure work must also seek to minimise environmental damage, and to ensure that the risk of machinery/equipment being damaged is managed appropriately.

Based on the closure objectives in Chapter 4, we consider it appropriate to divide the Directlink assets into:

- Above-ground assets (Domain 1)
- Below-ground assets (Domain 2)
- Converter stations (Domain 3).

Our overarching approach has been to determine a program (and duration) of works for the closure of assets in each domain, and then to identify the combination of labour and equipment (including materials), based on assumed productivity rates, that are needed to deliver the program.

Unit rates for labour and equipment are then mapped to the labour and equipment quantities, respectively, to determine an indicative cost estimate. Labour rates for closure have been informed by our in-house database of unit-cost rates that have been compiled from asset-closure delivery projects that we have advised on, or been involved with, in Australia. Equipment unit-cost rates and productivity rates have been sourced in a similar way.

As part of determining an indicative cost of closure for the assets, we have made assumptions for the analysis to simplify the demolition/rehabilitation approach for closure. The assumptions are all documented at the end of each of the domain-specific subsections below.

5.1 Above-ground assets (Domain 1)

The Directlink above-ground assets (DC cables only) total approximately 21 km[4]. They appear in a few forms and locations (e.g. in galvanised steel troughing (GST) in a forest, along a railway tunnel, or fixed to a bridge). Given the non-uniformity of where the assets are located along their journey, we sought to determine a ‘representative section’ cable profile. We then extrapolated our estimate of the costs for the representative section to all 21 km of above-ground cables.

Based on our review of the asset and discussions with Directlink, we determined that the most common cross-section was Type 8 (GST typical assembly to NSW railway specifications). Figure 1 depicts the Type 8 cross-section, which occurs for 14 km out of 21 km. The way in which the Type 8 cable is constructed is important for determining the most appropriate decommissioning and demolition method. The Type 8 cable comprises three GST trays, each of which contains a pair of cables. The trays are approximately 6 metres in length, held by supports every 3 metres on average.

[4] As advised by Directlink during discussions with GHD staff

A large portion of the GST runs close to train tracks, and it is likely a specialised machine that is required to access this area, or a new access road will be required at the time of closure. The train-track area is heavily vegetated in some areas; vegetation clearing will be required.

To simplify the analysis, with a view to identifying a lower-bound cost estimate for closure of the above-ground cables, we have assumed that access conditions for the infrastructure are straightforward. That is, no special access equipment or new access roads need be constructed at the point of asset closure. However, we have allowed for clearing vegetation for a maximum 5-metre width.

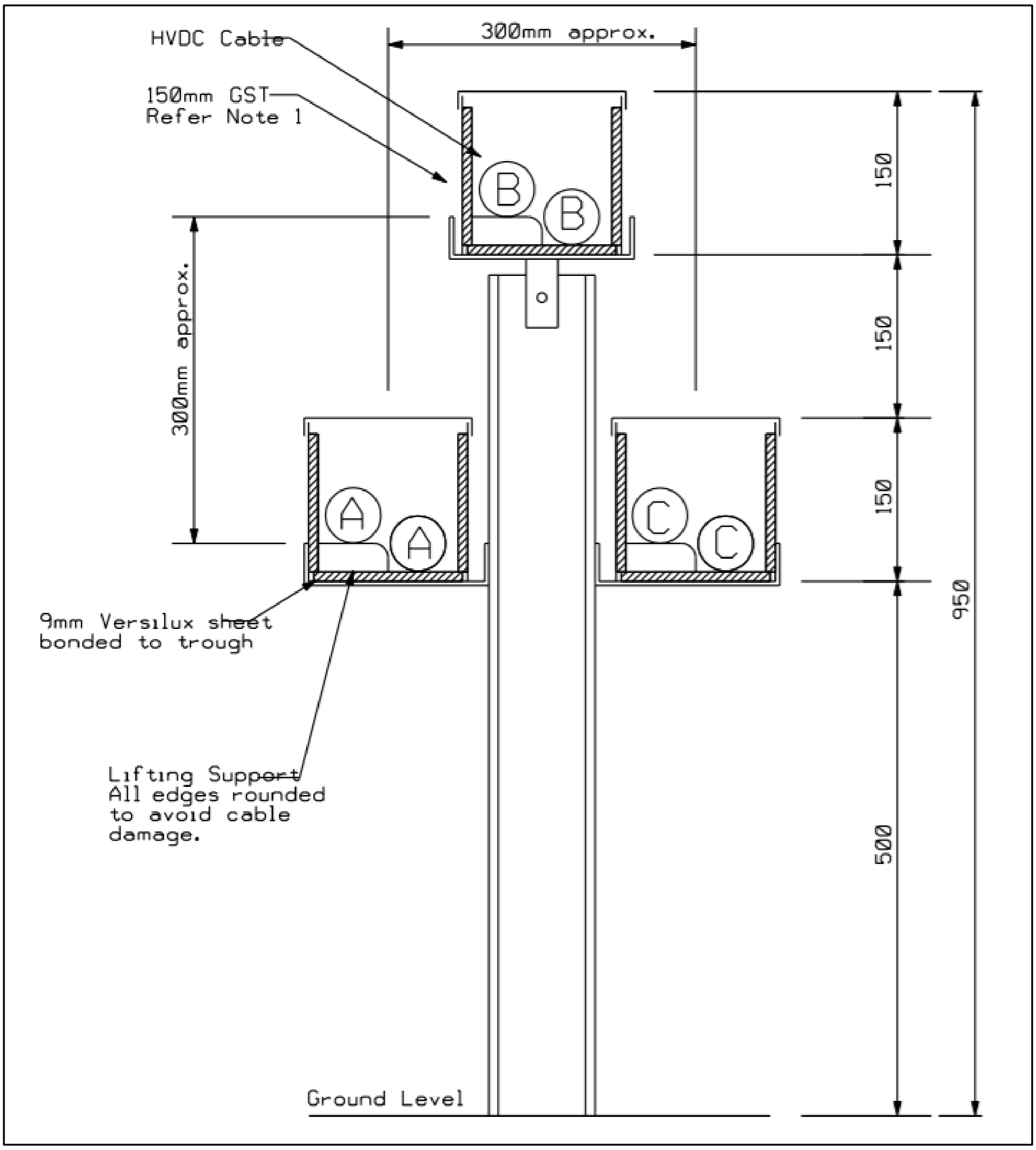


Figure 1: Cross-section of above-ground cable 'representative section'

5.1.1 Tasks

Our closure method for the representative section above-ground cables involves the following tasks:

- Early works
- Demolition works
- Disposal works
- Backfill works
- Rehabilitation works.

Table 2 sets out the scope of work for each of the tasks.

Table 2: Scope of work for above-ground assets

Task	Scope of task
Early works	• Decommission and de-energise the asset, with electricians prior to demolition • Create physical separations and air gaps in the cable to confirm disconnection of cable and prevent accidental reconnection. • Cut the cable at regular lengths along the cable to prevent backflow into the system. Install additional earthing spikes along cable length as required for worker protection.
Demolition works	• Open cable trays to allow access to cables • Cut cable as predetermined length in preparation to roll onto cable reels (Maximum 4T reels) • Remove remaining trays and support posts using excavator. Place into waste removal vehicle.
Disposal works	The disposal works will include the use of a truck to cart the material offsite. However, as most waste material on this site is recyclable through scrap merchants, it has been assumed that any other disposal costs (e.g. landfill fees) will be offset by the scrap value returned.
Backfill works	Backfill works will not be required for the above ground cable removal. An excavator will be used in the demolition phase to make the area safe for rehabilitation works to commence.
Rehabilitation works	• Minor earthworks, including shaping, drainage and other soil conservation measures (scarification along the contour). • Incorporation of soil ameliorates, including addition of lime and/or gypsum. • Direct seeding and fertiliser application. • Rehabilitation maintenance (ongoing), which might include re-seeding, watering, fertilising, erosion control and inspections.

The most time-consuming parts of the closure works for above-ground cables are rolling the cable onto the cable reel and removal of the cable tray structures.

5.1.2 Productivity and labour-availability assumptions

In undertaking the scope of tasks, we have assumed the following average productivity rates for machinery, which has been informed by our observations of what the closure industry achieves in practice:

- 375 metres per day for the processing of cable trays
- 150 metres per day for the extraction of the HVDC cable.

Our labour-availability assumptions are that crews work six days a week and work 10 hours per day. Based on the assumed productivity and labour-availability rates, we determined that a 32-week work program would be required to remove 21 km of the representative section.

5.1.3 Cost drivers

Over the 32-week program of works, the main factors contributing to costs include:

- 30 weeks of labour time required for five excavation labourers
- 25 weeks of labour time for an excavator operator
- 25 weeks of renting a 20-tonne excavator and 9 weeks of renting a dozer for access clearing works.

Table 3 sets out the proposed labour and equipment requirements for removing the above-ground cables and rehabilitating the area where the cables were located.

Table 3: Labour and equipment requirements for above-ground assets

Task	Proposed labour requirements	Proposed equipment requirements
Project management and overhead	A project manager, a safety manager and mechanic (one day per week, for 32 weeks)	Light vehicle and mobile service equipment.
Early works	NA - This work has been included in the below ground cable section only	NA
Demolition works	A dozer operator (9 weeks), an excavator operator (25 weeks), two Telehandler reel operators (24 weeks) and five labourers (30 weeks)	2 x 20-tonne excavators, 1 grapple, 1 shear
Disposal works	One truck driver (15 weeks)	A disposal truck (suitable to be on highways)
Backfill works	Not required for above ground works	NA
Rehabilitation works	A small dozer operator, an excavator operator and a water cart driver	Small dozer; 25-tonne excavator

5.1.4 Cost estimate

Table 4 sets out our proposed cost estimate for Directlink's above-ground cables.

Table 4: Cost estimate for above-ground assets

Task	Relevant information	Cost (Dec 2019, $M)
Decommissioning and demolition		
Labour (incl. project management)	17,430 hours	1.928
Machinery and equipment	15,765 hours	0.662
Mobilisation/De-mobilisation	One-off fee for mobilising and de-mobilising crews	0.019
Demolition sub-total	*n/a*	*2.609*
Rehabilitation (over a five-metre width for 21 kilometres, covering 105,000 square metres)		
Minor earthworks, shaping, drainage and other soil conservation measures	A small dozer and excavator will undertake this work. This will be performed over a 105,000m^2 area.	0.012
Spoil amelioration (adding lime / gypsum)	A 2.5 tonne per hectare assumption has been applied. The spoil amelioration will occur over a 105,000m^2 area.	0.009
Direct seeding / fertiliser	A pasture-grass species will be used	0.013

Task	Relevant information	Cost (Dec 2019, $M)
Rehabilitation maintenance	Re-seeding, watering, fertilising, erosion control and inspections	0.009
Rehabilitation sub-total	*n/a*	*0.044*
Total	**n/a**	**2.653**

Our estimate of the total costs for closure of the above-ground cables is **$2.653M**.

The average cost of closure (demolition and rehabilitation) for above-ground cables is $126,400/km.

5.1.5 Assumptions

The key assumptions underpinning our approach for the closure of above-ground cables are:

- Parts of the below-ground cables that lie in private property will be granted immediate access at no cost. In practice, this could be a considerable cost, especially if, for example, landowners wish to impose a fee for access to their properties
- We have not included cost of fencing removal and reinstatement where access through private property is required.
- We have assumed access to the area is straightforward.
- Excavation of roads or footpaths has not been included.
- The cost of traffic control in built-up areas has not been included.
- Mobilisation, maintenance and removal of amenities (e.g. temporary toilet facilities) and office buildings have not been accounted for.
- Wet/poor weather conditions may increase the total number of weeks of work required. While the average productivity rates allow for stoppages that may occur for maintenance and fatigue management, it does not allow for impacts from weather.
- We have not accounted for the cost of removing the transitions (concrete troughing filled with stabilised sand), where the GST above-ground cables start to transition to the below-ground assets. We understand that there are 71 transition sections; however, we did not have a typical cross section for these items. The cost for removal and disposal of the transition sections will likely have an average cost between the above ground and below ground cable rates. Therefore, by treating the transition sections as above ground cable, the cost estimate is conservative.

These assumptions mean that our cost estimate is very likely conservative, in the sense that it is understated.

5.2 Below-ground assets (Domain 2)

The Directlink below-ground assets (the DC cables only, not any part of the AC cable) total approximately 36 km. They appear in a variety of forms and locations (e.g. ploughed or trenched, buried in compacted bedding or contained in polyvinyl chloride (PVC) conduits surrounded by bentonite slurry, or positioned near easements or in fairly open-access areas). Given the non-uniformity of the cable types and the landscapes under which they traverse, we sought to determine a 'representative section' cable profile. We then extrapolated our estimate of the costs for the representative section to all 36 km of cables.

Based on our review of the asset and discussions with Directlink, we determined the most common cross-section type to be Type 2 (Open Cut/Fill General). Figure 2 depicts this cross-section type, which occurs for 22 km of the below-ground cables' total length of 36 km.

The way in which the Type 2 cable is buried is important for determining the most appropriate decommissioning and demolition method. The three pairs of transmission cables (see the bottom of Figure 2) are surrounded by compacted bedding, topped by a PVC cover strip. Backfill and a trench cap, separated by a warning tape, occupy the space between the PVC cover strip and ground level.

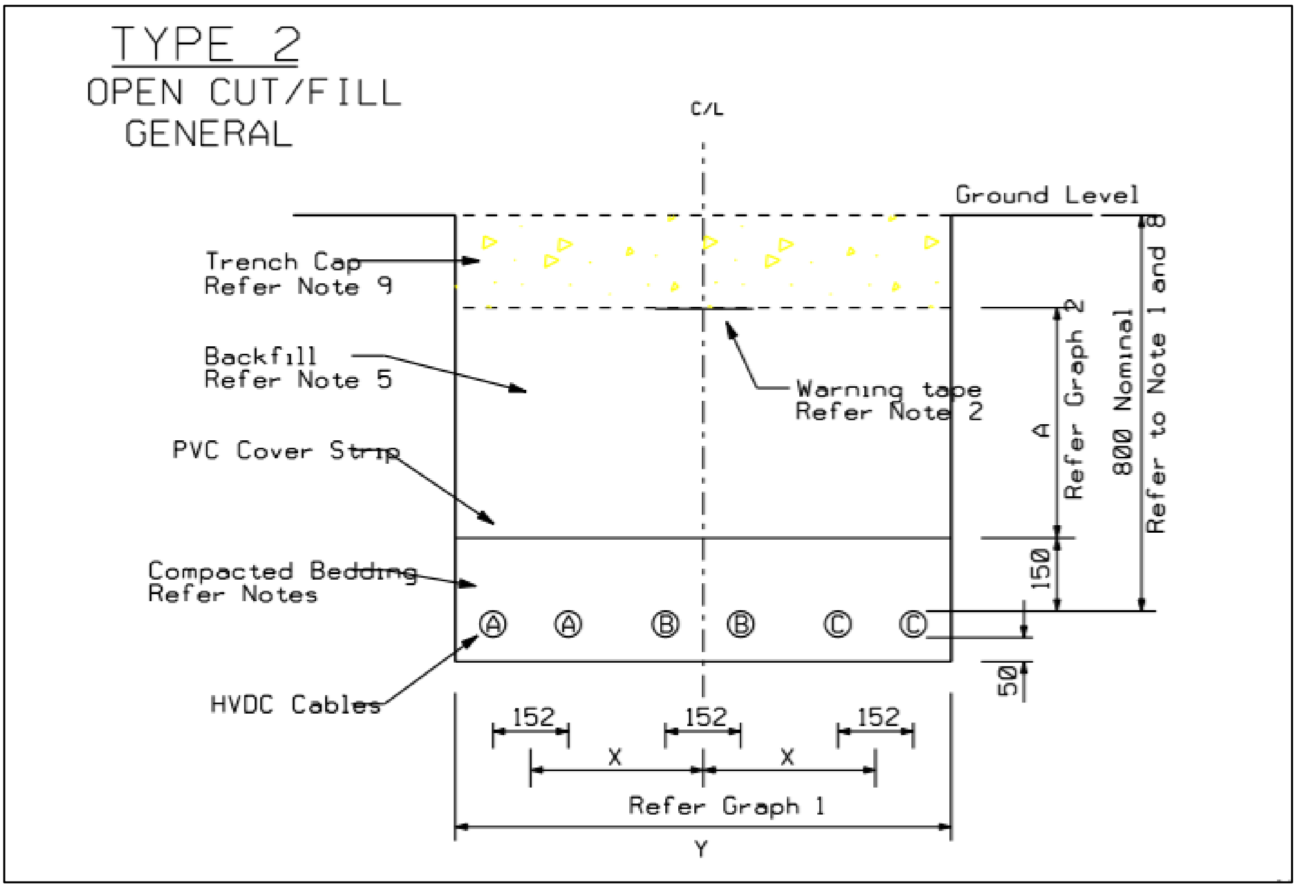


Figure 2: Cross-section of below-ground cable 'representative section'

Following discussions with Directlink, we selected, as representative, the section width of 1 metre and depth of 1.2 metres. We also assumed that the representative section is easement free, and that access conditions are ideal (e.g. in an open-access cane field near a good-condition road, rather than in a dense forest with no roads). This is consistent with our position of identifying a lower-bound cost estimate, similar to the analysis for above-ground cables.

5.2.1 Tasks

Our closure method for the representative section below-ground cables involves the following tasks:

- Early works (including decommissioning)
- Excavation works
- Disposal works
- Backfill works
- Rehabilitation works.

Table 5 sets out the scope of work for each of the tasks.

Table 5: Scope of work for below-ground assets

Task	Scope of task
Early works	• Disconnect the HV cable from the connecter stations • Complete 'Dial Before You Dig' investigations and undertake surveys or ground penetrating radar (GPR) testing, to identify other utilities or services that need to be accounted for during the demolition works. The results of such surveys and testing will have a bearing on the selection of the appropriate excavation method (e.g. use hand excavation in congested or suspect areas) • Separate the cable at 10-km lengths, to prevent backflow of the earth grid. This needs to be performed for safety reasons.
Excavation works	• Clear access along the length of the buried cable (clearing distance of 5 metres on either side of the cable centreline) • Excavate top 200/300 mm (0.20/0.30 metres), the trench cap, to expose the warning tape • Roll up the warning tape. The tape can be rolled up as excavation continues, provided there is a minimum of a 20-metre clearance between the excavator and labourers to satisfy safety-related considerations • Excavate next 750 mm (0.75 metres). Cease excavation while PVC cover strip is rolled up • Remove PVC cover strip. • Excavate next 150 mm (0.15 metres). • Remove HVDC cable (the three pairs).
Disposal works	The disposal works will include the use of a truck to cart the material offsite. However, as most waste material on this site is recyclable through scrap merchants, we have assumed that any other disposal costs (e.g. landfill fees) will be offset by the scrap value returned.
Backfill works	• Fill in the 1.2-metre deep trench with excavated material. A nominal amount for imported fill as required to level the site has been allowed for. • Compact and level the backfilled trench.
Rehabilitation works	• Minor earthworks, including shaping, drainage and other soil conservation measures (scarification along the contour). • Spreading of virgin excavated natural material (VENM), as a growth media. • Incorporation of soil ameliorates, including addition of lime and/or gypsum. • Direct seeding and fertiliser application. • Rehabilitation maintenance (ongoing), which might include re-seeding, watering, fertilising, erosion control and inspections.

The most time-consuming parts of the closure tasks relate to safety-related 'pauses' during the excavation works, where excavation may have to be halted while the removal of PVC cover strip and cable occur. Other key issues are limiting the amount of open trench, so that the public (and other people who have project-related responsibilities but do not have authorised access to the site) are not exposed to unprotected open trenches.

5.2.2 Productivity and labour-availability assumptions

In undertaking the scope of tasks, we have assumed the following average productivity rates for machinery, which has been informed by our observations of what the closure industry achieves in practice:

- 375 metres per day for excavation of earthworks
- 150 metres per day for extraction of the HVDC cable
- 187.5 metres per day for backfill and compaction, after the cable is removed.

Our labour-availability assumptions are that crews work six days a week and work 10 hours per day. We have also assumed that three crews will work simultaneously along the cable. Based on the assumed productivity and labour-availability rates, we determined that a 50-week work program would be required to remove 36 km of the representative section.

5.2.3 Cost drivers

Over the 50-week program of works, the main factors contributing to costs include:

- 50 weeks of labour time required for two excavator operators, three Telehandler (reel) operators and a truck driver
- 50 weeks of labour time from 7.2 labourers (including for peak-time labour allowances)
- 22 weeks of renting a dozer.

Table 6 sets out the proposed labour and equipment requirements for removing the below-ground cables and rehabilitating the area where it was buried.

Table 6: Labour and equipment requirements for below-ground assets

Task	Proposed labour requirements	Proposed equipment requirements
Project management	A project manager and a safety manager (one day per week, for 50 weeks) A mechanic (one day per week, for 38 weeks)	Light vehicle and mobile service truck
Early works	An electrician (4 weeks) and three surveyors (8 weeks)	Survey and GPR equipment
Excavation works	One dozer operator (22 weeks), two excavator operators (32 weeks), three Telehandler reel operators (50 weeks), and an average of 7.2 labourers (50 weeks)	Dozer x 1, 20-tonne excavator x 2, Telehanders with reel carriers x 3.6 (average), to reflect that one of the machines is called in 60 per cent of the time for loading and sorting operations), Light vehicles x 3.6 (average)
Disposal works	One truck driver (50 weeks)	A disposal truck (suitable to be on highways)
Backfill works	One excavator operator (32 weeks)	20-tonne excavator x 1
Rehabilitation works	A small dozer operator, an excavator operator and a water cart driver	Small dozer; 25-tonne excavator

5.2.4 Cost estimate

Table 7 sets out our proposed cost estimate for Directlink's below-ground cables.

Table 7: Cost estimate for below-ground assets

Task	Relevant information	Cost (December 2019, $M)
Decommissioning and demolition		
Labour (incl. project management)	43,650 hours	4.892
Machinery and equipment	31,425 hours	1.531
Materials	8 units of imported fill ($125 per cubic metre / km)	0.036
Mobilisation/De-mobilisation	One-off fee for mobilising and de-mobilising crews	0.075
Demolition sub-total	*n/a*	*6.534*
Rehabilitation (over a 10-metre width for 36 kilometres, covering 360,000 square metres)		
Minor earthworks, shaping, drainage and other soil conservation measures	A small dozer and excavator will undertake this work. This will be performed over a 360,000 m^2 area.	0.042
Spoil amelioration (adding lime / gypsum)	A 2.5 tonne per hectare assumption has been applied. The spoil amelioration will occur over a 360,000 m^2 area.	0.031
Direct seeding / fertiliser	A pasture-grass species will be used	0.045
Growth media	VENM applied ($70 per cubic metre), applied at a 10 cm depth for a 360,000 m^2 area	2.520
Cart and spread growth media	Applied ($3.26 per cubic metre) at a 10 cm depth for a 360,000 m^2 area	0.117
Rehabilitation maintenance	Re-seeding, watering, fertilising, erosion control and inspections	0.032
Rehabilitation sub total	n/a	*2.788*
Total	**n/a**	**9.322**

Our estimate of the total costs for closure of the below-ground cables is **$9.322M**.

The average cost of closure (demolition and rehabilitation) for below-ground cables is $258,950/km.

The cost estimate for below-ground cable assets does not account for the Directlink 4km 110kV AC cable. This cable is located under roads or on a steep slope, and a significant proportion of it is laid in conduit. The cable is located within congested corridors in an urban area, where residents and businesses are located.

To reflect the onerous access conditions to remove the AC cable, but acknowledging that the nature of rehabilitation requirements is unknown for the urban setting (e.g. areas under footpaths need not have a pasture grass and growth media placed on them), we have assumed that an appropriate unit rate to apply is double the average cost of demolition (but not for rehabilitation) for the below-ground cable assets. The average cost of demolition for below-ground cable assets is $181,503/km and, therefore, the unit rate for closure of the AC cable is $363,007/km. For the 4 km AC cable, the total cost is thus **$1.425M**.

5.2.5 Assumptions

The key assumptions underpinning our approach for the closure of below-ground cables are:

- Parts of the below-ground cables that lie in private property will be granted immediate access at no cost. In practice, this could be a considerable cost, especially if, for example, cane farmers wish to impose a fee for access to their properties. Fencing removal/reinstatements costs have not been accounted for
- If depths of trenches exceed 1.5 metres (our assumption is that the depth is 1.2 metres on average), bigger excavators will be required because of benches in the excavation. Our cost estimate does not account for this.
- Along road corridors, additional works will be required to compact to specification and reinstate surface finish (concrete and/or asphalt). Our cost estimate does not account for this.
- We have not included cost of fencing removal and reinstatement where access through private property is required.
- Excavation of roads or footpaths has not been included.
- The cost of traffic control in built-up areas has not been included.
- Mobilisation, maintenance and removal of amenities (e.g. temporary toilet facilities) and office buildings have not been accounted for.
- We have not allowed for removal of bored pipe sections.
- We have not allowed for additional approvals or requirements that may be required for waterway or major road crossings.
- Wet/poor weather conditions may increase the total number of weeks of work required. While the average productivity rates allow for stoppages that may occur for maintenance and fatigue management, it does not allow for impacts from weather.
- We have not accounted for the cost of removing the transitions (concrete troughing filled with stabilised sand), where the GST above-ground cables start to transition to the below-ground assets. We understand that there are 71 transition sections; however, we did not have a typical cross section for these items. The cost for removal and disposal of the transition sections will likely have an average cost between the above ground and below ground cable rates. Therefore, by treating the transition sections as above ground cable, the cost estimate is conservative.

These assumptions mean that our cost estimate is very likely conservative, in the sense that it is understated.

5.3 Converter stations (Domain 3)

The Directlink assets include two converter stations, each of which has three identical station buildings. Other key items in each converter station are:

- Concrete slabs containing significant amounts of copper for the earth grid
- The copper earth grid located under the whole compound yard
- Reactors
- A transformer (polychlorinated biphenyl (PCB) free), surrounded by a sound wall with wool-type insulation layers containing steel columns
- Cooling section containing water coolers
- Switching gear
- Fire system. This includes a masonry pump room, 200 kL steel tank with rubber bladder, hydrants and below-ground piping
- Bitumen and/or gravel hardstand, and masonry-retaining structures

- Fencing around the site.

To simplify the analysis, we have assumed that each converter station is identical, and used the Terranora HVDC converter station as the reference point. Given the varied composition of items in, and around, the converter stations, we considered it appropriate to partition the Terranora HVDC converter station into several Material Take Offs (MTOs).

5.3.1 MTOs

The MTOs we developed are:

- Heavy steel (tonnes)
- Light steel (tonnes)
- Concrete (cubic metres)
- Other materials (e.g. road asphalt, masonry).

To determine the MTOs for the converter station, we divided the site into several parts (see Figure 3).

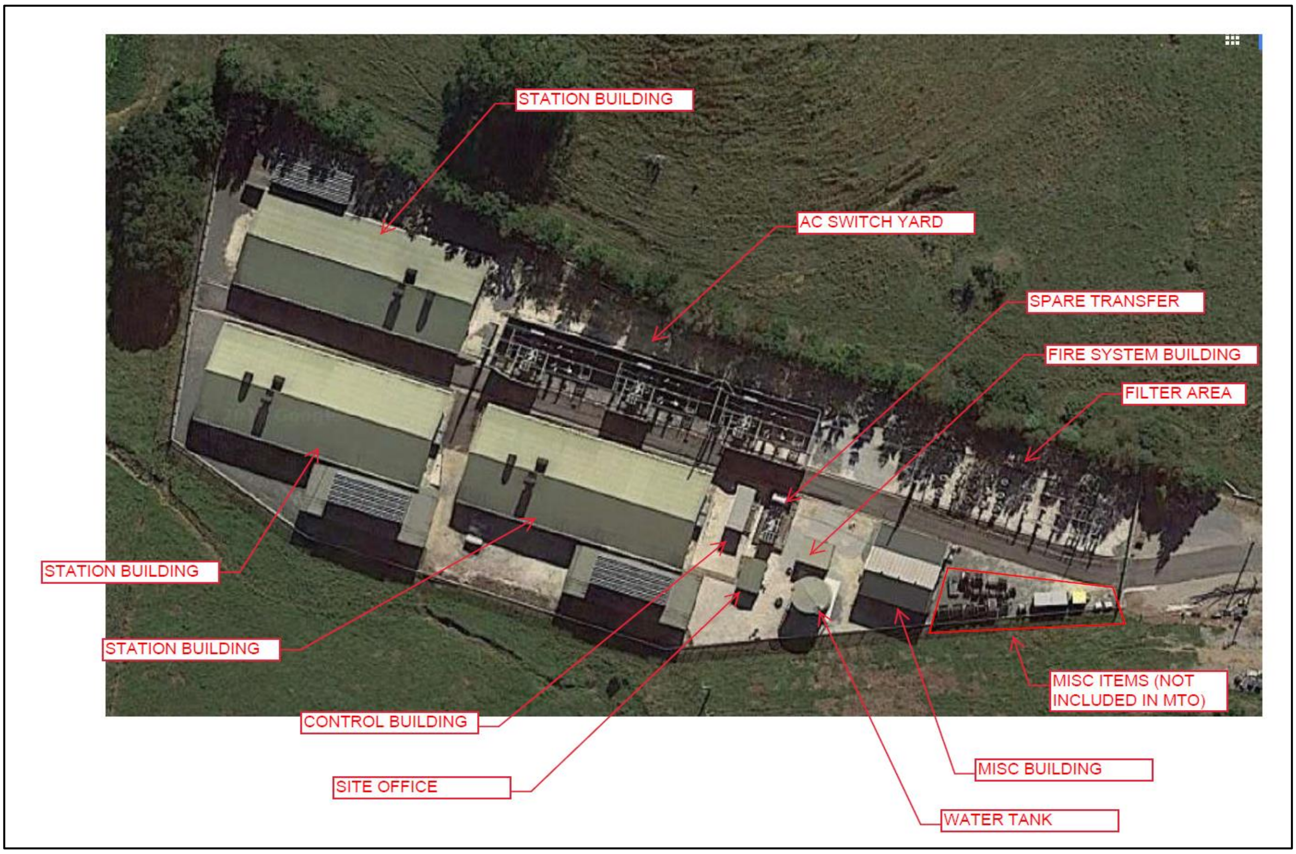


Figure 3: Terranora HVDC converter station (near Bungalora)

5.3.2 Bill of quantities

Table 8 sets out the proposed bill of quantities for each converter station, including the equipment and labour required.

Table 8: Bill of quantities for converter stations (and labour/equipment requirements)

MTO	Bill of quantities	Equipment required	Labour-crew mix required
Heavy steel	105.4 tonnes	50-tonne excavator 30-tonne excavator x 2 Breaker for excavator Shear Telehander Water truck Service tuck Tipper truck Light vehicles Other site vehicles	Project Manager x 1 (part time) HSE representative x 1 (part time) Labourer x 2 (decommissioning) Tradies x 2 (decommissioning) Supervisor (demolition) Operator x 3 (demolition) Labourer x 3 (demolition) Truck driver x 1 (disposal) Labourer x 2 (wool ins. removal) Operator x 1 (excavation) Labourer x 2 (excavation)
Light steel	120.4 tonnes		
Concrete	1,611.4 cubic metres		
Other material	83.4 tonnes		

5.3.3 Key productivity assumptions

Our key labour-related assumptions are that crews work six days a week and work 10 hours per day.

In undertaking the scope of tasks, we have assumed the productivity rates in relation to the main MTOs, which has been informed by our observations of what the closure industry achieves in practice:

- 30 tonnes of heavy steel can be removed per day. That is, it takes 3.5 days to remove the heavy steel.
- 50 tonnes of light steel can be removed per day. That is, it takes 3.5 days to remove the light steel.
- 200 cubic metres of concrete can be removed per day. That is, it takes nearly 2 days to remove the concrete.

5.3.4 Cost estimate

Table 9 sets out our proposed cost estimate for closure of the Terranora HVDC converter station.

Table 9: Cost estimate for Terranora HVDC converter station

Task	Relevant information	Cost (December 2019, $)
Demolition		
Decommissioning	2 days allowed for, to remove fluids and stored energy Oil disposal from capacitors, transformers and bushings	294,050
Heavy steel	105.4 tonnes	76,590
Light steel	120.4 tonnes	52,486
Concrete	1,611.4 cubic metres	175,574
Other	83.4 tonnes	39,908
Mobilisation/De-mobilisation	Nominal allowance	75,000
Demolition sub-total	*n/a*	*713,607*

Task	Relevant information	Cost (December 2019, $)
Rehabilitation (covering a 200 metre x 50 metre rectangular area)		
Minor earthworks, shaping, drainage and other soil conservation measures	A small dozer and excavator will undertake this work. This will be performed over a 10,000m^2 area.	1,180
Spoil amelioration (adding lime / gypsum)	A 2.5 tonne per hectare assumption has been applied. The spoil amelioration will occur over a 10,000m^2 area.	860
Direct seeding / fertiliser	A pasture-grass species will be used	1,240
Growth media	VENM applied ($70 per cubic metre), applied at a 10 cm depth for a 10,000 m^2 area	70,000
Cart and spread growth media	Applied ($3.26 per cubic metre) at a 10 cm depth for a 10,000 m^2 area	3,260
Rehabilitation maintenance	Re-seeding, watering, fertilising, erosion control and inspections	900
Rehabilitation sub-total	*n/a*	*77,440*
Total	**n/a**	**$791,047**

Our estimate of the total closure costs of the two converter stations is 2 x $0.791M = **$1.582M**.

5.3.5 Assumptions

The key assumptions underpinning our calculation for the closure of the converter stations are:

- We have assumed that the two Directlink converter stations are identical, including that access conditions are the same.
- We have made a nominal allowance for decommissioning assuming that the majority of fuels, chemicals and fluids were removed by the operational crew prior to ceasing operations.
- We have not allowed for the removal or disposal of hazardous materials .Based on the age of the site, it has been assumed that hazardous materials will not exist on the site.
- We have assumed that the site is easily accessible and no significant approvals will be required.
- We have assumed that the salvage value will offset disposal costs.
- We have assumed no significant buried services.

These mean that our cost estimate is very likely conservative, in the sense that it is understated.

5.4 Total cost estimate

We have estimated the closure cost of the Directlink assets to be **$15.009 M** (Dec 2019 dollars).

Table 10: GHD's cost estimate for closure of Directlink's assets

Domain	Cost (December 2019, $M)
Above-ground DC cable assets	2.653
Below-ground DC cable assets	9.322
AC cable	1.452
Converter stations	1.582
Total	**15.009**

GHD Advisory

Level 9 145 Ann Street Brisbane QLD 4000 Australia
GPO Box 668 Brisbane QLD 4001 Australia
61 7 3316 3000
advisory@ghd.com

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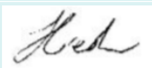
Final	H Devaser C Hermann M Kiejda	H Devaser		H Devaser		9 Dec 2019

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