Economic Impact of not dredging the Port of Gladstone for sustainable sediment management

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CQUniversity

Report provided to Gladstone Ports Corporation

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Research Ethics

Not required for this study.

Table of contents

Executive summary

- The aim of this report is to model the potential economic impacts of a hypothetical case where maintenance dredging was no longer conducted in the Port of Gladstone (PoG).
- The PoG currently has ten wharf centres and 20 operating wharves (or berths) which ship a wide range of cargoes, predominantly coal, liquid natural gas (LNG) and industrial chemicals and products.
- In 2017-18, there were 1840 major vessels moving in and out of the PoG, including 295 Cape, 212 Handy Max, 288 Handy, 78 Mini Bulker and 967 Panamax sized vessels. This equates to 5.04 major vessels per day using the PoG.
- In 2017-18, 75% of the major vessels using the PoG had a draft up to 13.8 metres, 50% had a draft of up to 11.9 metres, and 25% had a draft of up to 11.0 metres. The 25% of vessels with the deepest drafts (from 13.8 – 18 metres) carried 44.3% of the tonnes of cargo, while the next 25% of vessels (from 11.9 – 13.8 metres of maximum draft) carried 27.1% of the tonnes of cargo.
- The maximum vessel draft required in the PoG does not vary much across shipping, so restrictions in access will quickly curtail shipping. The initial impacts will have the largest effects, because it is the largest ships that will be restricted first.
- Restrictions in access are modelled to reduce shipping quickly, with major impacts within two years. Eight of the 20 wharves would cease operations by year 5, and seven others by year 10.
- When the value losses are combined across sectors (see Figure 14 from page 27), the results demonstrate that there are very rapid impacts across all industry sectors, with almost all sectors closed to port access after four years. This include the major sectors of LNG and alumina/aluminium.
- Decline in the coal sector is less marked because of the deeper access to the Clinton wharf, but the sector still loses more than 50% of market trade by year 7, and 96% of trade by year 20.

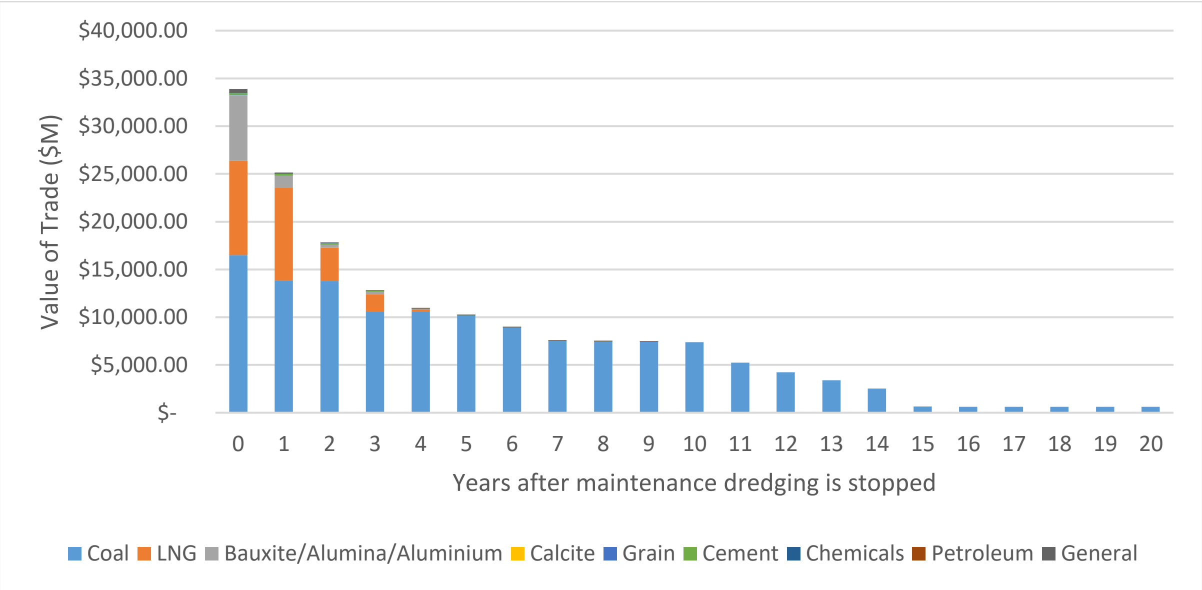

Figure 14. Value of cargo loss by industry over a 20-year period

The results of the analysis show that the economic effects on the Regional, State and National economy will be large and rapid. All sectors will suffer a reduction in access from year 1, as larger vessels are excluded from the PoG. The LNG and Grains sectors will lose all access after four yearsand bauxite/alumina/aluminium, cement, chemicals, petroleum and general cargoes will stop after nine years. Only coal exports will continue, but 96% of access is predicted to be lost by 20 years. The bauxite, alumina, aluminium and LNG industries would essentially close in Queensland, and 28% of coal export capacity would be lost in the state.

The economic impacts would be substantial (see Figure 23 below).Total output losses in the regional areas are modelled to be $61B per annum after 20 years, roughly the size of the entire Gladstone economy. These impacts are predicted to be associated with a loss in value added of $26,878M, a loss in income of $11,861M, and a reduction in employment of 111,275 people. While much of the impact will be on the Gladstone area, approximately 41% of the losses will accrue to the coal and grains sectors which are produced in the Fitzroy and Mackay-Whitsunday regions. The effect of those impacts will be concentrated in the wider region. Similarly, the losses in the bauxite industry will be concentrated in Far North Queensland (Weipa), and the losses in the LNG output will impact on the upstream production areas in the Surat and other basins.

In addition to these impacts on the regional economies, there will be a reduction of royalty payments to the Queensland Government, estimated at $2.38B per annum after 20 years ($1.78B for coal and $0.6B for LNG per year)[1] (see Figure 21 from page 35). The almost complete loss in royalties can be partly averted if some coal can be transferred to northern ports for export (external substitution), although this involves an implausible assumption that maintenance dredging could continue at those ports but not at Gladstone. If there is no transfer to other ports, there is some potential for royalty losses to be minimised by focusing on coking coal exports while capacity is available (the internal substitution option). There will also be a major or total reduction in dividends paid to government as consequence of the poorer operating conditions for the PoG.

The overall effects are summarised in Figure 23 from page 45. The indirect effects provide estimates of the total annual losses to the Central Queensland regional area after multiplier effects are included. Modelling results will not be precise but provide indications of the potential magnitude of losses.

[1] There will also be the loss of annual dividends provided to the Queensland Government, noting that these would be a component of the lost income modelled for the region.

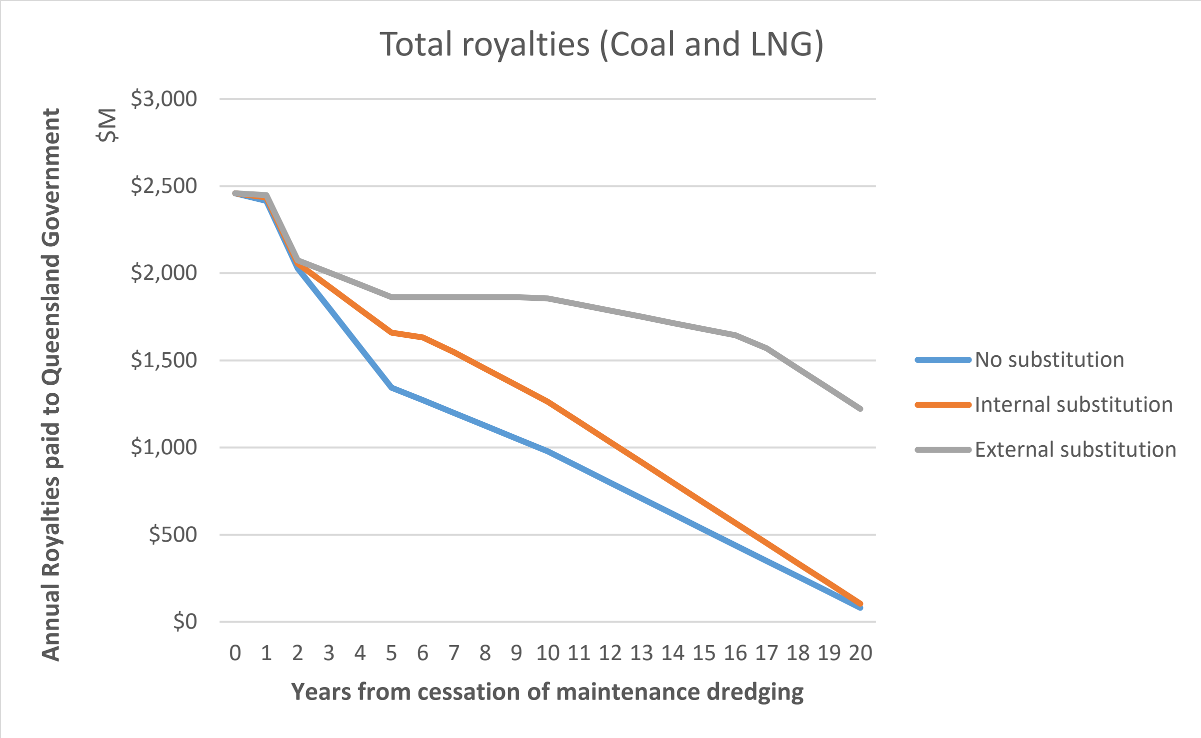

Figure 21. Changes in total royalties by substitution scenarios over a 20-year period

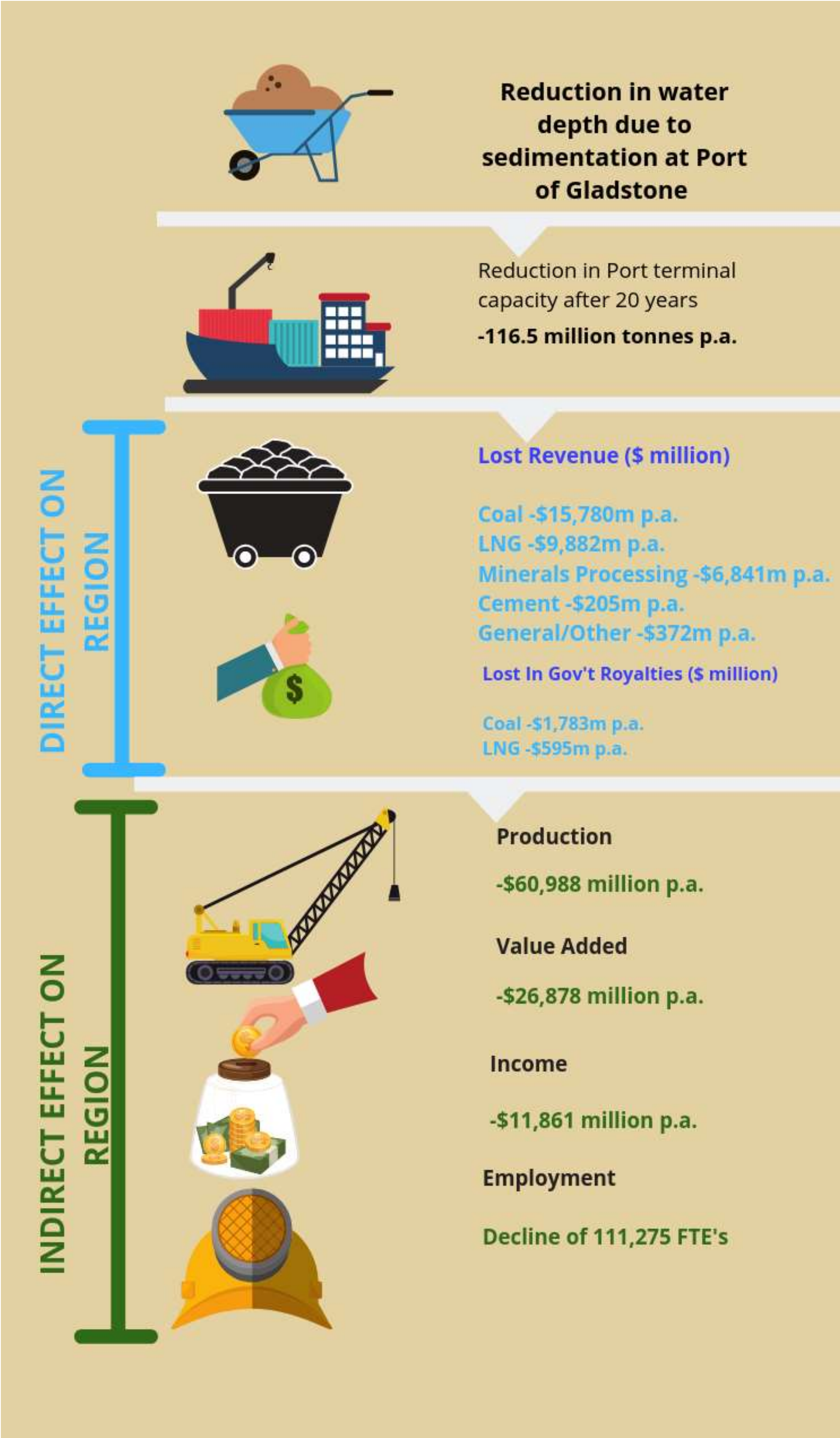

Figure 23. Summary of major impacts over a 20-year period

1. Introduction

The Port of Gladstone (PoG) in Central Queensland is one of Australia's major port facilities. It is the largest multi-commodity port in Queensland and the fifth largest in Australia, with a total throughput of around 120 million tons (Mt) annually (Gladstone Ports Corporation, 2018a). The PoG is the major point for coal exports from the southern Bowen Basin, and also supports a major industrial sector including alumina and aluminium refineries, chemical manufacturing plants, cement plant and three new liquid natural gas (LNG) processing and export facilities. As a consequence the PoG underpins the local economy of approximately 60,000 people in the local region (ABS, 2016). The PoG currently has eight wharf centres and 20 operating wharves (or berths) which ship a wide range of cargoes, predominantly coal, liquid natural gas (LNG) and industrial chemicals and products.

Gladstone Ports Corporation (GPC) is owned by the Queensland Government, and pays annual dividends from its operation ($61.8M in 2018) (GPC 2018a). There is potential for further development of the port, with GPC (2012) identifying that capacity could be 250 – 300 Mt per annum by 50 years. In economic terms, the PoG is an essential component of infrastructure in a number of minerals, energy and industrial supply chains, helping to link key energy production sectors with export markets, as well as facilitating the flow of inputs and outputs for minerals processing and industrial sectors. For example, bauxite mined on Cape York is transported by ship to Gladstone for processing, and then transported out again in the form of alumina or aluminium.

A fundamental part of the port infrastructure are the shipping channels that link the various wharves in the PoG to the outer harbour. The channel has been developed over several stages, most recently in 2011-2014 when the channel was extended in the Western Basin to facilitate access to the new LNG plants on Curtis Island. However, sedimentation processes largely from tidal resuspension of deposits within the PoG[2] mean that the existing shipping channels will gradually silt up to the levels of the surrounding sea floor without intervention. Without managing sediment accumulation most unladen vessels will not be able to access the PoG through outer cuttings. Tidal constraints on five berths will occur after one year and another four berths after five years, at which point there will also be no access for Cape size vessels.

Maintenance dredging is regularly conducted in the PoG to ensure the safe functionality of the shipping channels. This mirrors standard practices in most international ports where dredging is regularly conducted to continue access to shipping. As the size of cargo vessels increases, the requirements for adequate channel access become more critical. This is the case in PoG, where Cape-sized vessels draw over 18 metres of depth when laden, and need access channels to be able to handle this draft.

An important policy issue is to identify what the consequences would be of not maintaining the channel infrastructure. Over the medium term, the access channels would silt up, so access to shipping would be increasingly constrained. Within five years of no maintenance the largest vessels would no longer be able to access the PoG, and after 20 years of no maintenance a large percentage of vessels would no longer have access. Given the size of the PoG and its importance to key export sectors of the Queensland economy, the economic impacts would be substantial.

[2] While the Calliope and Boyne rivers flow into the harbour, the amount of new sediment contributed is a small proportion of the naturally resuspended sediment *(~5%).*

The aim of this report is to model the potential economic impacts of a hypothetical case where maintenance dredging was no longer conducted in the PoG. This involves modelling the potential slowdown in industry and export activity through the PoG, and its corresponding impact on production and employment in the local economy. The potential for some substitution of exports to other ports in Queensland is also considered. The resulting impacts on the Gladstone and Queensland economies over time is then predicted with the application of Input-Output models.

To perform the analysis of the effects of the restriction in shipping, a number of simplifying assumptions were made. First, the baseline for shipping movements was assumed to be constant from the 2017-18 year. This did not allow for any growth in cargo volumes into the future. Second, prices of cargoes were estimated from available prices and official forecasts in May 2019, with prices assumed to be constant over time. Third, there was assumed to be no substitution of cargoes to smaller vessels in the PoG, given that smaller vessels are less economic and can create crowding issues. Instead it was assumed that demand would shift to other suppliers and ports. Fourth, there was assumed to be no substitution of products to other ports in Queensland, although one variant of the modelling did test the effect of transferring some coal exports through northern ports. Fifth, the structure of the economy was not assumed to change over a 20-year period, although an allowance has been made for the shrinkage effects on the regional economy over time. Sixth, it was assumed that there would be no further growth in shipping activity at the PoG.

These assumptions allowed a scenario to be developed that used the 2017-18 shipping patterns as the baseline for activity in the PoG and modelled what would happen to that activity if access was increasingly restricted over a 20-year period. The simplifying assumptions are likely to underestimate the value of industry and cargo that would be handled through the PoG over twenty years into the future, particularly if growth scenarios are considered, but potentially also overestimates some of the impacts of slowdown because it does not allow for some substitution and adjustment effects. With these caveats in mind, it should be noted that the broad quantum of changes predicted are likely to be correct, as there are no viable access alternatives to the PoG for major sectors in the regional economy.

2. Case study setting

2.1 Gladstone region and economy

Gladstone is a regional coastal city of approximately 60,000 people with a median age of 35 years, slightly younger than the Australian median of 38 years (ABS, 2016). Since the construction of the Queensland Alumina Limited (QAL) refinery in 1963, the city and PoG have been characterised by large scale industries. Approximately 58% of economic production and 29% of total employment in the region is attributed to large scale industry (REMPLAN, 2015, cited in AECgroup, 2015). Industrial operations include QAL, Gladstone Power Station, Boyne Smelters Limited, Rio Tinto Alcan alumina refinery, Cement Australia, Orica chemical manufacturing complex, and the three newly developed LNG plants on Curtis Island owned by Australia Pacific LNG, Santos Gladstone LNG and Queensland Curtis LNG (Figure 1).

Coal is the major export from the PoG, accounting for about 70% of shipping activity (GPC, 2018a). The development of coal-seam gas extraction and completion of the LNG plants at Gladstone has allowed the sector to rise to be Queensland's second largest commodity export after coal (Queensland Treasury, 2018). In 2017-18, 97 million tonnes of cargo were exported from the PoG, including 67 million tonnes of coal and 20 million tonnes of LNG (GPC, 2019).

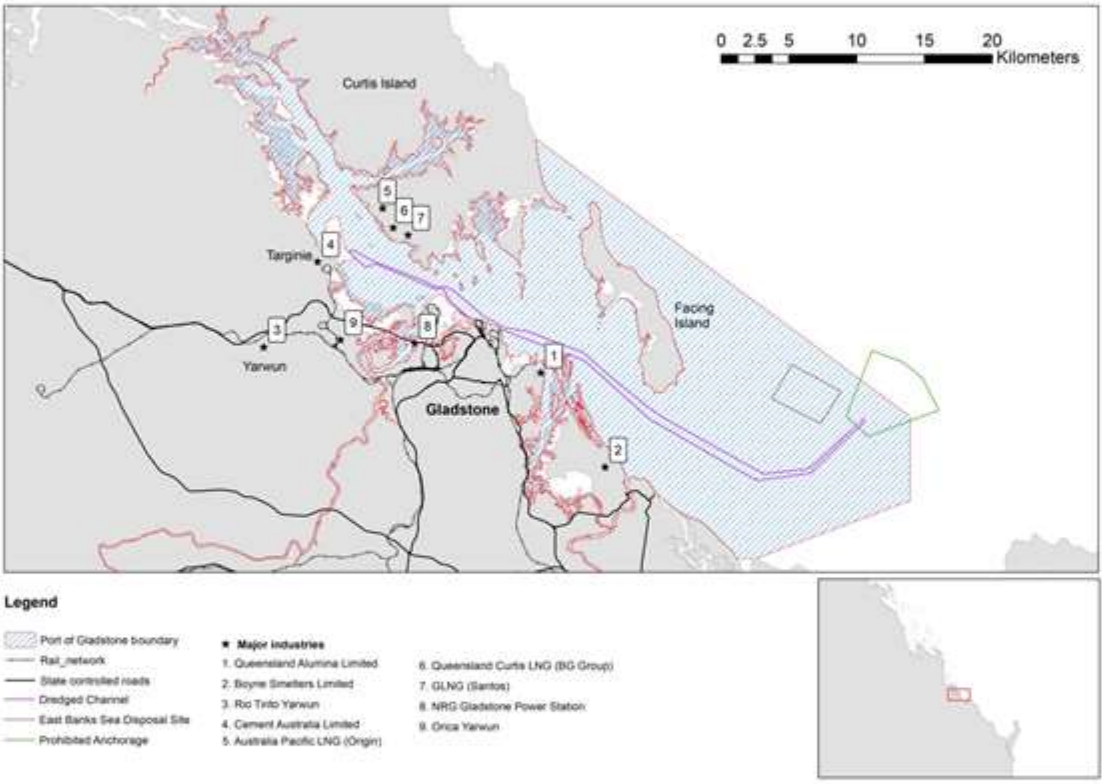

Figure 1: The Port of Gladstone, showing major industry, rail and road links (source: Flint et al., 2015).

The key to Gladstone's industrial productivity is access to the import and export facilities at the PoG. Key industrial inputs, including bauxite for the alumina refineries, and export of the products of portside industries (e.g. cement, alumina) are provided by shipping (Pascoe et al., 2016). The region has a series of other competitive advantages in terms of natural and economic assets including its location in proximity to the natural resources of the Bowen and Surat Basins, existing large-scale industries and advanced manufacturing, strong existing supply chains, interconnected transport and energy infrastructure and a highly skilled workforce (AECgroup, 2015). The region's workforce skills are reflected in the higher proportions of people employed as technicians and trade workers, labourers, or machinery operators and drivers in the Gladstone region (46.7%) in comparison to Australia as a whole (30.1%) (ABS, 2016).

The region's economy has changed significantly since 2010 following the construction on Curtis Island of the three LNG plants, the upgrade of Rio Tinto's alumina plant at Yarwun and the new coal export facility construction at Wiggins Island (AECgroup, 2015). Following the construction boom and a weakening in the resources sector, Gladstone has experienced increasing unemployment and declining socio-economic status (Windle et al., 2018). In 2016, unemployment in the region was at 11.1%, which 4.2% higher than the national average of 6.9% (ABS, 2016). The effects of the end of the construction phase and subsequent fall in investment spending had wider effects on the Queensland economy, sending it into a recession for several years (Queensland Investment Corporation (QIC), 2019).

Gladstone's economy in terms of Gross Regional Product increased from $2.8Bto $4.3Bin the ten years from 2006-2015, with major industry value added growth in construction, business services, mining, transport and utilities (Figure 2; AECgroup, 2015).

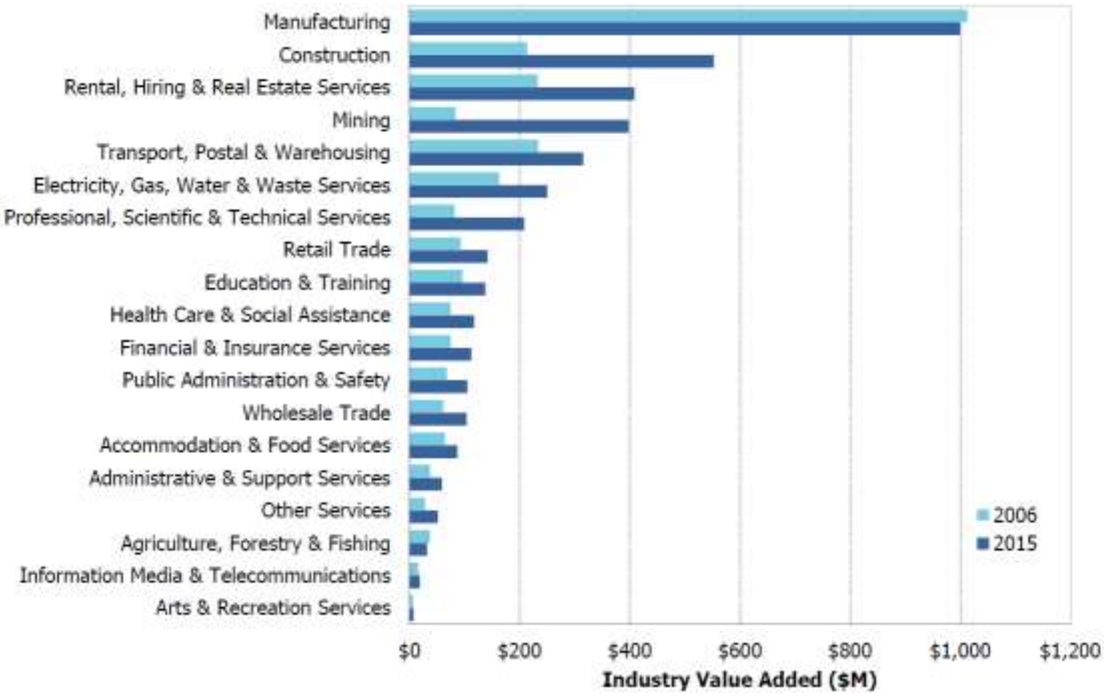

Figure 2: Industry value added, by industry, Gladstone region (AECgroup 2015, sourced from REMPLAN, 2015).

Annually reported economic indicators for the PoG identified shipping ($471M) and tourism ($341M) as dominant in Gladstone's economic performance (Windle et al., 2018). Recreation is also an important economic contribution at $138M, including recreational fishing ($31.19M) (Windle et al., 2018).

2.2 Gladstone port

The Port of Gladstone lies in Port Curtis, a natural and protected deep water harbour, with a boundary that covers 548 km^2. The PoG is adjacent to major shipping channels up the east coast of Queensland, with access to the harbour on the southern side of Facing Island (Figure 3a,b).

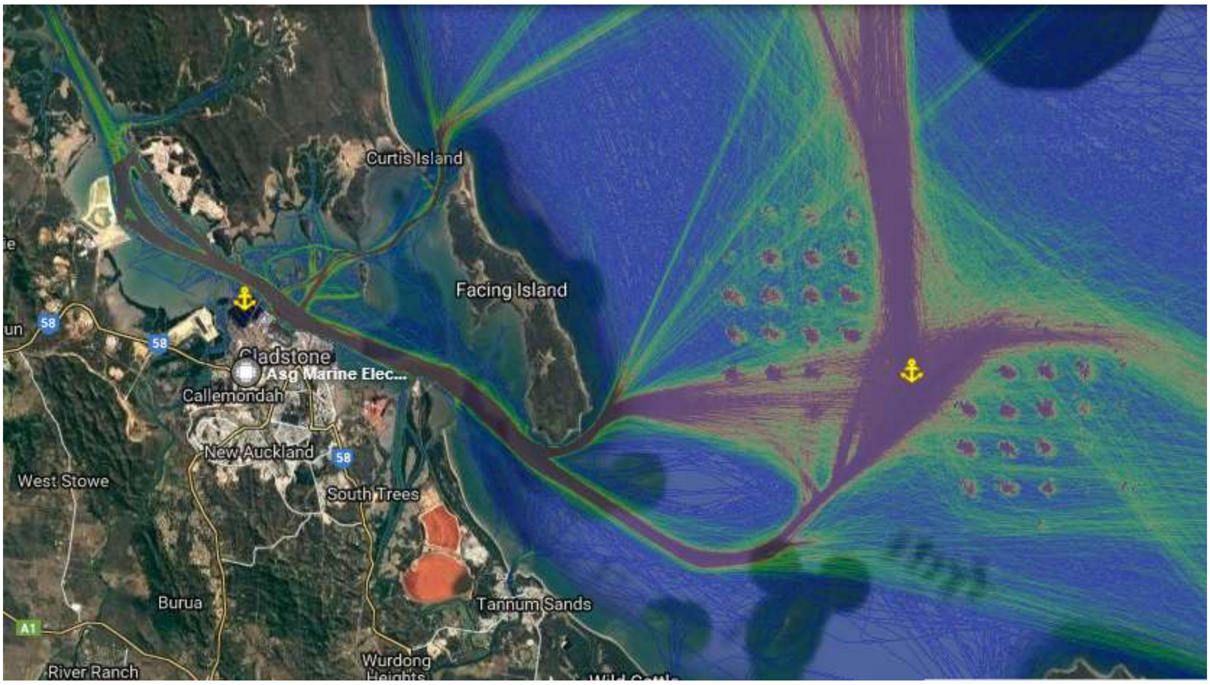

Figure 3a,b: Marine traffic to the Port of Gladstone (Marine Traffic, sourced from https://www.marinetraffic.com/en/ais/home/centerx:151.6/centery:-24.0/zoom:10, with acknowledgements to Lyndon Llewellyn at the Australian Institute of Marine Science).

The Port Curtis region is a macro-tidal estuarine system supported by an intricate network of rivers, creeks, inlets, shoals, mud banks, channels and islands (Flint et al., 2015). These physical features result in a complex water circulation pattern throughout the PoG, and combined with a large barotropic tidal flow, the PoG experiences high natural sediment loads. The PoG is adjacent to the Great Barrier Reef Marine Park and forms part of the Great Barrier Reef World Heritage Area (McIntosh et al., 2019). Estuarine areas have salinities of 30 to 35 parts per thousand for most of the year as a result of the usually low freshwater inputs (Apte et al., 2005).

The PoG currently has eight wharf centres and 20 operating wharves (or berths) which ship a wide range of cargoes, predominantly coal, LNG and industrial chemicals and products (Table 1). The natural deepwater harbour provided an ideal location for shipping and the first wharf, O'Connell Wharf, was constructed in 1863 followed in 1885 by a deepwater jetty at Auckland Point, which was capable of accommodating the largest class of vessels in operation at that time (GPC, 2009). Although the natural deep channels reduced the amount of dredging required, the early wharves still required dredging to obtain and maintain sufficient berthing depths. Following the sale of the Gladstone Meatworks site to Comalco in 1963, Gladstone's first major minerals processing plant, Queensland Alumina Ltd., was built (GPC, 2013). Construction of new wharves at Barney Point (coal) and South Trees (QAL) was conducted during the 1960s, and during the 1970s the Clinton Coal Facility was developed, and was later renamed RG Tanna Coal Terminal (GPC, 2013). Also in the 1970s, construction of a coal fired power station was completed and an aluminium smelter built on Boyne Island. After the largest single dredging project ever undertaken in Australia was completed in 1982, removing 18 million cubic metres of spoil, ships with a 16 m draft were able to utilise the PoG, from the previous maximum draft of 11.56 m (GPC, 2014). The spoil from this dredging activity was used to reclaim an additional 95 hectares of land from Auckland Point to Barney Point, increasing the total reclaimed area to 130 hectares. Another 67 hectares of land was reclaimed at Clinton Estate for future development (GPC, 2014). By 1985 six wharf centres were operational: Auckland Point, Barney Point, South Trees, Fisherman's Landing, Clinton (RG Tanna Coal Terminal), and Boyne Wharf which was constructed to meet the needs of Boyne Smelters Ltd.'s aluminium smelter (GPC, 2014). In 1988, the construction of Gladstone Marina for small craft was also completed.

In 2010, a 20 year Australian and Queensland Government Approval for the Western Basin Dredging and Disposal Project was granted to allow the construction on Curtis Island of three LNG wharves and the Wiggins Island Coal Export Terminal (WICET). The 22 million cubic metre LNG dredging project became the new largest dredging project undertaken in Australia, providing all-tide access to 120,000 tonne LNG carriers to the three Curtis Island wharves, and spoil was used to reclaim land at Western Basin Reclamation Area, with some additional disposal at sea (GPC, 2018b). By 2016, the construction of all wharves at Wiggins Island and Curtis Island was completed.

Table 1: Wharf centres and operations in the Port of Gladstone

Wharf centre	Wharf	Owner / Operator	Berth pocket (m below LAT)	Major products	Tonnage throughput			Vessel no.s
					2016-17	2017-18	Difference (%)	
Auckland Point Terminal	No. 1	GPC / GPC	11.3	Calcite, woodchip, general cargo, containers	374,929	197,397	(47.4%)	9
	No. 2	GPC / GrainCorp	11.3	Grain	272,008	162,397	(40.3%)	7
	No. 3	GPC / Multi-user	11.3	Petroleum, LP gas, sulphuric acid, general cargo	845,298	893,108	5.7%	93
	No. 4	GPC / Multi-user	11.4	Breakbulk, containers, general cargo	597,319	665,393	11.4%	41
RG Tanna Coal Terminal	No. 1	GPC	18.8	Coal	59,754,026	57,445,899	(3.9%)	585
	No. 2	GPC	18.8					
	No. 3	GPC	18.8					
	No. 4	GPC	18.8					
Wiggins Island		Wiggins Island Coal Export Terminal	18.8	Coal	9,191,882	9,713,164	5.7%	84
Curtis Island	QCLNG	Royal Dutch Shell / QCLNG	14.0	Liquified natural gas	7,332,532	6,563,739	(10.5%)	99
	APLNG	Origin, ConocoPhillips, Sinopec / APLNG	13.0	Liquified natural gas	7,002,027	8,520,986	21.7%	124
	GLNG	Santos, Petronas, Total, Kogas / GLNG	13.0	Liquified natural gas	5,057,890	5,236,655	3.5%	86
Barney Point Terminal		GPC / GPC	15.0	Calcite	-	104,442	-	3
Fisherman's Landing	No. 1 and No. 2	Rio Tinto Yarwun / Rio Tinto Yarwun	12.9	Bauxite	8,845,012	8,712,415	(1.5%)	115
				Alumina	3,063,092	2,900,014	(5.3%)	78
				Caustic soda	943,927	1,018,431	7.9%	24
				Alumina hydrate	269,000	356,150	32.4%	13
	No. 4	GPC / Cement Australia	11.2	Cement products	1,748,186	1,865,926	6.7%	102
	No. 5	GPC / Multi-user	11.2	Liquid ammonia	170,369	163,094	(4.3%)	24
				Caustic soda	120,355	167,783	39.4%	5
				Sulphuric acid	14,003	17,865	27.6%	2
South Trees	East	Queensland Alumina Ltd (QAL) / QAL	12.8	Alumina	2,681,378	2,733,754	2.0%	77
				Caustic soda	980,318	1,167,594	19.1%	36
				Petroleum products	150,039	146,122	(2.6%)	7
	West	QAL / QAL	12.8	Bauxite	10,368,052	10,041,241	(3.2%)	133
Boyne Wharf		GPC / Boyne Smelters Ltd (BSL)	15	Aluminium	360,151	361,974	0.5%	24
				Alumina hydrate	-	5,000	-	2
				Petroleum coke	44,497	186,406	318.9%	13
				Liquid pitch	221,533	42,633	(80.8%)	13
Total Port of Gladstone					120,407,823	119,389,582	(0.8%)	1,799

Data compiled from Flint et al. (2015); GPC (2017, 2018)

Over the last six years, GPC's total revenue from operations has increased from $363M to $426.6M (Figure 4). Revenue is received in the form of cargo handling charges, harbour dues, tonnage rates, other shipping charges, pilotage, property revenue and smallcraft services, and reflects actual activity in the PoG (GPC, 2018c). Increases in 2015-16 were attributed to increased sales revenue as LNG and WICET tonnages rose after the completion of construction (GPC, 2016).

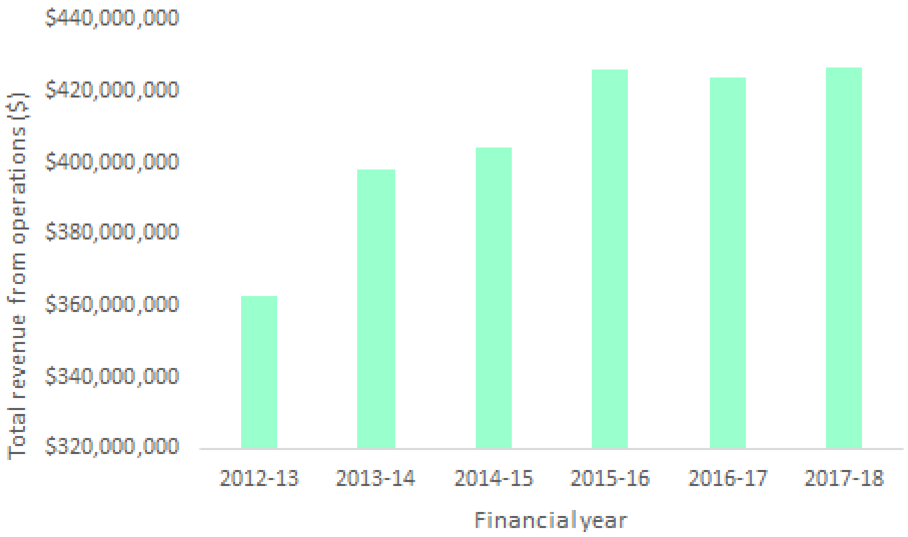

Figure 4: Gladstone Ports Corporations total revenue from operations by FY2012-13 to FY2017-18[3].

Gladstone Ports Corporation's total capital expenditure is available for the years 2012-13 through to 2015-16 and reflects the Ports growth strategy (Figure 5). High expenditure during construction of WICET and Curtis Island was experienced during 2012 to 2014 (GPC, 2016).

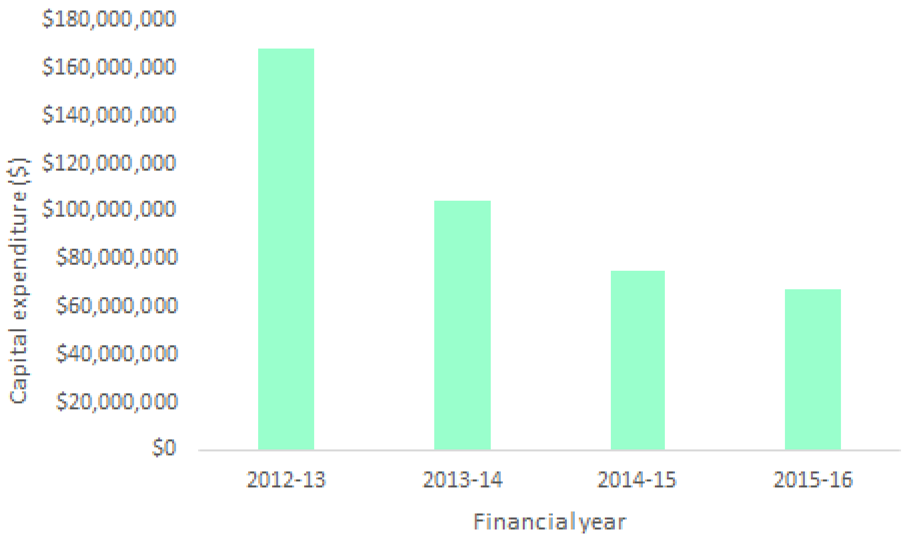

Figure 5: Gladstone Ports Corporations total capital expenditure by FY2012-13 to 2015-16.

[3] Data for Figures 4 and 5 compiled from GPC Annual Report Financials: http://gpcl.com.au/about-us/financial-reports

3. Identification of relevant economic activities to the Port of Gladstone

The impacts of lack of access to the PoG will depend on a number of factors, including the extent of shipping, the size of ships involved, the amount and value of cargo that is involved, and the flow of charges to the GPC. Some evidence for the extent of current activity is provided below, drawing on data made available for the 2017-2018 Financial Year (the most recent available). As the revenue for ports activities has been very stable from 2015-16 (Figure 4), this data should provide a good representation of PoG activities.

In 2017-18, there were 1840 major vessels moving in and out of the PoG, including 295 Cape, 212 Handy Max, 288 Handy, 78 Mini Bulker and 967 Panamax sized vessels. This equates to 5.04 major vessels per day using the PoG. When the types of vessels are compared by loaded draft (the most relevant measure for channel depth), the data shows that the Cape class requires the most draft (up to 18 metres), while the Mini Bulker class requires the lowest draft (up to 8.6 metres). The maximum draft required can be for either vessels bringing material into or out of the PoG.

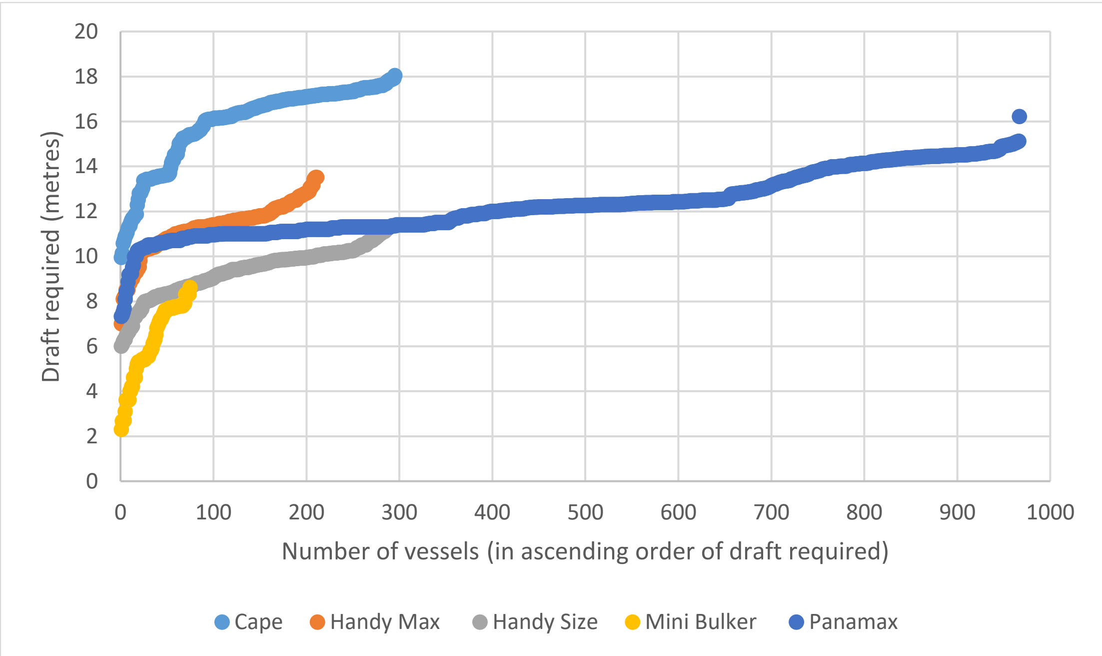

Figure 6: Number of ship movements by vessel type and maximum draft required. Data sourced from GPC.

The distribution of vessel movements to different parts of the PoG are summarised in Figure 7 by the maximum draft required. This amalgamates the different wharfs into key groups (e.g. the five Fisherman's Landing wharves are grouped into one category as Fisherman's Landing. The results show that the RG Tanna Coal Terminal has the most vessel movements and Boyne Smelter the least. In terms of the maximum draft requirements, the two major coal terminals (RG Tanna and Wiggins Island) have the largest requirements, but all wharf areas are hosting vessels with large drafts (the three LNG facilities at Curtis Island have the lowest maximum drafts at 11.8 metres).

In 2017-18, 75% of the major vessels using the PoG had a draft of up to 13.8 metres, 50% had a draft of up to 11.9 metres, and 25% had a draft of up to 11.0 metres. The 25% of vessels with the deepest drafts (from 13.8 – 18 metres) carried 44.3% of the tonnes of cargo, while the next 25% of vessels (from 11.9 – 13.8 metres of maximum draft) carried 27.1% of the tonnes of cargo.

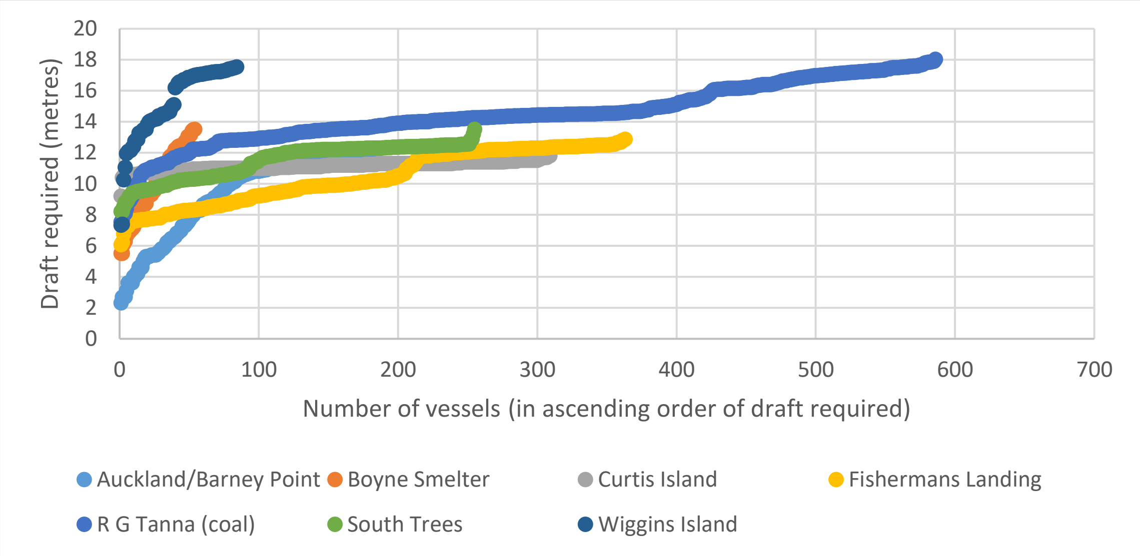

Figure 7: Number of ship movements by port area and maximum draft required. Data sourced from GPC.

As expected, there is a positive relationship between the maximum draft required and the volume of cargo carried (Figure 8). The larger vessels that carry bigger loads require more draft to be able to access the PoG. The simple linear relationship that is reported in Figure 6 from the 2017-18 data in Gladstone suggests that for every extra metre in maximum draft, the average load carried increases by 14,631 tonnes.

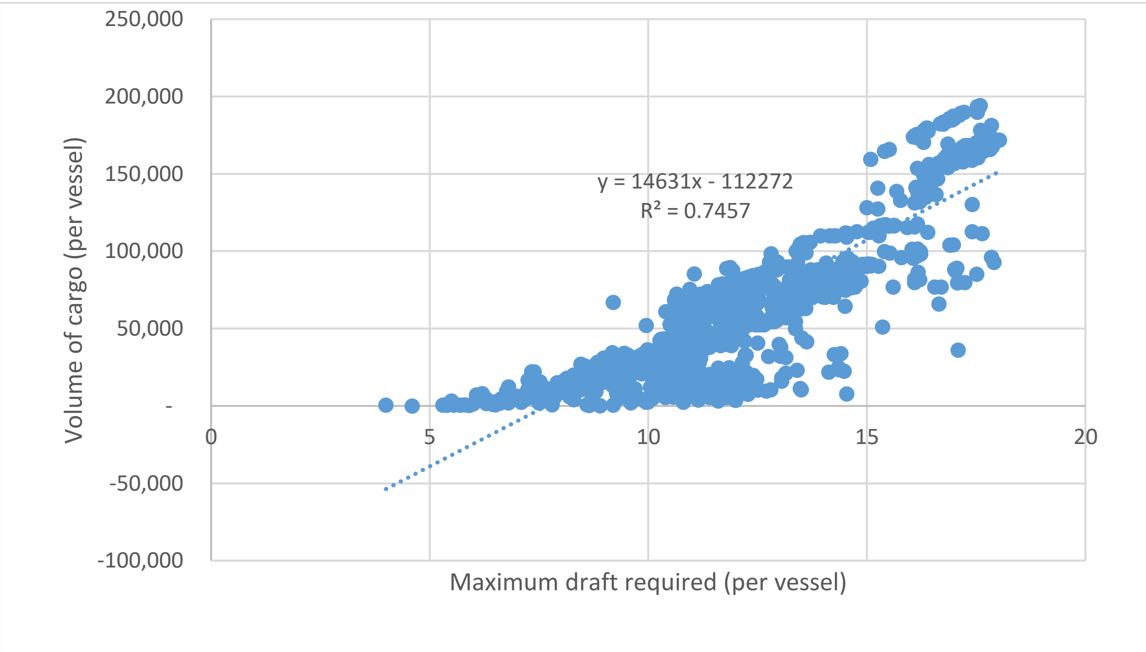

Figure 8: Tonnage per vessel by maximum draft required. Data for FY2017-18 sourced from GPC.

These estimates show that most access to the PoG involves larger vessels, that restrictions to access will initially have a major impact on volumes, and then on the number of vessels. By the time that access would be restricted to 10 metres of maximum draft, on current patterns 83% of vessels would not be able to access the PoG, and 96% of tonnage would not be able to be shipped.

These relationships are demonstrated in Figure 9, where vessels are plotted against their maximum draft in ascending order, as well as the cumulative cargo carried, in million tonnes. The Figure demonstrated that the maximum draft required does not vary much across shipping, and that restrictions in access will quickly curtail shipping. The analysis also shows that the initial impacts will have the largest effects because it is the largest ships that will be restricted first.

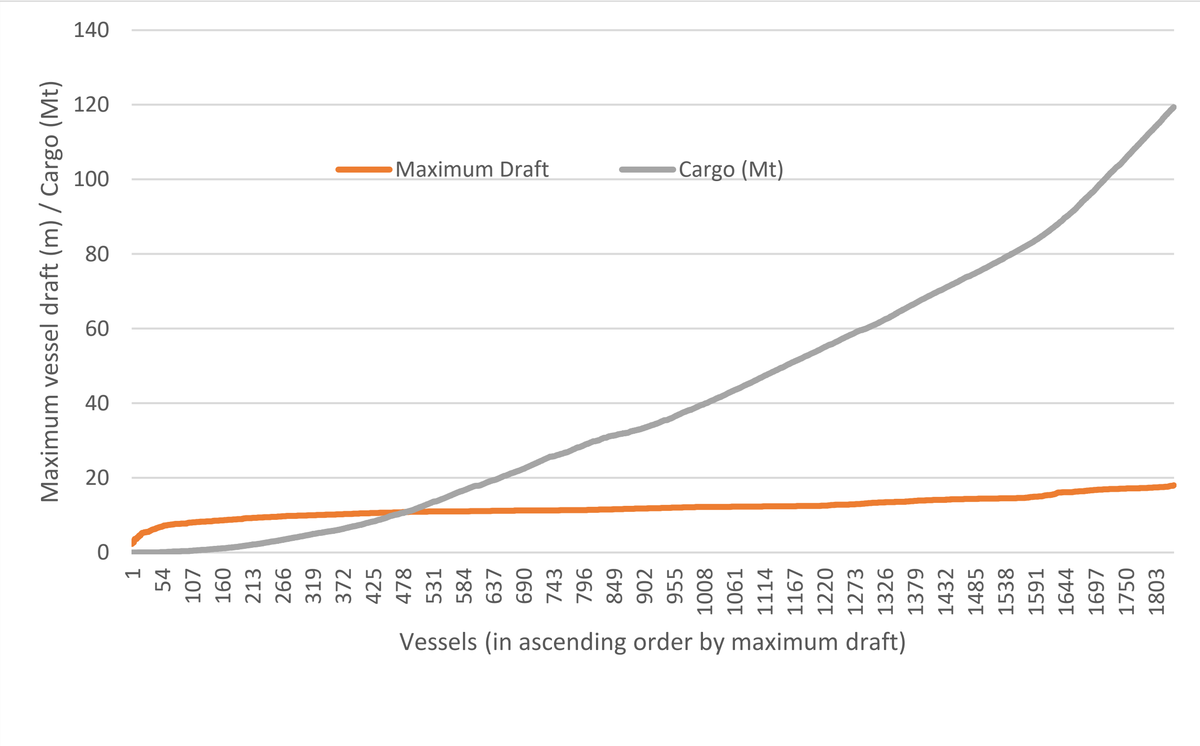

Figure 9: Number of ship movements by maximum draft required and cumulative tonnage of cargo. Data for FY2017-18 sourced from GPC.

4. Constructing a model of future shipping movements in the Port of Gladstone

4.1 Baseline scenario

The baseline situation shows that cargo transiting through the PoG is not evenly distributed across wharves (Figure 10). RG Tanna Coal Terminal (48%) dominates, representing almost half of cargo traffic. Constraints to be placed on this wharf will therefore have a significant impact on future traffic. WICET (3rd in cargo volume) adds 8%, leading to 56% of the total cargo volume related to coal. LNG exports from Curtis Island represent 16% of the PoG's traffic. South Trees West and Fisherman's Landing 1 combine to represent another 16% of the traffic, stressing the importance of bauxite movements in Gladstone. The remaining 12% of cargo is spread across the other ten wharves.

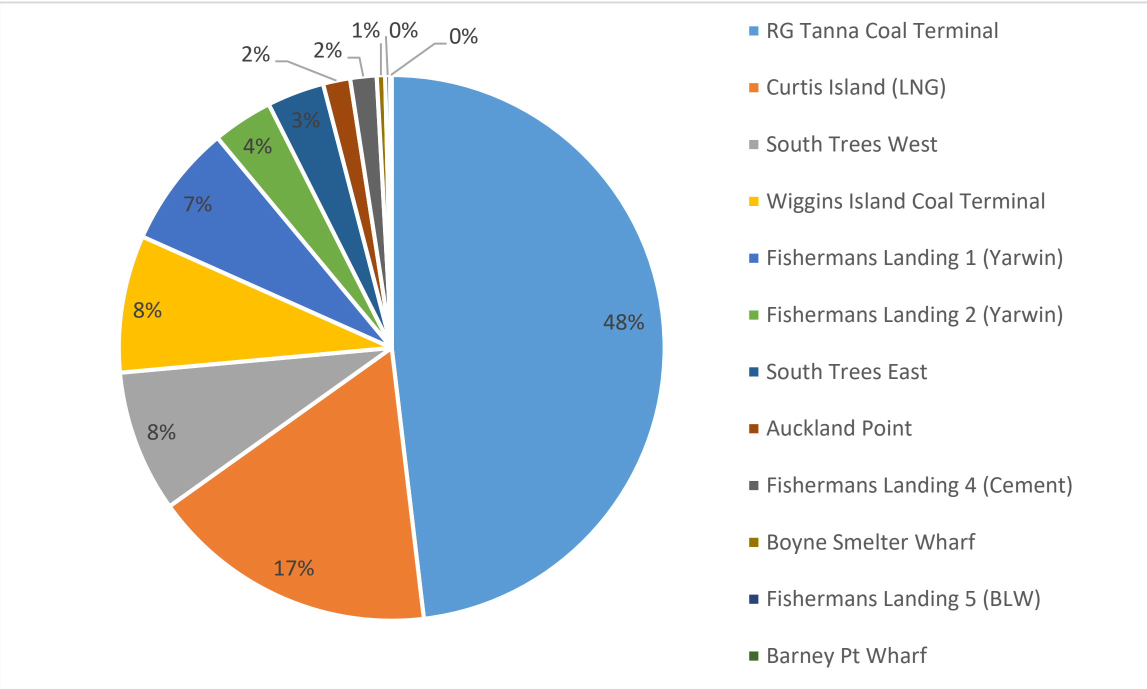

Figure 10. Proportion of cargo volume transiting through each wharf in the Port of Gladstone

4.2 Potential loss in cargo over a 20-year period

To construct a model of future shipping movements under different scenarios, we used the scenarios of future activity from the Port of Gladstone Master Plan as counterfactual case. Information extracted from the Master Plan included predicted future depth (in metres below lowest astronomical tide), impacts on vessel operations, estimated loss in cargo and estimated loss in revenues from the PoG. This information was, however, only available for years 1, 2, 5, 10 and 20 in the future and consequently needed to be completed using imputation to create the model. Various restrictions in shipping access also needed to be assumed, drawing on the summary provided in the Scope of Services document provided by the GPC (see Appendix 1). For robustness, we computed two different models relying on two different imputation methods – one was entirely developed in Excel and the other one was developed in R then processed in Excel.

Scenario 1: Linear decrease

In this scenario, we assumed a constant decrease in cargo volume over the missing years (Figure 11). For instance, cargo volumes for year 3 was calculated as 2/3 of the difference between year 2 and year 5, starting from tonnage value in year 2. Cargo volume for year 4 was calculated similarly but taking 1/3 of the difference between year 2 and year 5. A similar approach was used to calculate cargo volumes for years 6 to 9, and for years 11 to 19.

We note that future changes in cargo volumes will more likely follow a "stairs" pattern, with cargo decreasing by stages as depth becomes a limiting factor preventing certain types of ships to transit from one year to another. However, volumes may decrease in advance if contracting parties view transport through the PoG as risky. Accordingly, this model may be a fair representation of the expected loss in cargo volume over the 20-year period. As expressed earlier, we can see in Figure 10 that RG Tanna Coal Terminal will be the most affected.

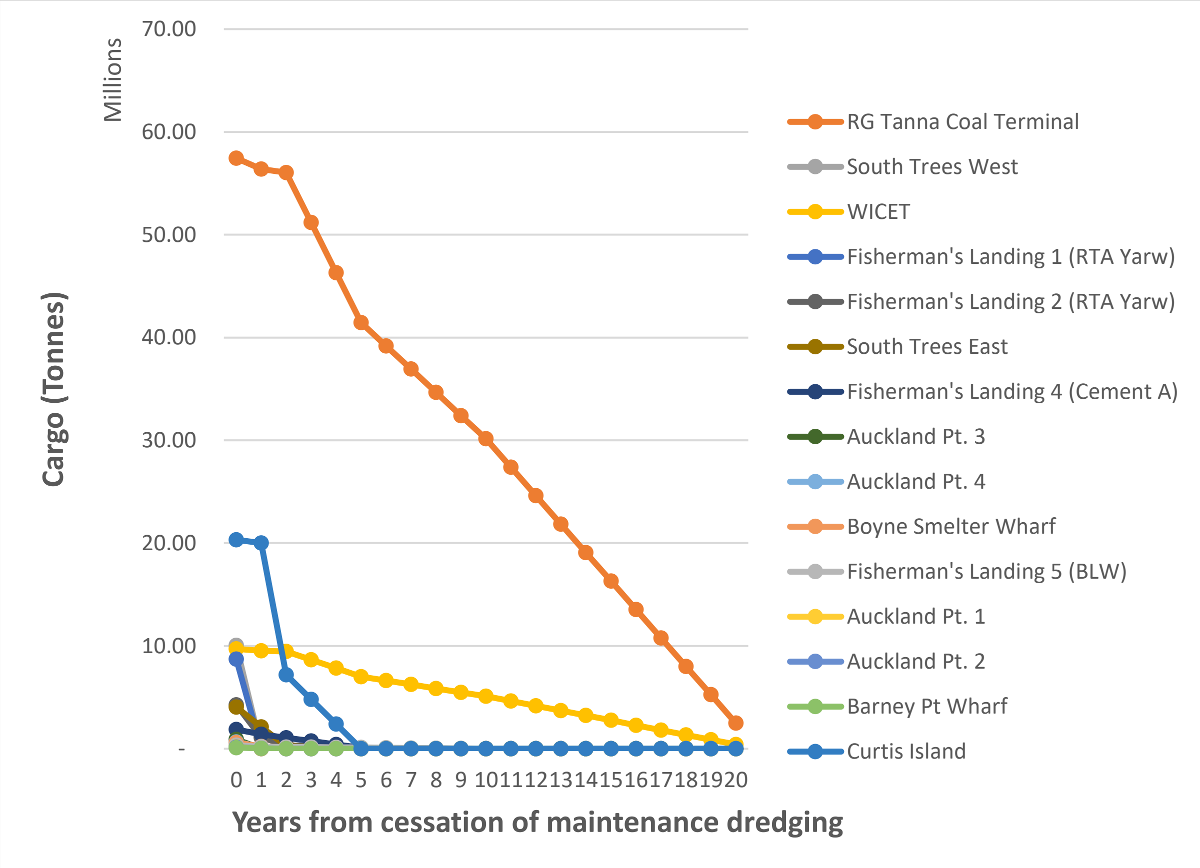

Figure 11. Loss in cargo per wharves in the Port of Gladstone over a 20-year period – Scenario 1

Scenario 2: Bounded sequence of random numbers

Another scenario was developed using the R statistical software and the MS Excel package. In this scenario data from missing years were imputed using a script that produces a sequence of random numbers from a bounded range that increases by 10 units. The range is defined by the two years of available cargo data before and after the year to be calculated. For each year and each wharf, a value is randomly selected from the range that is generated. This method produces a bit more variability in the data that is being generated and probably fits reality a bit better as it tends to show a "stairs" pattern that matches the different stages of depth reduction (see Figure 12).

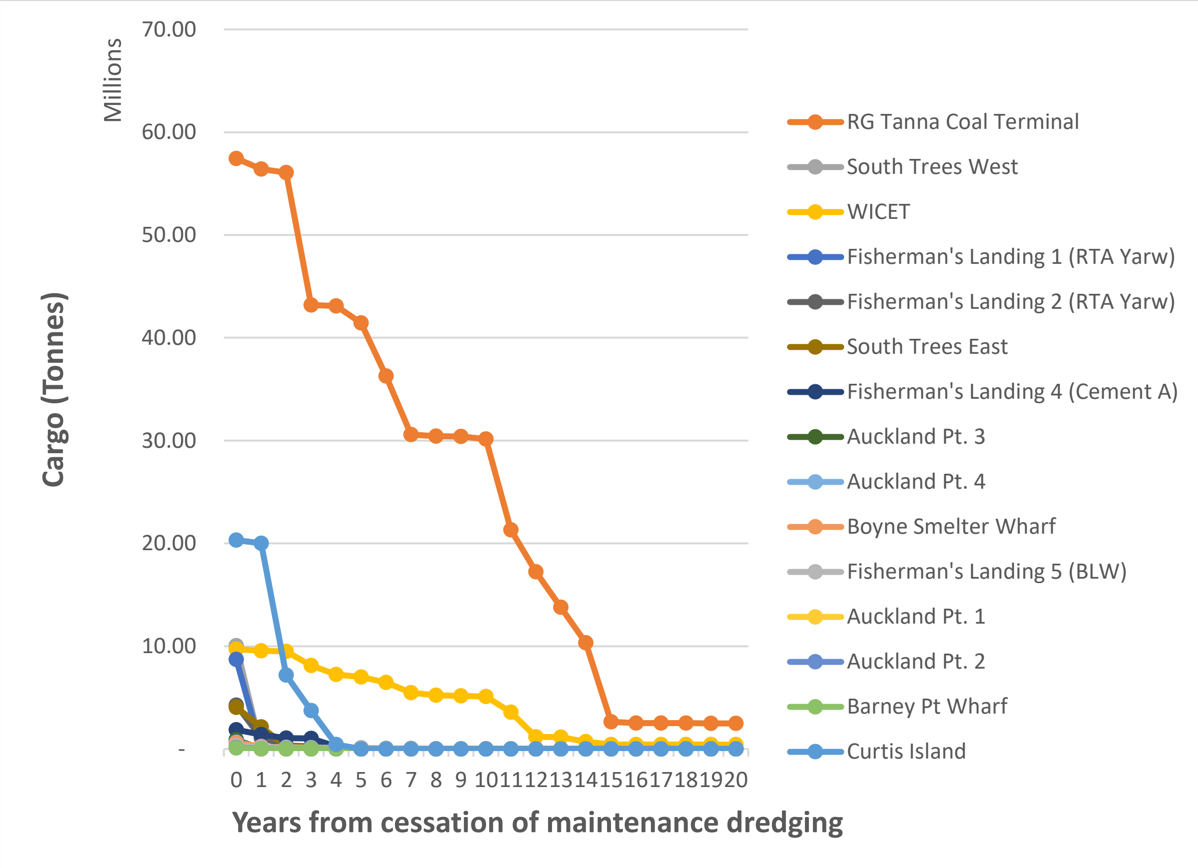

Figure 12. Loss in cargo per wharves in the Port of Gladstone over a 20-year period – Scenario 2

4.3 Commodity prices and assumptions

To estimate the potential loss in economic value related to the reduction in cargo volumes, prices were estimated for the main commodities transiting through each wharf. All results are detailed in Table 2 below, with sources identified in Appendix 2.

Table 2: Commodity prices for key commodities by wharf (see Appendix 2 for sources)

Wharf	Commodity	Assumption	Unit price estimate (AUD/tonne)	Unit price estimate (AUD/tonne)
RG Tanna Coal	Coal	32.4% thermal, 67.6% coking		**$245.58**
Barney Point	Calcite	Calcite		**$132.00**
Auckland Point 1	Calcite, Woodchip, General, Containers	Calcite		**$132.00**
Auckland Point 2	Grain	Grain		**$304.10**
Auckland Point 3	Petroleum, LP Gas, Sulphuric Acid, General	Petroleum		**$13.96**
Auckland Point 4	Breakbulk, Containers, General Cargo	General cargo (average)		**$465.60**
Boyne Smelter	Aluminium	Aluminium	$3,131.20	
	Alumina Hydrate	Alumina	$699.90	
	Petroleum Coke	Petroleum	$13.96	
	Liquid Pitch	Liquid Coal Tar Pitch	$607.60	
		AV. BOYNE SMELTER		**$1,113.20**
South Trees East	Alumina	Alumina	$699.90	
	Caustic Soda	Caustic soda	$100.00	
		Petroleum	$13.96	
		AV. SOUTH TREES EAST		**$271.30**
South Trees West	Bauxite	Bauxite	$12.80	
Fisherman's Landing 1	Bauxite	Bauxite	$12.80	
	Alumina	Alumina	$699.90	
	Caustic Soda	Caustic soda	$100.00	
	Alumina Hydrate	Alumina	$699.90	
		AV. FISHERMAN'S LANDING 1		**$378.15**
Fisherman's Landing 2	Bauxite	Bauxite	$12.80	
	Alumina	Alumina	$699.90	
	Caustic Soda	Caustic soda	$100.00	
	Alumina Hydrate	Alumina	$699.90	
		AV. FISHERMAN'S LANDING 2		**$378.15**
Fisherman's Landing 3	Cement Products	Lime		**$110.00**
Fisherman's Landing 5	Liquid Ammonia	Ammonia	$300.00	
	Caustic Soda	Caustic soda	$100.00	
	Sulphuric Acid	Sulphuric Acid	$360.90	
		AV. FISHERMAN'S LANDING 5		**$253.60**
Curtis Island LNG wharves	LNG	LNG		**$486.47**
WICET	Coal	32.4% thermal, 67.6% coking		**$245.58**

a. **Bauxite, alumina and aluminium:**

Bauxite, alumina and aluminium are three elements of the same refining process and their prices are consequently reported together by the Australian Government's Department of Industry, Innovation and Science. We used the Resources and Energy Quarterly report from March 2019 to estimate the prices for these three commodities. Bauxite is valued AU$12.8/t, alumina AU$ 699.9/t and aluminium AU$3,131.2/t. Bauxite figures are based on the 2017-18 export figures (Australian Government, 2019a, p.99 Table 11.1) expressed in real terms (2018-19 Australian dollars): AU$1,214M/29.88Mt = AU$40.63/t. Alumina figures are based on the same source: AU$8,707M/17.75Mt = AU$490.54/t. Aluminium figures were also computed using the same source: AU$4,093M/1.43Mt = AU$2,862.24/t.

b. **Ammonia:**

No Government-sourced figures could be found for ammonia. Instead we used a conservative estimation of AU$300/t, based on import prices from the eight main supplying countries and ranging between AU$300/t and AU$425/t. These prices were obtained from Chemlink (2018a), an Australian online portal for chemical products.

c. **Calcite:**

Calcite price was estimated using the lowest bound of average prices for calcium carbonate (US$101/ton) obtained from BINQ Machinery Company Inc (BINQ INC, 2012), converted to Australian dollars (Xe.com, 2019) and to metric tons (1 US short ton = 0.907 tonne), giving: AU$132/t.

d. **Caustic soda:**

As for ammonia, the price of caustic soda was obtained from Chemlink (2019b): AU$100/t.

e. **Cement (lime)**

Cement prices can vary a lot depending on their properties, quality level, brand and sold quantities. As the type of cement transiting through the PoG is more likely to be in the form of raw bulk material, we used lime price to estimate cement price. An average price of AU$110/t (100-120) was again obtained from Chemlink (2018c).

f. **Coal:**

We used the assumption that 32.4% of coal transiting through RG Tanna Coal Terminal is thermal coal and 67.6% is metallurgical coal (coking coal), while the reverse proportions were being shipped through WICET. Australian Government figures could be obtained in this case. Metallurgical coal had an average price of US$212/t in 2018 (Australian Government, 2019c), which equates to: AU$300.5/t (Xe.com, 2019). Thermal coal had an average price of US$108/t in 2018 (Australian Government, 2019e), which gives: $AU131/t. Average coal price was therefore estimated to be AU$245.58/t for RG Tanna, and $187.50/t for WICET

g. **Grain:**

We assumed that grain transiting through the PoG would be a mix of the main cereals produced in Queensland. We took the top five cereals produced in Queensland in 2017-18 (sorghum, wheat, barley, maize and oats) (Queensland Treasury, 2019) and calculated an average price for grain based on the relative importance of each cereal in Queensland (Table 3). Cereal prices were taken from recently sold grains on www.igrain.com.au (igrain, 2019) and based on lowest selling prices to be conservative.

Table 3: Predicted cereal prices

Cereal type	2017-18 Queensland production (kt)	Proportion (%)	Price (AU$/t)
Sorghum	974.5	47.43	350
Wheat	765.4	37.25	220
Barley	187.8	9.14	330
Maize	114.6	5.58	435
Oats	12.4	0.60	280
Grain (average)		**100**	**304**

h. Liquid coal tar pitch:

Price estimation for liquid coal tar pitch was based on some indicative value found on Alibaba.com (2019): US$420/t. That value was converted to Australian dollars (Xe.com, 2019): AU$607.6/t.

i. LNG:

The LNG price was again obtained from the Resources and Energy Quarterly March 2019 (Australian Government, 2019b). That report estimates that LNG prices should be around US$6.5/MMbtu in 2019. We converted the millions of British thermal units to tonnes using the following conversion: 1 tonne of LNG = 51.7 MMbtus (Global Tech Australia, 2019), so 1 MMbtu = 0.01934 tonne. Converted to Australian dollars (Xe.com, 2019), this gives an average LNG price of: AU$485.98/t.

j. Petroleum:

We assimilated petroleum products to oil and obtained an oil price estimation from the Resources and Energy Quarterly March 2019 statistics on oil (Australian Government, 2019d). That report states that average oil prices in 2019 should be around US$69/barrel. Using currency and unit conversion tools (Xe.com, 2019; Global Tech Australia, 2019), we calculated a value of AU$99.7/barrel. As a barrel equates to about 0.14 tonne, petroleum price is AU$13.96/t.

k. Sulphuric acid:

An FOB reference price for sulphuric acid was obtained from Kemcore (2019), equal to US$275/ton. When converted to tonnes and Australian dollars using the same conversion tools as described earlier, this gives: AU$360.9/t.

4.4 Estimating values of trade by wharf and commodity

To estimate the annual values of cargo trade, the different unit prices were assigned to the volume of cargo traded at each wharf (see Table 2). Wharves that handle one single type of cargo were assigned the commodity price corresponding to that cargo type, while wharves that handle a mix of cargo types were assigned a value equal to the average price of the main cargo types transiting through that wharf. For instance, Fisherman's Landing 5 was given the average value AU$253.6/t, since it trades ammonia, caustic soda and sulphuric acid. Auckland Point 4 was the only wharf trading "breakbulk, containers and general cargo" where there was no detailed information on the types of goods. A value of AU$427.3/t was assigned for general cargo, which corresponds to the average of all other types of commodities transiting through the PoG. Due to the aluminium price, Boyne Smelter Wharf is the wharf which transits the most valuable cargo (average price: $1,113.16/t).

Table 4 shows how trade value is currently distributed across the 17 wharves. Because of the large volume of coal transiting through RG Tanna Coal Terminal, this wharf has the highest trade value in the current situation. South Trees West, which ranked second in volume of traded cargo, only comes 12th in terms of traded value. This is because it mostly trades bauxite, which is a low value (AU$12.8/t), raw material.

Table 4. Total trade value (AU$M) by wharves in the Port of Gladstone – current situation

Wharf	Total trade value (AU$M) – current year	Relative trade value (%)
RG Tanna Coal Terminal	14,107.68	42.34
Curtis Island (LNG)	9,881.57	29.66
Fisherman's Landing 1 (Yarwun)	3,294.60	9.89
Wiggins Island (WICET)	1,821.22	5.47
Fisherman's Landing 2 (Yarwun)	1,616.44	4.85
South Trees East	1,098.02	3.30
Boyne Smelter Wharf	663.46	1.99
Auckland Pt. 4	309.81	0.93
Fisherman's Landing 4 (Cement)	205.25	0.62
South Trees West	128.53	0.39
Fisherman's Landing 5	88.45	0.27
Auckland Pt. 2	49.38	0.15
Auckland Pt. 1	26.06	0.08
Barney Pt Wharf	13.79	0.04
Auckland Pt. 3	12.47	0.04
Sum	**33,316.73**	**100**

Source: Calculated by authors from GPC Shipping data and external commodity prices

When the wharf traffic is approximately condensed to key commodities (Table 5), coal (48.7%), LNG (29.2%) and bauxite/alumina/aluminium (20.1%) dominate the value of trade.

Table 5. Total trade value (AU$M) by key commodity in the Port of Gladstone – current situation

Commodity	Value of trade per annum	Relative trade value (%)
Coal	$15,240.4	46.7
LNG	$9,881.6	30.3
Bauxite/Alumina/Aluminium	$6,801.1	20.8
General	$309.8	1.0
Cement	$205.3	0.6
Chemicals	$88.5	0.3
Grain	$49.4	0.1
Calcite	$39.8	0.1
Petroleum	$12.5	0.0
Sum	**$33,880.9**	**100.0**

4.5 Estimating values of reduced trade over a 20-year period

By assigning commodity prices to the main types of cargo transiting through each wharf, projections can be made about of the potential loss of economic value from cargo in the PoG over a 20-year period (Figure 13).

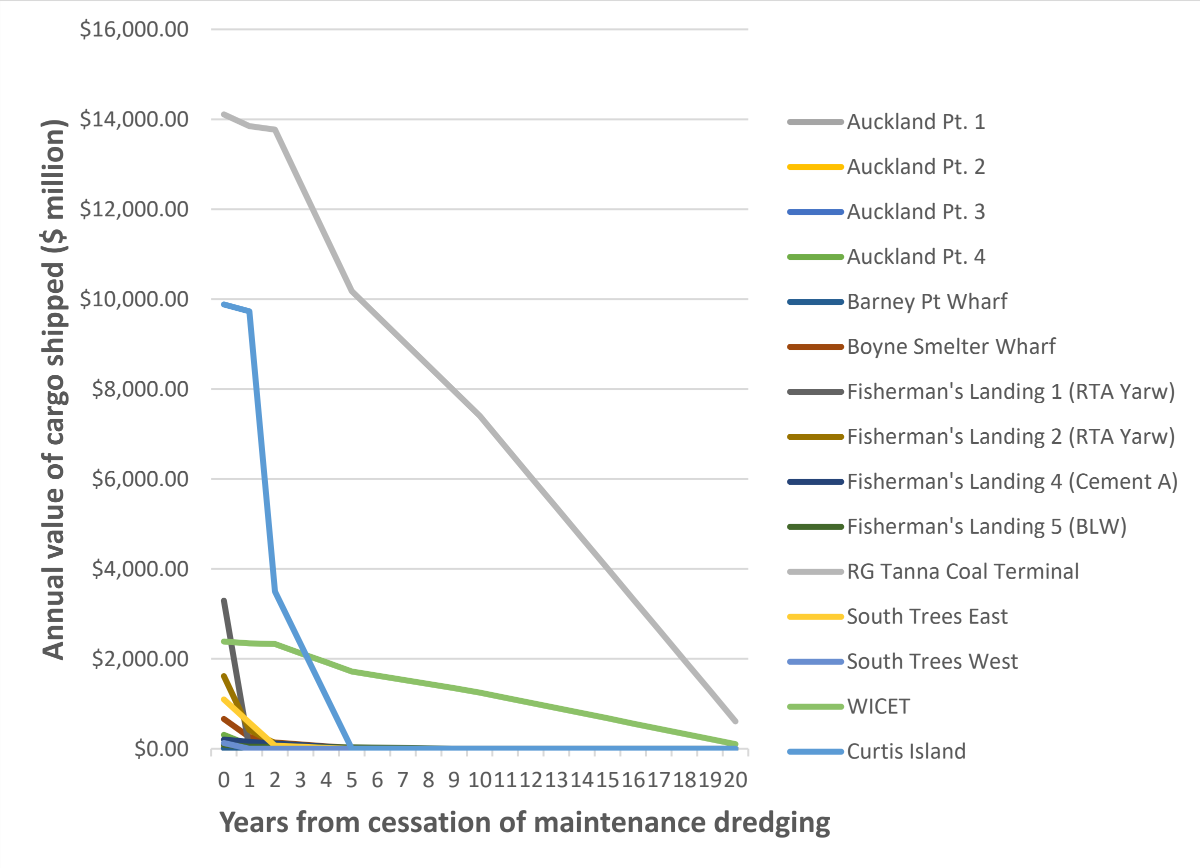

Figure 13. Value of cargo loss per wharves over a 20-year period – Scenario 1

As observed earlier, coal transit from RG Tanna Coal Terminal represents most of the cargo value so the cessation of maintenance dredging would primarily impact that industry. Value generated from coal in that wharf would plummet from AU$10.45B to AU$5.48B within ten years, and to AU$0.45b by year 20. That decrease is assumed to be gradual over the 20-year period. Other wharves would become non-operational much earlier: 9 of the 17 wharves would cease operation by year 5, and 7 others by year 10.

When the value losses are combined across sectors (Figure 14), the results demonstrate that there are very rapid impacts across all industry sectors, with almost all sectors closed to port access after four years. This include the major sectors of LNG and bauxite/alumina/aluminium. Decline in the coal sector is less marked because of the deeper access to the RG Tanna wharf, but the sector still loses more than 50% of market trade by year 11, and 96% of trade by year 20.

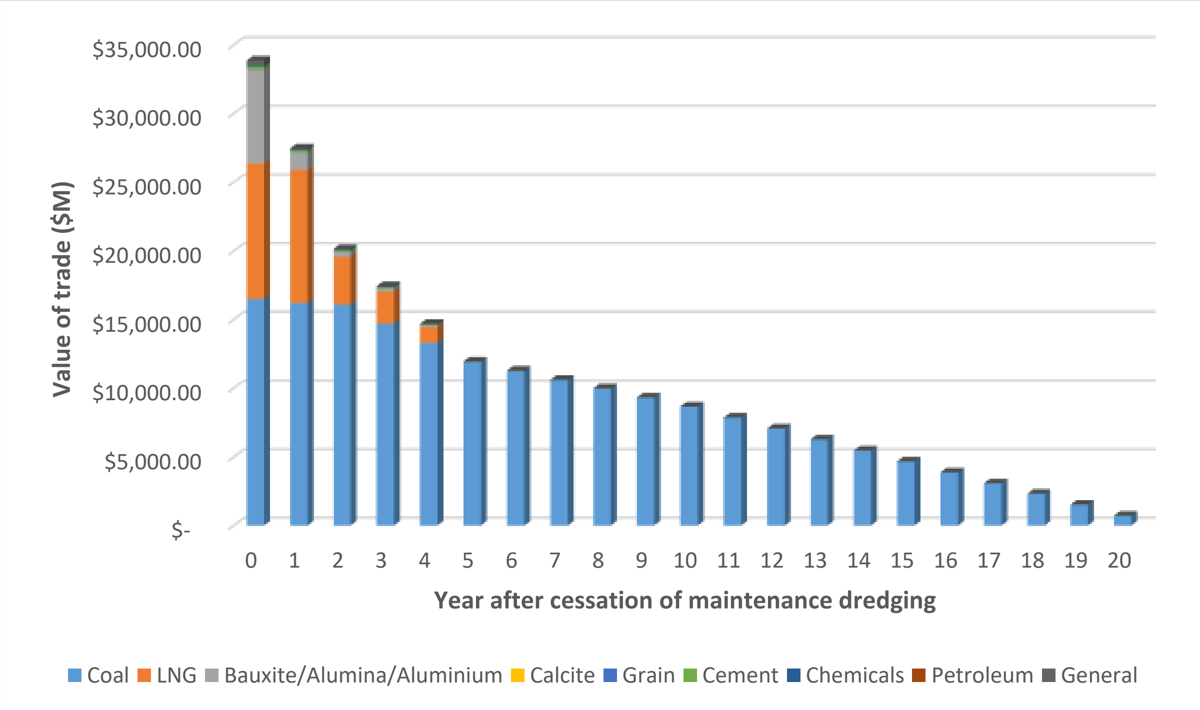

Figure 14. Value of cargo loss by industry over a 20-year period

Value of loss cargo per wharves over a 20-year period (Scenario 2)

Following the same procedure as described earlier for Scenario 1, an alternative model of cargo value loss has been built for the PoG (see Figure 15). The observations are similar to Scenario 1 but the decreasing trend in trade value is made more realistic, following different stages of cessation of maintenance dredging.

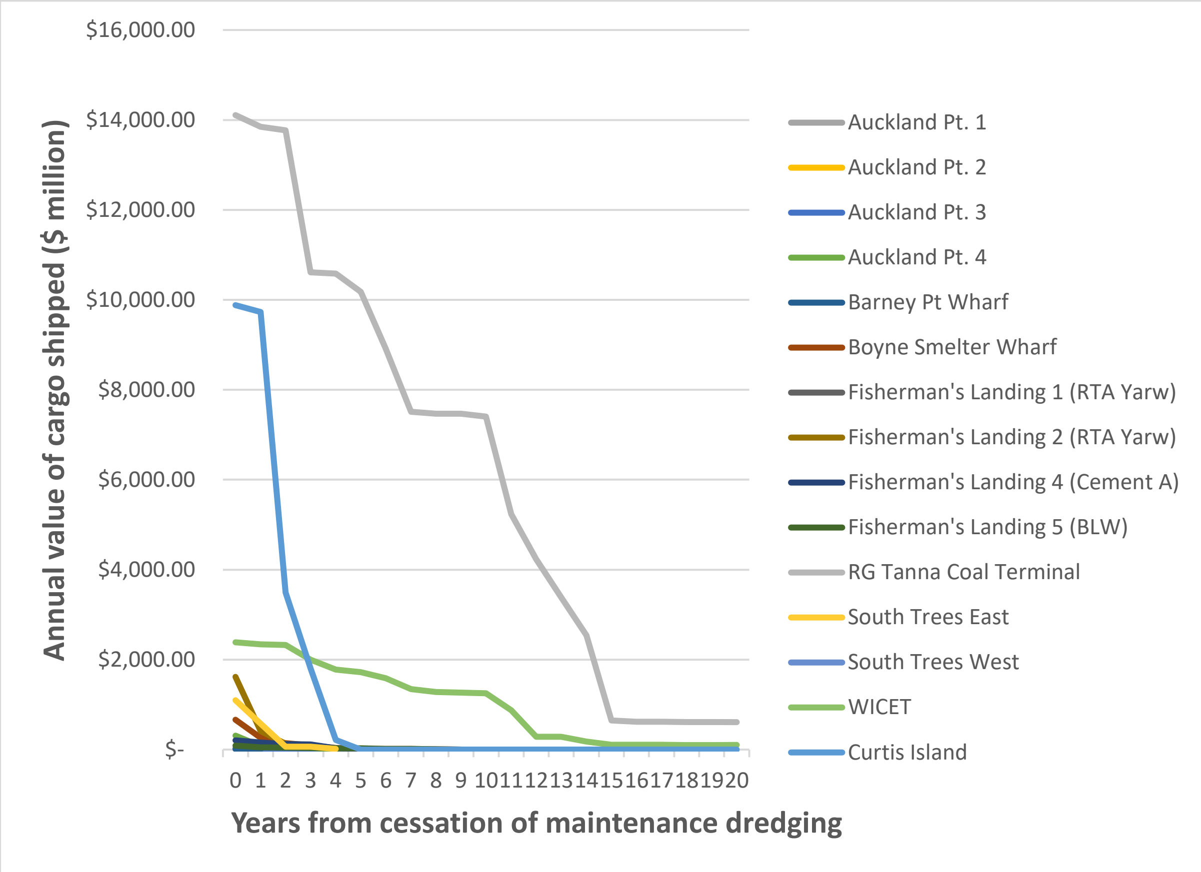

Figure 15. Value of cargo loss per wharves over a 20-year period – Scenario 2

Model comparison

Total loss of cargo value over twenty years has been estimated using two different imputation methods (Scenarios 1 and 2). A comparison of the two models is presented in Figure 16 below. Results suggest that most of the impact of stopping maintenance dredging will occur within the three first years, reducing total trade value from AU$33.88B to less than half by year 4 (AU$14.69B) in Scenario 1, and by year 3 (AU$14.85B) in Scenario 2. Coal trade will be primarily impacted by reduced access to RG Tanna Coal Terminal.

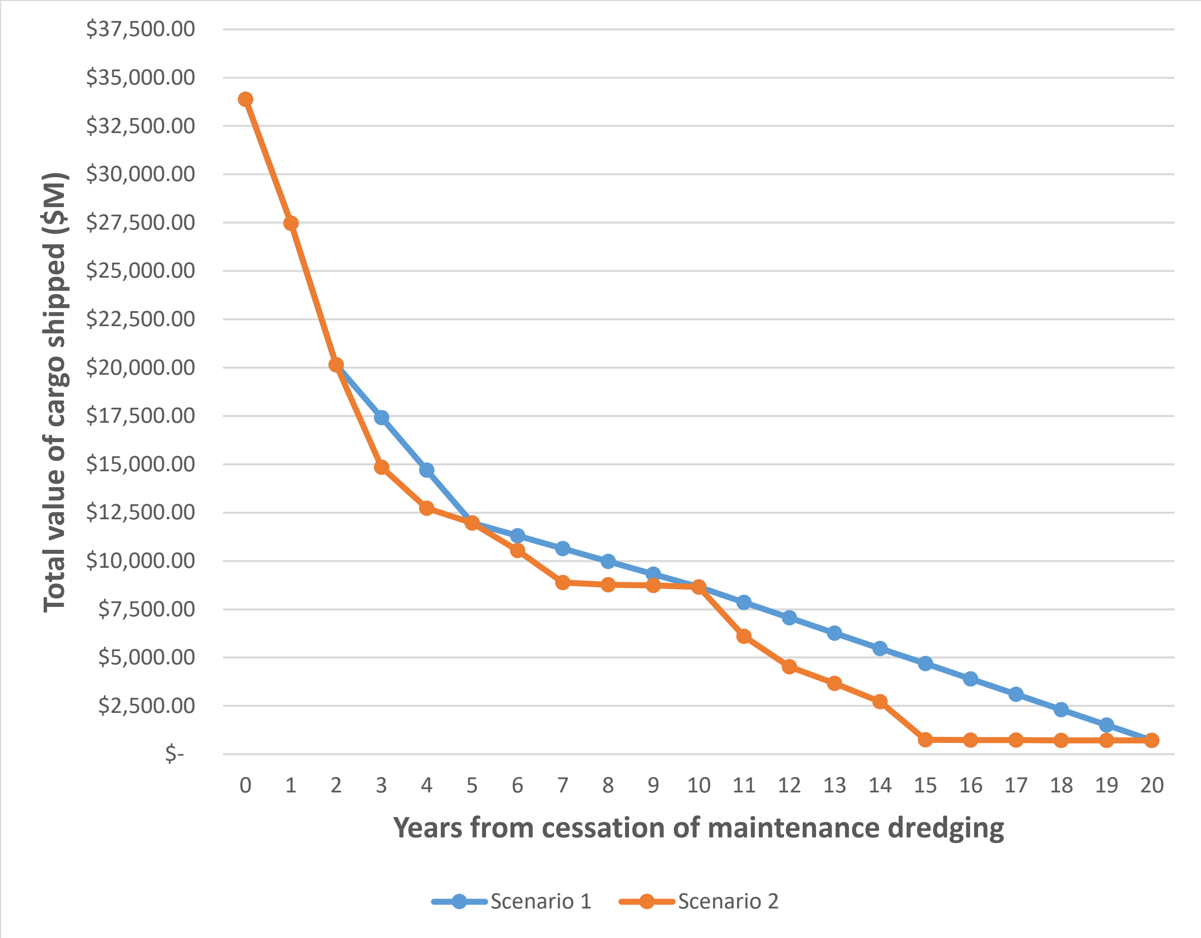

Figure 16. Total loss of cargo value over a 20-year period by sector

4.6 Potential substitution effects

There are three forms of potential substitution effects that should also be considered as part of the analysis.

(a) Substitution of smaller vessels for larger vessels

One potential strategy that may be considered is to substitute smaller vessels for larger vessels. While this may be possible, it has not been considered to be a viable strategy in the longer term because smaller vessels increase congestion, average transport costs are higher, and the relatively small differences in draft requirements by vessel types means that any substitution would only be temporary. As shown in Figure 5, the differences in draft required by the vessel types are not markedly different, so the potential for substitution to have major impacts is very limited.

(b) Substitution to other ports

Another potential strategy that may be considered is to transport commodities to (or from) other ports in Queensland. This may be realistic for some of the smaller volume commodities such as grain and timber, and potentially also for petroleum imports. It is not feasible for commodities that are tied to production facilities in Gladstone, particularly LNG, bauxite/alumina/aluminium, cement and chemicals. It is expected that without access to sea-borne transport, those sectors will close.

One major commodity with some potential for substitution to another port is coal, because mines in the central part of the Bowen Basin have some potential to send coal to either Gladstone or some ports in the Mackay region or further north. About 85% of coal being shipped from Gladstone comes from the Blackwater line servicing the central Bowen Basin, while only about 15% comes from the Moura line which services the southern Bowen Basin. Mines currently supplying Gladstone from the Blackwater line include: Blackwater, Ensham, Rolleston, Yarrabee, Jellinbah, Lake Vermont, Curragh, Cook, Minerva, Caval Ridge, Kestrel and German Creek. It will be possible for some, particularly the northern-most mines, to supply to more northern ports instead.

The potential for diverted supply will be limited by the capacity constraints on other ports. This requires an assumption that those ports will remain open for maximum throughput; if those ports would be subject to the same hypothetical restrictions on maintenance dredging, then it is expected that overall volumes for available export will fall, and no diversion will be possible. Current capacities of other Bowen Basin coal ports are approximately 55Mtpa (Hay Point), 85Mtpa (Dalrymple Bay Coal Terminal) and 50Mtpa (Abbot Point) (DBCT Management 2018; North Queensland Bulk Ports Corporation 2018). Estimates of excess capacity currently available are 20Mtpa at the Mackay ports (Hay Point and Dalrymple Bay)[4] and 25Mtpa at Abbot Point[5]. However, capacity at the latter port includes Mtpaa commitment for the Carmichael Mine (Adani) that is still in development stages. For the purpose of this exercise, the maximum potential for coal to be diverted from Gladstone has been assumed to be 30Mtpa, allowing 15Mtpa in northern port capacity to be allocated to Carmichael or other mines.

(c) Substitution between products

A change of strategy by the PoG to substitute the transit of high-value commodities such as alumina and aluminium over low value commodities may allow some higher value sectors to operate for longer. However, the potential for this may be limited, because the wharf with the deepest channel access (RG Tanna) is only designed for loading coal out, and the capital costs of retrofitting to handle other commodities for short term access is unlikely to be viable.

4.7 Substitution scenarios for coal

As we have demonstrated earlier, coal trade has a significant impact on the activity of the PoG. Therefore, particular attention should be paid to this commodity, and to the wharves that handle it in Gladstone, i.e. RG Tanna Coal Terminal (mostly) and WICET. We explored three scenarios: 1. No substitution organised for coal, 2. Internal substitution, and 3. External substitution. Coal scenario 1 is our reference; it involves no change. Coal scenario 2 implies the gradual switch from less valuable thermal coal (currently 32.4% of coal exports), to more valuable coking coal (currently 67.6%). Finally, coal scenario 3 assumes a gradual transfer of coal to northern ports, to a maximum transfer of 31.2 Mtpa.

(a) Coal scenario 1: No substitution

[4] In 2017-18, there was 70.8 Mt and 49.6 Mt of coal exported from Dalrymple Bay and Hay Point respectively (NQBP 2018), which is 19.6t below reported capacity for the two ports together.

[5] In 2017-18, there was 28Mt of coal exported from Abbot Point (NQBP 2018), rising to 30Mt in 2019 (https://nqbp.com.au/our-ports/abbot-point (Accessed 28/8/2019)). This is 25Mt below capacity

This scenario is similar to Scenario 1 described in Section 4.5. Coal cargo volume is assumed to gradually fall over the 20-year period after cessation of maintenance dredging. Figure 17 below shows that RG Tanna dominates coal transit in Gladstone relative to Wiggins Island. Coal traffic at the Wiggins Island Coal Export Terminal will fall from 9.71Mtpa to less than 0.42Mtpa over 20 years, while traffic at RG Tanna will fall from 57.45Mtpa to 2.48Mtpa over that same 20-year period. RG Tanna's current coal cargo volume is about six times as big as Wiggins Island's. Our model assumes that this ratio will be maintained over the years despite the gradual fall in coal cargo volume.

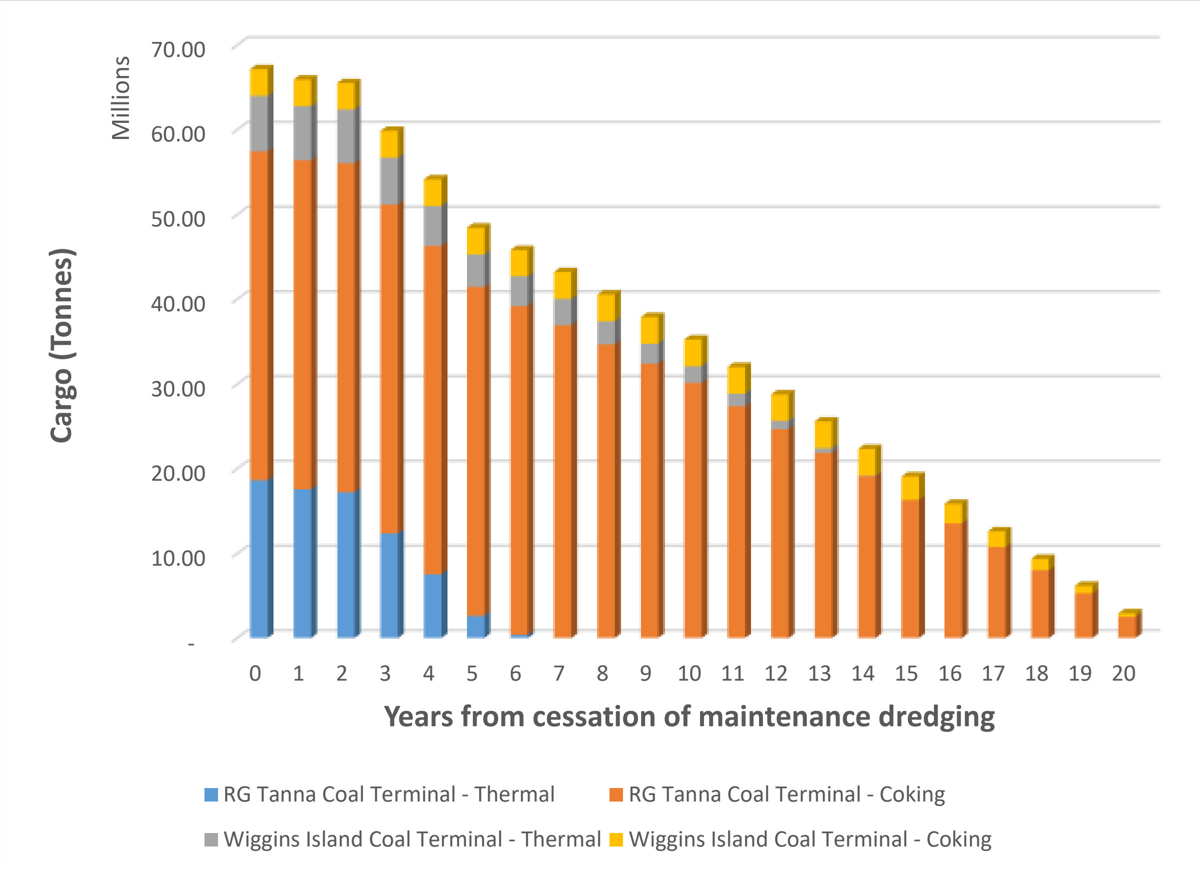

Figure 17. Loss in coal cargo at RG Tanna and WICET wharves over a 20-year period assuming linear decrease

(b) Coal scenario 2: Internal substitution

In this scenario, we assume that metallurgical coal (coking coal) is given priority over thermal coal because its trade value is superior. Of the 57.45Mtpa currently transiting through RG Tanna, 18.61Mtpa is thermal coal and 38.83Mtpa is coking coal. To maximise the value that can be created from substituting thermal coal to coking coal, we use that coking coal figure as the amount of coking coal to be traded in priority, up to the capacity that RG Tanna can handle. The capacity of RG Tanna is based on our estimations depicted in Figure 17. A similar approach is used for Wiggins Island, starting from the assumption that the ratio of thermal to coking coal is 0.676/0.324, and giving gradual priority to coking coal within allowed capacity at that wharf. As can be observed from Figure 18, coking coal and thermal coal volumes both decrease over time, but thermal coal traffic stops earlier.

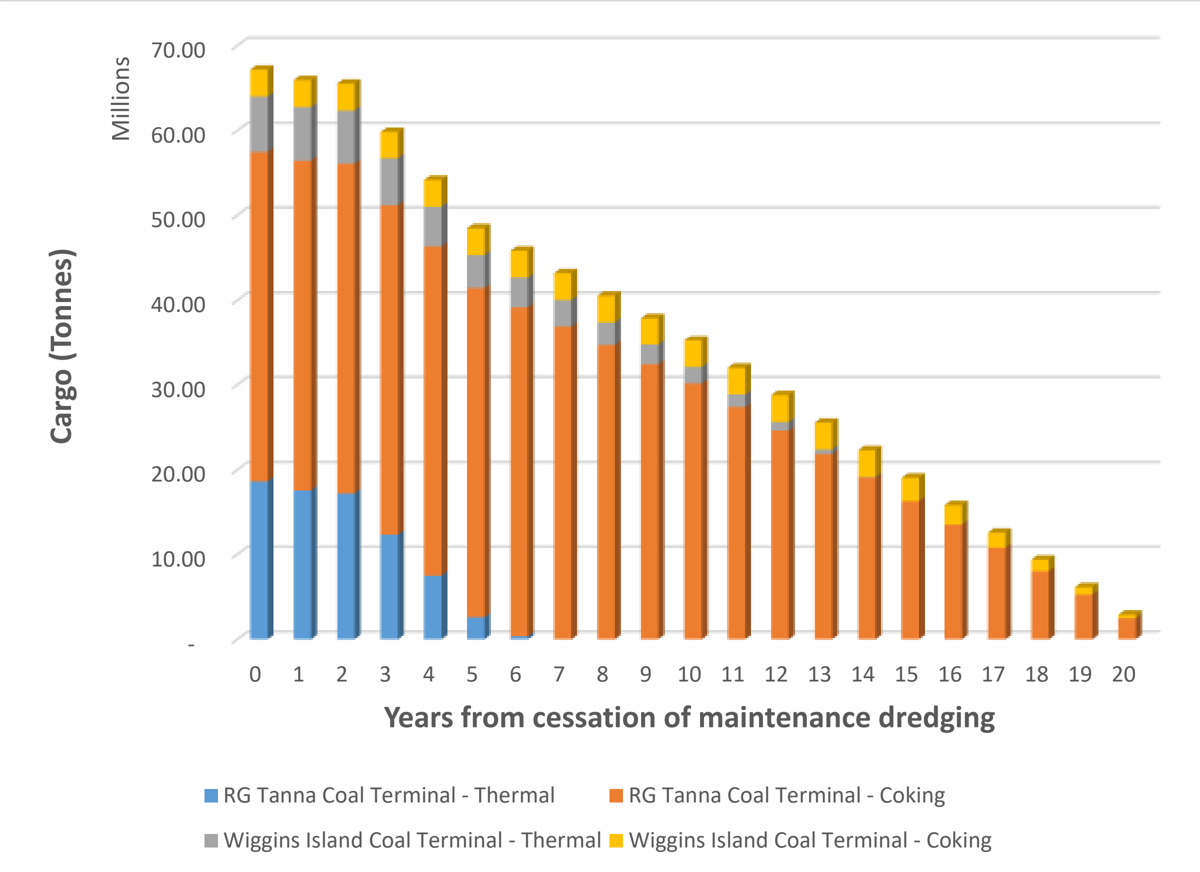

Figure 18. Loss in coal cargo at RG Tanna and WICET wharves over a 20-year period assuming linear decrease and priority given to coking coal through internal substitution

(c) Coal scenario 3: External substitution

In this substitution scenario, we build on the previous scenario, but we assume that a fraction of coal can also be transferred to northern ports. The objective is to gradually reach a value of 30.0Mtpa of coal being diverted from Gladstone. We use the same reduction in capacity as in Scenario 1 (described in Section 4.5), meaning that an increasing proportion of coal could be diverted to other ports as access became constrained to the PoG. Figure 19 shows that the amount of coal that could be transferred to other ports would gradually increase from 1.23Mtpa in the first year to the 31.2 Mtpa increased capacity limit within ten years. This means that, over the same period, a maximum of 10.15Mtpa coking coal cargo could be transferred. Similarly, between 1.23 and 21.05Mtpa thermal coal could also be diverted to northern ports. In this substitution scenario, it would take 17 years before the 30.0Mtpa to be diverted would fully comprise of coking coal, as thermal coal would be part of the diversion mix up to that point.

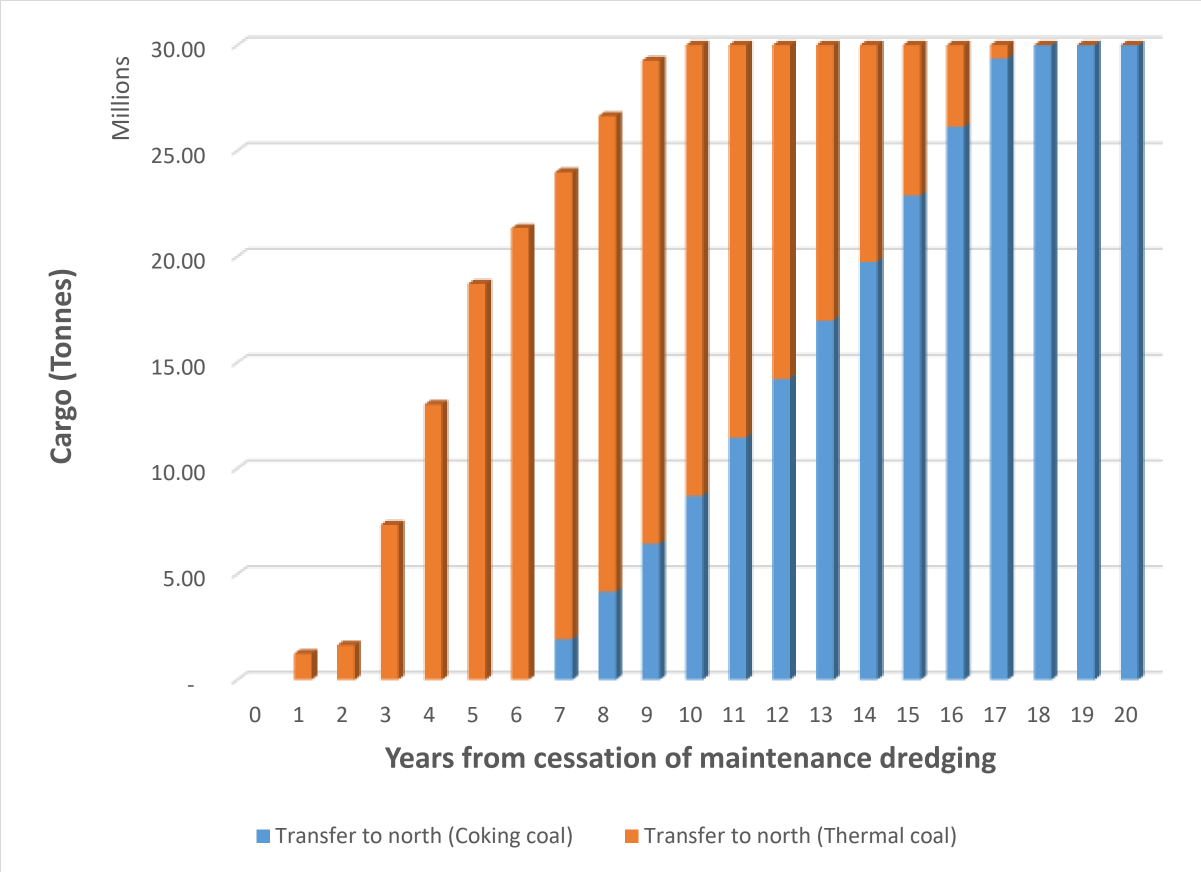

Figure 19. Transfer of coking and thermal coal to northern ports from RG Tanna and WICET wharves over a 20-year period

Changes in royalties would also differ depending on the substitution strategy taken by the PoG. Still relying on our commodity price assumptions from Table 2, we applied the following formulas to calculate the rate per tonne of changes in coal royalties to the Queensland Government[6]:

- For thermal coal: (7% x AU$100/t) + (12.5% x (AU$131/t-AU$100/t)
- For coking coal: (7% x AU$100/t) + (12.5% x AU$50/t) + (15% x (AU$300.5/t-AU$150/t)

Starting from current figures of AU$236.6M for thermal and AU$1.626B for coking coal, the current situation generates AU$1.863B in royalties per annum. Over twenty years, and assuming a no-substitution scenario (blue curves in Figure 20), this gives a total value of royalties (not discounted to present value terms) of AU$20.5B. In the event of an internal substitution scenario, royalties from thermal coal would rapidly fall, but as can be seen in Figure 19 (yellow curves), royalties from coking coal are still much more substantial. After year 7, royalties would only come from coking coal. Over the 20-year period, the internal coal substitution scenario would generate AU$24.2B, so more than the no-substitution scenario because of the delayed reduction in coking coal. Finally, the external coal substitution scenario would generate close to AU$36.5B over twenty years due to the combination of delayed reduction in coking coal and transfer to northern ports.

[6] https://www.business.qld.gov.au/industries/mining-energy-water/resources/minerals-coal/authorities-permits/payments/royalties/calculating/rates

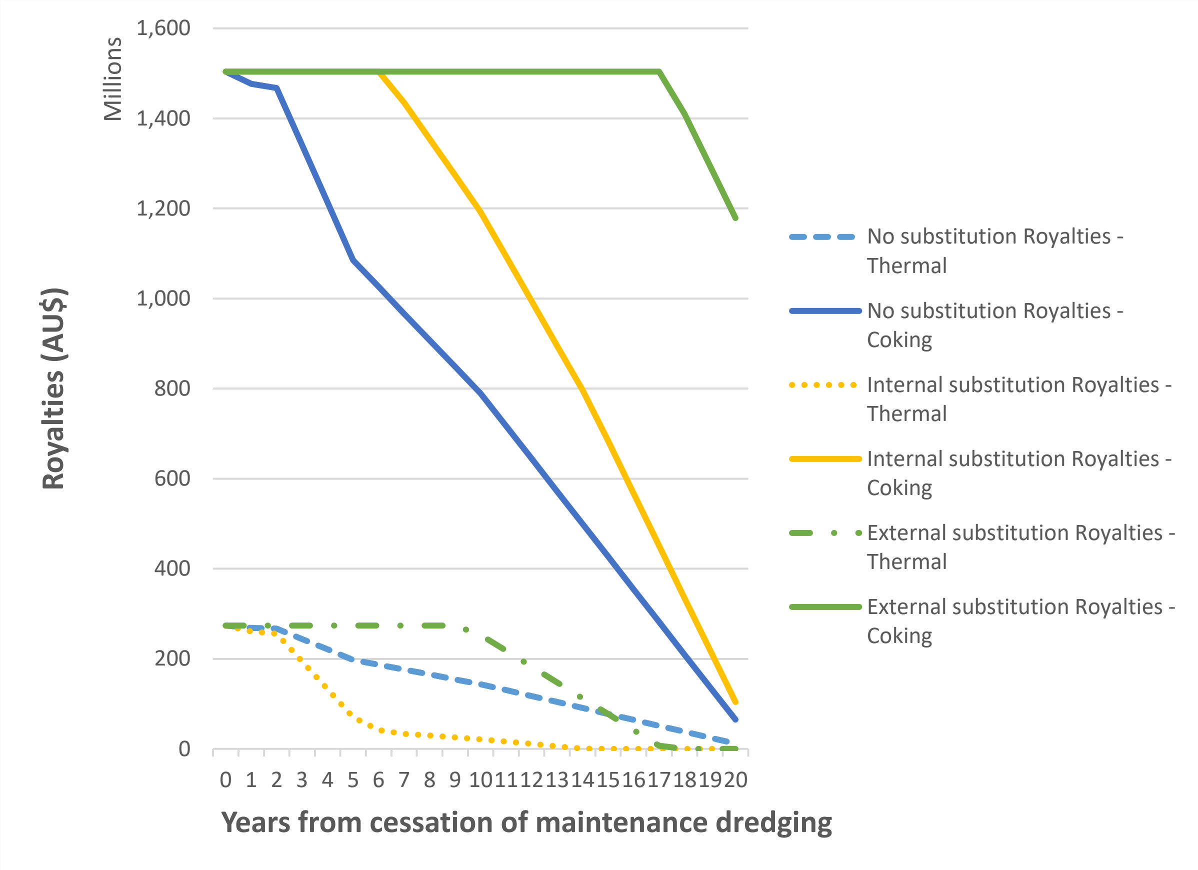

Figure 20. Changes in coal royalties by substitution scenarios over a 20-year period

LNG royalties have been estimated from the 2019 Queensland Government budget papers, factoring in the royalty increase from 10% to 12.5% of wellhead value from 2019-20[7]. Because LNG royalties are calculated at the wellhead, it is difficult to estimate them from the values at port. We assume that the increase in royalties estimated in the 2019 budget papers of $476M over four years generated by a 25% rate increase is underpinned by equal volumes of LNG over the four years. This means that the total LNG royalty per annum (using the 12.5% rate) is $595M per annum. As shipping access to Curtis Island is rapidly curtailed under restrictions to maintenance dredging, there will be a rapid fall in those royalty payments, with all LNG royalties ceasing after four years. The effect of reduced shipping activity on the total royalty payments to the Queensland Government is demonstrated in Figure 21, incorporating the different substitution scenarios for coal.

[7] https://budget.qld.gov.au/files/4.%20Revenue.pdf

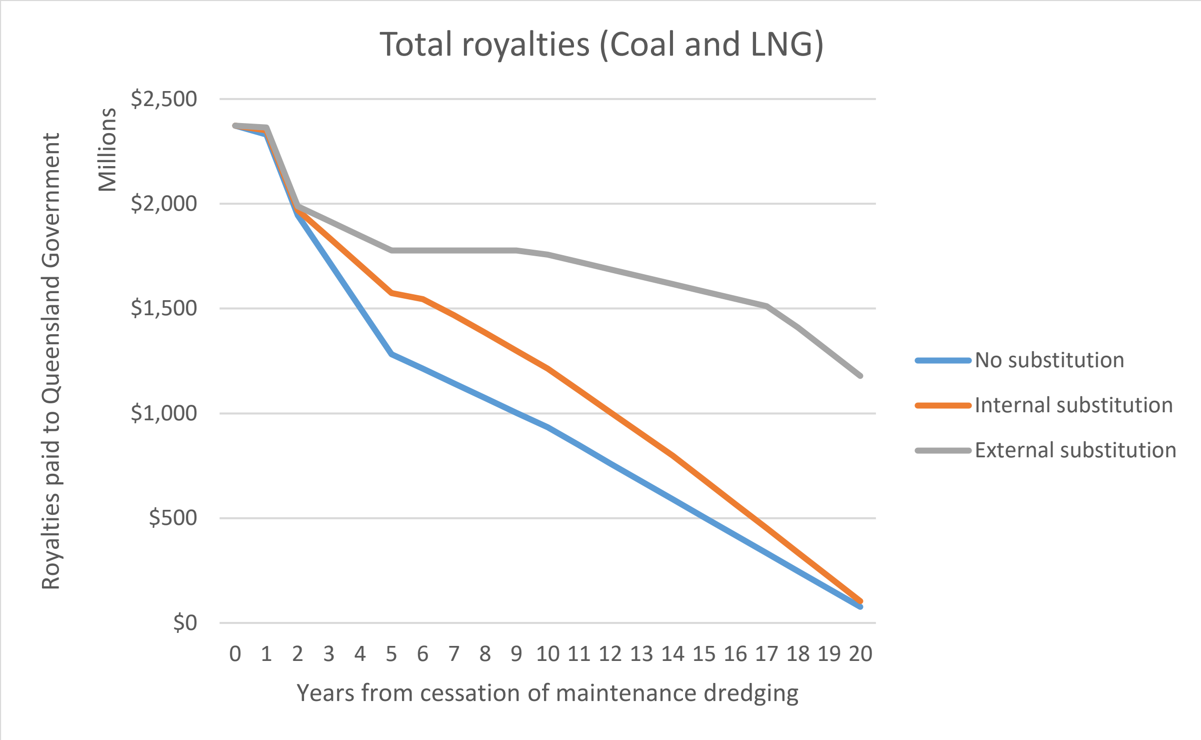

Figure 21. Changes in total royalties by substitution scenarios over a 20-year period

5 Economic model of the Gladstone economy

5.1 Economic models

The most common models to assess the economic changes in the economy are input output (IO) and Computable General Equilibrium (CGE) models. CGE require a vast amount of data that is typically available at a regional level, whereas IO models are simpler to apply and allow internal adjustments to adapt models to local and regional factors. However, CGE models can generate different results to IO models because IO models are more static, and fail to capture the changes in production technology and reallocation of resources in dynamic situations. Therefore, in some cases, the predictions of production loss in CGE models can be lower than in IO models.

IO analysis is considered to be a simpler version of a CGE model but requires less data to derive the estimates of the total response of the economy to the changes in final demand, policy and production. For the assessment of the economic impact of the PoG on Queensland regions, an IO model was used for estimating economic impacts due to two reasons. First, data availability at the regional level was limited, making an IO model easier to apply. Second, while there is some substitutability between economic sectors at Gladstone, it is very limited at the regional level. Therefore, a CGE model might underestimate the impacts of PoG's reduction in operations.

IO analysis can be valuable source of information about structure of the economy, the inter-industrial linkages and distributional effects on households (Gretton 2013). IO modelling describes the regional economy in terms of a number of industries, and further allows for differential impacts between industries, depending upon the extent to which industries supply inputs to each other. IO analysis is a descriptive technique used to identify how different industries in the economy interact, and how changes in one industry generates 'ripple' effects through the wider economy. These models are used to help estimate the flow-on effects of changes in income, value added, expenditure and employment.

The impacts on the economy are shown in the following indicators:

- Gross regional output: the gross value of business turnover
- Value added: the difference between the gross value of business turnover and the costs of factors of production brought in to produce the output,
- Household income: compensation of employees including wages and salaries,
- Employment: the number of full–time equivalent people employed, including full-time and part-time,

The impacts are also summarised in terms of how a stimulus transfers into the economy as follows (reductions have opposite effects):

- Initial stimulus: this represents the initial contribution made by the industry specifically to the economy,
- Direct impacts: this represents the direct flow-on effects that the industry has into the business industry through the purchase of goods and services from other industries in the economy,
- Indirect impacts: this represents the effects on other businesses as a consequence of the direct effects,
- Induced impacts: this represents the induced impacts on final household demand as a consequence of higher employment across all industries.

Type I (Closed Model) multipliers include the direct and indirect business spending. Type II (Open Model) multipliers include direct, indirect spending and household spending as a result of higher employment and therefore predicts a large total income across all industries.

IO analysis involves several simplifying assumptions which can be seen as a limitation for the analysis. The assumptions are (Gretton, 2013):

- The inputs are fixed in each industry
- All products of an industry are identical to each other
- There is a constant return to scale in production
- There is unlimited labour and capital available at fixed prices
- No constraints including government policies
- Relationships between sectors remain constant over time

The effect of these assumptions is that they tend to slightly overpredict impacts, because the model does not fully account for dynamic adjustments over time. Therefore, it is recommended that results be used with caution. If the flow on impacts are used, they should be based on Type I multipliers, because Type II multipliers further assume that the consumption pattern will remain the same with changes in economic activity in the region.

For this analysis the IO tables for the Queensland regions were constructed using the latest National IO tables (ABS, 2018). There are 30 industries of the economy considered in the analysis (Table 6). The industries are:

Table 6. Economic sectors used in model of regional, state and national economy (ABS Cat. 1292)

#	Sector		
1	Agriculture	**16**	Accommodation and food
2	Coal mining	**17**	Road transport
3	Other mining	**18**	Rail transport
4	Mining services	**19**	Water transport
5	Food and beverages	**20**	Other transport
6	Textile, leather, clothing	**21**	Postal
7	Wood, paper, printing	**22**	Publishing
8	Petroleum, chemicals, polymer, mineral	**23**	Telecommunication
9	Metal production	**24**	Finance
10	Equipment production	**25**	Ownership of dwellings
11	Furniture	**26**	Professional services
12	Electricity, gas, water	**27**	Public admin and defence
13	Building	**28**	Education
14	Wholesale trade	**29**	Health care services
15	Retail trade	**30**	Other services

The Bureau of Transport and Regional Economics (BTRE) (2014) outlines a general framework for undertaking port impact studies in Australia. Port impacts include output, income, and employment that are generated by port-related activities. It does not include the economic benefits of export and imports handled at the port. BTRE (2014) advocates for clear definition of the port industries and port-related activities to ensure that the modelling is performed correctly. The standard approach would include the survey of relevant businesses. That would allow constructing the input output tables to provide port specific multipliers. The detailed survey of businesses involved in port-related activities was not available for this analysis.

Typical activities included in the port-related input output analysis are ship operations including loading/unloading, cargo services, land transport and service, port authority operations and government agencies. BTRE (2014) estimated that in the Port of Fremantle (1998-99) the proportion of port activities' total impacts were as follows: ship loading and unloading (30%), ship operations (23%), land transport (18%), cargo services (14%), port authority operations (11%) and government agencies (4%).

Given that no local port data was obtained through the business survey, there is insufficient data on port industry expenditure patterns. Therefore, the generic sectors from input output tables were used. The following sectors were assumed to be partially related to the port activity: water, rail, and road transport industries. It is possible to estimate the weighted average multipliers if data for each port activities is available on industry-by-industry basis at regional and state level. In the absence of such data, the multipliers for the most similar component of the existing input output tables (e.g. water transport) can be calculated.

Water, pipeline and other transport industry consists of Water Freight Transport, Water Passenger Transport, Scenic and Sightseeing Transport, Pipeline transport and other transport. Given that port activities represent a fraction of total water, pipeline and other transport industry activities the resulting multipliers are likely to overstate the impacts of port activities on output, employment, value added and income.

First, the water transport multipliers are estimated. Then the data from PoG was used to estimate the final demand changes to the key industries that are affected by PoG closure. The impacts included the loss of revenue from not being able to ship goods from the PoG. The main industries include: 1) agriculture, 2) coal mining, 3) other mining, 4) petroleum, chemicals, polymer and minerals and 5) metal production.

Therefore, instead of modelling the indirect impacts of PoG industry, the analysis used the estimates on major industries of direct impacts from not maintaining dredging at the PoG. The affected industries in IO table include the coal industry, LNG, bauxite/alumina/aluminium, calcite, grain, cement, chemicals, petroleum, and others.

The initial multipliers were reduced by 35% to take into account efficiency of industry in Gladstone. The benchmark used was the revenue per employee. PoG data showed that the revenue per employee was $549,000 which was 35% lower than the employment multiplier in water transport industry. Furthermore, multipliers were reduced by 2% per annum to consider the reduction in the economy over time.

5.2 Impacts of reduced port activity

Economic impact of not dredging the PoG are modelled as the reduction of port activity. The effects are estimated at two levels: state and regions affected the most. Central Queensland and Mackay-Whitsunday statistical areas cover the majority of PoG impacts (Figure 22). The underlying model parameters for the regional, state and national multipliers are summarised in Appendix 3.

However, given the possible substitution effect, the net effects on the broader (e.g. state or national) economy might be offset by increased activity in other regions including ports in the Mackay – Isaac - Whitsunday (MIW) region.

Figure 22. Central Queensland and Mackay- Isaac-Whitsunday (MIW) regions, QGSO (2016)

5.3 Model Results

According to ABS (2018) a total of $0.35 of output of water, pipeline and other transport industry is required in order to produce $100 worth of output for all sectors on average (direct requirements). It pays $25.69 and $16.34 in compensation of employees and gross operating surplus and mixed income from $100 worth of output. A $100 of total use (total output requirements including initial, direct and indirect effects) from all industries of primary inputs by water, pipeline and other transport industry consists of $38.59 compensation of employees, $48.89 gross operating surplus and mixed income, $1.05 taxes less subsidies on products, $2.15 other taxed less subsidies on product and $9.33 of imports.

The water, pipeline and other transport industry is specialised and mostly produced within the country. More than 75% of output of the water, pipeline and other transport industry is attributed to the output primary to this industry. More than 79% of water, pipeline and other transport industry is produced domestically by water, pipeline and other transport industry to which the product is primary.

The potential impacts of not dredging the PoG might reduce the capacity of the port to provide its services. The impact is hard to quantify due to lack of specific data on PoG expenditure at the state and regional level. PoG services are mainly contained in the water transport sector, so that sector has been used for modelling purposes. The impacts of the sector are shown in Table 7. The reduction of the port services is modelled to reduce the water transport sector output, employment and income.

Table 7. Disaggregated multipliers for the water transport sector.

Output	**CQ+MIW**	**Queensland**	**Australia**
Initial	1	1	1
First Round (Direct)	0.24	0.28	0.47
Industrial Support (Indirect)	0.12	0.21	0.39
Consumption (Induced)	0.30	0.41	0.80
Total	1.31	1.55	2.66
Total Output Multiplier (Closed Model)	1.01	1.14	1.87
Total Output Multiplier (Open Model)	1.31	1.55	2.66
Value Added			
Initial	0.32	0.32	0.49
First Round (Direct)	0.11	0.14	0.23
Industrial Support (Indirect)	0.06	0.10	0.19
Consumption (Induced)	0.13	0.17	0.44
Total	0.62	0.73	1.35
Type I	0.99	1.13	1.85
Type II	1.25	1.48	2.73
Income			
Initial	0.11	0.11	0.18
First Round (Direct)	0.05	0.07	0.11
Industrial Support (Indirect)	0.03	0.05	0.10
Consumption (Induced)	0.07	0.10	0.20
Total	0.27	0.33	0.58
Type I	1.12	1.32	2.20
Type II	1.54	1.89	3.31
Employment			
Initial	0.48	0.48	0.74
First Round (Direct)	0.48	0.60	0.99
Industrial Support (Indirect)	0.30	0.51	0.96
Consumption (Induced)	0.90	1.21	2.31
Total	2.17	2.80	5.01
Type I	1.71	2.15	3.65
Type II	2.94	3.78	6.78

The disaggregated employment multiplier in Table 7 shows the total multiplier (initial, first round, industry support and consumption) from an assumed $1M change in demand. For example, a decrease in demand by $1M would decrease total employment by 3.34 persons in Central Queensland and Mackay-Isaac-Whitsundays region, 4.3 persons in Queensland and 5 persons in Australia. It should be noted that the reduction in employment is likely to be slightly overstated due to linearity of the input output modelling. The sector affected the most would be retail trade, professional services, road transport and other services.

6 Predictions of impacts

6.1 Impacts of the PoG slowdown

The data supplied by GPC indicates that ports revenue will fall from $356.7M per annum to $134.1M per annum after 20 years without dredging. The reduction of economic activity from the reduction in ports is calculated below. The assumptions and limitations of the model are that the impacts are assumed to proportionally change over 20 years, but we note that there is no data to reflect the changes in the purchasing patterns in other industries over 20 years. To account for this we have made two types of manual adjustments in the model. Given that Gladstone industry is generally newer and more efficient than the average industry in Australia, the income and employment multipliers are expected to be lower for the region. Furthermore, since there is no data to adjust for the change in import pattern, the reasonable assumption would be that the smaller the region the higher is the proportion of import for each industry. Therefore, the multipliers for the Central Queensland and Mackay-Isaac-Whitsunday regions and Queensland multipliers have been reduced by 25%.

We also assume that over time of 20 years there will be a reduction in the industrial sector and regional economy, and correspondingly smaller linkages between industry sectors. To account for the regional economy being more constrained over time, we assumed a reduction of 2% annually and reduced the multipliers accordingly for the 20-year analysis.

The results are presented in Table 4, and represent the negative impacts that the port closure is expected to have. For example, the reduction in PoG activity is expected to reduce final demand by $411M in the initial impact, which will be $1,761M at the regional level after all multiplier impacts are considered. Similarly, there will be a direct reduction in employment at the regional level of 838 persons from the port slowdown, which will generate a total regional reduction in employment of 3,789 persons after multiplier effects are considered. These impacts would flow through to major if not total reductions in the dividends paid to the Queensland Government.

Table 8. Predicted impacts of reduced port access over 20 years

Cumulative	CQ+MIW	Queensland	Australia
Output ($ M)			
Final Demand	411.5	495.6	823.5
First round (Direct)	214.8	358.4	687.3
Industrial Support (Indirect)	522.3	710.7	1394.9
Consumption (Induced)	2283.0	2699.0	4650.9
Total	1760.7	1988.3	3256.0
Value Added ($ M)			
Final Demand	561.7	561.3	863.6
First round (Direct)	195.2	238.7	397.9
Industrial Support (Indirect)	101.4	173.0	334.5
Consumption (Induced)	220.1	305.4	760.2
Total	1078.4	1278.4	2356.2
Income ($ M)			
Final Demand	199.5	199.1	306.3
First round (Direct)	92.4	113.5	188.9
Industrial Support (Indirect)	53.0	92.0	177.2
Consumption (Induced)	127.2	175.3	342.7
Total	472.2	579.9	1015.2
Employment, persons			
Final Demand	838.8	838.0	1289.2
First round (Direct)	843.2	1041.1	1729.2
Industrial Support (Indirect)	528.2	888.2	1683.7
Consumption (Induced)	1579.1	2112.1	4034.5
Total	3789.3	4879.4	8736.6

CQ = Central Queensland
MIW = Mackay, Isaac and Whitsundays

6.2 Impacts on other sectors

The predictions to this point have only accounted for the economic activity generated by the port itself. Additional models are needed to account for the wider impacts of industry closure, the reduction in exports from the coal and agricultural sectors, and the reductions in general cargo (both inwards and outwards) through the port. The indirect changes on key sectors such as agriculture, coal, other mining, chemicals and LNG were estimated from data provided by the PoG. The estimates of value of the key sectors that are shipped through the PoG have been reported in section 4; these inputs were then used to calibrate the IO models to predict the wider impacts. The data for bauxite, alumina and aluminium were not available for separate commodities. Therefore, they all were included in Metal industry.

From the model predictions, the losses from restricted shipping access to the PoG were estimated by taking the difference between the base year and the corresponding year. Year 20 shows the maximum total loss of output from the corresponding industry (Table 9). For example, the loss in agriculture will peak in year 5, with no change after that. The loss to the coal industry will continue to grow until it peaks in year 20.

Table 9. Cumulative impacts from non-dredging Gladstone Port ($M) on Central Queensland and Mackay Isaac and Whitsunday regions.

	year 1	year 5	year 10	year 20
Agriculture	$ 39.68	$49.38	$49.38	$49.38
Coal	$1,949.05	$4,667.97	$6,730.46	$11,761.32
Other mining (LNG)	$190.20	$9,920.88	$9,921.41	$9,921.41
Chemicals	$102.46	$265.39	$306.17	$306.17
Metal	$5,548.24	$6,785.88	$6,801.05	$6,801.05
General (water transport)	$228.35	$300.26	$306.78	$306.78
Total	$8,057.98	$21,989.78	$24,115.26	$29,146.11

The IO model outputs for the full impacts of the port slowdown are summarised in Appendix 4. The predictions assume that there is no potential for transfer of products to other ports, which is likely to be accurate for minerals, LNG and coal, but may not be as appropriate for agriculture (grains) and some general cargo. The results show that the total impacts at the regional level are predicted to be a loss in output of $60,988M, a loss in value added of $26,878M, a loss in income of $11,861M, and a reduction in employment of 111,275. These estimates compare to a Gross State Product for Queensland of $317.5B in 2017-18[8], suggesting that the impacts of restricted shipping access would reduce state incomes by about 3.7%.

[8] Gross State Product is available at: http://www.qgso.qld.gov.au/subjects/economy/state-accounts/tables/gsp-factor-cost-industry-components/index.php (Accessed 28/8/2019).

6 Conclusions

This report has assessed the economic consequences of not maintaining shipping access to the PoG through maintenance dredging. The modelling of effects on shipping access to the key wharf areas in the PoG provided by the GPC shows that shipping access will be quickly restricted.

To perform the analysis of the effects of the restriction in shipping, a number of simplifying assumptions were made. First, the baseline for shipping movements was assumed to be constant from the 2017-18 year. This did not allow for any growth in cargo volumes into the future. Second, prices of cargoes were estimated from available prices and official forecasts in May 2019, with prices assumed to be constant over time. Third, there was assumed to be no substitution of cargoes to smaller vessels in the PoG, given that smaller vessels are less economic and can create crowding issues. Fourth, there was assumed to be no substitution of products to other ports, although one variant of the modelling did test the effect of transferring some coal exports through northern ports. Fifth, the structure of the economy was not assumed to change over a 20 year period, although an allowance has been made for the shrinkage effects on the regional economy over time.

These assumptions allowed a scenario to be developed that used the 2017-18 shipping patterns as the baseline for activity in the PoG and modelled what would happen to that activity if access was increasingly restricted over a 20-year period. The simplifying assumptions are likely to underestimate the value of industry and cargo that would be handled through the PoG over twenty years into the future, but potentially also overestimate some of the impacts of slowdown because it does not allow for some substitution and adjustment effects. With these caveats in mind, it should be noted that the broad quantum of changes predicted are likely to be correct, as there are no viable access alternatives to the PoG for major sectors in the regional economy.

The results of the analysis show that the economic effects on the regional, state and national economy will be large and rapid. All sectors will suffer a reduction in access from year one, as larger vessels are excluded from the PoG. The LNG and grains sectors will lose all access after four years, calcite exports will stop after eight years, and bauxite/alumina/aluminium, cement, chemical, petroleum and general cargoes will stop after nine years. Only coal exports will continue, but 96% of access is predicted to be lost by 20 years. The bauxite, alumina, aluminium and LNG industries would essential close in Queensland, and 28% of coal export capacity would be lost.

The economic impacts would be substantial, with total output losses in the regional areas modelled to be $61B per annum after 20 years, roughly the size of the entire Gladstone economy. These impacts are predicted to be associated with a loss in value added of $26,878M, a loss in income of $11,861M, and a reduction in employment of 111,275 people. While much of the impact will be on the Gladstone area, approximately 41% of the losses will accrue to the coal and grains sectors which are produced in the Fitzroy and Mackay-Whitsunday regions. The effect of those impacts will be concentrated in the wider region. Similarly, the losses in the bauxite industry will be concentrated in Far North Queensland (Weipa), and the losses in the LNG output will impact on the upstream production areas in the Surat and other basins. In addition, there will be a reduction of royalty payments to the Queensland Government, estimated at $2.38B per annum after 20 years.

The overall effects are summarised in the Figure below.

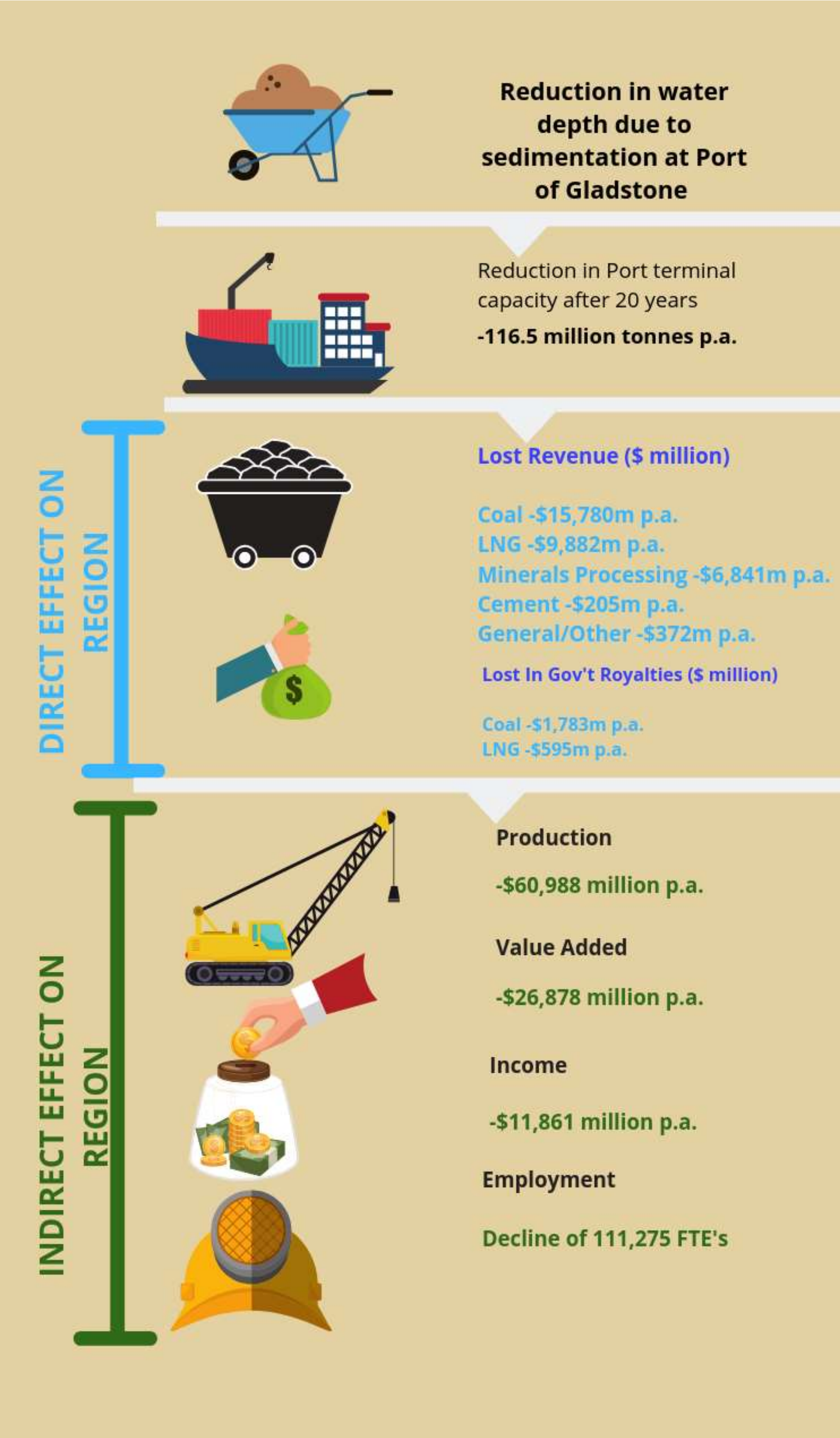

Figure 23. Summary of major impacts over a 20-year period

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Appendix 1: Predictions for Impact on vessels from sediment accumulation

					Declared Depth	Predicted Future Depth (m below LAT)					Impact to vessel operations				
	Vessel Type	**Unladen Draft (m)**	**Laden Draft (m)**	**UKC (m)**	***(m below LAT)***	**Year 1**	**Year 2**	**Year 5**	**Year 10**	**Year 20**	**Year 1**	**Year 2**	**Year 5**	**Year 10**	**Year 20**
APLNG	LNG	9.44	11.65	0.5	***13***	12.1	11.4	9.4	5.7	2	0	0	-1	-1	-1
QCLNG	LNG	9.47	11.8	0.5	***14***	13.3	12.7	10.9	7.8	2	1	1	0	-1	-1
GLNG	LNG	9.38	12	0.5	***13***	12	11.2	8.9	4.7	2	0	0	-1	-1	-1
Fishermans Landing Berth5	Handy	5.68	10.10	0.5	***11.2***	10.4	9.9	8.4	5.6	5	0	0	0	-1	-1
Fishermans Landing Berth5	Handy Max	7.89	11.75	0.5	***11.2***	10.4	9.9	8.4	5.6	5	0	0	0	-1	-1
Clinton Coal Facility Berth 4	Cape	9.75	17.85	0.5	***18.8***	18.3	18.2	17.3	15.7	12.6	0	0	0	0	0
Clinton Coal Facility Berth 4	Handy	6.39	10.06	0.5	***18.8***	18.3	18.2	17.3	15.7	12.6	1	1	1	1	1
Clinton Coal Facility Berth 4	Handy Max	7.14	14.72	0.5	***18.8***	18.3	18.2	17.3	15.7	12.6	1	1	1	1	0
Clinton Coal Facility Berth 4	Panamax	7.34	15.09	0.5	***18.8***	18.3	18.2	17.3	15.7	12.6	1	1	1	1	0
Clinton Coal Facility Berth 4	Post Panamax	7.77	15.43	0.5	***18.8***	18.3	18.2	17.3	15.7	12.6	1	1	1	0	0
Auckland Point Berth 1	Cruise Vessels	7.6	8.1	0.5	***11.3***	10	9.4	7.6	4	4	1	1	-1	-1	-1
Auckland Point Berth 1	Handy	6.79	11.05	0.5	***11.3***	10	9.4	7.6	4	4	0	0	0	-1	-1
Auckland Point Berth 1	Handy Max	7.10	11.53	0.5	***11.3***	10	9.4	7.6	4	4	0	0	0	-1	-1
South Trees West	Handy Max	8.00	12.38	0.5	***12.8***	11	10	7	5	5	0	0	-1	-1	-1
South Trees West	Panamax	8.62	12.49	0.5	***12.8***	11	10	7	5	5	0	0	-1	-1	-1
South Trees West	Post Panamax	8.58	13.21	0.5	***12.8***	11	10	7	5	5	0	0	-1	-1	-1
Golding Cutting	Cape	9.78	18.03	2	***16.1***	16.1	16.1	14.9	12.7	8.3	0	0	0	0	-1
Golding Cutting	Post Panamax	10.20	15.62	1.8	***16.1***	16.1	16.1	14.9	12.7	8.3	0	0	0	0	-1
Golding Cutting	Panamax	7.80	15.11	1.8	***16.1***	16.1	16.1	14.9	12.7	8.3	0	0	0	0	-1
Golding Cutting	Handy Max	9.15	16.21	1.5	***16.1***	16.1	16.1	14.9	12.7	8.3	0	0	0	0	-1
Golding Cutting	Handy	7.10	11.14	1.5	***16.1***	16.1	16.1	14.9	12.7	8.3	1	1	1	1	-1
Golding Cutting	LNG	9.43	12.00	1.2	***16.1***	16.1	16.1	14.9	12.7	8.3	1	1	1	0	-1
Golding Cutting	Cruise Vessels	7.6	8.1	1.2	***16.1***	16.1	16.1	14.9	12.7	8.3	1	1	1	1	-1

Key

1	sufficient depth for laden vessel throughout tide
0	insufficient depth for laden vessel throughout tide, but sufficient depth for unladen vessel throughout tide (i.e. reduced load)
-1	insufficient depth for unladen vessel throughout tide, indicating that vessel type no longer operable

Notes

For Berths assuming average unladen drafts and maximum laden drafts based on vessels operating from that berth in table provided by GPC and minimum and average cruise vessel drafts

For Golding Cutting assuming average unladen drafts and maximum laden drafts based on all vessels of that type in table provided by GPC and minimum and average cruise vessel drafts

0.5m UKC based on discussion with Regional Harbour Master

Note: Data Provided by Gladstone Ports Corporation

Appendix 2: Commodity prices for key commodities

Wharf	Commodity	Assumption	Unit price estimate (AUD/tonne)	Unit price estimate (AUD/tonne)	Source
RG Tanna Coal	Coal	32.4% thermal, 67.6% coke		**$245.58**	Australian Government (2019c,e)
Barney Point	Calcite	Calcite		**$132.00**	BINQ INC (2012)
Auckland Point 1	Calcite, Woodchip, General, Containers	Calcite		**$132.00**	BINQ INC (2012)
Auckland Point 2	Grain	Grain		**$304.10**	Queensland Treasury (2019); igrain (2019)
Auckland Point 3	Petroleum, LP Gas, Sulphuric Acid, General	Petroleum		**$13.96**	Australian Government (2019d)
Auckland Point 4	Breakbulk, Containers, General Cargo	General cargo (average)		**$465.60**	Price assumption based on average of all other commodity prices.
Boyne Smelter	Aluminium	Aluminium	$3,131.20		Australian Government (2019a)
	Alumina Hydrate	Alumina	$699.90		Australian Government (2019a)
	Petroleum Coke	Petroleum	$13.96		Australian Government (2019d)
	Liquid Pitch	Liquid Coal Tar Pitch	$607.60		Based on conservation estimate: US$420/tonne, converted to AU$607.6/tonne. Source: Alibaba.com (2019)
		AV. BOYNE SMELTER		**$1,113.20**	
South Trees East	Alumina	Alumina	$699.90		Australian Government (2019a)
	Caustic Soda	Caustic soda	$100.00		Chemlink (2018b)
		Petroleum	$13.96		Australian Government (2019d)
		AV. SOUTH TREES EAST		**$271.30**	
South Trees West	Bauxite	Bauxite	$12.80		Australian Government (2019d)
Fisherman's Land 1	Bauxite	Bauxite	$12.80		Australian Government (2019d)

Wharf	Commodity	Assumption	Unit price estimate (AUD/tonne)	Unit price estimate (AUD/tonne)	Source
	Alumina	Alumina	$699.90		Australian Government (2019d)
	Caustic Soda	Caustic soda	$100.00		Chemlink (2018b)
	Alumina Hydrate	Alumina	$699.90		Australian Government (2019a)
		AV. FISHERMAN'S LANDING 1		**$378.15**	
Fisherman's Land 2	Bauxite	Bauxite	$12.80		Australian Government (2019a)
	Alumina	Alumina	$699.90		Australian Government (2019a)
	Caustic Soda	Caustic soda	$100.00		Chemlink (2018b)
	Alumina Hydrate	Alumina	$699.90		Australian Government (2019a)
		AV. FISHERMAN'S LANDING 2		**$378.15**	
Fisherman's Land 3	Cement Products	Lime		**$110.00**	Chemlink (2018c)
Fisherman's Land 5	Liquid Ammonia	Ammonia	$300.00		Conservative estimation: AU$300/tonne based on Chemlink (2018a)
	Caustic Soda	Caustic soda	$100.00		Chemlink (2018b)
	Sulphuric Acid	Sulphuric Acid	$360.90		FOB Reference Price: US$275/ton. Source: Kemcore (2019)
		AV. FISHERMAN'S LANDING 5		**$253.60**	
Curtis Island (3 LNG wharves)	LNG	LNG		**$486.47**	Australian Government (2019b)
WICET	Coal	32.4% thermal, 67.6% coke		**$245.58**	Australian Government (2019c,e)

Appendix 3: Output, income, value added and employment disaggregated multipliers.

Output	**Sector**	**CQ & MW regions**	**Queensland**	**Australia**
		Percent	Percent	Percent
Agriculture	1	1.09	1.19	1.23
Coal mining	2	0.06	0.08	0.09
Other mining	3	0.59	0.61	0.69
Mining services	4	0.05	0.06	0.07
Food and beverages	5	1.33	1.39	1.42
Textile, leather, clothing	6	0.04	0.05	0.06
Wood, paper, printing	7	0.35	0.76	0.95
Petroleum, chemicals, polymer, mineral	8	3.10	2.80	2.87
Metal production	9	0.43	0.49	0.51
Equipment production	10	1.51	1.85	1.96
Furniture	11	0.06	0.09	0.10
Electricity, gas, water	12	1.82	1.97	2.06
Building	13	1.91	2.52	2.94
Wholesale trade	14	2.16	2.25	2.43
Retail trade	15	2.48	2.64	2.67
Accommodation and food	16	1.49	1.58	1.63
Road transport	17	2.95	2.65	2.49
Rail transport	18	0.33	0.31	0.30
Water transport	19	55.06	46.61	41.64
Other transport	20	0.42	0.52	0.53
Postal	21	2.78	2.57	2.53
Publishing	22	0.23	0.43	0.64
Telecommunication	23	0.62	1.12	1.55
Finance	24	4.70	7.13	8.71
Ownership of dwellings	25	3.99	4.15	4.21
Professional services	26	5.62	8.86	10.30
Public admin and defence	27	0.34	0.52	0.56
Education	28	1.07	1.13	1.16
Health care services	29	1.27	1.35	1.38
Other services	30	2.15	2.30	2.31
	Total	100.00	100.00	100.00

Value Added	**Sector**	**CQ & MW regions**	**Queensland**	**Australia**
		Percent	Percent	Percent
Agriculture	1	1.05	1.14	1.10
Coal mining	2	0.06	0.07	0.07
Other mining	3	0.72	0.73	0.78
Mining services	4	0.06	0.07	0.08
Food and beverages	5	0.78	0.81	0.77
Textile, leather, clothing	6	0.03	0.05	0.06
Wood, paper, printing	7	0.25	0.54	0.62
Petroleum, chemicals, polymer, mineral	8	2.25	2.03	1.95
Metal production	9	0.20	0.22	0.22
Equipment production	10	1.19	1.46	1.44
Furniture	11	0.05	0.08	0.08
Electricity, gas, water	12	1.58	1.70	1.66

Building	13	1.25	1.64	1.79
Wholesale trade	14	2.32	2.41	2.43
Retail trade	15	3.19	3.38	3.20
Accommodation and food	16	1.61	1.71	1.64
Road transport	17	2.88	2.59	2.27
Rail transport	18	0.33	0.31	0.28
Water transport	19	57.71	48.69	40.67
Other transport	20	0.33	0.41	0.39
Postal	21	2.90	2.68	2.46
Publishing	22	0.25	0.45	0.63
Telecommunication	23	0.55	0.99	1.28
Finance	24	6.10	9.23	10.56
Ownership of dwellings	25	0.00	0.00	6.38
Professional services	26	6.35	10.00	10.86
Public admin and defence	27	0.47	0.71	0.72
Education	28	1.58	1.67	1.59
Health care services	29	1.88	1.99	1.91
Other services	30	2.09	2.23	2.09
	Total	100.00	100.00	100.00

Income	**Sector**	**CQ & MW regions**	**Queensland**	**Australia**
		Percent	Percent	Percent
Agriculture	1	0.50	0.53	0.54
Coal mining	2	0.05	0.06	0.06
Other mining	3	0.39	0.38	0.43
Mining services	4	0.07	0.09	0.10
Food and beverages	5	1.05	1.06	1.06
Textile, leather, clothing	6	0.05	0.07	0.08
Wood, paper, printing	7	0.37	0.78	0.95
Petroleum, chemicals, polymer, mineral	8	2.32	2.02	2.04
Metal production	9	0.32	0.35	0.36
Equipment production	10	1.92	2.26	2.35
Furniture	11	0.08	0.10	0.11
Electricity, gas, water	12	1.13	1.18	1.21
Building	13	1.49	1.89	2.17
Wholesale trade	14	3.31	3.32	3.53
Retail trade	15	4.76	4.87	4.85
Accommodation and food	16	2.41	2.47	2.50
Road transport	17	3.66	3.17	2.93
Rail transport	18	0.49	0.45	0.42
Water transport	19	46.81	38.08	33.48
Other transport	20	0.40	0.47	0.47
Postal	21	2.75	2.45	2.37
Publishing	22	0.27	0.47	0.70
Telecommunication	23	0.43	0.74	1.01
Finance	24	4.32	6.31	7.59
Ownership of dwellings	25	0.00	0.00	0.00
Professional services	26	9.85	14.97	17.12
Public admin and defence	27	0.87	1.27	1.35
Education	28	3.15	3.22	3.23
Health care services	29	3.64	3.73	3.76
Other services	30	3.14	3.24	3.20
	Total	100.00	100.00	100.00

Employment	Sector	CQ & MW regions	Queensland	Australia
		Percent	Percent	Percent
Agriculture	1	1.78	1.78	1.78
Coal mining	2	0.05	0.05	0.05
Other mining	3	0.30	0.28	0.31
Mining services	4	0.06	0.07	0.07
Food and beverages	5	1.42	1.36	1.34
Textile, leather, clothing	6	0.07	0.10	0.11
Wood, paper, printing	7	0.50	1.00	1.20
Petroleum, chemicals, polymer, mineral	8	2.27	1.88	1.86
Metal production	9	0.31	0.32	0.33
Equipment production	10	2.07	2.33	2.37
Furniture	11	0.40	0.53	0.53
Electricity, gas, water	12	1.19	1.18	1.19
Building	13	2.32	2.81	3.15
Wholesale trade	14	2.80	2.68	2.78
Retail trade	15	8.88	8.67	8.45
Accommodation and food	16	5.01	4.89	4.84
Road transport	17	6.07	5.02	4.53
Rail transport	18	0.44	0.38	0.35
Water transport	19	24.53	19.05	16.37
Other transport	20	0.67	0.76	0.74
Postal	21	3.72	3.17	3.00
Publishing	22	0.32	0.54	0.78
Telecommunication	23	0.48	0.80	1.07
Finance	24	5.81	8.09	9.52
Ownership of dwellings	25	0.00	0.00	0.00
Professional services	26	8.40	12.16	13.60
Public admin and defence	27	0.91	1.27	1.32
Education	28	3.98	3.87	3.81
Health care services	29	4.75	4.64	4.57
Other services	30	10.50	10.33	9.98
	Total	100.00	100.00	100.00

CQ = Central Queensland
MW = Mackay Whitsundays

Appendix 4: Output, Income, Value added and Employment Predictions

	Year 1				Year 20			
Output	**Final Demand**	**Industrial Support**	**Consumption**	**Total**	**Final Demand**	**Industrial Support**	**Consumption**	**Total**
Agriculture	-40	-130	-142	-312	-49	-158	-517	-724
Coal mining	-1949	-102	-4	-2055	-11761	-769	-16	-12546
Other mining	-190	-551	-33	-774	-9921	-2907	-119	-12947
Mining services	0	-249	-3	-252	0	-1828	-12	-1840
Food and beverages	0	-66	-192	-258	0	-125	-697	-822
Textile, leather, clothing	0	-3	-5	-9	0	-6	-19	-24
Wood, paper, printing	0	-26	-15	-41	0	-48	-54	-102
Petroleum, chemicals, polymer, mineral	-5548	-515	-68	-6131	-306	-792	-246	-1344
Metal production	-102	-200	-20	-323	-6801	-1095	-74	-7971
Equipment production	0	-60	-48	-108	0	-272	-174	-446
Furniture	0	-4	-9	-12	0	-13	-31	-44
Electricity, gas, water	0	-406	-166	-572	0	-1298	-601	-1899
Building	0	-297	-66	-363	0	-1903	-239	-2142
Wholesale trade	0	-292	-198	-490	0	-914	-717	-1631
Retail trade	0	-96	-319	-415	0	-320	-1158	-1478
Accommodation and food	0	-91	-207	-298	0	-280	-750	-1029
Road transport	0	-217	-77	-294	0	-474	-279	-753
Rail transport	0	-49	-17	-65	0	-288	-60	-348
Water transport	-228	-101	-16	-345	-307	-146	-57	-510
Other transport	0	-21	-47	-68	0	-75	-170	-245
Postal	0	-260	-69	-329	0	-868	-252	-1120
Publishing	0	-10	-26	-36	0	-25	-96	-121
Telecommunication	0	-31	-76	-107	0	-76	-275	-351
Finance	0	-208	-337	-545	0	-979	-1223	-2201
Ownership of dwellings	0	0	-631	-631	0	0	-2290	-2290
Professional services	0	-645	-242	-887	0	-2103	-879	-2982
Public admin and defence	0	-88	-20	-107	0	-282	-71	-353
Education	0	-16	-160	-176	0	-46	-580	-626
Health care services	0	-15	-194	-209	0	-11	-703	-714
Other services	0	-157	-210	-367	0	-611	-762	-1373
Total	**-8,058**	**-4,905**	**-3,617**	**-16,579**	**-29,146**	**-18,711**	**-13,120**	**-60,978**

Value added	Year 1				Year 20			
	Final Demand	Industrial Support	Consumption	Total	Final Demand	Industrial Support	Consumption	Total
Agriculture	-18	-59	-65	-142	-22	-72	-235	-329
Coal mining	-849	-44	-2	-895	-5121	-335	-7	-5463
Other mining	-109	-316	-19	-444	-5687	-1666	-68	-7421
Mining services	0	-133	-2	-135	0	-978	-6	-984
Food and beverages	0	-18	-53	-71	0	-35	-192	-227
Textile, leather, clothing	0	-2	-2	-4	0	-2	-8	-11
Wood, paper, printing	0	-9	-5	-14	0	-16	-18	-34
Petroleum, chemicals, polymer, mineral	-1905	-177	-23	-2105	-105	-272	-84	-462
Metal production	-22	-43	-4	-70	-1468	-236	-16	-1721
Equipment production	0	-22	-18	-40	0	-101	-65	-166
Furniture	0	-1	-3	-5	0	-5	-12	-18
Electricity, gas, water	0	-166	-68	-234	0	-531	-246	-777
Building	0	-92	-20	-112	0	-588	-74	-662
Wholesale trade	0	-148	-100	-248	0	-463	-363	-826
Retail trade	0	-58	-194	-252	0	-194	-703	-897
Accommodation and food	0	-47	-106	-152	0	-143	-383	-526
Road transport	0	-100	-36	-136	0	-219	-129	-348
Rail transport	0	-23	-8	-31	0	-137	-28	-165
Water transport	-113	-50	-8	-171	-152	-72	-28	-253
Other transport	0	-8	-17	-25	0	-28	-63	-91
Postal	0	-128	-34	-162	0	-428	-124	-552
Publishing	0	-5	-13	-18	0	-13	-48	-60
Telecommunication	0	-13	-32	-45	0	-32	-115	-147
Finance	0	-128	-207	-335	0	-601	-750	-1351
Ownership of dwellings	0	0	0	0	0	0	0	0
Professional services	0	-345	-129	-474	0	-1124	-470	-1593
Public admin and defence	0	-57	-13	-69	0	-182	-46	-228
Education	0	-11	-112	-123	0	-32	-406	-438
Health care services	0	-10	-135	-146	0	-8	-491	-499
Other services	0	-72	-97	-169	0	-281	-350	-631
Total	**-3,016**	**-2,285**	**-1,524**	**-6,825**	**-12,556**	**-8,792**	**-5,530**	**-26,878**

Income	Year 1				Year 20			
	Final Demand	Industrial Support	Consumption	Total	Final Demand	Industrial Support	Consumption	Total
Agriculture	-4	-12	-14	-30	-5	-15	-49	-69
Coal mining	-322	-17	-1	-339	-1942	-127	-3	-2071
Other mining	-26	-75	-4	-105	-1349	-395	-16	-1760
Mining services	0	-73	-1	-74	0	-534	-4	-537
Food and beverages	0	-11	-31	-42	0	-20	-114	-134
Textile, leather, clothing	0	-1	-1	-2	0	-2	-5	-7
Wood, paper, printing	0	-6	-3	-9	0	-11	-12	-22
Petroleum, chemicals, polymer, mineral	-861	-80	-11	-951	-47	-123	-38	-208
Metal production	-16	-31	-3	-50	-1053	-170	-12	-1234
Equipment production	0	-16	-13	-28	0	-71	-46	-117
Furniture	0	-1	-2	-3	0	-3	-8	-11
Electricity, gas, water	0	-52	-21	-73	0	-167	-77	-244
Building	0	-48	-11	-59	0	-307	-39	-345
Wholesale trade	0	-93	-63	-155	0	-289	-227	-517
Retail trade	0	-38	-127	-165	0	-127	-459	-586
Accommodation and food	0	-31	-69	-100	0	-94	-251	-345
Road transport	0	-56	-20	-76	0	-122	-72	-194
Rail transport	0	-15	-5	-20	0	-89	-18	-107
Water transport	-40	-18	-3	-61	-54	-26	-10	-90
Other transport	0	-4	-9	-13	0	-15	-33	-48
Postal	0	-53	-14	-67	0	-178	-52	-229
Publishing	0	-2	-6	-9	0	-6	-23	-29
Telecommunication	0	-4	-11	-15	0	-11	-39	-50
Finance	0	-40	-64	-104	0	-186	-233	-419
Ownership of dwellings	0	0	0	0	0	0	0	0
Professional services	0	-234	-88	-322	0	-763	-319	-1082
Public admin and defence	0	-46	-10	-56	0	-148	-37	-185
Education	0	-10	-98	-107	0	-28	-354	-382
Health care services	0	-9	-115	-124	0	-6	-417	-424
Other services	0	-47	-64	-111	0	-185	-231	-416
Total	**-1,268**	**-1,121**	**-881**	**-3,270**	**-4,450**	**-4,215**	**-3,196**	**-11,861**

	Year 1				Year 20			
Employment	**Final Demand**	**Industrial Support**	**Consumption**	**Total**	**Final Demand**	**Industrial Support**	**Consumption**	**Total**
Agriculture	-107	-351	-385	-844	-134	-428	-1398	-1959
Coal mining	-2411	-126	-5	-2542	-14549	-951	-20	-15520
Other mining	-162	-469	-28	-659	-8446	-2474	-101	-11021
Mining services	0	-461	-6	-467	0	-3385	-22	-3407
Food and beverages	0	-117	-340	-456	0	-221	-1232	-1453
Textile, leather, clothing	0	-11	-16	-28	0	-18	-59	-77
Wood, paper, printing	0	-62	-35	-97	0	-115	-128	-243
Petroleum, chemicals, polymer, mineral	-6733	-624	-82	-7440	-372	-961	-299	-1631
Metal production	-123	-240	-25	-388	-8157	-1314	-89	-9560
Equipment production	0	-137	-109	-246	0	-618	-394	-1012
Furniture	0	-37	-89	-126	0	-137	-321	-458
Electricity, gas, water	0	-441	-180	-621	0	-1408	-652	-2060
Building	0	-599	-133	-732	0	-3839	-482	-4321
Wholesale trade	0	-628	-425	-1053	0	-1964	-1541	-3505
Retail trade	0	-571	-1897	-2468	0	-1900	-6881	-8781
Accommodation and food	0	-509	-1154	-1663	0	-1561	-4185	-5746
Road transport	0	-743	-263	-1006	0	-1619	-955	-2574
Rail transport	0	-107	-36	-143	0	-632	-132	-764
Water transport	-169	-74	-12	-255	-227	-108	-42	-377
Other transport	0	-54	-123	-177	0	-198	-447	-644
Postal	0	-579	-155	-733	0	-1932	-561	-2493
Publishing	0	-22	-60	-82	0	-58	-218	-275
Telecommunication	0	-40	-98	-138	0	-98	-355	-453
Finance	0	-427	-692	-1119	0	-2008	-2509	-4517
Ownership of dwellings	0	0	0	0	0	0	0	0
Professional services	0	-1601	-601	-2202	0	-5219	-2180	-7399
Public admin and defence	0	-388	-87	-474	0	-1244	-314	-1558
Education	0	-96	-990	-1086	0	-282	-3590	-3872
Health care services	0	-92	-1204	-1296	0	-68	-4368	-4436
Other services	0	-1274	-1707	-2980	0	-4966	-6190	-11157
Total	**-9,705**	**-10,881**	**-10,935**	**-31,520**	**-31,883**	**-39,726**	**-39,666**	**-111,275**