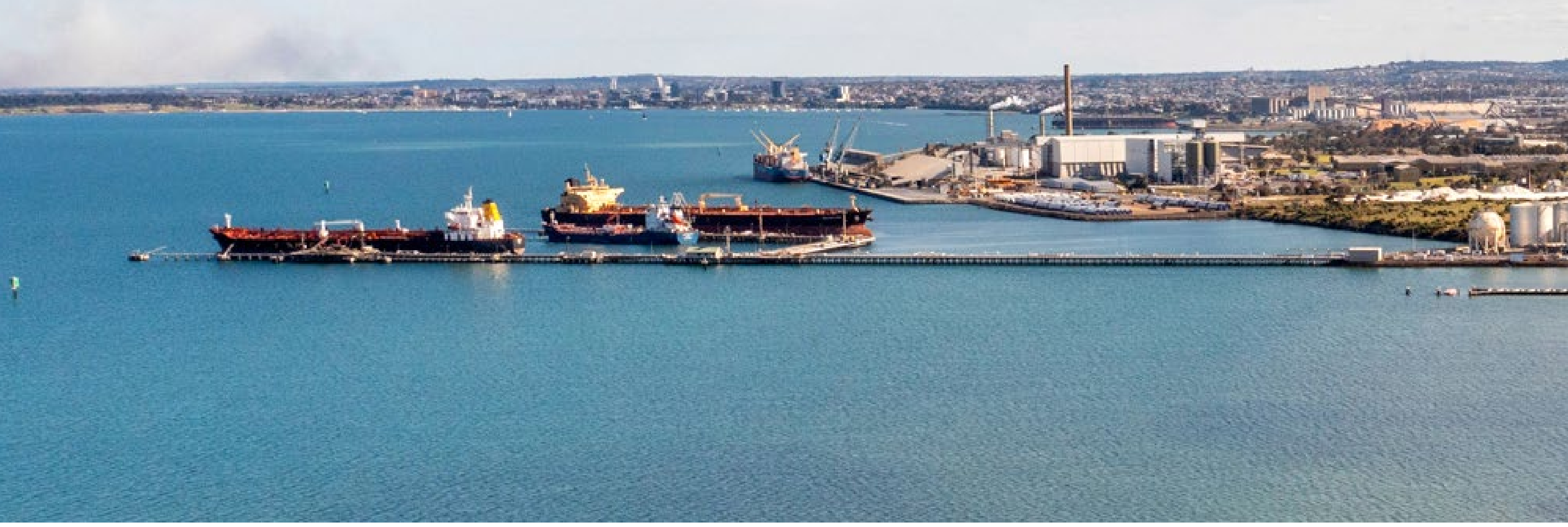
# Chapter 3

# Project alternatives and development

This chapter describes the process used by the proponent to develop the proposed Viva Energy Gas Terminal Project (the project), including the identification and evaluation of alternatives considered prior to adoption of the preferred development proposal selected for assessment in this Environment Effects Statement (EES). The selected development proposal for the project is described in Chapter 4: Project description.

This chapter also provides an overview of feasible design alternatives that were considered for each of the project components, including relevant environmental considerations.



## 3.1 Relevant EES scoping requirements

Section 3.4 of the EES scoping requirements requires the proponent to outline feasible alternatives considered for the project and to include an explanation of how specific alternatives were shortlisted for evaluation within the EES. The EES is also required to assess and document the likely environmental, social and economic effects of the feasible alternatives, particularly where these offer potential to minimise and/or avoid significant environmental effects, while meeting the project objectives.

The scoping requirements state that the assessment of feasible alternatives and their effects should include:

- Selection of the floating storage and regasification unit (FSRU) approach
- Site selection for the FSRU over that of onshore regasification
- Selection of the proposed regasification mode from the range of available options, including variations to the FSRU design and potential to use a combination of closed and open loop systems
- Discussion of interdependency between the FSRU design and the refinery operations and how in the event of maintenance periods or shutdown these will operate independently of each other
- Selection of the proposed pipeline route
- Identification and assessment of design alternatives for the other project components
- Environmental considerations.

The assessment should also consider the short, medium and long-term advantages and disadvantages of different alternatives considered.

In addition, the scoping requirements require the effects of the preferred project to be compared to those of other feasible alternatives or to a 'no project' base case. Where appropriate, the assessment of environmental effects of feasible design alternatives should address matters set out in the scoping requirements. The depth of investigation of feasible alternatives should be proportionate to their potential to minimise potential adverse effects as well as meet project objectives.

## 3.2 Overview

A number of feasibility and preliminary assessments were undertaken to identify and evaluate feasible design alternatives to be considered for each of the project components. These include:

- Preliminary engineering and design studies to assess different regasification technologies, including onshore and offshore alternatives and site selection
- A cooling water synergy study to assess potential synergies between the FSRU and the existing Geelong Refinery in terms of utilising FSRU discharge water as cooling water in the refinery
- A pipeline route options assessment study
- A nitrogen storage tank selection study.

Project design alternatives have been assessed with consideration of the likely environmental, social, economic and safety effects. Following selection of the FSRU as the preferred regasification approach rather than construction of an onshore regasification plant, potential sites for the project were identified and assessed comparatively. Selecting Refinery Pier adjacent to the existing Geelong Refinery as the preferred site allowed the project to make use of existing infrastructure within a developed industrial and port setting.

With the FSRU selected as the preferred regasification technology, and Refinery Pier selected as the preferred project location, further design development was undertaken including:

- Minimisation of the dredged area at the proposed Refinery Pier berth
- FSRU design including seawater intake and discharge
- Potential regasification alternatives
- Treatment facility design and location
- Pipeline route refinement
- Integration of sustainability principles into all aspects of project design.

Further information on the design development and alternatives considered for each of the project components is provided in the following sections.

## 3.3 Selection of the offshore or onshore regasification alternative

As part of the initial screening phase of the project, both onshore and offshore regasification and storage technologies were considered. A comparative assessment was undertaken for onshore and offshore alternatives to determine the most suitable option for the project.

The key difference between an onshore and offshore alternative is the location of the regasification equipment. An onshore regasification alternative would involve a floating storage unit (FSU) continuously moored at Refinery Pier storing liquefied natural gas (LNG) until required for processing and a regasification plant located onshore. The FSU is an LNG storage ship that does not have regasification equipment on board. The FSU would store LNG to then be transported to the onshore regasification plant via cryogenic piping (piping that allows for transfer of material at a temperature range from negative 150 degrees Celsius to absolute zero).

In comparison, the offshore alternative involves a floating storage and regasification unit (FSRU) continuously moored at Refinery Pier, which is also an LNG storage ship, but with regasification equipment onboard. The FSRU would store and regasify the LNG onboard.

### 3.3.1 Onshore regasification facility

To locate the regasification equipment onshore within the existing refinery, a significant land area footprint would be required, along with modification to existing refinery infrastructure. The following equipment that would otherwise be located on an FSRU would need to be located within the refinery for an onshore alternative:

- Boil Off Gas Compressors
- Recondenser / Suction drum
- Booster pumps
- Vapourisers.

A preliminary assessment was undertaken to determine where the regasification equipment could be located within the existing constraints of the refinery site. An initial location was considered at the current fire station at the refinery.

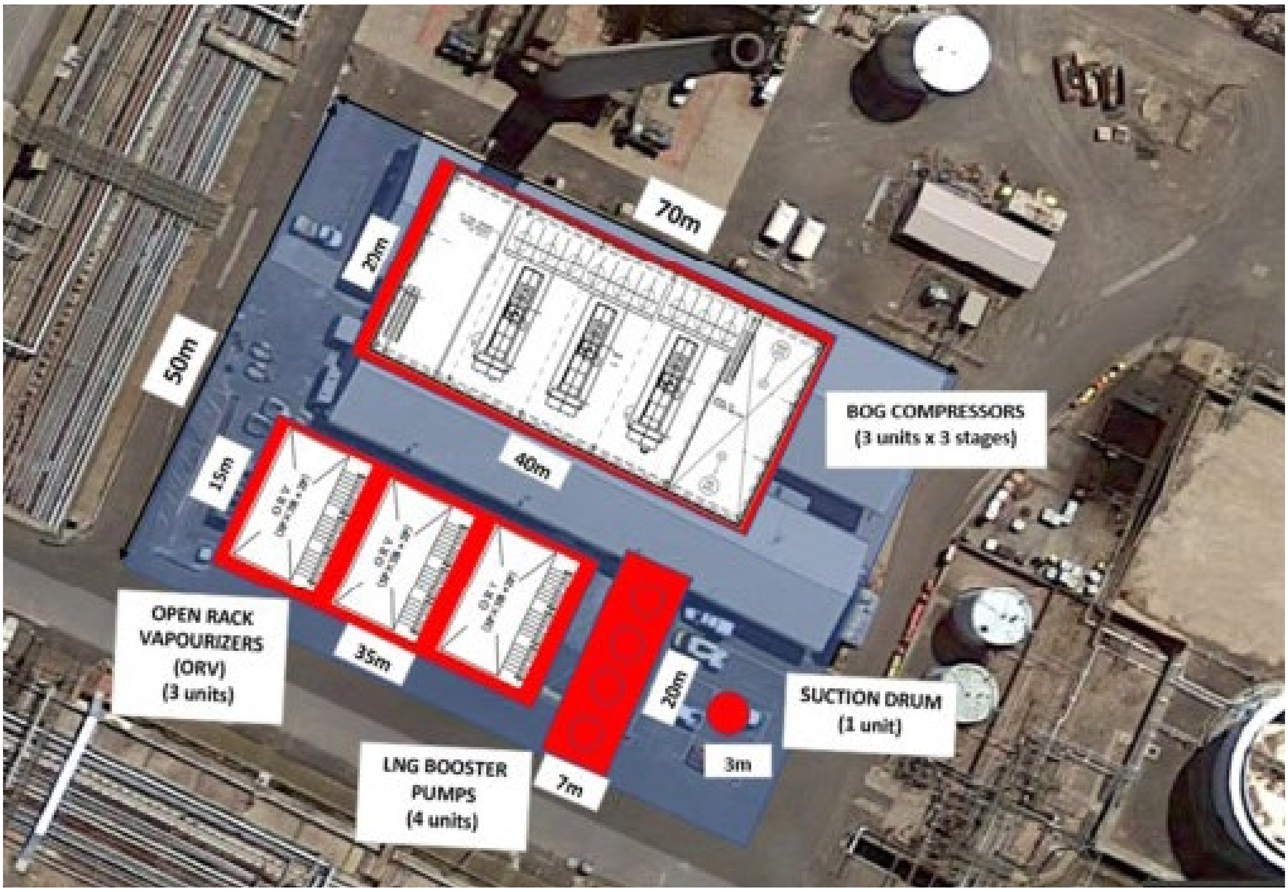



Figure 3-1 Onshore regasification equipment option layout

**Figure 3-1** shows an indicative layout of the regasification equipment in the considered location, with the existing fire station relocated elsewhere on the site. However, there were concerns regarding the proximity of the proposed infrastructure to other refinery equipment, with the potential for minimum separation distances for the equipment unable to be achieved.

Due to the limited space within the refinery, potential to locate the regasification equipment outside of the refinery premises was considered. However, this option was not progressed further on the basis that it would require extensive cryogenic piping to transfer the LNG from the FSU to the regasification equipment, removed the benefits of locating the facility outside of the existing major hazard facility boundaries and would represent a more energy intensive and costly alternative.

### 3.3.2 Comparative analysis

A comparative analysis was undertaken for the onshore and offshore alternatives by evaluating the advantages and disadvantages of each option.

The onshore facility alternative was assessed as requiring up to an additional year to construct due to complexities within the refinery site. Locating the regasification equipment within the refinery would require a large onshore footprint, significant modification to existing refinery infrastructure and generate a larger number of safety considerations when compared with the offshore option.

Comparatively, the FSRU with regasification equipment onboard is able to be moored at the end of an extension to the existing Refinery Pier, with less construction requirements. This provides additional separation distance from nearby public areas and refinery infrastructure. The space required for onshore facilities under this option was considered to be minimal and pose a lower safety risk in relation to other refinery equipment. A significant benefit of the offshore FSRU option considered for the project was the fact that, on completion of the project, the FSRU could be easily relocated elsewhere in the world without the need for decommissioning of extensive onshore infrastructure with associated impacts, energy use and costs.

A significant environmental benefit from the decision to locate either an onshore or offshore facility on or adjacent to the existing refinery was an ability to recycle the FSRU discharge water into the refinery for cooling purposes, effectively replacing the current intake of refinery cooling water from Corio Bay and not requiring a second water intake for the project if operated independently. The onshore plant option was considered marginally better from an infrastructure viewpoint to enable this reuse option than the offshore FSRU which requires additional pipework to pump the discharge water into the refinery, but this was not considered to be a significant differentiator.

Full reuse of the seawater discharge from the FSRU would have significant environmental benefits, however, there may be limited instances where seawater discharge from the FSRU could exceed the intake requirements for the refinery (e.g., when parts of the refinery are shut for maintenance or if the refinery was closed at a future point and reuse of cooling water was no longer an option). In the event that this did occur, excess seawater would need to be discharged directly to Corio Bay.

Two alternatives were considered for this discharge in the event that it was required, namely direct discharge from the FSRU or discharge via a diffuser located under the new pier. Of the two alternatives, discharge via the diffuser was selected on the basis that it creates rapid dilution of the cool water discharge with the surrounding waters and results in a localised cold water plume and mixing zone in the immediate area of the FSRU and jetty. Without the diffuser, the cold water plume on the bottom of Corio Bay would be larger in extent. With use of the diffuser as preferred option, the offshore option is considered better than an onshore regasification plant as surplus water from the onshore plant would require additional pipework and energy to discharge via the diffuser. Conversely, there may be instances where seawater discharge from the FSRU is lower than the intake requirements for the refinery (e.g., when the production rate for the FSRU is low due to reduced demand). In the event that this did occur, the refinery would draw the remaining volume of seawater required through the existing inlet.

**Table 3-1** provides a comparison of the onshore and offshore alternatives considered for the project, including the relevant advantages and disadvantages that were considered during the screening phase.

Table 3-1 Comparison between an onshore facility and an offshore FSRU

| Criteria | Onshore regasification | FSRU |
|---|---|---|
| Location | • Situated on land<br>• Requires a larger footprint on land for storage and regasification equipment<br>• Limited space within the refinery, requiring modification to the existing layout | • Moored at the end of a pier<br>• Able to make use of existing Refinery Pier<br>• Smaller footprint on land compared to the onshore option<br>• Located in port waters, away from nearby public areas and refinery infrastructure |
| Construction requirements | • Construction works would be on a brownfield site and involve significant modifications to existing refinery infrastructure<br>• Requires a larger construction footprint due to greater scale of onshore infrastructure compared to the FSRU<br>• Potential increased environmental risks from contaminated soil exposure and waste disposal during construction associated with footprint of onshore facilities | • The FSRU is an existing vessel requiring potential minor construction works. The vessel would be commissioned for optimal operating parameters prior to arriving at Refinery Pier<br>• Smaller construction footprint on land compared to the onshore alternative, as less infrastructure is required |

| Criteria | Onshore regasification | FSRU |
|---|---|---|
| Construction schedule | • Construction of the onshore facility would take considerably longer as it requires the procurement and construction of many items of equipment to form the regasification facilities onshore and relocation of existing infrastructure at the refinery<br>• Construction could take up to a year longer than the offshore alternative (up to 30 months to construct the entire project) | • Shorter construction timeframe for the offshore alternative- approximately 18 months to construct the entire project<br>• Approximately 18 months to complete FSRU chartering agreement, approvals and project-specific modifications |
| Risk and safety | • Locating regasification equipment within the refinery and in proximity to existing equipment could create safety issues requiring detailed consideration in the design and operation of the facility<br>• Separation distances would have to be maintained and access ways and maintenance programs would be affected<br>• Regasification equipment would be closer to public access areas | • The FSRU would be located away from the refinery and at a greater distance from public access areas<br>• If any safety, emergency or operational issues arise, the FSRU could depart the berth if required and remain at sea until the issue is resolved or return to a shipyard for maintenance. An alternate vessel could be sourced if required |
| Interference with port users | • Minimal impact on port users and existing Viva Energy operations<br>• This option would require continuous mooring of the FSU and regular visits from LNG carriers.<br>• Degree of interference with other port users would be to the same extent as the FSRU option. | • Minimal impact on port users and existing Viva Energy operations<br>• This option would require continuous mooring of the FSRU and regular visits from LNG carriers.<br>• Degree of interference with other port users would be to the same extent as the onshore option. |
| Capital expenditure | • Approximately 33% higher capital expenditure for the onshore alternative due to additional equipment requirements such as pumps, vapourisers and compressors which would otherwise be already present on the FSRU | • Lower capital expenditure due to the FSRU already being equipped with the necessary infrastructure |
| Synergy with refinery cooling system | • Locating regasification equipment within the refinery would provide a simpler connection between the water discharge from the vapourisation process and the refinery cooling water infrastructure, as the preferred option to manage discharge water is to reuse and recycle as a replacement for the current cooling water drawn from Corio Bay | |

| Criteria | Onshore regasification | FSRU |
|---|---|---|
| Environmental impacts | • Potential environmental impacts would be similar to the FSRU option, predominantly associated with the required dredging and the discharge of cooler water into Corio Bay<br>• A greater onshore footprint would be required for this option, with potential increased environmental risks from contaminated soil exposure and waste disposal<br>• Use of the diffuser for discharge from the FSRU (described in the FSRU column) could still occur but would require additional pipework and energy use to transfer surplus water from the onshore plant to the diffuser | • Potential environmental impacts would be similar to the onshore option, predominantly associated with the required dredging and the discharge of cooler water into Corio Bay<br>• This option would require the seawater transfer pipe, which may result in impacts to the seabed<br>• Where the seawater discharge from the FSRU exceeds the intake requirements for the refinery seawater could be discharged through a diffuser located under the new pier. Discharge through a diffuser would minimise impacts as the cold water discharge would be spread out across a number of outlets and rapidly diluted rather than concentrated directly from a single discharge point on the FSRU |
| Visual amenity and social considerations | • This option would involve a vessel permanently moored at Refinery Pier with frequent visits from LNG carriers, resulting in the same visual impact as the FSRU option. This is considered 'business as usual' within the port environment.<br>• Regasification plant and equipment located closer to sensitive receptors and communities onshore. | • This option would involve a vessel permanently moored at Refinery Pier with frequent visits from LNG carriers, resulting in the same visual impact as the onshore option. This is considered 'business as usual' within the port environment.<br>• Regasification equipment located away from onshore sensitive receptors. |
| Refinery Major Hazard Facility (MHF) Safety Case | • Regasification within the refinery would likely require a significant facility modification and resubmission of the refinery MHF Safety Case | • A new Safety Case and MHF Licence would be required for the FSRU |
| Operational expenditure | • Operational expenditure is slightly less (less than 10%) for the onshore alternative<br>• Additional operational personnel would be required to operate the vapourisation facilities | • Operational expenditure is slightly more for the offshore alternative<br>• Small operational crew would be required for the FSRU |
| Decommissioning | • Regasification infrastructure would be redundant after project closure and would require decommissioning of the onshore plant | • The FSRU would depart the pier upon completion of the project and be used elsewhere<br>• Pier infrastructure, treatment facility and seawater discharge pipe would need to be decommissioned or alternate uses would need to be found |

### 3.3.3 Selection of the preferred regasification alternative

Following completion of the comparative analysis to evaluate the advantages and disadvantages of each option, the offshore FSRU alternative was selected based on a combination of the factors discussed in **Section 3.3**.

It was determined that selecting an offshore FSRU based approach for the project, compared to an onshore alternative, provided the following advantages:

- Eliminates the requirement for a large onshore footprint to construct the necessary regasification equipment, which if located outside of the refinery premises due to limited space, would require expensive cryogenic piping to transfer the LNG from the pier
- It would not require significant modification to existing refinery equipment and layout
- A lower safety risk due to the distance of the FSRU from public access areas and refinery infrastructure, providing a greater safety buffer
- Construction requirements would be considerably less as the FSRU would arrive commissioned for operation with only potential minor modifications required
- Can be developed in a shorter timeframe, compared to the onshore alternative which could take an estimated 6 to 12 months longer to construct
- Provides greater flexibility should there be a change in gas market demand as the FSRU can simply depart from its mooring and be reused elsewhere in the world
- The FSRU would not require decommissioning of extensive land-based infrastructure that would be associated with the onshore option.

## 3.4 Site selection for the FSRU

The Port of Geelong and Corio Bay area was selected as the preferred area to locate the project in order to meet the key objectives of the project. These objectives included providing a new secure and stable source of gas to the south-eastern Australia domestic and industrial gas market, and to ensure forecasted annual supply shortfalls in Victoria are avoided.

Under the Australian Energy Market Operator's (AEMO) central gas demand scenario in the 2021 Gas Statement of Opportunity (GSOO), there is still over 500 petajoules (PJ) of gas needed in south-eastern Australia[1] including around 200PJ for Victoria every year until at least 2040. Locating the project in the Port of Geelong and Corio Bay area supports these project objectives by providing an existing port and industrialised setting close to the major population centres of Melbourne and Geelong and close to the existing Victorian gas transmission pipeline network.

Three locations were considered for the project, all of which are located close to Geelong with two in Corio Bay inner harbour and one in the outer harbour. The following three options were considered:

- Refinery Pier (either rebuilding existing Refinery Pier No.1 or a new pier extension to create Refinery Pier No.5)
- Lascelles Wharf No. 4
- Point Henry Pier.

The location of each of these options is shown in **Figure 3-2**.

Offshore FSRU location options, particularly along the western shoreline of Port Phillip Bay which is relatively proximal to the Victorian gas network, were given consideration at the project screening stage. They were not progressed to the next stage of assessment after the initial screening stage for the following reasons:

- Potential locations would be outside of existing port and industrial areas and likely to display more environmental constraints than an existing port setting
- Locations closer to Melbourne would be more problematic due to factors including shipping congestion, potential conflict with recreational boating, visual impact and difficulty obtaining onshore pipeline access for connection to the Victorian gas network
- Weather at anchorage in a more exposed setting could preclude Ship to Ship (STS) operations (transfer of LNG) at critical times; particularly during winter when demand is greatest which could potentially affect reliability of Victorian gas supply

1 *AEMO 2021 GSSO Figure 7, page 22*

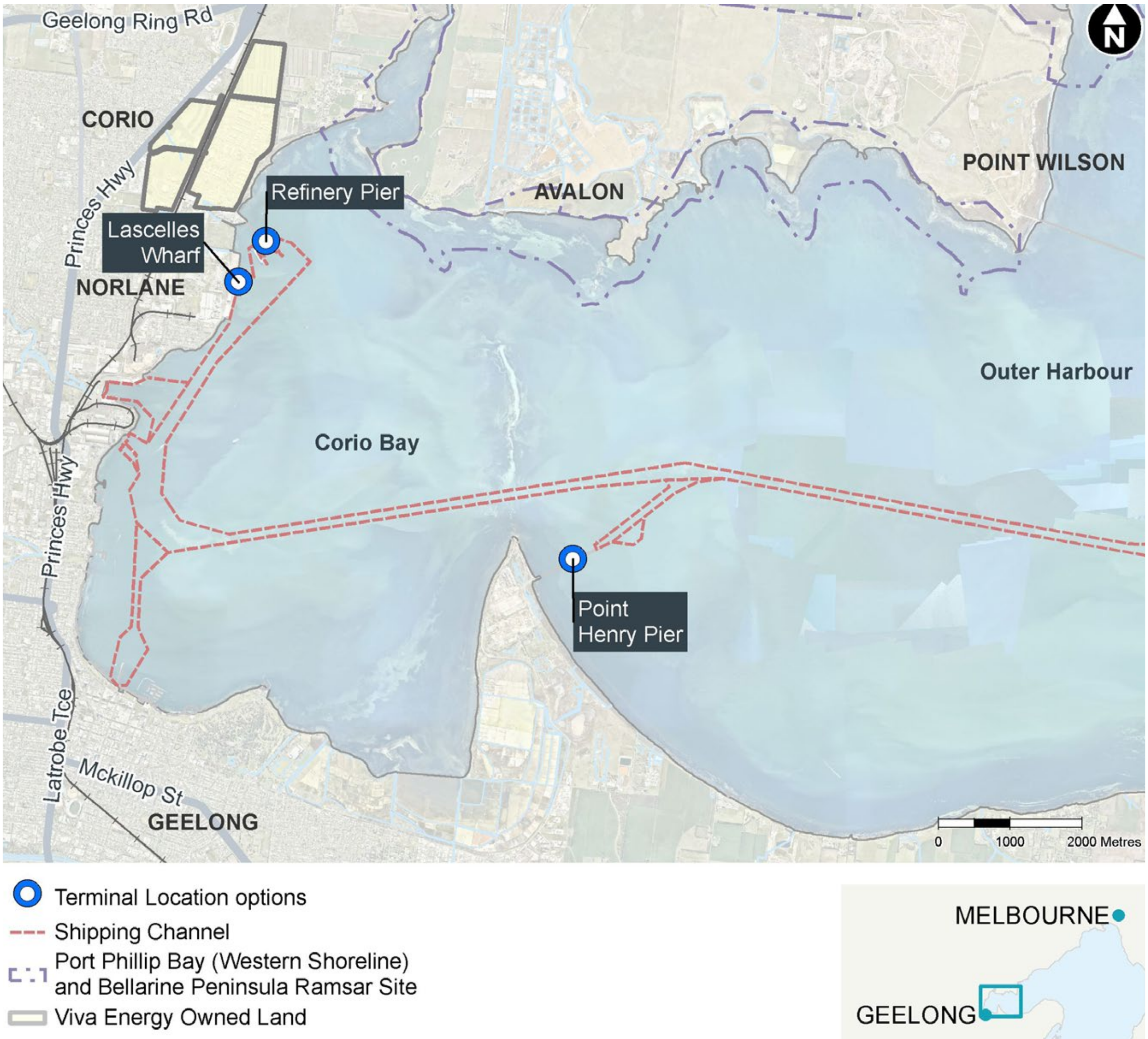



Figure 3-2 Gas terminal location options

- Subsea pipeline construction is complex with significant infrastructure required
- If located in the western area of Port Phillip Bay, the underwater section of the pipeline required would be greater than 15km and could pass through a Ramsar site depending on the proposed offshore location
- The location could potentially conflict with the announced Bay West port proposal
- An offshore location does not align with the vision for an Energy Hub at the Geelong Refinery
- Locating the FSRU offshore would not enable synergies to be captured with the Geelong Refinery such as seawater reuse and the potential for boil off gas usage at the refinery.

The assessment concluded that the proposed location at Refinery Pier proximal to the existing Viva Energy Geelong Refinery has significant benefits when assessed and compared with the alternatives having regard to a range of environmental, social, engineering, operational and economic parameters. These benefits are outlined in more detail in following sections.

### 3.4.1 Refinery Pier

Refinery Pier is located adjacent to Viva Energy's Geelong Refinery. There are four berths currently at Refinery Pier which service refinery operations importing and exporting liquid hydrocarbons. Refinery Pier No. 1 and Refinery Pier No. 2 are generally used for refined product export, with No. 1 usually reserved for loading bunkering vessels. Refinery Pier No. 3 and Refinery Pier No. 4 are used for importing crude oil, jet fuel and bitumen.

**Refinery Pier options**

The options considered for Refinery Pier were utilisation of an existing berth or construction of an additional pier to provide a new berth. Of the current berths at Refinery Pier, berthing the FSRU would only be possible at Refinery Pier No. 1 and No. 4. as only these berths would have sufficient manoeuvring space for berthing an LNG carrier adjacent to the FSRU. However, the Refinery Pier No. 4 utilisation rate for crude oil import of at least 50% precludes the conversion of this berth to LNG import without causing significant adverse impact on refinery operations.

Due to this constraint, the two options considered for Refinery Pier were utilisation of the existing berth at Refinery Pier No. 1 or construction of an additional pier arm for Refinery Pier No. 5. Table 3-2 provides a comparative assessment of Refinery Pier No. 1 and Refinery Pier No. 5.

Of the two pier options considered, Refinery Pier No. 5 was considered to be the preferred option due to the minimal impact on existing refinery operations and other port users, fewer safety risks associated with construction and operation of a new pier compared to upgrading and utilising an operating pier and a potential lower amount of dredging and dredged spoil disposal.

Locating the project at Refinery Pier would provide the following benefits when compared to other alternate locations at Lascelles Wharf and Point Henry Pier:

- Fits with existing refinery operations of managing liquid hydrocarbon products
- Provides the shortest distance of the three options for the new gas pipeline to connect into the South West Pipeline (SWP) adjacent to land owned and operated by Viva Energy
- Would have minimal visual impact being proximal to the existing refinery and port landscape
- Can accommodate LNG carriers with less localised dredging required for the berth pocket and swing basin
- Close proximity to the refinery gives the potential for FSRU seawater discharge to be utilised in the refinery cooling water process.

The proposed layout for Refinery Pier No. 5 is shown in Table 3-3.

Table 3-2 Refinery Pier No.1 and Refinery Pier No.5 comparative assessment

| Criteria | Refinery Pier No. 1 | Refinery Pier No. 5 |
|---|---|---|
| Additional construction required | • Refinery Pier No. 1 is 65 years old and is capable of berthing vessels up to 185m long. Major structural and dimensional upgrades would be required to accommodate the larger vessels to 300m. This would be equivalent to the construction of a new pier.<br>• Pipeline and berthing fender upgrades would also be required at Refinery Pier No. 2 and No. 3 to allow these berths to accommodate the shipping that is currently serviced by Refinery Pier No.1. | • A new piled pier head would be required, while the pipeline / utilities gantry and road access would be connected to the existing pier access. |
| Interference with port users | • Berth upgrade activities would result in periods of unavailability for Refinery Pier No. 2 due to its proximity to No. 1. Loss of both berths concurrently would impact refinery operations.<br>• A permanent loss of this berth for both refinery and Quantem operations would increase berth utilisation on the remaining three berths resulting in operational impact as the remaining piers would approach maximum capacities. | • Minimal impact on Refinery Pier No. 1 operations during construction<br>• Minimal impact on port users during operation. |
| Safety | • Construction around an operating pier would increase safety risk and significantly limit refinery operations during construction due to unavailability of Refinery Pier No. 2<br>• Proximity of LNG vessels to Refinery Pier No. 2 would increase operational safety risk and potentially result in constraints on refinery operations. | • LNG shipping safety studies and risk assessments identified fewer constraints and less interference with refinery operations by constructing a new remotely located berth specifically for the project<br>• Less interference with other berth operations would reduce potential operational safety risks associated with an increased use of other berths. |
| Dredging quantities | • Navigational simulations have identified a substantially similar dredge footprint and dredge volume as Refinery Pier No. 5 as dredging quantities are a result of vessel manoeuvring requirements. | • Approximately 490,000$m^3$ for the berth pocket and swing basin. |
| Environmental impacts | • Similar dredging quantities would have a very similar impact on the marine environment due to the close proximity of locations. | • Similar environmental impact due to similar dredging quantities at close proximity. |

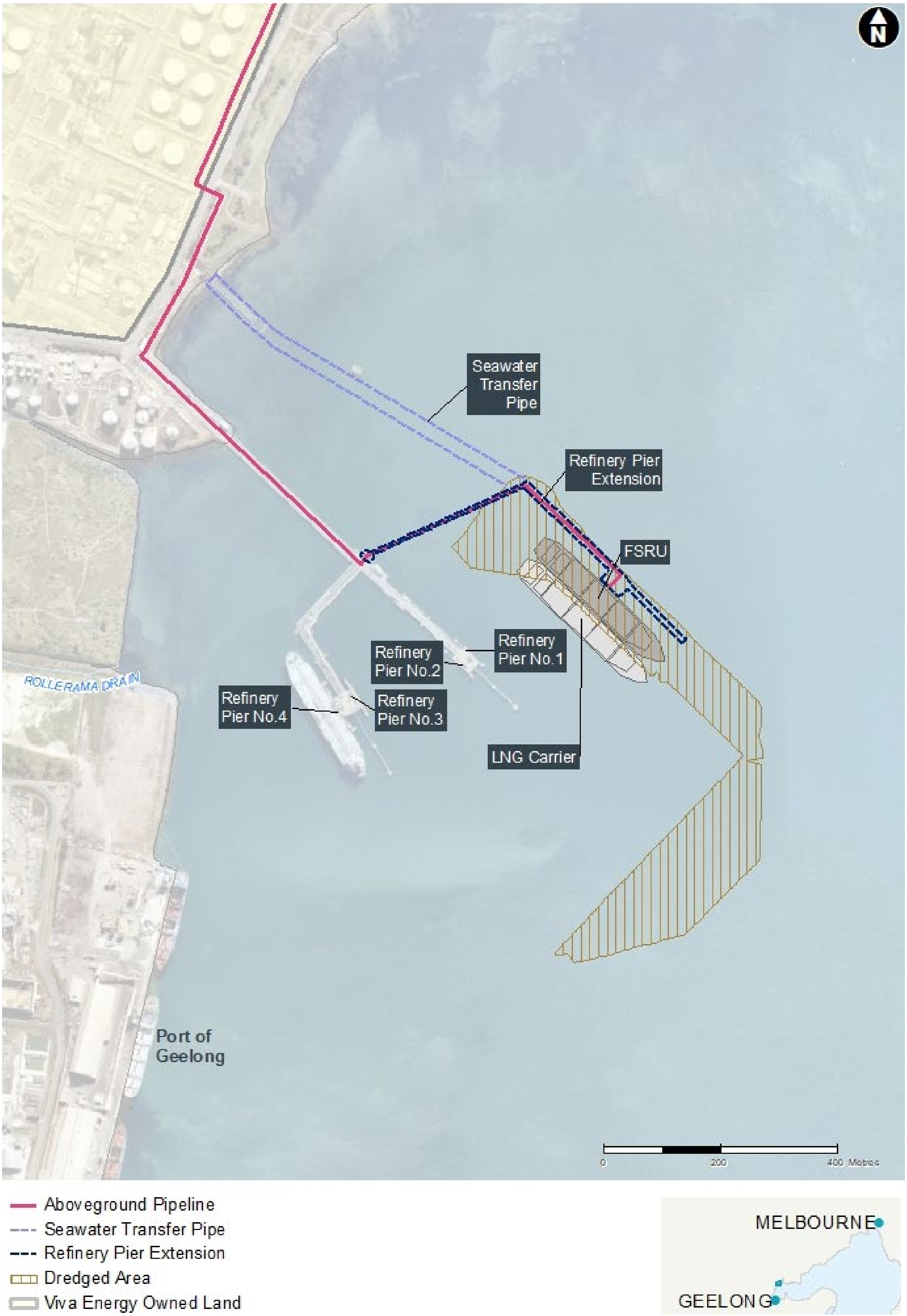



Figure 3-3 Refinery Pier No.5 layout

### 3.4.2 Lascelles Wharf No. 4

Lascelles Wharf is located to the north of Corio Bay, just south of the Refinery Pier. The wharf currently has three dry bulk handling berths in use. A fourth berth would need to be constructed at the northern end of the wharf to allow for continuous mooring of the FSRU and this area has been identified by GeelongPort for possible future development.

The proposed location is currently used to store wind turbines following offloading. Both excavation and dredging would be required at the site in order to allow sufficient space for tankers to access Refinery Pier No. 4 located to the immediate east whilst both the FSRU and LNG carrier are moored at Lascelles Wharf No. 4. Based on the preliminary layout proposed for Lascelles Wharf No. 4, the distance between a tanker berthed at Refinery Pier No. 4 and an LNG carrier berthed alongside the FSRU would be in the range of 100m to 150m.

This option would be dependent on ship manoeuvring simulations and safety studies to confirm feasibility. There would be a potential for impact to existing Refinery Pier No. 4 operations from the FSRU moored at this location, along with an impact on potential future developments due to ship manoeuvring at this location.

The preliminary layout considered for Lascelles Wharf No. 4 is shown in **Figure 3-4**.

Locating the project at Lascelles Wharf No. 4 would provide the following benefits:

- It has been identified by GeelongPort for possible future development, however, use for the Gas Terminal Project would only be considered if the footprint on the wharf was minimal so as to not preclude future development
- A short distance for the pipeline to connect into the South West Pipeline (SWP) although it would require a creek crossing when compared with the Refinery Pier No. 5 option.

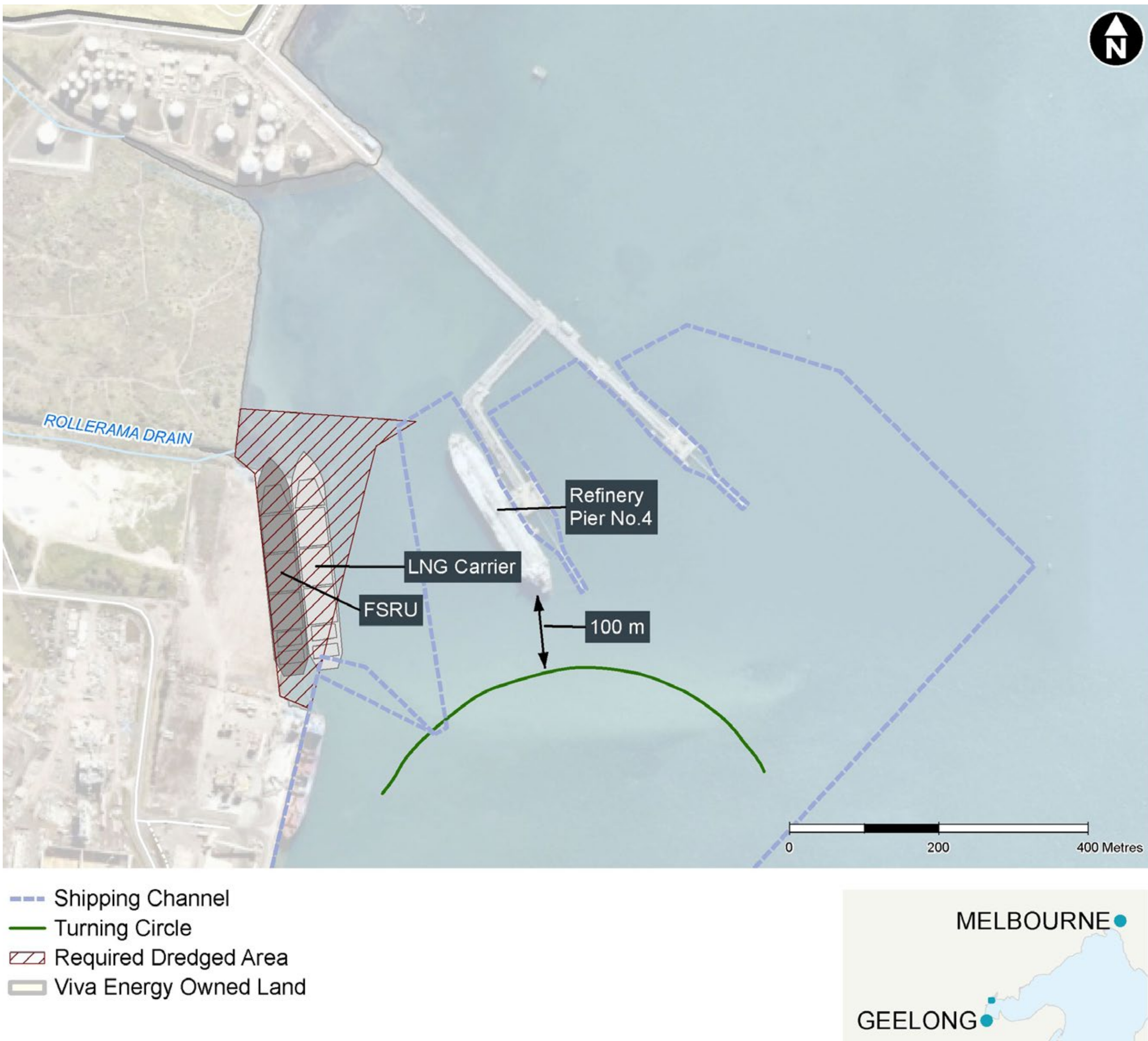



Figure 3-4 Lascelles Wharf No. 4 layout

### 3.4.3 Point Henry Pier

The Point Henry Pier is located to the south of the Outer Harbour as shown in **Figure 3-2** The approach channel is located between the Hopetoun Channel and the Wilson Spit Channel. The existing pier is part of the former Alcoa works but has not been used since that facility closed in 2014.

This option would require additional dredging of the approach channel, dredging of a new swing basin and substantial modification to the existing pier structure. Construction of a Point Henry Pier berth would have minimal impact on port operations however, the required dredge volume would be significant. The preliminary layout considered for Point Henry Pier is shown in **Figure 3-5**.

The associated pipeline route from Point Henry Pier would be very long, circling Geelong if located onshore or would be a very challenging subsea pipeline that would need to cross the shipping channel if located offshore. In addition, there is a likelihood of future channel deepening campaigns that could impact a subsea pipeline.

Locating the project at Point Henry Pier would provide the following benefits:

- The location does not require LNG carriers to transit through the Corio Channel city bend and the narrower part of the Port of Geelong approach channel
- Construction works, being located in the Outer Harbour, would have minimal impacts on port operations as there would be limited interaction with port users during operation.

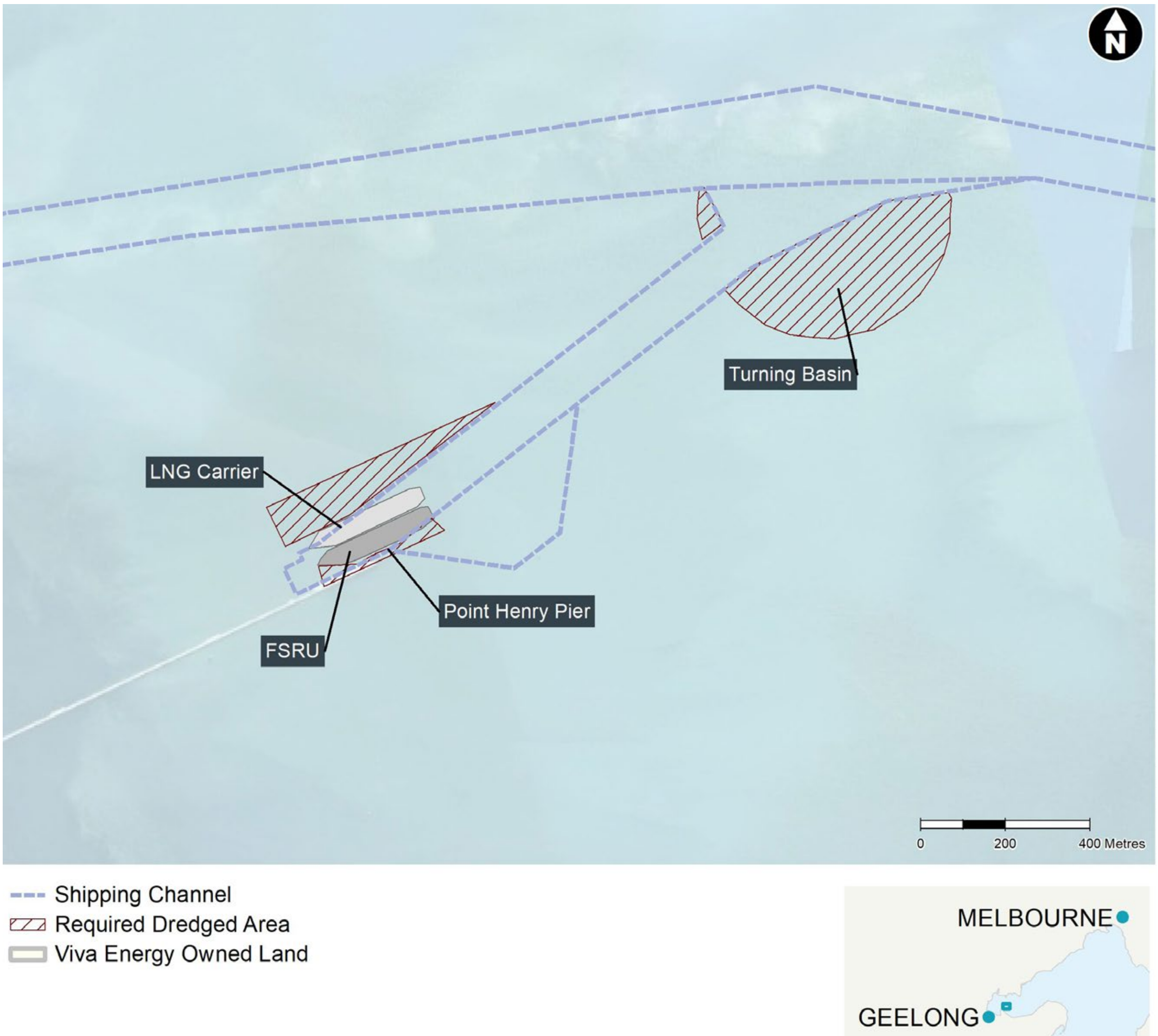



Figure 3-5 Point Henry Pier layout

### 3.4.4 Comparative assessment

A high-level comparative assessment was undertaken for the three sites to determine the preferred location and suitability for the gas terminal. The comparative site evaluation was performed by reviewing a range of criteria for each of the locations to determine their suitability. A summary of the comparative assessment of the three sites is provided in **Table 3-3**.

Table 3-3 Comparative assessment for gas terminal locations

| Criteria | Refinery Pier No. 5 | Lascelles Wharf No. 4 | Point Henry Pier |
|---|---|---|---|
| Navigational issues | • Minimal navigation issues, final berth at the end of the channel with a typical berthing arrangement | • LNG carriers would be berthed into a compact berth due to dry bulk vessels to the south and tankers at Refinery Pier No. 4 to the east<br>• Likely a high risk manoeuvre required by pilots and tug operators | • LNG carriers would be towed astern along the approach channel to the berth, deemed a higher risk by pilots and tug operators |
| Interference with port users | • Minimal impact on Refinery Pier No. 1 operations during construction<br>• Minimal impact on port users during operation | • Impact on Lascelles Wharf and Refinery Pier No. 4 operations during construction<br>• Would impact on other port users during LNG carriers manoeuvre (vessels at Lascelles Wharf and tankers at Refinery Pier No.4)<br>• Would potentially prevent future port expansion by GeelongPort | • Minimal impact on other port users due to the location of the pier being in the outer harbour |
| Dredging quantities | • Approximately 490,000m$^3$ for the berth pocket and swing basin | • Approximately 955,000m$^3$ for the berth pocket and swing basin (includes 235,000m$^3$ of material required to be excavated from the existing wharf) | • Approximately 1,000,000m$^3$ for the berth pocket and swing basin |
| Additional construction required | • A new piled pier head would be required, while the pipeline/ utilities gantry and road access would be connected to the existing pier access. | • Substantial work required, including a new wharf with considerable landside excavation | • Existing pier does not have capacity for a FSRU, strengthening and new dolphins required. |
| Power and utility availability | • Easy access to power and utilities from existing pier facilities | • Requires new source of power and utilities | • Requires new source of power and utilities |

| Criteria | Refinery Pier No. 5 | Lascelles Wharf No. 4 | Point Henry Pier |
|---|---|---|---|
| Land acquisition | • Minimal land acquisition required for pipeline. Onshore facilities to be located at the refinery | • The pipeline and utilities corridor to the refinery would likely require land acquisition | • Onshore land would need to be acquired for facilities buildings and the onshore pipeline corridor |
| Pipeline connection | • Shortest distance of the 3 options<br>• Would run through the refinery and use the existing pipeline corridor/road reserve to the SWP tie in | • Second shortest option<br>• Would require an additional creek crossing prior to running through the refinery | • Longest option<br>• Would require a long onshore route around Geelong or a challenging route under the existing shipping channel |
| Residential proximity | • Closest residential area is North Shore, 1.5km to the south. However, extension of existing pier operation considered 'business as usual' for hydrocarbon management at Refinery Pier and within port environment | • Closest residential area is North Shore, 1km to the south<br>• Onshore construction works would be required, likely to result in noise impacts | • Closest residential area is 5km.<br>• Construction impacts likely to occur as equipment and materials would travel through Geelong |
| Visual amenity and social considerations | • Visual impact from the north of Corio Bay, however, still fits in the port and refinery context.<br>• Limited impact on surrounding communities and sensitive receptors as land use fits within existing context of the port setting | • Close proximity to North Shore would result in visual impacts for residents. The FSRU would be considerably larger than the current vessels that berth at the wharf. | • Major visual impact on surrounding business and residential area<br>• Point Henry has been chosen for potential future development and return to public land (Moolap Development), and would create visual impact concerns for local homeowners and businesses |
| Environmental | • Potential for contaminated dredged material due the nature of Refinery Pier operations<br>• Lower degree of environmental impact due to lower dredging quantities | • Potential impacts from pipeline creek crossing<br>• Potential for contaminated dredged material as the wharf was previously used as a refuse landfill area<br>• Greater dredging quantities required would have a greater impact on the marine environment | • Potential for contaminated dredged material due to the proximity of the aluminium smelter<br>• Pipeline would likely have impacts due to its lengthy route<br>• Greater dredging quantities required would have a greater impact on the marine environment |

| Criteria | Refinery Pier No. 5 | Lascelles Wharf No. 4 | Point Henry Pier |
|---|---|---|---|
| Seawater re-use | • Can re-use seawater discharge from the regasification process within the refinery by directing seawater discharge to the existing refinery seawater intake | • Not able to re-direct seawater discharge from Lascelles Wharf to the existing refinery seawater intake due to location of Lascelles Wharf No. 4 | • Not able to re-direct seawater discharge to the existing refinery seawater intake due to significant distance |
| Economics | • Can utilise existing personnel and facilities at the refinery during operation<br>• Capital expenditure costs associated with new pier arm and pier infrastructure | • Can utilise existing personnel and facilities at the refinery during operation<br>• Costs associated with new pier arm and pier infrastructure<br>• Higher dredging volumes would make it more costly | • Would require new facilities and personnel located at the site<br>• Highest capital expenditure of all options due to a new wharf being required and significant dredging volumes<br>• Higher costs associated with a longer and more challenging pipeline route |

### 3.4.5 Selection of the preferred site for the FSRU

Following completion of the comparative assessment to evaluate the advantages and disadvantages of each of the locations, Refinery Pier No. 5 was selected as the preferred site for the FSRU.

Co-locating the project with the existing Geelong Refinery and within the Port of Geelong offers significant opportunity to minimise potential environmental effects and utilise a number of attributes that exist within the port and industrial setting. In particular, the ability to redirect and reuse the cooled water discharge from the FSRU in the adjacent refinery process rather than discharging the water directly into Corio Bay provides a significant opportunity to enhance the overall environmental performance of the project. The short distance to the SWP connection point into the Victorian gas network is also a significant benefit of the preferred option as it only requires a 7km pipeline of which 3 kilometres would be located aboveground along Refinery Pier and within the refinery premises, and 4 kilometres would be underground which, where practicable, would be constructed within or adjacent to the existing pipeline corridor.

The Refinery Pier No. 5 option was considered to be the preferred option on the basis that it:

- Would have minimal navigation issues, being the final berth at the end of the channel with a typical berthing arrangement. This option would have minimal impact on other port users during both construction and operation.
- Would have easy access to power and utilities, including firefighting systems, available from the existing pier facilities.
- Would require no additional onshore land acquisition for the treatment facility, as the pier is adjacent to the refinery.
- Would enable onshore pipework to be routed through the refinery and onshore facilities to be located on Viva Energy owned land as required.
- Enables use of the existing pipeline corridor to the SWP tie-in point at Lara.
- Would have minimal visual impact compared to the other options as Refinery Pier is considered 'business as usual' and within a port environment.
- Has a lower dredging volume than alternative options.
- Has potential synergies with refinery operations including re-use of the FSRU seawater discharge in the refinery cooling water system.
- Has lower capital expenditure than the Lascelles Wharf option, where a new wharf would have to be constructed, and lower operating costs than the Point Henry Pier option through utilisation of existing facilities and refinery personnel.

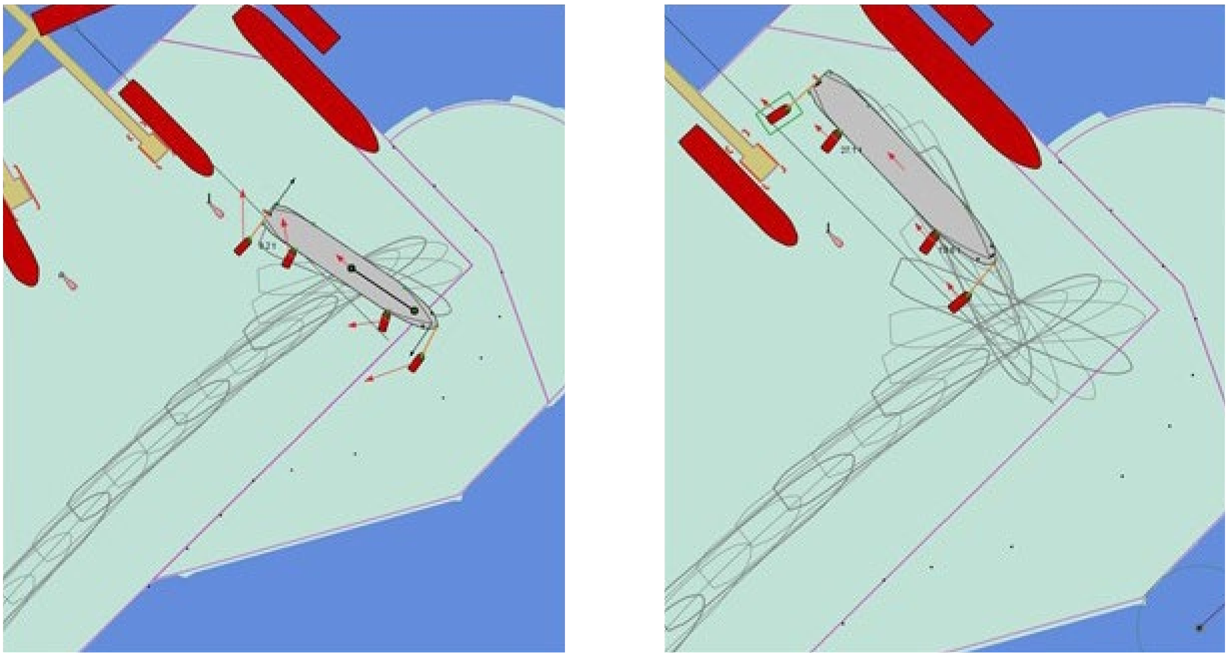


Figure 3-6 Visual representation of the LNG carrier approach (Smartship Australia, 2021)

In addition to the advantages of selecting Refinery Pier No. 5 for the FSRU, use of the existing refinery site for the land-based components of the project also provides a number of other benefits. Preliminary assessments indicated that the refinery site offered a significant number of attributes which made it a suitable location including:

- Location within and adjacent to an existing port and industrial complex.
- The refinery is already a designated Major Hazard Facility (MHF) with stringent controls on safety and risk in place including significant separation distances from sensitive land uses.
- Highly modified environment, landscape and visual setting.
- Ecological studies conducted during 2020 indicate the absence of any significant flora and fauna on the refinery site and proposed pipeline corridor.
- Absence of watercourses on the project site.
- Long history of Viva Energy co-existing with its neighbours at the proposed treatment facility site within the refinery.
- Longstanding relationships with nearby stakeholders as a basis for direct engagement on the proposed project.
- Ability to extend the existing Refinery Pier rather than create new pier infrastructure.
- All land-based infrastructure, such as the treatment facility, is planned to be located within the existing refinery footprint with buffer/separation distances to sensitive receptors.
- Limited number of sensitive receptors proximate to the current refinery and proposed project area.
- Short underground gas transmission pipeline distance (approximately 4km) between the proposed treatment facility and the connection point into the SWP at Lara.
- Due to existing MHF separation distances from sensitive land uses, potential impacts such as safety, hazard, noise and air quality from the proposed FSRU and land-based facilities should be readily manageable and meet compliance requirements.
- A large portion of the proposed pipeline corridor traverses land held by Viva Energy, Greater Geelong City Council and VicRoads with a small number of landholder interactions required.
- Direct access to the treatment facility for nitrogen supplies via the Princes Freeway and Shell Parade which are VicRoads gazetted High Productivity Freight Vehicle roads.
- Availability of existing environmental monitoring data from the refinery for a range of parameters such as noise, air quality and groundwater provide baseline conditions for assessment of impacts from the project.
- Supports Viva Energy's vision to transform the Geelong Refinery into the Geelong Energy Hub to help build a sustainable operation and long-term energy security.

## 3.5 Dredging design development

During the preliminary Front End Engineering Design (FEED) for the project, it was assumed that LNG carriers would be required to turn around in the swing basin prior to berthing adjacent to the FSRU for transfer of LNG. Initial designs estimated approximately 1.1 million $m^3$ of dredged material would be required to be removed adjacent to the existing shipping channel to provide sufficient water depth at the new berth and within the swing basin to allow for the vessel to turn prior to berthing.

Further berthing simulations for the selected site of Refinery Pier No. 5 were undertaken for multiple vessel types in a variety of weather conditions. Following these simulations and further design development, it was determined that an LNG carrier would be able to safely back up with the assistance of four tugs in a considerably smaller swing basin. It was also confirmed that the LNG carrier would be able to safely depart the berth. Figure 3-7 provides a visual representation of the LNG carrier approaching the berth with the assistance of the tugs.

This resulted in a reduction to the required swing basin and subsequently a reduction in dredging requirements. This design development resulted in a reduction in the estimated volume of dredging to approximately 490,000$m^3$. A comparison between the original dredge footprint and the proposed dredge footprint is shown in Figure 3-7.

This refinement to the berthing arrangements was considered to represent a major environmental enhancement on the original project design and represents a lesser amount of dredging when compared with the other project locations considered.

A number of dredge sediment disposal options were assessed to determine the most suitable option for disposal and management of the 490,000$m^3$ of dredged material. It was determined that disposal at an existing dredged material ground (DMG) in Port Phillip Bay to the east of Point Wilson located approximately 26km from Refinery Pier was the preferred option subject to regulatory approvals. The DMG has been used for disposal of sediments from past dredging programs in Corio Bay and displays similar sediment characteristics to the dredged spoil from the project. It is also by far the closest disposal ground in Port Phillip Bay with attendant benefits of reduced travel time, cost and energy use. Potential onshore options for disposal of dredged sediments were considered to be less favourable as the low level of contamination in the sediments does not require treatment under regulatory guidelines and costs and energy use associated with treatment, storage, drying and ultimate disposal on land would be significantly higher. The findings of the disposal options assessment are documented in Technical Report B: *Dredged sediment disposal options assessment*.

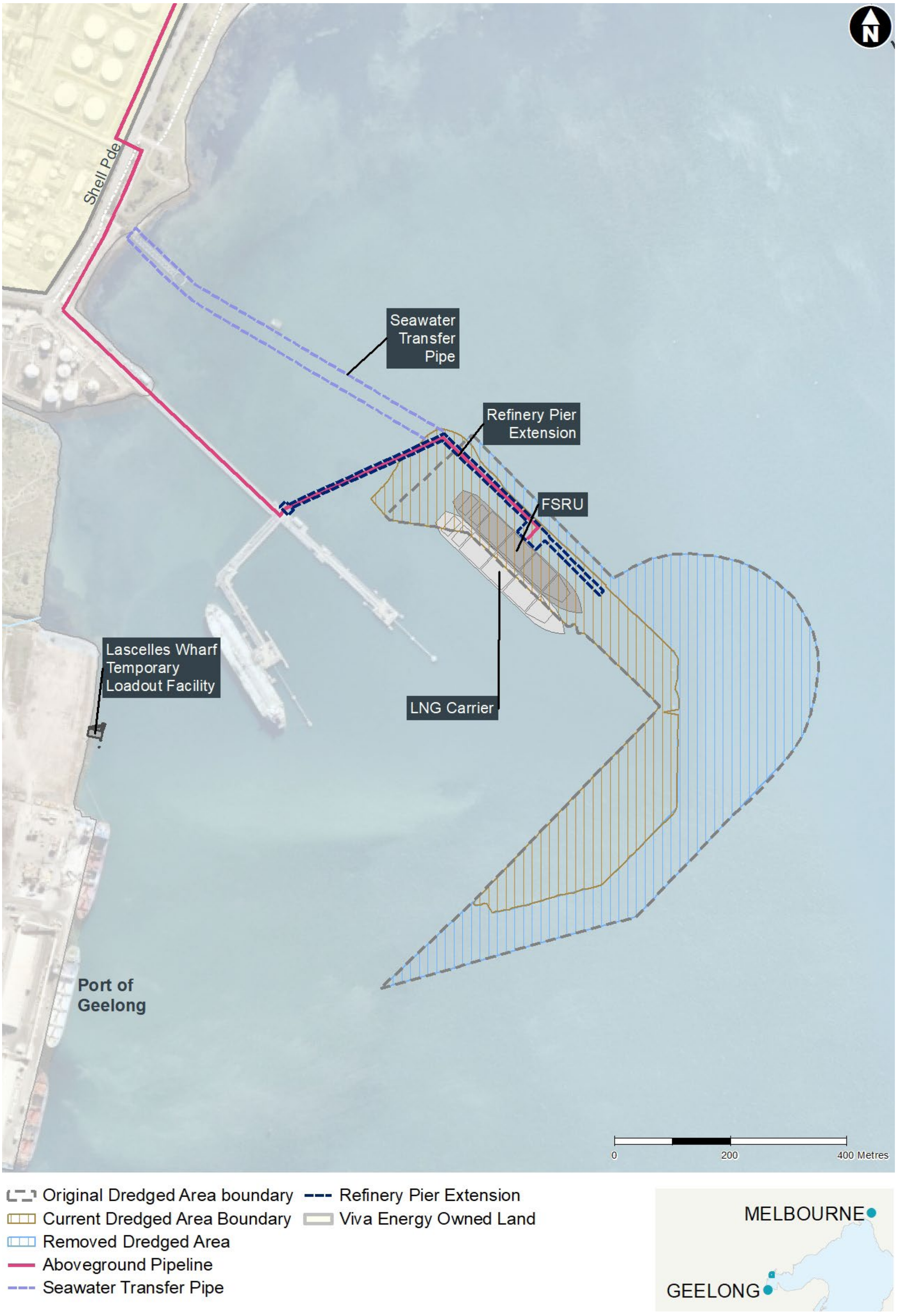



Figure 3-7 Comparison of the original dredge footprint and the proposed dredge footprint

## 3.6 FSRU design development

The following section outlines the key aspects involved in the design development of the FSRU, including the design of the seawater intake and discharge processes, an assessment of regasification mode alternatives and selection of the proposed regasification mode for the FSRU.

After the selection of Refinery Pier as the preferred site for the FSRU, key features of the FSRU including the seawater intake and seawater discharge ports were designed progressively. This included assessment of the different regasification modes and the volumes of seawater intakes and discharges under a range of operating scenarios to develop a functional FSRU operating design that would operate efficiently and avoid or minimise adverse environmental impacts.

### 3.6.1 Seawater intake

Design development of the FSRU seawater intake has taken into consideration potential impacts on the marine environment. Seawater would be drawn into the FSRU through the vessel sea chest or dedicated water inlet ports in the hull. Two intakes would be located on the FSRU, one on the port side approximately five metres below the sea surface, and one starboard side approximately eight metres below the sea surface.

The intake velocity of the FSRU seawater intake has been reduced to 0.15 metres per second (m/s) in accordance with the US EPA requirement and to be able to demonstrate best practice. Reducing the intake velocity allows mobile marine organisms to swim away. The intakes would also be fitted with grilles spaced at less than 100 mm x 100 mm to prevent the intake of fish and other matter into the FSRU.

### 3.6.2 Seawater discharge

**Refinery cooling water synergy**

During design development for the project, a potential synergy was identified between the FSRU cold water discharge and the seawater intake for cooling water currently used at the refinery. The discharge volume from the FSRU would be approximately 300,000m$^3$/day for regasification of 500TJ/day during the winter months. On a limited number of peak demand days, the gas production rate would fluctuate throughout the day, but the maximum daily flowrate of seawater would be 350,000m$^3$/day. The Geelong Refinery currently uses a similar volume of seawater for cooling purposes (350,000m$^3$/day). It was considered that the refinery cooling water flowrate could be offset by the FSRU cold water discharge flow rate.

Where seawater discharge from the FSRU exceeds the intake requirements for the refinery (e.g., when parts of the refinery are shut for maintenance), excess seawater from the FSRU would be discharged to Corio Bay through a diffuser located under the new pier. Conversely, where seawater discharge from the FSRU is lower than the intake requirements for the refinery, for example, when the production rate for the FSRU is low due to reduced demand, the refinery would draw the remaining volume of seawater require through the existing inlet. The cooled (7°C below ambient temperature) seawater discharge from the FSRU regasification system would be directed to the existing refinery seawater intake for reuse within the refinery and would replace the seawater intake volume currently extracted by the refinery.

The FSRU would be located approximately 500m south-east of the refinery cooling water intake and the cooled water discharge would be directed to the cooling water intake by means of a pipe which would run beneath the seabed.

Currently, the refinery inlet takes in seawater at ambient temperature and discharges the cooling water through EPA licensed outlets at a warmer temperature. The resulting average temperature of the water discharged through the outlet from the refinery is approximately 8-10°C above ambient seawater temperature. Diverting the cooled water discharge from the FSRU to the refinery inlet reduces the temperature of the water taken into the refinery by approximately 7°C. This in turn reduces the temperature of cooling water discharged from the refinery by 7°C. The resulting outlet temperature averaged across the refinery discharge points would then be approximately 1-3°C above ambient seawater temperature, compared to the current 8-10°C above ambient temperature from normal refinery operations. **Table 3-4** provides an overview of the effect of the FSRU seawater discharge on the refinery cooling water discharge points.

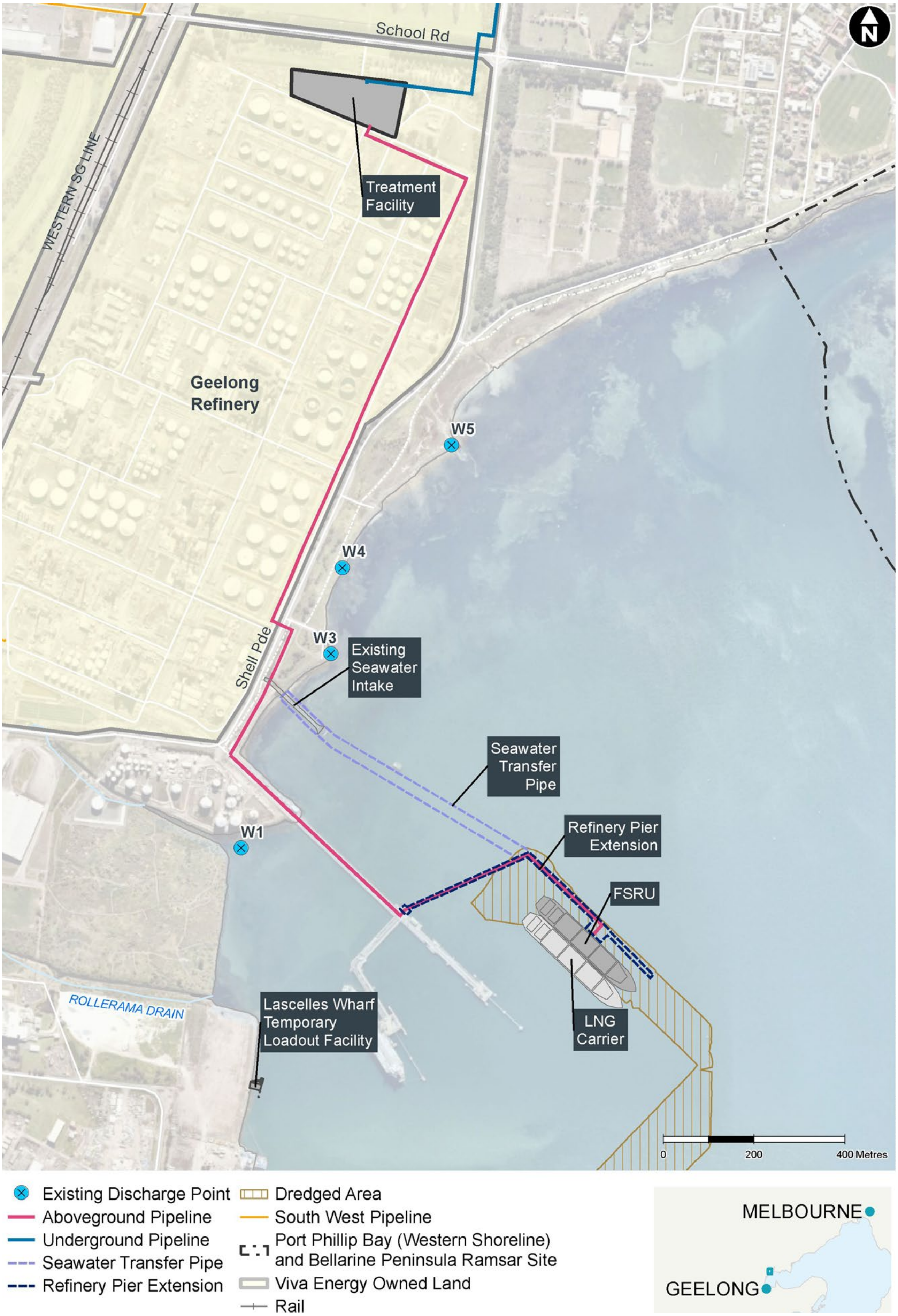



Figure 3-8 Refinery seawater intake and discharge points

Table 3-4 Impact of the FSRU discharge on the refinery outlet cooling water temperature (Ambient seawater temp = 10°C)

| Cooling water outlet location | Outlet temperature (no FSRU) | | Outlet temperature (with FSRU) | |
|---|---|---|---|---|
| | Temperature (°C) | Above ambient seawater temperature (°C) | Temperature (°C) | Above ambient seawater temperature (°C) |
| W1 | 19 | 9 | 14 | 4 |
| W4 | 18 | 8 | 13 | 3 |
| W5 | 20 | 10 | 15 | 5 |
| Average | 19 | 9 | 14 | 4 |

Using the cooled water discharge from the FSRU as a source of refinery cooling water would provide the following benefits:

- Reduces the potential environmental impact associated with discharging cold water (7°C below ambient seawater temperature) from the FSRU at a single location below the vessel
- Reduces the potential environmental impact at the refinery cooling water outlet locations by lowering the discharge temperature from 9°C to 4°C above ambient seawater temperature
- Reduces the potential environmental impact by spreading the FSRU discharge flowrates across the three refinery outlet locations. This results in a more diffuse and lower concentration of warm temperature water being discharged.

In addition to FSRU seawater discharge being approximately 7°C cooler than ambient seawater temperature, discharge from the FSRU after it has been used in the heat exchange process would also contain short-lived residual chlorine. The refinery cooling water discharge also currently contains short-lived residual chlorine. However, it was considered that management of residual chlorine in the discharge water at acceptable environmental limits was achievable utilizing existing management practices at the refinery and that this would be further developed in the detailed design process.

It was also considered necessary to develop an option to directly discharge the FSRU regasification water (7°C below ambient seawater temperature) into Corio Bay in situations where the refinery may be 'offline' for maintenance or other reasons and reuse in the cooling water process could not occur.

It was considered that the best option to manage this cooled water discharge was via a diffuser located on the jetty extension which would spread the cold water across a number of outlets rather than concentrated directly from a single discharge point on the FSRU.

**FSRU design modifications**

To transfer the cooled water discharge from the FSRU to the refinery, modifications to the FSRU design would be required. Standard FSRU design would involve direct discharge into the receiving waters in which the vessel was located.

To enable reuse of the FSRU discharge as refinery cooling water which is a major environmental enhancement when compared with direct discharge to Corio Bay (normal FSRU discharge approach), modifications to the vessel would be required. These modifications would consist of the FSRU seawater discharge being directed to a common line located above the upper deck at the forward side of the vessel, where it would reach a manifold on the port side. The seawater return manifold would have four take-off trains, equipped with Quick Release Couplings (QRC) and flexible hoses for the transfer of the cold seawater to an export pipeline routed towards the refinery cooling water inlet.

Each seawater discharge manifold train would be located outside the ship hull at an optimal location following the shape of the vessel. The pipeline trains would be extended downwards on the upper deck and connected to the offloading/discharge hoses via QRC. **Figure 3-9** and **Figure 3-10** show the proposed FSRU regasification seawater overboard manifold system.

The cooled water discharge from the FSRU would be transported to the existing refinery cooling water intake by means of a DN1200 pipeline, approximately 500 metres long. This pipeline is proposed to be buried approximately 2 metres below the seabed and utilise a trenched option, rather than the pipe being anchored to the seabed, to protect the pipe and ensure that it remains submerged during low tide. The seawater discharge pipe would run along the straight arm of the new pier in a pipe rack, however, unlike all other piping that would run along the pier arm back towards the existing Refinery Pier, the seawater discharge pipe would continue straight along the seabed and into the existing refinery seawater intake.

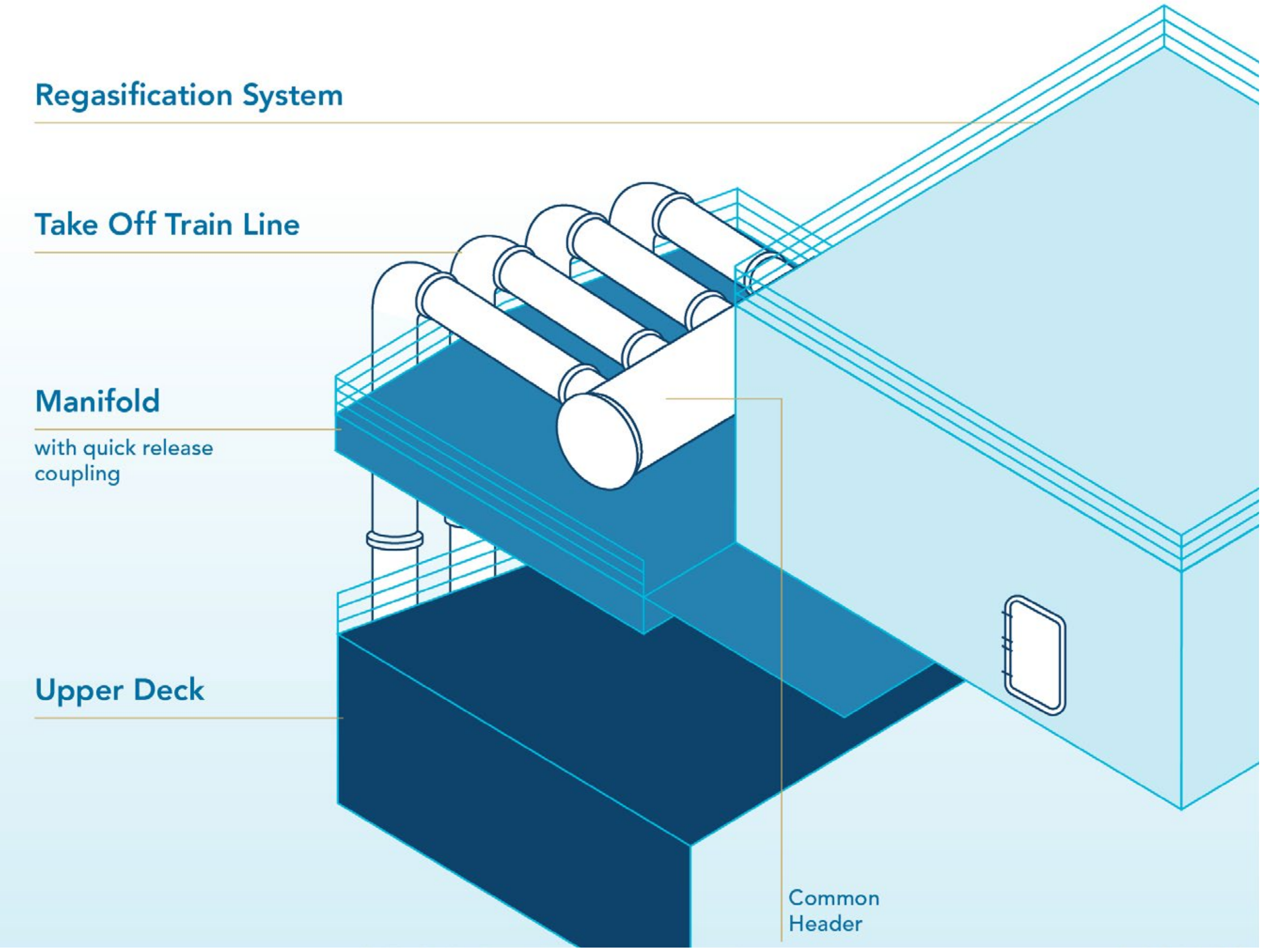



Figure 3-9 Proposed design for the FSRU regasification seawater system overboard manifold

Figure 3-10 Example of a regasification seawater system overboard manifold integrated onto an FSRU

### 3.6.3 Alternative regasification modes

The FSRU converts stored LNG into natural gas via a process called regasification using onboard regasification equipment. A heat-exchanger is used as an interface to transfer heat from a heat source to the LNG in the regasification train. The regasification trains can operate in either open loop mode which uses seawater as the heat source, closed loop mode which uses gas-fired boilers as the heat source or combined loop utilising a combination of the other modes. Combined loop was not considered as an operating option for the project as it is only used in very limited circumstances, in particular, to heat seawater when it falls below a specified temperature prior to regasification.

There are a number of methods for regasification of LNG available and the selection of an optimum process depends on plant site location, climatic conditions, throughput capacities, energy efficiency and environmental and regulatory compliance. **Table 3-5** outlines the different methods that are available for LNG regasification. Ambient air vaporisation (AAV) was not considered appropriate for the project due the unsuitable climate conditions at Geelong.

Table 3-5 Regasification alternatives

| Regasification process | Description | Advantages | Disadvantages |
|---|---|---|---|
| Open loop system | Uses seawater to heat the LNG. Seawater is continuously drawn in via intakes, passes once through a heat exchange system and is then returned directly to the sea. Propane would be used as the intermediate fluid | • Most commonly used system globally for FSRUs<br>• Simpler process of regasification<br>• Lower greenhouse gas emission compared to closed loop | • Potential marine impacts from FSRU discharge<br>• Potential for entrainment during seawater intake |
| Closed loop system | A closed loop of circulating seawater within the FSRU is used as an intermediate heating medium by gas-fired steam boilers in the LNG regasification trains. Propane would be used as the intermediate fluid | • Lower seawater intake and discharges than open loop | • Higher greenhouse gas emissions than open loop<br>• Higher consumption of LNG for fuel<br>• Greater capital expenditure costs for gas-fired boilers |
| Ambient air vaporisation | Utilises air as the heating medium and avoids the use of seawater and fuel gas as heating mediums | • Less potential impact on marine environments as it does not involve discharge of cooled seawater | • Better suited to regions where ambient temperature is high all year round<br>• In cooler climates, a heat system is required to supplement the AAV process<br>• Larger infrastructure required<br>• Can produce vapour fogs |

#### Open loop system

An open loop system on the FSRU uses seawater to heat the LNG. Seawater is continuously drawn in via intakes, passes once through a heat exchange system and is then returned directly to the sea at temperatures of 7 °C below ambient water temperature. Propane would be used as an intermediate fluid, whereby seawater would be used to heat the propane, and the propane would then heat the LNG. The energy used to pump the seawater through the heat exchanger consumes about 1.5% of the send out gas for power generation, similar to onshore terminals (Songhurst 2017). Seawater is generally used as a heat source for warming and vaporising the LNG, except in cold climates where there is a risk of freezing the seawater (Patel et al. n.d.). Open loop is the most commonly used system globally for FSRUs.

#### Closed loop system

A closed loop system uses gas-fired steam boilers to heat a closed loop of circulating seawater within the FSRU as an intermediate heating medium for heat exchange in the LNG regasification trains. Propane would also be used as an intermediate fluid in closed loop, whereby steam from the gas-fired boilers would be used to heat the propane, and the propane would then heat the LNG. Around 500 $m^3$ of seawater would be required to fill the FSRU heat exchange piping. Instead of being discharged from the FSRU as per open loop mode, the seawater is continually circulated in the process. Seawater would only be discharged to Corio Bay when maintenance is required (anticipated to be annually) or when the FSRU changes between operating modes. Discharged seawater from the closed loop process would be around 5 °C warmer than the ambient water temperature.

This method uses 2.5% of the send out gas to heat the circulating fluid to vaporise the LNG compared to 1.5% for open loop (Songhurst 2017). This contributes to an increase in greenhouse gas emissions when compared to open loop operation and reduces the regasification plant output. Due to the environmental and economic implications, closed loop systems are becoming less commonly used.

#### Combined loop mode

To provide flexibility, there is a trend for new build FSRUs to have both open and closed loop capability, which is referred to as ‘combined loop’. The combined loop mode operates similar to open loop mode; however, seawater is heated via steam from gas-fired boilers prior to reaching the regasification system on the FSRU. The seawater is continuously drawn into the FSRU through seawater inlets and the seawater is heated by heat exchange with steam. Seawater use associated with combined loop regasification mode is the same as seawater use for open loop regasification.

#### Selection of the preferred regasification mode

The main benefit of the open loop regasification mode is that seawater from Corio Bay can be used by the onboard regasification plant on the FSRU to heat the LNG. This is an efficient and readily available means of heating the LNG without using additional fuel to generate heat for LNG vaporisation. Greenhouse gas emissions from open loop mode are substantially less than closed loop mode.

The preferred regasification mode of the FSRU is for operation in open loop mode, with modifications so that the FSRU seawater discharge from the regasification process can be redirected and reused within the adjacent refinery cooling water process. This provides significant environmental benefits as it results in the FSRU largely replacing the current seawater intake for the refinery and means that there is only one intake and one marine discharge when both the refinery and FSRU are operating at the one time. The alternative of direct discharge from the FSRU to Corio Bay would result in two separate water intakes and discharges from the refinery and FSRU. Use of the cooled water from the FSRU also reduces energy use and costs in the refinery.

The open loop mode of operation was considered to be the preferred option for the project based on environmental and economic grounds. The EES has also assessed the closed loop mode of operation as this would be used in the event where the refinery would not be able to accept discharge from the FSRU e.g., malfunction of the seawater transfer pipe.

Further information on the proposed regasification mode for the project is provided in Chapter 4: *Project description*.

## 3.7 Treatment facility design development

The following section outlines the key aspects involved in the design development of the onshore gas treatment facility, including site selection and facility layout, and potential nitrogen supply sources considered.

The treatment facility is where nitrogen and odorant injection, and gas metering would occur and where the pipeline would change from aboveground to underground prior to its connection to the Victorian gas network.

### 3.7.1 Site selection for the treatment facility

Site selection for the treatment facility was undertaken with consideration of site safety and security, suitable access for nitrogen trucks, access for operation and maintenance, and visual amenity.

A review was completed within the existing refinery boundaries to identify potential locations. The refinery was considered a 'base case' preferred location as an alternative to potentially locating the treatment facility external to the refinery. An external location was considered less desirable as it would not capitalise on the synergies associated with a refinery location and would be likely to have more potential environmental and amenity impacts. It was determined that the site selection process would only consider external site alternatives if the refinery option proved non-viable. Two areas within the refinery boundaries were identified for consideration: at the southern end of the refinery near the existing fire station (Option 1) and at the northern boundary within an existing laydown area known as Nerita Gardens (Option 2). A summary of the assessment is outlined in **Table 3-6** and the two areas that were considered are presented on **Figure 3-11**.

Table 3-6 Treatment facility location comparative analysis

| Criteria | Southern end of Refinery | Northern boundary of Refinery |
|---|---|---|
| Truck Access | • Good truck access to the refinery through existing heavy vehicle gazetted roads. Difficult access within the refinery for access and egress due to tight location. | • Good truck access through refinery and existing heavy vehicle gazetted roads |
| Visual Amenity | • Located adjacent to refinery equipment with an existing industrial outlook | • Located adjacent to existing tanks with screening from trees at the site boundary |
| Security | • Site would be difficult to separate from refinery operations making it challenging to secure the site for separate pipeline metering station access should this be required<br>• Site would be secure within existing MHF | • Site would be secure within existing MHF with potential for separate pipeline metering station access available, should this be required |
| Operational / Maintenance Access | • Easy access for personnel to site through using existing site staff to support operations and maintenance | • Easy access for personnel to site through using existing site staff to support operations and maintenance |
| Area | • Site location very restricted and challenging to fit facility within available space | • Sufficient room for facility |
| Environmental impacts | • Would require excavation of already disturbed area within the refinery, with the potential to disturb sediments that may contain some contaminants.<br>• Potential impacts would be similar to the option in the north of the refinery | • Would require excavation of already disturbed area within the refinery, with the potential to disturb sediments that may contain some contaminants.<br>• Potential impacts would be similar to the option in the south of the refinery |

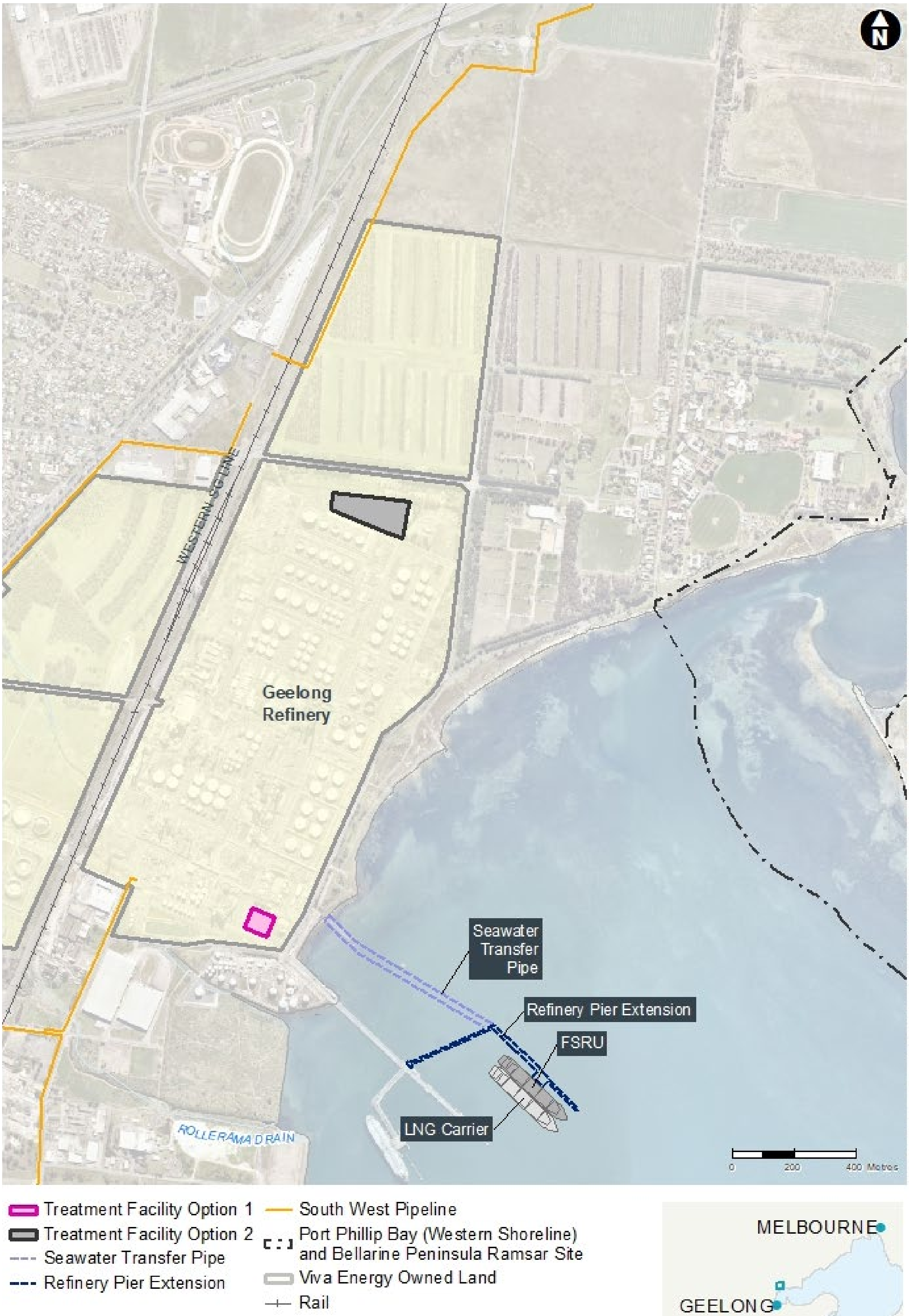



Figure 3-11 Treatment facility location alternatives

After the assessment, the Nerita Gardens area at the northern boundary of the site was identified as the preferred location for the treatment facility as it was a less restricted area than the southern site and did not involve location of the facility in close proximity to existing refinery plant and equipment. Safety studies (refer Technical Report N: *Safety, hazard and risk assessment* for further detail) completed during facility design have resulted in optimisation of the location of the facility within the Nerita Gardens area so as to minimise risk to refinery neighbours and the public.

### 3.7.2 Nitrogen supply sources

Following regasification on the FSRU, the gas would be transferred to the treatment facility where nitrogen injection into the gas may be required to bring it up to standards specified by the Australian Energy Market Operator (AEMO), prior to the gas entering the network. There were three options considered for the supply of nitrogen to the injection facility:

- Direct supply of nitrogen gas from a third-party
- Onsite nitrogen gas generation
- Onsite liquid nitrogen storage.

#### Third-party supply

Viva Energy currently sources nitrogen gas directly from a third-party co-located with the refinery. It is used within the refinery for activities such as purging and drying to pipeline pigging and pressure testing. However, the capacity of that plant would be much less than the potential amount of nitrogen gas required for this project. The advantage in having a third-party supply is that the nitrogen could be turned on and off as required, removing the cost and difficulties associated with installing, operating and maintaining the associated nitrogen equipment which could potentially be sitting idle for long periods of time if the LNG is lean (contains more than 95% methane) and meets specification. The disadvantage is that it is unlikely that a third party would be able to supply the required maximum rate of nitrogen necessary for the required duration.

#### Onsite generation

A wide range of nitrogen generation packages are commercially available, however, at the potential rates required for nitrogen injection, several large units would need to be installed on site and would constitute a nitrogen generating plant. An example of a nitrogen generation pack is shown in **Figure 3-12**. The disadvantage of this option was considered to be that a significant amount of compression power would be required. This could result in power loads in excess of 5 MW with additional load required for interstage cooling making the operating costs associated with this option extremely high.

Onsite production would, however, provide another potential synergy with current refinery operation. Production of nitrogen also results in the production of high purity oxygen which could be captured and used elsewhere in the refinery (e.g., for combustion). Also, as Viva Energy currently sources third-party nitrogen for use in the refinery, having the ability to produce nitrogen would remove this dependence.

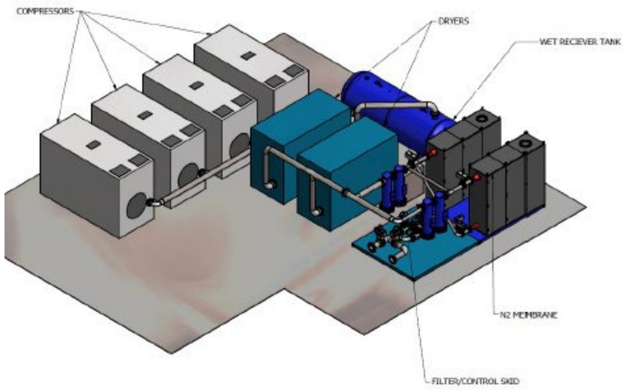



Figure 3-12 Example of a nitrogen generation pack

#### Onsite liquid nitrogen storage

This option would involve liquid nitrogen being trucked to the refinery from nitrogen suppliers and stored in cryogenic tanks installed at the treatment facility. The advantage of the onsite liquid nitrogen storage option is that the power required to pump liquid nitrogen from the storage tanks to vapourisers prior to injection is considerably less than for an onsite nitrogen gas generation package. The disadvantage is that the associated tanks, pumps, vaporisers and trim heaters all require significant space within the refinery.

**Selection of the preferred nitrogen supply source**

After detailed assessment, onsite liquid nitrogen storage was selected as the preferred option for nitrogen supply as it would be the most economical solution primarily by avoiding the need for compressors to generate nitrogen onsite.

There are two main types of storage for liquid nitrogen which are widely used for treatment facilities involving nitrogen injection. These are flat bottom tanks (FBT) and vacuum insulated vessels (VIV). The FBT is considered to be the best option for storing large amounts of liquid nitrogen, usually over 15,000m$^3$, with VIV the preferred option for volumes less than 250m$^3$.

It is anticipated that up to 575m$^3$ of nitrogen would be required per day based on a preliminary assessment of a 'rich' high energy density North West Shelf LNG composition. To discharge 170,000m$^3$ of North West shelf natural gas continuously at 500 TJ/day from the FSRU, it would take approximately 9 days and require 4,625m$^3$ of nitrogen.

To meet the nitrogen demand, the treatment facility would comprise of multiple liquid nitrogen storage vacuum insulated vessels containing up to 1200m$^3$ of liquid nitrogen. Nitrogen would be sourced from a variety of existing nitrogen providers by truck to both refill this storage volume but also to supplement the nitrogen consumed during rich LNG cargo campaigns.

Based on a comparative assessment of the two options which considered design, construction and safety and risk factors, VIV was considered to be the preferred storage option for the project for the following reasons:

- Less energy consumption
- Lower noise and vibration
- Shorter construction duration, with equipment being delivered fully assembled
- Greater accessibility for maintenance and inspection
- Lower visual profile
- Flexible operation with multiple tanks allows for future expansion
- Overall cost is approximately 50% less than the FBT option
- Lower potential for leaks or spills.

VIV can be positioned horizontally or vertically, with larger ground area required for horizontal placement. An example of a VIV is shown in **Figure 3-13**.

### 3.7.3 Blending with refinery gases

In order to reduce the nitrogen demand, the possibility of blending gases available within the refinery (e.g., hydrogen and/or carbon dioxide) was explored. The supply of such gases could not be guaranteed and would require additional pipework to be added. For these reasons this option was not further developed.


Figure 3-13 Example of VIV liquid nitrogen storage

## 3.8 Pipeline design development

The following sections describe the design development of the pipeline including selection and refinement of the proposed pipeline route and construction methodology, and selection of the pipeline tie-in facility location.

### 3.8.1 Pipeline route selection and refinement

The proposed pipeline route has been defined iteratively over a two-year period (since late 2019) through desktop and field studies and assessments, and engagement with stakeholders and landowners and occupiers.

The commencement point for the pipeline was determined by the selection of a new pier arm (Refinery Pier No. 5) extending to the northeast from the existing Refinery Pier as the proposed location for mooring of the FSRU (refer to **Section 3.4**). Selection of the termination point for the pipeline is discussed in **Section 3.9**.

Alternative pipeline routes were initially considered in a workshop to select a 'favourable route'. Since then, the design process and landowner, occupier and stakeholder consultation has continued resulting in further refinement of the route, as described below.

The criteria adopted for initial comparison of the pipeline route options were:

- Victorian Transmission System
- Safety/SIMOPs issues
- Constructability
- Land access
- Commercial
- Environmental and social
- Financial.

The route was considered in four segments with the selected 'favourable route' being a combination of favourable options from each segment. The identified segments were:

- Segment 1 – Refinery Pier
- Segment 2 – from Shell Parade to the treatment facility at the northern boundary of the refinery site, adjacent to School Road
- Segment 3 – from School Road to Bell Road
- Segment 4 – from Bell Road to the SWP tie-in point, Lara.

An overview of the segment options considered is shown in **Figure 3-14**.

**Segment 1**

As identified, in consultation with GeelongPort and Ports Victoria, this route runs along the new pier extension in a new pipe rack to the existing Refinery Pier and then within the existing pipe track (on the northern side of the pipe track) to the point where the existing pipelines divide adjacent to the Refinery Pier Gatehouse.

**Segment 2**

Three potential options were identified for this segment which extends from the Shell Parade to the treatment facility at the northern boundary of the refinery site, adjacent to School Road.

- Option 2A Refinery Road 9 - This option passes under Wharf Road adjacent to or in the existing under-crossing to run aboveground west of Road 9 within the refinery pipe trench to the treatment facility site north of Road 16.
- Option 2B Shell Parade - This option follows the existing pipe trench on the eastern side of Shell Parade north across the refinery cooling water intake. After crossing under Shell Parade, the pipeline continues underground in the Shell Parade road verge adjacent to the eastern boundary fence of the refinery to north of Road 16. The route turns west to enter the refinery and into the treatment facility site. The route is parallel to the white oil pipeline (WOPL) between Foreshore Road and Road 16.
- Option 2C Western railway line - This route crosses over the existing pipe track to run underground in the Wharf Road verge to Lowe Street. The route crosses into Lowe Street and runs west to the Western railway line reserve. Turning north the route runs in the reserve on the eastern side of the railway line, traversing the refinery employee car park leased from VicTrack. The route enters the refinery south of Road 16 to a potential alternative treatment facility site in the northwest corner of the refinery. This option would intersect with a heritage overlay site, the former Corio Distillery Complex on Lowe Street.

Option 2A was selected as the favourable option following the constraints analysis. The high asset co-location, third-party asset crossing and workspace constraints affecting all route options could be managed by the pipeline being located aboveground on existing pipe track and primarily within the refinery. Additionally, this would minimise potential land access / tenure issues.

The route was subsequently revised to avoid the highly constrained Wharf Road under-crossing and refinery entry such that it follows Option 2B along


Figure 3-14 Pipeline route alternatives (source: Coffey, 2020)

the existing pipe trench on the eastern side of Shell Parade and across the cooling water intake before crossing under Shell Parade and entering the refinery.

Optimisation of the location of the treatment facility site within the refinery laydown area known as Nerita Gardens (refer **Section 3.7.1**) has resulted in the aboveground pipeline section in the refinery Road 16 pipe trench being extended.

**Segment 3**

Three potential route options were identified in this segment, which extends from treatment facility at the northern boundary of the refinery site to Bell Road.

- Option 3A Shell Parade – This option runs east to Shell Parade from the treatment facility site, turning north to run in the road verge to School Road. After crossing the School Road-Shell Parade roundabout, the route continues north in the road verge to the Bell Road intersection. The route is parallel with and adjacent to the Westernport-Altona-Geelong crude oil pipeline (WAG), black oil pipeline (BOPL) and WOPL.,
- Option 3B Viva Energy/private & public property adjacent to Shell Parade – This option adopts the same route as 3A from the treatment facility to the School Road-Shell Parade roundabout but then runs north through the Viva Energy-owned paddocks and the Corio Native Grassland Reserve on the western side of Shell Parade to the Bell Road intersection.
- Option 3C Viva Energy/private & public property adjacent to the Western railway line – This option adopts the same route as 3A from the treatment facility to the School Road-Shell Parade roundabout. At the roundabout it turns west to run in the School Road verge. East of the Western railway line level crossing, the route enters the Viva Energy-owned paddocks to run north in the paddocks and then adjacent to the APA Brooklyn–Corio Gas Pipeline through the Corio Native Grassland Reserve to Bell Road.

Option 3A was initially chosen as the favourable option following the constraints analysis as it avoids potential impacts on the Corio Native Grassland Reserve.

Subsequently, following 'dial before you dig' enquiries and assessment of as-built location of assets, Option 3A was found not to be viable due to insufficient space being available in the Shell Parade road verge. Option 3B became the favourable option following further detailed ecological surveys which confirmed that native grassland and associated flora and fauna species would not be affected by the proposed alignment. The route was also revised to reduce traffic disruption by not interfering with the School Road roundabout and exiting the refinery site a short distance to the west.

Optimisation of the location of the treatment facility site (refer **Section 3.7.1**) has resulted in the underground pipeline section within Nerita Gardens being extended.

**Segment 4**

Five potential route options were identified in this segment, which extends from Bell Road to the SWP tie-in point at Lara.

- Option 4A Macgregor Court – From Bell Road the route follows the APA Brooklyn–Corio Gas Pipeline north to Cummins Road crossing under Bell Road and Macgregor Court to follow the gas pipeline on the eastern side. At Cummins Road, the route crosses Macgregor Court to run in the road verge on the western side parallel with and adjacent to the WAG and BOPL. At the northern end of Macgregor Court, the route is within the Lara City Gate access road which it follows to the facility, situated within Hovells Creek Reserve.
- Option 4B Rennie Street – From Bell Road this option heads north and crosses under the Princes Freeway to Rennie Street, west of the freeway. Then it follows Rennie Street northwards in farmland on the western side of the road. This route has two potential connection points, one on the SWP at a new facility west of the Princes Freeway and the other at Lara City Gate.
- Option 4C Bell Road, Biddlecombe Avenue, Cummins Road and Macgregor Court – This option runs east along Bell Road then turns north and heads along Biddlecombe Avenue. It then turns west and heads along Cummins Road until it reaches the Macgregor Court intersection where it then follows Option 4A.
- Option 4D Macgregor Court and Rennie Street – This option adopts Option 4A to Cummins Road where it proceeds as per Option 4B.
- Option 4E - Bell Road, Biddlecombe Avenue, Cummins Road and Turnstyle Court – This option adopts Option 4C to Cummins Road, where it then turns east and heads along Cummins Road. From there it turns north into Turnstyle Court, through the Hovells Creek Reserve carpark and to Macgregor Court where it turns to run along the Lara City Gate access road which it follows to the facility, situated within Hovells Creek Reserve.

Option 4A was selected as it is the most direct route. Subsequently, this route was revised so to avoid potentially affecting native grassland identified during further detailed ecological surveys by crossing Shell Parade north of the Bell Road intersection. The route was also revised to avoid affecting cultivated farmland to the east of Macgregor Court (south) (identified through ongoing landowner consultation) by remaining in the road verge.

To avoid land access constraints (identified through ongoing landowner consultation), Option 4A was subsequently realigned further to the west of Macgregor Court (south) and adjacent to the Princes Freeway. This section of pipeline would be constructed using HDD due to space constraints from pipeline and other infrastructure assets on the western side of Macgregor Court (south) and to avoid disturbance of native grass and threatened fauna habitat in the Macgregor Court road verge.

As a result of the change described above, Option 4A was further revised such that after crossing the APA Brooklyn-Corio Gas Pipeline, the pipeline continues north on the western side of Shell Parade traversing one private rural residential property and crossing under Rennie Street – Shell Parade roundabout. To reduce traffic disruption by not interfering with the Rennie Street – Shell Parade roundabout and impact on the affected landowner, this section of pipeline would also be constructed using HDD.

Space constraints in the Lara City Gate access road identified through 'dial before you dig' enquiries and assessment of as-built location of assets, also necessitated the route being altered to traverse private rural residential land at the northern end of Macgregor Court running parallel with and between the WAG and the APA Brooklyn-Corio Gas Pipeline before entering Hovells Creek Reserve.

## 3.9 South West Pipeline tie-in location

Two tie-in cases for connection to the SWP were considered:

- Tie-in to the DN500 Iona -Lara Gas Pipeline (SWP) - PL231 at Lara
- Tie-in to the DN350 Brooklyn-Corio Gas Pipeline (SWP) - PL81 close to C115 (Rennie Street - Shell Parade) roundabout.

It was determined that there could be potential flow constraints at the proposed gas production rate associated with a DN350 pipeline. Adopting a larger pipeline size for the project would not assist in resolving the issue if the DN350 Brooklyn – Corio Gas Pipeline location was chosen as the tie-in point would then become a bottleneck and prevent further increases in production. It was therefore not recommended to use the Brooklyn-Corio Gas Pipeline tie-in location, even though it is closer to the refinery and would be easier to construct.

For the purposes of selecting a 'favourable route' (see **Section 3.8**), it was concluded that tie-in to the SWP would be either within or close to the existing Lara City Gate Station facility on the eastern side of the Princes Freeway or across the freeway in existing farmland where a new facility would need to be constructed.

Subsequently, it was considered that the Lara City Gate tie-in location had the advantage of offering the potential for tie-in to an existing connection without the need to 'hot tap' (a procedure that makes a new pipeline connection while the pipeline remains in service). Furthermore, if a new facility were to be constructed on the western side of the Princes Highway, it would mean acquiring land and utilities such as power would also need to be installed.

This section has outlined the various alternatives and options considered during the development and design phase of the project. Detailed consideration has been given to a wide range of options related to preferred project location, onshore and offshore regasification alternatives, treatment facility location and pipeline alignments. It is considered that the detailed and thorough investigation of alternatives has led to optimisation of the project and enabled the most appropriate project to be considered in this EES.