

CHAPTER II

PROJECT DESCRIPTION

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1.0 INTRODUCTION

PERU LNG S.R.L. hereby referred to as the “Company” is undertaking a project to build a Liquefied Natural Gas (LNG) Export Facility (Facility) referred to as the LNG Export Project (Project) located on a greenfield site at Pampa Melchorita, on the west coast of Peru.

The Environmental Impact Assessment (EIA) presented herein evaluates the Project designed to provide LNG for transportation and export by sea. The Project will be located on a 521 hectares arid coastal site at Pampa Melchorita, located between the 167 to 170 kilometer (km) markers south of Lima on the west side of the Pan Americana Sur Highway.

The Project will provide Peru with capital investments, jobs and infrastructure creation, income through royalties and taxes, and a positive trade balance from energy exports.

The Project involves the construction and operation of a nominal 4.4 million metric tons per annum (MMTA) LNG Export Facility. The facility will process natural gas from the Camisea gas fields in the Camisea region located 500 km east of Lima. The detailed engineering and construction for the Project is planned to commence in 2004 with the first LNG production in 2007. The facility will include a marine trestle to load the LNG product into LNG Tankers for transportation by sea to potential customers. The Project location and adjacent areas are identified in Figure 1.

The Project consists of the following components (Figures 2 and 3 General Project Layout):

- Liquefaction Plant;
- Marine Facilities;
- Administration, Housing, Infrastructure and Utilities.

Associated projects include a high-pressure pipeline that will deliver the feedgas to the plant from the Camisea Gas Project in the Camisea region. The EIA for the main gas pipeline to Lima has already been approved by regulatory authorities. The approximately two kilometer spur line from the main pipeline to the plant site will be presented under a separate EIA.

LNG is created when natural gas is cooled to approximately minus 163 degrees Celsius (°C) at atmospheric pressure. Since there are economic limitations on the distance that natural gas can be transported through onshore or offshore gas pipelines, the liquefaction of natural gas to LNG product

facilitates the transportation and storage of natural gas in a safe and economic manner. LNG occupies a volume of approximately one - six hundredth of the equivalent volume of natural gas, which facilitates the storage and transportation of bulk supply of LNG using dedicated marine vessels.

LNG weighs less than water, is odorless, colorless, non-corrosive, and non-toxic. LNG vapors are only flammable under certain specific conditions that require a methane gas concentration of between 5.3% and 15% in air and an ignition source. One of the characteristics of LNG is not being explosive.

The Project has been designed to be safe and economically and environmentally efficient while providing a source of alternative clean fuel for the overseas market.

1.1 Nature of Project

The Project is a new task to design and construct a grass roots facility that has a normal capacity of 4.4 million metric tons per annum (MMTPA) of LNG.

Due to its location and requirements, central and local government entities including the MEM and Navy will have jurisdiction over portions of the project. The Company will obtain authorization from the corresponding entities in accordance with the applicable laws and regulations described in Chapter I of this EIA.

1.2 Justification and Objectives

The Camisea Project's recoverable gas reserves have been estimated at $3.11 \times 10^{11} \text{ m}^3$ with peak gas production rates of approximately $13.0 \times 10^9 \text{ m}^3/\text{yr}$. The natural gas reserves will be utilized to the maximum degree in Peru for domestic and industrial consumption.

The plant will process surplus natural gas supplies of $6.7 \times 10^9 \text{ m}^3/\text{yr}$ for export to meet the growing global LNG demand. In addition to the five economic benefits to Peru stated previously of capital investment, jobs creation, infrastructure creation, income through royalties and taxes, and a positive trade balance from energy exports, this Project will also add four key benefits of:

- Increased Camisea Project development to provide a greater supply of natural gas and liquids in Peru such as propane, butane, naphtha and diesel products for domestic use;

- New employment opportunities and foreign investment inflows during construction and ongoing operation of the new facilities and an incentive for additional outside investment to explore and develop additional gas reserves in Peru;
- Provide greater natural gas price stability and revenues to the Peru government from the long-term sale of exported LNG, and
- Economic impact to the area and a reliable, constant supply of a stable source of natural gas as a clean fuel or feedstock to support expansion of industrial and commercial projects.

1.3 Required Investment

The estimated capital investment for the Project is approximately \$ 1,000 MM US dollars.

1.4 Life Span of the Project

The life span of the plant will be about 30 years and may be extended by providing proper operation and maintenance (O&M) based on the ample experience with the construction and operation of plants worldwide.

The Company will implement O&M practices in order to extend the useful life of the plant. O&M practices will be addressed in the operating manual and programs that will be designed to maintain all equipment at its peak efficiency while providing maintenance and replacing parts as needed. The plant will implement a comprehensive condition monitoring and maintenance program.

At the conclusion of the life span of the plant, the equipment will be dismantled and sold on the open market and the site will be restored to accommodate other industrial uses.

1.5 Future Growth Plans

The LNG Plant is to be built as a single train facility with a nominal capacity of 4.4 million metric tons per annum (MMTPA). The plant site has space available for a second train, although no preinvestment or additional plans for future growth have been made.

1.6 Legal Condition

The proposed site for the plant will be located on a parcel of land purchased from the Superintendence (Superintendencia) of National Goods (SBN). This 521 hectares parcel of land, referred to as Pampa Melchorita, was previously transferred from the Ministry of Agriculture to the SBN for sale to the project at fair market price approved by a supreme decree signed by the Ministry of Economy and Finance approving the sale. The property will be zoned industrial by the Municipality of Cañete.

1.7 Consideration of Alternative Sites

Extensive siting studies were performed along the coastline of Peru to identify the appropriate location for the Project. In the process of site selection, potential sites were identified and evaluated using the following parameters and criteria:

- Evaluate potential coastal locations within 200 km south of Lima. Initial site selection criteria required a minimum 100 hectares land space;
- Eliminate all locations in areas with a high degree of environmental sensitivity;
- Eliminate densely populated areas;
- Identify clear areas of land on the coast with a minimum distance from shore to at least 15 m water depth and with a site elevation of at least 20 m to mitigate the effects of a tsunami hazard;
- Exclude areas where site preparation would result in significant difficulties;
- Exclude areas with potential of soil liquefaction from earthquakes, soil instability from soils movement and most importantly, no nearby faulting and seismically unstable soils due to the high seismic (earthquake) zones in Peru;
- Exclude areas where significant dredging and continuous maintenance dredging will be required;
- Give preference to oceanic conditions suitable for reliable tanker berthing operations;
- Give preference to sites with proximity to commercial centers that can provide raw materials and labor; and
- Give preference to sites with sufficient land area to accommodate expansion.

Using the above criteria, 17 specific sites were identified between the cities of Pisco and Lima during the year 2001; visits were made to candidate areas where additional information was collected. The main candidate sites included the following locations and their distance south of Lima: Sarapampa (106 to 110 km); 12 Beach Areas (113 to 131 km), Punta Corriente (123 km), Cerro Azul (130 km), Pampa Clarita (154 km) and Pampa Melchorita (167 km) (See Figure 4).

From this investigation two sites were selected initially for further investigation, Pampa Clarita (154 km south of Lima) and Punta Corriente (122 km south of Lima). The need identified during the Front End Engineering Design for the Project of a greater land space of 150 hectares eliminated the Punta Corriente site from consideration due to its limited land space in a heavily developed area. Pampa Clarita located 154 km south of Lima was considered as the preferred site due to greater land space availability and less cost for site preparation and this site was investigated in greater detail. Onshore and offshore engineering studies, environmental baseline studies, archeological, geotechnical, and socio-economic studies were conducted at the Pampa Clarita site. Based on the results of the studies at Pampa Clarita, the Pampa Clarita site was discarded. This was due to encountering swelling clays, which create unstable foundation conditions for the critical LNG Storage Tanks and to archaeology and socio-cultural impacts associated with the construction of the proposed Facility on this site.

Pampa Melchorita was considered as the third most likely site for the Project, but was not initially selected as the preferred site due to its elevated location of 135 masl requiring a significant road for coastal access. The elevated site was also expected to reduce the amount of LNG that could be shipped due to additional boil-off gas generated from heat leak as the LNG is carried by pipeline from the 135 m elevation to near sea level at the marine loading facilities for LNG Tanker loading. After further engineering evaluation, however, a safer, more economic configuration was designed for the site. This configuration uses gravity drainage to a remote secondary containment sump at an elevation of 70 m. This permits the use of two 110,000 m³, double walled, single containment tanks versus an originally designed 185,000 m³ full containment tank for LNG storage offsetting the disadvantages of the elevated site. With this configuration, Pampa Melchorita was then selected as the site for the LNG Export Facility to conduct the EIA studies described in this report.

2.0 COMPONENTS OF THE PROJECT

The following sections present a description of the major process units of the plant. An overall process block diagram of the plant is presented in Figure 5. Detailed block diagrams of the natural

gas treatment and refrigeration and liquefaction processes are presented in Figures 6, 7. and 8. The raw natural gas from the Camisea Project is processed in the Malvinas NGL Plant to filter, dry and remove propane, butane, naphtha and heavier components. No sulfur compounds are known to exist in the raw natural gas. A spur pipeline from the main pipeline will deliver the dry and lean processed feedgas to the LNG facility. The proposed LNG Export Project as described in this EIA begins at the outlet flange of the pig receiver of the spur pipeline.

2.1 Liquefaction Plant

The proposed plant involves the construction and operation of a 4.4 MMTPA capacity LNG plant using the Air Products and Chemicals, Inc (APCI) propane precooled mixed refrigerant (MR) liquefaction process.

The plant contains the following process units:

- Feedgas Receiving, Liquid Separation, Gas Metering and Pressure Reduction;
- Acid Gas Removal (Carbon Dioxide);
- Gas Dehydration and Carbon Adsorption Units;
- Refrigeration and Liquefaction;
- LNG Storage;
- Refrigerant Storage;
- Marine Facility.

The major plant process units at the Project site will be located at an elevation of 135 meters above mean sea level (masl) with the LNG Storage Tanks located at an elevation of 127 masl.

2.1.1 Feedgas Receiving Unit (FRU)

As a safety measure, the Feedgas Receiving Unit (FRU) will be designed to separate and store any liquids that might remain in the gas supply pipeline after initial hydro testing operations or form due to any upstream upset and pigging operations. The feedgas will flow through an Inlet Knock Out (KO) Drum to remove any free liquids that collect in the pipeline. Liquids removed from the Inlet

KO drum are sent to a Flash Drum, where the vapors are routed to the flare/vent system and the liquid phase is sent to the plant Slop Oil Tank for offsite recycling or disposal.

After the Inlet KO Drum, the feedgas is reduced in pressure to the plant operating pressure of 72 bara and then heated in a hot oil heat exchanger to maintain the outlet gas temperature at 18 °C. The feedgas is then sent to an Inlet Filter Separator to remove any entrained liquids and any particulate matter before entering the metering system.

The Plant inlet area is designed for a full range of feedgas and ambient conditions as presented in the following table:

Parameter	Units	Design Specifications
Feed Temperature	°C	30
Feed Pressure	Bar	71-159
Total Mass Flow (dry basis)	Kg/h	607,370
Feed Molecular weight	Kg/kg mol	17.97

Component	Mole %
Nitrogen	0.53
Carbon Dioxide	1.50
Methane	87.71
Ethylene	0.00
Ethane	10.24
Propane	0.02
Total	100.00

2.1.2 Acid Gas Removal Unit (AGRU)

The Acid Gas Removal Unit (AGRU) will process natural gas from the FRU to remove carbon dioxide, the acid gas contaminant present in the feedgas. The carbon dioxide is considered a contaminant because it would freeze in the cryogenic process of converting gaseous methane to liquid

methane and block the process flow. BASF AKTIENGESELLSCHAFT (BASF) is an International chemical company who licenses the technology for removal of carbon dioxide (CO₂) and hydrogen sulfide (H₂S) (collectively referred to as acid gas) from natural gas using activated Methyl Diethanolamine (aMDEA), a tertiary amine. The activated MDEA (aMDEA) is an aqueous solution of MDEA plus an activator chemical. There is no hydrogen sulfide present in the Camisea feedgas. The aMDEA is a non-toxic and non-corrosive solution. A Material Safety Data Sheet (MSDS) for activated Methyl Diethanolamine is presented in Appendix 1.

2.1.2.1 Gas Treatment

Carbon dioxide (CO₂) in the feedgas will be removed to acceptable levels by amine absorption. Sufficient CO₂ is removed to ensure that the feedgas arrives at the LNG liquefaction unit with less than 50 ppm (v) of CO₂. At any greater concentration of CO₂, the feedgas will freeze, blocking the flow of feedgas and preventing the production of LNG. The CO₂ is removed by countercurrent contact of the feedgas with the circulating aMDEA solution in the Acid Gas Removal (AGR) Absorber. After the CO₂ is removed the now treated or "sweetened" gas is cooled. This cooling process condenses water from the feedgas that was picked up in the AGR Absorber. The cooled gas enters the Treated Gas Wash Drum where makeup water is used to wash the feedgas and remove aMDEA carryover from the sweetened gas. The makeup water and the condensed water from Wash Drum are sent to HP Flash for water makeup to the AGRU.

2.1.3 Dehydration Unit

The Dehydration Unit dries the water-saturated gas leaving the AGRU to meet cryogenic process specification requirements. The Dehydration Unit uses a three-bed molecular sieve configuration; two beds operating in the absorption mode while the third bed is undergoing regeneration. Each molecular sieve bed is regenerated every 24 hours. The Dehydration Unit dries the water-saturated treated gas down to less than 1 ppm(v) of water to avoid freezing and plugging in the cryogenic liquefaction unit by gas hydrates.

Dehydration is achieved by first precooling the treated feedgas from the AGRU in the Wet Feed/HHP Propane Vaporizer to condense and remove the bulk of the water. By reducing the water content of the feedgas, the load on the Dehydration Unit is decreased significantly. Liquids formed in the cooling process are removed in the Dehydrator Inlet Separator and returned to the AGRU as water

makeup. The remaining water is then adsorbed from the feedgas in the Molecular Sieve System. A Material Safety Data Sheet (MSDS) for molecular sieve is presented in Appendix 1.

The regeneration gas is initially heated in the Regeneration Gas Heater and then passes through the molecular sieve bed to remove the adsorbed water. The regeneration gas is then air-cooled to condense and separate the water and fed to the fuel gas system. Dried feedgas from the Dehydration Unit passes through the Natural Gas Dehydrators Afterfilter before entering the Activated Carbon Adsorber.

2.1.4 Activated Carbon Adsorber

An Activated Carbon Adsorber is being provided as a safety measure to ensure, reliable operation of the LNG facility. An Activated Carbon Adsorber will remove any heavy metals present in the feedgas to avoid corrosion problems in the aluminum components of the liquefaction process equipment. This is achieved by adsorption through an activated carbon bed. The treated feedgas continues to the LNG Liquefaction unit. Spent sulfur-impregnated, activated carbon filters will be returned to the supplier for regeneration and/or disposal. . A Material Safety Data Sheet (MSDS) for Activated Carbon Adsorber is presented in Appendix 1.

2.1.5 Refrigeration/Liquefaction Unit

Treated gas from the Activated Carbon Adsorber is fed to the Refrigeration and Liquefaction Unit. The Refrigeration and Liquefaction Unit liquefies the treated feedgas into LNG to enable storage at near atmospheric pressures. The Refrigeration and Liquefaction Unit will utilize the Air Products and Chemicals, Inc. (APCI) Propane Pre-cooled/Mixed Refrigerant (C3-MR) LNG process. Refrigerant compressors will be driven by two - GE Frame 7 gas turbines equipped with 10 megawatt (MW) starter/helper electric motors, a proven technology in the LNG industry. The GE Frame 7 gas turbines used to operate the compressors are ISO rated for 85 MW each. The gas turbines will be fired using treated natural gas obtained from the feedgas stream following the acid gas removal, dehydration and heavy metal removal processes.

Due to the moderate climate along the coast of Peru, the system will use less costly and more environmentally friendly, air-cooled heat exchangers instead of seawater cooling that is used in most LNG plants in operation today.

2.1.5.1 Natural Gas Liquefaction

The Air Products and Chemicals, Inc. (APCI) propane precooled multi-component refrigerant process uses two types of refrigeration cycles to precool and liquefy the feedgas. The feedgas is first precooled using propane refrigerant at four different descending pressure levels with corresponding temperatures. After being cooled by the propane refrigeration, the feedgas enters the Main Cryogenic Heat Exchanger (MCHE). In the MCHE the feedgas is further cooled and totally condensed by the mixed refrigerant (MR). The subcooled LNG leaving the MCHE is reduced in pressure by a control valve and is then sent to the LNG Storage Tank. The LNG entering the Storage Tanks is at 1.08 bara pressure and -163.1°C temperature.

2.1.5.2 Propane Circuit

Propane vapor from the heat exchangers at each pressure level is fed to the four-stage propane compressor at a high-high pressure (HHP), high pressure (HP), medium pressure (MP), low pressure (LP), where it is compressed to approximately 15 bara. The propane refrigerant is cooled and condensed at 29°C using air before being returned to the various propane refrigerant heat exchangers. Propane refrigeration is provided at the following four temperature levels:

- High High-Pressure (HHP) Propane Refrigeration Level which operates at 12.61°C and 6.85 bara;
- High Pressure (HP) Propane Refrigeration Level which operates at 5.01°C and 4.06 bara;
- Medium Pressure (MP) Propane Refrigeration Level which operates at -20.55°C and 2.39 bara and;
- Low Pressure (LP) Propane Refrigeration Level, which operates at -36.25°C and 1.30 bara.

Propane will be trucked in and stored in two horizontal bullet type storage tanks.

2.1.5.3 Mixed Refrigerant Circuit

Low temperature refrigeration is provided by a closed loop MR system. This mixture of nitrogen (N_2), methane (C_1), ethylene (C_2), ethane (C_2) and propane (C_3) is used to liquefy and subcool the feedgas in the MCHE. The MR refrigeration is compressed from 4.7 bara in three stages as follows:

- Low Pressure (LP) Mixed Refrigerant at 20 bara;
- Medium Pressure (MP) Mixed Refrigerant at 29.1 bara; and
- High Pressure (HP) Mixed Refrigerant at 59.5 bara.

The mixed refrigeration compression cycle is powered by a Frame 7 gas turbine and helper motor that drives the LP MR Compressor and the MP MR Compressor. The HP MR Compressor is powered by the same Frame 7 gas turbine and helper motor that drive the Propane Compressor. After compression, the MR refrigerant is precooled to -33.5°C by the four stages of propane refrigeration in parallel with the feedgas cooling. The precooled MR is then flashed to the MCHE to cool the feedgas to -163.1°C to make LNG. MR make-up will be provided from the feedgas containing mostly methane with some ethane and nitrogen. Nitrogen make-up will be provided by an air separation package. Ethylene will be trucked in and stored in vacuum jacket insulated bullet storage tanks.

2.1.6 LNG Storage

The two (2) LNG Storage Tanks proposed for the plant are of single containment design with each tank having a capacity of $110,000\text{ m}^3$. As required by NFPA 59A, the tanks will have a common secondary containment area. The LNG product from the MCHE is stored at near-atmospheric pressure in the Storage Tanks. Approximate tank dimensions are 70 meters in diameter by 32 meters in height.

The LNG storage tanks operate at a pressure of 1.08 bara and a temperature of -163.1°C . Each LNG Storage Tank will be provided with four in-tank LNG Loading Pumps located in vertical pump wells. To maintain pipe cooling when not loading an LNG Tanker, the pump recycle piping will allow the loading pumps to kick back LNG to provide precise flow control and maintain minimum flow circulation.

Vapor in the LNG Storage Tanks is not flared but will be collected by the Boil Off Gas (BOG) Compressors. The gas collected by the BOG Compressors is used as fuel for the plant equipment. The staging control of the BOG Compressors keeps the pressure in the LNG Storage Tanks at the desired operating pressure range. The LNG Storage Tanks will have pressure-control valves (PCVs) designed to open at predetermined maximum pressures to prevent excess vapors from accumulating in the tanks.

A common secondary containment system has been provided in the event of an LNG spill. This containment area has been located approximately 300 meters to the West of the two LNG tanks. A system of channels has been provided to divert any potential spill from an LNG tank, away from the adjacent LNG tank and into the secondary containment area. As is typically done in other LNG facilities, the secondary containment and the channels will be constructed of natural granular material. In the event of an LNG spill in this area, the LNG will flow by gravity to the lower elevation where the secondary containment is located. The LNG will not pollute or harm the granular soil in this area, because of the Leidenfrost effect, which occurs when a cold liquid comes into contact with a warm surface that is at a temperature much higher than its boiling point, and it causes the liquid to vaporize at such a rate that it forms a layer of insulating vapor between it and the surface, thereby insulated the ground from the LNG. Because of this effect, no LNG can migrate into the ground making the need for an impermeable membrane of seal is unnecessary and industry practice is to use natural granular material for the secondary containment areas without any specified permeability requirement. NFPA 59A requires this containment area to be 100% of the largest tank volume. The containment has been increased to 110% to be in compliance with paragraph's band c, Article 24 of Supreme Decree No. 046-93-EM (Regulations for Environmental Protection in Hydrocarbon Activities).

The LNG Storage Tanks will also have vacuum breakers on the tank that open to control the maximum vacuum in the storage tank. Dry, high-pressure feedgas is introduced into the tank to prevent pulling a vacuum on the tank during ship loading operations.

The Project site is located in seismic zone 4 and therefore all structures and equipment will be designed to Uniform Building Code, vol. 2, Chapter 16, Division IV (Earthquake Design). LNG structures and system shall be designed to resist earthquake forces in accordance with NFPA 59A. LNG storage tanks are designed in accordance with API 620 and their anchorage with Appendix E of API 650 Zone 4 and Appendix L of API 620.

The plant will produce LNG with approximately the following components:

Component	Mole %
Methane	89.55
Ethane	10.45
Total	100.00

2.1.7 Refrigerant Storage

Since the feedgas is very lean and the propane and ethylene refrigerants are not available directly from the feedgas, the make up refrigerants will be imported. Refrigerant storage facilities will be provided on site to receive the refrigerant, which will be delivered by truck and stored in dedicated bullet tanks. Propane will be available locally as a by-product of the Camisea Gas Project and will be obtained from the LPG Fractionation Plant. Ethylene is not available locally and therefore the Plant will import and store ethylene in small quantities to maintain adequate standby inventory as part of the C3-MR refrigeration and liquefaction process. Propane and ethylene will each be stored in horizontal bullet type storage tanks. The two propane bullets will be 4.5-m diameter and 25 m long with a volume of 602 m³ each. The two ethylene bullet storage tanks will be 4 m in diameter and 20 m long with a total capacity of 200 m³ each.

2.2 Marine Facilities

The LNG plant will be designed to include marine loading facilities. These facilities include:

- Trestle;
- Breakwater;
- Access Navigational Channel for LNG Tankers;
- LNG Tanker Berth and LNG Loading Arms;
- Tug Berths;
- Utility Dock; and
- Lighting and Navigational Aids.

2.2.1 Trestle

The marine facilities include an approximately 1.3 km long trestle aligned along an azimuth of 225 degrees extending from shore to the loading platform. The trestle consists of a steel superstructure supported by driven steel pipe piles and a cast-in-place concrete abutment. The trestle supports piping, auxiliary mechanical and electrical systems, and an access roadway. (See Figures 9 and 10)

2.2.2 Breakwater

The site has some natural wave protection from the Peninsula of Paracas to the south, but is exposed to long-period Pacific swells, primarily from the southwest. To provide acceptable berth availability, a “fit-for-purpose” breakwater is required to limit wave-induced tanker motions and mooring line tensions.

A berm style breakwater design is selected for use and is planned to be an “island” located seaward from the loading dock with no causeway or other type of connection to the land. The proposed breakwater is located in approximately 14 m of water, is 800 m long, and is aligned along an azimuth of 135 degrees to orient it approximately parallel to the coastline and to the sea bottom contours. A crest elevation of 8.5 m above mean lower water springs (MLWS) allows the 100-year design wave to overtop with very little damage.

The breakwater will have a core consisting of quarry run rock material ranging from small size rock up to 3 tonne size with filter rock and exposed layers made up rock varying from 3 to 10 tonne size. The smallest size rock in the core will be approximately 5 kg in size (See previous Figure 9 for location and Figure 11 and Figure 12 for details). No silts, sand or small gravel material will be incorporated into the breakwater; the total volume in-place will be approximately 1,200,000 m³.

2.2.3 Access Navigational Channel for LNG Tankers

A LNG Tanker access channel will be dredged approximately one to two meters, 250 m width and 800 m in length to provide the required water depth at the berth of 15 m at MLWS. The approach channel to the berth area will require a water depth of 18 ms at MLWS to accommodate the tanker turning operations for long period swell under keel clearance. LNG Tankers may approach the berth from either the north or south depending on environmental conditions. A turning operation is required on arrival and departure due to the shape of the approach channel. The approach and departure channels (navigational channel) will be dredged approximately 3 m, 250 m width and approximately 2,700 m in length to a depth of 18 m. (See Figure 13)

2.2.4 LNG Tanker Berth and Loading Dock

The LNG berth structures consist of a 30-meters by 30 meters loading platform, four breasting dolphins and six mooring dolphins. These berth structures consist of open grid steel decks on steel

beams supported by steel pipe piles driven through steel jackets. The loading platform provides sufficient area for the loading arms, operator's station, power supplies, control systems, emergency systems and access for a mobile crane or other equipment for maintenance purposes. A closed deck area with curbs and a containment sump is provided under the loading arms.

No facilities for treating ballast water are provided for at the berth, however, LNG carriers will be required to operate and receive and treat ballast waters in accordance with MARPOL A 774 (18) as specified in Directorate Resolution No. 0178-96-DCG. LNG Tankers have dedicated ballast water tanks that only contain clean seawater and never contact any pollutants. In accordance with these requirements the LNG Tanker will discharge up to 48,000 m³ of ballast water from its port of departure and re-ballast with clean water from the 12 mile limit of the Peruvian coast line. As recommended by the IMO guidelines this practice currently provides the best available measure to reduce the risk of transferring harmful aquatic organisms. This clean ballast water will be discharged as ballast and a water curtain during loading. LNG Tankers will also be required to comply with applicable Society of International Gas Tanker and Terminal Operators (SIGTTO) regulations applicable Peruvian maritime regulations as well as the California Ballast Management Program.

2.2.5 Tug Berths

Permanent berth facilities are provided to maintain three tugs on location on a full-time basis. Tug berths are located immediately adjacent to the northern mooring dolphins. Personnel access to the tugs is provided via a series of catwalks between the loading dock and mooring dolphins to the tug berths. The location of the berths relative to the breakwater has been chosen to provide maximum shielding from both sea and swell. (See Figure 14)

2.2.6 Utility Dock

A small Utility Dock has been provided on the south side of the trestle approximately 90 m from the loading platform. The Utility Dock is used to temporarily berth a tug for refueling, to support seawater intake equipment, to provide a deck area for vehicle parking, and to provide a working area for a mobile crane to support routine maintenance and tug supply operations. The Utility Dock will have facilities for tug refueling and spill containment. Waste from the tugs will be removed in barrels or by vacuum truck for processing by the plant waste handling systems. Access to the tug from the Utility Dock is provided via a gangway between the trestle deck and the berth. The location of the

utility dock relative to the breakwater allows a tug or service vessel protection and has been chosen to provide high berth availability.

2.2.7 Other Marine Facilities

2.2.7.1 Vapor Handling

During normal operation, boil-off gas is produced in the LNG Storage Tanks by heat leak from surroundings at a rate equivalent to 0.05 percent per day of the tank's inventory. Vapor from the tanks is routed via BOG Compressors where the gas pressure is increased to the HP Fuel Gas pressure of 28 bara and used in the plant fuel gas system. During normal operations, some LNG will be circulated through the tanker loading and return lines at a low rate of 300 m³/hr to keep the loading and return lines cold and collect any vapor caused by heat gain in the LNG Storage Tanks where it is collected by the BOG Compressors. All significant lengths of loading lines filled with LNG shall have continuous circulation to maintain a cryogenic condition.

During the beginning of tanker loading operations, the quantity of boil-off gas increases significantly. Additional gas is generated because the volume displacement in the LNG Tanker's tanks, gas generated from energy input from the plant pumps, the pressure differential between the LNG Tanker and the LNG Storage Tanks, and heat leaks through the Loading Arm lines. A marine flare is not provided for vapor in the LNG Tanker's tanks; instead, a large size return vapor line is provided back to the plant. The BOG Compression System has a large capacity to avoid any unnecessary flaring. Throughout the non-loading operations the loading lines are kept cold by recirculating about 30% of the LNG rundown stream.

During tanker loading mode, LNG rundown is sent directly to the LNG Tanker. LNG pumped from the tanks will enter the loading header, where a fraction of the LNG will be diverted to the return header.

2.2.7.2 Navigational Aids

The following navigational aids will be provided at the proximity of the marine facilities and structures:

- Racon;

- Sea Buoys;
- Leading Lights;
- Gate Buoys;
- Breakwater Markings;
- Extreme Mooring Dolphins Markings; and
- Laser berthing aid system for speed and distance approaching the dock.

2.2.7.3 Loading Arms

LNG loading is accomplished by using four 16-inch specialty LNG Loading Arms of the pipe and swivel design. Three arms will be used for LNG loading and one for vapor return to the BOG Compressors. One of the three Loading Arms will also be suitable for a vapor return service, if needed. The Loading Arms will be supplied with power emergency release couplings (PERC's) for remote release should the tanker need to quickly disembark during LNG loading operations. The PERC's have mechanically linked double block valves that close before the release can be engaged to reduce LNG spillage to less than 0.02 m³. The design loading rate from the Plant to the tanker is 11,250 m³/hr using the three LNG Loading Arms. The pumps are sized to load 134,000 m³ of LNG within 12 hours into an LNG Tanker. The arms will have the ability to allow for all of the combinations of tanker movement associated with changes in draft condition, tidal changes and wave conditions at the loading dock.

2.2.7.4 Drainage and LNG Spill Containment

The loading platform will have drainage and a minor LNG spill containment system. The system is sized to handle a spill with a duration of approximately 70 seconds, which is in excess of the lead time to observe and execute an emergency shutdown. Such an LNG spill will be retained in a curbed deck area and collected in a stainless steel vessel under the dock and above the water. This LNG containment system is in addition to the NFPA 59A requirements. A containment system will be constructed around the diesel above ground fuel tank to contain any accidental spills associated with the operation of this tank. In addition, all sanitary sewage generated from the operations of the control room at the trestle will be collected in a sump and periodically removed by a vacuum truck to the wastewater treatment plant.

2.2.7.5 Breasting and Mooring Structures

The breasting and mooring arrangements consist of four (4) breasting dolphins and six (6) mooring dolphin structures. All of the tanker berthing or mooring forces will be resisted by the breasting and mooring structures mentioned above. Each mooring and breasting structure will be equipped with a load monitoring system, lights and a quick release mooring hooks system for manual or remote control. Figure 14 presents the proposed breasting and mooring structures for the Marine Facilities.

2.2.7.6 Gangway Tower

An articulated, hydraulic gangway will be provided at an inner breasting dolphin to allow access to and from the tanker for crewmembers, customs, health and port officials, pilots, etc. An emergency release system will be provided to retract and clear the vessel during any emergency.

2.2.7.7 Vessel Docking Assistance and Load Monitoring System

A Berthing Aid System (BAS) will be provided to inform in real time the speed of approach, distance to berth, and angle of approach for a vessel up to 200 m from the berth. The Vessel Load Monitoring System (VLMS) will be provided to inform the facility operator in real time the loads on all mooring lines. All of these systems will be integrated to other information systems such as weather radar and loading arm monitoring systems.

2.3 Utilities

The LNG Project will be a totally self-contained development that will include all the required utility facilities to support both plant and ancillary operations. The major utility generation and distribution systems include:

- Power Generation System;
- Fuel Gas System Process;
- Heating Medium (Hot Oil) System;
- Diesel/Gasoline Storage System;
- Nitrogen System;
- Plant and Instrument Air Systems;
- Fire Protection System;

- Flare and Blowdown System;
- Plant Controls and Information Systems;
- Water Utility Systems; and
- Waste Handling and Disposal Systems.

2.3.1 Power Generation System

The LNG plant will be designed with a power generation system to supply all electrical power demands of the plant.

2.3.1.1 Power Generators

Three GE Frame 5 industrial gas turbine generators having a total installed capacity of 69 MW will supply electricity to provide for the total facility requirements. During normal operations two gas turbines will be in operation and one on standby. The power demands for the plant will be 33 MW during normal operations with a peak load demand of 40 MW during tanker loading of the LNG. This includes a 10 MW helper motor for each of the main process refrigeration compressors. The gas turbines will be fired using dry natural gas from the plant fuel gas system.

2.3.1.2 Emergency Generators

A 2 MW diesel-driven emergency generator will be provided to supply emergency power for plant start-up and in the event of any power system failure. Diesel fuel for the generators will be stored on-site in a cone roof 170 m³ aboveground storage tank with an impervious secondary containment. The tank will be 6.5 m in diameter and 6 m in height.

2.3.2 Fuel Gas System

The Fuel Gas System design is based on supplying high-pressure fuel gas to two GE Frame 7 gas turbine drivers and three GE Frame 5 gas turbines. (See Figure 15) The GE Frame 7 turbines will be used to drive the propane compressor and the mixed refrigerant compressors. The GE Frame 5 turbines will be used for power generation with two gas turbines operating at base load and one on standby. The fuel gas will also be used to supply the flare systems with purge gas and pilot fuel gas, the dehydration unit direct fired Regeneration Gas Heater and the Hot Oil Heaters.

The natural gas needed for fuel gas is provided from the following sources: natural gas collected from the BOG Compressors, off gas from regeneration of the feedgas dehydrators, with make up from the natural gas feed from both downstream of dehydration and upstream of the AGRU. The combined gas is preheated to 27 °C using hot oil as the heating medium prior to mixing in the HP Fuel Gas Drum. This drum supplies high-pressure gas to the gas turbine drivers. Fuel gas is also let down to a LP Fuel Gas Drum for supply to the Hot Oil Heaters and miscellaneous services.

2.3.3 Medium Heating System

The Plant is equipped with a hot oil system that provides heat to the Inlet Gas Heater, the AGRU Regeneration Reboilers and the HP Fuel Gas Heater. (See Figure 16)

2.3.3.1 Hot Oil System

The equipment associated with the Hot Oil System is located within the area of the plant adjacent to the utility systems and consist of a storage tank, transfer and circulation pumps, two oil heaters, filter and an expansion drum. Hot oil is delivered to the Facility in drums by truck and loaded into the Hot Oil Storage Tank. A Material Safety Data Sheet (MSDS) for Hot Oil is presented in Appendix 1.

The maximum operating temperature of the hot oil used in the operations will be limited to 180 °C (Normal Operating Temp 170 °C) to prevent degradation of the solvent in the AGRU. The hot oil is anticipated to last 15 years and will only require make-up and will be replaced after its useful life. The following sections provide descriptions of the various components of the Hot Oil System. The used oil will be properly recycled or disposed according to standards in effect at the time of its removal from the system.

2.3.3.2 Hot Oil Transfer Pump

The Hot Oil Transfer Pump will be utilized for filling the Hot Oil System from the Hot Oil Storage Tank. This pump will start manually since the use of the system is intermittent. The pump has a capacity of 10.8 m³/hr and will fill the system in 48 hours during the commissioning of the plant.

2.3.3.3 Hot Oil Expansion Drum

The Hot Oil Expansion Drum provides a buffer for variations in the system volume and allows the removal of process gasses generated from the hot oil. The drum is blanketed with nitrogen to

maintain a constant system pressure during changes in system volume and to exclude air. The Expansion Drum will be elevated to minimize its capacity during drain down on total hot oil systems loss. Approximate volume of the Drum is 145 m³, which gives 5 minutes residence time.

The capacity allows time for operator correction due to losses, leaks, malfunctions, expansion and contraction. The drum provides separation of gas from oil and process leaks. Vapor from the Hot Oil Expansion Drum is sent to the Wet Gas Flare.

2.3.3.4 Hot Oil Circulation Pump

Hot Oil Circulation Pump draws oil from the Expansion Drum to the Hot Oil Heaters where it is heated to 170 °C. The Hot Oil Circulation Pump has an operating flow rate of 1270 m³/hr (including slipstream). The Plant has been designed with one operating pump plus one on pump on standby. The 10% slipstream from the pump discharge is sent through a filter and back to the inlet of the Expansion Drum.

2.3.3.5 Hot Oil Heaters

The oil will be heated using two fuel gas fired heaters with a total capacity of 25 MW, which normally heats the oil from 130 °C to 170 °C.

2.3.3.6 Hot Oil Storage Tank

The 50 m³ Hot Oil Storage Tank is an aboveground tank that is nitrogen blanketed to keep air and water out of the Hot Oil System, which minimize the degradation of oil and any operational problems from water. The Hot Oil Storage Tank and Hot Oil Transfer Pump will provide for charging and make up losses (from leakage and maintenance drains) for the hot oil systems. Hot oil will be stored on-site in a cone-roof tank with an impervious secondary containment. The tank will be 3.5 m in diameter and 6 m in height.

2.3.4 Diesel/Gasoline Storage System

A 170 m³ aboveground Diesel Storage Tank is proposed for the plant to provide fuel to the following: (See Figure 17)

- Operation of engine-driven plant equipment such as fire pumps and emergency generators;

- Fueling of plant vehicles; and
- Marine fueling for tugboats.

The Diesel Storage Tank has been designed on refueling requirements for three tugboats used to assist the LNG Tankers into port every five days. The tank will replenish the fuel consumed by the tugboats as well as supply a plant working volume of 100 gallons per day which is equivalent to the site maximum anticipated demand over a 7-day period and normal demand over a 30-day period. The tank will be nitrogen blanketed. The tank will be 6.5 m in diameter and 6 m in height.

A small Gasoline Storage Tank will be provided for fuelling light duty cars and trucks.

All engine-driven plant equipment will be provided with its own diesel day tank, sized to store sufficient fuel for 12 hours of continuous operation. Day tanks are refilled from the bulk Diesel Storage Tank via two diesel transfer pumps rated at 20 m³/hr each. All aboveground fuel tanks will be designed with a secondary containment. A Material Safety Data Sheet (MSDS) for Diesel and Gasoline is presented in Appendix 1.

2.3.5 Nitrogen System

The LNG Plant will utilize the inert nitrogen gas for purging or blanketing of equipment. Nitrogen at the plant will be generated by separating atmospheric air in a cryogenic air separation unit. (See Figure 18) The dry feed air to the air separation packages is supplied from the plant's instrument air system at a pressure of 9.0 bara. The nitrogen gas is distributed as gas directly to the various users at the plant, or stored as liquid in a cryogenic storage tank. Liquid nitrogen is then vaporized for use during peak demands.

The plant will have a single cryogenic storage vessel designed to store 100,000 kg of liquid nitrogen. The storage vessel will be sufficient to store the extra nitrogen required during all peak demands.

Two liquid nitrogen ambient fin type vaporizers will be provided, one for duty and one on standby. The vaporizers are rated for 1000 Nm³/hr each at a nominal outlet pressure of 7.0 bara. A separate vaporizer also maintains pressure in the tank to meet nitrogen supply pressure of 7 bara.

2.3.6 Plant and Instrument Air Systems

The LNG Plant will be provided with a system to supply compressed air for the following purposes (See Figure 18):

- Dry air for instruments and purging;
- Dry air as feed to the air separation plant; and
- Wet air for pneumatic tools and other utility needs.

Major components of the plant air and instrument air system include two electric motor-driven main air compressors, one smaller electric motor-driven air compressor for startup and emergency use.

Two main motor-driven air compressor packages will be provided, one duty and one standby. Each main air compressor package is to be capable of providing at least the design air demand of 2222 Nm³/hr. In addition the motor-driven air compressor package that is provided power from the emergency generator system designed to deliver at least 360 Nm³/hr to provide essential instrument air for startup and emergency conditions.

Each air compressor package includes the compressor, motor driver, intercoolers and aftercooler as necessary, lube oil system, inlet filter, and controls. The air compressors deliver oil-free air.

Two instrument air dryer packages are provided, one duty and one standby. Each dryer package is to be capable of supplying the design dry air demand of 1725 Nm³/hr at a pressure dew point of – 40 °C.

2.3.7 Fire Protection System

The Fire Protection System will be designed in accordance to applicable NFPA codes and standards. (See Figure 19) Firewater will consists of a closed-loop water system using raw water and seawater as backup to protect the LNG Plant, Marine and Ancillary Facilities. A Reverse Osmosis (RO) Unit described in more detail in section 2.3.10 will produce the firewater. The firewater system includes two freshwater diesel driven fire pumps, each having a design capacity of 900 m³/hr (4000 gpm), two fresh water electric jockey pumps, each having a design capacity of 45 m³/hr (200 gpm), and one diesel engine driven seawater fire pump, having a design capacity of 900 m³/hr (4000 gpm), along with an extensive system of hydrants, fire monitors, hose reels, foam protection systems and sprinkler

systems. Raw fresh water will be stored in a 5,819 m³ (21 m by 18 m) above ground storage tank that will provide 4 hours of dedicated water. The distribution system shall be sized to deliver the design firewater demand to the hydraulically most remote location in the network at a minimum pressure of 689 kPag (100 psig). Underground firewater piping will be constructed using HDPE or lined steel pipe and aboveground firewater piping will be constructed using Glass Reinforced Plastic (GRP) or lined steel pipe.

Firewater to the trestle will be provided via an aboveground, non-looped system. An international tanker to shore connection shall be provided at the trestle head for connection between a LNG Tanker and the firewater supply. Firewater to the trestle will normally be freshwater provided from the plant firewater tank with the seawater firewater pump system available as a backup.

The following table presents the firewater requirements and flow rates to various areas of the Plant.

Area / User	Design Flow Rate m ³ /hr (gpm)
Process	900 (4000)
LNG Storage	450 (2000)
Trestle	900 (4000)
Utilities	680 (3000)
Process Buildings	450 (2000)
Community Area	230 (1000)

In addition to firewater the plant will employ active and passive safety measures. Systems and equipment to mitigate incidents associated with LNG spills and vapor releases and to protect plant personnel, equipment, and the surrounding areas. This Fire Protection System includes:

- Fire sprinkler and Hose Systems;
- Fire Monitors;
- High Expansion Foam System;
- Dry chemical;
- Portable Fire Fighting and Emergency Equipment;
- Fire and Gas Detection and Alarm Signaling System;

- Emergency Shower and Eyewash Units; and
- Trained personnel.

2.3.7.1 Fire Sprinkler and Hose System

Dry pipe sprinklers will be provided in support buildings that are not occupied on a 24-hour basis such as the administration building and warehouse; and

The firewater system at the onsite community housing area will have a firewater distribution network with a design demand of 230 m³/hr (1000 gpm).

Indoor hose reels will be installed in all support buildings such as the administration, warehouse, maintenance, kitchen and recreation hall. Cabinets containing hoses and an inventory of accessories and tools will be set in all areas.

The firewater source will be a potable water/firewater storage tank that is capable of 4 hours storage at the design demand plus an additional 864 m³ for potable water use.

Two diesel engine driven firewater pumps (one operating and one standby) will be provided for firefighting measures and two firewater jockey pumps will be provided for distribution system pressure maintenance. In addition, separate pumps will provide water to the water treatment package system.

2.3.7.2 Fire Monitors

Fire monitors shall be strategically located to assist in fire control and to protect equipment against fire exposure. All monitors shall have a locking device suitable for unattended operation. Each monitor will have an actuation valve located at the base of the monitor. The trestle will have two tower-elevated monitors. The monitors shall be remote controlled, electrical or electro-hydraulic operated type suitable for hazardous locations. Monitor remote controls shall be located at the loading trestle at least 30 m (100 ft) from the trestle.

Due to an inherently safe design and to prevent the possibility of a rapid phase transition reaction caused when LNG is covered and vaporized rapidly by warm water, the LNG Storage Tank area will not be provided with fire monitors, but will utilize dry chemical extinguishing and a fire truck and portable fire extinguishers as needed.

2.3.7.3 High Expansion Foam System

The Plant will be equipped with fixed High Expansion Foam Systems to control ignited and unignited LNG spills in the facility. The foam systems shall be manually cycled on and off as necessary to maintain a nominal one-meter depth of foam on the LNG spill until the LNG is completely vaporized. The foam system shall be used to protect the spill containment sump in the process area.

2.3.7.4 Dry Chemical

A dry chemical extinguishing system shall be provided for each LNG Storage Tank at the safety relief valves discharging to atmosphere.

2.3.7.5 Portable Fire Fighting Equipment

Dry chemical ABC portable fire extinguishers shall be provided inside buildings, at the LNG Storage Tank platform level. CO₂ extinguishers will be provided in electrical rooms, gas turbine enclosures and other areas where electrical hazards are potentially present. Wheeled dry chemical extinguishers shall be provided in specific locations of the facility as needed. A hose box shall be provided at the trestle head. This box will contain fire equipment (such as hoses and nozzles) that the fire truck would normally hold.

An industrial fire truck shall be provided for the LNG plant. The fire truck shall have a 341 m³/hr (1500 gpm) fire pump and will be equipped to fight a fire. Also, the fire truck will carry quantities of water, low expansion foam solution and high expansion foam solution. A portable high expansion foam generator will be provided on the truck.

2.3.7.6 Fire and Gas Detection and Alarm Signaling System

A fire and gas detection and alarm signaling network system will be provided for the LNG Plant.

2.3.7.7 Emergency Shower and Eyewash Units

Emergency shower and eyewash units shall be provided in areas where dangerous materials are handled and personnel exposure may result in skin burns or eye injury.

2.3.7.8 Trained Personnel

The development of an effective LNG safety program includes the training and certification of all plant operators. Training will be conducted in all levels of operation, maintenance, security, and emergency procedures that carefully consider the potential hazards and evaluate the best manner to handle each hazard.

2.3.8 Flare and Blowdown System

The Flare and Blowdown System provides for the reliable and safe disposal of hydrocarbon vapor and liquid streams that result from upsets and emergencies. In addition, the Flare System will be handling hydrocarbon streams that result from operating conditions such as start-up, shutdown, venting, draining, gas purging, heating and cooling of equipment and/or piping.

The Flare System will be designed to segregate and collect any liquids from the wet or potentially wet hydrocarbon vapor streams and dry vapor. (See Figure 20) Vapors containing significant water concentrations will be relieved to the wet flare. Dry/cold hydrocarbon streams will be relieved to the separate Dry Flare System so that excess hydrate formation/freezing does not block any system that could potentially happen if those vapors were relieved to the Wet Flare System. Three separate systems are provided for this purpose, Wet Flare, Dry Flare and a Low Pressure (LP) Dry Flare.

The Wet Flare and Dry Flare stacks will be located in a common derrick structure. To minimize flame impingement both stacks will be the same height. This structure will be installed in the northwest quadrant of the site. The Dry Flare of natural gas is a smoke free operation and therefore steam injection or air assist for smokeless operation is not required. The LP Dry Flare is the BOG Flare located approximately 300 m south of the Wet and Dry Flares.

All flares and vents tips will be provided with mechanical seal devices and continuous purges to prevent the infiltration of air into the stacks.

2.3.9 Plant Controls and Information Systems

The plant will be designed with a state of the art Distributed Control System (DCS) to perform basic process control, safeguarding, monitoring, and data recording of the facilities from a single Central Control Room (CCR). The DCS shall also communicate in both directions with packaged system

controllers such as the gas turbine control systems. The communication links are redundant to maintain monitoring and control capability during any routine maintenance activity or if any segment is damaged.

The telecommunications systems will provide the communication pathways for voice, data, fax and video signals within the facility and provide links to the outside world. The design of the telecommunication systems will support both project execution and normal facilities operations. Long-range transmission will utilize fiber-optic technology while short-range transmission will be by radio.

The facilities Information Systems shall serve as the umbrella to integrate the controls, technical and business information systems. The data shall be collected, managed, evaluated, and supported through a system of Wide Area and Local Area Networks (WAN/LAN).

2.3.10 Water Utility Systems

No surface or groundwater is available at the Pampa Melchorita site that can be developed for use. All of the water required for the operation of the plant and for providing for the needs of staff and other personnel will be processed from raw seawater. Seawater will serve as the only source of water for the LNG plant. A Reverse Osmosis (RO) Unit will produce service quality freshwater for storage. This service water will be used for the Drinking Water System, Demineralizer Water System, Service water and Firewater. (See Figure 21) The primary source of firewater for the LNG plant will be service water with seawater available as a backup.

2.3.10.1 Seawater Supply System

The Seawater Supply System will consist of an intake structure consisting of a large bore caisson pipe that will be piled into the seabed and extend to the trestle platform where the pumps will be mounted. A hole will be cut into the side of this caisson pipe so that the bottom of the hole is above the seafloor. Seawater will pass through a series of screens to remove marine debris and then enter the intake box assembly.

The intake structure will be designed for two seawater pumps (each rated for 80 m³/hr) to supply water to the reverse osmosis unit and for a third seawater pump rated at 900m³/hr to provide backup

firewater. Sodium hypochlorite solution from a hypochlorite generator will be injected into the seawater between the screens in the intake box to control marine growth.

2.3.10.2 Service Water System

Service water will continuously be produced by the RO unit and stored in the Firewater/Service Water Storage Tank. The RO Unit will consist of two parallel RO Modules with common pumps. Treated water design capacity of the RO unit is 30 m³/hr (5 m³/hr to plant drinking water, 6m³/hr to plant demineralized water, 12 m³/hr to employee camp community drinking water, and 7 m³/hr to utilities/service water users). A continuous 'Brine Reject' flow of approximately 65 m³/hr will be produced and directed to the treated effluent discharge pipeline. The product recovery (service water) from the RO unit is about 35%.

The service water will be treated with a hypochlorite solution that will be added to the tank inlet water to control algae growth in the tank. The tank vent will have a HEPA filter to control entrance of dirt and bacteria. The tank will be sized based on four hours of firewater storage capacity plus three days of service water for the entire plant.

The service water will be distributed to various users at the plant by pumps rated for 35m³/hr each, will deliver water from the to all service water users. Service water users include the Utilities Area, LNG Storage Area and the Process Area with an estimated design flow of 25 m³/hr (7 m³/hr on average). Water for the employee camp will be distributed using a 12 m³/hr rated pump from the Potable Water/Firewater Storage Tank.

2.3.10.3 Drinking Water System

Service water will be treated in the Potable Water Treatment Package for the plant and employee housing areas. The unit includes carbon filtration and hypochlorite solution injection. The potable water plant will have a treated water design capacity of 17 m³/hr. Potable water is distributed to all manned buildings in the operating areas for consumption and to all safety showers and eye wash stations in the process area. The design of the potable water system is sized to permit 250 people using 0.5 m³/day during a limited period such as morning and evening.

2.3.10.4 Community Water System

The service water from the potable treatment package unit will also provide water to the employee camp and will have a treated water capacity of 12 m³/hr.

2.3.10.5 Demineralized Water System

Demineralized water for the plant will be used in the AGRU, for water washing gas turbine inlet blades, solvent make-up and flushing equipment and for utilities water make-up. The demineralized water will be generated in a demineralization package unit that will consist of a one-stage reverse osmosis unit followed by an e-cell demineralizer packaged unit. The e-cell unit uses electric power for ion exchange instead of acid/caustic regeneration. The unit will have a treated water design capacity of 5 m³/hr. Demineralized water is stored in a 120 m³ demineralized storage tank under a nitrogen blanket to prevent CO₂ ingress into the demineralized water and thus preventing the formation of carbonic acid, depressing the pH and increasing the TDS of the water. Effluent from demineralizer packaged unit will be routed back to the Firewater/Service Water Storage Tank.

2.3.11 Wastewater Collection, Treatment, Disposal

The design of the LNG Plant includes provision for effluent collection, segregation, routing, treatment (if necessary), monitoring followed by discharge to the sea if the effluents comply with discharge limits. In the case of sanitary effluent the treated water may be stored in tank for onsite irrigation purposes. A block flow diagram of the effluent water treatment for the plant is presented in Figure 22.

The plant has been designed to ensure that the liquid effluents are minimized, and that discharges are within limits established by effluent standards by Peru, EPA or other International Organizations.

The discharges associated with the LNG plant will not be from waste process streams, but are from surface runoff caused by rainfall, firewater testing or equipment washdown associated with equipment maintenance. These surface water sources that come in contact with the plant area or have the potential to come into contact with oil or suspended solids within the plant area and would carry these contaminants to drainage basins are routed to the effluent treatment areas.

An air-cooling system has been chosen as the preferred option for the rejection of process heat. Air-cooling has significant environmental benefits in that the impacts on the marine ecosystem caused by the return of warm water contaminated with halogen compounds used for bio-fouling control are avoided.

The plant will generate the following sources of liquid effluents:

- Drainage from paved areas where there is potential for operational or accidental contamination (routed for treatment);
- Clean drainage from unpaved areas such as roads, administrative areas, building roofs;
- Drainage from specific process drains, sumps and curbed areas such as those in the acid gas removal unit area, diesel tank bunds etc.;
- Process effluents from the regeneration of the demineralizing system;
- Desalination Unit - seawater blowdown;
- Sanitary effluent;
- Acid Gas Removal Unit - spent amine solution; and
- Spent or used operational and maintenance fluids such as oils and test liquids.

2.3.11.1 Wastewater

Segregated wastewater sewer systems will be provided for drainage and collection of wastewater sources to allow necessary treatment to meet Peruvian Effluent Standards and World Bank Effluent Guidelines or best available technology where no guideline exists.

2.3.11.2 Process Wastewater

No process wastewater sources are anticipated during normal operations. The AGR Unit is a curbed area draining to a low point sump allowing spills and leaks to be collected and recycled. If a blowdown from this system is required it will be discharged to the plant combined outfall sewer at a regulated rate to ensure effluent quality criteria or alternatively transported to an offsite disposal facility.

2.3.11.3 Utility Wastewater

Wastewater from the utility system during operation consists of a continuous concentrated brine reject stream from the Reverse Osmosis Desalination Unit as fresh water is produced from the raw seawater. This stream will be discharged directly to the outfall sewer.

2.3.11.4 Sanitary Wastewater

Sanitary wastewater from the plant building sources will flow via an underground sewer system to centrally located lift stations; one in the plant area and a second unit in the employee camp area. The sanitary wastewater will be pumped to the package treatment units where the wastewater will undergo biological oxidation, clarification and chlorination. It is planned to collect the treated effluent in a storage tank where it can be utilized for irrigation purposes on the site.

The bio-treatment unit will be specified as an extended aeration system to minimize sludge production. Sludge disposal will be landfarmed onsite or trucked offsite to a local landfill, as necessary.

2.3.11.5 Potentially Contaminated Wastewater Runoff

Since the plant site lies in a very arid area, the anticipated rainfall at the site is very low and main source of runoff from the plant will be from testing firewater systems in the process/utility areas and any equipment washdown sources. Runoff from these areas will be channeled to an American Petroleum Institute (API) gravity type oil separator where free oil will be skimmed off to a collection sump. The treated effluent will then discharge to the sea outfall. The separator will be designed to treat peak flows corresponding to rainfall or firewater discharge rates. The major source of contamination will be oil and grease from gas turbine, compressor, pump machinery areas and wastewater from these areas will be treated in a Coalescing Plate Interceptor (CPI) oil separator. Effluent from the CPI separator will then go to the API separator along with the plant surface runoff. The oil separated from the CPI separator will be collected in a slop oil tank. This tank will also be used for storing spent lubrication oil prior to offsite disposal or recycling.

Potentially contaminated surface runoff from remote areas such as the Trestle, Cargo Dock and Seawater Intake will be diverted to containment sumps. Whenever required the contents of the sump will be emptied by a vacuum truck for transfer to the CPI separator.

2.3.11.6 Clean Water Runoff

Clean water runoff from roads, buildings etc will drain to a drainage ditch system for discharge to storm water outfall.

2.3.11.7 Incinerator

Solid waste and non-recyclable liquid waste will be disposed in an onsite incinerator. The design of the incinerator system is based on a capacity to process up to 4,800 kilograms per day solids or 2,400 kilograms per day of used oil.

2.4 Administration Housing and Infrastructure

The plant will be designed to include a permanent employee camp and all required supporting infrastructure with capacity to accommodate additional contract personnel on a temporary basis for larger plant maintenance projects.

2.4.1 Buildings

Buildings supporting the operations of the plant will be designed in accordance with International and Peruvian standards. Small units may be prefabricated with factory equipment installed such as analyzer houses, motor control centers, etc. Local control rooms in the process and utility areas will be blast resistant to protect personnel and control systems. The following ancillary buildings will be provided to support the LNG operations:

- Administration & Training;
- Fire and Emergency Station;
- First Aid Building (Clinic);
- Maintenance Workshops;
- Warehouse;
- Compressor Shelters;
- Analyzer Shelters;

- Central Control Room/laboratory;
- Local Control and Instrument I/O Rooms (Blast Resistant);
- Electrical Substations;
- LNG Loading Dock Shelter/Control Room;
- Employee housing, kitchen/mess hall, laundry, recreational and sports;
- Gate house and guard stations; and
- Chemical Storage.

2.4.2 Roads, Bridges, Fencing and Drainage

Roads and culverts will be designed with adequate drainage. All drainage will be managed with ditches and culverts that outfall to the sea. All storm water runoff or wash water in contact with industrial processes will be collected and drained into the API oil water separator for treatment.

2.4.3 Lay-down Areas

Construction lay-down areas shall be provided on the site to meet the initial construction and any future expansion needs of the facilities. Lay-down areas required to support permanent plant operations shall also be provided. The location of the proposed lay down areas is indicated on Figure 3.

3.0 CONSTRUCTION OF MAJOR COMPONENTS

3.1 Construction Program and Infrastructure

3.1.1 Temporary Construction Camp

The construction Contractor will install a temporary camp and facilities on the site to house Contractors personnel, subcontractor's personnel, the Owner's Construction Management Team and other personnel as required. Contractor is expected to provide housing for entire labor force of approximately 3,000 persons, with an option of allowing the labor force from the two adjacent communities to live at home and travel by bus to the site each workday. Additional temporary facilities will be installed to support construction such as craft training center, material storage

warehouses, workshops, fabrication shops, field offices, watchmen stations and medical clinic. All temporary facilities will be self-sufficient and provide for its own power from diesel generators, water treatment and sewage collection and treatment.

3.1.2 Facilities

The LNG Export Project to be constructed will consist of two primary components being the Liquefaction Plant and the Marine Facilities. The Contractor will be responsible for the detailed final design of the Plant and Marine Facilities plus the provision of all equipment, materials, fabrication, supervision, inspection, testing, project management, commissioning and start-up. The Contractor will provide experienced personnel and be responsible for compliance with safety and environmental regulations, standards, permit conditions, as well as Company policies in order to comply with all the legal requirements applicable during the construction phase of the project. The construction of the LNG plant is projected to begin in 2004 with start up of the plant projected for 2007. A tentative schedule is presented in Figure 23.

Construction activities related to each of these segments of the project are described as follows.

3.1.3 Liquefaction Plant

The LNG Plant component of the work will include the installation of all roads, concrete foundations, piperacks, equipment, tanks, piping, permanent buildings, power systems, control systems and utilities and services. Site preparation is included in this portion of the work. The construction activities associated with the plant portion of the project are estimated to be completed in 2007 approximately 41 months after the construction contract is awarded. Access to the site will be provided from the existing Panamericana Sur Highway with gravel roads constructed from the Highway throughout the site.

3.1.4 Marine

The Marine portion of the work will consist of the construction of the trestle, LNG loading dock, utility dock, breakwater, dolphins, navigation channel, navigation aids and the LNG loading facilities.

The trestle will be constructed using large diameter steel pipe piles with fabricated steel topside structures. Pile driving will be a key item to complete in a timely manner to permit the topside structure to be installed and the piping, equipment and utilities to be installed.

The open coastline of Peru experiences persistent wave and long-period swells. The berth must be protected from the waves by a breakwater and will also be incorporated into the overall design to reduce the wave action at the loading berth and therefore movement of the LNG Tanker and associated loading arms during loading operations. Although the final design for the trestle and breakwater have not been completed, the trestle will be constructed using large diameter steel pipe piles. The breakwater will be constructed using coarse material mined from a permitted existing or new borrow source. A quarry EIA will be presented under a separate cover if a new source of rock fill material is required. The breakwater will have a base footprint of 800 m by 130 m and will extend 8.5 m above the mean sea level from the -14 m contour line. The proposed construction of the navigation channel to provide tanker access to the berth area will consist of the dredging of approximately 3 million m³ of material from an area located 1.3 km from the shoreline; between -13 m, -14 m and -15 m contour lines. The channel will be dredged to a depth of 15 m (dredge 1 to 2 m of material) at the loading dock area (behind the breakwater) and to 18 m (dredge 4 m of material) in the channel where the tanker will be turning into or away from the dock area and where there is reduced protection from the breakwater and the swell could be broadside the tanker generating rolling motions and requiring additional allowance for under keel clearance. Generally the channel is 250 m in width and a total of approximately 2,700 m in length throughout its “U” shape. It is anticipated that the Contractor will utilize a cutter suction dredge or a trailing suction hopper dredge to remove the sand and gravel material to construct the tanker access channel. The material removed will be moved to a designated dumping area by barge. The marine facilities will be constructed during the same time period as the plant facilities. (See Figure 23)

3.1.5 Utilities

During the construction phase, the Contractor will have to provide all water for personnel subsistence and construction purposes. No surface water or any aquifer exists at the plant site. The Contractor will be required to install a temporary seawater-processing unit as part of the temporary construction infrastructure as quickly as practicable. It is expected that during the beginning of the construction phase potable water for use by construction workers and raw water for dust control and initial civil works will be supplied by local suppliers and transported to the site by trucks. Water from the Cañete

River will be utilized during the first year of construction for dust control, moisture conditioning during soil compaction, for concrete production, and treated for sanitary purposes for the construction camp. Bottled potable water will be delivered to the site. The use of water from the river and bottled potable water will occur for the first year while the desalinization plant is under construction. Sanitary effluent from the temporary camp facility will have extended aeration biological treatment with effluent irrigation and the waste biosolids will be land-farmed onsite or trucked offsite to a local landfill.

3.1.6 Testing

As the piping, LNG Storage Tanks and associated pipeline are constructed they will all be inspected by Non Destructive Examination (NDE) methods such as x-ray, etc. and hydrostatic tested in full compliance with ASME B31.3 and other applicable codes to ensure structural integrity.

3.2 Site Preparation

The overall approach to construction of the Plant and Marine Facilities is to minimize impacts to the environment and disruption to local communities. It is anticipated that the Plant and Marine Facilities will begin construction activities in 2004 with a start-up in 2007.

To accomplish this goal, most of the initial site preparation will be conducted through the use of National contractors so that earthmoving equipment can be delivered to the site from nearby cities utilizing the existing infrastructure to start the work quickly. All construction equipment that will be transported to the site will be within the posted weight limits of the roadway system to minimize impacts to existing roadways and disruption of local traffic patterns. The majority of construction equipment used to construct the marine facilities will be delivered by barge as part of the marine fleet.

Initial activities will include the mobilization of the initial resources and the preparation of the site for the subsequent construction activities that will take place. The start of construction work will consist of leveling the site by balancing the amount of cutting and filling required to reach the final grade elevations and the construction roads to the Plant and Marine Facilities. Endemic moss and lichens exist on site at various times but no rooted vegetation exists on the site so no grubbing or topsoil removal activities will be needed. Other activities will include the installation of temporary facilities (i.e. fencing, parking, construction offices, staging areas, Contractor's an employee camp, laydown areas, equipment maintenance and fuel storage).

3.2.1 Earth Moving Activities and Temporary Works

The Company or EPC (Engineering, Procurement and Construction) Contractor will award a contract for site preparation, because of the volume of material that must be removed, before or very shortly after EPC Contract award. Mobilization of the site preparation contractor will begin immediately after contractor award and approval of the EIA.

The amount of material that will be required to move is approximately as follows:

Major Areas	Cut	Fill
LNG Tank Area	3,000,000 m ³	
Process Train	115,000 m ³	
Outside of the process area / Roads	1,750,000 m ³	200,000 m ³
Trestle Access Road	8,5000 m ³	955,000 m ³
Construction Areas	1,300,000 m ³	
Approximate total site cut/fill quantities:	6,250,000 m ³	1,155,000 m ³

Using conventional earth moving equipment available in Peru, an estimated 16-month schedule was developed for the entire site preparation work. This will require two 10-hour shifts per day working 6 or 7 days per week.

The equipment required for this excavation will be obtained locally within Peru but some larger sized excavation equipment may be required to be imported to expedite the schedule. The equipment will be delivered to the site via the Pan American Highway.

The site cut and fill activities will be accomplished using front-end loaders, backhoe, rippers, shovels, dozers, motor graders, rollers, water trucks, and dump trucks for hauling spoils. No drilling and blasting will be required. Existing vegetation at the site (Tillandsials) will be removed and stored temporally for further landscaping. Excavated cut material will be used for fill where suitable and the surplus deposited within the site. The surplus material will be spread; compaction of this material is not required. Water will be used for road bases and in building areas of structural fill to optimize compaction. Dust control will be maintained by the use of water spray application. All concrete will

be mixed on-site using a concrete batching plant and delivered by transit mixer trucks to the foundations.

3.2.2 Control Measures

Control measures will be implemented during site preparation to minimize erosion and sedimentation resulting from grading, excavations and compaction.

Erosion control measures will be designed, implemented and maintained using Best Management Practices. Examples of methods that will be used to control against erosion and sedimentation include:

- Schedule site activities to minimize the disturbance of the project surface;
- Avoid maintaining open excavations for prolonged periods of time and compact loose materials;
- Irrigate exposed surface soils to control dust;
- Compact soils soon after excavation, filling or leveling activities are completed; and
- Install silt fences, hay bales or other measures to prevent the transport of sediments.

3.3 Construction and Installation of Process Units and Workforce

The process units, equipment and many other components will be fabricated offsite at vendor's shops and delivered to the site for installation. Thousands of other items such as piping, fittings, steel, alloy plate, cables conduit and other materials will be delivered in bulk form and fabricated in national fabrication shops or on site. Steel structural supports for the process unit piping and other components will be assembled onsite using prefabricated structural members supplied to the plant by offsite vendors. In addition to the process and utility units, administrative buildings, service building, warehouses, repair and maintenance shops will be constructed onsite.

3.3.1 Construction Workforce

Approximately 15 million direct construction work man-hours will be required for the construction of this project. This estimate is based upon experience for similar LNG projects. The construction workforce is expected to peak at approximately 3000 people. This number includes specialty subcontract workers during the latter phases of the construction.

The majority of manpower and skills required to construct the LNG Export Facility can be supplied from within Peru. The contractor and some specialty subcontractors will bring existing key staff to Peru from other worldwide locations to plan, organize, train and manage their work. Peruvian nationals will be the source of a very large percentage of the remaining jobs. A list of craft categories with an estimate of the total number of jobs that will have to be filled by the main contractor or his subcontractors is shown below.

Craft	Peak Level
Laborers, semi-skilled	500
Carpenters	300
Iron workers (Structural & Rebar)	200
Cement Masons	100
Electricians/Instrument, helpers	250
Millwrights, Mechanics	100
Tank Fabricators	100
Pipe fitters, Welder helpers	500
Carbon Steel Welders	225
SS & Alloy Welders	200
Riggers	20
Equipment operators	50
Marine specialty crew	50
Drivers	100
Painters	50
Others- insulators, surveyors, materials men, guards, catering	500
Total jobs - all crafts	3,245

Other personnel categories will include management, engineering, supervision, technical personnel, quality control and inspection personnel and administrative support. These categories could represent an additional 10% in workers.

The goal of the Company is to maximize the contracting of personnel from the local region and within Peru to make every practical effort to provide preferential treatment (assessment, training, etc) to using local craftsman and laborers to supply the majority of the construction requirements for the Project. Some craftsman that may be difficult to hire in the local area may be relocated to the site from other areas of Peru, while some management, engineering, supervision and specialist personnel could be relocated from other parts of South America or abroad.

Figure 24 shows the manpower schedule and the sequence of work on the site that relates to the craft categories listed. During the first two years, the work would entail crafts that should be available from within Peru. During year three, more stainless steel and alloy welders will be needed as well as instrument fitters and cryogenic insulators than are currently available in Peru. This shortfall will be made up increasing the skill level of existing similar craftsman by training and by recruiting crafts with current experience outside the country.

3.4 Raw Materials

The potential natural resources that will be used during each phase of the Project are presented as follows.

Materials used to construct the Plant and Marine Facilities will utilize local, natural or renewable resources. Raw water during construction for use in mixing concrete and dust control will be trucked to the site from the Cañete River during the first year or until the temporary seawater desalination plant can be constructed. Once the desalinization plant has been constructed and it is operational, withdrawals from the Cañete River will be minimized. Estimated water used during the first year of construction until the desalination plant is operational will be around 200 m³ per day to satisfy both staff and construction needs.

Rock aggregate for use as a concrete component, for road bases, ground cover, and other civil applications will be obtained from local commercial suppliers that are properly authorized.

Other materials that will be used during construction include wood products, cement, construction blocks, structural steel, building materials, safety equipment, consumables, fuel and lubricants for machinery. The majority of the construction materials will be purchased from local suppliers, fabricators, material suppliers and services.

Material storage areas will be constructed and staging areas will be designated as shown on Figure 2. These areas lie within the proposed project site boundaries.

3.5 Material and Construction Equipment Handling

All capital equipment, bulk materials, necessary construction equipment, and materials will be delivered to a combination of the public ports of San Martin Port, Pisco and Callao Port, Lima. It is planned for very large pieces of equipment to be delivered to San Martin Port by chartered self-offloading, heavy lift ships. Similarly, cargoes of containerized goods and bulk items such as steel pipes, etc. will be consolidated and forwarded using a charter vessel for fast delivery to San Martin Port. Small cargoes such as individual containers will probably use the regular liner services that discharge at Callao Port on a scheduled basis. It is expected that 80 to 90 percent of cargo will enter Peru through the port of San Martin. From the San Martin Port, the equipment will be transported overland using heavy haul vehicles when necessary.

Transportation of equipment to the site from the San Martin Port will use approximately 60 km of roadway that includes the crossing of five bridges from the port to the Pampa Melchorita site. Prior to the mobilization of equipment a pre-construction survey of bridges and roadways will be conducted by the EPC Contractor to document the conditions of the roadway and to determine the reinforcement requirements for the existing bridges and submit the survey to the required authority for the necessary permits.

The major equipment that has been identified for heavy haul is the following:

Equipment	Weight (tons)
AGR Absorber	545
MCHE	272
Propane Compressor Skid	225
Heavy Metal Absorber	203
HP MR Separator	139
2 Ea. Frame 7 Gas Turbine Driver Skids	137 Ea.
2 Ea. Propane Storage Bullet	125 Ea.
3 Ea. Generators	100 Ea.
2 Ea. Ethylene Storage Bullets	100 Ea
MP MR Compressor	92
LP MR Compressor	92

Bulk freight that will be imported to Peru will consist of approximately 70 million kg or 5,000 loads at 14,000 kg per load. The anticipated local supply loads will be approximately 35 million kg or 2,500 loads at 14,000 kg per load. A total of 7,500 Loads will be transported to the site from the port or from local Peruvian suppliers. The loads during the first year will be limited to the transportation of construction equipment, camps and supplies for the site preparation and the beginning of the concrete work. The balance of the 7,500 loads will be spread over an 18-month period in years one and two of the construction period with an average of 90 to 100 loads per week arriving at the Pampa Melchorita site.

The transport trailer systems to be used, load configurations and load arrangements and routes will be developed by the EPC Contractor or subcontractor. Turning and acceleration lanes between the highway to the site access road will be designed and constructed to minimize disruption to highway traffic. As noted, permanent improvements or temporary shoring/reinforcement of roads, bridges, the cargo dock and/or bypasses will be designed and finalized by the EPC Contractor who will also be required to get the appropriate local government/authorities approval and applicable permits prior to transporting materials.

3.6 Emissions

3.6.1 Air

The maximum air quality impacts during construction are anticipated to be temporary and intermittent from various sources. These emissions will occur during the construction period when heavy equipment is engaged in the site preparation earthwork operations, material transportation, marine construction and remaining erection work for the Project. Construction equipment used to construct the Facility will produce emissions to the atmosphere from the combustion of fuels such as diesel and gasoline. These gases include NO_x, hydrocarbons, CO, PM, and SO₂. These emissions are expected to be temporary and intermittent during the construction phase of the Project producing low air quality impacts.

3.6.2 Solid Waste

Solid waste generated from construction will consist primarily of construction debris and domestic waste. Construction and domestic waste generated during the construction phase will include plastic, glass, cardboard, paper, packaging materials, metal containers and all waste generally associated with

a construction office, warehouse, sanitation and dinning hall, etc. These wastes will be collected onsite at central collection points for incineration, recycling or transported and disposed offsite in an approved landfill.

3.6.3 Liquid Effluent Discharge Sources

Contractor will have several discharges, storm water run off, desalination plant return flow and wastewater treatment plant liquids. Any storm water will be allowed to disperse from the site by sheet flow storm water conveyance to the sea. The desalination plant, when built, will discharge the return flow to the sea. The wastewater treatment plant will be used for irrigation onsite or discharged to the sea under Peruvian permit.

4.0 OPERATION OF THE FACILITY

4.1 General

The plant is required to operate and produce LNG on a 24 hours per day basis for long periods of time without unplanned shutdowns to maintain a reliable supply to LNG buyers and on down through the supply chain in accordance with long term contracts. The equipment and systems chosen for the plant are selected to be highly reliable. Similarly, all the design audits, site inspections and quality checks conducted during construction and testing are to ensure this requirement is met. Critical equipment has redundant instrumentation to avoid unnecessary shutdowns due to electrical or other faults and specialized condition monitoring equipment is used to predict and anticipate changes in machinery condition that can be rectified on a scheduled basis ahead of a failure that could disrupt operations.

Operators will control and monitor the operation of the plant on a multi-shift basis to provide full coverage for around the clock operation. Similarly, the loading dock operators will operate on a multi-shift basis when a tanker is at the berth or at anchorage. A reduced fire station response team will be on the night shift to alert the emergency response team and a full complement of security guards will be on watch. Maintenance activities, warehousing, clinic, office duties and process laboratory operation will normally be on a day shift basis only.

4.2 Site Staffing

The base operating and maintenance organization will consist of a staff of around 100 persons to handle all of the operations, maintenance and administration responsibilities on the site on a seven-day per week basis. All staff will live in the employee housing complex on the plant site. Full catering facilities are provided, including late meals for the night shifts. A training program will be established at the beginning of operations to train nationals for a succession plan. The staff will be approximately 80% foreign – 20% national at the beginning of plant operations with an objective to achieve 20% foreign – 80% national within ten years.

The base staff level will be supplemented by a significant number of contract jobs that fall into three categories; 1) a routine full-time basis, 2) a seasonal basis and 3) fairly large periodic temporary workforce for special activities. The routine full-time contract positions will total around 50 persons made up of catering, cleaning, fuel hauling, bus operators and material transporters. Contract crews of up to 20 or 30 would be hired on a seasonal basis for maintenance painting, road maintenance, etc. A special workforce would be brought on site every three years for scheduled plant turnarounds involving a plant shutdown and completion of an extensive pre-planned list of inspections, repairs and replacements on an around the clock basis. Additional crews of around 50 to 75 persons will be onsite for these planned plant turnarounds with around one-half of them from the original equipment manufacturers (OEM) outside Peru.

4.3 Marine Operations

Sixty-five (65) to seventy (70) LNG Tankers will be loaded each year resulting in a cargo of LNG once every four to five days, depending on the receiving terminal requirements, tanker availability and weather conditions. Navigational aids at the LNG Dock will be suitable to provide support for 24 hour for berthing. During the first year of operations as operating procedures and personnel skills are developed to a high degree, tanker will be restricted to arrive and depart in daylight hours only. Loading can be done on a 24-hour basis. The procedures for entering the berth after daylight hours can be reviewed in the future if the need arises.

4.4 Loading LNG to Tanker Operations

Ships will arrive in a "cooled" down condition with a slight heel of LNG; three tugboats will assist the LNG Tanker to enter the harbor and berth at the dock. While the tanker is berthed and moored, it

is under constant electronic instrumentation surveillance to closely monitor the safety of the tanker and the loading facility.

LNG loading is accomplished by using four LNG Loading Arms. Three loading arms will be used for loading liquid to the ship, one for vapor return from the tanker. One of the liquid loading arms can be used for vapor return in case the primary vapor loading arm is down for service - albeit with a reduced tanker loading rate. The LNG is pumped approximately 1.7 km through the LNG loading line to the LNG Tanker by the eight LNG loading pumps. The maximum design-loading rate from the Plant to the ship is 11,000 m³/hr using the three liquid LNG loading arms. These pumps are sized to load a 137,000-m³ ship within 12 hours. The fourth arm will be used to return vapors generated during the ship loading operation to the storage tank to displace the liquid volume removed by the pumps, with the excess gas going to the boil off compressors. The plant is designed to use dry fuel gas to supplement the vapor return from the ship if the vapor generated is insufficient to make up the displaced volume the LNG Storage Tanks. During loading operations, clean ballast water will be used to create a water curtain to protect and control metal temperatures in the loading area to prevent metal stress cracking on the tanker. Tankers will not be allowed to discharge any waste while at port.

4.5 Maintenance

Maintenance activities will be an ongoing activity during the operation of the LNG Plant and Marine facilities. The frequency and type of equipment maintenance will vary depending on the equipment type, which will be finalized in the detailed engineering phase of this project. For the marine area, sand is expected to accumulate in the sections of the dredged channel over time. The build-up would first appear in the edges of the channel. Additional dredging is planned in these areas and it may take several years before the volume of material would provide any restrictions on tanker operations. The tugs will be provided with sounding equipment to monitor and map the condition of the channel and monitor any sand ingress. Maintenance dredging of the navigational channel will be conducted periodically as required to restore the original channel cross-sectional profiles. Detailed modeling studies and testing are underway to evaluate the breakwater and sediment transfer mechanisms. The results of the modeling will be utilized to optimize the design.

4.6 Plant Materials

An extensive list of materials, supplies and services will be required to support the operation and maintenance of the LNG Plant and Marine Facilities. Sources within Peru can satisfy a large portion of these requirements and additional sources will develop during and after the construction phase to provide an increased level of support. The lists of items and quantities of materials required will be developed during the detailed engineering phase of the design. The following chemicals are expected to be used in the process and utilities areas of the LNG Plant.

Area	Chemical
Inlet Area	Methyl Alcohol
Acid Gas Removal	activated Methyl Diethanolamine (aMDEA) Amerel 1500 foam control agent
Dehydration	Molecular Sieve (Type 4A)
Heavy Metal Removal	Sulfur impregnated activated carbon HGR 4X10
Refrigerant Storage	Ethylene Ethylene, refrigerated liquid Propane Propane, refrigerated liquid
Hot Oil System	Therminol® 55 heat transfer fluid
Diesel Fuel System	Diesel fuel
Fuel	Gasoline, Diesel
Water System	Sodium Hypochlorite Resin bed for E-cell
Waste Water System	Sodium Hypochlorite
Other	Solvents, paints, lube oils,

Material Safety Data Sheets (MSDS) will be kept for each of these chemicals and for any proposed chemicals to be used at the Plant. MSDS for all of the above materials are included in Appendix 1

4.7 Emissions and Discharges

4.7.1 Air Emissions

The sources of air emissions associated with the Project are described in Chapter IV Table 9 and include the combustion turbines drivers for compressors and power generation, the Dehydration

Regeneration Heater, Hot Oil Heaters, standby diesel firewater pumps standby diesel emergency generators and flares systems. The air quality modeling for the proposed for the plant when in operation indicates that the Project's maximum air quality impacts are predicted to be significantly below the World Bank Ambient Air Quality Guidelines (World Bank, 1999). The maximum impacts are also compared to the Peru Air Quality Standards and U.S. Ambient Air Quality Standards

4.7.2 Liquid Effluents Discharge Sources

Two types of stormwater discharges anticipated for this Project are contact and non-contact stormwater. Contact water is water that comes in contact with industrial processes and can become contaminated if any residue exists around the equipment. This water is segregated and treated in a CPI and API oil water separator before being discharged from the Project site to sea. Non-contact stormwater is non-contaminated. Non-contact stormwater runoff at the site from rooftops, parking lots, undeveloped areas, etc. will be allowed to disperse via sheet flow to the designed storm water conveyance system.

4.7.3 Solid Waste Sources

Solid waste generated during the operational phase will consist of domestic and industrial waste characterized as either hazardous or non-hazardous. Domestic wastes generated during the operational phase will include plastic, glass, cardboard, paper, packaging materials, metal containers and all other waste generally associated with a operating offices, warehouses, sanitary facilities kitchens and housing, etc. Non-hazardous industrial waste will be collected in properly labeled containers located at several designated areas of the plant. To the extent possible any materials will be reused or recycled. The non-hazardous waste that cannot be reused or recycled will be collected, incinerated or transported by authorized transporters to an offsite recycler or landfill for final disposal.

Hazardous waste which will include spent oil, solvents, filters, containers, oily rags, mineral spirits, used paint cans, or any other materials contaminated with oil, solvents, paint, etc. will be stored in dedicated containers located in an concrete pad with a secondary containment and a collection sump with sufficient capacity to hold the volume of the largest volume container held in the containment area. The containment area will be fenced with a roof structure with open sides to allow for proper ventilation. To the extent possible these materials will be reused, recycled or incinerated. The

hazardous waste that cannot be reused or recycled onsite will be collected and transported by Peruvian authorized transporters to their final destination for either destruction or treatment.

5.0 SITE CLOSURE/DECOMMISSIONING

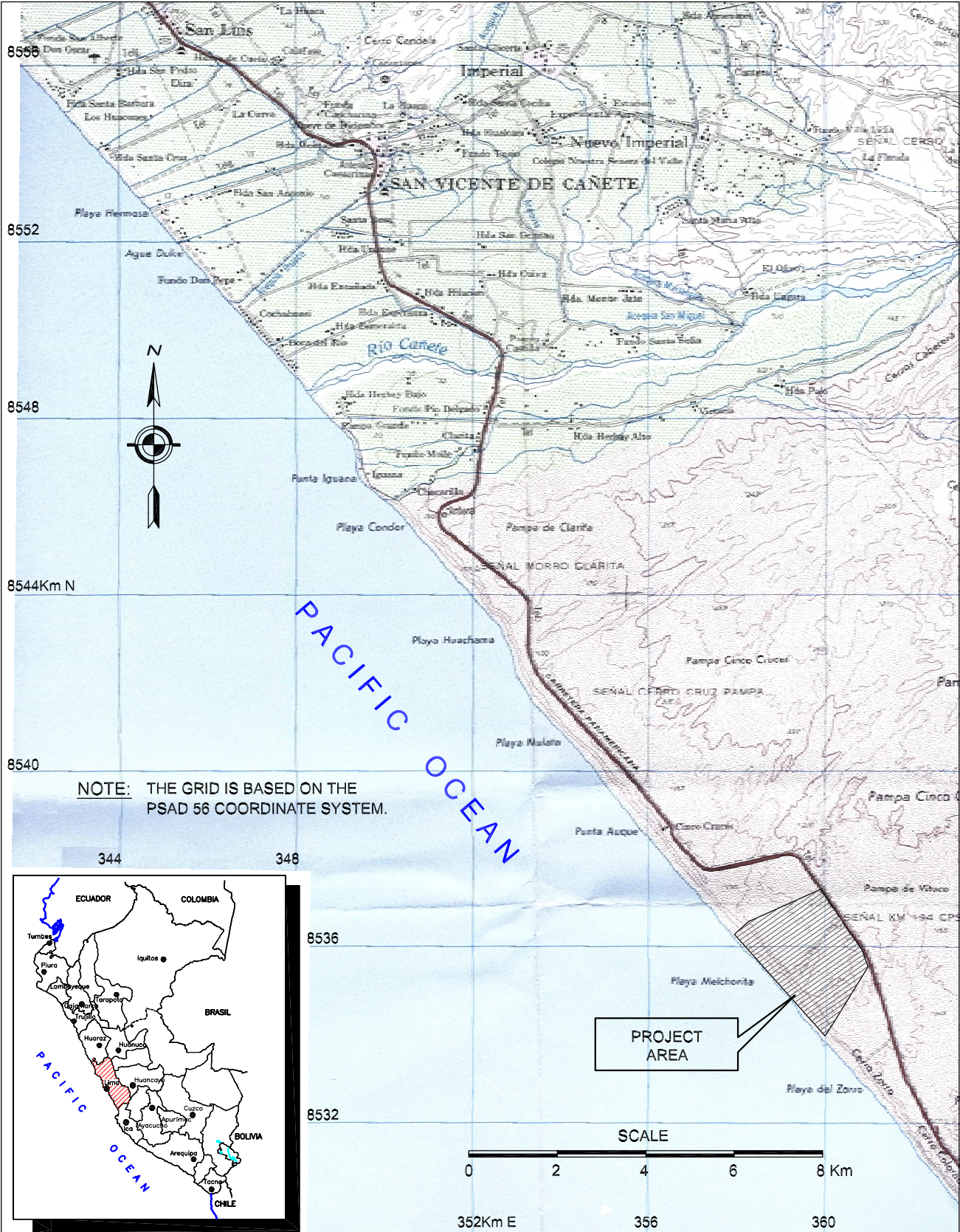
In the event that the LNG Plant and Marine Facilities are dismantled/decommissioned, the activities associated with the site closure will be treated as a separate project and the Company would present DGAAE and DICAPI with the Terms of Reference for the development of the abandonment plan, EIA and a site restoration plan.

The abandonment plan would include a schedule for the decommissioning and disassembling of equipment indicating the approximate time required to remove, dispose and abandon all installations, for which re-use of such structures and installations is not possible, and the restoration of the site to a condition for subsequent land use.

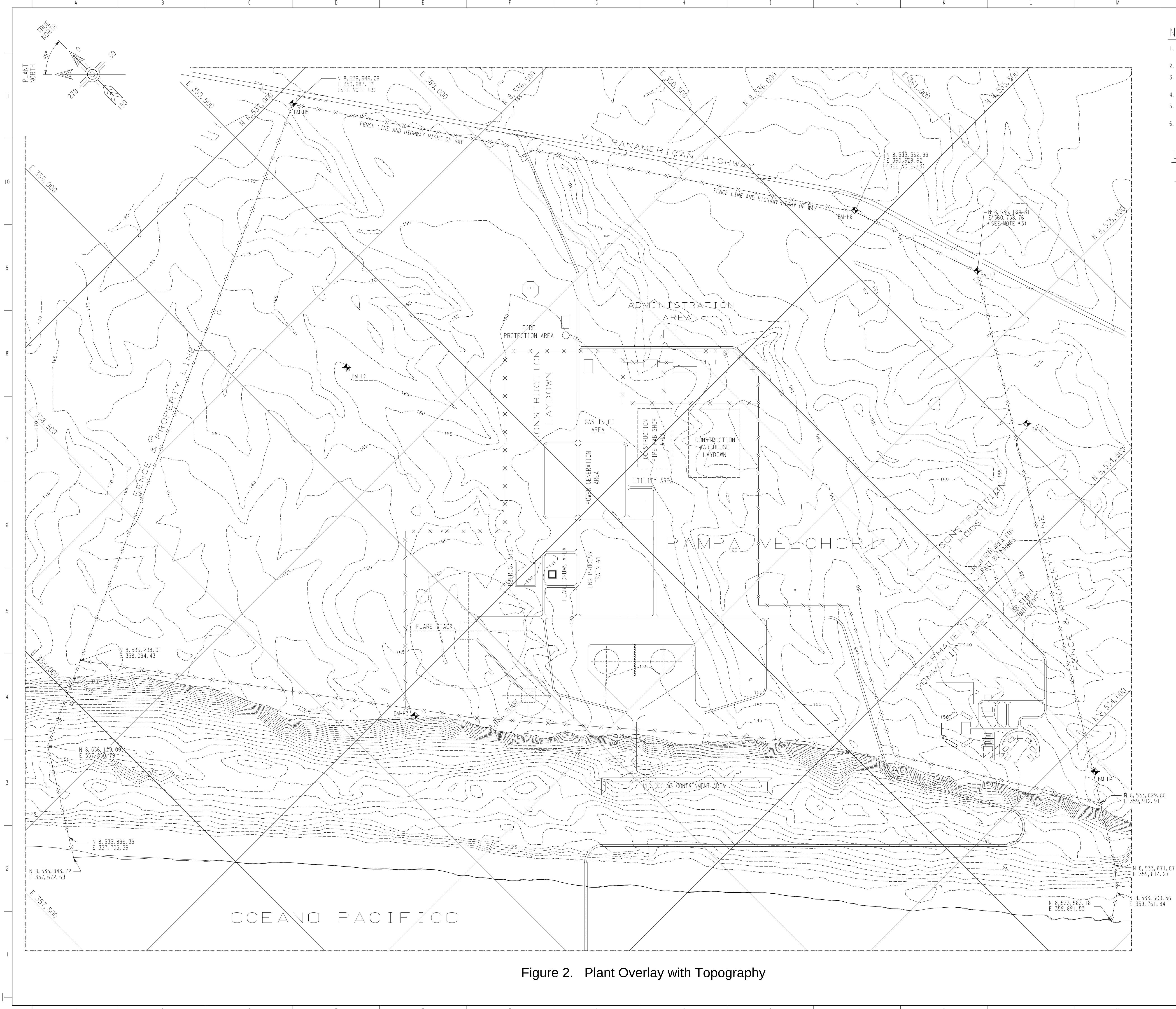
The plan would identify the quantities and types of materials that will have to be removed and disposed as well as proper handling, staging, treatment, and disposal hazardous and non-hazardous according to Peruvian requirements.

The plan would also include a site restoration plan describing the programs that will be implemented once the facility closes.

Figure 1: Project Location



6825 - 10C15 - FA \6825\10c15\cv21-002-01.dgn (10-Sep-2002 4:10 PM) hdb6676 [T16B]



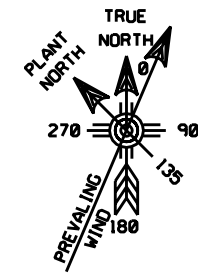
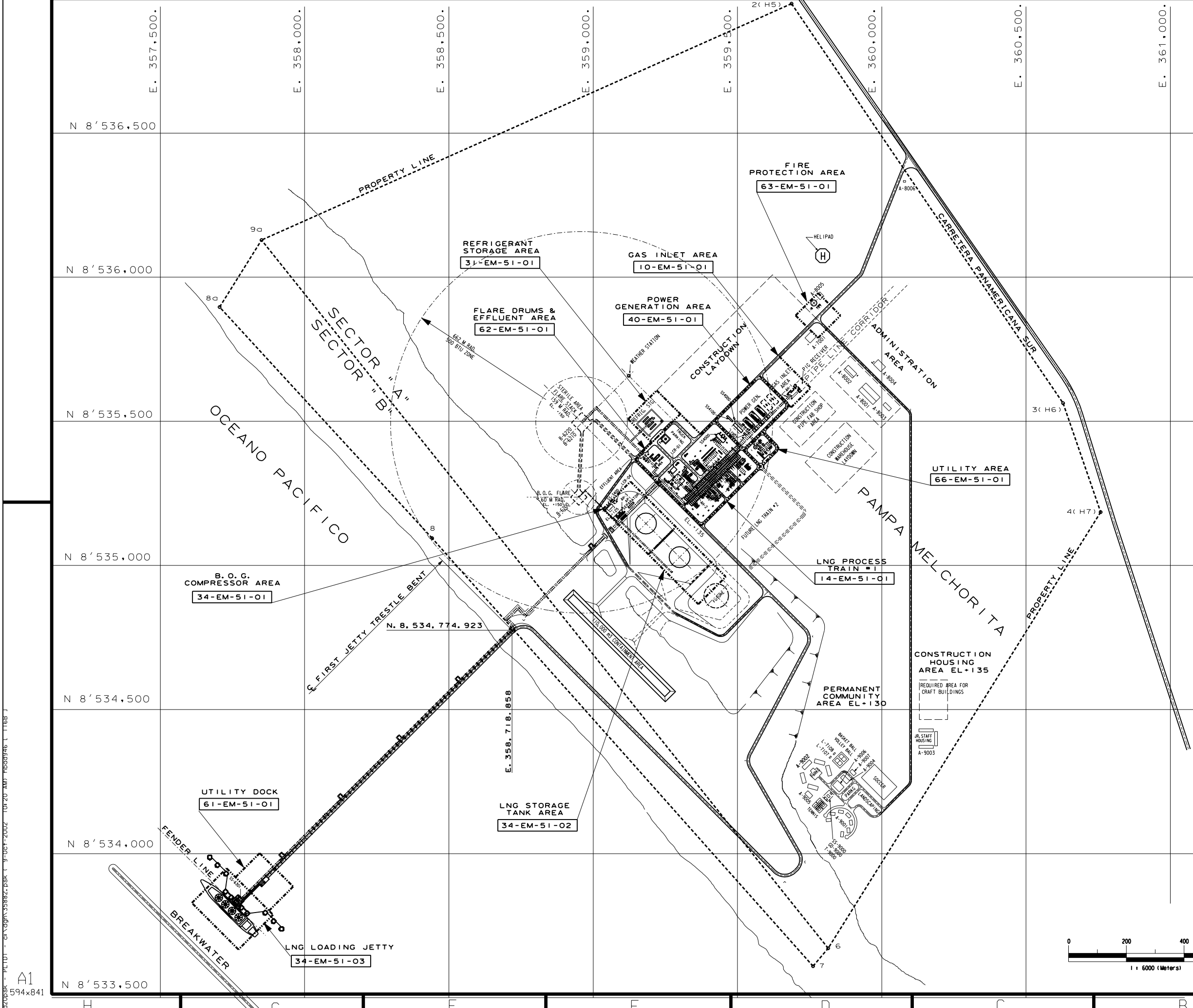
- NOTES:
1. FOR GENERAL NOTES AND REFERENCES, SEE DRAWING CV21-001-01.
 2. FOR FENCING DETAILS, SEE SPECIFICATION C32-1C-6B25.
 3. COORDINATES TO BE ADJUSTED AS REQUIRED FOR HIGHWAY RIGHT OF WAY.
 4. ALL COORDINATES SHOWN ON THIS DRAWING ARE IN METERS.
 5. ALL COORDINATES SHOWN ON THIS DRAWING ARE IN UTM COORDINATES, WGS 84.
 6. FINAL LOCATION OF PLANT AREA FENCING TO BE DETERMINED DURING EPC PHASE.

LEGEND

BM- PROPOSED BENCHMARK LOCATION WITH BENCHMARK NUMBER

BENCHMARK LOCATION			
BM NUMBER	COORDINATE LOCATION		
	N	E	ELEVATION
BM-H1	8,534,768.117	360,547.432	134.683
BM-H2	8,536,293.260	359,253.625	162.400
BM-H3	8,535,430.781	358,673.929	152.500
BM-H4	8,533,905.638	359,967.736	127.550
BM-H5	8,536,951.262	359,689.927	165.456
BM-H6	8,535,566.082	360,631.891	141.056
BM-H7	8,535,187.213	360,760.776	132.049

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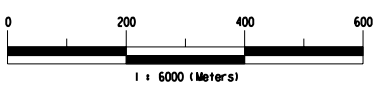


PAMPA MELCHORITA PROPERTY LIMITS COORDINATES		
POINT	EAST (m)	NORTH (m)
2 (H5)	359,687.12	8'536,949.26
3 (H6)	360,628.62	8'535,562.99
4 (H7)	360,758.76	8'535,184.81
6	359,814.27	8'533,671.87
7	359,761.84	8'533,609.56
8	358,441.50	8'535,094.85
8a	357,705.56	8'535,896.39
9a	357,850.79	8'536,129.09

Figure 3. Overall plot plan

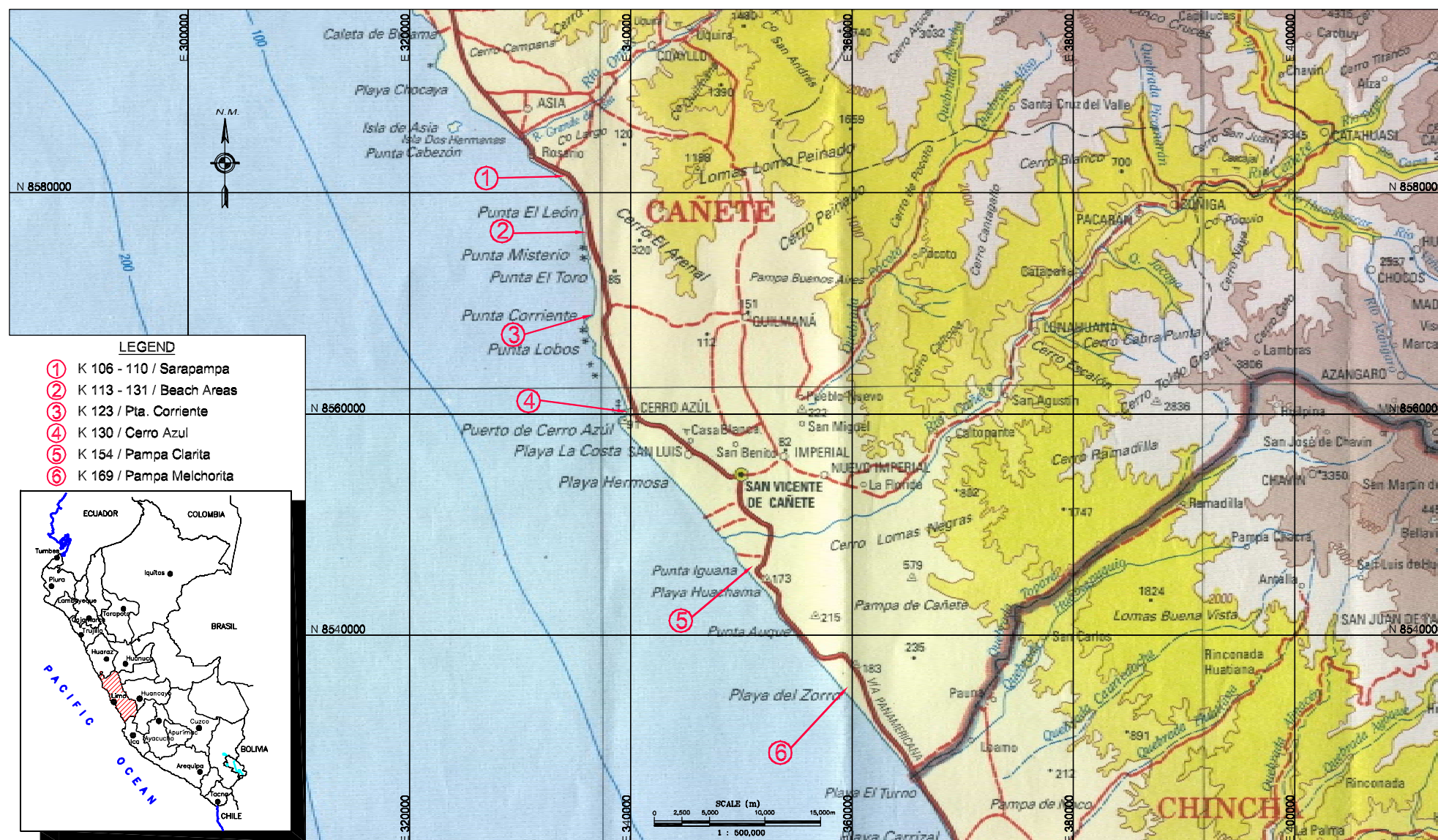
- NOTE:**
- COORDINATES ON THIS PLOT PLAN ARE BASED ON W.G.S. 84
 - FOR GENERAL NOTES SEE MASTER PLOT PLAN DWG. 6825-00-EM-51-01

2	ISSUED FOR FEED BOOK	PKP	JCD	GG	08/10/02
1	ISSUED FOR DESIGN	PKP	DP	JCD	07/09/02
0C	REISSUED FOR CLIENT APPROVL	PKP	DP	JCD	05/06/02
0B	ISSUED FOR CLIENT APPROVAL	PKP	DP	JCD	01/07/02
0A	NEW SITE ISSUED FOR CLIENT REVIEW	PKP	DP	JCD	05/05/02
0	ISSUED FOR CLIENT REVIEW	PKP	DA	JCD	05/09/02
NO	REVISION DESCRIPTION	DRAWN BY	ENG.	CHK.	APPR. DATE
ENGINEERED	DRAWN PERGANDÉ	CHECK D.PATEL	SCALE 1:6000		
DESIGNED	APPR. J.C. DUMLAO		ISSUED FOR FAB		
PERGANDÉ	DATE 06-25-02		ISSUED FOR CONST		
HALLIBURTON Engineering Services & Technical Services, Inc.					
CAMISEA LNG HOLDING CO.					
CAMISEA LNG EXPORTING PROJECT					
PAMPA MELCHORITA					
OVERALL PLOT PLAN					
P	-	6825	00-EM-51-02	2	
CLASS	AREA	JOB NO.	DOCUMENT NO.	REV	



A1
594x841

Golder Associates



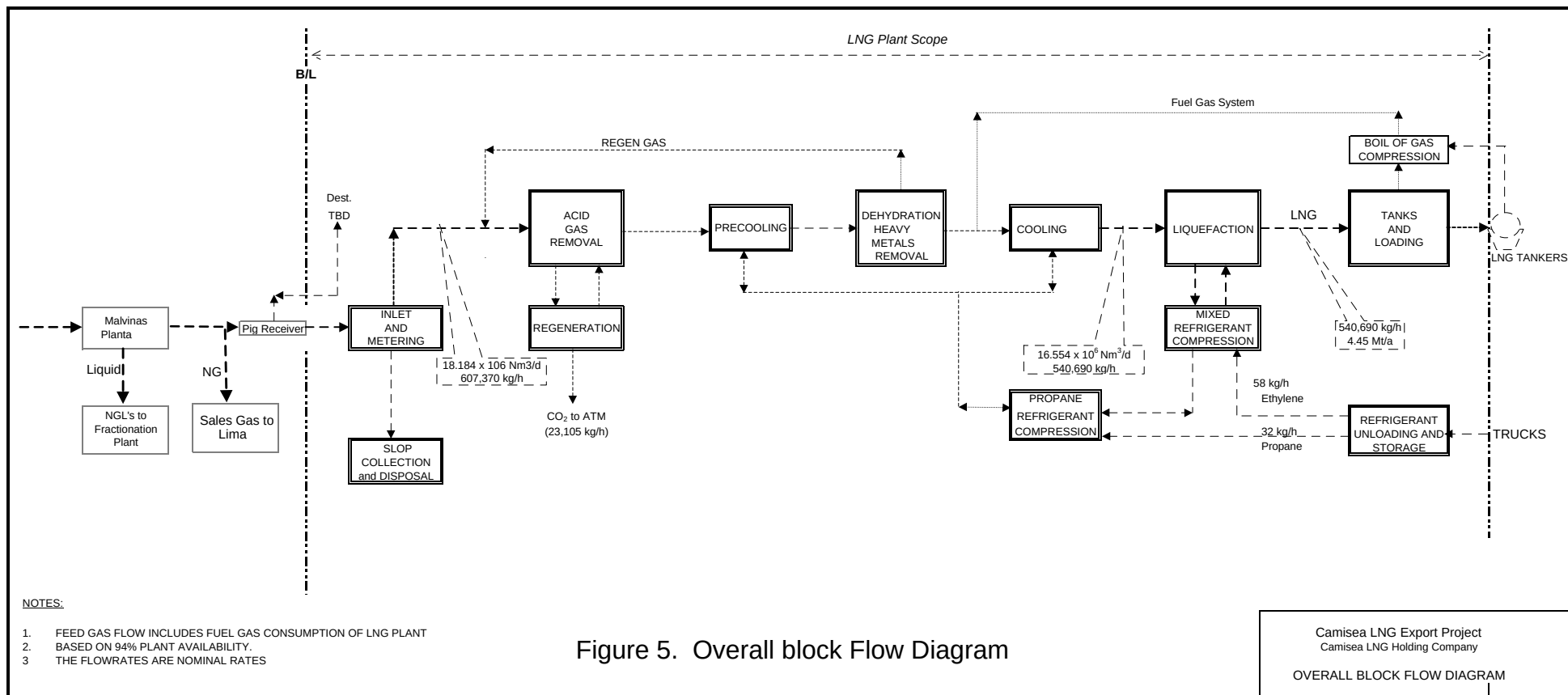
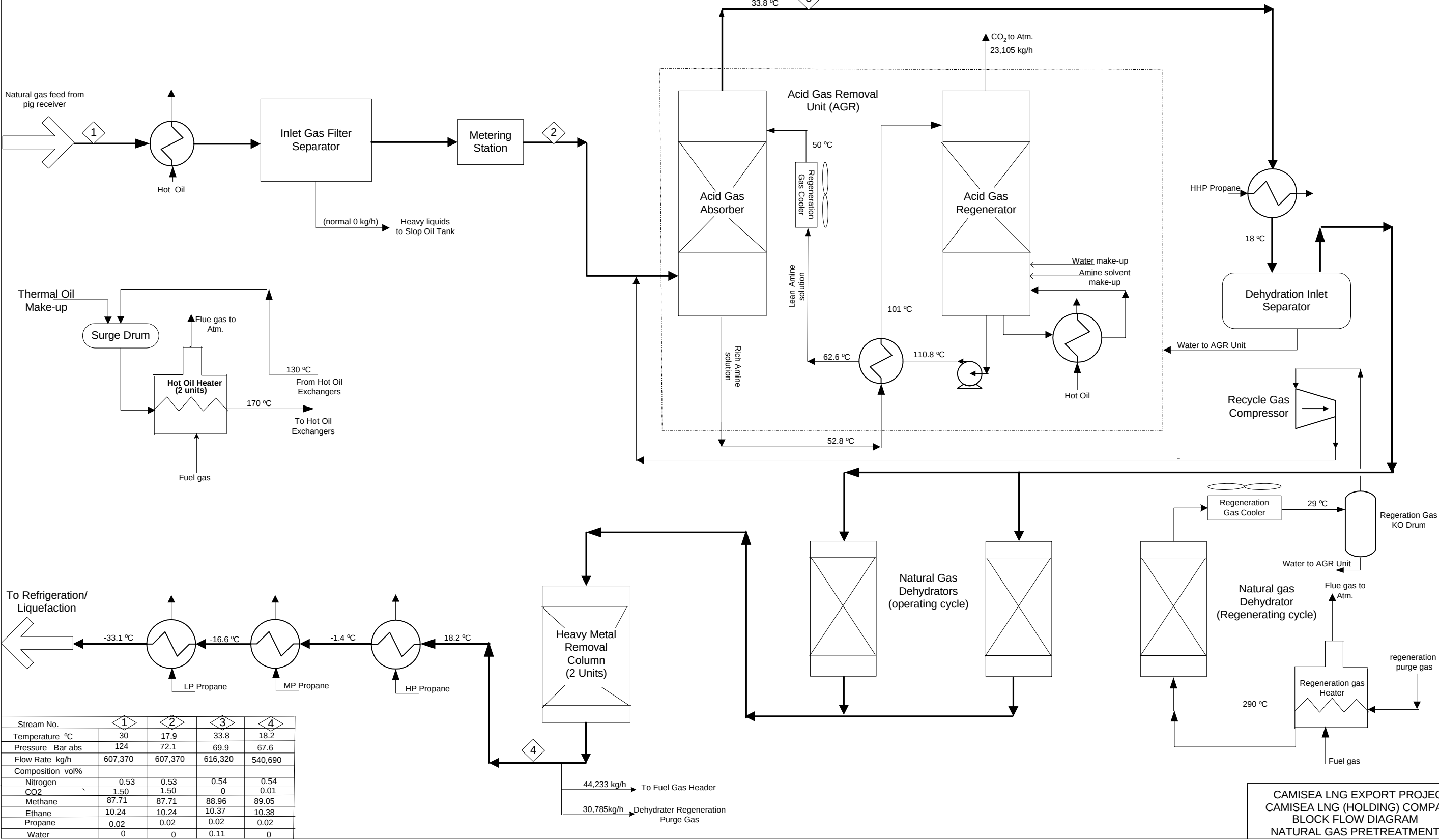
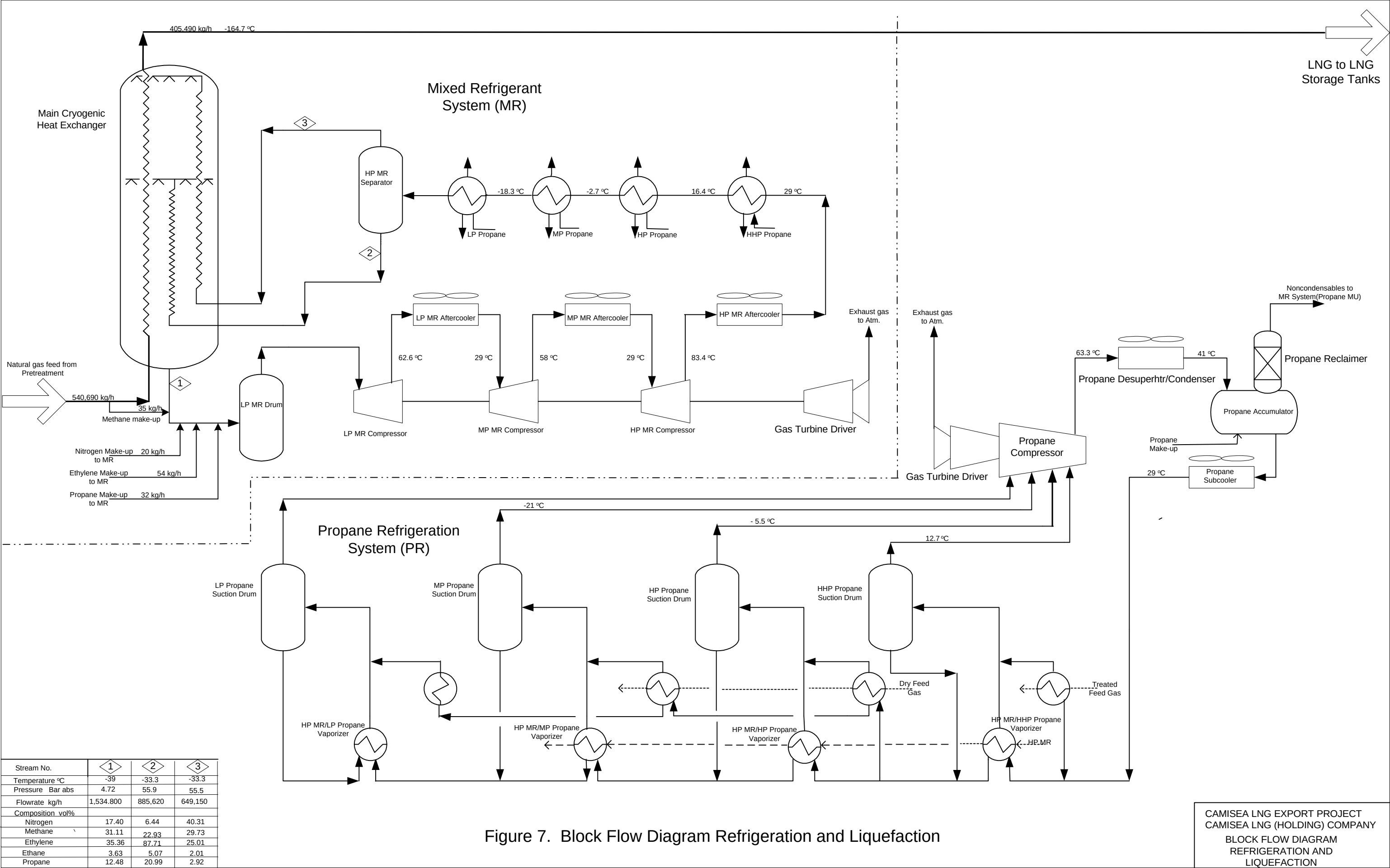


Figure 6. Block Flow Diagram Natural Gas Pretreatment





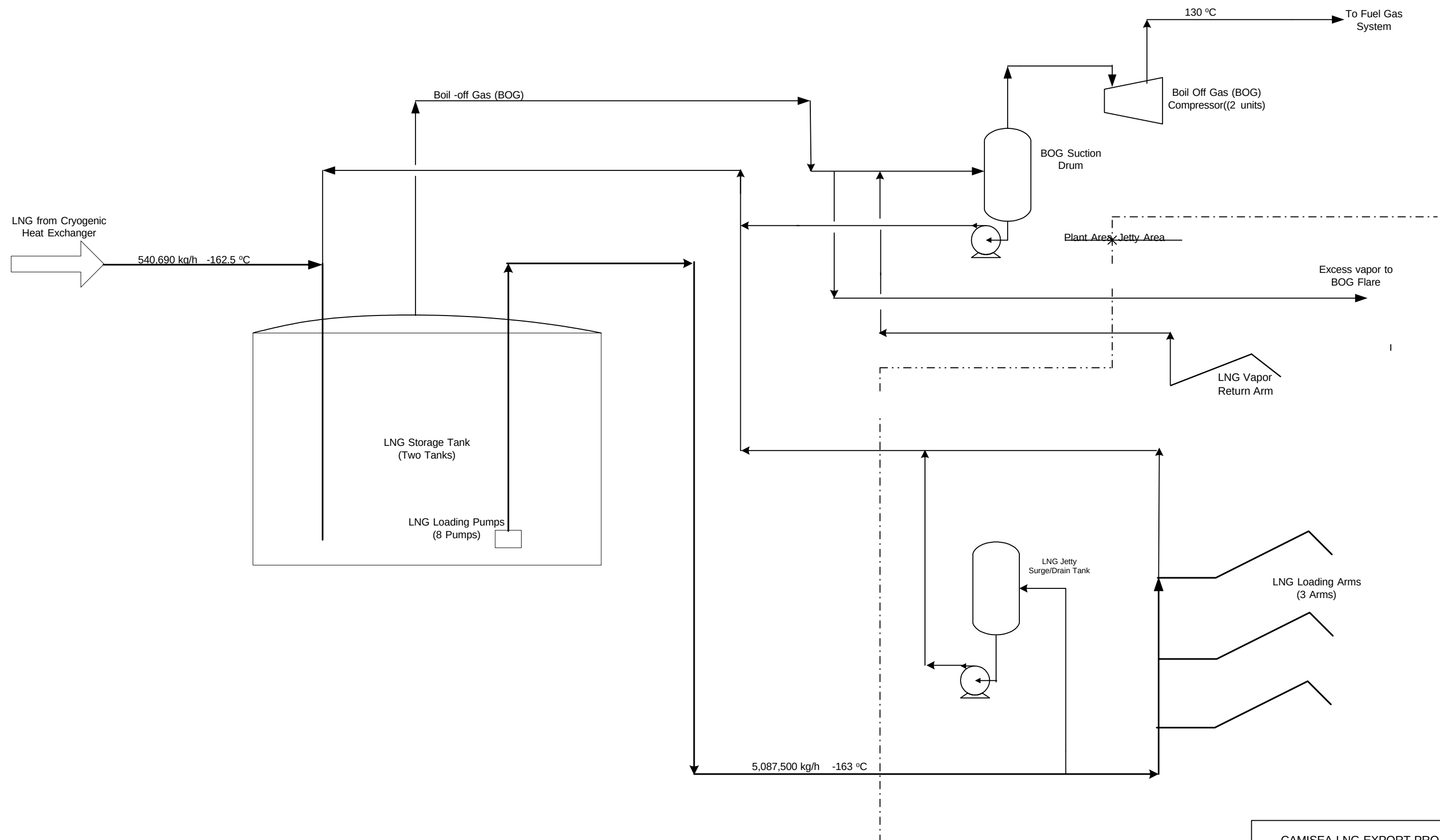


Figure 8. Block Flow Diagram LNG Storage and Loading System

CAMISEA LNG EXPORT PROJECT
CAMISEA LNG (HOLDING) COMPANY
BLOCK FLOW DIAGRAM
LNG STORAGE AND LOADING
SYSTEM

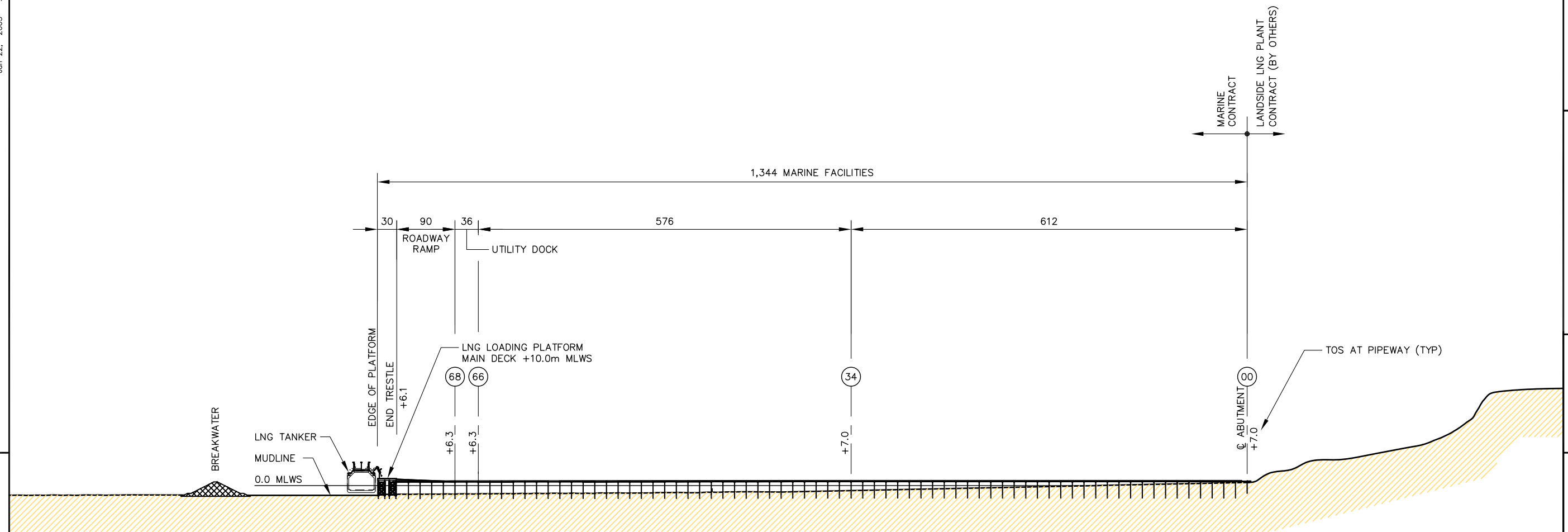
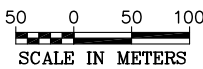


Figure 9. LNG Tanker Berth Profile



APPROVED BY:
[Signature]

NOT FOR CONSTRUCTION

MOFFATT & NICHOL
INTERNATIONAL

NO.	REVISION	DESCRIPTION	DRAWN BY	ENG.	CHK.	APPR.	DATE
ENGINEERED	JAE	DESIGNED	DRAWN	RCW	CHECK	APPR.	WGS
DATE DEC. 2, 2002			ISSUED FOR FEED BOOK				

HALLIBURTON KBR
Engineering services by Halliburton Technical Services, Inc.

CAMISEA LNG HOLDING CO.
CAMISEA LNG EXPORT PROJECT
MELCHORITA, PERU
LNG TANKER BERTH

PROFILE

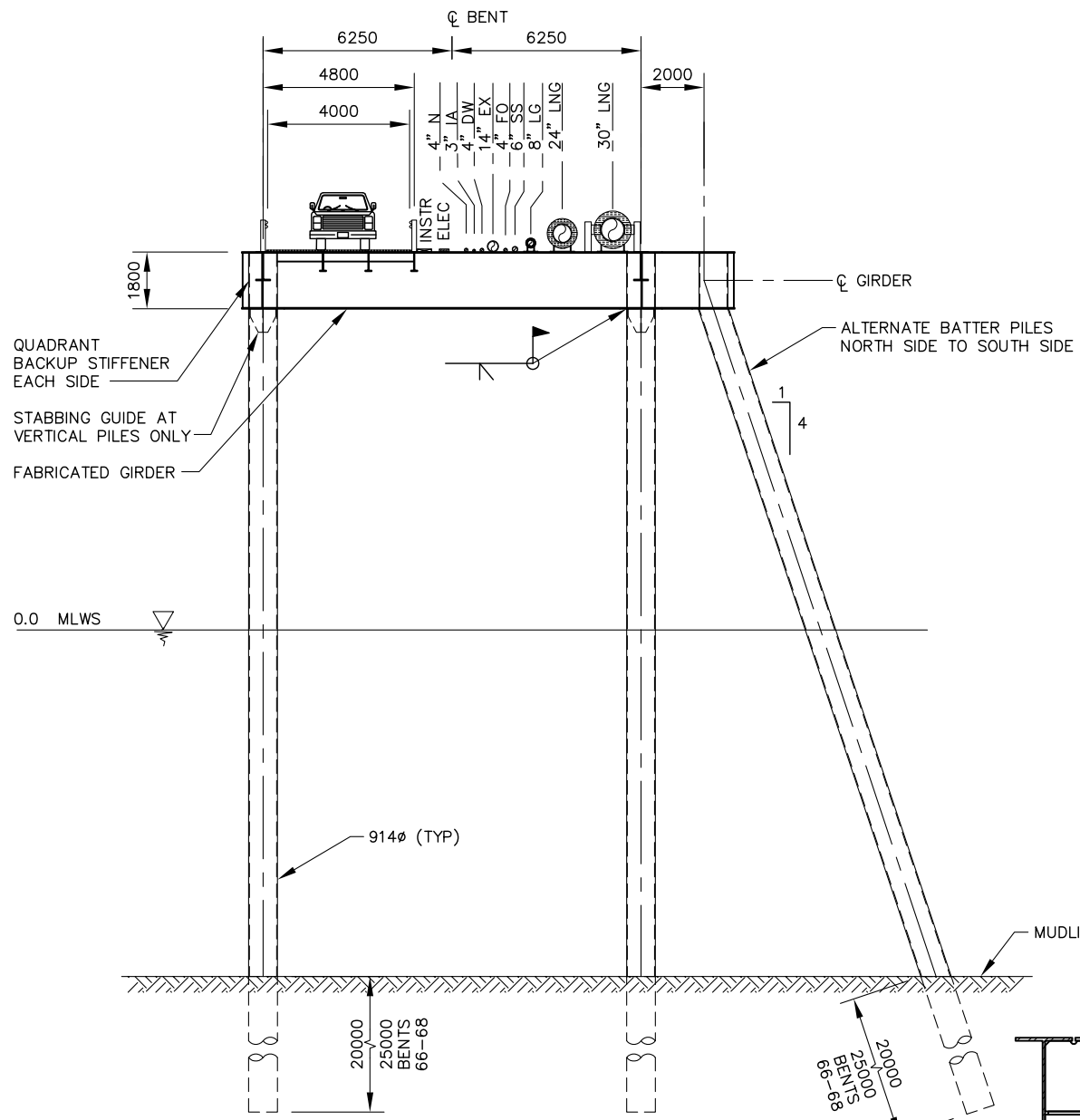
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1 IN.
DIMENSIONAL INDEX

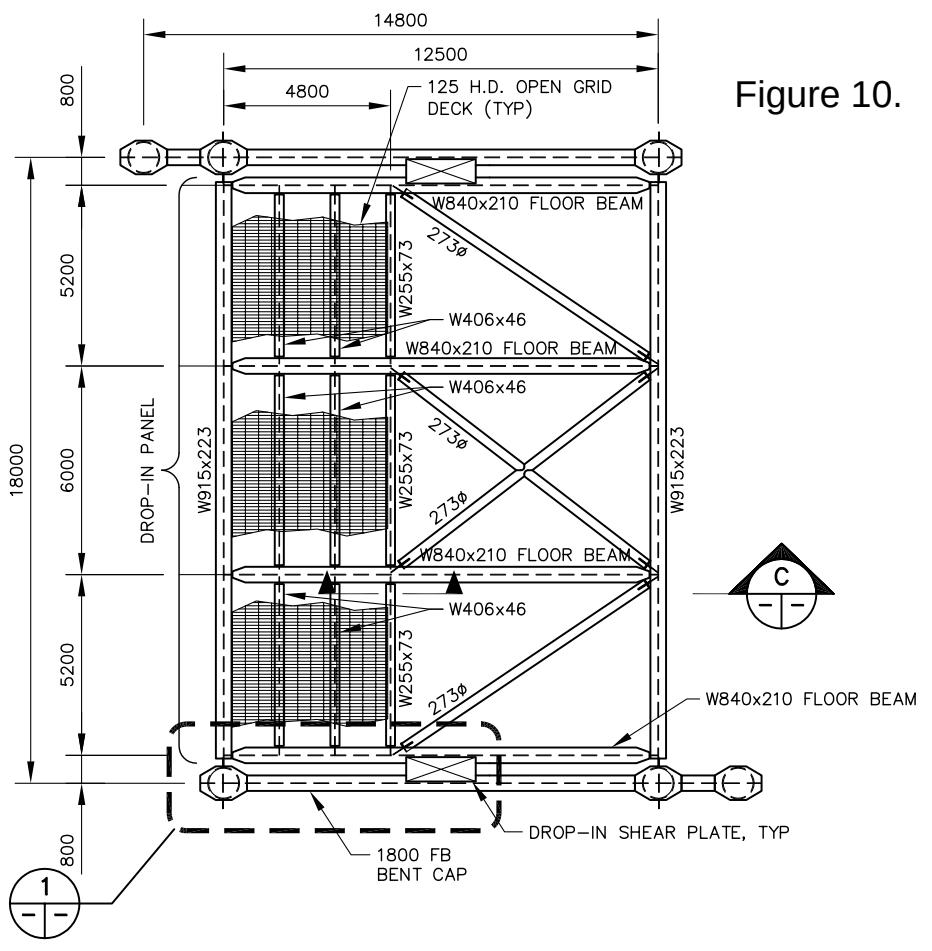
Jan 22, 2003 - 9:34am RWareck

P: 4953-01 Pompa Melchorita\CADD\495301S014.dwg

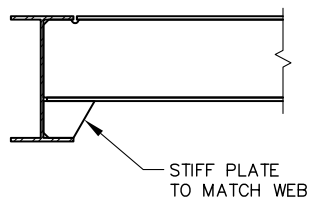
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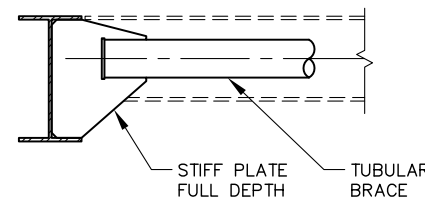
TYPICAL SECTION



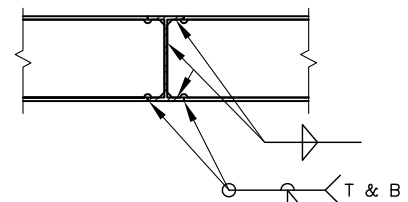
TYPICAL FRAMING PLAN



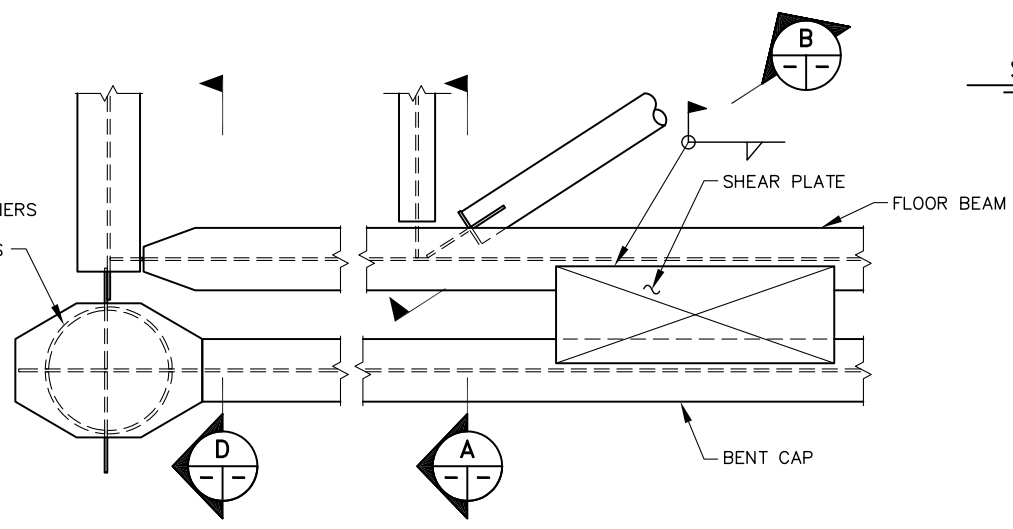
SECTION A
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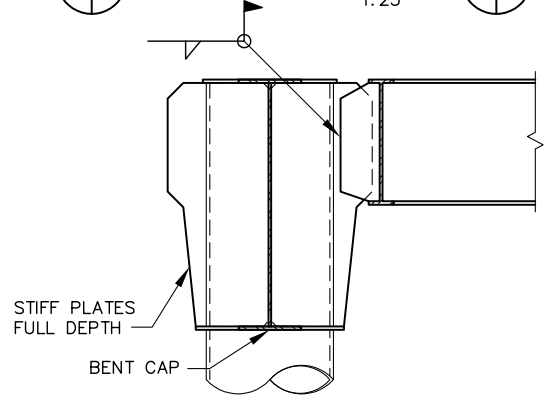
SECTION B
1:25



SECTION C
1:25



DETAIL 1
1:25



SECTION D
1:25

NOT FOR CONSTRUCTION

MOFFATT & NICHOL INTERNATIONAL

NO.	REVISION	DESCRIPTION	DRAWN BY	ENG. CHK.	APPR.	DATE
1	ENGINEERED	JAE	RCW	SCALE	SHOWN	
2	DESIGNED	APPR.	WGS	ISSUED FOR	FEED BOOK	
3	JAE	DATE DEC. 2, 2002		ISSUED FOR		

HALLIBURTON KBR
Engineering services by Halliburton Technical Services, Inc.

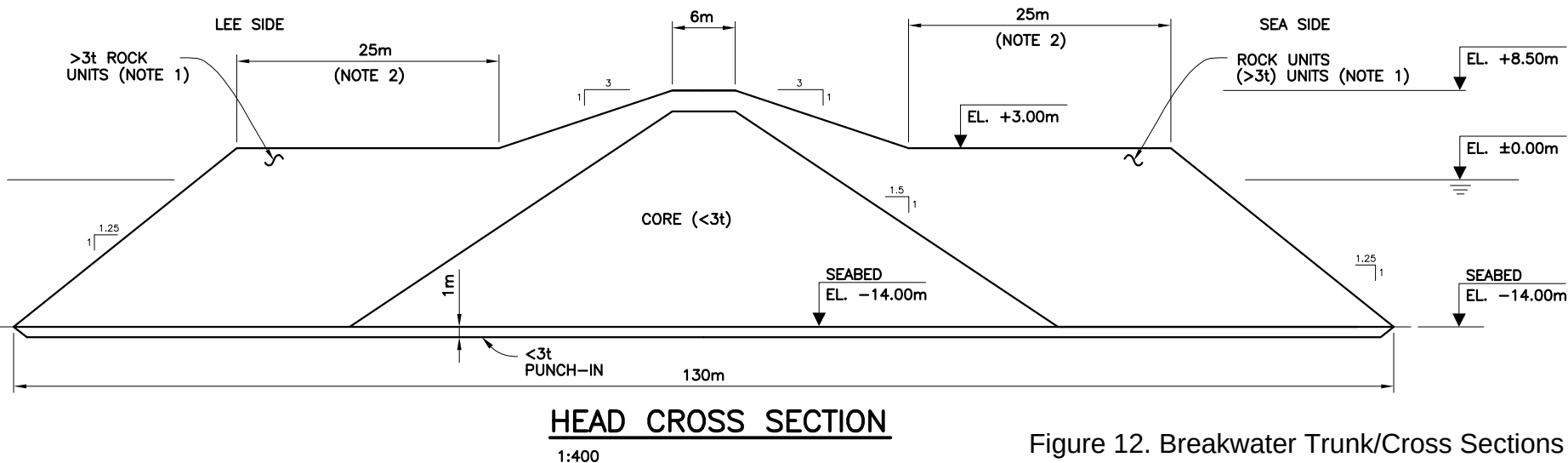
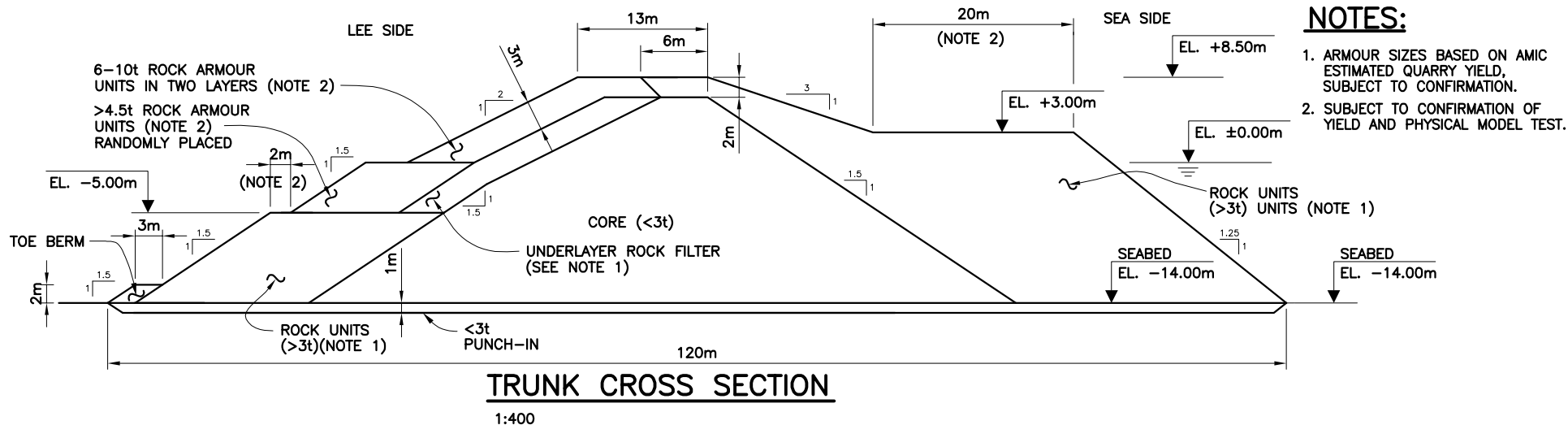
CAMISEA LNG HOLDING CO.
CAMISEA LNG EXPORT PROJECT
MELCHORITA, PERU

ROADWAY - PIPEWAY TRESTLE DETAILS
SECTIONS & FRAMING PLAN

CLASS	AREA	JOB NO.	DOCUMENT NO.	REV
		4953-01	495301S014	1

APPROVED BY:
W. Warck

1 IN.
DIMENSIONAL INDEX



NOTES:

1. ARMOUR SIZES BASED ON AMIC ESTIMATED QUARRY YIELD, SUBJECT TO CONFIRMATION.
2. SUBJECT TO CONFIRMATION OF YIELD AND PHYSICAL MODEL TEST.

Figure 12. Breakwater Trunk/Cross Sections

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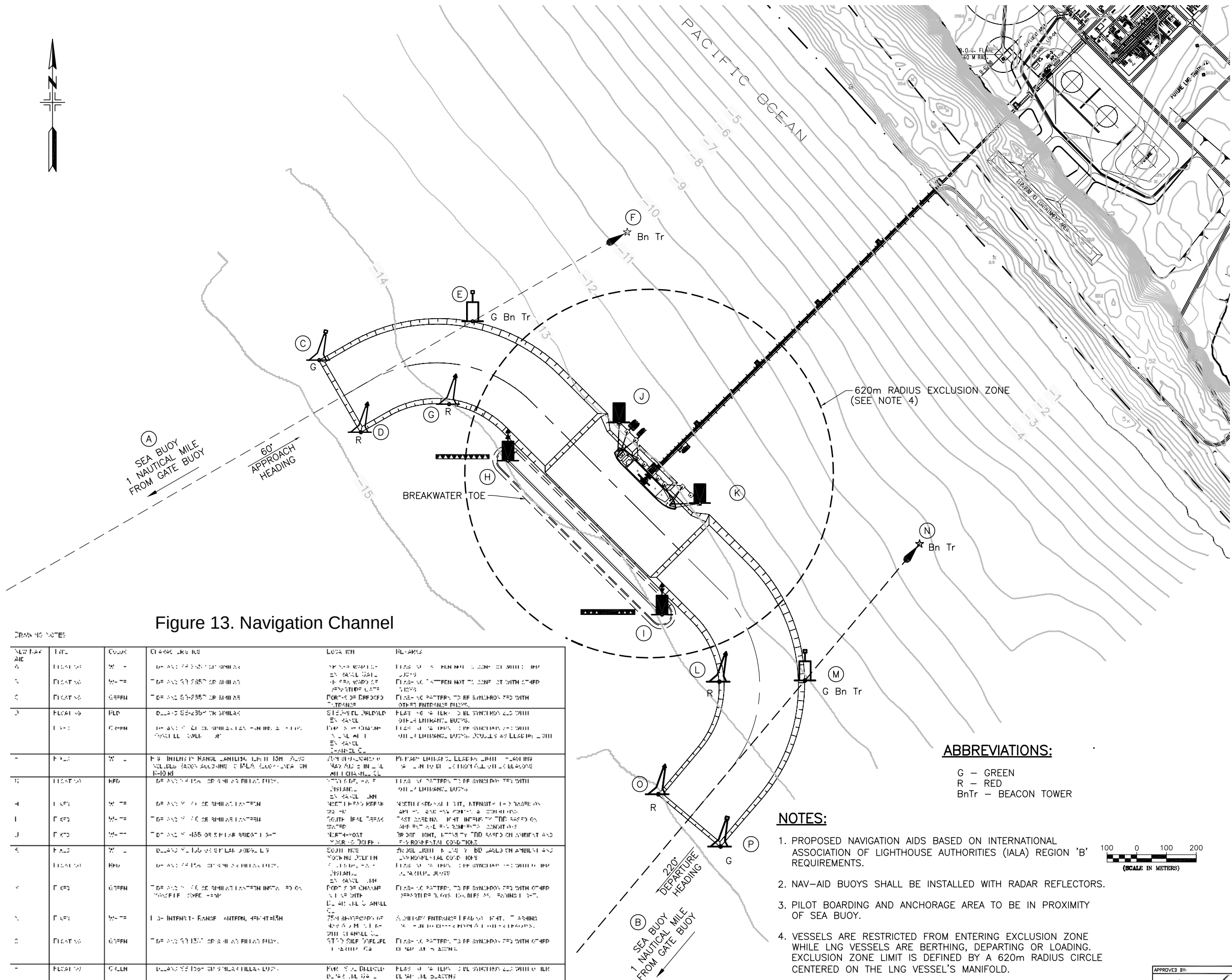


Figure 13. Navigation Channel

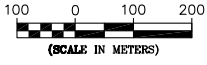
DRAWING NOTES:

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3	DESIGNED	AP	WGS			
4	CHECKED	WGS				
5	DESIGNED	AP	WGS			
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ABBREVIATIONS:
G - GREEN
R - RED
BnTr - BEACON TOWER

NOTES:

1. PROPOSED NAVIGATION AIDS BASED ON INTERNATIONAL ASSOCIATION OF LIGHTHOUSE AUTHORITIES (IALA) REGION 'B' REQUIREMENTS.
2. NAV-AID BUOYS SHALL BE INSTALLED WITH RADAR REFLECTORS.
3. PILOT BOARDING AND ANCHORAGE AREA TO BE IN PROXIMITY OF SEA BUOY.
4. VESSELS ARE RESTRICTED FROM ENTERING EXCLUSION ZONE WHILE LNG VESSELS ARE BERTHING, DEPARTING OR LOADING. EXCLUSION ZONE LIMIT IS DEFINED BY A 620m RADIUS CIRCLE CENTERED ON THE LNG VESSEL'S MANIFOLD.
5. NAVIGATION AID SYMBOLS AS SPECIFIED IN "SYMBOLS AND ABBREVIATIONS USED ON ADMIRALTY CHARTS, CHART 5011".

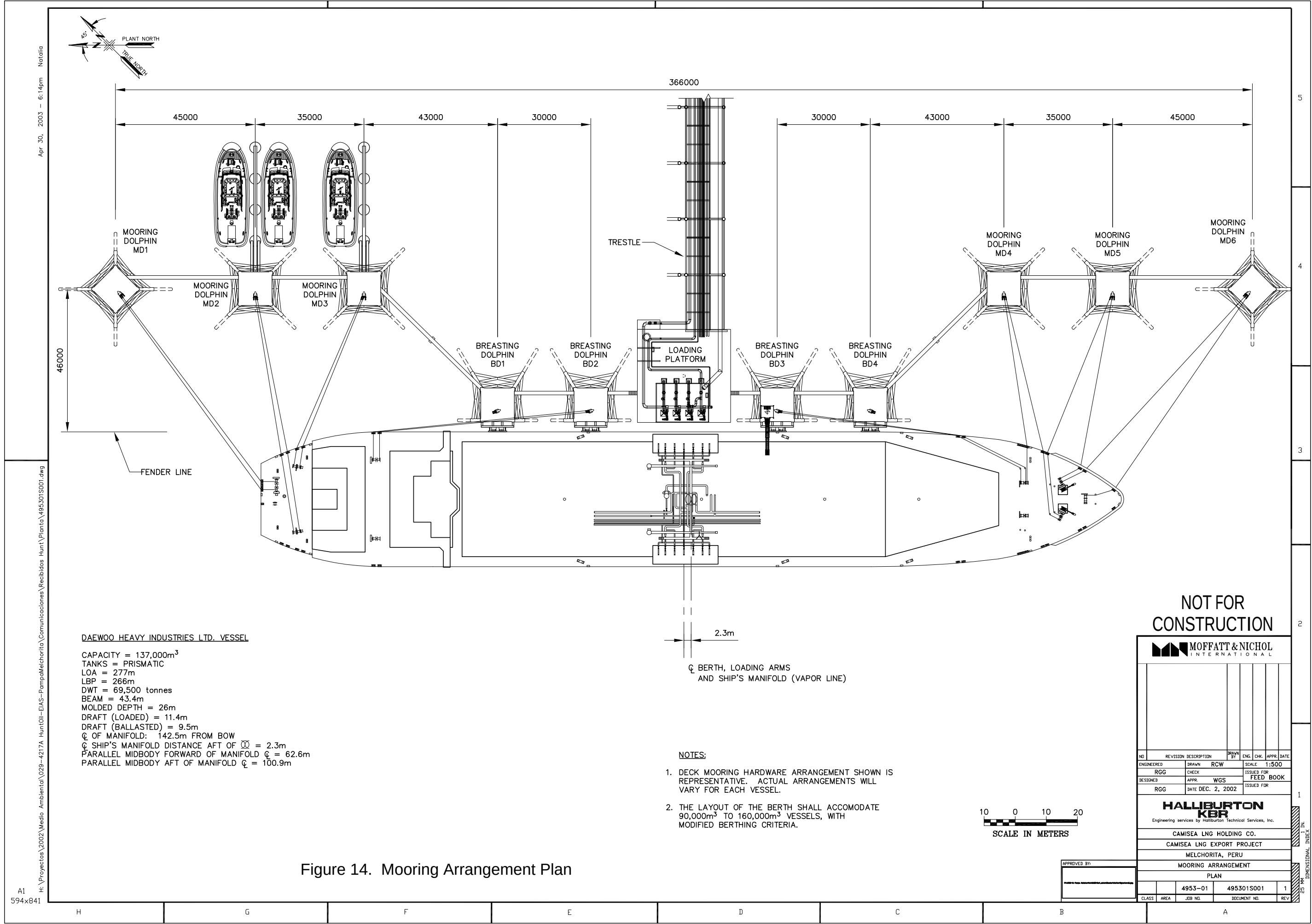


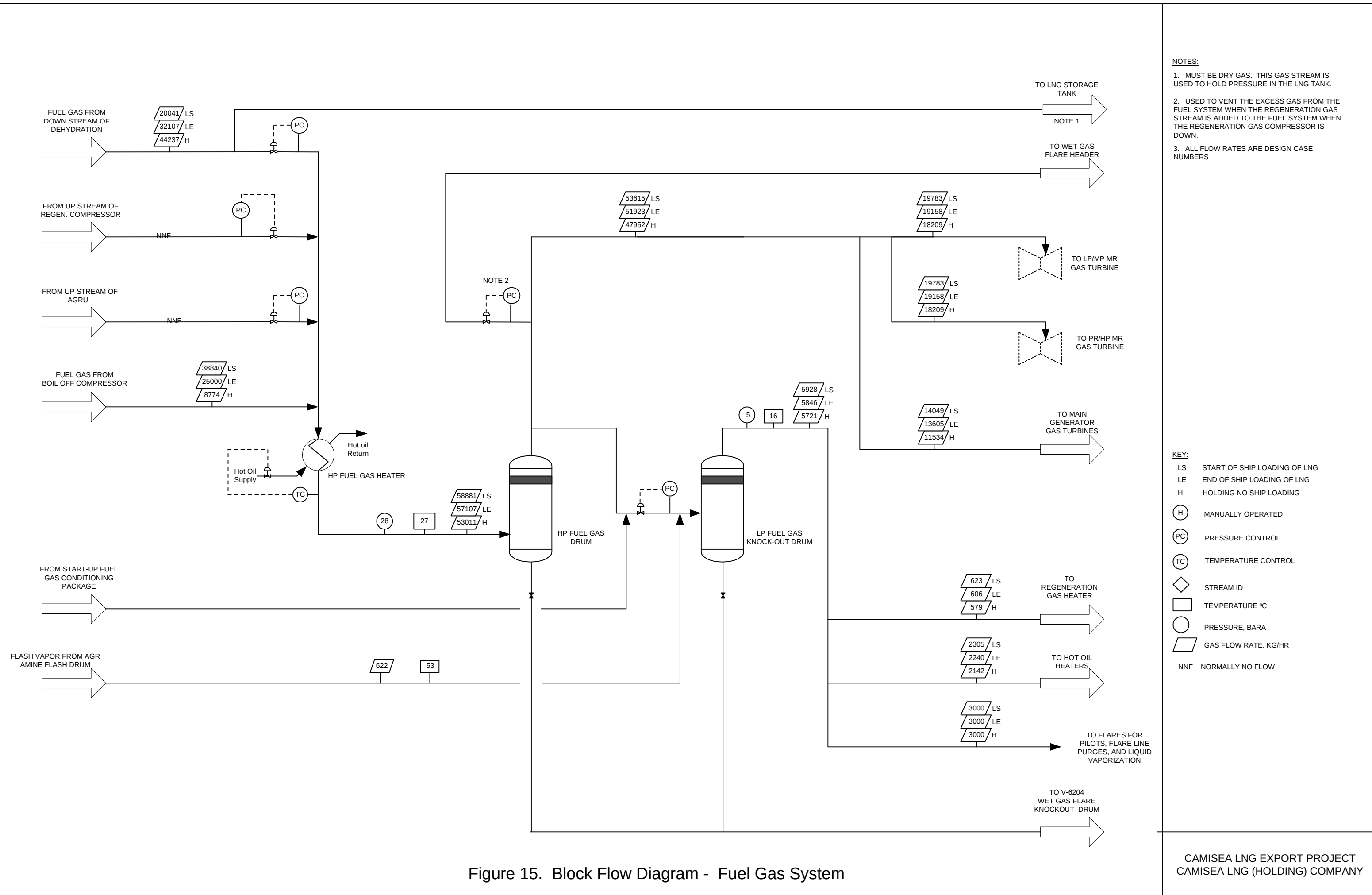
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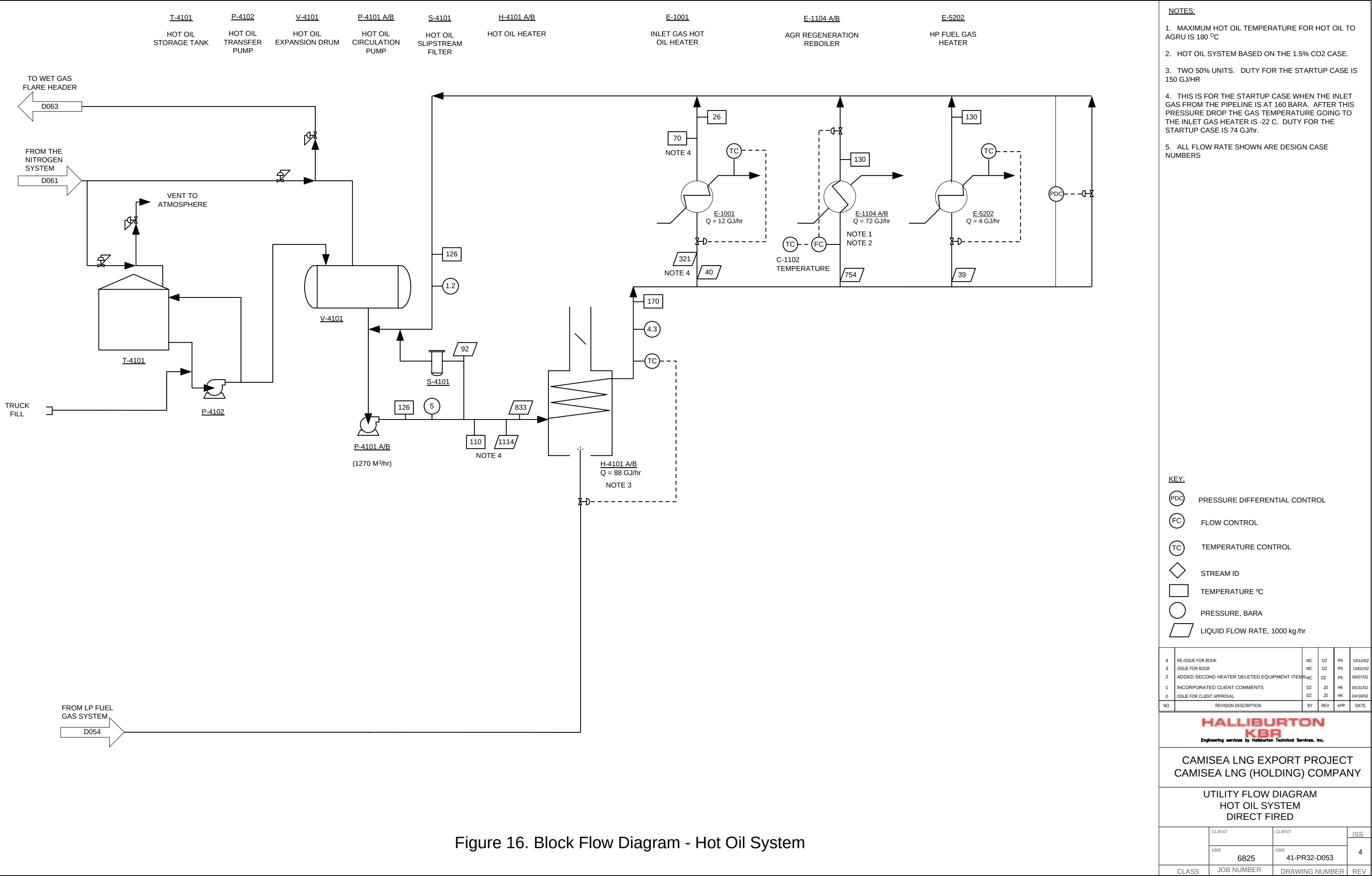
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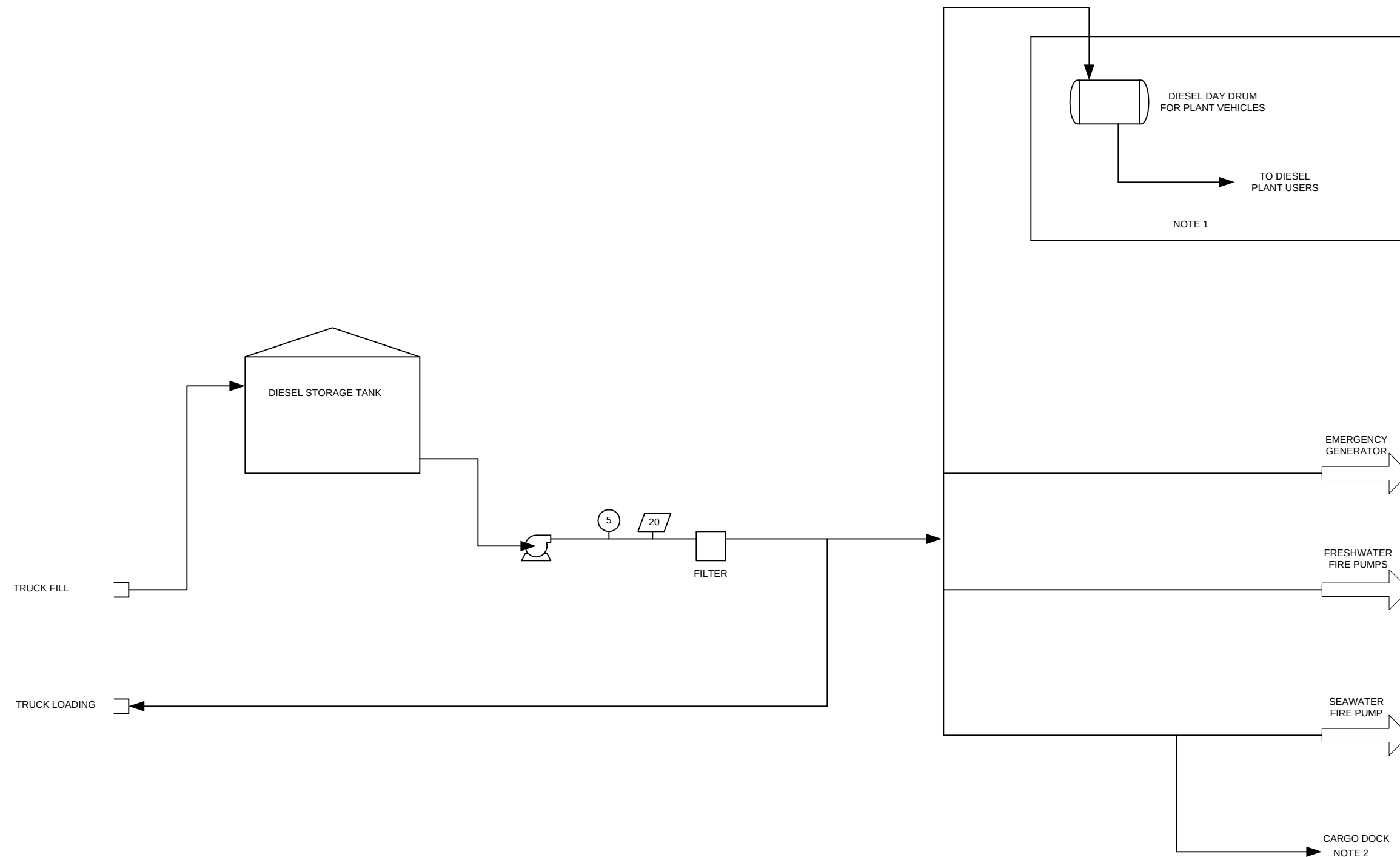
MOFFATT & NICHOL
INTERNATIONAL

NO.	REVISION	DESCRIPTION	DRAWN BY	ENG.	CHK.	APP.	DATE
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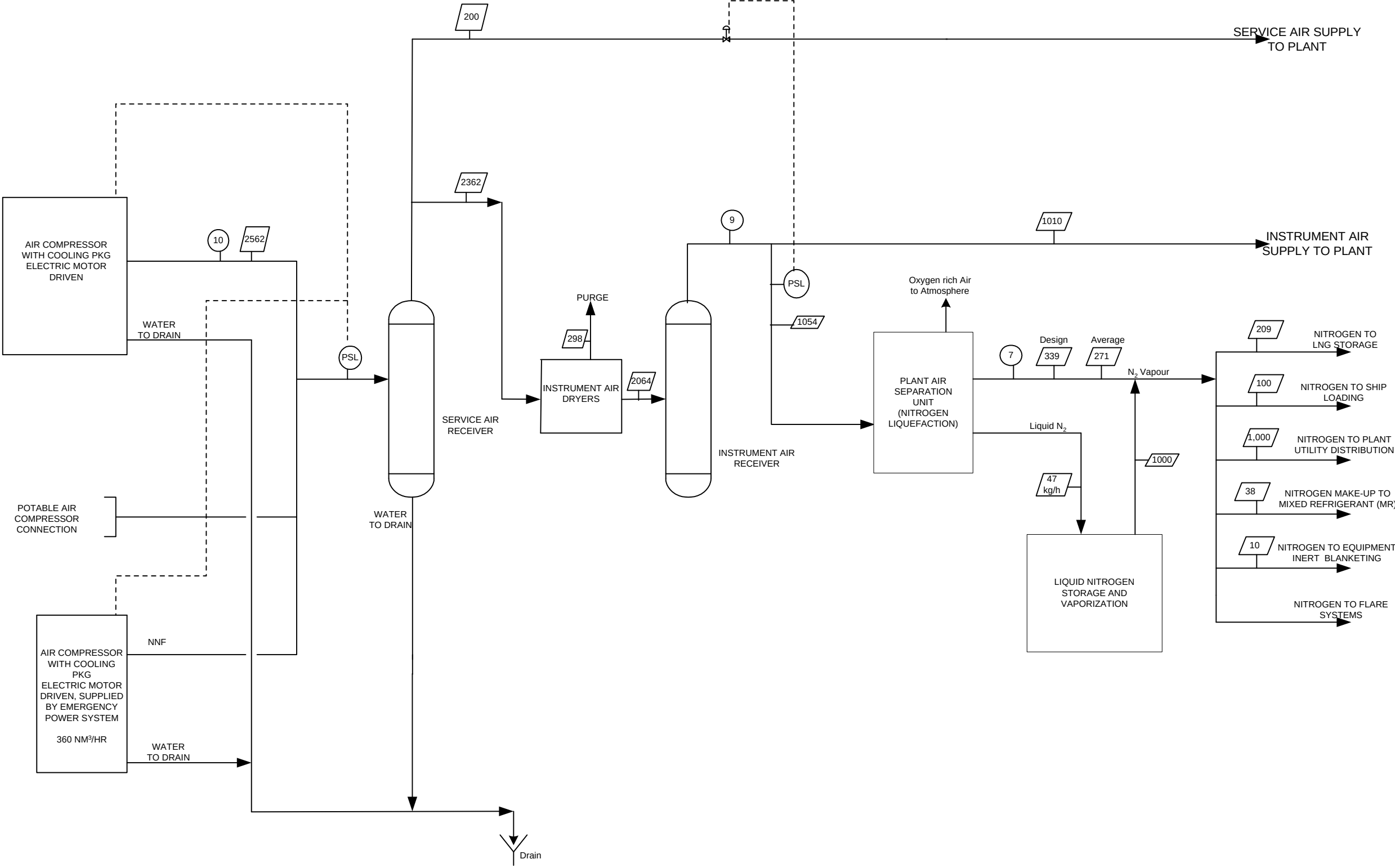
NOTES:

1. LOCATED AT THE MAINTENANCE SHOP AREA.
2. DIESEL FOR TUGS AT CARGO DOCK

KEY:

- ◇ STREAM ID
- TEMPERATURE oC
- PRESSURE, BARA
- ▱ LIQUID FLOW RATE, m3/hr

Figure 17. Block Flow Diagram - Diesel Fuel System



NOTES:

1. ALL FLOW RATE SHOWN ARE DESIGN CASE NUMBERS
2. LIQUID NITROGEN VESSEL DESIGNED TO HOLD 100.000 kg OF LIQUID NITROGEN FOR LNG TRAIN SHUTDOWN. VAPOR RATE SHOWN IS FOR SHUTDOWN.

KEY:

- PSL PRESSURE SWITCH LOW
- STREAM ID
- TEMPERATURE °C
- PRESSURE, BARA
- GAS FLOW RATE, Nm³/hr

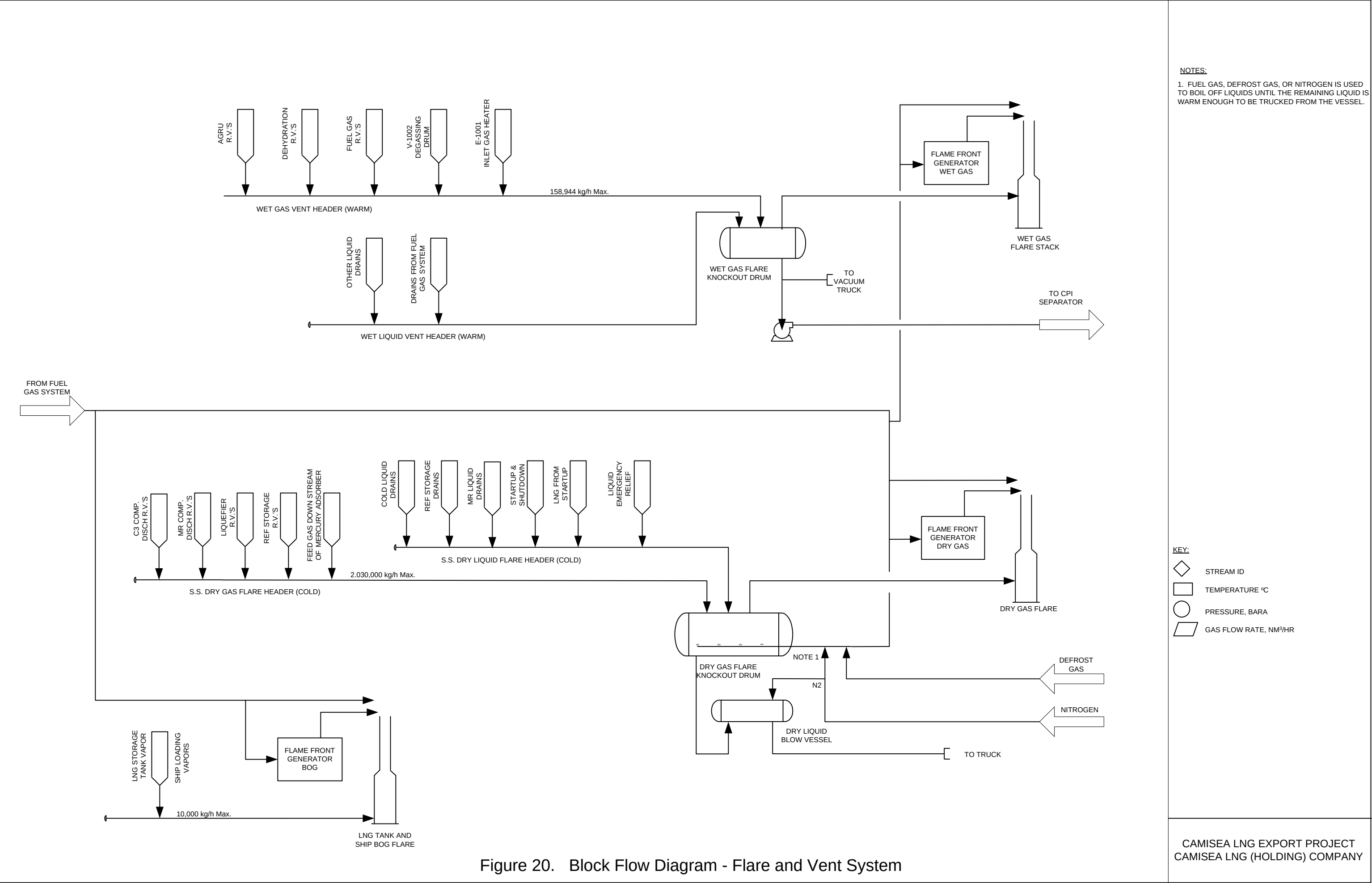
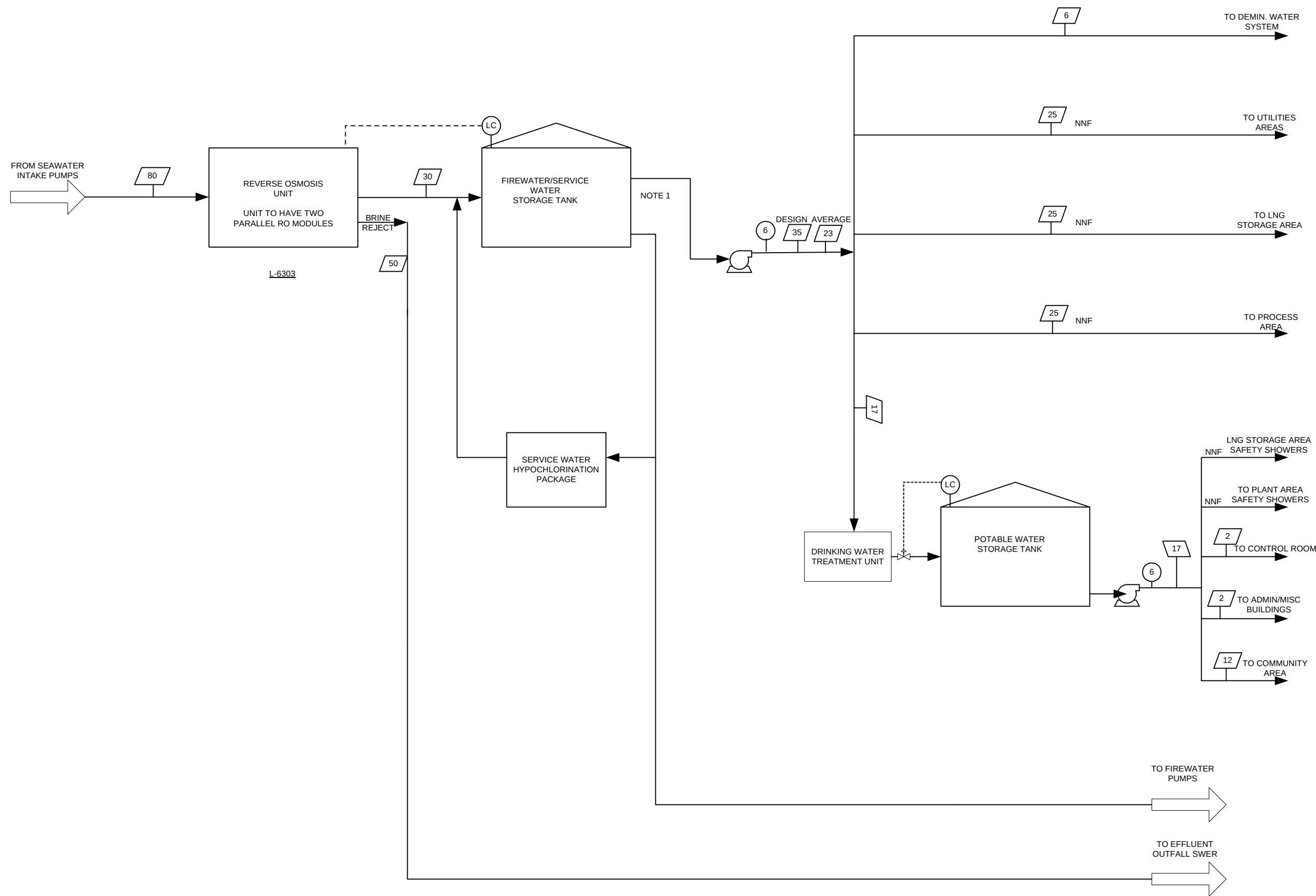


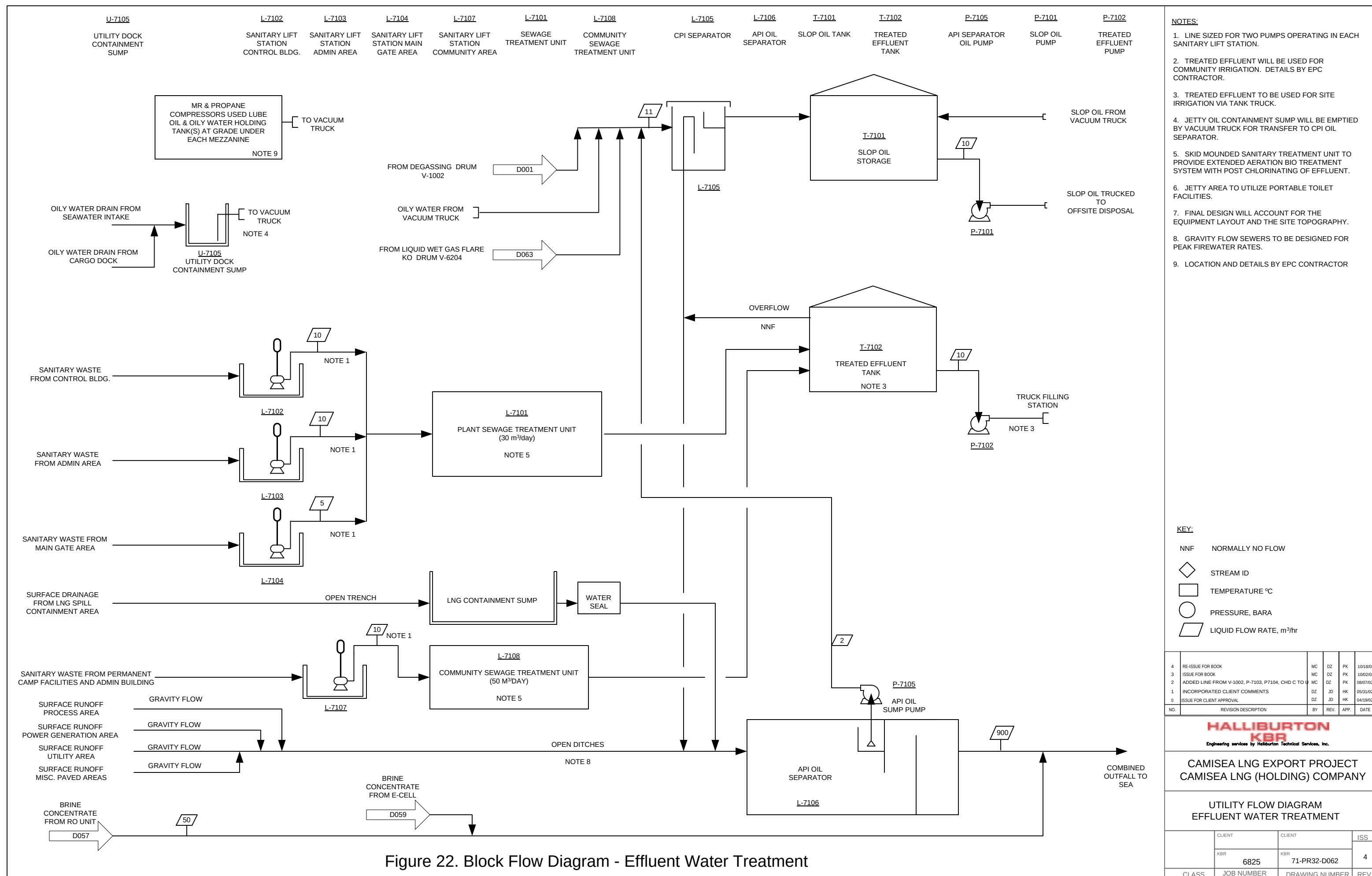
Figure 20. Block Flow Diagram - Flare and Vent System



- NOTES:**
1. THE BOTTOM 63% OF THE STORAGE TANK IS RESERVED FOR FIREWATER
 2. NO SERVICE WATER IS DELIVERED TO JETTY AREA
 3. ALL FLOW RATE SHOWN ARE DESIGN CASE NUMBERS

- KEY:**
- LC LEVEL CONTROL
 - TEMPERATURE °C
 - PRESSURE, BARA
 - LIQUID FLOW RATE, m³/hr
 - NNF NORMALLY NO FLOW

Figure 21. Block Flow Diagram - Service Water System



1.0 LNG Facility Milestones

1.1 EPC Contract

2.0 Site Activities

2.1 Earthmoving and Build Construction Camp

2.2 Transportation of Bulk Materials

2.3 Transportation of Special Heavy Loads

2.4 Civil Foundations and Structures

2.5 Permanent Buildings

2.6 Pipe Fabrication and Installation - CS and Alloy

2.7 Tank Welding - Carbon Steel

2.8 Tank Welding - Alloy

2.9 Equipment Installation

2.10 Electrical and Instrumentation

2.11 Paint and insulation

2.12 Marine Installations - Jetty

2.13 Construct Breakwater

2.14 Plant Commissioning and Start-up

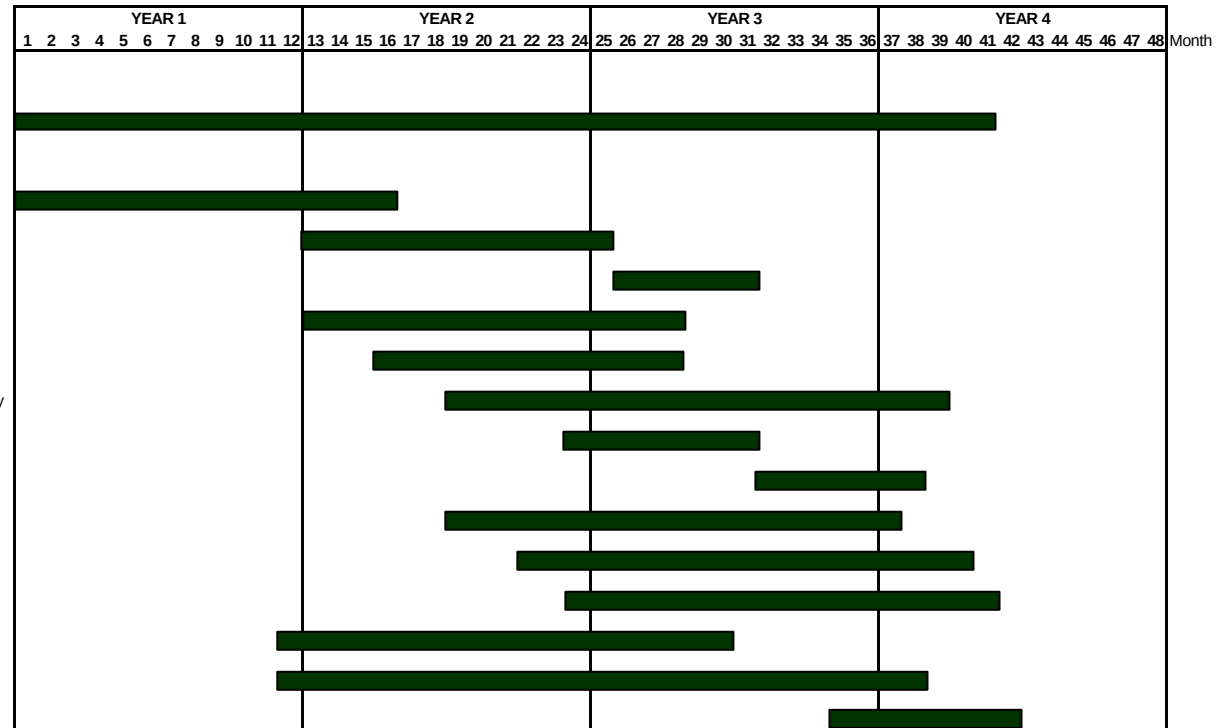


Figure 23. LNG Export Project Schedule

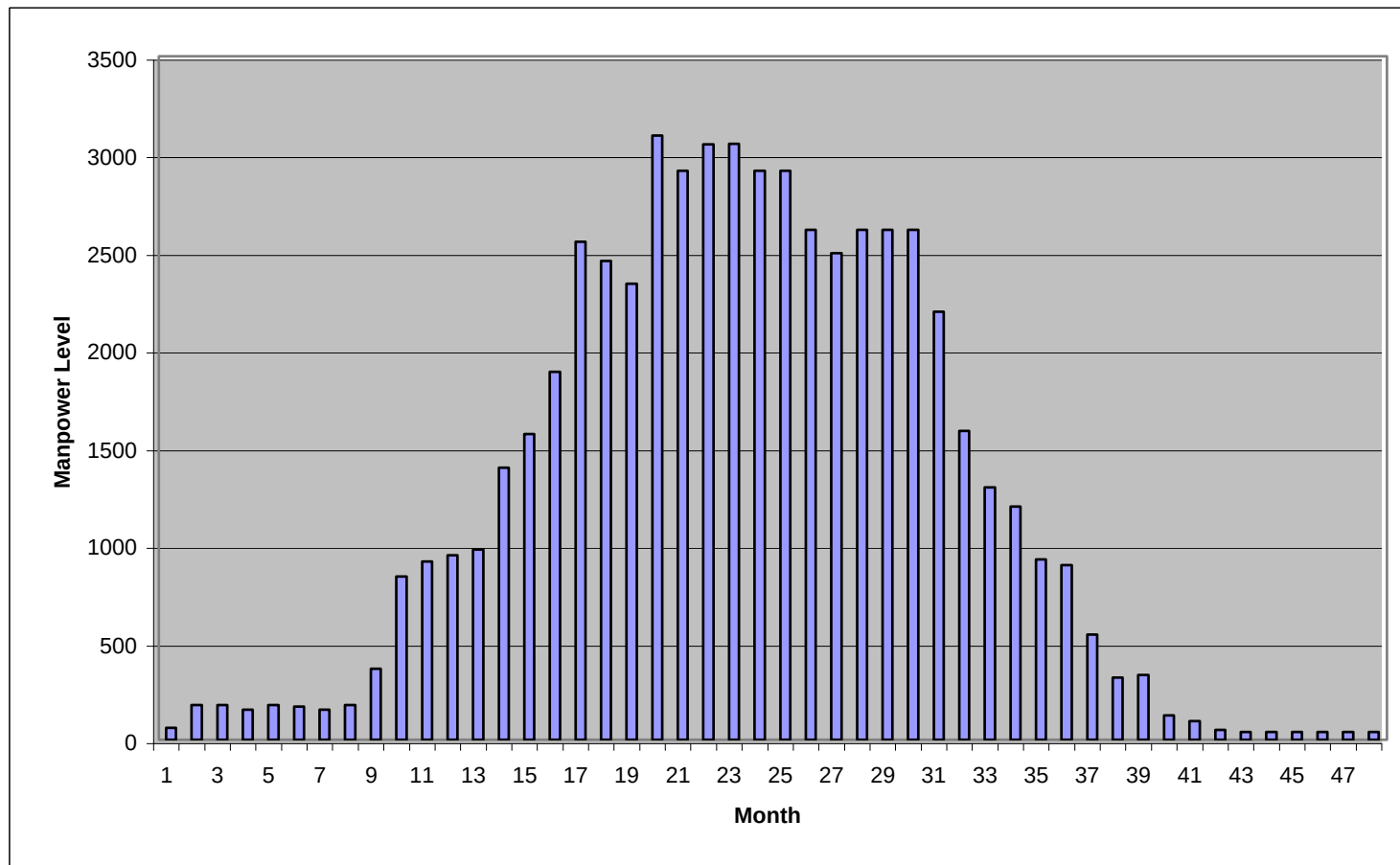


Figure 24. LNG Export Project Manpower