Energía del Pacífico

Proyect: LNG to Power
Addendum to EsIA

February 2018 – 16-3489

ECO INGENIEROS
LÍDERES EN CONSULTORÍA AMBIENTAL

DILLON CONSULTING

Energía del Pacífico

Proyect: LNG to Power

Addendum to EsIA

Chapter 1: Introduction and Project Description

February 2018 – 16-3489

ECO INGENIEROS
LÍDERES EN CONSULTORÍA AMBIENTAL

DILLON CONSULTING

Table of Contents- Chapter 1

Lists of Figuras Chapter 1

List of Tables Chapter 1

List of PhotographChapter 1

Lists of Appedix Chapter 1

1 Introduction and Project Description

1.1 Introduction and Background

The "LNG TO POWER" Project (the Project), which consists of the installation of a Thermal Power Plant for the generation of electric power with a net capacity of 378 MW using natural gas as a fuel, and a Marine terminal to receive the Liquefied Natural Gas (LNG) and convert it to Natural Gas (NG), submitted an application for an environmental permit through the documentation of an Environmental Impact Study (EsIA) submitted to the Ministry of Environment and Natural Resources (MARN). To date the Project has an environmental approval, as notified through Resolution MARN-DEC-GEA-20245-1104-2017, issued by MARN on December 21, 2017. See Appendix 1A

The Project will be located in the Port of Acajutla, Municipality of Acajutla, Department of Sonsonate, El Salvador. The geographic coordinates of the Project location are: 13° 34'59" N and longitude 89°49'43" W. The Environmental impact assessment carried out to obtain the environmental permit, was developed considering a preliminary engineering approach for the Marine Terminal. After the submission of the EsIA, EDP has continued developing the final engineering and evaluating the most favorable alternatives for final design with its team of specialists, leading to some changes to the project design, primarily with the Marine Terminal. Modifications to the Power Plant consist only of changes to the substation.

The main modifications are in relation to:

- Substituting FSU/FSRU forn an FSRU
- Design and technology of the mooring system for the FSRU.
- Definition of construction technology HDD-Ditch for subsea installation of gas pipeline.
- Minor changes in final layout, in location of Marine Terminal elements (FSU/FSRU and pipeline) and restriction zones.
- Definition of Gas Insulated Substation (GIS).
- Reduction of the area to be waterproofed and consolidation in a rainwater retention pond.

Each of the modifications are described in this addendum document. The environmental impact assessment and environmental management program (Chapters 7 and 10 of original EsIA respectively) have also been updated according to the changes made to the project (See chapters 2 and 3). It is important to keep in mind that this addendum, and all this chapters include a description only, of the proyect changes; the rest of the components of the proyect remain the same as those presented previously. Due to the nature of the environmental management program, chapter 3, it emerges completely.

1.1.1 Comparative Matrix

In order to identify and explain better the modifications proposed to the project, the following matrix compares each of the project components between the previous proposal and the new final engineering alternative. See table 1-1

Table 1-1 - Comparative Matrix Between Previous Engineering Alterantive and Final Engineering Alternative.

Comparison Component or Element	Previous Engineering Alterantive	Final Engineering Alternative
Thermal Power Plant		
Location and Layout	Within CEPA Port of Acajutla facilities	Within CEPA Port of Acajutla facilities, no changes to power plant layout, only reduction of substation area and technology.
Total, Area of Development leased to CEPA for Power Plant	126,431.09m^2	No Modifications
Infiltration Loss Area	53,748.19m^2	Infiltration loss area will be reduced to 44,368.36m^2 due to smaller substation and detention pond areas
Complementary Areas: Pipeline ROW, laydown áreas.	56,853.21 m^2	No Modifications
Combustion Engines Technology and Power Generation	• 19 Wärtsilä 18V50SG internal combustion engines with a capacity of 18.3 MW each, for the generation of a total of 348 MW; • A combined steam cycle that will use the exhaust gases of the engines to produce steam to be used in a 30.0 MW steam turbine	No Modifications
Substation Technology	Air insulated Substation (AIS),	Gas Insulated Substation (GIS)
Tree Removal	Removal of 603 trees, including 2 endangered species	519 trees, including 2 endangered species
Detention Pond 1	24 x 60 m and 1.8m high, capacity for 2,544.48 m^3	No Modifications

Table 1-1 - Comparative Matrix Between Previous Engineering Alterantive and Final Engineering Alternative.		
Comparison Component or Element	**Previous Engineering Alterantive**	**Final Engineering Alternative**
Detention Pond 2 (Substation)	15 x 10m and 1.8m high, capacity for 267.84m^3	There will be no pond for substation. Rainwater will be diverted to the larger power plant pond.
Earthworks / Excavations	85,000m^3	Excavations will be reduced to: 81,745m^3
Marine Terminal		
Location and Layout	Within CEPA Port of Acajutla facilities.	Same location with reduction in Projects elements (cofferdam and jetty no longer needed).
Restriction Zones	Defined in conjunction with with AMP and CEPA authorities	New restriction zones consider new layout, project has preliminary approval of AMP and CEPA
Floating Storage and Regasification Unit (FRSU)	100.000 m^3 maxium capacity	138,000-174,000m^3 storage capacity
Floating Storage unit (FSU)	125.000 m^3 maxium capacity	No longer required
Mooring System	FSRU within Cofferdam	Restricted Catenary Mooring (RCM) for the FSRU
Pipeline FSRU to Power Plant	Carbon Steel, 24” diameter, 11 Bar operational pressure, 5°C operational temperature	Carbon Steel, 24” diameter, 80 Bar operational pressure, 5°C operational temperature
Construction Method for Pipeline	Partially buried and part on a trestle	Horizontal Directional Drilling procedure (HDD) and partially buried in a trench
Temporary Construction Trestle	Temporary easel type trestle for supporting activities during construction	No need for trestle with new construction methods for Marine Terminal
Construction Method for Marine Terminal	Dredging for cofferdam construction, dredging for pipe installation, piling for temporary trestle.	Minorcivil works required for RCM ; HDD and ditch for pipes

Table 1-1 - Comparative Matrix Between Previous Engineering Alterantive and Final Engineering Alternative.		
Comparison Component or Element	**Previous Engineering Alterantive**	**Final Engineering Alternative**
Material a dragar	130,000m^3 from seabed dredging material, to be disposed at an offshore location	2,500m^3 of drill fluid with bentonite, from seabed drilling, to be disposed at a defined site for filling

Source: Consulting Team based on information provided by EDP, January 2018.

The main modification to the project are explained in detail in this addendum.

1.1.2 General description of the main modifications

1.1.2.1 Thermal Power Plant Modification: Substation

For the substation's preliminary engineering a Gas Insulated Substation (GIS) technology was considered.This is largely due to the fact that GIS systems are significantly smaller and weigh less (despite the gas weighing more than air, they are also quicker to install. The average installation time is reduced by approximately 30% with a GIS installation (when no gas-handling is required). The GIS systems also take up less space than AIS. The physical footprint of a GIS is about 35% less than AIS.

1.1.2.2 Marine Terminal Modification: Configuration and Mooring System

Four alternative we evaluated for the storage and regasification of the GNL, and configuration of the maritime terminal as part of the project planning stage:

a) Large Floating Storage and Regasification Unit (FSRU), this option involves:

- A vessel, equipped with LNG storage tanks and all equipment required for regasification.
- Pipelines for transporting the natural gas produced in the regasification to the thermal power plant.
- Storage on land and management systems for HFO to provide fuel to the plant during periods of stormy weather and when both the floating storage unit and the regasification unit be moved to the open sea; and dock for access to FSRU.

b) Floating Storage Unit (FSU) and storage tank on land, this option involves:

- A vessel equipped with LNG storage tanks (FSU);
- LNG storage tank on land;
- Equipment for GLN regasification on land; and

- Cryopreserved and insulated pipelines for the transfer of LNG to the storage tank on land and to the regasification equipment; and dock for access to FSU

c) ***Barge for regasification/storage (FSRU) and barge for storage (FSU), this option involves:***
- FSRU with regasification and 50,000 m3 of LNG storage
- FSU for storage of GNL and feed of the regasification plant with LNG.
- Pipeline for transporting the natural gas produced in the regasification to the thermal power plant.
- FSRU will provide fuel to the thermal power plant continuously, or storage when the floating storage unit moves into the open sea.

d) ***Large Floating Storage and Regasification Unit (FSRU), this option involves:***
- A FSRU, equipped with 138,000-174,000m^3 LNG storage tanks and all equipment required for regasification;
- Pipelines for transporting the natural gas produced during the regasification to the power generation plant;
- FSRU to provide fuel to the plant during periods of stormy weather, with a restricted catenary mooring system (RCM).

Alternative (d) was selected as the optimal option due to the reasons presented in able 1-2. It is important to note that the discontinuous gas delivery was one of the main reasons for eliminating alternative (a). While alternative (b), was discarded due to the longer construction time required, which made it impossible to deliver energy in the requested time. Alternative (d) is more optimal than (c) due to the reduction of environmental impacts and cost effectiveness as no cofferdam is required.

Table 1-2 – Evaluation of Alternatives for Marine Terminal				
Criteria	**Alternative (a) Large floating storage unit and regasification (FSRU)**	**Alternative (b) Floating storage unit (FSU) and storage tank onshore**	**Alternative (c) Barge based FSRU and FSU**	**Alternative (d) Large Floating FSRU – Offshore Storage**
Foot print and impact with respect to safety distances	Low, LNG at sea	High, LNG Tank onshore	Low, LNG at sea	Low, LNG at sea
Continuous availability of natural gas to the Thermal Power Plant	NO, in extreme weather situations	YES, from tank onshore	YES, from FSRU with protection structure (cofferdam)	YES, from FSRU with RCM
Compliance with the energy delivery time established in the PPA	Unlikely, by dock construction	NO, by tank onshore construction and dock construction	YES, availability of boats	YES, availability of boats
TOTAL	**NORMAL**	**NORMAL**	**LOW**	**LOW**

Source: Cosulting Team, january 2018.

1.2 Thermal Power Plant Description

All the Power Plant elements will remain the same by the exception of the substation, for which a new alternative is proposed. The characteristics of the new solution are explained in the following sections.

1.2.1 Substation Description

As explained in the original EsIA, the Thermal Power Plant requires an electrical distribution system for all the energy produced by the plant and to raise its voltage so that it can be delivered to the transmission network. The substation will have all the equipment for the transformation, delivery of energy, and protection of the network.

After a review of preliminary engineering, a Gas Insulated Substation (GIS) has been proposed due to its advantages regarding construction, installation, operation, ongoing maintenance and total cost of ownership.

1.2.1.1 Construction

GIS high voltage substation engineering uses the gas sulfur hexafluoride for insulation which is five times heavier than air and offers excellent extinction behavior. GIS systems use fixed, mounted circuit breakers. The sealed mounted breakers are a 'sealed-for-life' technolog in comparison to previous techonoly proposed for the substation.

Installing a GIS high voltage substation can be faster than its counterparts. This is largely due to the fact that GIS systems are significantly smaller and weigh less (despite the gas weighing more than air). The average installation time is reduced by approximately 30% with a GIS installation (when no gas-handling is required).

GIS systems are significantly easier to care for on a regular basis as they offer front instead of rear access. They also contain their own integrated testing instruments. Arc flashes are rare in GIS because all the interior elements are insulated, with only the cable compartment being accessible. As the parts are fully insulated, there are no cables or rods that can join the active parts.

GIS switchyards require significantly less maintenance. On average, GIS systems need only be visually inspected every four years or more, and GIS drives only need to be re-greased after about 20 years (this is an average but may vary between manufacturers).

1.2.1.2 General Characteristics of the Substation

The proposed distribution device is a switching device with Gas Isolation type B105, 230 kV has characteristic and performances according to table 1-3. These performances have been proposed taking account of the project requirements.

Table 1-3 - General Data for Gas Insulated Switchgear		
Description	**Unit**	**Grid Solutions Values**
Ambient minimum temperature	°C	-25
Ambient maximum temperature	°C	40
Seismic level (IEEE)	g	0.5 max
Reference standards		IEC
Service voltaje	kV	220
Maximum service voltage	kV	245
Nominal insulation level (withstand voltages, to ground)		
○ at power frequency 1 min	kV	460
○ at lightning impulse (1.2/50 µs wave)	kVp	1050
○ at switching impulse (250/2500 µs wave) (1)	kVp	850
Frequency	Hz	50
Rated service current		
○ Busbar	A	3150
○ Feeder bay	A	2000
○ Transformers bay	A	2000
○ Bus coupling bay	A	3150
Rated short-time resistence current	kA	40
Rated peak supported current	kAp	100
Increase in temperature rise at rated service current		
○ Conductor	°C	≤ 65
○ Enclosure	°C	≤ 30
Rated SF6 gauge pressure at 20 °C		
○ Circuit breaker	bar rel.	6.3
○ Switchgear	bar rel.	6.3
SF6 gas recharge signal		
○ Circuit breaker	bar rel.	5.8
○ Switchgear	bar rel.	5.8
SF6 alarm level (2)		
○ Circuit breaker	bar rel.	5.5
○ Switchgear	bar rel.	5.5
Enclosure design pressure		
○ Circuit breaker	bar	9.0
○ Switchgear	bar	9.0
Enclosure design code		CENELEC
Leakage rate of SF6 per annum for the whole substation	%	< 0.5
Maximum partial discharge at 1.2 times rated voltage in factory	pC	≤ 5
Factory Dielectric routine test 50Hz	kV	460

Table 1-3 - General Data for Gas Insulated Switchgear		
Description	**Unit**	**Grid Solutions Values**
Site dielectric test	kV	380
Rated test voltage of secondary circuit	kV	2

Source: Energia Del Pacifico 230 kV GIS Tender: 1149150SLV (Technical data & Performances)
(1) Tested value not required by IEC standard.
(2) The values apply at this gas pressure.

1.2.1.1 Transformers

The following table 1-4 compares the characteristics of the current transformers.

Table 1-4- Current Transformers Main Characteristics						
Identification	**CT1**	**CT2**	**CT3**	**CT4**	**CT5**	**CT6**
Standard	IEC	IEC	IEC	IEC	IEC	IEC
Rated primary current	2000	2000	2000	3000	3000	3000
Rated secondary current	5	5	5	5	5	5
Accuracy Burden (VA) (*)	15	15	30	15	15	30
Accuracy Class (*)	0.2	0.5	5P20	0.2	0.5	5P20
Thermal Withstand (k In)	1.2	1.2	1.2	1.2	1.2	1.2
Short-time withstand Current Ith (kA/sec)	40/3	40/3	40/3	40/3	40/3	40/3

Source: Energia Del Pacifico 230 kV GIS Tender: 1149150SLV (Technical data & Performances)
(*) Given only on the highest ratio.

The following table 1-5 presents the main characteristics of the voltage transformers.

Table 1-5 - Current Transformers Main Characteristics		
Identification	**VT1**	
Standard	IEC	
Primary voltage (kV)	230 / √3	
Voltage factor (time)	1.5 for 30 s, 1.2 continuous	
Secondary voltage(s) (V)	115/ √3	115/ √3
Accuracy Class	0.2	3P
Accuracy burden (VA)	50	50
Total thermal withstand at secondaries (VA)	1000	

Source: Energia Del Pacifico 230 kV GIS Tender: 1149150SLV (Technical data & Performances)

The plans from the new alternative are presented in the **¡Error! No se encuentra el origen de la referencia.**.

1.2.2 Distribution of Areas for Thermal Power Plant

The project will be located within the Port of Acajutla, on land owned by CEPA. The main components of the Thermal Power Plant with their respective areas are presented below in Table 1-6 and Table 1-7.

Table 1-6 - Areas to be occupied by the Thermal Power Plant and Electrical Substation		
Description	**Area (m^2)**	**Percentage**
Electrical Substation	12,000.00	9%
Main building	21,019.53	17%
Retention pond	2,812.32	2%
Parking lot	702.39	1%
Various structures	1,819.26	1%
Streets	5,700.26	5%
Area for 4 wells	314.6	0%
Area of future use	59,031.46	47%
Green Area	23,031.27	18%
Total Area:	**126,431.09**	**100%**

Source: Consulting Team, 2018.

Table 1-7 – Areas that will be occupied by pipeline route and Laydown Area		
Description	**Area (m^2)**	**Percentage**
NG pipeline ROW on land	15,976.68	28%
Laydown area	40,876.53	72%
Total Complementary Area:	56,853.21	100%

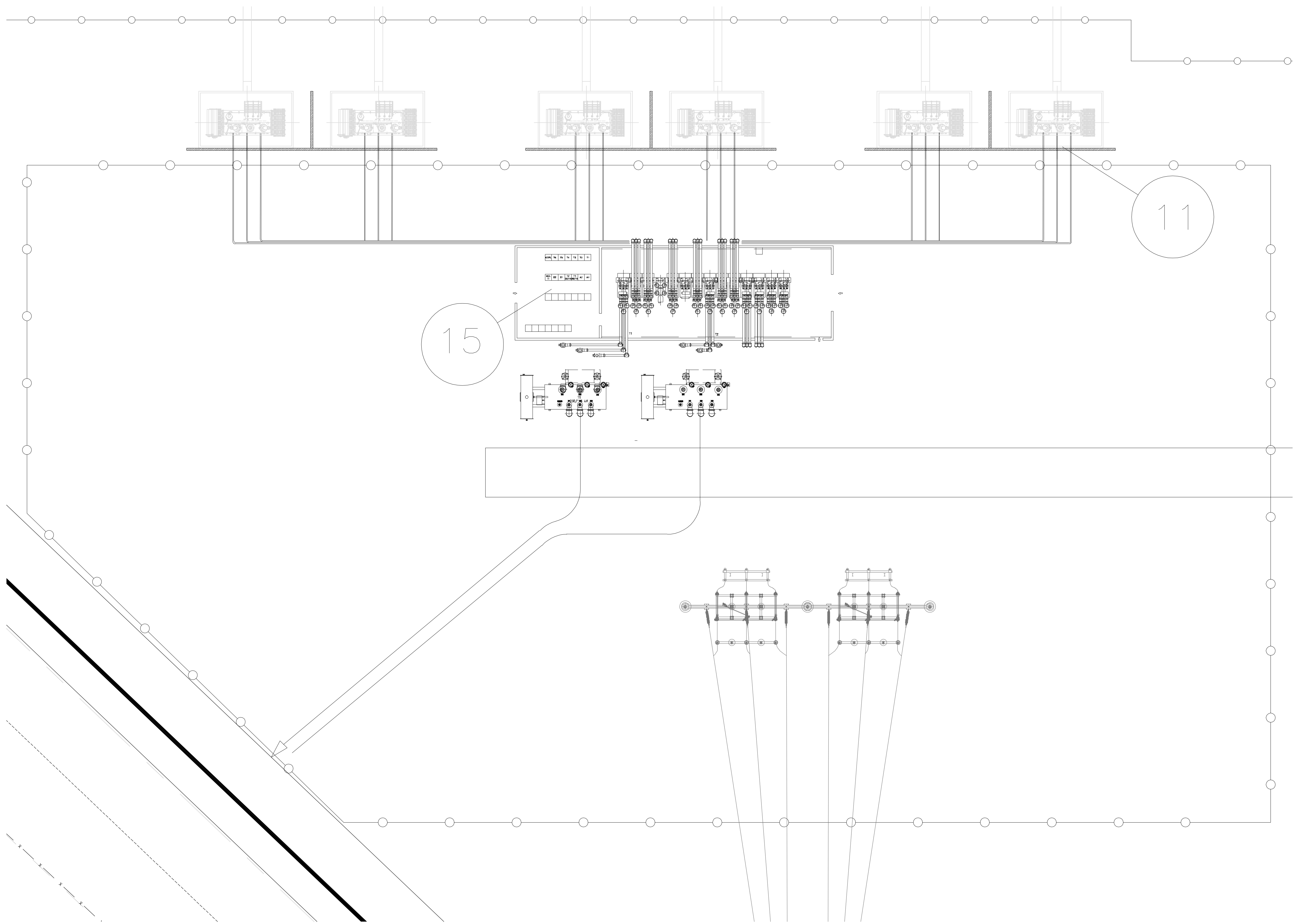
Source: Consulting Team, 2018.

¡Error! No se encuentra el origen de la referencia. shows the layout for the different elements of the Thermal Power Plant.

1.2.3 Infiltration Loss

The GIS requires less area than the previously proposed substation. With the reduction of this area it is expected that infiltration loss area or total paved area will be reduced as well. The type of ground material to be used for the Thermal Power Plant and Substation area is detailed as follows:

- pavement/asphalt or concrete for access roads;
- Gravel in areas of tanks, substation; and
- Grass in gardens, where there is no traffic. Remaining material from earthworks will be use for filling at these areas.



Energía del Pacífico

ENERGÍA DEL PACÍFICO

LNG TO POWER PROJECT

PLAN DE SUBESTACIÓN ELÉCTRICA / ELECTRICAL SUBSTATION PLAN

FIGURA 1.1 / FIGURE 1.1

INTERCONNECTION POINTS (PUNTOS DE INTERCONEXION)	
No.	System (Sistema)
1	LFO/Black start (Arranque)
2	Natural gas (Gas Natural)
3	Lubrication oil system (Sistema de lubricacion)
6	Raw water (Agua no tratada)
7	Sewage water system (Sistema de agua residuales)
8	Rejected water (Agua rechazada)
9	Stormwater (Agua pluvial)
10	Sludge/Oily water system (Sistema de aguas grasas y aceitosas)
11	HV system (Sistema HV)
15	Telecommunication & RTU (Telecomunicación y RTU)
16	Telephone & Internet connection (Conexión de teléfono e Internet)

0 10 20 30 40 50m

N W E S

FUENTE / SOURCE:
PLANOS WARTSILA / WARTSILA SITE PLAN

MAPA CREADO POR / MAP CREATED BY: ECO INGENIEROS
MAPA REVISADO POR / MAP CHECKED BY: LF
PROYECCIÓN DE MAPA / MAP PROJECTION :
UTM ZONA 16 WGS84 / UTM ZONE 16 WGS84

ARCHIVO / FILE
C:/ECO,DRAWING 1, EL SALVADOR/ ECO INGENIEROS
C:/ECO,DIBUJO 1, EL SALVADOR/ ECO INGENIEROS

PROYECTO / PROJECT: 14-9114
ESTADO / STATUS : FINAL / FINAL
FECHA / DATE: 20/12/2017

DILLON CONSULTING

ECO INGENIEROS

The new detail of the areas to be Waterproofed in presented inTable 1-8

Table 1-8- Impermeable Areas			
Description	**Area (m^2)**	**To Pave**	**%**
Electrical Substation	12,000.00	12,000.00	9%
Main building	21,019.53	21,019.53	17%
Parking lot	702.39	702.39	1%
Various Structures	1,819.26	1,819.26	1%
Streets	5,700.26	5,700.26	5%
Wells Areas	314.6	314.60	0%
Retention ponds	2,812.32	2,812.32	2%
Green area	23,031.27		
Future use area	59,031.46		
Total Impermeable Area:	126,431.09	44,368.36	35%

Source: Consulting Team, 2018.

To reduce the hydrological impact by the generation of flow rates in the project area, they will build detention works with capacity to store the additional volume to the conditions without project. Within the project area, a pond has been designed to absorb the original flow, corresponding to 210L/s, based on the previous design. A detention pond is proposed consisting of a lagoon and pumping system; since, the point of discharge of this one is in an upper level, in the gutter of CEPA, on the Boulevard Coronel Oscar Osorio

The calculated flow for the terrain without project generated, is based on the maximum intensity of rain, 0.17mm/min, for a return period of 100 years is 179L/s, according to the regulations of the United States, by request of the owner of the project the storm duration used is 24 hours. The difference in flow rates between the conditions with and without a project is 0.033m3/sec for the substation area, and 0.16m3 / sec for the rest of the terrain. The maximum daily rainfall data used corresponds to the Acajutla rainfall station, for the period 1971-2011 (41 years). No more recent data; however, the period analyzed includes catastrophic meteorological events, such as IDA (2009), AGHATA (2010) and 12E (2011).

Preliminarily, it is expected that the retention pond will have minimum dimensions of 24 x 60 meters at the base and 1.95 meters high, having a capacity of 2,812.32 m3. These dimensions will be confirmed during the final engineering stage, always maintaining the design criteria mentioned above. The emptying time of the tank will be double the filling, so that the criterion of zero hydrological impact is fulfilled.

The recommended pumping equipment is of submersible type, since it will be submerged inside the pond. Due to the low flow and the small hydraulic load that must overcome, a required power of 1.1 HP has been estimated, data to be confirmed in the final design stage. The water will be evacuated in 48 hours. A solids trap will be installed in the entrance of the rainwater to the detention ponds, in order to avoid that large solids can damage the pump, it is recommended to use a submersible pump for wastewater, since they have the capacity to handle solid particles up to 2 inches in diameter. The pond will be inspected periodically to verify that there are no obstructions or excessive sedimentation in it. The inspection must be daily in the rainy season, having to clean or remove garbage and sediment when necessary.

1.2.4 Earthworks

As the GIS requires less area, it subsequently requires less earth works. It is assumed that the reduction in the required volume of earthworks at substation area is proportional to the areas of AIS and GIS, multiplied by the preliminary volume of the anticipated amount of earthworks. Our calculation suggests that earthworks will be reduced to 65% of the previously estimated area, explained as follows:

AIS 24,000m^2
GIS 12,000m^2
-- > ratio 12,000/24,000 = 0.5 + laydown area, 0.15= 0.65 o 65%.
Reduction in amount excavation volume at substation: 9,300 m^3 x (1-0.65) = 3,255 m^3

The following **¡Error! No se encuentra el origen de la referencia.** shows the total expected volumes of earthworks at the Thermal Power Plant, which has been reduced from 85,000.00m^3 to 81,745.00m^3, due to proposed changes to the substation.

Table 1-9- Expected Volume of Earthworks

Description	Quantity	Unit
Organic soil collection in property leased for Thermal Power Plant	46,745.00	m^3
Organic soil collection in laydown areas	35,000.00	m^3

Source: Consulting Team, 2018.

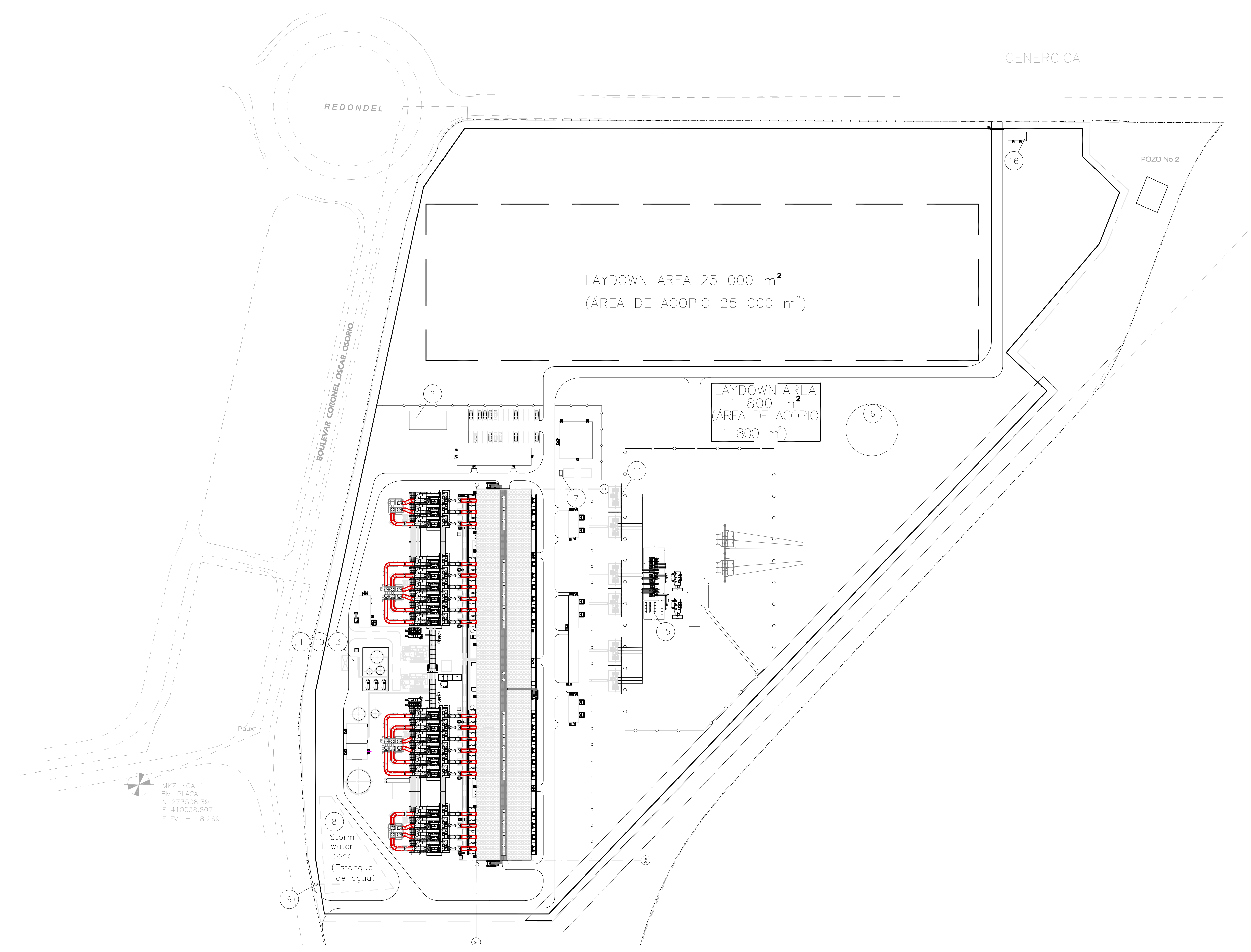
Energía del Pacífico

ENERGÍA DEL PACÍFICO

LNG TO POWER PROJECT

ZONIFICACIÓN GENERAL DEL ÁREA DE DISTRIBUCIÓN / GENERAL ZONING OF THE LAYDOWN AREA

FIGURA 1.2 / FIGURE 1.2



No.	INTERCONNECTION POINTS (PUNTOS DE INTERCONEXION) System (Sistema)
1	LFO/Black start (Arranque)
2	Natural gas (Gas Natural)
3	Lubrication oil system (Sistema de lubricacion)
6	Raw water (Agua no tratada)
7	Sewage water system (Sistema de agua residuales)
8	Rejected water (Agua rechazada)
9	Stormwater (Agua pluvial)
10	Sludge/Oily water system (Sistema de aguas grasas y aceitosas)
11	HV system (Sistema HV)
15	Telecommunication & RTU (Telecomunicación y RTU)
16	Telephone & Internet connection (Conexión de teléfono e Internet)

0 10 20 30 40 50m

N W E S

FUENTE / SOURCE:
PLANOS WARTSILA / WARTSILA SITE PLAN

MAPA CREADO POR / MAP CREATED BY: ECO INGENIEROS
MAPA REVISADO POR / MAP CHECKED BY: LF
PROYECCIÓN DE MAPA / MAP PROJECTION :
UTM ZONA 16 WGS84 / UTM ZONE 16 WGS84

ARCHIVO / FILE
C:/ECO,DRAWING 1, EL SALVADOR/ ECO INGENIEROS
C:/ECO,DIBUJO 1, EL SALVADOR/ ECO INGENIEROS

PROYECTO / PROJECT: 14-9114
ESTADO / STATUS : FINAL / FINAL
FECHA / DATE: 20/12/2017

DILLON CONSULTING

ECO INGENIEROS

1.3 Marine Terminal Description

1.3.1 FSRU Description

The location of the marine elements will be very close to where they were originally proposed in the previous EsIA. The FSRU will be, an existing FSU, retrofitted with the regasification equipment. The vessels Gemmnata and Hispania that were presented in the original EsIA are still the representative of the most likely options for the FSRU.

The FSRU will be moored permanently by a new Restricted Catenary System (RCM), which is explained further in section 1.3.2. The FSRU storage system will have a LNG capacity of approximately 138,000-174,000m^3.

In the EIS of 2016 presents the detailed specifications of the HISPANIA SPIRIT and GEMMATA vessels. HISPANIA SPIRIT was built in 2002 and has membrane type tanks (GT 96) with a total capacity of 140,678 m3. The GEMMATA was built in 2004 and has Moss Rosenberg spherical tanks with a total capacity of 138,000m3 (See

Photograph 1-1 - **Gemmata Vessel**
and Photograph 1-2 - Hispania Spirit Vessel).

The Table 1-10 shows the main characteristics of the above-mentioned vessels.

Table 1-10- Possible FSUs to use for Floating Storage Regasification Unit

Characteristic	**HISPANIA SPIRIT**	**GEMMATA**
Flag	Spain	Singapur
Type	Tanker boat	Tanker Boat
Gross tonnage	94822	111459
Displacement	79363	72727
Length x sleeve	279.8m x 43.4m	290m x 46.28m
Year of construction	2002	2004
State	Active	Active

Source: Energía del Pacífico, 2014

Photograph 1-1 - Gemmata Vessel

Source: vesseltracker.com

Photograph 1-2 - Hispania Spirit Vessel

Source: vesseltracker.com

The spaces between the inner hull of the vessel and the outer hull are used to ballast the vessel and as protection of cargo tanks in emergency situations such as a collision or a strand. The cargo tanks are separated from other compartments by five transverse cofferdams, which are dry compartments.

The ballast spaces around the cargo tanks are divided into two double-bottom side tanks, port and starboard, in each cargo tank.

The FSRU will have three 4.5MW internal combustion (IC) engines that will run on natural gas. It is expected that the three engines will be running at the maximum gas sendout rate of 280 MMSCFD. Each IC engine will consume approximately 450 kg / hour of natural gas. The IC engines will also have the capability to operate on diesel fuel during emergency circumstances.

As an alternative energy source, a submarine electrical power cable of 6 to 8 inches in diameter will be installed next to the submarine pipeline installation via the HDD methodology described in the following sections.

For cooling of the engines, a refigeration system will be installed consisting of shell and tube heat exchangers that will use seawater as the cooling medium. The intake of sea water for cooling will be 1,200 m^3 / h while it is operating for the Marine Terminal.

The FSRU will have a fresh water generator of approximately 6 tons / day for the personnel needs.

Other general specifications include:

- Ballast water tanks, including peak tanks: Enough to maintain the keel even under all load conditions.
- Heavy fuel oil: Not required.
- Diesel fuel: Enough to power the FSRU in with its own fuel for 10 days.
- Fresh water tank: $400m^3$.
- Distilled water tanks: to the design of the builder.

Items such as Cargo tanks, water ballast tanks, fuel tanks, fresh water tanks will be arranged on the FSRU hull, to the manufacturer's design.

1.3.1.1 Cargo Tanks

Four or five MOSS or two membrane tanks will beinstalled in the hull on the FSRU..

In case of membrane tanks: The primary membrane is made of SS304L and the secondary membrane is made of composite INVAR membrane. Insulation is fitted on to each membrane to minimise the heat ingress in to the LNG cargo system.

This membrane system therefore has a fully secondary barrier which a patented system used on many LNG carriers. If there is a leak from the primary membrane, the second membrane is designed in accordance with the International Gas Carrier Code (IGC).

Leak detection is also provided for this membrane system. The two independent insulation spaces are continuously flushed with nitrogen gas. The integrity of both membranes is permanently monitored by detection of hydrocarbon in the nitrogen gas.

For the MOSS tanks: The tanks are encased within void spaces of the hull. The spaces between the inner hull and outer hull are used for ballast and also provide protection to the cargo tanks in the event of an emergency situation, such as a collision or grounding. The basis of this design philosophy is the ”leak before failure” concept. This presumes that the primary barrier will fail progressively, not suddenly or catastrophically.

In the case of a potential crack occurring in the tank material, a small leakage of LNG within the insulation will be immediately detected at an early stage by the gas detection system fitted at the equatorial ring area and at the drip pan. The drip pans, installed directly below each cargo tank, are fitted with temperature sensors to detect the presence of LNG.

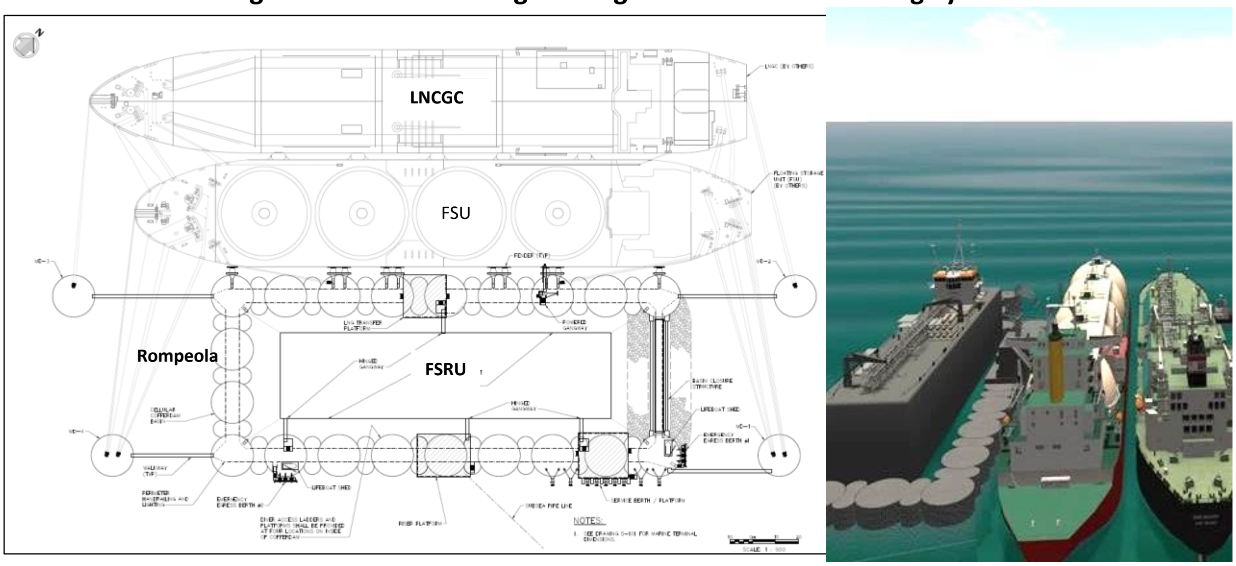
The typical characteristics of the tanks are expected to be the same as previously reported in the EIA and will meet all industry regulations and standards.

1.3.2 Mooring System for FSRU

Previous mooring system for the marine terminal consisted of a cofferdam containing the FSRU, this will be substituted by a Restricted Catenary Mooring system (RCM), for the permanent mooring of a Floating Storage Regasification unit (FSRU) offshore Acajutla, El Salvador, in a water depth of approximately 17m. The new alternative has less of an environmental impact, and has further advantages related to construction, installation, operation, ongoing maintenance and total cost of ownership, as will be described in the subsequent sections.

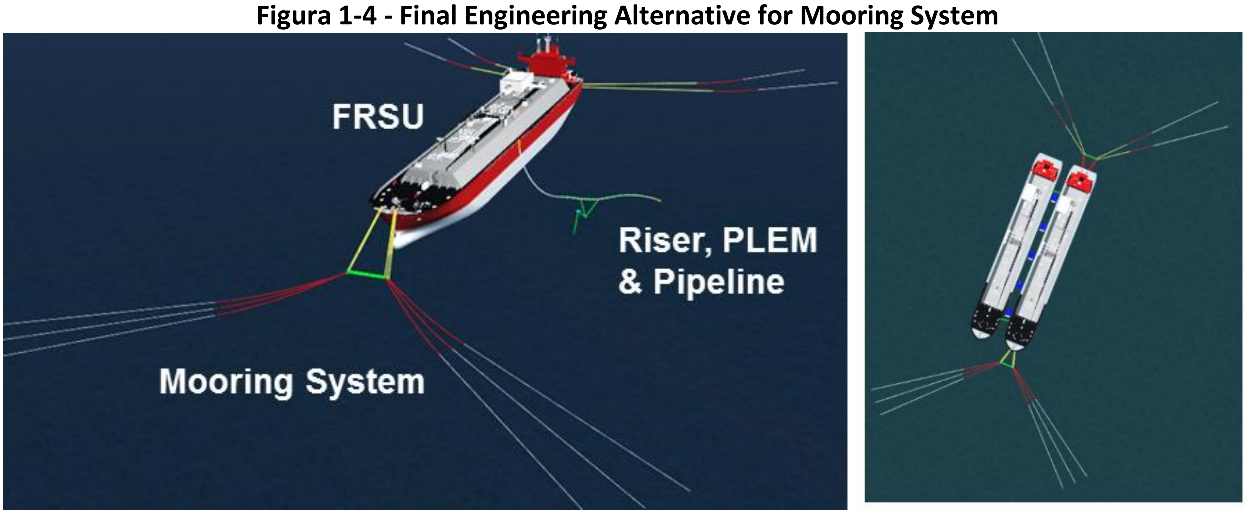
Figura 1-3 shows the previous engineering alternative with cofferdam, and Figura 1-4 shows the new alternative consisting of the RCM system.

Figura 1-3 - Previous Engineering Alternative for Mooring System



Source: M&F Feed Drawings, 2016

Figura 1-4 - Final Engineering Alternative for Mooring System



Source: CAN Systems "RCM – System Description", November 2017.

The Maritime Terminal will be formed by an FSRU fixed in position by means of the RCM mooring system, said system will allow the LNGC berthing by means of a Ship-to-Ship system. The LNGC will berth only when it is necessary to supply the FSRU. The LNGC will dock to one side of the FSRU. Floating foam or pneumatic fenders will be located between both boats, for protection during berthing.

The RCM system is a system formed by mooring lines that act as an extended mooring system (Spread Mooring).

The key components are mentioned:

1. **Mooring system in bow**

Chains, grouped from the ship's bow and a chain of restraint to hold the lashing lines together.

2. **Chain Restrictor**

Maintains tie lines together to avoid interference with the hull of the boat.

3. **Lift pipe and umbilical cable**

The lifting pipe will be located towards the side of the boat. The umbilical cable will be mounted on the lifting pipe and will serve for the operation and control of the Pipeline End Multiple (PLEM).

4. **PLEM**

End of pipe (Pipeline End Manifold, PLEM) located at the end of the riser pipe and represents the transition from the pipe to the seabed.

5. **Aft mooring lines**

Polyester ropes and chains, grouped from the stern of the vessel with a chain restrictor to hold the lashing lines together. The upper part (above the restriction chains) will be chains, while the first portion of the lower part (below the restriction chains) will be polyester cords to avoid interference with the existing pipes at the site. After the polyester cords cross the existing pipes, the tie line will be made up of chain

6. **Pipe**

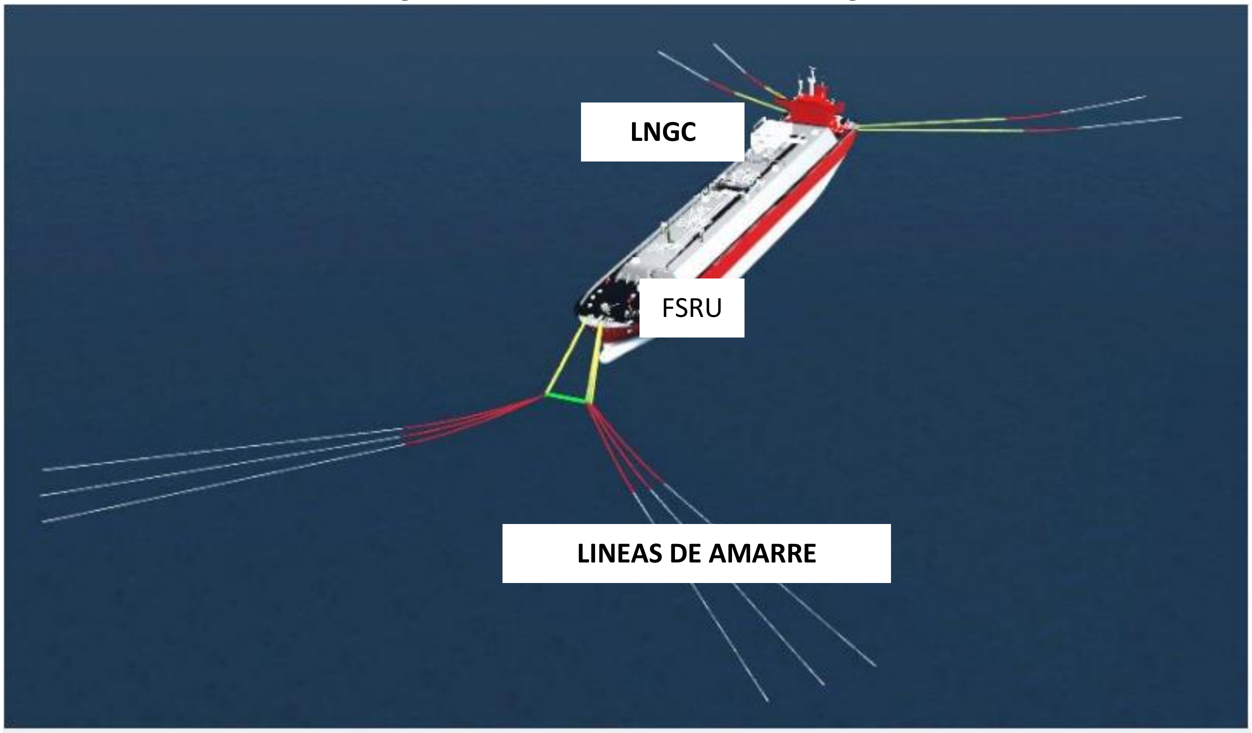
A 24-inch, 1,400m long gas pipeline runs from the PLEM to the connection point on the coast.

7. **Electric Power Cable**

A submarine power / electric power cable of 6 to 8 inches will be installed next to the gas pipe.

The Figure 1-5 shows a typical design of the Maritime Terminal with the RCM option.

Figura 1-5 – Marine Terminal final design



Source: CAN Systems RCM Description Rev C.

The supply of natural gas already regasified, to be provided by the FSRU, will be transported through an underwater pipeline which will continue to be buried until reaching the power plant.

On land, the pipeline will include a measuring station, pipe integrity indicator, PIG receiver station, emergency shut-off valve (ESD) and purge valves. This infrastructure on land will be located within the fenced land of the Thermal Power Plant.

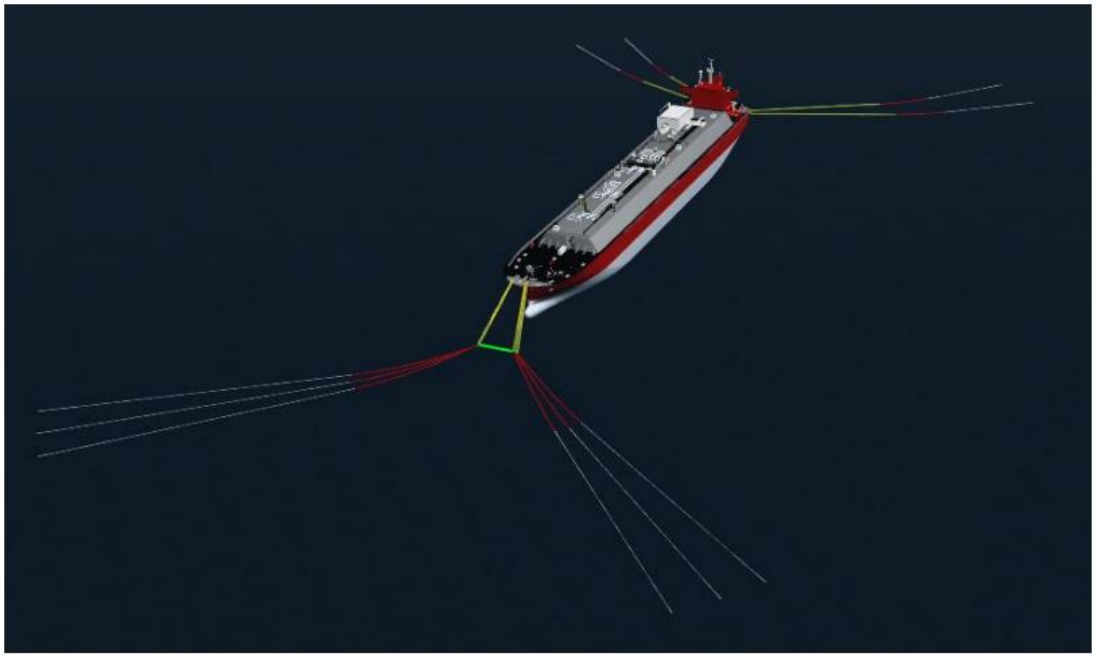
The location of the elements in the sea is presented in Figure 1-7. Next, the elements of the system are described.

1.3.3 Description of Components of the RCM System

1.3.3.1 Bow Lines

Tie lines 3 + 3 bow with restrained nail anchors. The restrictor in the upper part of the lines helps to use a practically horizontal mooring system under the restrictor, and a relatively smaller cantilever that is favorable with respect to the depth of the site. The restriction chains are shown in green. See Figura 1-6.

Figura 1-6 – Catenaria Mooring Restricted in 17 meters deep



Source: CAN Systems RCM Description Rev C.

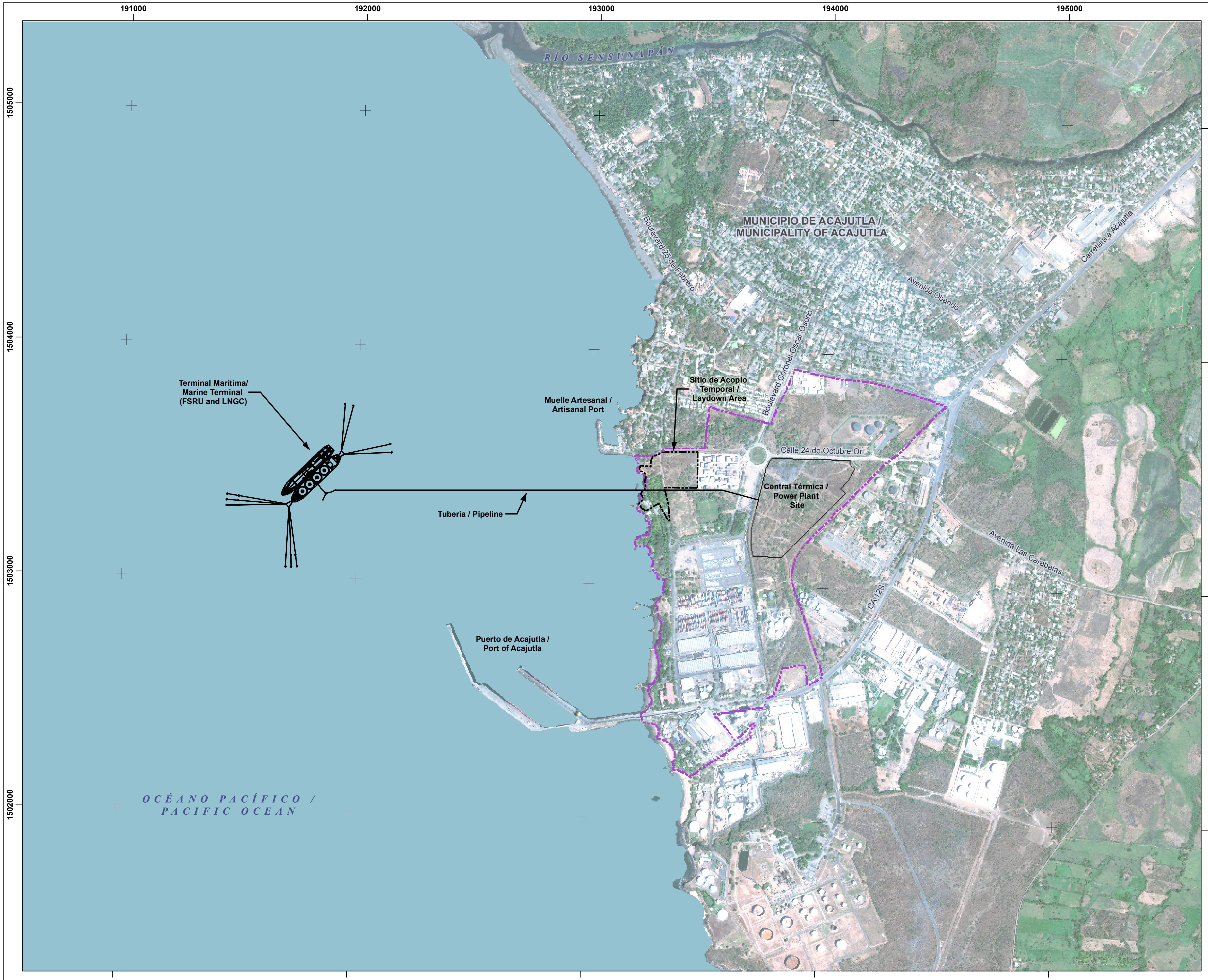
1.3.3.2 Restriction Chains

The restriction chains contain the relocated lee lines pointing forward, making it possible to configure 3 + 3 tie lines. The horizontal movements in the restriction chains are small and makes the configuration of the lifting pipe feasible. The restrictor stays in tension and joins the lashing lines to keep these lines away from the LNGC. The restrictor also decreases the size of the cantilever.

The restriction system consists of a series of chains ordered by a structure known as "Triplate[1]" and that end in H-type terminals (H-links).

In Figure 1-8, a schematic of the Restriction Chains system is shown, its construction plans will be developed through detailed engineering and submitted for approval by the AMP in the construction permit application.

[1] The “Triplate” system is used as a trasitional joint between two mechanical elements in the construction of ships and large-scale coast/marine projects.



Energía del Pacífico

ENERGÍA DEL PACÍFICO

LNG TO POWER PROJECT

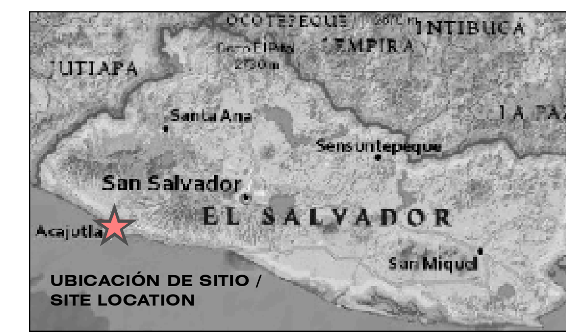
ÁREA DE UBICACION DEL PROYECTO / PROJECT LOCATION

FIGURA 4.1 / FIGURE 4.1

SITIO DEL PROYECTO / PROJECT SITE

SITIO DE ACOPIO TEMPORAL / TEMPORARY LAYDOWN AREA

TERRENO PROPIEDA DE CEPA / CEPA PROPERTY



0 100 200 400 m

1:16,000

N W E S

FUENTE / REFERENCE
VISIÓN DEL MUNDO 2 IMÁGENES DE ALTA RESOLUCIÓN / WORLDVIEW 2 HIGH RESOLUTION IMAGERY (2014-02-12)

MAPA CREADO POR / MAP CREATED BY: PFM/SFG
MAPA REVISADO POR / MAP CHECKED BY: MW
PROYECCIÓN DE MAPA / MAP PROJECTION: UTM ZONE 16 WGS84

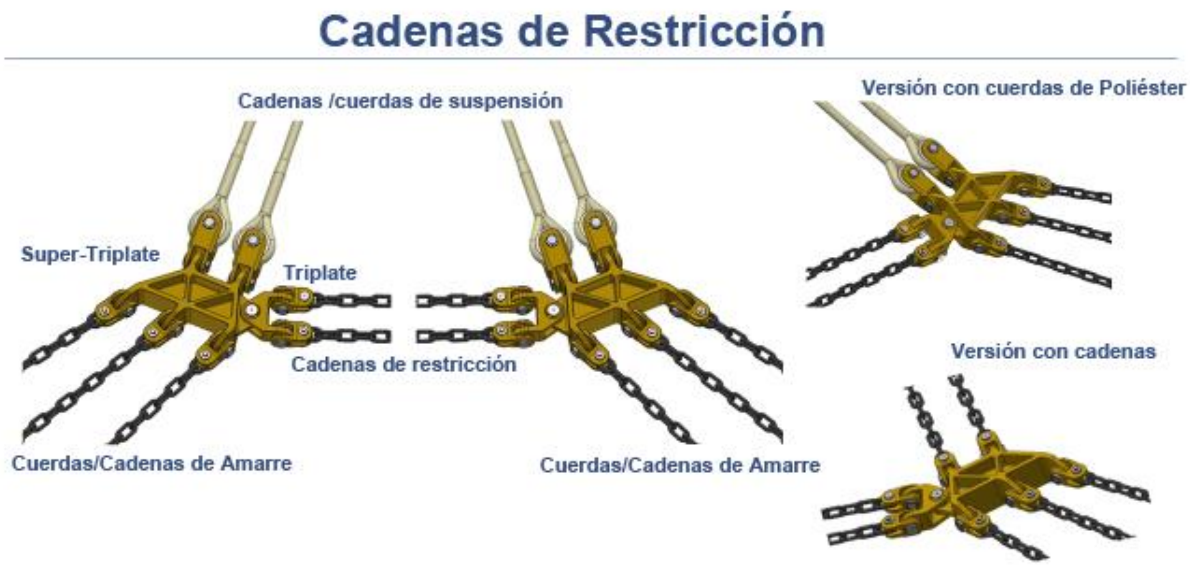
ARCHIVO / FILE:
G:\GIS\163489 Acajutla\GIS\MXDs\Reporting - 2016\4-1 - Project Location.mxd

PROYECTO / PROJECT: 163489
ESTADO / STATUS: FINAL / FINAL
FECHA / DATE: 1/17/2018

DILLON CONSULTING

ECO INGENIEROS
LÍDERES EN CONSULTORÍA AMBIENTAL

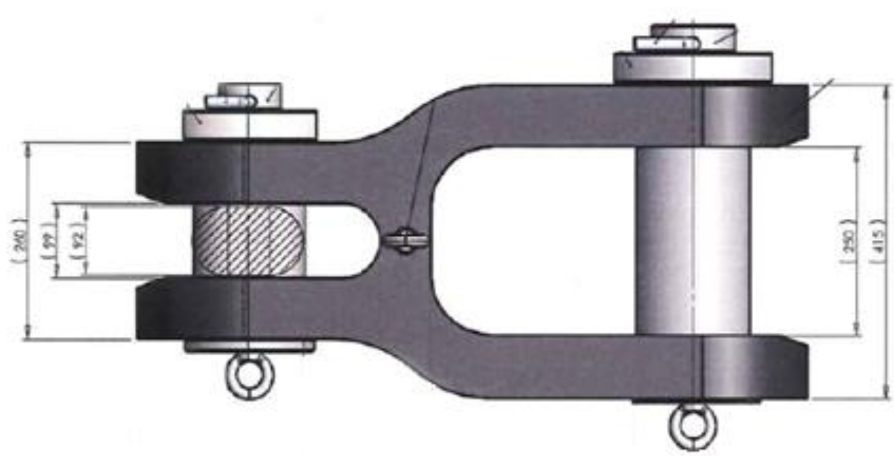
Figura 1-8 – Restriction Chain System



Source: CAN Systems RCM Description Rev C.

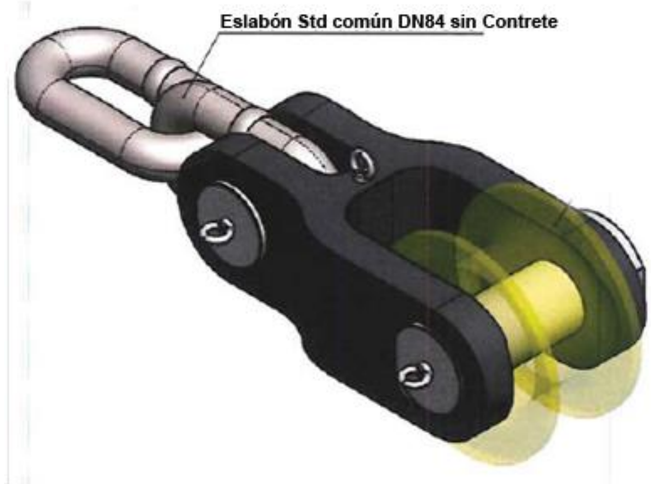
In Figures 1-9 and Figure 1-10, a typical scheme of a terminal type H (H-link) and an unconnected link similar to those used in the control chain system can be observed. Both the chains and the "Triplet" are compatible to comply with the anti-corrosion standards applicable to the industry.

Figura 1-9 – Type H Terminal Scheme (H-link)



Source: CAN Systems RCM Description Rev C.

Figura 1-10 – Scheme of Terminal type H (H-link) with a Typical Link without Concrete

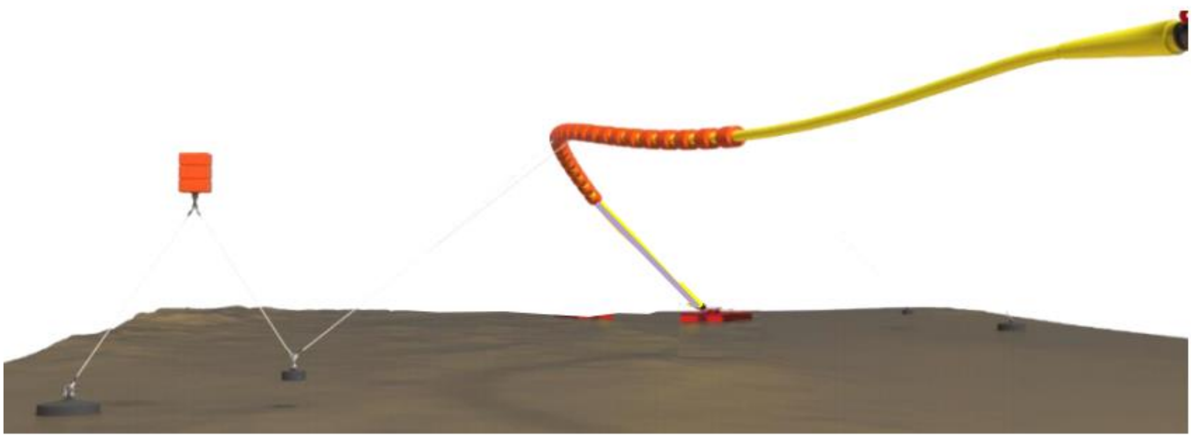


Source: CAN Systems RCM Description Rev C.

1.3.3.3 Lift pipe (Riser) / Umbilical

The preliminary design considers a 14 "diameter flexible riser pipe. The 3D system of riser pipe (Riser) is shown in Figure 1.11. The Riser will go from the PLEM to one side of the FSRU. As shown in Figure 1-11.

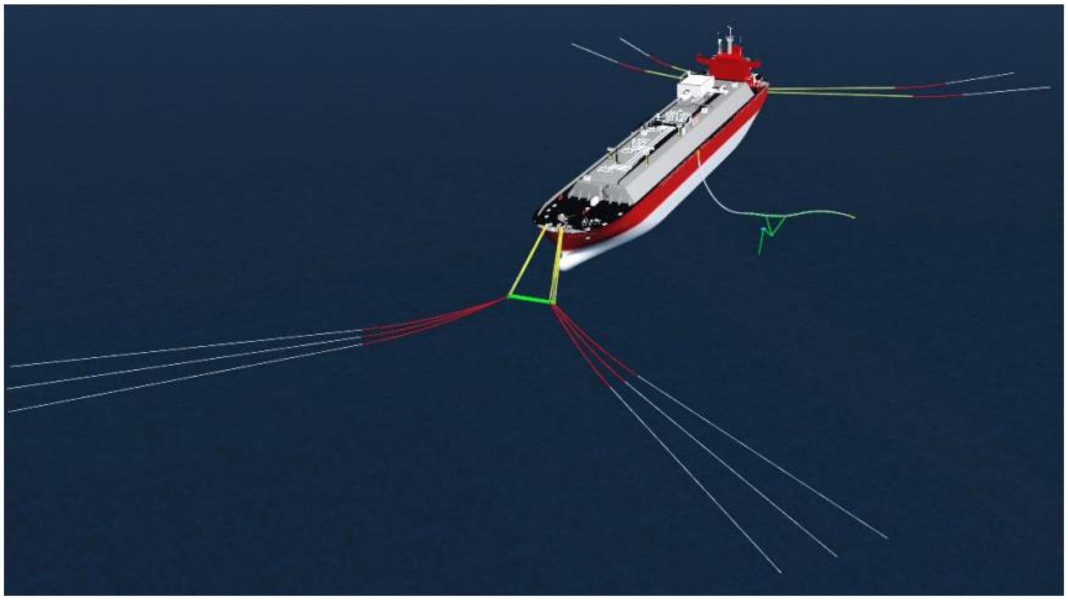
Figura 1-11 – 3D lifting pipe configuration



Source: CAN Systems RCM Description Rev C.

A tie is made between the boat and the lifting pipe with a flange by means of two special clamps. The upper part ends with an angle in order to provide enough slack with the hull of the boat. See figure 1-12.

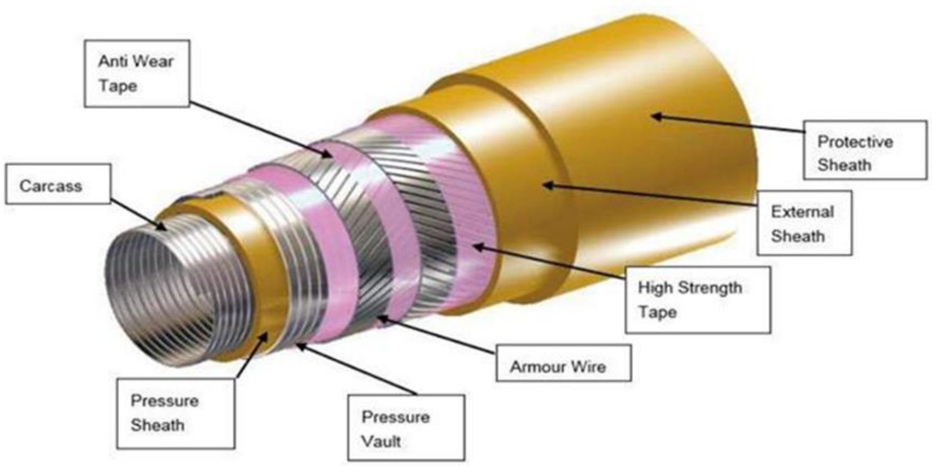
Figura 1-12 – Arrangement of the lifting pipe in the meddle of the boat and mooring lines



Source: CAN Systems RCM Description Rev C.

The Figure 1-13 shows the components of the riser (Riser):

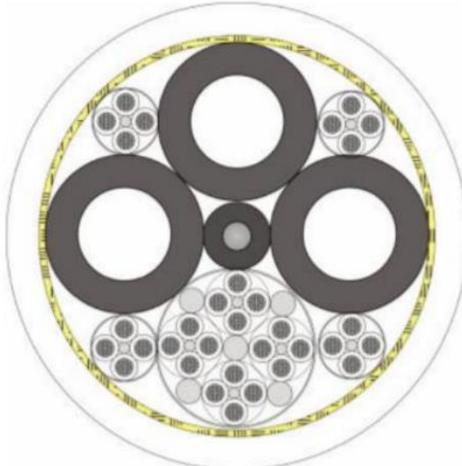
Figura 1-13 – Components Pipeline Elevator



Source: CAN Systems RCM Description Rev C.

An umbilical tube will be provided for the control and operation of the PLEM. A typical section of an umbilical tubing is shown below in Figure 1-14.

Figura 1-14 – Typical section of umbilical tubing

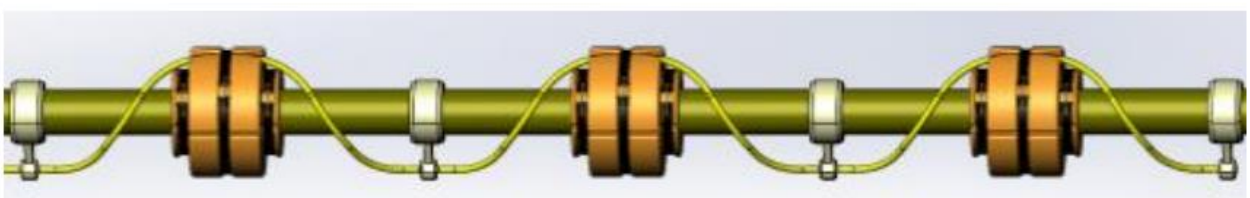


Source: CAN Systems RCM Description Rev C.

An umbilical cable is provided for the control and operation of the PLEM. The piggy-back system is proposed to carry the umbilical cable to the Riser. (See Figure 1-15)

The piggy-back system requires spacer clamps along the riser. The umbilical cable can be changed, if necessary, without having to uncouple the lifting pipe or its accessories.

Figura 1-15 – Sistema piggy-back with spacers

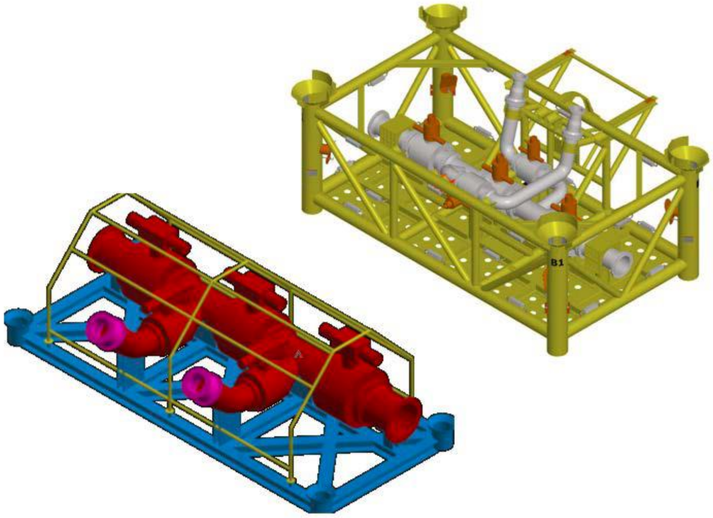


Source: CAN Systems RCM Description Rev C.

1.3.3.4 Pipeline end manifod (PLEM)

The PLEM will connect the pre-installed flow line system to the Riser / umbilical cable of the RCM system. The PLEM must weigh approx. 100 metric tons and have a typical footprint of 10m x 10m. See figure 1-16.

Figura 1-16 – Piggy-back system with spacers



Source: CAN Systems RCM Description Rev C.

1.3.3.5 Stern lines

An arrangement of 2+2 lashing lines is proposed on the back of the FSRU to keep it in position. Therefore, 4 rear mooring lines with a length of approximately 250 m would be required. The aft mooring lines are presented in an arrangement that allows to fix the orientation of the RCM in all conditions. The proposed mooring arrangement will not interfere with the transit of the GNLC vessel for the ship-to-ship operation. See figure 1-17.

Figura 1-17 – Ship "Sendje Berge" in Okwori Oil Field, Nigeria

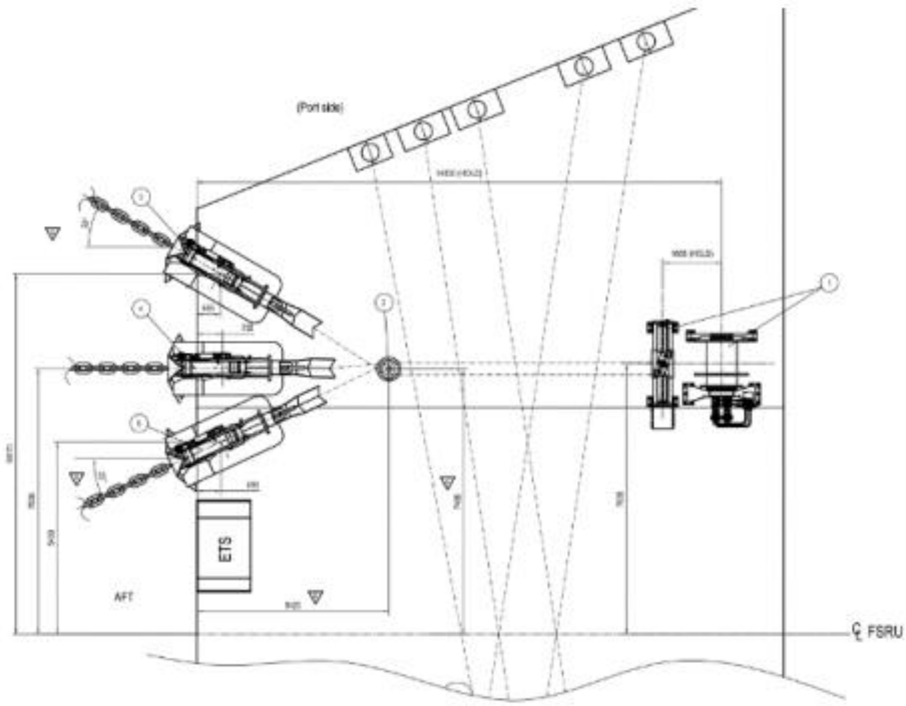
Source: CAN Systems RCM Description Rev C.

Normal operating conditions:

- The Halado of the chains is done by means of ordinary mooring winches.
- The excess length of the chains on the deck can be handled by the use of an auxiliary winch.

After reaching the pre-tensioning level, the detent pawls on the quick release retainers are closed. The stopping pawls are operated by hydraulic cylinders. See figure 1-18.

Figura 1-18 – Stern mooring on deck



Source: CAN Systems RCM Description Rev C.

The chain is pulled towards the quick release retainer by means of existing machinery on the deck, the subsequent disconnection of the chains is done following the same principle. If necessary, the same winches can be used for the adjustment of the mooring lines.

The pulling and tensioning of the lines will be done according to the following sequence:

- Introduce the outer lines to the mark
- Introduce the inner lines to the mark
- The course must be at that moment 214 °.

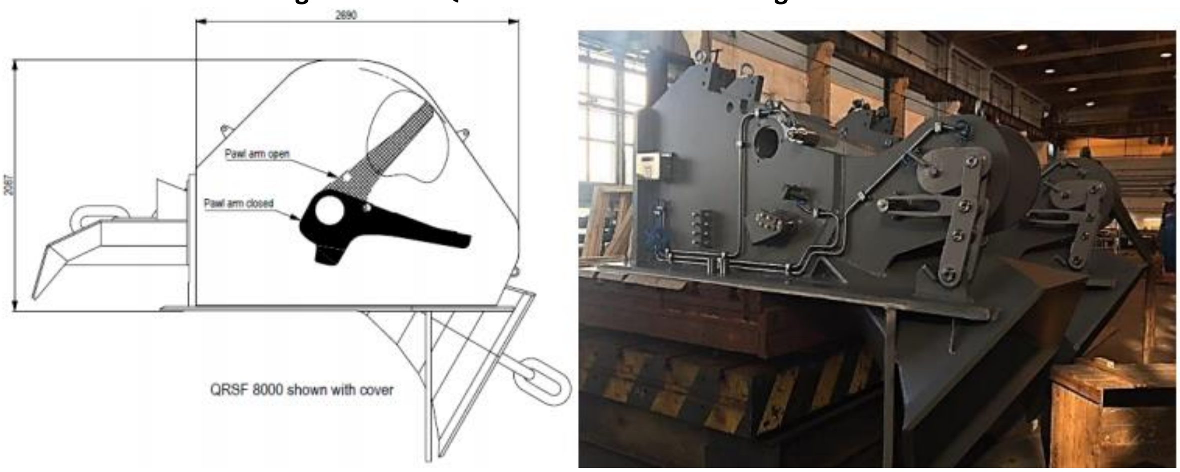
1.3.3.6 Quick releade retainer with guides (Quick release stopper, QRSF)

The Quick Release Retainer with guides (Quick Release Stopper, QRS) has a fairly simple construction. Each retainer consists of the following main parts: See Figures 1-19 and 1-20.

- Body of the guide, to be welded to the deck and to the side of the ship. Ratchet chain with hinges.
- Mechanical seal on the center of the mechanism to support mooring loads.

- Hydraulic cylinders for chain ratchet actuator
- Connection platform for hydraulic hoses

Figura 1-19 – Quick reléase retainer with guides

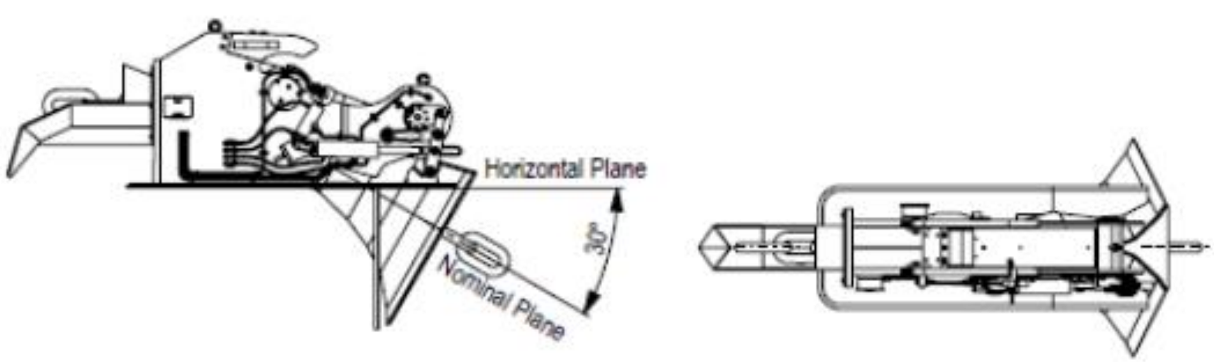


Source: EDP, 2018

Functions:

- "Pull through and close" chain retainer with integrated guide
- Mechanical closing mechanism - Over-center-
- Optimal design for the life of the chain
- Full tension release
- Prototype tested at 3500 kN
- To be sold on deck
- Hydraulic release up to 500 TON of load
- Voltage monitoring

Figura 1-20 – General arrangement



Source: EDP, 2018

Structural interface:

- The quick release retainer with guide is designed to be welded directly into a cut in the stern of the FSRU and adjacent to the main deck cladding
- Horizontal loads in the chain retainer will be transferred directly to the deck structure
- The entrance structure (bellmouth type) will be designed to fit the new and existing structure below the main deck
- It is expected that additional reinforcement of the roof structure will be necessary

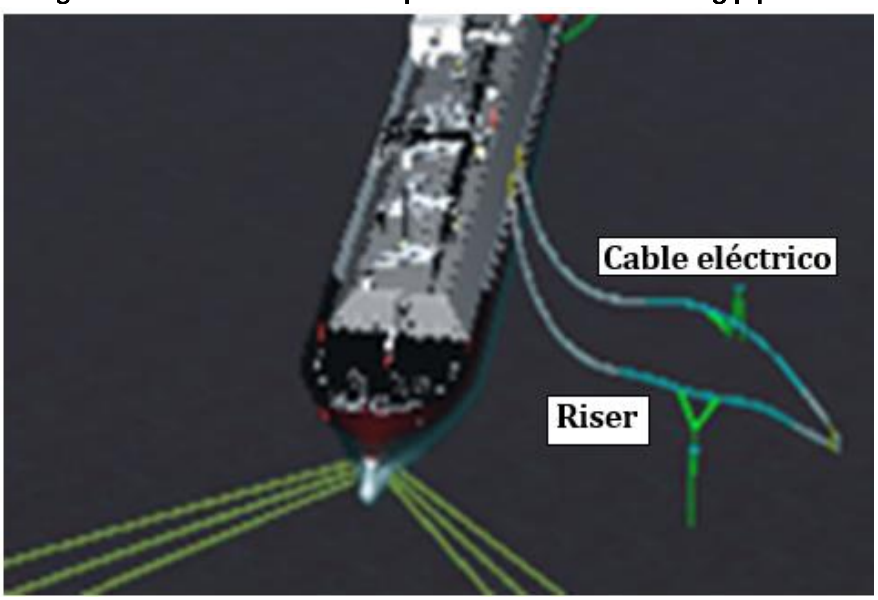
1.3.3.7 Electric power cable

An electric power cable will be installed from the EDP generation plant to the FSRU. This cable will be installed next to the gas pipe using the described HDD methodology.

The preliminary design provides that the cable will be 6 to 8 inches in diameter, will be constructed of annealed copper. The cable will comply with the standards ISO 13628-5, ISO 13628-5, IEC 60502 (or similar North American standard) among others.

It is envisaged that the electric power cable will be raised to the torque of the Riser only that the curvature will be to the opposite side as shown in Figure 1-21.

Figura 1-21 – Electric cable on par with the flexible lifting pipe



Source: EDP, 2018

In the Figure 1-22 shows the typical configuration of the power cable.

Figura 1-22 – Typical configuration of the electric cable

Source: EDP, 2018

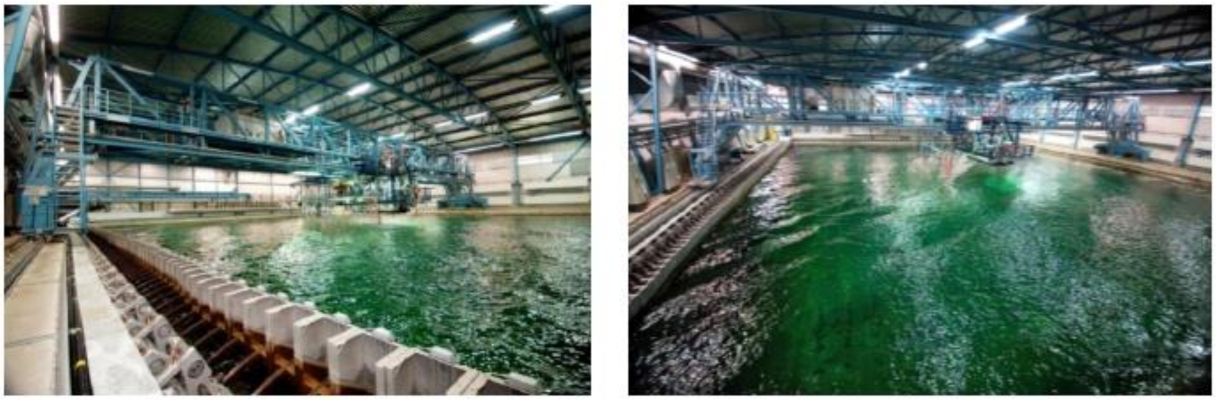
1.3.4 Hydrodynamic Studies of the Numerical and Physical Mooring Systems

The previously described arrangement together with the RCM system is being studied and confirmed by "Marin Engineering", a Norwegian company, specialized in the process of design and optimization of marine discharge terminals. Marin's scope of work includes the development of dynamic mooring analyzes using proprietary software. A diffraction study is being carried out using proprietary software called DIFFRAC. The effects of mass, cushioning, wave loads, and wave deviation are calculated by the program in order to compile a hydrodynamic database based on the characteristics of the FSRU and the LNGC.

Subsequently, the database generated by DIFFRAC is used as an input for the proprietary software aNySIM-XMF which is a time domain-based program which calculates the behavior of the multiple floating bodies under the combined action of the tide, wind waves, current and wind. This program also considers the effects and parameters of the mooring lines and other mechanical components exerted on the floating bodies.

Subsequently, the design will be subjected to physical model tests using a pool with meta-oceanic characteristics at scale and with scale ships. The offshore pool laboratory generates long and short crest waves. The pool is 45 meters long and 36 meters wide with adjustable depth. The pool has been designed to test models of fixed offshore structures, anchored, or controlled by dynamic positioning in waves, wind and currents. The pool beaches are designed to minimize wave reflections even for long period tide events as experienced in the project area. See Photograph 1-3.

Photograph 1-3- Pool of physical model tests



Source: EDP, 2018

These tests will be used to:

- Calibrate the mooring design in extreme and operational conditions
- Confirm the performance of the FSRU and LNGC during the download
- Calibrate relative movement data such as speeds and accelerations
- Quantify low frequency motion damping
- Provide calibration to numerical hydrodynamic models
- Study the behavior of the riser in various conditions

The RCM mooring system is being designed with enough redundancy for the FSRU to remain docked to the seafloor even in the failure situation of any single component. Based on the strength of the RCM, waiting tugs will not be necessary. Even so, there will always be a tugboat of the project with crew ready to respond at any time to emergencies or fires.

1.3.5 Pipeline

The characteristics of the pipeline are presented in Table 1-11- . These characteristics are consistent with what was presented in the original EIA.

Table 1-11- Technical Information of the Pipeline

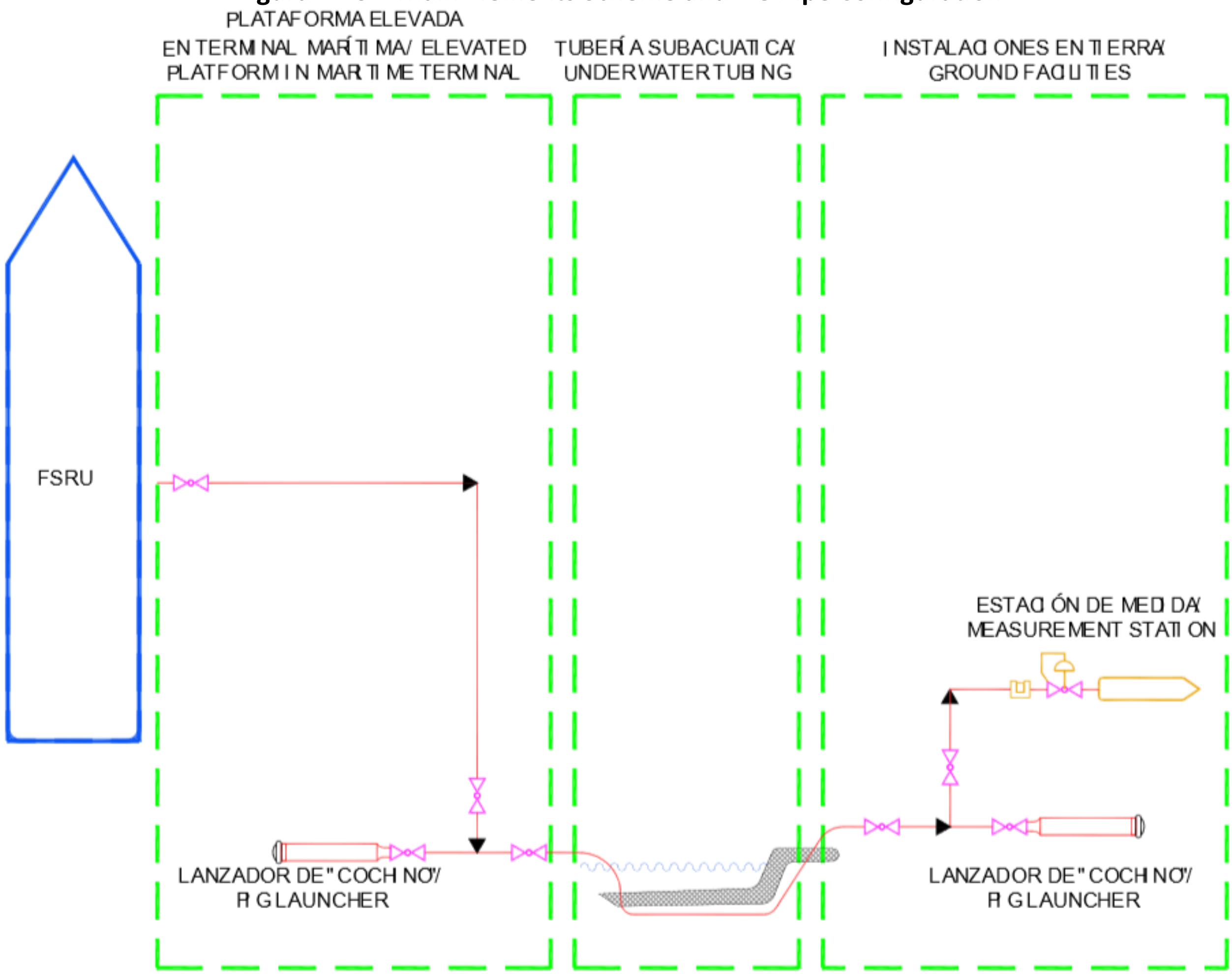
Pipeline Type	Start	End	Material	Diameter (inches)	Intake operation pressure (Bar)	Operating Temperature (ºC)	Transfer rate	
							Value	Unit
NG	FSRU	CENTRAL TERMICA	Acero al carbón	24	80	5	280	MMCFPD

Source: M&N 2016

Pipeline flow, pressure and temperature will be monitored through an instrumented measuring station that will be near the Thermal Power Plant. The data will be received and monitored using a monitoring and data acquisition (SCADA) system that will monitor and evaluate the status of the pipeline during operations.

Once installed, the integrity of the pipeline will be guaranteed by periodic hydrostatic or pneumatic pressure tests, as well as by a “smart pig system”, which will measure the thickness of the pipe wall and the integrity of the pipe throughout its entire length. Figure 4-23 presents a schematic diagram of the pipeline elements.

Figura 1-23 – Main Elements Scheme and NG Pipe Configuration



Source: Energia del Pacífico, 2014.

.

1.3.6 Distribution of Areas for Marine Terminal

The Marine Terminal will be located near areas under CEPA management. The main components of the Marine Terminal with their respective areas are presented below. Each of the areas is presented in detail in Table 1-12 and Figure 1-23.

Table 1-**12 - Areas to be Occupied Offshore**

Description	Area (m^2)	Percentage
FSRU (Restriction Area)	312,461.02	96%
Pipeline under the sea bed	13,000.00	4%
Total Offshore Area:	325,461.02	100.00%

Source: Consulting Team basedoin EDP maps, January 2018.

1.3.7 Rules, Regulations, Codes and Standards

The codes and standards presented in the EIA report for the elements of the project are maintained. The RCM system for the FSRU will be designed considering the regulations present in Tables1-13, 1-14 ,1-15.

The FSRU shall be classed by the "American Bureau of Shipping" ABS[2] or similar. The mooring will therefore be designed according to API RP 2SK or similar. In addition, the following DNV[3] and other international standards will be used in the design:

Table 1-**13 - Classification Standard**

DNV GL Publication	Title	Edition
DNVGL-RU-OU-0102	Rules for Classification of Floating Production, Storage and Loading Units	2015
DNVGL-OS-B101	Metallic Materials	2015
DNVGL-OS-C101	Design of Offshore Steel Structures, General (LRFD method)	2015
DNVGL-OS-C301	Stability and Watertight Integrity	2015
DNVGL-OS-C401	Fabrication and Testing of Offshore Structures	2015
DNVGL-OS-E301	Position Mooring	2015

Fuente: CAN Systems "RCM – System Description", November 2017.

[2] The American Bureau of Shipping (ABS) is a classification society, with a mission to promote the security of life, property and the natural environment, primarily through the development and verification of standards for the design, construction and operational maintenance of marine-related facilities. ABS core service is the provision of classification services through the development of standards called ABS Rules. These Rules form the basis for assessing the design and construction of new vessels and the integrity of existing vessels and marine structures.

[3] DNV GL is the world's largest classification society, providing services for 13,175 vessels and mobile offshore units (MOUs) amounting to 265.4 mill gt, which represents a global market share of 21%. It is also the largest technical consultancy and supervisory to the global renewable energy (particularly wind, wave, tidal and solar) and oil & gas industry - 65% of the world's offshore pipelines are designed and installed to DNV GL's technical standards.

Table 1-14- International Standards		
International Standard	Title	Edition
ISO	EN-ISO-19901-7:2013	2013
NORSOK	P-001 Process Design	XXXX
ASME VIII Div 2	Boiler & Pressure Vessel Code	2010

Source: CAN Systems "RCM – System Description", November 2017.

Table 1-15- Informative and Recommended Practice References		
Designation	**Title**	**Edition**
DNVGL RP-C203	Fatigue Strength Analysis of Offshore Steel Structure	2015
DNVGL-RP-B101	Corrosion protection of floating production and storage units	2015
DNV No 2.22	Standard for Certification of Lifting Appliances	2015
API	RP-2SK	2005

Source: CAN Systems "RCM – System Description", November 2017.

1.3.7.1 Base de Diseño

1.3.7.1.1 Datos meteoceánicos

The meteoceanic data are relatively favorable and directional:

- Olas Hs 3m/Tp 12-16s (Principalmente swell)
- Viento 15 m/s (promedio de 1 hora)
- Corrientes 1 m/s corrientes superficiales.

The currents are directed mainly by the wind, the site is located to the south of the belt of hurricanes/tropical ciclones. It is observed thar 97% of the waves are below Hs 1.5m and 91% come from SSO.

1.3.7.1.2 Condiciones de suelo

El suelo es relativamente arenoso y adecuado para los Anclajes de arrastre que para los anclajes de succión.

1.3.7.2 Design Parameters

All marine infrastructure components will be designed to withstand extreme waves, water levels and wind events, including tsunami conditions. Project elements may be designed for different conditions. The event data to be used for the final design is described below.

Acajutla presents cycles of semi-diurnal waves characterized by two high tides and two low tides, of different size, each lunar day. Tide information was obtained from the Sea Level Center of the University of Hawaii data between 1962 and 2012 and data taken by a wave buoy at the project site for a short period. (See **¡Error! No se encuentra el origen de la referencia.**)

Table 1-16- Tide Information Considered for Design

Datum	Description	UHSLC082 Acajutla (m)	AWAC (m)
HAT	Highest astronomical tide	1.33	1.36
MHHW	Highest high tide mean	0.85	0.84
MHW	Average high level	0.75	0.76
MSL	Level average	0.0	0.0
MLW	Low level average	-0.75	-0.75
MLLW	Low tide lows	-0.79	-0.79
MLWS	Average low tide	-0.98	-1.0
LAT	Lower astronomical tide	-1.2	-1.2
MN	Average tide amplitude (MHW-MLW)	1.5	1.55

Source: Sea Level Center, University of Hawaii, Data between 1962 and 2012 and data taken by a wave buoy at the project site for a short period.

1.3.7.2.1 Wind

Wind data from Acajutla was retrieved from NOAA station 9648958 Acajutla covering a period of 2 years. The winds blow mainly from the north and from the northeast, followed by the south winds. In the summer, the north winds are strongly dominant. Wind speeds greater than 5, 10 and 20 knots occur approximately 38%, 8.4% and 0.1% of the time, respectively. The highest recorded wind speed is 45.3 knots from the east-southeast.

For the final design, data from the meteorological and oceanographic studies will be used. The analysis of extreme values will be carried out after the calibration of the numerical model to determine the height of the waves and period of return of events.

1.3.7.2.2 Currents

The current baseline conditions at the site were obtained from a 1-year simulation with the MIKE 21 FM two-dimensional hydrodynamic model. The model was run with astronomical water levels from the Oregon State University database and calculated residuals from the water level measurement in Acajutla as well as OWI Hind cast winds.

In addition, an AWAC was deployed at the vicinity of the Marine Terminal to measure the direction and magnitude of the current. Approximately 12 months of wind, wave, averaged currents and tide data were discharged and processed.

The velocities of currents that have the ability to cause damage are low at the site, less than or equal to 0.1 knots about 13% of the time. The maximum current calculated is 0.28 knots.

1.3.7.2.3 Tsunami

A detailed numerical modeling study was conducted to assess the risk of tsunami at the terminal site. A total of 16 scenarios were modeled using 2 different numerical models to develop 32 separate time series that are used to develop exceedances curves for the project site.

Maximum peak elevations along the berth vary from 3.2 to 3.8m for the 10% exceedance condition, and 2.0 to 2.4m for the 50% exceedance condition. The maximum detractions are between -2.6 and -3.0 m for the exceedance condition of 10% and -1.8 and -1.9 m for the condition of exceedance of 50%.

In other directions (e.g., perpendicular to the berth) the estimated current velocities are less than 2 m / s. The results of the simulation show that the first tsunami wave arrives approximately 40 minutes after the earthquake and the first crest of the wave arrives at about 5 minutes later. The assessment of the Tsunami hazard indicates that the tsunami-induced currents in the area can be as high as 5.8 knots.

1.4 Installation of Marine Elements (Construction Phase)

This section describes the Marine Terminal and Pipeline installation that will include a floating FSRU supported by an RCM mooring system described above.

1.4.1 Equipment and FSRU

The FSRU will consist of an existing FSRU that will be retrofitted with regasification equipment (as explained in the original EIA). The vessels Gemmnata and Hispania still represent the most likely candidates for the FSRU.

Specialized equipment will be manufactured outside the country and takes some time for its preparedness including: engines, generators, auxiliary equipment, tank parts, pumps, compressors, transformers, switching equipment, water tanks, etc. These will installed in a shipyard outside of the project area of influence.

1.4.2 RCM Outline Installation

The following outline installation sequence is proposed for the RCM installation (will depend on installation contractor preferences):

- Install 3+3+2+2 fluke anchors
- Install PLEM
- Install riser tether
- Install riser and umbilical

- Connect riser tether spring
- Install and cut back chain according to chain cutting scheme
- Install holdback polyester lines
- Pull in the chains/polyester and connect to restrictor chains
- Assemble/lower the Restrictor – the aft one including the upper chains ready for pull-in
- Install polyester ropes with pull-in lines
- Arrive with FSRU and hold her in position
- Connect bow polyester lines and hang off
- Pull-in holdback chains to final position
- Pull up riser/jumper and hang off
- Dewater riser
- Pressure/Leak test / Commission
- Ready

Surveys and installation related to the RCM will require divers.

1.4.2.1 Installation Scheme

The following installation scheme is proposed:

- Installation of anchors 3 + 3 + 2 + 2
- Installation of Manifold PLEM
- Installation of fastening of the lifting pipe
- Installation of elevating and umbilical pipes
- Connection of the spring of the fastening of the lifting pipe
- Installation and cutting of chains according to the required cutting scheme
- Installation of polyester stern lines
- Pull and introduce the polyester chains and lines and connect them to the restriction chains
- Assemble and lower restriction chains
- Install polyester ropes with drawn lines
- The FSRU arrives at the site and is kept in position
- Connection of polyester back lines
- Pull the retaining chains to their final position
- Pull the riser to its position
- Draining the Riser
- Pressure tests and start-up
- Ready for operation

1.4.3 FSRU Anchoring

The FSRU will be mobilized to the location of the Marine Terminal in the following way:

- FSRU positioning / heading control Fleet (Assuming 2-off tugs – one at Bow / 1 at stern)

- Complete mobilisation of FSRU positioning Fleet with project equipment and personnel at nominated Port;
- Transit of Positioning / Heading Control Vessels (HCVs) to the field and rendezvous with FSRU (self-propelled to the field)
- Hook-up of HCVs fleet to FSRU and positioning / heading control trials
- FSRU positioning / Heading control during hook-up to restrictor frame
- FSRU positioning / Heading control during hook-up of hold-back lines
- Disconnect HCVs from FSRU;
- Demobilization

1.4.4 Marine Spread

The Project marine spread consists of all the offshore support equipment and services that might be needed for an offshore construction, such as business-related vessels, including tugs, accommodation barges and crew boats. It also includes related services, such as skilled manpower, and offshore inspections.

The marine spread required specifically for the installation of the RCM system may comprise of the following:

- 1-off Construction and Diving Support Vessel (CDSV)
- 2-off Heading Control / Positioning Tugs (HCVs)
- 2-off Heavy Lift Transportation Vessels (HLVs)

1.4.5 Offshore Pipeline Installation Process

No less than 700 meters of underwater pipe installation will be installed by means of horizontal directional drilling (HDD). The HDD section consists of the portion that starts from the ground and travels perpendicular to the cliff going west (offshore).

The rest of the pipe section will be installed using the trench methodology previously described in the EsIA. During the excavation of the trench, the sediments will be deposited next to the trench. To connect the PLEM to the pipe, you need to raise a portion of the pipe to a platform to achieve the connection. Subsequently, the PLEM and the pipeline will be deposited at the bottom of the sea.

1.4.5.1 Installation process by ditching

For the excavated section of the pipeline, the route will be dredged and the pipeline will be installed in a trench 2 m deep from the HDD pipe exit to the marine terminal with an approximate slope of 3H:1V. In the trench, the appropriate base for the pipeline will be prepared in a non-liquefiable base (dense sand or tuff layer) and a rock berm will be installed in the pipeline after installation, in order to protect it from erosion, anchors and the tsunami currents.

Due to the variable depth of water along the marine pipeline, different means of excavation have been proposed to create the trench; The excavation can be done by means of a backhoe with dredger (shallow zone) or by means of a suction dredge (deeper zone); The excavated material from the trench will be deposited next to the trench to be used for filling after the pipe is laid or left to one side.

1.4.5.2 HDD Installation sequence

The HDD will run from the ground to the sea through a drilling platform located on land. The process begins with the drilling of a pilot hole (pilot hole) of small diameter, from 6 to 10 inches, drilling the bottom outlet of the sea.

Subsequently, the hole will be expanded using the push reaming methodologies (amplification via push). The hole extension typically takes place in increments of 6 inches in diameter (eg 18 ", 24", 30 "etc). Before the prepared pipe section can be inserted into the HDD reaming hole, the drill channel will be subjected to a certain number of cleaning passes with the reamer. Later the pipe will be laid, welded and mounted on pipe rollers.

For the installation of the pipeline, a ground push unit will be necessary to pull / push the pipe along the drilling line and into the prepared HDD. It is anticipated that another hole similar to the previously described pilot hole will be drilled in parallel to that of the gas pipe, approximately 3 to 6 meters away, inside this hole will be installed the power cable for the FSRU and the communication cables.

The installation activities of the HDD pipeline are described in detail below.

1.4.5.3 Site preparation

Prior to the mobilization of HDD equipment to the drilling site, the site must be prepared to ensure the delivery, installation and operation of all equipment with maximum efficiency and safety during the execution of excavation work.

The tasks of preparation of the site aim to cover the following aspects:

- Leveling and location of the HDD drilling platform, filled in if necessary
- Provision of site facilities, for example, offices, bathrooms, parking areas, fences, etc.
- Provision of water lines, communication and electricity
- Installation of anchors for the drilling platform and for the pipe drive.
- Transportation and installation of equipment

1.4.5.3.1 Site Leveling

There will be a leveling of the ground on which the base of the drilling machine will be installed. To ensure the stability of the surface for the installation and operation of the equipment, the site will be covered with gravel or similar material to a depth of 300mm and will be compacted in the areas that are necessary. See figure 1-24

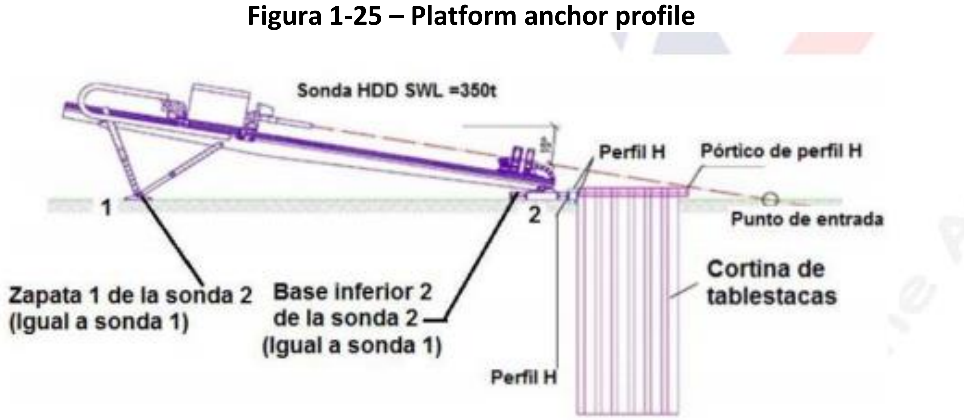
Figura 1-24 – Base example for HDD platform with gravel filling and concrete slabs

Source: Instalación de Tubería HDD, Energia del Pacifico, 2018.

1.4.5.3.2 Platform Anchoring

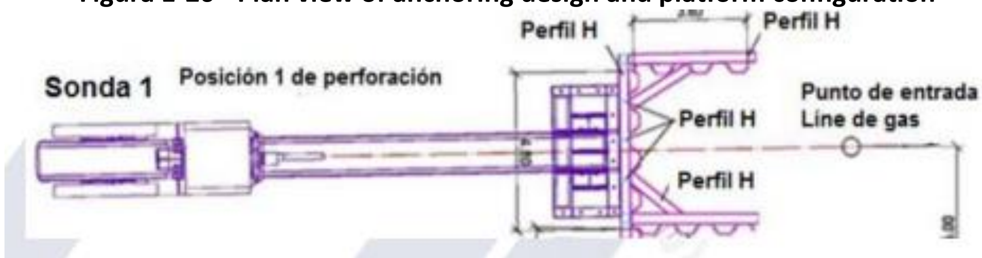
An anchoring is necessary to ensure proper operation of the drilling platform. The pipeline booster will require its own anchoring system designed specifically for the installation of the pipeline. The structure is normally made of concrete blocks, piles or pipes buried in the ground. The design detail and specifications of the platform anchor will be provided during the detailed engineering development. See Figure 1-25 and Figure 1-26.

Figura 1-25 – Platform anchor profile



Source: Instalación de Tubería HDD, Energia del Pacifico, 2018.

Figura 1-26 - Plan view of anchoring design and platform configuration



Source: Instalación de Tubería HDD, Energia del Pacifico, 2018.

1.4.5.3.3 Installation og HDD equipment

The equipment required for the execution of the drilling and installation of the pipeline can be mobilized to the site immediately after completing the preparation stage of the site previously described. See Figure 1-27 and Figure 1-28.

The equipment to be provided will include at least the following:

- HDD drilling rig with sufficient capacity to perform the drilling work required by the project
- Electrohydraulic power supply package and control cabinet
- Mixing and cleaning systems for the manufacture and recycling of drilling fluid
- High pressure pumping system to transfer the drilling fluid to the drilling tools
- Tubes and drilling tools, including: drill bits, reamers, handling tools, etc.
- Spare parts and workshop
- Pipe propulsion system

Figura 1-27 - On-site distribution of the HDD system - Gas Project in Otway

Source: Pipe Installation HDD, Energia del Pacifico, 2018

Figura 1-28 - Distribution of HDD equipment - Serra de Inoa

Source: Pipe Installation HDD, Energia del Pacifico, 2018

1.4.5.4 Drilling operations

The HDD process can be divided into two main components:

1. Pipe drilling and installation
2. Pipe manufacturing, laying and testing

1.4.5.4.1 Directional drilling

According to the soil conditions of the site along the planned alignment, drilling can be carried out using a mud motor. See figure 1-29

Figura 1-29 - Broca de dientes de molino para condiciones de suelo suave

Source: Pipe Installation HDD, Energia del Pacifico, 2018

1.4.5.4.2 Mud drilling and cuts

To cut the soil in front of the bit at the bottom of the hole, drilling fluid is used, based on bentonite, which will be released by the high-pressure mud pump through the inner ring of the pipes perforation coupled, towards the drill. When passing the mud motor, the drilling fluid drives the internal rotor of the motor, which finally turns the bit. With this technology, the high rotation speed required to cut a rock formation is achieved without putting the drill pipes coupled under high torsional stress.

The fluid leaves the drill pipes coupled through the jet nozzles at pressures that depend on the mud flow rates controlled by the driller. The drilling fluid, due to its density and viscosity, transports the cuts or debris from the drilling back to the surface through the drill ring.

The fluid returning from the head together with the excavated material is recycled using the fluid cleaning system, which is detailed below. This equipment separates the excavation material from the drilling mud and returns the clean mud to the active tank to be used again in the drilling cycle. The excess sediments are stored in a pond at the site before being transported to the final disposal site, either in the field of the Thermal Power Plant or to an authorized disposal site. This excavation material is not expected to contain any contamination, however, previous analyzes will be made to define its final disposal.

1.4.5.4.3 Reaming

After drilling the pilot hole, an expansion process called Reaming is carried out. The hole extension typically takes place in increments of 6 inches in diameter (eg 18 ", 24", 30 "etc).

The drilling fluid remaining in the borehole once the drilling and reaming operations are completed will be pushed slowly out of the sea floor exit hole to the ocean during the pipe push / installation process. The amount of drilling fluid released during this step will be less than 1,000m3 of drilling fluid.

1.4.5.5 Drill fluid hydraulic fracture mitigation.

Due to the varity of geological material present on the site fratures could be generated in the soil that filter part of the drilling materiales to the sea, known as “Frac-out”. Given the characteristics of the proyect, it was determined that the preferred method to mitigate the risk of a fraction seperation event would allw the HDD driller to carefully monitor the downhole annular pressures by the instrumentation located at the end of the drill string during drilling. This will allow the driller to detect pressure surges or drops within the borehole, which may indicate the existence of a drilling fluid leak.

In addition, the driller will closely monitor the drill flud returns (drill fluid returning up-hole to the drill rig), and the volume of the drill fluid within the recycling system. If the driller detects a drill fluid loss through pressure or fluid monitoring, drilling operations would be ceased, and cement grout would be pumped through the drill rods into the borehole to fill the voids. Once the grouting has solidified the drilling activities would resume.

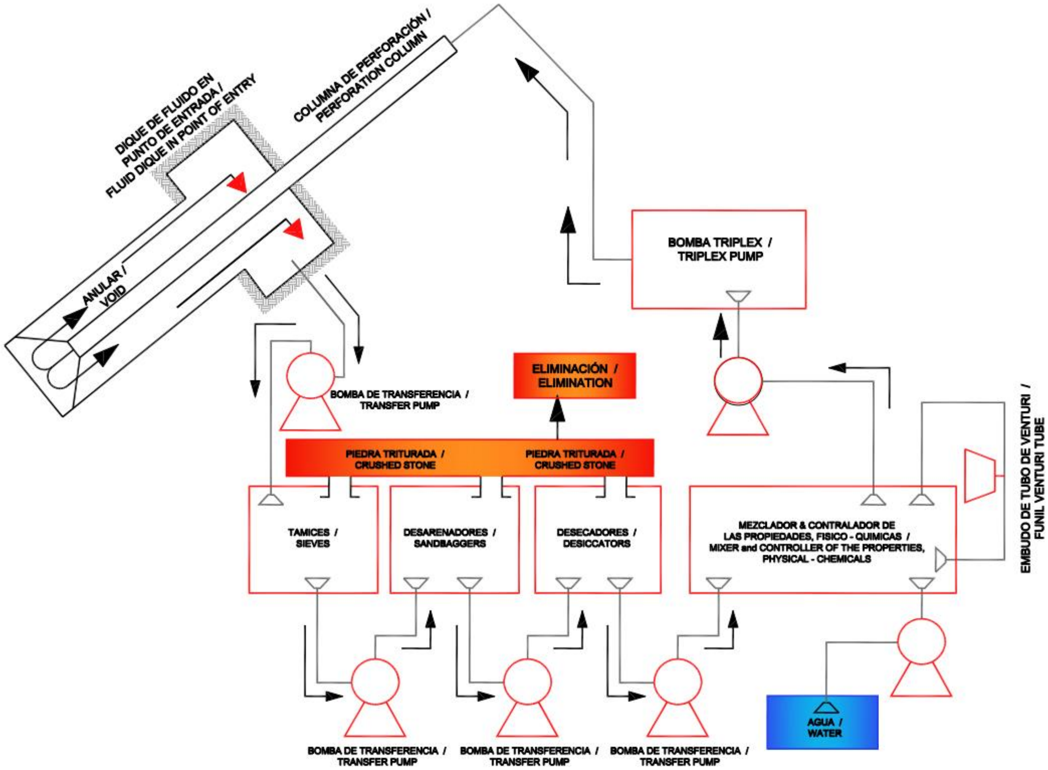
1.4.5.6 Bentonite-based drilling fluid

A concentrated bentonite-based drilling fluid will be used, such as TRU-BORE from Wyo-Ben Inc., which designed for difficult drilling operations in both vertical and horizontal borings. It is non-toxic and environmentally safe. It is a fast-hydrating formula that allows contractors to mix fast and build viscosity quickly. TRU-BORE stabilizes formations ranging from moderate clay soils to high concentrations of sand. By forming a thin tough filter cake, fluid loss to areas around the borehole is reduced.

1.4.5.7 Recycling System

The HDD contractor will use a recycling system to remove the cuttings (sediment) from the drill fluid. This is typically composed of three (3) distinct components: vibrating screens, desanders and desilters, which progressively remove the sediment according to their grain size. Specification of a representative Recycling System are provided below (in Table 1-17), along with example diagrams (Figure 1-30 and Figure 1-31).

Figura 1-30 - Schematic of the fluid circulation system



Source: Acajutla LNG Import, Tender Method Statement (HDD), Conduto/DrillTec, November 2017.

Table 1-**17 - System Capacity**

ITEM	CAPACITY	
Capacity of tank	150m^3	
Length	3.9m	
Width	2.1m	
Weight	18t	
Capacity of the screens	895 GPM	3390 LPM
3 screens-mesh 70		
3 screens-2010 mesh		
Capacity of desanders	895 GPM	3390 LPM
2 x 10” hydrocyclones		
Capacity of desilters	895 GPM	3390 LPM
12 x 4” hydrocyclones		

Source: Acajutla LNG Import, Tender Method Statement (HDD), Conduto/DrillTec, November 2017.

Figura 1-31 - Recycling

Copyright © DERRICK

Source: Acajutla LNG Import, Tender Method Statement (HDD), Conduto/DrillTec, November.

1.4.5.7.1 Cleaning

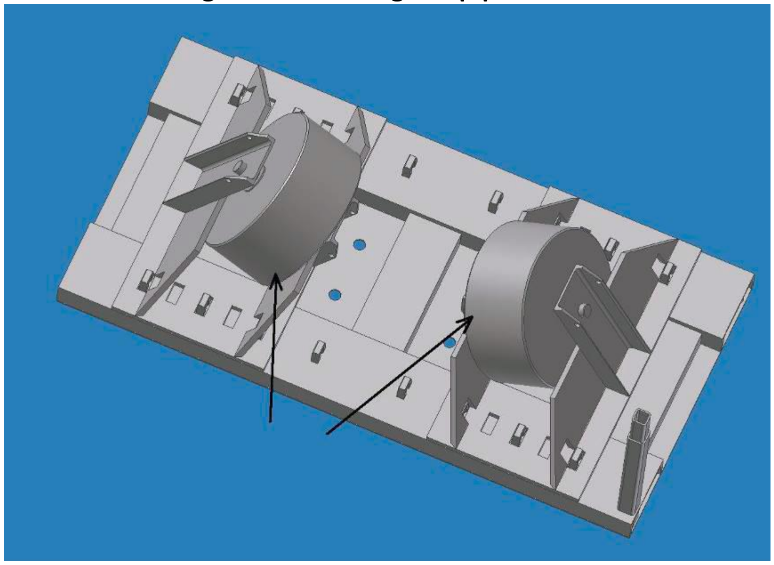
Before the prepared pipe section can be introduced into the HDD borehole, the drill channel will undergo a certain number of cleaning passes; under normal conditions, the number of passes will be from one to three; the final decision must be made during construction by the specialists on the site depending on the actual condition of the drilling.

The purpose of the cleaning passes is to remove the remaining cuts from the bottom floor of the perforation (cleaning) and, at the same time, control the stability, size and integrity of the perforation.

1.4.5.7.2 Fabrication of the pipeline

Pipe laying, and fabrication operations will be executed on land. The pipe will be laid and placed on the pipe rollers before installation. The pipe rollers minimize friction and the resulting thrust / drag forces and ensure that there is no damage to the lining of the mounting joint or pipe during installation. See figure 1-32.

Figura 1-32 - Design of pipe rollers



Source: Instalación de Tubería HDD, EDP, 2018

1.4.5.7.3 Pipe thruster

For the installation of the pipeline, a ground push unit will be necessary to pull / push the pipe along the drilling line and into the prepared HDD. The pipe thruster has the ability to push or pull during installation if the pipe is stuck.

The pipe thruster is installed at the location of the drilling platform before installing the pipe. Two axially arranged hydraulic cylinders of the pipe thruster exert their variablely adjustable force on the pipeline through a clamping unit..

1.4.5.7.4 Offshore work

The offshore laying will be performed by means of diving including the alignment of the pipeline as the pipeline emerges from the exit point of the HDD in offshore.

Medium or light marine machinery or maneuvers (such as small boats or others) can help in the lateral alignment, while means or marine machinery heavier or larger / power (such as larger vessels, tugboats, pontoons or other temporary floating media) / can help by pulling with a cable connected to the tip of the pipe. It is not expected that the trawl installed on the offshore work vessel will have a lot of load, but rather it will provide a drag force to guide it to the end and the pipe propeller will do most of the installation from the shore.

1.4.5.8 Equipment

The equipment for the pipeline installation will include:

1. Drilling equipment.
2. Pipe Thruster with cabin control and power unit.
3. High pressure pump –Equipment responsible for continuous pumping of drilling fluid under pressure through the internal drill pipe diameter.
4. Recycling System.
5. Cabin Control. Place where the operator controls the drilling parameters and operations of all stages of directional drilling. During the execution of the pilot hole, it is also the place where the directional controls the navigation according to the project.
6. Generators. Provide electricity to all units that do not have their own generation.
7. Centrifugal pump. Pumps are used for water transfer or drilling fluid between the units of the site.
8. Shipyard of drill pipes. Located parallel to the drilling rig to facilitate the operations of removal and placement of the pipes during connections and disconnections. Aproximately 300 drill pipes will be mobilized.

1.4.5.9 Installation HDD and RCM sequence

Then, the chronological construction procedure to include on the permit would be:

1. Engineering, logistics and setting up on site equipment for the pipeline: Aproximately 3 months total with 1 month for setting up on site.
2. Drilling: from 3 to 4 months
3. Pipeline assembly, welding, testing, installation and inspection: 1 month. The pipeline will be pushed onshore with a thruster and tug boats will pull it offshore once the pipeline is near to the punch out location.
4. Trenching, installation and anchoring the pipeline to the sea floor: 1 month. This activity will overlap with the previous one.
5. Mooring system risers, elevators, umbilical and PLEM installation: this will be done several months after pipeline installation. Offshore heavy equipment as described in the RCM installation section will be mobilized for these activities, including vessels, tug boats and potentially a jack-up barge. Drag anchors and mooring lines can be installed ahead of schedule, however, FSRU needs to be onsite in order to complete all the installations.

1.4.5.10 Handling and final disposal of waste and solis waste

The solid waste to be generated during the construction of the plant will be temporarily managed within the same construction site. These will be collected in an orderly manner in containers (metal barrels) specially designed for it, so that they do not represent a risk of accident or environmental contamination, and will finally be disposed of in an authorized site.

The waste will be collected through transportation from the Municipal Mayor's Office and private transportation when necessary and taken to the sanitary landfill of Salinas de Aya Cachapa. The landfill operates under the administration of CAPSA DE C.V. and has its operation permits. There is feasibility of eviction of the waste by the Mayor's Office, which is included in Appendix 3E. This sanitary landfill has an environmental permit and it will be required that the company that transports the waste has the corresponding permits.

The term of temporary storage of the waste produced during the construction stage is estimated at a maximum of 15 days, after its generation and / or collection. Larger materials such as pieces of metal or scrap will be stored in a properly marked and delimited place. These materials do not contaminate the soil due to their characteristics.

Reusable materials such as wood, sheet metal parts, tubes and metal angles are sometimes donated to company personnel, sometimes they are marketed as scrap, in the case of metallic materials.

The following Table 1-18 summarizes the main types of waste that will be generated during the construction phase and what are the potential options for the disposal of them.

Solid waste of special type will be generated by greasing and oil changes of the equipment. The maintenance of heavy equipment will not be allowed on the site of the plant, however, it is always necessary to keep the equipment lubricated, review that will be done periodically, being able to have waste and residues, such as used lubricating oil and oil deposits new lubricant.

For proper handling, plastic containers of adequate capacity, with a lid, and properly marked to keep the waste labeled as follows: "Hazardous waste" (contaminated with oils and fats) will be installed.

The waste will be periodically removed and delivered to a company authorized for transportation and the final disposal of this type of waste. The following Table 1-18 presents a summary of the waste that is expected to be generated during the construction phase of the project.

Table 1**-18- Desechos y Residuos a Generarse en la Etapa de Construcción***

Scrap/Waste	Origin	Handling	Disposition
Used fuel or oil	Preparation of machinery and equipment daily	Storage in reciclable oil tank	Sale to be used as fuel

Table 1-18- Desechos y Residuos a Generarse en la Etapa de Construcción*			
Scrap/Waste	**Origin**	**Handling**	**Disposition**
Used absorbent material (wipes, sawdust)	Preparation of machinery and equipment daily	Storage in closed tanks or bags, properly closed and labeled as "hazardous waste"	Incineration by controlled methods, in sites with authorization from the competent authority
Wood or firewood	Cuting and trimming of vegetation, concrete molding, scaffoldings, among others	Gathering at a designated site. Wood will be trimmed and put in groups	Sale of Wood or firewood
Leaf and branches	Cutting and dethroning	Gathering at a designated site on each work front	Eviction to authorized site
Paper	office and packing	Storage in a warehouse pointing	Recycling sale
Domestic (dining y offices)	Foods, several	Storage in closed tank	With the cleaning train or authorized trnsport and transfer to the landfill
Glass	Packaging	Storage in closed tank	Sale for reuse
Plastic	Packing material	Storage in closed tank	Sale for recycling
Construction debris	Of the construction itself	Storage	Taken to an authorized debris dump
Metal pieces	Surplus pieces of support structures and metal pipes	Storage	Sale of scrap
Sterile material of earthworks	Earthworks	Stacked in a defined area of the land	Evicted to defined site for filling
Cylinders for welding	Of the construction	Storage in cylinders in defined area	Sale for recycling
Mud with Bentonite, 2,500m^3	Of drilling on the seabed	Stacked in a defined area of the land	Evicted to defined site for off-site landfill or project land

**Hazardous waste includes: empty tans, used lubricating oil, solvents and other reagents, batteries and other consumables.*

Source: Consulting team, 2018.

The gravel will be taken to an appropriate disposal site, authorized by the Municipal Mayor's Office and by the MARN.

The drilling liquid (sediments with bentonite), which is collected in the tanks and pond will be disposed in a sanitary landfill of the material, it will be checked that it does not present characteristics of dangerous material.

1.4.6 Consumption of the water resource construction stage

During the construction phase temporary water storage tanks will be used, which will be filled with water from the well, without exceeding the pumping flow, which is 4.5 L / s (for 20h of pumping).

If more water is required to be pumped, it will be supplied by tankers, which come from sites authorized by ANDA and the MARN. Water uses during construction include:

- Water for the pipe drilling process.
- Domestic consumption of employees, for washing and cafeteria. The human consumption will be supplied by bottled water and portable toilets without water consumption will be used.
- Consumption for making concrete and cement mixtures. For casting large volumes of concrete, this will be supplied to the ready-mixed project.
- Cleaning of work areas.
- Irrigation for dust control, during dirt in the dry season.
- Irrigation of green areas that are adapted.

1.5 Operating Phase

The main activities in the plant will be:

1. Dockage of the methane tanker and LNG discharge, when there is a scheduled discharge, it is estimated that it can last up to 40 hours;
2. Transfer and storage (at cryogenic temperatures and atmospheric pressure) of LNG from the methane tanker to the FSRU;
3. Handling of evaporation gas (boil-off gas for its acronym in English, BOG;
4. Regasification and transfer of GN from the FSRU to the plant and measurement of natural gas permanently;
5. Generation of energy, through the combustion of natural gas and steam turbine;
6. Cooling system operation;
7. Power injection in the substation; And
8. Equipment maintenance.

Activities 1 to 4 are modified with the change in the maritime terminal and are presented below.

1.5.1 Technology and Equipment specifications

The FSRU will be a converted LNGC (which has some of the equipment originally planned for the FSRU) in which additional functionalities will be added (regasification in particular and power engine). The equipment will be shown in Table 1-19.

Table 1-19- Teams of the SFRU	
Description	**Identification**
LD compressor	LDC
HD compressor	HDC
Air conditioner	ACF
Glycol pump	GP
SB machine room fan	ERV_SB
PS machine room fan	ERV_PS
Compressor room fan SB	CRF
Steam boiler	LDC
BOG Compressor 1	BOG_Comp1
BOG Compressor 2	BOG_Comp2
Fan of the engine room SB 2	ERV_SB2
Air compressor 1	AC1
Air compressor 2	AC2
PS machine room fan	ERV_PS2
LNG transfer pump 1	LNG_P1
LNG transfer pump 2	LNG_P2
LNG 3 transfer pump	LNG_P3
LNG transfer pump 4	LNG_P4
LNG transfer pump 1	LNG_TP1
LNG transfer pump 2	LNG_TP2
Generator set 1	GS1
Generator set 2	GS2
Generator set 3	GS3
Generator 4	GS4
Fresh and salt water pump 1	FSWP1
Fresh and salt water pump 2	FSWP2
Fresh and salt water pump 3	FSWP3
Fresh and salt water pump 4	FSWP4
Nitrogen generator 1	NG1
Nitrogen generator 2	NG2

Source: EDP, 2018

The auxiliary equipment in the FSRU includes: electric generators, other equipment such as air compressors and nitrogen generators, emergency generators (diesel). The main equipment is described below.

1.5.1.1.1 Nitrogen Generator

The purpose of the nitrogen generator is to produce enough nitrogen to protect the LNG tank from sub-atmospheric conditions that may arise during discharge. All purge tasks are also performed using nitrogen.

Two nitrogen generators will be available to produce enough nitrogen to protect the LNG storage tank from the sub-atmospheric conditions that may arise during unloading. A generator will be located in the FSRU, with a purity of 97%. The nitrogen generator in the FSRU will have a capacity of 2x60m^3/ h.

1.5.1.1.2 Instrumentation air generator

The purpose of the air generator is to produce enough instrumentation air for the operation of the terminal valves. The air is produced by drying and compressing the air in the environment.

1.5.1.1.3 Maritime Terminal Control

The objective of the control system is to guarantee the safe and proper operation of the LNG Maritime Terminal. There will be two control centers for the entire project; one inside the FSRU and the other inside the Thermal Power Plant on land.

In general, the control and monitoring of the Maritime Terminal will be carried out by a small programmable logic control center (PLC) with a SCADA / HMI system located in the FSRU. Transfer processes and ESD systems will be controlled within the control room of the FSRU.

During the transfer of LNG from the LNGC, an ESD control system will be available on board the LNGC, to control the transfer of liquid and vapor. The operation of the FSRU will be full time (24 hours / 365 days).

All processes will be fully automated. Only the execution of a few steps by the operator will be necessary for the start and end of the operations, such as LNG tanker discharge, LNG transfer and natural gas delivery.

The control system will interact with all the other systems necessary for the automation of the terminal. The system will also be linked to the control system of Central Térmica, allowing the exchange of data between both, by means of fiber optic submarine wiring, high speed and broadband. Fiber optic connection from the Maritime Terminal / FSRU to FSU will be through a quick coupling system. There will be redundant telecommunications by microwave radio link..

The following systems are interconnecting with the terminal control system:

- Pressure, temperature and volume monitoring of tanks;
- Detection of fire and gas leaks;
- ESD system (qualified SIL); And

- Control of hoses.

1. Emergency shutdown system

The emergency shutdown system will monitor the plant during critical situations. It will act on engines and other equipment to prevent catastrophic failures from occurring.

All hoses, steam and liquid, will have an emergency opening system..

2. Gas detection and fire leakage system

Instruments dedicated to the detection of fire and gas will be installed according to studies and regulations of the industry. Gas detection immediately activates emergency shutdown systems to prevent gas propagation and prevent the risk of ignition. Gas detectors will also be installed in the CEPA quay according to what is recommended in the project's risk study.

Fire signals will also be sent to the control system and will activate the emergency systems to stop the supply of fires with fuels. The fire protection system will also be activated to prevent the spread of a fire.

1.5.1.1.4 Fire control system

The FSRU will be equipped with its own fire protection systems. In the unlikely event that a fire breaks out at the Maritime Terminal, ESD systems will be activated to eliminate the fuel source. The LNGC, if present, will proceed to withdraw from the terminal.

1.5.1.1.5 Instruments

The instruments to be installed in the plant will be dedicated to one of the two systems: Process control system or emergency shutdown system.

The process control instruments will be used to control the plant, control, regulation, alarm and stop the process. All instruments will be connected to the control system. The values will be available to the operator at all times. They will also be registered in a system to facilitate reporting, maintenance, performance monitoring and problem resolution.

ESD´s instruments will be used to monitor critical processes and to initiate emergency actions to avoid catastrophic failures. All instruments will be connected to the ESD controllers.

A large number of instruments and sensors of different types will be installed. In the matter of emergency systems, the instruments to be installed include, but are not limited to:

- Gas flow, pipe pressure, gas chromatographs, to analyze gas samples and calculate the gross calorific value; And
- Instruments to detect densities and pressures inside tanks. Levels will be monitored.

1.5.2 Ship Unloading Process

The cargo ship (LNGC) will dock at the side of the FSRU. Floating foam or tire protections will be placed between the boats and connected to the FSU. The mooring lines of the LNGC will be transferred to the FSRU. The FSRU will tie the line using quick release hooks installed on the starboard side of the FSRU. It is envisaged that the following typical arrangement for cargo ships will be used: 2 springs at the bow and stern and 6 tiers at the bow and stern.

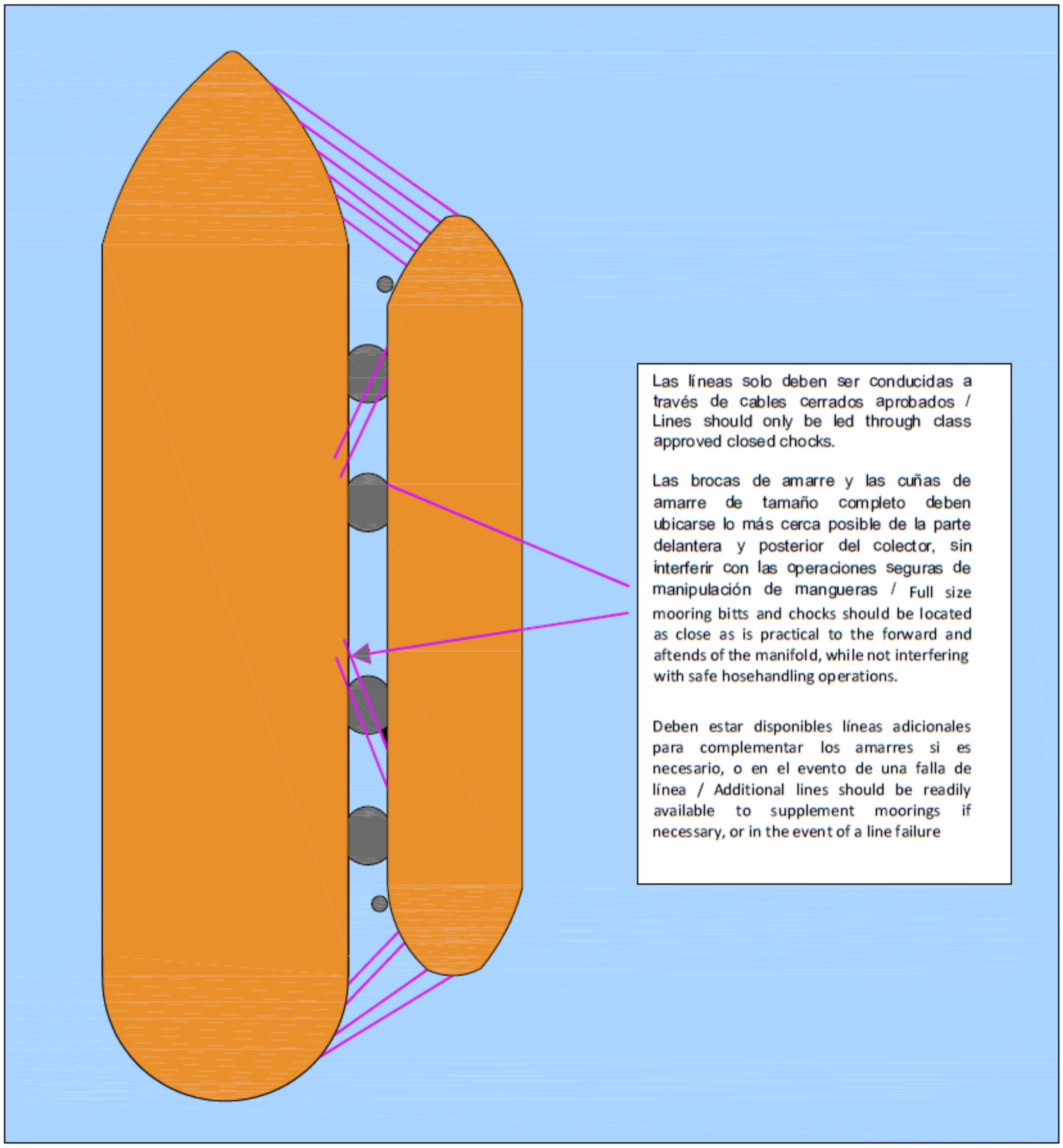
The LNG is transferred from the LNGC to the FSRU through flexible hose systems. It is expected that the Maritime Terminal can receive LNGC vessels between 138,000 m3 and 174,000 m3 capacity.

The LNGC will be supported by support tugs during the approach to the Maritime Terminal, all coordinated and in support of control personnel of the Port of Acajutla. A fire tug at the Maritime Terminal will be required at all times for the FSRU. When an LNGC is docked three tugboats will be maintained, in order to serve the methane vessel during docking operations and for emergency response due to tsunamis, fires, or any other event, one of its own and the two of the port.

The LNGC will be placed with the stern oriented towards the side of the shore, making the orientation coincide with that of the FSRU. The turning area will be in deeper waters southwest of the terminal. To leave the terminal, the LNGC will also be under the support of tugboats, and the vessel will go directly forward towards areas on the high seas. The FSU will be permanently docked.

During the discharge a "Water curtain" will be applied during the whole time on the side of the vessel, so that in the case of an LNG spill the metal of the ship is protected by the sudden change in temperature. See figure 1-33. See Photograph 1-4.

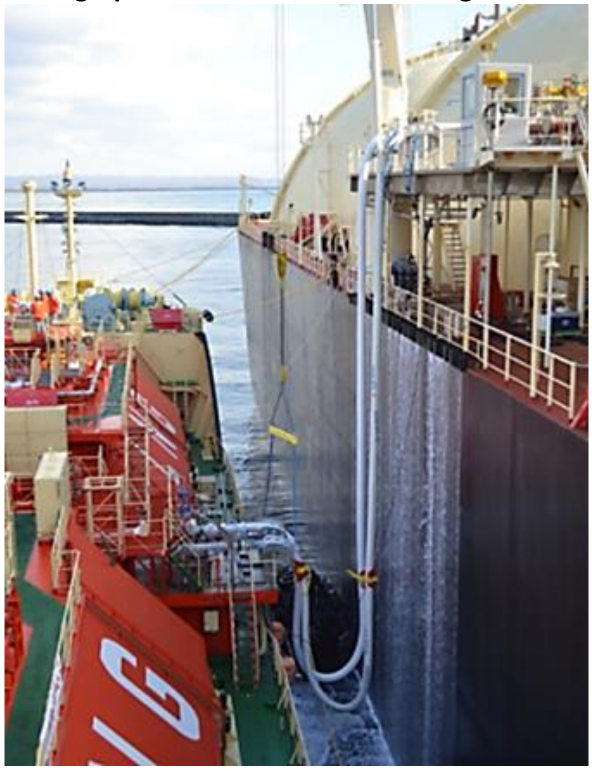
Figura 1-33 - LNGC vessel docking scheme next to the FSRU



Source: EDP, 2018

The LNG will be the responsibility of the supplying company until it is downloaded into the FSRU. The gas will be measured and analyzed in each delivery.

Photograph 1-4 - Water Curtain During Transfer



Source: Wärtsilä, 2014

1.5.2.1 Load of the FSRU

The LNG transfer is carried out through LNG STS hoses (cryogenic). Each hose is coupled to a Hydraulic Power Unit (HPU) for release in case of emergency.

1.5.2.2 Hose connection (Approximate duration: 2.5 hour)

When vessels are safely moored, personnel will be transferred to LNGC by means of an approved personnel transfer basket for:

- Pre- transfer meetings; and
- Connection of hoses.

The pre-transfer meeting shall address chronologically all matters of concern which might affect the safe and efficient operation of the ship to ship operation.

1.5.2.3 Connection

The FSRU will be prepared with all hoses connected to the manifolds with the other ends hanging on straps under the drip tray. Saddles and spool pieces will be ready on the FSRU.

- Nitrogen purging hose will be available, manifolds purged, measured and ready for opening

- The FSRU crane brings the LNGC equipment boxes and the portable deluge system
- At completion of connection, all hoses are confirmed purged with Nitrogen.
- ESD link is connected between FSRU and LNGC.
- Emergency shutdown test (warm ESD)
- The ESD connection between both vessels are tested. In warm condition from LNGC
- When test confirmed satisfactory, the water deluge system is started and Hydraulic Power Unit (HPU) is confirmed working/ Emergency release couplings confirmed operational.

1.5.2.4 Hose cooling (Approximate duration: 1.5 hours)

After completing the hot ESD test, the hoses must be cooled before the LNG transfer; The cooling process is guided by the FSRU. The condensation of LNGC Cargo Lines and the STS hoses will occur simultaneously.

- Load of the FSRU operation (Approximate duration: 22 hours)
- When the ESD is confirmed active, the load of the FSRU can begin.
- Disconnection of the hose (approximate duration: 6 hours)
- After the loading operation, the STS hoses will be drained and purged up to <40% LEL before disconnection.
- Disconnection (approximate duration: 0.5 hours)
- The boats will untie themselves by releasing the quick release hooks in the pre-set sequence.
- Maneuvers and piloting OUT
- LNGC will maneuver away from the FSRU and release the pilot in a predefined location. Then LNGc will proceed to the sea until the next visit.

1.5.3 Regasification Process

The regasification will be carried out according to the demand, that is, the fuel that will be regasified will be regasified according to the demand of the power generation plant.

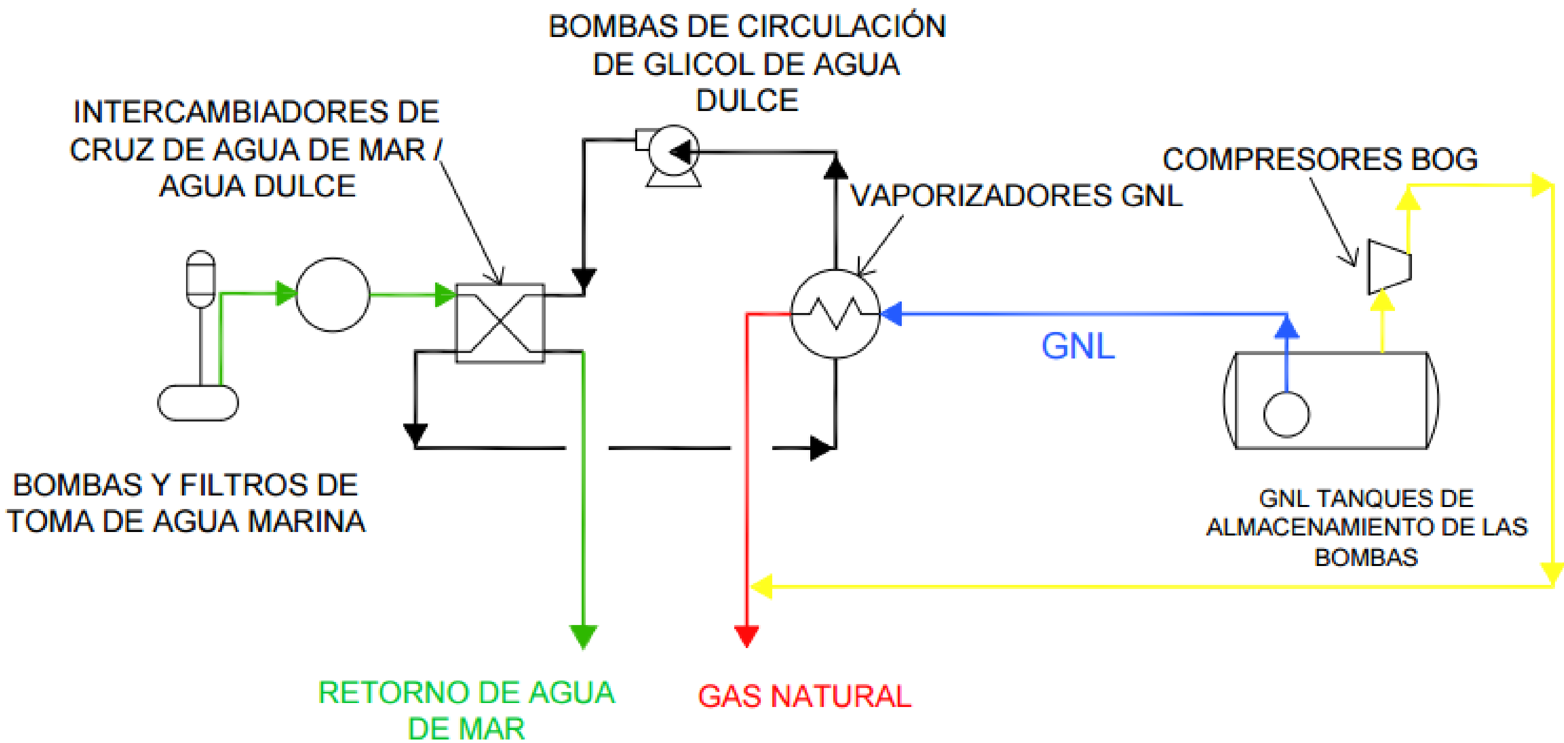
The LNG will be pumped from the storage tanks of the FSRU to the shell and tube vaporizers where a cycle of fresh water with glycol is used to vaporize the LNG. The water with glycol is subsequently heated in a second shell and tube heat exchanger, the heat source will be seawater. The regasification unit consists of four (4) trains, which can operate completely independently. The three trains have a capacity of 93.3 million cubic feet per day (MMPCD) each.

At low gas delivery speed (4-12MMPCD), the load pumps in the FRSU are stopped and BOG is sent directly to the plant at 80 bar to the collector, through redundant compressors. The same compressors are used to supply fuel gas to the FSRU engines and to control the pressure in the cargo tank. The latter is done by sending the excess BOG directly to the plant as part of the regasified gas that is sent. The combination of LNG vaporizers and BOG compressors will be used to send natural gas to ground facilities.

The heat of the regasification plant will be provided by seawater. Heating of the regasification system is carried out with a closed-cycle freshwater glycol system. The closed cycle system is heated by an open-cycle seawater system, as shown in the following Figure 1-34 and in the diagram in Figure 1-35.

The main characteristics of pipelines, and the LNG and GN currents in the regasification and delivery of GN are presented in Table 1-20.

Figura 1-34 - Simplified Regasification and Fuel Delivery Diagram

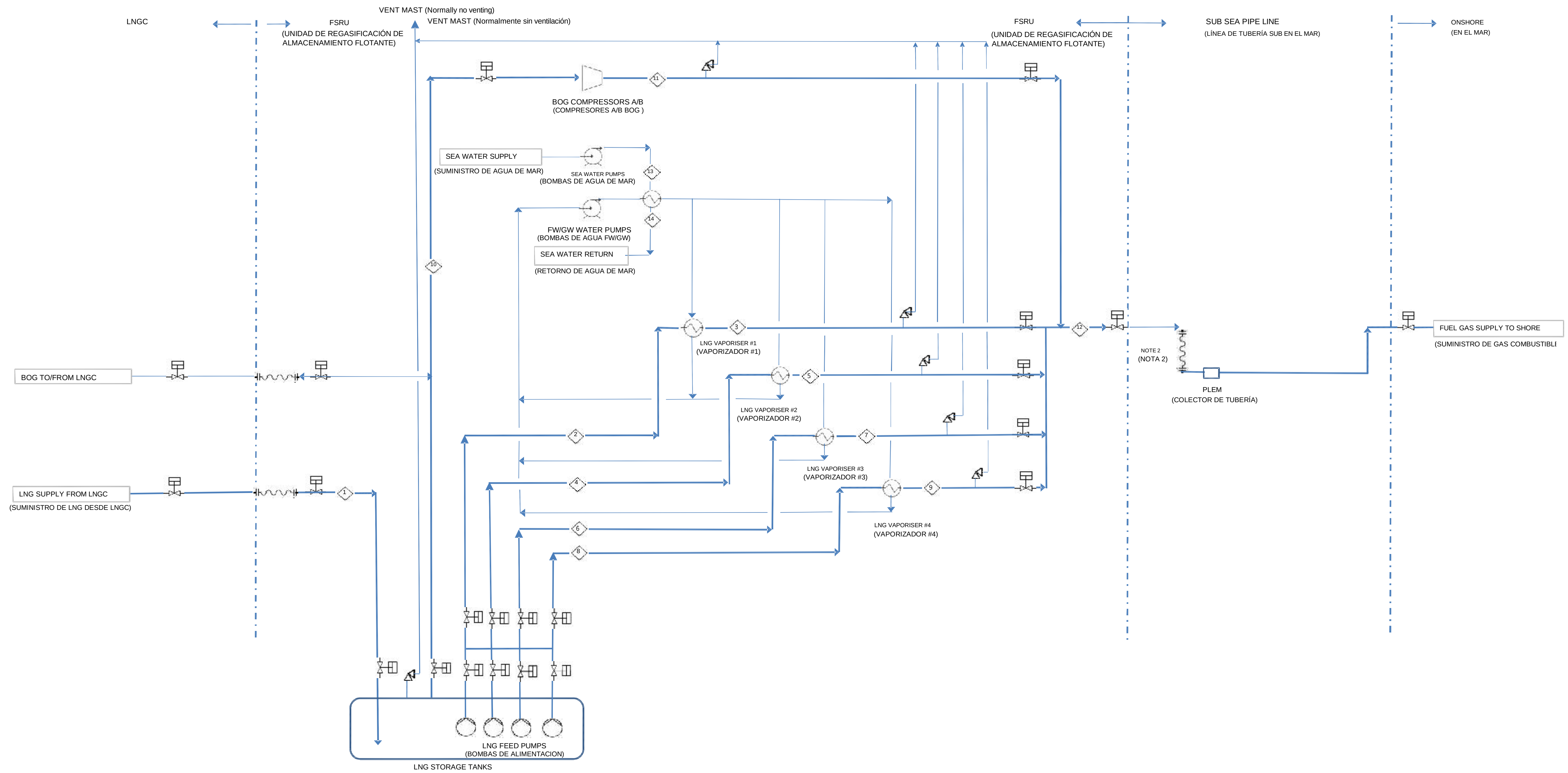


Source: M&N, 2016

Table 1**-20- LNG and NG Streams in Regasification Process and Delivery of NG**

STREAM	1. LNG From LNGC to FSRU	2. FSRU Tank to Vaporizer 1	3. NG from Vaporizer 1 to valve (before pipeline)	4. FSRU Tank to Vaporizer 2	5. NG from Vaporizer 2 to valve (before pipeline)	6. FSRU Tank to Vaporizer 3	7. NG from Vaporizer 3 to valve (before pipeline)	8. FSRU Tank to Vaporizer 4	9. NG from Vaporizer 4 to valve (before pipeline)	10. Evaporation gas from FSRU to BOG Compresor	11. Evaporation gas from BOG compresor to PLEM	12. NG pipeline to plant	13. Sea water for regasification entrance	14. Sea water for regasification output	15. BOG for BOG compresor to recondenser	16. LNG to Vaporizers 1 to 4
Flow (m^3/h)	6,000	150		150		150		150					10,000	10,000		600
Flow (MMSCFD)			70		70		70		70	12	12	280			280	
Phase	Liquid	Liquid	Gas	Liquid	Gas	Liquid	Gas	Liquid	Gas	Gas	Gas	Gas	Liquid	Liquid	Gas	Liquid
Density (kg/m^3)	450	450	55.4	450	55.4	450	55.4	450	55.4	1	55.4	55.4	1,000	1,000	6	450
Pressure (bar)	2	85	80	85	80	85	80	85	80	1.1	80	80	5	1	8	6
Temperature (ºC)	-163	-163	5	-163	5	-163	5	-163	5	-140	5	5	28	23	20	-163
Diameter (inches)	24	6	12	6	12	6	12	6	12	24	10	12			8	10
Length (m)	100	50	50	50	50	50	50	50	50	150	150	150	40	40	150	150
Volume (m^3)	29.2	0.9	3.6	0.9	3.6	0.9	3.6	0.9	3.6	43.8	7.6	10.9			4.9	7.6
Mass (kg)	13,134	410	202	410	202	410	202	410	202	44	421	606			29	3,420

Source: EDP, Acajutla LNG Terminal Project Process Flow Diagram, January 2018.



STREAM (CORRIENTE)	1	2	3	4	5	6	7	8	9	10	11	12	13	14
FLOW [m3/h] (FLUJO m³/h)	6000	150		150		150		150					10000	10000
FLOW [MMSCFD] (FLUJO)			70		70		70		70	12	12	280		
PHASE (FASE)	LIQUID	LIQUID	GAS	LIQUID	GAS	LIQUID	GAS	LIQUID	GAS	GAS	GAS	GAS	LIQUID	LIQUID
DENSITY [kg/m3] (DENSIDAD)	450	450	10	450	10	450	10	450	10	1	10	10	1000	1000
PRESSURE [bara] (PRESION)	2	14	13	14	13	14	13	14	13	1.1	13	13	5	1
TEMPERATURE °C (TEMPERATURA)	-163	-163	5	-163	5	-163	5	-163	5	-140	5	5	28	23
LINE SIZE [inch] (TAMAÑO DE LÍNEA)	24	6	12	6	12	6	12	6	12	24	10	20	40	40
LENGTH [m] (LONGITUD)	25	50	50	50	50	50	50	50	50	50	50	100		
VOLUME [m3] (VOLUMEN) (NOTE 1)	7.3	0.9	3.6	0.9	3.6	0.9	3.6	0.9	3.6	14.6	2.5	20.3		
MASS [kg] (MASA)	3283	410	36	410	36	410	36	410	36	15	25	203		

Energía del Pacífico

ENERGÍA DEL PACÍFICO

LNG TO POWER PROJECT

DIAGRAMA DE FLUJO DEL PROCESO DEL PROYECTO TERMINAL LNG / FLOW DIAGRAM OF THE LNG TERMINAL PROJECT PROCESS

FIGURA 1.35 / FIGURE 1.35

GENERAL NOTES: (NOTAS GENERALES):

A) THIS DRAWING HAS BEEN PREPARED ON PRELIMINARY INFORMATION FROM THE VENDOR AND IS INTENDED TO BE USED AS BASIC INFORMATION FOR PRELIMINARY SAFETY/QRA STUDIES. THIS DRAWING SHALL BE UPDATED BY THE FSRU CONTRACTOR.

NOTAS GENERALES:

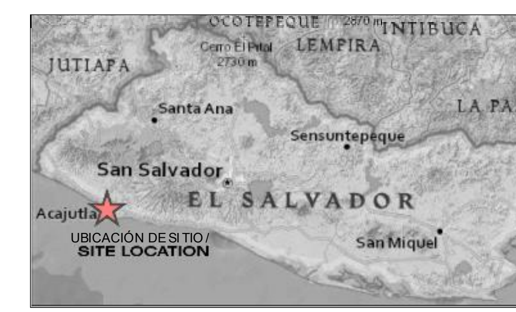
A) ESTE DIBUJO HA SIDO PREPARADO CON INFORMACIÓN PRELIMINAR DEL PROVEEDOR Y ESTÁ DESTINADO A SER UTILIZADO COMO INFORMACIÓN BÁSICA PARA ESTUDIOS PRELIMINARES DE SEGURIDAD / QRA. ESTE DIBUJO DEBE SER ACTUALIZADO POR EL CONTRATISTA FSRU

NOTES:

1. HYDROCARBON INVENTORY REFER TO VOLUME BETWEEN TWO ISOLATION VALVES.
2. FLEXIBLE RISER FROM PLEM.

NOTAS:

1. INVENTARIO DE HIDROCARBUROS QUE SE REFIERE AL VOLUMEN ENTRE DOS VÁLVULAS DE AISLAMIENTO.
2. TUBO FLEXIBLE DE SALIDA DESDE EL COLECTOR DE TUBERIA



0 10 20 30 40 50m

N W E S

FUENTE / SOURCE:
PLANOS WARTSILA / WARTSILA SITE PLAN

MAPA CREADO POR / MAP CREATED BY: ECO INGENIEROS
MAPA REVISADO POR / MAP CHECKED BY: LF
PROYECCIÓN DE MAPA / MAP PROJECTION :
UTM ZONA 16 WGS84 / UTM ZONE 16 WGS84

ARCHIVO / FILE
C:/ECO,DRAWING 1, EL SALVADOR/ ECO INGENIEROS
C:/ECO,DIBUJO 1, EL SALVADOR/ ECO INGENIEROS

PROYECTO / PROJECT: 14-9114
ESTADO / STATUS : FINAL / FINAL
FECHA / DATE: 17/01/2018

DILLON CONSULTING

ECO INGENIEROS

1.5.3.1 Seawater Intake

During the operation of the FSRU there will be releases of cooled and heated seawater into the surrounding waters. Comparatively, the flow rates and temperature differentials from ambient are the same for the RCM concept and the previous cofferdam concept.

Regasification requires a seawater flow of ten thousand cubic meters per hour. To be returned, after being used for regasification. Base temperature for water intake is 28ºC, with the water being returned 5ºC colder, i.e. at 23ºC.

To protect the process equipment and piping system, a Marine Growth Prevention System (MGPS) is installed in the seawater system (SW). For the FSRU, a small amount of seawater is taken from the water intake and enters an electro-chlorination system, equipped with electrodes energized under direct anodic and cathode current. In this condition, the aqueous solution of sodium chloride (NaCl) will be transformed into sodium hypochlorite (NaOCl).

NaOCl is the active agent that will protect the system. The natural NaOCl will decay after a few minutes to recombine in NaCl and H2O.

1.5.3.2 Regasification Process

There will be four regasification units in the FSRU, initially only two regasification trains will be installed which will provide the 70MMSCFD demand to the power plant with 100% redundancy..

From the FRSU tanks, the LNG is delivered around -163 C to the regasification equipment; the re-gasified NG is delivered at 5ºC to the pipeline that will bring the gas to the plant at 80 bara of pressure. This operation will be carried out permanently, when the plant is operating.

During operation of the FSRU there will be releases of cooled or heated seawater into the surrounding waters, these include:

- FSRU – process related outfall release
- FSRU – engine related outfall release

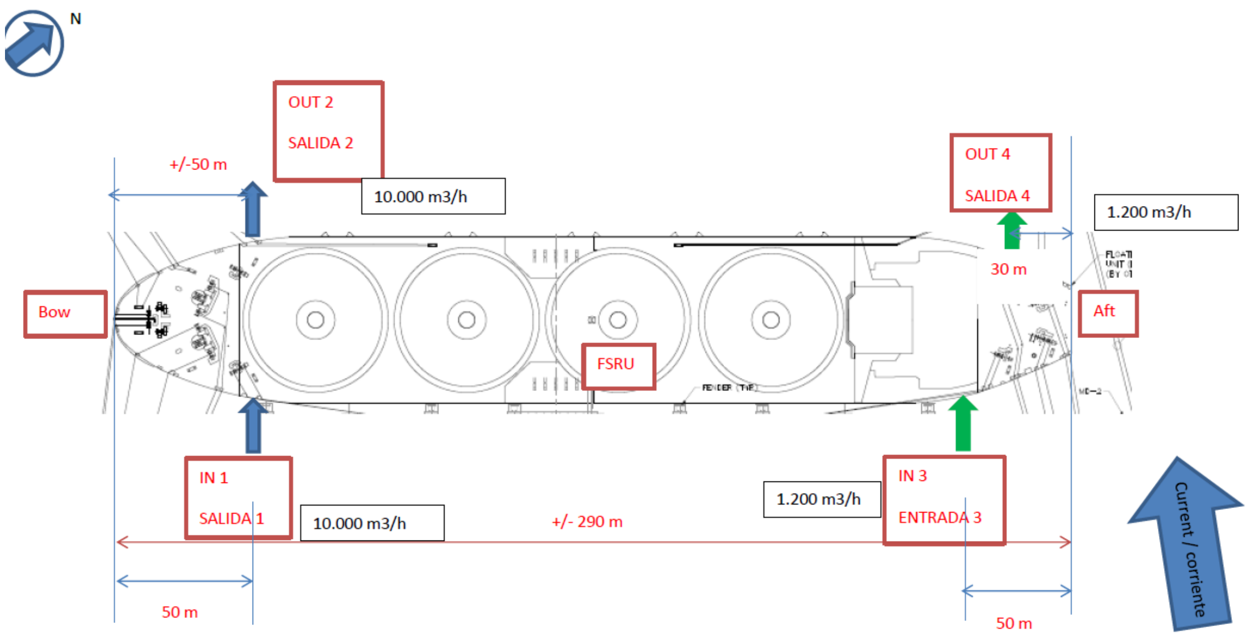
Table 1-21 and Figure 1-36 show the flows and input and output gateways.

Table 1-21 - Seawater Emissions from the FSRU		
Item	**Flow**	**Temperature**
Seawater vaporizer IN	10,000 m^3/h	T

Table 1-21 - Seawater Emissions from the FSRU		
Item	**Flow**	**Temperature**
Seawater vaporizer OUT	10,000 m^3/h	T-5°C
Seawater engine cooling IN	1,200 m^3/h	T
Seawater engine cooling OUT	1,200 m^3/h	T+5°C

Source: M&N, Review of Thermal Plume RCM Concept, December 2017.

Figura 1-36 - FSRU Intake/Outfall Parameters



Source: EDP, December 2017.

A thermal plume dispersion analysis was conducted as part of the ESIA submitted to MARN, in order to study the development of discharge plumes in relation to the metocean conditions at and around the project site. Since completion of the thermal plume study, the terminal concept has changed, and the applicability of the previous results to the current system has been examined. More details are presented in chapter 2.

1.5.3.3 Boil off Gas (BOG)

The boil-off gas generated in the cargo tanks of the FSRU or shuttle LNGC shall be partially used for the power generating plant. The balance of boil-off gas shall be sent to shore or alternatively to the Gas Combustion Unit in the abnormal case where there would be no consumption onshore and the maximum pressure in the cargo tanks is reached.

A fully redundant fuel gas handling unit will be installed,be capable of delivering pressurized boil-off gas from the compressors to the FSRU dual fuel engines, to shore or in emergency situations to the Gas Combustion Unit.

The evaporative gas to be generated in the storage tanks of the FSRU will be used partially for the power generation plant. If the maximum pressure in the tanks is reached, the evaporation gas will be sent to the plant or, alternatively, to the gas combustion unit.

The evacuation of excess BOG is strictly an emergency measure to control the pressure of the cargo tank. The International Gas Code requires two means for BOG elimination. The main one is the burning in the engines. The use of gas combustion units is the second means to remove excess BOG to be used.

With low gas emissions (4-12MMSCFD), the cargo pumps in the tank are stopped and BOG is sent directly to the plant with 10 barg in the manifold through redundant compressors. The same compressors are used to supply fuel gas to the FSRU engines and to control the pressure in the cargo tank. The latter is done by sending the excess BOG (from FSRU) directly to land as part of the regasification delivery. The combination of LNG vaporizers and BOG compressors will be provided to deliver natural gas to offshore facilities.

The evaporation gas exits the tanks at -140 C, at 1.1 bar pressure, and is taken to the compressors to take it to 80 bra and 5 ^{o}C, to be delivered.

1.5.4 Operation of the Floating Storage Unit (FSRU)

The FSRU will have three 4.5MW rated IC engines which will run on natural gas. It is foreseen that all three engines will be operating at the maximum gas send out rate of 280 MMSCFD. Each IC engine will consume approximately 450 kg / h of natural gas. The IC engines will also have the capability of operating on diesel fuel during emergencies only.

For the engine plant, a cooling system will be installed, that will consist of shell and tube heat exchangers using sea water as cooling medium. The sea water intake for cooling will be 1,200 m3 / h while moored to the marine terminal.

1.5.5 Operating Limitis Conditions

The Maritime Terminal will have established operating limits, environmental parameters that when exceeded will result in not performing the robbery, stopping operations or anchoring and leaving the terminal. This section presents the safe operable limits foreseen for the terminal. The operation plan of the Maritime Terminal will define the load limits, admissible movements for the connection to the ship's collector and operation of the mangeras. It will also include limits defined as permissible for mooring, the one for defenses and movements of the vessel while it is docked.

The Maritime Terminal operational limits will include:

- Approach and berth limits. Climatic conditions for the approach and berthing of the LNGC in the terminal;
- Load transfer limit. Limiting climate conditions for the LNGC docked at the Maritime Terminal connected to any line, mooring buoy or defenses, or movement of the ships as a result of winds, currents or wave action; And
- Departure limits - limitation of climatic conditions for the LNGC departing from the berth.

Preliminary operational limits have been established based on tugboat, dynamic mooring, and bridge studies performed at the LNGC for approaching the site and docking. These limits are preliminary and will be defined after further analysis in the final design stage in consultation with the regulatory entities. Preliminary limits are also presented for the operation of the LNGC at berth.

1.5.5.1 Craft Type and Berth Criteria

The operating limits are based on the following vessel capacities, which are presented in Table 1-22.

Table 1-22- Ship Capacity to Establish Design Criteria for Climatic Conditions Limits

Design glasses	Capacity (minimum)	Capacity (maximum)
FSRU	125,000 m^3	174,000 m^3
LNG transporters	136,000 m^3	180,000 m^3

Source: M&N, Terminal Operating Limits Memo, 2018

Los sistemas de amarre de la Terminal Marítima se basan en lo siguiente:

- The LNG carriers will leave the berth when the environmental limiting conditions are reached or forecasted to be exceeded.
- It is assumed that tugs will not operate in conditions exceeding a significant wave height of HS=1.5 m. If more sea worthy tugs are procured for the project then this restriction can be increased.
- For steel wire mooring lines, the allowable safe working load (SWL) in the mooring lines is defined as 55% of the Minimum Breaking Load (MBL) per OCIMF recommendations;
- For synthetic mooring lines, the allowable safe working load (SWL) in the mooring lines is defined as 50% of the Minimum Breaking Load (MBL) per OCIMF recommendations, and the allowable working load in the fenders is the rated reaction at design performance;

1.5.5.1.1 Limitation of Climatic Conditions for Approach and Berthing og the LNGC

The limitation of the conditions for the approach of the LNGC, in the Maritime Terminal will be those presented in Table 1-23:

Table 1-23 - Approach and Berth Limits FSU and LNGC		
Activity (Normal operation) [1]	**Wind (nknots)** [2]	**Wave Hs (m)** [3]
LNGC approach and docking	20	1.0 m

(1) Applicable for vessels up to 180,000 m3.
(2) Wind speed is the measured speed at the standard reference height of 10 meters MSL and is representative of an average sustained speed of 30 seconds.
(3) Limit of hs provided is applicable for wave periods (Tp) less than 12 seconds. For Tp> 12 seconds, wave limits may be lower depending on vessel conditions and types.
Fuente: M&N, Terminal Operating Limits Memo, 2018

1.5.5.1.2 Visibility

Limitations due to visibility will be at the discretion of the pilots.

1.5.5.1.3 Currents

Limitations due to currents will be at the discretion of the pilots.

1.5.5.2 Limiting Conditions for Load Transfer of the LNGC

The below values (in Table XX) are preliminary and are being studied through numerical hydrodynamic modeling as well as through physical basin test modeling which is ongoing at the time of this submission.

Table 1-24- Limiting conditions for LNG cargo transfer			
Vessel Sector	**Wave direction**	**Wave peak period**	**Limiting significant wave height for offloading**
[-]	**[deg]**	**Tp [s]**	**Hs [m]**
Head on	180 – 270	<8 or >14	1.5
Head on	180 – 270	8 -14	2.5
Beam on	90-180, 270-360	<14s	1.5
Beam on	90-180, 270-360	>14s	0.5

Source: M&N, Terminal Operating Limits Memo, 2018

1.5.5.2.1 Visibility

Limitations due to visibility will be at the discretion of the pilot

1.5.5.2.2 Currents

Limitations due to currents will be at the discretion of the pilots.

Actual operable limits will be further refined during detailed design and also during operations, as experience of the site-specific facilities and environmental interactions become better understood.

There will be a weather station and monitoring equipment installed on the completed Terminal. Data such as wind speed and direction, temperature, barometric pressure, humidity, and visibility, will be measured along with wave, tidal data, and water temperature. This information will be provided to the berth operator. In addition, the Terminal will be equipped with real-time current meters capable of measuring water velocities and directions in the entire water column. Detailed list of weather station instrumentation and specifications of this equipment will be established during detailed design phase.

Together with the National Service of Territorial Studies (SNET) issued weather warnings, this data will allow the terminal operator to grant or deny access to the facility, limit or end loading operations, and/or order the vessel to leave the berth, based on forecast environmental conditions.

1.5.5.3 Monitoring of meteorological variables and coastal dynamics

The safe operation of the Maritime Terminal is controlled through the use of a combination of predictive tools, such as weather forecasting, and real-time field measurement, such as water elevation meters and anemometers (wind speed). When environmental conditions such as wind speed or wave heights exceed the specified safety limits, loading operations will stop and in extreme conditions, the LNG discharge vessel may leave the berth.

For the case of tsunamis, the Maritime Terminal will depend on tsunami warnings and Tsunami information from the Pacific Warning Center (PTWC), led by NOAA and located in Hawaii, and the national tsunami warning center, part of of the Ministry of Environment.

For the warning of extreme weather and ocean conditions, such as hurricanes or winds, tropical depression / waves, the Maritime Terminal will be based on information from the National Hurricane Center of the NOAA (NHC) and national meteorological warnings. For weather phenomena not related to storms, the Maritime Terminal will respond in the local weather forecast reports.

Real-time weather information and sea-state data will be collected at the Maritime Terminal through a Marine Monitoring Monitoring System (MEMS). This will allow the Maritime Terminal to know the conditions that occur in real time and make effective decisions to guarantee safe operating conditions.

1.5.6 Maintenance activities of the LNGMaritime Terminal

The maintenance consists in the periodic review of instrumentation, pipes, tanks, pumps, valves, hoses, regasification equipment, to evaluate their condition and operation and proceed to cleaning, repair and / or replacement of parts (see Table 1-25).

Table 1-25**- Equipment Maintenance at FSRU**

System	**Equipment**	**Maintenance activities**
General	Electric motors	6-month electric motor electric resistance test (CbM)
		6-month electric motor vibration measurement (CbM)
		Annual lubrication of electric motor bearings
	Helmet	5 annual inspection of the class

Table 1-25- **Equipment Maintenance at FSRU**

System	**Equipment**	**Maintenance activities**
	Hydraulic actuators	3-month functional test
	All bearings	Ultrasound measurement (CbM)
Structure and tanks	Ballaste tanks	Hydrostatic test inspection and tank tank 5 years
		inspección anual de tanque
	Air ventilation rubric	inspección visual anual
	Breakwater	Estudio 5 año de rompeolas
	Distilled wáter tank	Hydrostatic test inspection and tank tank 5 years
	MDO tank	Hydrostatic test inspection, cleaning and tank deposit 5 years
	HFO drainage tank	Hydrostatic test inspection and tank tank 5 years
		6 month test level alarm
	Fresh wáter tank	Hydrostatic test inspection and tank tank 5 years
		annual deposit inspection and tank cleaning
		6 months drinking water analysis
	Oily bilge tank	Hydrostatic test inspection and tank tank 5 years
		6 month test level alarm
	Oily drainage inspection tank	Hydrostatic test inspection, cleaning and tank deposit 5 years
	Tank LO	6 month test level alarm
		5 year visual inspection and tank cleaning
		annual verification of valve operation
	Sludfe tank	Hydrostatic test inspection and tank tank 5 years
		6 month test level alarm
	Empty space	Study 5 year of empty space
		annual inspection of empty space
Anchoring, mooring and towing in your case.	Anchor and mooring winches	3 months inspection and functional test
		annual brake test
		5 years renew the oil bath
		renew yearly oil changes planetery bath
		6 months lubricant analysis oil and water content test
		5 year anchor chain calibration / measurement
	Hydraulic power package	3-month electric motor vibration measurement
		Electric motor 6-month electrical resistance test
		Annual lubrication of electric motor bearings
		5 year review of the oil cooler pump

Table 1-25- **Equipment Maintenance at FSRU**

System	**Equipment**	**Maintenance activities**
		Review of the hydraulic pump after 20000 rhrs
	Emergency towing system	monthly functional test
		2-year control
	Quick Release hooks	Visual inspection and quarterly lubrication
		Verification of the operation function of 6 months
		Calibration / annual load cell certification
	CAN system	Annual inspection
		Calibration / measurement of the chain 5 years
Load	Charge heater	annual inspection 5
	Refrigeration and sealing of wáter systems	annual inspection 5
	Electrical installation	annual inspection 5
	Pressure and vacuum devices	annual inspection 5
	Main load pumps	Revision of the pump after 10000 rhrs (CbM)
		Electrical resistance test of submerged motor 6 months
	Extraction and spraying pumps	Pump revision after 10000 rhrs
		6-month electric submerged motor resistance test (CbM)
	Safety valves	Valve test of 5 years (some of them annually)
	Spray injectors	Spray inlet filters for annual spray condition verification
		6 months leak check and nozzle operation
	Vacuum pump	Cleaning Screen sieve after 3000 rhrs
		Renewal of lubricant oil cylinder after 2000 rhrs
		Check the pump after 4000 rhrs
	Cargo compressors	Vibration test and megger of 3 months (CbM)
		6 - Monthly functional test
		Visual visual inspection seals and couplings
Regasification	Control valves	3-month functional test
	Actuadores hidráulicos	3-month functional test
	Safety valves	Valve test of 5 years (some of them annually)
	Electric motors	6-month electric motor electric resistance test (CbM)

Table 1-25- **Equipment Maintenance at FSRU**

System	Equipment	Maintenance activities
		6-month electric motor vibration measurement (CbM)
	BOG compressor	Preventive maintenance 4000 rhrs
		Preventive maintenance 8000 rhrs
	Unidad de medición	annual calibration
	Emergency power pump	6-month electric motor electric resistance test (CbM)
		Pump revision after 10000 rhrs
	Heating wáter booster pump	6-month electric motor electric resistance test (CbM)
		Review of the pump after 40000 rhrs
		6-month visual inspection and functional test
	Vaporizers	annual inspection 5
		Annual calibration instrumentation in vaporizer
Boat to ship system (ship to ship STS)	Saddles	6 months lubrication / lubrication
	STS hoses	renovation every 5 years
		annual pressure and condituctivity test
	Emergency unlocking coupling	annual revision of the couplings
	Reel piece	Visual inspection of dye
Auxiliary Diesel engine	Motor	According to the plan of Wartsila Maitenance, preventive maintenance check after 4,000 rhrs 8,000 rhrs, 12,000 rhrs, 16,000 rhrs, 24,000 and 32,000 and 48,000 hours.
	MDO pump	5 year review
	Pilot fuel pump	Pump revision after 20,000 rhrs
Ballast waster system and sea	Ballast pumps	Functional verification of 2-monthly air injector
		Alignment Check every 5,000 rhrs
		Grease pump bearings every 1000 rhrs
		6 - monthly functional test
	Seawater pumps	Pump lubricate every 5000 rhrs
		Pump revision after 20,000 rhrs
		6 - monthly functional test
	Seawater circulation pump and seawater cooling water pump	Pump revision after 20,000 rhrs
Freashwater system	Fresh wáter pumps	6-month electric motor electric resistance test (CbM)
		6-month electric motor vibration measurement (CbM)

Table 1-25- **Equipment Maintenance at FSRU**		
System	**Equipment**	**Maintenance activities**
		Grease electric motor every 2,000 rhrs
	Filter and filters	annual inspection and cleaning
	Fresh wáter generator	4 months chemical cleaning and internal control
	Fresh wáter coolers	annual cleaning
	Seawater filter	2-monthly seawater filter cleaning

Source: EXMAR 2016.

1.5.7 Provision of basic services to FSRU

For the loading and unloading of personnel, consumables and waste, it will be carried out by means of equipment in the FSRU. The FSRU will be reached through the periodic leasing of a work boat from 20 to 30m.

In the FSRU there will be cranes and the necessary equipment for the movement of supplies and equipment. The project will load and unload crew, consumables and waste through the use of a 20 to 30 meter work boat and the existing CEPA facilities that will be leased to the project at regular rates.

The energy for the FSRU itself will be provided from the FSRU, to be generated locally from stored LNG or by means of an underwater electrical cable.

There will be a diesel emergency generator system (in a fixed position), and a manual transfer switch to start the generator and execute the essential services on the generator platform in case the FSRU primary energy can not be operated.

The loading of drinking water to the FSRU and the discharge of effluents (garbage, bilge water, sludge, etc.) from the FSRU will be carried out by means of the transfer through a service balcony through pipelines to and from the vessels of service.

The delivery of supplies and equipment to the FSRU will be done through roams of the service barges docked directly to the starboard side of the FSRU.

The FSRU will have a fresh water generator with an approximate capacity of 6 tons per day for the needs of the personnel.

1.5.8 Restriction zone

There are two objectives for the safety zones of LNG vessels

- To minimize decollision possibility during regasification operations; And
- To protect surrounding property and personnel from hazards that could be associated with emergencies.

In relation to the risks, it is sought to avoid collision with commercial traffic that passes to the Port of Acajutla and collision with pleasure boats / fishing vessels / supply vessels for anchoring and mooring of CENERGICA.

An area of 300m of restricted diameter has been established for the passage of vessels, reduced in some points to maintain the 600m requested by stock, and access to Cenergica pipeline; this zone extends where the anchors are located to protect them.

And a security circle of 500 for other vessels, which are not controlled by CEPA, such as the fishermen's boats; this zone is also reduced to maintain the distance with CEPA spring.

It is proposed to modify the entrance basin for entry of ships to the port of Acajutla, in preliminary agreement with CEPA and the AMP, in order to establish the aforementioned protection zones.

For the pipeline, an installation zone of 50m has been initially considered on each side of the axis so that the builder can have a field to vary the route in the case of rocks or subsoils that are unfavorable to the construction methodologies. Once installed, an easement of 15 meters will be established on each side of the pipeline.

These distances will be reviewed in the final design stage and operations for optimization. The restrictive marine areas are observed below; for the operations stage see Figure 1-37.
Additionally, restriction areas have been defined for the construction stage to facilitate operations and prevent accidents (See Figure 1 38).

1.5.9 Materials, waste and hazardous waste

The main residues and hazardous materials on board the FSRU are the following:
Materials:

- Lubrication oil for all machinery
- Hydraulic oil for the emergency generator, hydraulic systems and actuators

Solid waste:

- Filter elements, cartridges
- Spent non-toxic adsorbents
- Waste maintenance form

Liquid waste:

- Oil residues
- Oily wáter
- Sanitary waste, gray wáter

Waste and solid, common and dangerous waste will be brought periodically to the plant on land for proper disposal according to the tables on the previous pages.

The design of the management system of the FSRU and HSE on board will be such to comply with IMO regulations, MARPOL.

Under the MARPOL (International Convention for the Prevention of Pollution from Ships), a waste management plan must be in place during operations in order to handle all types of food, domestic and operational waste including chemical waste. The follow-up of the good execution of this plan is guaranteed by the correct maintenance of the Garbage Record Book that will record the collection, processing, storage and disposal of the garbage.

As in the waste registry book, a Hydrocarbon Record Book will also be maintained to handle any water / oily sludge from the engine room according to the MARPOL requirement.

The FSRU will be provided with a waste water treatment unit suitable for crew compliment with 42 m3 (5 days) storage of waste water. Approximately 8m3/day of discharge treated waste water as per MARPOL Annex IV specification and approved by administration standards.

1.6 Test Protocol

The protocol presented in the EIA is maintained.

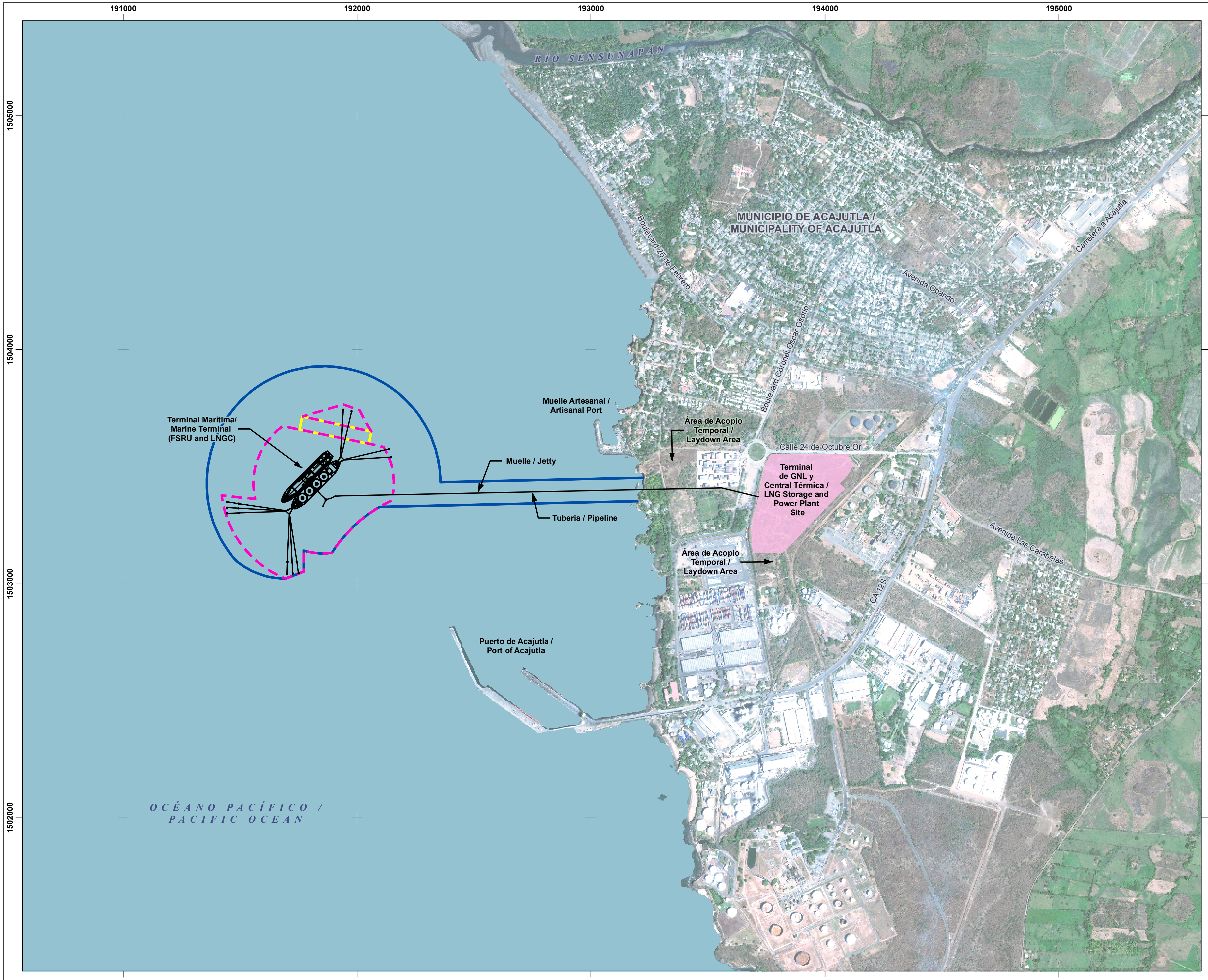
1.7 Project Schedule

The following **¡Error! No se encuentra el origen de la referencia.**26 **¡Error! No se encuentra el origen de la referencia.** shows the proposed project schedule for key

Table 1-26 - Proposed project for Pipe installation

N°	Activity	Duration	January 2018				February 2018				March 2018					April 2018				May 2018					June 2018				July 2018				
			01-01	01-08	01-15	01-22	01-29	02-05	02-12	02-19	02-26	03-05	03-12	03-19	03-26	04-02	04-09	04-16	04-23	04-30	05-07	05-14	05-21	05-28	06-04	06-11	06-18	06-25	07-02	07-09	07-16	07-23	07-30
1	Logistics, supply and supply	91 days																															
2	Planning and control documents	15 days																															
3	HSE and quality procedures	15 days																															
4	HDD - Engineering, designs, marine procedures and executives	15 days																															
5	Approval	15 days																															
6	Survey preparations	15 days																															
7	Patio construction	125 days																															
8	Execution of civil works - Responsibility of the client	34 days																															
9	Site preparation	14 days																															
10	Fence and signal installation	7 days																															
11	Waste management facility	3 days																															
12	Offices of the site	17 days																															
13	Ready on land																																
14	Construction and assembly of pipes	124 days																															
15	Pipe 1600m for HDD	36 days																															
16	After the installation of the pipe	10 days																															
17	Pipe 500m	10 days																															
18	Mobilization of drilling personnel	5 days																															
19	HDD works 24 "	76 days																															
20	Demobilization	13 days																															
21	Final acceptance	2 days																															

*Source: Acajutla LNG Import Project Proposed Schedule - BID PHASE, 2017.*activities.



ENERGÍA DEL PACÍFICO

LNG TO POWER PROJECT

ZONAS DE RESTRICCIÓN MARÍTIMOS PARA TUBERIA Y MARINE TERMINAL / MARINE RESTRICTION AREAS FOR PIPELINE AND MARINE TERMINAL (OPERATION PHASE)

FIGURA 4.37 / FIGURE 4.37

SITIO DEL PROYECTO / PROJECT SITE

ÁREAS MARINAS DE RESTRICCIÓN / MARINE RESTRICTION AREAS

BÚFER DEL MUELLE, TUBERIA 100 m / 100 m JETTY, PIPELINE BUFFER

BÚFER DEL FSU 250 m / 250 m FSU BUFFER

BÚFER DEL FSU 500 m / 500 m FSU BUFFER

UBICACIÓN DE SITIO / SITE LOCATION

0 100 200 400 m

1:16,000

N W E S

FUENTE / REFERENCE
VISIÓN DEL MUNDO 2 IMÁGENES DE ALTA RESOLUCIÓN / WORLDVIEW 2 HIGH RESOLUTION IMAGERY (2014-02-12)

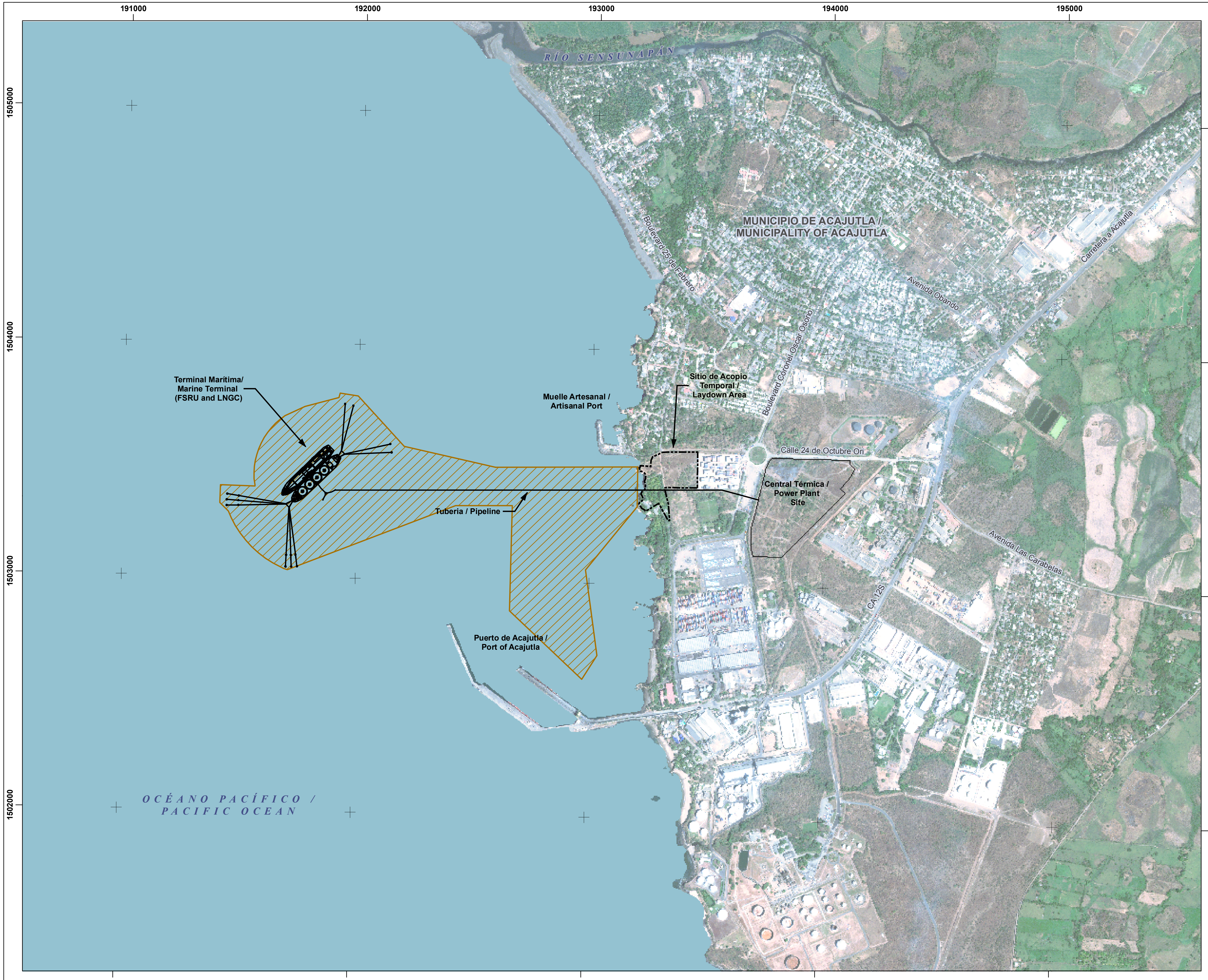
MAPA CREADO POR / MAP CREATED BY: PFM
MAPA REVISADO POR / MAP CHECKED BY: MW
PROYECCIÓN DE MAPA / MAP PROJECTION: UTM ZONE 16 WGS84

ARCHIVO / FILE:
G:\GIS\163489 Acajutla\GIS\MXDs\Reporting - 2016\X - Marine Restrictions.mxd

PROYECTO / PROJECT: 14-9114
ESTADO / STATUS: FINAL / FINAL
FECHA / DATE: 1/17/2018

DILLON CONSULTING

ECO INGENIEROS
LÍDERES EN CONSULTORÍA AMBIENTAL



Energía del Pacífico

ENERGÍA DEL PACÍFICO

LNG TO POWER PROJECT

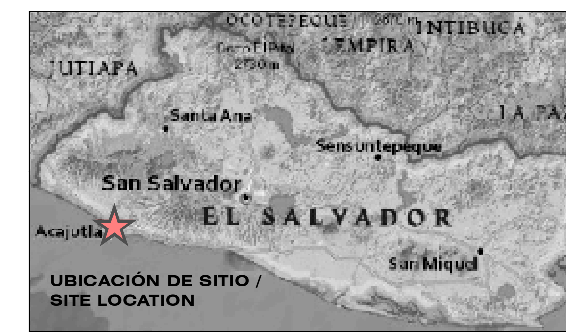
ZONA DE EXCLUSION DE CONSTRUCCION / MARINE CONSTRUCTION EXCLUSION ZONE

FIGURA 3.8 / FIGURE 3.8

SITIO DEL PROYECTO / PROJECT SITE

SITIO DE ACOPIO TEMPORAL / TEMPORARY LAYDOWN AREA

CONSTRUCCIÓN DE ZONA DE MITIGACIÓN MARINA / CONSTRUCTION MARINE MITIGATION ZONE



UBICACIÓN DE SITIO / SITE LOCATION

0 100 200 400 m

1:16,000

FUENTE / REFERENCE
VISIÓN DEL MUNDO 2 IMÁGENES DE ALTA RESOLUCIÓN / WORLDVIEW 2 HIGH RESOLUTION IMAGERY (2014-02-12)

MAPA CREADO POR / MAP CREATED BY: PFM
MAPA REVISADO POR / MAP CHECKED BY: MW
PROYECCIÓN DE MAPA / MAP PROJECTION: UTM ZONE 16 WGS84

ARCHIVO / FILE: I:\GIS\163489 Acajutla\GIS\MXDs\Reporting - 2016\7-5 - Construction Marine Mitigation Zone.mxd

PROYECTO / PROJECT: 14-9114
ESTADO / STATUS: FINAL / FINAL
FECHA / DATE: 2/7/2018

DILLON CONSULTING

ECO INGENIEROS
LÍDERES EN CONSULTORÍA AMBIENTAL

1.8 Decommissioning

The project will operate under the regulations and requirements as specified in the Power Purchase Agreement (PPA). The PPA for the project has an established term of 20 years, subject to revision and extension. The installed infrastructure has a viable physical life to extend in the coming decades and would remain in operation until the project is determined that it will no longer be viable; Over 50 years of life are estimated with adequate maintenance.

Therefore, the decommissioning phase of the project would be carried out on the basis of factors related to current productivity and the sustainability of the project as an energy source for the area. Given the uncertainty about the final end point of project operations, at the time of closure in the future, an assessment will be conducted to determine the prevailing conditions in order to develop a detailed and specific environmental and social management context for this phase. The options for the final management of the infrastructure assets of the project will include, but would not be limited to:

- Conversion of power plant facilities and operations to meet the needs of a future energy strategy;
- Sale of the facilities to a third party;
- Demolition and removal of the entire infrastructure of the project; or
- Dismantling of facilities and infrastructure without demolition.

1.9 Stakeholder Engagement

Since the presentation of the EIA to MARN, stakeholder engagement activities have continued, and the proposed changes have already been presented to key focal groups:

- Acajutla Municipality
- Fishermen

No important issues were raised during the meetings. The complete report is presented on Appendix 1B.

Energía del Pacífico

Project: LNG to Power
Adendum to the EIA
Identification, Prioritization, Prediction and Quantification of Potential Environmental Impacts, Including Potential Risk Situations

February 2018 – 16-3489

ECO INGENIEROS
LÍDERES EN CONSULTORÍA AMBIENTAL

DILLON CONSULTING

Table of Contents Chapter 2

List of Tables Chapter 2

2.0 Identification, Prioritization, Prediction and Quantification of Potential Environmental Impacts, Including Potential Risk Situations

2.1 Impact Assessment Approach

The following provides an updated description of potential environmental and social impacts of the project for the revised project design (January 2018 design update) as presented in Chapter 7.0 of the December 2016 ESIA Report.

The approach to the effects assessment as previously presented in the 2016 report remains unchanged. Where the description of impact is unchanged for specific environmental components, this is noted and the reader should reference the 2016 ESIA report.

The main project design changes that had an influence on the impacts assessment include: 1) the use of a floating FSRU kept in position with a spread footing of sea anchors as opposed to the previously proposed marine terminal enclosure concept and; 2) use of horizontal direction drilling (HDD) to install the initial portion of the undersea pipeline instead of mounting it on a trestle.

The other considered change relates to the change in the design of the sub-station to be located on the proposed thermal power plant site.

2.2 Impacts Identification and Assesment

As per the previous approach followed for the ESIA, the potential project issues (potential effects) have been identified using a modified Leopold matrix approach. The approach consists of a matrix with columns representing the various project activities, and the rows representing the various environmental factors to be considered. The project activities used in the screening matrix, covering both the construction phase and operations phase that have changed as a result of the project design revision, are listed and described in **Table 2.1.**

The updated screening matrix table is presented in **Table 2.2** which presents all of the project activities, including those that have and have noted changed as a result of the project design update.

The potential issues identified in the evaluation matrix, and the justification of each, are presented in **Table 2.3** which also has been revised to reflect the project design changes. Only potential project effects that have changed because of project design changes are presented in the table.

Table 2-1 – Project Activities Used in the Impact Assessment Matrix	
Phase Activity/ Characteristic	**Description**
CONSTRUCTION PHASE	
Driving piles (on land and sea)	Mechanical driving of piles to provide support for the mounting of HDD drill rig on-shore, as well as the foundations of the central thermal power plant (pending results of the Geotechnical study).
General offshore construction activities	Pipeline trenching /seabed preparation for off-shore section of pipeline (approximately 700 m or further from the shoreline). Use of Horizontal Directional Drilling (HDD) to install the NG pipeline under the seabed through section close to shoreline. HDD staging will be from on-shore.
OPERATION PHASE	
LNG Delivery	A maximum of 32 LNG deliveries will be made on tankers over the course of a year, including inbound and tankers outbound shipping and mooring, and LNG transfer from vessel / to the FSRU LNG Storage Tank. Note that the foreseen deliveries number for the Power Plant operation are 8 vessels per year. To reach the 32 deliveries, there would need to be demand for natural gas from other users, as such this is a longer term projection. .
Facilities physical presence	The facilities physical footprint and presence include: floating FSRU vessel, LNG pipeline, thermal power station, engine room, substation, and other structures and supporting infrastructure, along with internal roads and parking areas.
LNG storage, management, and regasification	The LNG will be stored in the FSRU. The LNG will be re-gasified in the FSRU and will then be transported to the thermal plant through a pipeline.
Regasification Sea Water Draw & Discharge	Sea water is required to warm the LNG to convert it to NG (vaporization). This water will be discharged at a cooler temperature than ambient but will not exceed a delta of 5C degrees.
Boiler Cooling Water Sea Water Draw & Discharge	Sea water will also be drawn to cool the FSRU engines/boiler. This water will be discharged at a warmer temperature than ambient but will not exceed a delta of 5C degrees.

Source: Consultant team

Table 2-2 – Impacts Identification Matrix :⊗ Potential negative interaction resulting from normal activities, ⊕ Potential positive interaction resulting from normal activities, ∅ Potential interaction as a result of an accident or abnormal conditions

Environmental factors		The Project Elements and activities																										
		Construction phase													Operations phase													
		Logging and chopping off	Earthwork	Pile Driving (on land)	Installation of NG Pipeline (HDD and trenching)		General construction activities on land	General construction activities at sea	Traffic related to construction	Storage, handling, use and disposal of materials, waste and hazardous waste	Cleaning and pressure testing of tanks and pipelines	Workforce management during construction	Purchasing and supply chain	Facility safety	LNG delivery	The facilities physical presence	General operating activities	LNG storage, management and regasification	Transfer of NG Via Pipeline	Water discharge from the Regasification process	Energy generation	Water supply	Storage, handling, use and disposal of materials, and hazardous waste	Wastewater discharge	Rainwater management	Labor Force Management during the operations stage	Purchasing and Supply Chain	Facility safety
Air quality	Environment air quality	⊗	⊗		⊗		⊗	⊗	⊗												⊗							
	Disturbing dust	⊗	⊗		⊗		⊗	⊗	⊗																			
Greenhouse emissions and climate change							⊗	⊗	⊗									⊗			⊗							
Noise	Disturbing noise	⊗	⊗	⊗	⊗		⊗	⊗	⊗												⊗							
	Low Frequency Noise																				⊗							
Soil	Quality of soil (contamination)									∅													∅					
	Soil quality (physical)		⊗				⊗																					
Superficial water	Quality		⊗	⊗	⊗					∅	⊗												∅	⊗	⊗			
	Quantity		⊗				⊗									⊗							∅	⊗	⊗			
Groundwater	Quality			⊗	⊗					∅	⊗						⊗					⊗	∅	⊗				
	Quantity			⊗												⊗						⊗	∅					
Seawater	Quality			⊗	⊗			⊗		∅					⊗			⊗		⊗			∅					
Coastal dynamics	Marine currents and sediment transport				⊗											⊗												
Protected natural areas	Terrestrial																											
	Marine																											
Terrestrial Biota	Flora	⊗			⊗					∅													∅					
	Fauna	⊗		⊗			⊗		⊗	∅						⊗	⊗						∅					
Marine Biota	Flora			⊗	⊗		⊗	⊗		∅					⊗	⊕				⊗			∅	⊗				
	Fauna			⊗	⊗			⊗		∅					⊗	⊕				⊗			∅	⊗				
Disease vectors		⊗	⊗				⊗									⊗	⊗								⊗			
Security and protection of the community		∅	∅	∅	∅		∅	∅	∅	∅	∅	∅		∅	∅		∅	∅	∅				∅			∅		∅
Demography	Population											⊗														⊕		

Table 2-2 – Impacts Identification Matrix :⊗ Potential negative interaction resulting from normal activities, ⊕ Potential positive interaction resulting from normal activities, ∅ Potential interaction as a result of an accident or abnormal conditions

Environmental factors		The Project Elements and activities																										
		Construction phase													Operations phase													
		Logging and chopping off	Earthwork	Pile Driving (on land)	Installation of NG Pipeline (HDD and trenching)		General construction activities on land	General construction activities at sea	Traffic related to construction	Storage, handling, use and disposal of materials, waste and hazardous waste	Cleaning and pressure testing of tanks and pipelines	Workforce management during construction	Purchasing and supply chain	Facility safety	LNG delivery	The facilities physical presence	General operating activities	LNG storage, management and regasification	Transfer of NG Via Pipeline	Water discharge from the Regasification process	Energy generation	Water supply	Storage, handling, use and disposal of materials, and hazardous waste	Wastewater discharge	Rainwater management	Labor Force Management during the operations stage	Purchasing and Supply Chain	Facility safety
	Cultural characteristics																											
Views and landscape																∅												
Community Health	Human health	⊗	⊗	⊗			∅	∅	∅	∅		⊗					∅	∅			⊗		∅	⊗		⊗		
	Health infrastructure											⊗														⊗		
Recreation		⊗			⊗		⊗	⊗	⊗							∅			∅									
Relocation or eviction	Relocation or eviction of residences or businesses / way of life																											
Land use	Current land use				⊗														∅									
	Projected land use				⊗														∅									
Streets, traffic and public services	Streets and traffic								⊗			⊗					⊗											
	Public services (water / wastewater, energy)		⊗		⊗		⊗	⊗									⊗											
Artisanal dock and commercial fishing				⊗	⊗			⊗							⊗	⊗	⊗	⊗										
Puerto de Acajutla	Security and operations in Puerto de Acajutla `and dock			⊗	⊗			⊗	⊗						⊗	⊗		⊗										
Economy	Employment											⊕														⊕		
	Economic activity												⊕														⊕	
Archaeological, cultural, ceremonial and historical resources		⊗	⊗	⊗			⊗																					
Workers Health and safety		∅	∅	∅	∅	∅	∅	∅	∅	∅	∅				∅		∅	∅					∅					

Source: Consultant team

Table 2-3 – Justification for Identifying Potential Interactions / Significant Issues			
Environmental factors		**Basics for the problems identification/significant interactions**	
		Construction phase	**Operations phase**
Ground water	Quantity	Ground water will be required during HDD activities. Water draw will not exceed permitted draw of 4.5 liters of water per second (over 20 hr period).	The power plant Operation will require approximately 4.5 liters of water per second
Coastal Dynamics	Marine currents and sediment transport	Minimal and temporary impact to sediments from HDD activities and trenching.	Non-applicable – the FSRU floating vessel will not impact marine currents/sediment transport
Marine Biota	Flora/Fauna	The positioning of the FSRU vessel will generate some noise and will require lighting that can have temporary effects on marine mammals. HDD activity will lead to short term sediment disturbance (from daylighting of drill head, release of drill fluid during pipeline thrusting, risk of a frac-out, and trenching). Fauna could also be affected by an involuntary release of hazardous raw materials or hazardous waste, vessel traffic on the site, and disruption from general activities.	Marine biota may be affected by: discharge of hot / cold water, discharge of treated wastewater, an involuntary release of hazardous materials/waste, and vessel traffic to access the floating FSRU Additionally, the lighting of the moored vessels could affect the behavior of marine life, including sea turtles.
Fishing and artesanal pier		During the positioning of the FSRU and completion of the NG pipeline installation, an exclusion area may impact fishing and travel to fishing grounds.	The physical presence of the floating FSRU and associated restriction area could impact the local fishing areas.
Acajutla Port	CEPA pier and port operations and safety	Construction activities, including pipeline installation, and the positioning of the FSRU floating vessel will introduce additional ship/boat traffic in the port area and introduce new navigation hazards	The physical presence of the floating FSRU and the need for restrictive zones around it including the LNGC when it is navigating to/from the floating facility may create navigation hazards for incoming and outgoing Port traffic.

Source: Consultant team

The remaining sections of this chapter discuss the interactions identified in the environmental factor matrix.

2.3 Project's Benefits

Project benefits as previously described in the December 2016 ESIA report are largely unchanged as a result of the project design modifications.

2.4 Impacts to Physical Conditions and Characteristics

Further the Table 7.2, "Impact Assessment Matrix", the physical environmental factors have been identified and assessed and include:

- Air quality;
- Greenhouse Gas Emissions and Climate Change;
- Noise and Vibrations;
- Soil;
- Surface water;
- Groundwater;
- Sea water and marine sediments; and
- Coastal Dynamics.

2.4.1 Air Quality

2.4.1.1 Methodology

The approach to the assessment of air quality effects of the projects changes was the same as previously followed and documented in the 2016 ESIA.

2.4.1.2 Construction phase

Project construction could have a short-term impact on air quality conditions in the study area. The potential air quality effects as reported in the 2016 ESIA report are expected to be similar if not less under the revised project design. A temporary concrete batch plant will no longer be required for the project which should result in a reduction of construction related air emission to the local environment. No changes to the previously proposed construction period air emission mitigation measures are proposed.

2.4.1.3 Operations Phase

During the operational stage, NOx and CO would be emitted from the power plant and from the stacks associated with the FSRU vessel and the LNGC vessel that will be moored against the FSRU vessel for LNG transfer. The emissions from the revised FSRU facility design will be very similar to the emissions modelled for the previously proposed off-shore facility. The new facility is to be located in a very similar location to the previously proposed facility. Modeling conducted to date has shown that the off-shore emissions sources FSRU and LNGC vessel) have a very small contribution to the total concentrations of air quality compounds at modeled receptors. Projected air quality impacts as reported in the December 2016 ESIA report are considered to be applicable to the updated facility now proposed.

2.4.2 Greenhouse Effect Gas Emissions and Climate Change Impacts

2.4.2.1 Methodology

The approach to estimating greenhouse gas (GHG) emissions as reported in the 2016 ESIA report remains unchanged.

2.4.2.2 Construction Phase.

Project construction will result in short-term greenhouse gases emission. The contribution to climate change should be insignificant. No significant changes to GHG emissions during the construction period are anticipated as previously reported in the 2016 ESIA Report.

2.4.2.3 Operation phase

Project operations may generate GHG emissions, from the following sources:

- Natural Gas Combustion in the Central Thermal Power Plant;
- SF_6 leaks from high voltage switches and the sub-station.
- the FSRU Unit Operations; and
- LNG / Natural Gas leaks from the maintenance and storage system.

The change to the substation design results in a higher rate of SF6 gas leakage. With the new substations design, the SF6 leakage rate of the high voltage switches will increase from 0.15 to 0.40 kt/year. This change is very minimal and does not change the overall total annual GHG emissions of the project as reported in the 2016 ESIA Report which is 1,741.59 CO2e kt / year.

2.4.3 Noise and Vibration

2.4.3.1 Methodology

The previously followed noise assessment approach as documented in the 2016 ESIA report has not changed.

2.4.3.2 Construction Phase

Construction noise reported in the 2016 ESIA report is expected to be representative of expected construction noise for the revised project design. With the off-shore marine enclosure terminal no longer being proposed, off-shore construction noise will be less than previously described in the 2016 ESIA Report. Off-shore construction period related noise will largely be related to vessel operation to position the floating FSRU in place and trenching of the pipeline. As well, with the temporary concrete batch plant no-longer required, there would be some reduction in on-shore construction noise although the HDD operation would be a new temporary noise source. And while the pile driving associated with the previous proposed construction trestle, there would be some on-shore pile driving to create a stable platform for the HDD drill rig and pipe thruster (located in the construction staging area). Overall construction related noise for existing receptors is not expected to be significantly different that previously reported. A Construction Noise Mitigation Plan will be developed and implemented that will consider all major construction noise sources.

2.4.3.3 Operations Phase

For the proposed off-shore floating FSRU facility, which will be located in a very similar location to the previous proposed marine terminal, since there will fewer sources than assessed in the previous configuration, and the sources associated with FSRU have the same or similar noise levels as the previous configuration, the noise impact for the proposed floating FSRU at the selected representative on-shore receptors is expected to be similar to those of the previous configuration.

2.4.4 Soils

No changes to effects on soils as previously reported in the 2016 ESIA Report as a result of the project design revisions are expected.

2.4.5 Surface Water

2.4.5.1 Methodology

While there were no changes to the approach to assess impacts on surface sea water, as a result of the project design changes, the potential for impact of surface water from HDD activity including the use of drill fluids were assessed.

2.4.5.2 Construction Stage

The use of HDD to install the undersea pipeline has the potential to impact surface water quality during construction. Bentonite will be used and mixed with extracted groundwater to create the drilling fluid (drilling "mud") needed for the HDD operation.

Bentonite lubricates and cools the drill head and assists in the, removal of the cuttings. Bentonite is an absorbent aluminum phyllosilicate clay. While bentonite clay is a chemically inert, non-corrosive, and a non-toxic/hazardous material, if released into water bodies this could result in sedimentation and temporary turbidity effects and could impact aquatic flora and fauna and could cause visual impacts (e.g. cloudy water). As such, during HDD operations the use of bentonite and the disposal of the onshore drilling fluid will be carefully managed.

Mitigation to be implemented during HDD activity includes the following:

- The drilling fluid mix will be appropriate for use in proximity to aquatic life);
- Storage of drilling fluid during HDD operations will prevent the fluid from flowing into local watercourses using a berm or sediment control structure, tanks or other containment methods;
- Drilling cuttings (soil extracted from boring) to be sampled and analyzed for contaminant prior to on-site or off-site disposal;
- Develop and follow an Inadvertent Release of Drilling Fluid Containment and ContingencyPlan in the event that an inadvertent release of drilling fluid to the ground surface or a water body is identified or suspected;
- The Contractor will monitor the volume, pressure and parameters of the drilling fluid to detect any losses during HDD operations. The drilling fluid pumping rate and the rate of drilling fluid return to the surface will be constantly monitored by the Contractor;
- In the event of an inadvertent fluid release, the Contractor will refer to the Inadvertent Release of Drilling Fluid Containment and Contingency Plan, temporarily cease drilling operations, and notify the Construction Manager and Environmental manager immediately; and
- Maintain hydrovac truck(s) on site during drilling operations.

Considering that watercourses are well removed from the HDD sites and with the above noted mitigation in place, effects to surface waters from HDD activity are not expected. Potential effects on the marine environment as a result of HDD activity is discussed in **Section 2.4.7** further below.

2.4.5.3 Operations Phase

There are no changes to the assessment of effects on surface water during the operations phase as reported in the 2016 ESIA Report.

There will be a reduction in the area of ground imperviousness because the footprint of the substation will be significantly less than the originally proposed substation area. The size of the stormwater retention pond will remain the same as previously proposed in the 2016 ESIA Report. Pond design parameters will be revisited during detailed design and proposed dimension may change, however zero impact to the post construction stormwater outflow based on the 100 year storm will be observed. A single pond is proposed for the site.

2.4.6 Groundwater

2.4.6.1 Methodology

Impacts to groundwater were assessed in the same manner as reported in the 2016 ESIA report. As a result of the need for groundwater during HDD activities to install the undersea pipeline, the potential for impact on ground water quantity was assessed.

2.4.6.2 Construction Phase

Ground water will be required during construction. The construction activity that would require the greatest amount of groundwater would be for HDD (a required component for the drilling fluid). The amount of groundwater that would be drawn for HDD activity would not exceed the permitted 20 hr per day period draw of 4.5 m/s. The amount of groundwater is not expected to cause interference with existing wells or pose a risk of intrusion into the groundwater resource.

2.4.6.3 Operations phase

No changes to the potential for effects to groundwater during operations as previously reported in the 2016 ESIA.

2.4.7 Sea Water and Marine Sediments

2.4.7.1 Methodology

During the construction period, the project design modifications have some potential for different impacts on sea water and sediments, compared with the previous conditions. The key changes assessed are change in volume of sediment release, the potential for sea bed sediment disturbance from daylighting of HDD drill head, the release of drill fluid during drilling and pipeline thrusting and the potential for a inadvertent release ("frac-out") event to occur. A 'frac-out' is the unintentional return of drilling fluids to the surface during HDD. A frac-out can occur when the bore hole drilling fluid pressure exceeds the overburden pressure or the fluid finds a preferential seepage pathway (such as fault lines and fractures).

2.4.7.2 Construction Phase

Sediment Suspension and Water Turbidity

An increase in baseline turbidity in the marine environment surrounding the project location during construction is possible. Eggs, sessile creatures (e.g. coral, benthic invertebrates) and juvenile fish may be subject to sediment suspension and re-suspension due to their lack of mobility. Filter feeders may be particularly affected due to impaired filtering, leading to reduction in foraging ability and survival. Sediment suspension and re-suspension reduces visibility for predators that rely on visual cues for hunting. Corals are particularly sensitive to sedimentation impacts due to the smothering likelihood, burial and shading.

The floating FSRU vessel will be located approximately 1.4 km west of the Acajutla coast, positioned at a water depth of approximately 16 to 17 m under average low tide. The setting of the sea anchors to keep the floating FSRU in place would result in some minor sediment disturbance. The effect of this is considered to be negligible based on the small footprint and depth of embedment.

The submarine pipeline would extend from the floating FSRU vessel to run along/under the sea bed to the shoreline, then to connect with the on land thermal power plant. A combination of HDD and seabed trenching will be used to install the pipeline. HDD will be used install the pipeline from on-shore to a location approximately 700 m from the PLEM. Using of HDD will minimize seabed impacts close to the shoreline/surfzone which is considered the area of more sensitive/valued marine habitat. The final length of the pipeline route to the FSRU location will be installed through trenching as described in the Project Desription. The 2016 ESIA report describes the results of sediment dispersion modelling that was undertaken under the assumption that the entire length of the marine pipeline would be installed by trenching. The revised project design involves using trenching for about 700 m or less of the pipeline route. During trenching, the excavated sediment will be placed to the side of the trench. The sediment will not be removed and disposed off at another location as was previously proposed. From the previous analysis, the main contributor to suspended sediment and turbidy was the disposal of the material from the footprint of the cofferdam concept.

This process is no longer included as part of the revised project design.. The release of sediments into the water column from the pipeline trenching and disposal of these materials has significantly reduced based on the reduced trench length (because of the HDD). Additionally, the displaced material from the trench will not be removed from the location of excavation. This results in minimization of suspension of the sediments through the water column and then reintroduction of a sediment plume into a disposal site. From the numerical sediment transport modeling, the plume trajectory and total suspended sediment load, is predicted to be signifianctly less than the previous concept. Under the previous concept, the modelling assumed that 41,600 m3 of sediment would be displaced. The amount of sediment displaced for 700 m of pipeline trenching would be about half of this amount.

In addition to the sea floor trenching, there will be the release of a small amount of sediment when the HDD drill/cutting head daylights through the sea bed and/or when the pipe is pushed through the bore hole. There is also the chance that an unintentional frac-out could occur. The most likely location for a frac-out is close to the end of the borehole length due to the reduced amount of soil under the drill head leading out to its daylighting through the sea floor.

The dispersion and trajectory of the drill fluid (bentonite clay slurry/drill cuttings of natural formation) is expected to behave similarly to the previously numerically modelled fine grained silt as documented in the 2016 ESIA report. The HDD drill fluid is a high parts per million concentration of bentonite, which is a fine grained inorganic clay. The credible maximum volume of the slurry from a frac-out or release event during pipeline completion is estimated to be 1,000 m^3. With an assumed 5% clay to water ratio (based on bentonite material U.S. supplier information), this would equate to 50 m^3 of bentonite release. In order to estimate the dispersion and trajectory, a comparison to the numerical sediment transport modeling, as previously noted above, was made.

The total suspended sediment concentration (TSS), dispersion, settling and trajectory of clays, silts or fine grained sediments will be impacted by the environmental conditions (waves, currents), by the overall volume introducted into the ocean, and by the rate (volume per time) of material released. The environmental conditions are the same as the previously modeled subsea pipeline – given that the pipeline location remains essentially the same. Therefore, it was concluded that any release of drill fluid either from the drill head daylighting, from release during pipeline thrusting or from a frac-out event would be subjected to tidal currents, and wave action at the surface. The tidal currents are not strong in this area, particularly near bed level. The directionality follows the sea bed contours, which are parallel to the shoreline. Therefore, the trajectory of any released bentonite slurry is predicted to be to the Northeast, and to the Southwest with the change in tidal current direction on the ebbing tide. The measured current data suggests that the current is stronger to the Northeast.

The smaller particle size of the clay is expected to remain in suspension for longer than the modeled silt. However, the volume of material that could potentially be released is significantly less than previously modeled (about 1/3,500th compared to the disposal volume). Although the TSS of the slurry will be high, when diffused into the ocean at high pressure, it is expected to disperse immediately. At the deepest location close to the spread mooring, a small volume released at the sea bed into +17 m of water is likely to be barely perceptible at the surface considering the exposed metocean conditions. Nearshore in the breaker zone, the agitation from breaking waves will quickly disperse a release of this size.

To manage a potential HDD frac-out event, mitigation options were reviewed considering water depth, wave/surf conditions, and the nature of a frac-out event. In calm protected areas one option is a turbidity curtain. Another method is a gravity cell which is a circular or box-like structure that is placed over the frac-out location. As previously described in the 2016 ESIA Report, the use of a turbidity curtain was determined to not be a practical or effective mitigation tool to control sedimentation effects given the wave/surface conditions of the study area. The deployment of such a curtain may cause a navigation hazard or worsen the impacts of the release. Similarly, the use of a gravity cell was also deemed to be problematic to implement given sea wave/current conditions in the study area and that it would have questionable effectiveness. As due to the seabed volcanic soil conditions, the release of bentonite could be at multiple locations making it difficult if not impossible to contain the release with a gravity cell.

Considering the above noted challenges of the project area, it was determined that the preferred method to mitigate the risk of a frac-out event would befor the HDD driller to carefully monitor the downhole annular pressures through instrumentation located at the end of the drill string during drilling. This will allow the driller to detect sudden pressure surges or drops within the borehole, which can signal the occurance of a drill fluid escape. In addition, the driller will closely monitor the drill fluId returns (drill fluid returning up-hole to the drill rig), and the volume of the drill fluid within the recycling system. If the driller detects a drill fluid loss through pressure or fluid monitoring (loss of greater than

25% returns or recycling system volume), drilling operations would be ceased, and cement grout would be pumped through the drill rods into the borehole to fill the voids. Once the grouting has solidified the drilling activities would resume.

As well, prior to construction, a study will be undertaken to assess the potential for frac-out events including the likelihood for these events, probable locations along the route that frac-outs may occur, and magnitude of the release of the bentonite slurry. This information will be used to confirm the mitigation/impact management measures to be put in place to manage such an event.

Considering the above, possible sedimentation and turbidity effects in the marine environment from HDD operations are considered to be temporary and localized and not of significance.

2.4.7.3 Operations Stage

The operation of the FSRU and delivery of LNG via tankers have the potential to impact seawater and sediment quality. Potential impacts to seawater and marine sediments during site operations are expected to be minimal, mainly limited to potential spills (fuels, etc.) and potential discharge of: waste water , ballast water, and process water from the FSRU and the visiting tankers. The potential for these effects as previously described in the 2016 ESIA report remain unchanged.

Hot & Cold Water Discharge

The Project will require the following warm and cold water discharges:

- Warm water will be discharged from the FRSU boiler and cooling engine.
- Cold water will be discharged from the FSRU vaporizer (to convert LNG to NG)

A thermal plume dispersion analysis was previously conducted to study the discharge plumes in relation to the met ocean conditions at and around the project site. The results of this analysis were documented in the 2016 ESIA Report. Since completion of the thermal plume study, the terminal concept has changed and an assessment was undertaken to analyze the applicability of the previous results to the current system.

The now proposed restricted catenary mooring (RCM) system for the floating FSRU is in approximately the same location as the previously analyzed cofferdam concept, in 16-17 m of water. The previous modelled concept encompassed a barge-type FSRU enclosed in a cofferdam with a permanently moored FSU alongside it. The RCM concept is a single FSRU ship (assumed to be a converted LNG carrier) on a spread mooring. **Table 2.4** details the characteristics of the FSRU, compared to the characteristics of the previous modelled concept for the formally proposed marine enclosure.

Table 2-4 - Comparison of Intake/Outfall Characteristics					
RCM Concept			**Previous Modeled Concept**		
FSRU Intake 1 (port side fore)	FSRU Outfall 1 (starboard side fore)	10,000 m^3/hr -5°	FSU Intake 1 & 2 (starboard and port side aft)	FSU Outfall 3 (starboard side aft)	10,000 m^3/hr +5°
FSRU Intake 2 (port side aft)	FSRU Outfall 2 (starboard side aft)	1,200 m^3/hr +5°	FSRU Intake 1 & 2 (starboard and port side aft)	FSRU Outfall 3 (starboard side aft)	1,200 m^3/hr +5°
			FSRU Intake 4 & 5 (port and starboard side fore)	FSRU Outfall 6 (bow)	10,000 m^3/hr -5°

Comparatively, the flow rates and modeled temperature differentials from ambient are the same for the RCM concept and the previously modeled concept as documented in the 2016 EDSIA Report. The cooled water plume was modelled as discharged outside the cofferdam. The warmed water plume from the previously modelled FSU is no longer present in the RCM concept. The warmed water plume will be less compared to the previously modelled concept, since the FSU is no longer present in the RCM concept.

The depth averaged currents previously modelled would be the same. Currents during ebb tide generally less than 0.15 m/s and during flood tide current speeds up to 0.25 m/s can occur. Eddies were observed in the hydrodynamic model forming around the corners of the cofferdam. This would not occur in the RCM concept. It is speculated that the currents would follow the flooding or ebbing tide and would not be impacted by the moored vessel.

The following is noted from the previous modeling:

- The environmental conditions that drive the thermal plume dispersion will be the same as previously assumed, However;
  - Without the cofferdam, the eddies that formed around the solid structure will not be present, therefore the currents impacting the shape of the plume will be different; and

    - The trajectory of the cooled water plume was influenced by the cofferdam. Therefore the shape/trajectory of the plume will not be the same.
- The shape and trajectory of the heated water plume is likely to be similar to the previously modeled FSU plume. Although;
    - The heater water plume volume in the RCM concept is significant less than previously simulated (1,200 m^3/hr compared to 10,000 m^3/hr modelled); and
    - The size and extent of the plume will be less based on the smaller flow rate.
- The vertical profile of the cooled plume is likely to be similar to the previous modeling;
- The vertical profile of the heated plume is likely to be similar to previous modeling (particularly from the FSRU since that will be the same volume);
- There is unlikely to be significant mixing of the outfall discharges with the intake draw, to a level that would impact the process (based on location of the intakes/outfalls) and the sensitivity analysis performed for the previous concept modeling.

Based on the comparison of the two concepts, the following provides commentary on the previously described effects of the water discharges:

- The warm water plume (from the boiler of the FSRU engine cooling outfall) would impact the surface layers of the surrounding waters up to a 2 m depth;
- The cold water plume (from the FSRU vaporizer) primarily impacted the bottom layers of the surrounding waters 2 to 3 m from the bed;
- The warm water plume temperature was reduced to less than 0.5°C from ambient within 70 m from the FSRU. This distance is speculated to be similar for the RCM concept since the flow rate and temperature differential is the same.
- The cold water plume temperature was increased to less than 0.5°C from ambient within 250 m from the FSRU. This distance is speculated to be similar for the RCM concept since the flow rate and temperature differential is the same.
- The increase in water temperatures at the intakes, as a result of mixing from the outfalls, will not be more than 0.25°C relative to the ambient temperature.
- The plume distance may be related to flowrate (based on the limited scenarios run). Dispersion to less than 0.5°C from ambient temperature occurs at a greater distance from the outfall with increasing flowrate.
- Increased flowrate does not greatly impact the depth or location of the temperature plume in the water column, for warm or cold discharges, based on the limited scenarios modeled.

2.4.8 Coastal Dynamics: Marine Currents and Sediments

2.4.8.1 Methodology

There are no changes to the manner in which impacts on coastal dynamics were assessed. Changes in project interactions considered include the replacement of the marine terminal with the floating FSRU vessel.

2.4.8.2 Construction phase

The positioning of the floating FSRU vessel is expected to have no impact on marine currents and coastal processes in the study area.

2.4.8.3 Operations phase

The floating FSRU vessel and system of sea anchors used to keep it in position is expected to have no impact on marine currents and coastal processes in the study area.

2.5 Impact on Biological Conditions and Characteristics

As identified in the Impact Screening Matrix, Table 7.2 and Section 7.2, biological environmental factors for a potential interaction or significant problem has been identified are:

- Terrestrial biota;
- Marine biota; and
- Disease Vectors.

2.5.1 Terrestrial Flora and Fauna

The proposed project design changes will not result in any changes to the previously described potential effects on terrestrial flora and fauna in the 2016 ESIA document.

2.5.2 Marine Flora and Fauna

2.5.2.1 Methodology

Compared to the interactions identified in the 2016 ESIA, the main change with the revised project design includes reduced potential for sea bed sediment dispersal effects as seabed preparation for the previously proposed marine terminal enclosure is no longer required. As well, less length of seabed trenching will be required for the NG pipeline. HDD will be used to install the pipeline close to the shoreline. The approach to assess impacts on marine flora and fauna are unchanged.

2.5.2.2 Construction phase

Habitats loss

With the use of a combination of HDD/ trenching for pipeline installation, and use of a floating FSRU instead of the marine terminal enclosure, marine habitat loss effects are greatly reduced under the revised project design.

The pipeline corridor located in the sea, presents / displays different marine habitats; near the beach there are rocky areas with sensitive species like "Sea cucumbers" (Filo Echinodermata) and lobsters. Lobsters are harvested by local fishermen. The rest of the corridor is a silt-clay-sand combination, with no sensitive presence or unique species. No soft corals were identified along the pipeline route. The use of HDD to install the pipeline in the near shore zone will geatly minimize marine habitat direct impacts. Where the seabed trenching is to occur (approximately 700 m from the PLEM) the seabed is composed of sand/silt and is not considered to be significant or sensitive habitat. As such direct habitat loss will be minimal. Once the pipeline is installed the trench will naturally refill and seabed conditions will return to close to pre-construction conditions.

The pipeline construction using HDD could disturb a small area of habitat from drill head “day lighting” on the sea floor, fluid release during pipe installation, and from potential “frac-out” events. Although the amount of habitat removal from this would be very minimal (a few cubic meters). There would also be a small area of the seabed where the PLEM (pipeline manifold) would sit on the sea bed floor. This is a relatively small area of about 100 m2. Similarly, the sea anchors required to keep the floating FSRU in position could potentially displace some habitat. As the PLEM and sea anchors will be located in an area of sand with silt, the marine habitat in this area is not considered to be significant value. Overall, marine habitat loss impacts formt he project are considered to be minimal and not signifcant.

Noise / Vibration

Off-shore construction related noise and vibration effects are expected to be less than previously reported in the 2016 ESIA report. Some noise would be associated with the use of vessels to position the floating FSRU. This noise would be significantly less than associated with the construction of the previously proposed marine terminal enclosure. The vessel noise would not be dissimilar to CEPA port related activities. If the construction trestle is determined not to be required, then noise associated with marine pile driving would also not occur. As such, construction related noise effects to marine life are considered to be minimal.

Suspended Sediments

Sediment suspension or resuspension is possible from pipeline trenching and when the HDD drill head "daylights" and during a possible "frac-out" and drill fluid release during pipeline installation. The potential for sediment suspension or resuspension in the marine environment from these events is significantly less than under the formerly proposed coonstruction activities including trenching the full length of the pipeline and the marine terminal construction. The potential for sediment dispersion from HDD activities has been previously described.

The marine habitat/species effects of suspended sediment release were previously described in the 2016 ESIA report. With the reduced length of trenching (about half or less of what was previously assumed) and no longer requiring sediment removal for the marine terminal construction, related effects on marine life will be substantial less than previuosly reported. As well sediment removal will be away from the shoreline which is considered to be the area of more sensitive habitats. As previous described in the 2016 ESIA report:

- Sediments suspension or re-suspension reduces visibility for predators that rely on visual cues for hunting. Filter feeder fish may be particularly affected due to impaired filtering, leading to reduction in foraging ability and survival. There is an oysters area north of the pipeline route, near the shore, that won't be affected by suspended sediments, according to the plume modeled.

- Fish and mammals visiting the area will not be affected, considering that they can move within the area, and the temporary sediment suspension/resuspension effect during construction. As well, during the rainy season, there is a greater sediment concentration in the area, mainly around the water discharge rivers point, such as the Sensunapan. The levels found in the reference baseline are around 180 to 300 mg / l.

- Corals are especially sensitive to sedimentation impacts, due to the suffocation likelihood, burial and shadowing. There are soft coral areas located south of the pipeline, closer to the existing CEPA pier and to the coast. Due to currents moving northwards and using the measures listed below, impacts to nearby corals are expected to be minimal. From the previous numerical modeling, the maximum sediment deposition was predicted to be less than 7.5 cm. This value was calculated in the area with sensitive species, taking into account currents and waves, and for a larger volume of resuspended sediment (i.e. trenching of the entire pipeline length).

Regarding HDD activities, it was noted that the maximum volume of drill fluid/slurry that would be released in the unlikely event of a frac-out is significantly less than previously modeled construction activities (1/3,500th). Although the TSS of the slurry will be high, when diffused into the ocean at high pressure, it is expected to disperse immediately . At the deepest location close to the spread mooring, a very small volume released at the sea bed into +17 m of water is likely to be barely perceptible at the surface. Nearshore in the breaker zone, the agitation from breaking waves will quickly disperse a release of this size. Considering this assessment, effects on the marine environment would be correspondingly less than previously reported in the 2016 ESIA report and are generally considered to be minimal.

Mitigation measures to minimize sediment dispersion from a frac-out event are previously described in Section 2.4.5.2. Other mitigation measures, as previously propose and which are still applicable include:

- A qualified Environmental Supervisor will observe the works to determine the need for mitigation and confirm that the measure applied works as expected; and
- Sediments in the water column will be monitored at selected locations including sensitive habitats. Construction activity will be temporarily haulted if turbidity criteria are exceeded.

General Construction Activities (Off-shore)
As previously reported in the 2016 ESIA, there is potential for other related constructed effects such as from lighting. Less construction related lighting will be required for the positioning of the FSRU than previously required for the construction of the mariner terminal enclosure. No additional mitigation is warranted beyond previously reported.

General Construction Activities (on the ground), sedimentation
As previously reported, the temporary construction staging area that is to be located along the coast line on CEPA lands has the potential to result in sediment release effects into the marine environment. The need to cut into the bluff to access the temporary construction trestle had the greatest potential for sediment related effects, however the new floating FSRU facility and pipeline construction methodologies do not require this trestle. This reduces the potential for on-shore to marine sedimentation effects.

Storage, handling, hazardous materials and hazardous waste use and disposal

There is a possibility that the exposure of the marine flora and fauna to hazardous materials released to the environment may result in the progressive death of the flora and the poisoning of marine fauna. The management plans for the handling, storage and the hazardous materials use, as well as to respond quickly to an accidental release (as described in Section 2.4.7.2) will limit the potential for exposure to short-term, minor events.. No significant marine flora or fauna poisoning is expected as a result of this project.

---

[8] State of Florida. 2014. "Wildlife Lighting - About Light Pollution" Florida Fish and Wildlife Conservation Commission. Online: http://myfwc.com/conservation/you-conserve/lighting/pollution/

2.5.2.3 Operation Phase.

LNG Receiving Terminal, Physical Presence, and General Operation Activities - Sea water intake for the regasification

As described previously in 2016 ESIA Report, Sea water will also be required for the LNG regasification process (for warming of the LNG to convert it to NG) and for the engine system (boilers). There will be several (3-4) water intake locations along the sides of the floating FSRU. Two different sized openings will be used. The dimensions of the openings will be about 1.7m x 0.65 m and 1.4m x 0.45 m. in size located about 4 to 9 m below surface (variation due to different locations of inlets and whether ship is in laden or ballast). The openings will be covered by a course grating with 21 mm spacing.

A "sea chest" will be located behind the openings/grating within the hull of the vessel. Each sea chest will have the approximate dimensions of 3m by 4 m (12 m2). Connected to the sea chest will be an intake pipe that will draw water from the sea chest to be used in the regasification process. A second screen (pump strainer) will be located on the pipe drawing water from the sea chest.

As previously described, it was determined that the target species to keep out of the "sea chest" are adult and juvenile hawksbill turtles which are known to frequent the project area. While there is a hawksbill turtle nesting area to the south of the project area, recently hatched/very young turtles are not expected in the project area. Typical size for hawksbill turtles is 20 cm for juveniles and 40 cm + for adults. The proposed grating size of 21 mm will prevent turtles from entering the "sea chest".

Sea water will be drawn when the regasification process is occurring. A 10,000 m3/h constant draw will be required for the regasification plant. As well, a 1,200 m3/hr variable flowrate is anticipated to feed the engine room. The water intake velocity of the sea chest will not exceed 1 m/sec. The facility design consultants have advised that to their knowledge, there are no regulations that set specific technical requirements for ballast system sea chest and inboard filter design. For this equipment, there are no known industry or US regulations or officially recommended guidelines applicable to LNGC (or FSRU). The design specifications noted above are based on common practice in LNGC and FPSO design.

2.5.3 Disease Vectors

No changes to the potential for impact to disease vectors are anticipated as a result of project design changes.

2.6 Impacts and Characteristics on Socioeconomic and Cultural Conditions

The project design changes do not result in changes to most of the potential socioeconomic effects previously reported on in the 2016 ESIA Report including effects on:

- Community Safety and Security;
- Demography;
- Landscape and Views;
- Community Health;
- Recreation;
- Relocation and Eviction;
- Land Use;
- Highways/traffic;
- CEPA activities;
- Economy; or
- Cultural.

The key change to the project design that has implications for the socio-economic environment relates to changes in the exclusion area around the new floating FSRU vessel. The revised exclusion areas are presented in the revised project description (Chapter 1.0). This change was considered with respect to potential impacts on the artisanal fishery and to CEPA port related vessel traffic.

As per the previous project design, the pipeline route will be located within the CEPA vessel restriction area. And while there is no facility that would physically restrict boating, fisherman are not supposed to be within the vicinity of the pipeline as it is within the CEPA restriction area. As such, the installation of the pipeline through HDD and its operations should have no impact on permitted fishing activity. The floating FSRU will have a 500 m radius boating restriction area imposed around most of it. The exception is to the south where CEPA related marine vessel traffic will be allowed to pass through the permitted port entrance channel which is within approximately 300 m of the planned position of the floating FSRU. As before, with the imposed boating restriction area around the FSRU vessel, fishers wanting to travel to the south will need to travel a further distance which will require more time and consume more fuel. The impacts of this are described in the 2016 ESIA Report. No additional mitigation or compensation is proposed as a result of the project design changes.

The proposed location of the floating FSRU and the associated boating restriction areas has been presented to CEPA. CEPA has verbally indicated to EDP that the proposed configuration is acceptable. No significant or different effects on CEPA activity are expected as a result of the facility design changes.

2.7 Associated Facilities

There are no changes in regards to effects with associated facilities as a result of project design changes.

2.8 Assessment of Ecosystem Services

There are no changes to potential effects to ecosystem services as previously reported in the 2016 ESIA Report.

2.9 Assessment of Cumulative Effects

There are no changes to the assessment of cumulative effects as previously reported in the 2016 ESIA.

2.10 Decommissioning Phase Effects

The LNG to Power Project will operate under the regulations and requirements of EDP or its successor, as specified in the power purchase agreement (PPA). The PPA for the Project has an established term of 20 years, subject to revision and extension. However, with regular maintenance of the Project facilities they could have a much longer shelf life extending for several decades beyond the initial PPA.

As under the revised project design, the decommissioning of the off shore project components would have less impact as compared to the previous proposed marine terminal. All that would be required would be the extraction of the sea anchors and then the vessel could be moved to a new location.

Energía del Pacífico

Project: LNG to Power
Addendum to Modification to EsIA
Chapter 3: Environmental Management Program

July 2017 – 16-3489

ECO INGENIEROS
LÍDERES EN CONSULTORÍA AMBIENTAL

DILLON CONSULTING

Table of Contents Chapter 3

Figures Chapter 3

Photographs Chaprter 3

Tables Chapter 3

APPENDIX

3.0 Environmental Management Program

Once that we have established the main environmental effects that the project will generate on the environmental factors, the next step is to define the environmental measures that shall be taken to prevent and/or control the impacts, or to improve and/or enhance the compatibility of the project with the environment.

The owner of the project is responsible for the execution of each of the proposed measures, and give the respective monitoring at all project´s phases. The Ministry of Environment and Natural Resources, in accordance with the Law of the Environment, is the institution responsible for ensuring the minimization of the negative environmental impacts.

3.1 Framework for Environmental and Social Management of the Project

At the time of drafting this report, the key roles of the various entities who will build and operate the project are as follows:

1) Project's Sponsor: EDP
    - Final responsibility for all aspects of the project;
    - Owner of Thermal Power Plant, charter contract for the Maritime Terminal (FSRU), Mooring System and Gas Line; and
    - To date, EDP is evaluating marine concession agreements for the FSRU.
2) Thermal Power plant contractor: Wärtsilä.
    - Engineering design, acquisition of equipment and construction of the power plant
3) Thermal Power Plant, operation and maintenance contractor: Wärtsilä.
    - Operation and Maintenance of the thermal power plant;
4) Maritime Terminal EPC Contractor: to be determined
    - Engineering design, acquisition of fixed installations and equipment, and installation of the RCM (Mooring System) and FSRU in it`s location.
5) FSRU & M Contractor: to be determined
    - Operation and maintenance of the FSRU, including the pipeline;
6) Contractor gas pipe: to be determined
    - Engineering design, acquisition of materials and equipment, and construction of the gas pipeline that connects the marine terminal (FSRU) and the power plant
7) Fuel supply contractor: Shell
    - Operation of LNG cargo chips that will supply LNG periodically to be stored and regasified in the FSRU.

The EDP agreements with each of its contractors should clearly identify the relevant expectations of environmental and social performance related to the scope of supply of each one. To facilitate a coherent approach to the issues among all, share lessons learned and promote continuous improvement throughout the project, EDP will establish a system of environmental and social management (ESMS) and will require the same from its contractors.

Prior to construction, and in consultation with their contractors, EDP will develop and implement an ESMS based on the guidance provided in "Manual for the Implementation of the Environmental Management System and Social Construction" (IFC, Revision 2.2 4 June 2014). The ESMS will be updated prior to the operations, as appropriate, based on "Manual for the Implementation of the Environmental Management System and Social Construction" (IFC, Revision 2.2 4 June 2014). The SGAE of EDP will address, as appropriate to the scale and scope of the activities of the project, the nine elements of an effective SGAE listed in the two manuals:

- Policies;
- Identification of risks and impacts;
- Organizational, Capacity and Competence;
- Emergency Readiness and Response;
- Involvement of stakeholders;
- External Communications and Arbitration; and
- Continuous Reports to the Communities.

Each one of the main contractors of EDP are international companies that are well established and experienced. Each one has its own ESMS established, as well as plans and detailed procedures for environmental, health and safety. Before starting the activities in situ, each contractor shall provide to EDP its documentation on the ESMS and confirmation on how they have incorporated the various methods and actions of mitigation, management and monitoring into their plans and internal processes set out in this ESIA report.

EDP will receive periodic reports from each contractor that will contain indicators of environmental performance and social and coordinate periodic coordination meetings, which shall be attended by the directors of the ESMS of each contractor.

3.2 Description of Environmental Measures, Construction Phase

Each of the proposed measures to mitigate, prevent, correct or compensate for the environmental impacts generated by the project, in the construction phase are explained in the following pages.

3.2.1 Reduction of Air Emissions

Type of Measure: Attenuation

Description of the Measure

To reduce air emissions, the following mitigation measures shall be applied:

- Plan for equipment maintenance, maintenance program, and record of observed monitoring;
- Locate the stationary power generators at more than 50m of the property north side boundary;
- Have a protocol in relation to idling (shutdown of equipment when stopped); and
- Use of buses to transport workers from outside Acajutla to the site, which are coming from the main cities: Sonsonate, Lourdes, San Salvador. Meeting points and hours will be established in these cities. This measure also prevents the saturation of local buses at the peak of construction.

Location of the Environmental Measure

The project area and transport routes for the construction personnel.

Estimated Amount of Environmental Measure

Table 3-1– Calculated Amount of the Environmental Measure – Reduction of Gas Emission

Description	Quantity	Unit	Unit price	Term (months)	Total
Equipment and truck maintenance plan	1.00	s.g.	$2,000.00	1.00	$ 2,000.00
				TOTAL	**$ 2,000.00**

Source: Consulting Team

3.2.2 Dust Management Plan

Type of Measure: Attenuation

Description of the measure

To prevent dust during the construction phase, a dust management plan is proposed which includes:

- Application of water irrigation in the internal streets of the Project during the dry season and the days with greater wind, in the earth works activities; and

- Install a tire washing system at the exit for trucks and the installation of a paved area before the entrance so that the dust adhered in the tires is deposited in the ground before leaving the property.

Photo 3.1– Image of the tire washing system

Source: https://venzario.com/2010/01/26/sistemas-de-lavado-de-ruedas-mobydick/

- Stabilize the promontories of dirt material with water or plastic cover;
- Establish a vehicle speed limit of 20 km / h on the inner streets; and
- Coverage of trucks with awnings, all the trucks transporting material that can produce dust.

Location of the environmental measure

Within the Project Property in areas uncovered during earth works and at the laydown area, where containers will be installed with materials and equipment.

Estimated Amount of Environmental Measure

Table 3-3-2– Irrigation estimate	
Description	**Quantity**
Layer to spread	2mm
In meters	0.002m
Irrigation volume in 1 m	$0.002m^3$
Three times a day (A)	$0.006m^3 / m^2$
Uncovered surface: (50% of the land)	
Project land	$40,000.00\ m^2$
Temporary Collection Site	$23,000.00\ m^2$

Table 3-3-2– Irrigation estimate	
Description	**Quantity**
Total area to moisturize (B)	63,000.00 m^2
Total volume by 3 watering's per day (AXB)	378.00m^3
Price per m^3	$ 0.10
Price per day	$ 37.80
Per month	$ 1,134.00
Per semester	$ 6,804.00
Price per day per pipe plus 2 people	$ 56.00
Per month	$ 1,680.00
Per semester	$10,080.00
TOTAL	**$ 16,884.00**
For three years	$ 50,652.00

Source: Consulting Team

Table 3-3-3– Estimated Amount of Environmental Measure - Dust Management Plan Measure					
Description	**Quantity**	**Unit**	**Unit price**	**Term (month)**	**Total**
Irrigation	3.00	years	$16,884.00	1.00	$ 50,652.00
Tire washing	1.00	s.g.	$ 3,000.00	1.00	$ 3,000.00
Temporary paving at exit	60.00	m^2	$ 6.00	1.00	$ 360.00
				TOTAL	**$ 54,012.00**

Source: Consulting Team

3.2.3 Noise Management during Construction

Type of Measure: Attenuation

<u>Description of the measure</u>

The main activities that produce noise during construction are the piles drilling, HDD drilling and the use of vehicles and machinery. A Noise Management Plan will be developed which will consider the following measures to reduce construction noise, including:

- Coordination of type, number, duration and location of pile drilling;
- Use low noise techniques for pile drilling if possible (ex: Vibratory stack, stacking by pressing);
- Hours of construction activity, including pilotage and operation of the temporary generator in batches;
- Routes and establishment of schedules for transport.

Location of the Environmental Measure

Within the construction site and area of influence.

Estimated Amount of Environmental Measure

Table 3-4 – Estimated amount of the environmental measure I - Management of Noise During Construction					
Description	**Quantity**	**Unit**	**Unit Price**	**Term (months)**	**Total**
Noise Reduction Plan	1.00	s.g.	$ 1,000.00	1.00	$ 1,000.00
TOTAL					**$ 1,000.00**

Source: Elaboration by Consulting Team

3.2.4 Soil and Rainwater Management in Construction

Type of Measure: Attenuation

Description of the Measure

Apply all the soil management measures established in the procedures of the Wärtsilä Company, builders of the Thermal Power Plant, in the document "Instruction for quality and installation, earthwork, for Power Plants" which includes:

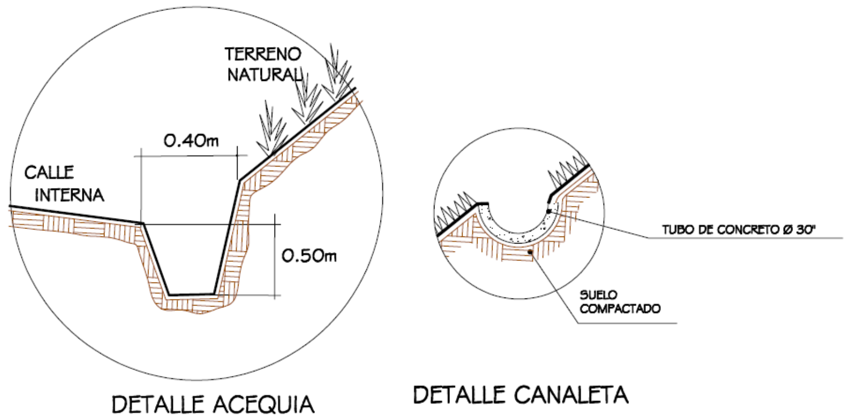
- Cut and separate organic soil for reuse from common soil;
- Use of berms and barriers for sedimentation and erosion control and to prevent sediment in the rainwater;
- Installation of barriers to prevent the passage of machinery outside work areas ;
- Protect and stabilize exposed material (using grass, plastics, concrete or other material);
- Protect corners and curves with rocks or gravel;
- Placement of sedimentation ponds prior to discharge rainwater.

Location of the Environmental Measure

Due to the flatness of the property, a single perimeter ditch has been placed on the edges of the less elevated areas and sedimentation ponds before being discharged to the existing drainage system at CEPA. In the property for the Thermal Power Plant, a temporary pond will not be necessary, since the final pond will be built at the beginning of the construction.

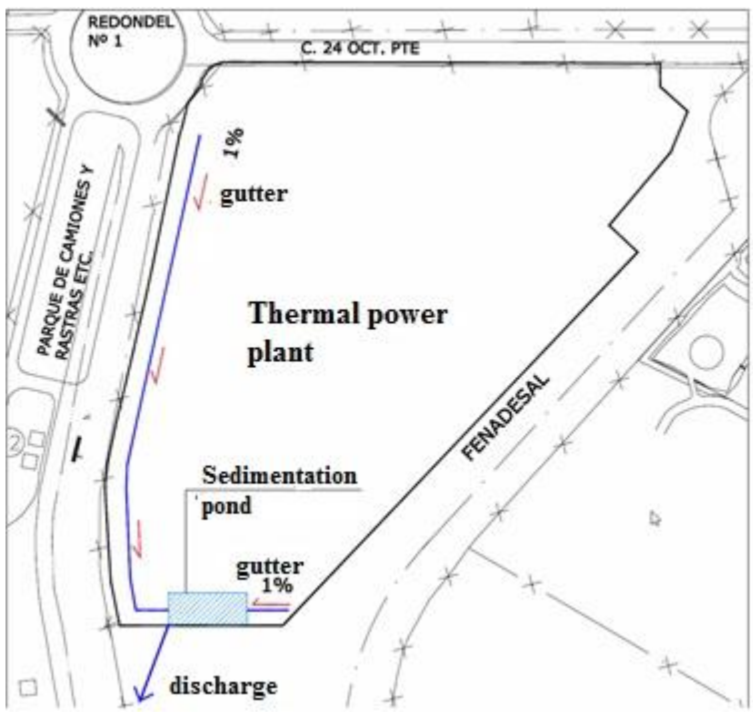
A detail of the temporary ditches and channels is presented below in Figure 3-1., Figure 3-2 and 3-3, which show the location of proposed temporary drainage and ponds.

Figure 3-1– Detail of ditch and / or canal to transport rainwater during the site preparation and construction phase



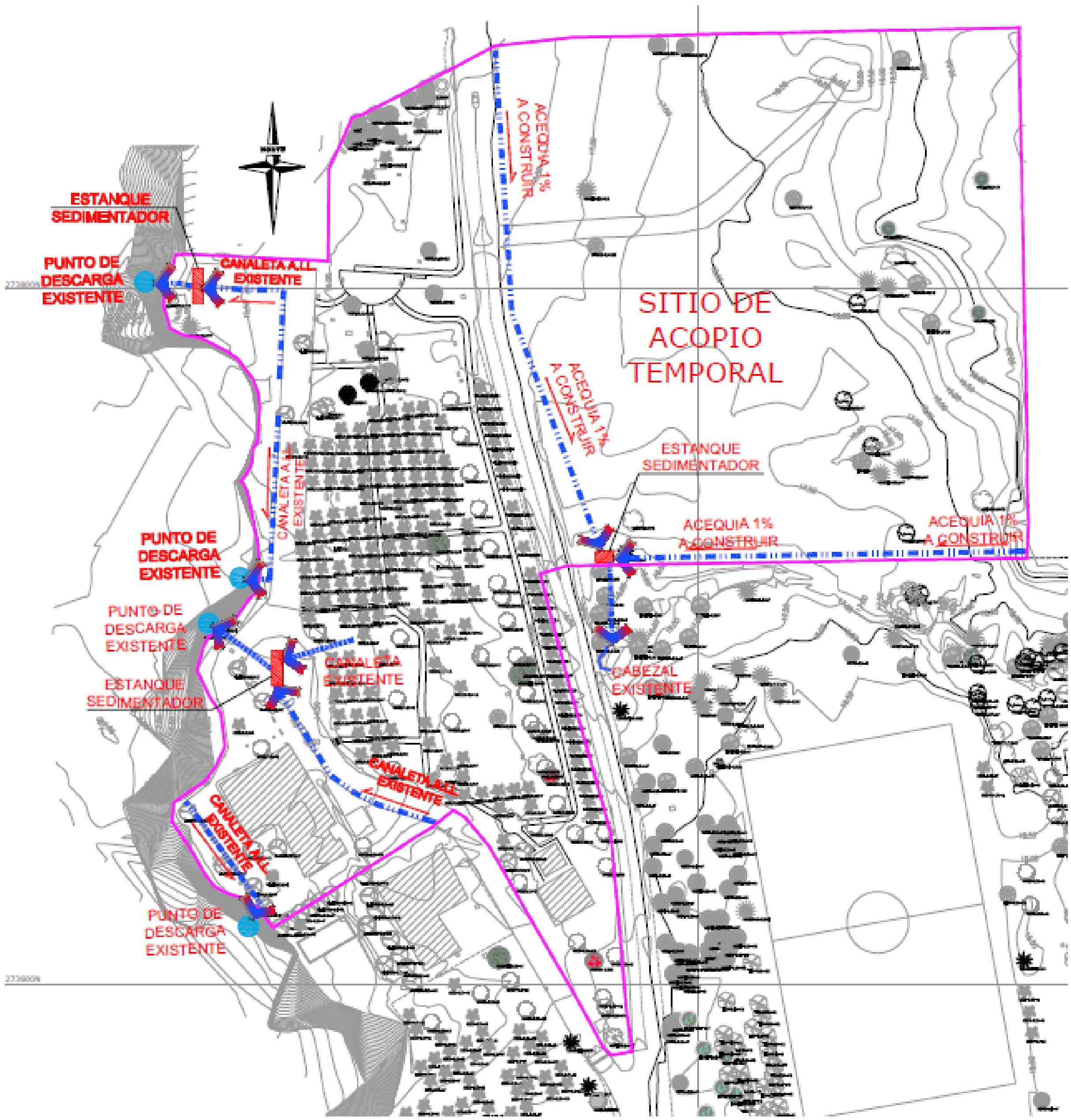
Source: Consulting Team DILLON-ECO

Figure 3-2 – Temporary Drainage During Construction



Source: Consulting Team DILLON-ECO

Figure 3-3– Temporary drainage during construction, temporary collection site



Sitio de Acopio temporal = Temporary storage site, Punto de descarga existente= Existing discharge point
Estanque sedimentador=Sedimentation pond, Acequia= gutter

Source: Consulting Team DILLON-ECO

Sedimentation ponds will be 1m high by 10m long by 3m wide to handle water in a peak storm (see measure 3.2.25).

<u>Estimated Amount of Environmental Measure</u>

Table 3-5– Estimated amount of the environmental measure - Soil and Water Management in Construction					
Description	**Quantity**	**Unit**	**Unit Price**	**Term (months)**	**Total**
Organic soil collection in main land	50,000.00	m^3	$ 0.80	1.00	$ 40,000.00
Organic soil collection in collection site	35,000.00	m^3	$ 0.80	1.00	$ 28,000.00
Sedimentation pond	3.00	Unit	$ 3,000.00	1.00	$ 6,000.00
Rainwater channels	600.00	M	$ 3.00	1.00	$ 1,800.00
				TOTAL	**$ 75,800.00**

Source: Elaboration by Consulting Team

3.2.5 Handling and Storage of Hazardous Materials

Type of Measure: Attenuation

<u>Description of measure</u>

The tasks and activities to be developed during the construction put at risk the safety of personnel; with the aim of preventing health risks and minimize the likelihood of incidents, during construction activities the personnel working in the construction will be instructed on the proper handling of equipment and tools.

The contractor shall be responsible for requiring workers the use of safety equipment such as gloves, helmet, and harness for protection during construction activities.

Construction personnel should implement and be trained in the proper handling of hazardous materials. Fire extinguishers shall be provided where necessary, as well as proper personal protective equipment. Works will be carried out to reduce the risk of spills.

To effectively inform the personnel, a management plan should be implemented to keep a complete list of hazardous materials, as well as material safety data sheets. In addition, personnel should be trained on the use of material safety data sheets.

Industry best practices for the handling, storage and use of hazardous materials will be used, including:

- Training of personnel and use of personal protective equipment;
- Overfill and spill protection;
- Inventory control and signaling;

- Use of secondary containment, when applicable;
- Separate storage of incompatible materials; and
- Material for response to spills and clean-up will remain available.

Hazardous materials to be used include:

1. Fuels for equipment and vehicles;
2. Lubricating oils, for daily filling. Oil changes will be made outside the construction site at an authorized location;
3. Solvents;
4. Paints;
5. Muriatic acid or other for cleaning;
6. Among others.

These materials will be stored in the laydown area and within the Project property, so two fenced and closed areas have been considered for this purpose.

The area will be equipped with the following:

- Aboveground fuel tank (diesel) with approximately 1,000 gallons capacity, with its containment berm;
- Spill containment sand;
- Wipes;
- Gloves;
- Listing of Material Safety Data Sheets; y
- Eyewash sink.

The materials that are listed in Table 3-6, will be held in the site in large quantity, so its handling is detailed.

Table 3-6 – List of Hazardous Materials in Construction Site

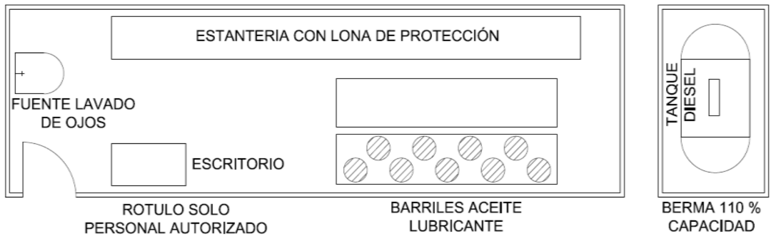
Product	Risks	First aid	Signaling	Protection Equipment	Waste Treatment
DIESEL FUEL	Flammable and combustible Health: Low degree of toxicity by inhalation or ingestion, skin and eye irritation. Carcinogenic Potential.	Eyes: Rinse with soft jet of water. Skin: In Cold: Apply plenty of water, remove contaminated clothing and wash with soap and water. Inhalation: Remove to fresh site and call your doctor. If not breathing start resuscitation and apply oxygen. INGESTION: Do not induce vomiting, keep at rest, and call the doctor.	SIGNALING: "FLAMMABLE"	Only for high exposure or risk of contact: cartridge respirator and goggles with side protection.	Spills: Isolate an area of 50-100 m depending on the spill. Eliminate all sources of ignition, confine the spill contain with sand or other absorbent material. Subsequently properly dispose this material.
LUBRICATING OILS	Fuel Health: Irritant to eyes, skin and inhalation by prolonged exposure. Abdominal discomfort, nausea and diarrhea on ingestion.	Eyes: Flush with running water, soft. Skin: Apply plenty of water, remove contaminated clothing and wash with soap and water. Inhalation: Remove to fresh site and call your doctor. INGESTION: Do not induce vomiting, keep at rest, call the doctor.	NOT REGULATED	Foam, water spray, chemical dust, carbon dioxide.	In case of spill, absorb and contain. Wear protective equipment for vapors.

Source: Material Safety Data Sheets

Diesel storage: Keep the area of storage of these materials away from sources of ignition. Keep the barrels closed when not in use. Installation of contention berm is necessary to protect the receiver of any spilled fuel. This must be in a waterproofed area and with absorbent material.

Figure 3-4 shows the schematic storage of hazardous materials.

Figure 3-4 – Hazardous Materials Storage Scheme



Fuente lavado de ojos = Eyewash sink, Escritorio = desk, Estanteria con la lona de proteccion = Shelf with protective cover, Barriles aceite lubricante = lubricating oil barrels, Tanque Diesel = diesel tank, Berma = berma, Capacidad = capacity

Source: Consulting team

Signaling and location of extinguishers: The signaling of the areas indicating the different zones at the site, the risk, the use of protective equipment and the handling of hazardous materials is necessary. In addition, fire extinguishers should be located in a visible, accessible site and without any obstruction and with the proper information. Suitable fire extinguishers for stored products should be installed.

Training in occupational safety and hygiene: The environmental management in the site requires changes in attitudes, patterns of behavior and thought processes of employees, in addition to basic knowledge of environment conservation. This process begins with the improvement of the understanding of all individuals of environmental matters, and of the elements of an environmental management process.

For the training of personnel, the most important trainings for safety should focus on establishing methods by which the employee is being continuously transmitted with information about hazardous materials that could be exposed. These include label types, signals used within the site, first aid, the importance of protective equipment, care and use of machines, as well as how to act in case of any accident or emergency, such as fire and earthquakes, among others.

The most important areas to include in the training are:

a. Introduction to environmental management: the importance and understanding of environmental management.
b. Aspects on occupational health and safety:
   - First aid;
   - Fire Prevention and control;
   - Handling of hazardous materials or chemicals;
   - Signaling;
   - Use and importance of personal protective equipment;
   - Contingency Plan: knowledge and training.

c. Contingency Plan and accident prevention.

Due to the handling of hazardous materials such as explosives and the risks identified in chapter 9: Risk Assessment and Prevention and Contingency Plan, there should be a contingency plan for the plant, a preliminary plan is included in the same chapter. The final Contingency Plan to be developed during the detailed design phase will include: description of possible and probable accidents, information on the mechanisms and intervention and communication measures in cases of emergency, description of security measures, review and update of the contingency measures.

The contingency plan should be implemented in the Laydown areas and work fronts, through signage, training and drills. A record of accidents and incidents must be kept, to update the contingency plan.

Location of the Environmental Measure
Laydown area, material storage sites and Project Property.

Estimated Amount of Environmental Measure

Table 3-7 – Estimated Amount of Environmental Measure - Handling and Storage of Hazardous Materials

Description	Quantity	Unit	Unit Price	Term (month)	Total
Fence	260.00	m	$ 35.00	1.00	$ 9,100.00
Kit for collection of oil spills: sand, wipes, shovel.	3.00	s.g.	$ 300.00	1.00	$ 900.00
Safety Training	150.00	c/u	$ 4.00	1.00	$ 600.00
Fire Extinguishers	20.00	c/u	$ 80.00	1.00	$ 1,600.00
				TOTAL	**$ 12,200.00**

Source: Consulting Team

3.2.6 Sewage Waste Water Treatment

Type of measure: Prevention.

Description of measure
In the different sites of work: given the type of project and the areas to be used, to avoid the disposal of open excreta, portable toilets for the management of excreta disposal shall be installed. One toilet for 25 or fewer workers in the work fronts will be installed.

During the construction phase, between 10 and 48 portable toilets will be available for the approximately 1,200 construction employees distributed in the construction area. Portable toilets will be maintained according to personnel at each phase. (See Table 3.8).

Table 3-8 – Estimated Portable Toilets per Month

MONTH	Estimated employees per month	Number of portable toilets
Month 1	6	1
Month 2	79	4
Month 3	190	8
Month 4	244	10
Month 5	406	17
Month 6	339	14
Month 7	580	24
Month 8	670	27
Month 9	734	30
Month 10	772	31
Month 11	993	40
Month 12	1001	41
Month 13	1239	50
Month 14	1270	51
Month 15	1084	44
Month 16	1072	43
Month 17	1102	45
Month 18	959	39
Month 19	843	34
Month 20	781	32
Month 21	554	23
Month 22	412	17
Month 23	236	10
Month 24	197	8
Month 25	95	4
Month 26	95	4
Month 27	95	4
Month 28	95	4
Month 29	73	3
Month 30	95	4
Month 31	62	3
Month 32	62	3

Table 3-8 – Estimated Portable Toilets per Month		
MONTH	**Estimated employees per month**	**Number of portable toilets**
Month 33	40	2
	TOTAL UNITS PER MONTH	**674**

Source: Own elaboration ECO/DILLON based on information from EDP/Wärtsilä, 2014.

The portable toilets services will be leased to companies that have the appropriate permissions, who will be responsible for the cleaning and maintenance, which should take place on a regular basis. These will be distributed in the various work fronts.

<u>Location of the Environmental Measure</u>
Distributed on different work fronts.(See Figure 3-17).

<u>Estimated Amount of Environmental Measure</u>

Table 3-9 – Estimated Amount of Environmental Measure - Domestic Wastewater Treatment Measure					
Description	**Quantity**	**Unit**	**Unit Price**	**Term (months)**	**Total**
Portable toilets	674.00	c/u	$70.00	1.00	$ 47,180.00
				TOTAL	**$ 47,180.00**

Source: Consulting Team

3.2.7 Hazardous Materials in Installation of RCM and FSRU

Type of measure: Prevention

<u>Description of measure</u>
In addition to the general processes for storing and handling hazardous materials, in the case of the installation of RCM and FSRU, temporary trestle the following complementary measures will be taken:

1. Store hazardous materials, including fuels and lubricants in confined areas.
2. Spill containment materials shall be available:

- Spill containment barriers (oil booms) (1.000 m); material for absorption of spills (500 m);
- Floating oil collector (2) Training will be provided to personnel working on offshore tasks on spill prevention, response and cleaning.

3. Workers trained in spill prevention, immediate response and cleaning will be available at work fronts.

Location of the Environmental Measure

Installation site for the pipeline and RCM in the open sea..

Estimated Amount of Environmental Measure

Table 3-10 – Estimated amount of the environmental measure - hazardous materials in installation of RCM and piping

Description	Quantity	Unit	Unit Price	Term (months)	Total
Floating barriers (1,000 m)	1.00	s.g.	$ 7,000.00	1.00	$ 7,000.00
Floating Absorbent (500 m)	1.00	s.g.	$ 2,000.00	1.00	$ 2,000.00
Floating oil separator	2.00	c/u	$ 900.00	1.00	$ 1,800.00
Training	20.00	persons	$ 6.00	6.00	$ 720.00
				TOTAL	**$ 11,520.00**

Source: Consulting Team Elaboration

3.2.8 Closing of Perforations in Soil

Type of measure: Prevention

Description of measure

At the end of the hole drilling activities for soil studies, among others. Where ever is necessary to drill holes more than 5 m deep, we will proceed to:

1. Close any open hole during the construction process with bentonite or other suitable material.

Location of the environmental measure

Where ever there were piles, in location of tank on land, Power House or other.

Estimated amount of the environmental measure

Table 3-11 – Estimated Amount of Environmental Measure – Soil Perforation Holes closing

Description	Quantity	Unit	Unit Price	Term (months)	Total
Closing of an estimate of 10 holes with bentonite	1.00	s.g.	$ 1,000.00	1.00	$ 1,000.00
				TOTAL	**$ 1,000.00**

Source: Consulting Team elaboration

3.2.9 Discharge of Test Water

Type of measure: Prevention

Description of measure

The water of hydrostatic pressure test will be analysed to confirm the absence of contamination. The water free of contamination will be released to local drainage areas. If it does not comply with the applicable criteria, the water will be treated prior to discharge. The water will be channelled to the sedimentation pond and then to the CEPA channel. If seawater is used for the test, it must be done using barriers in the pipe or hose to be used to prevent the entrainment of fauna and sediments.

Location of the Environmental Measure

Tanks and pipes.

Estimated Amount of Environmental Measure

Table 3-12 – Estimated Amount of Environmental Measure - Test Water Discharge

Description	Quantity	Unit	Unit Price	Term (months)	Total
Tank truck with pump	1.00	m	$ 3,000.00	1.00	$ 3,000.00
				TOTAL	**$ 3,000.00**

Source: Elaboration by Consulting Team

3.2.10 Relocation of Terrestrial Fauna

Type of measure: Attenuation

Description of measure

With the protection of fauna is pursued:

- Develop actions for the protection and care of wildlife;
- Train workers for the environmental sustainability of the project area during the execution of the construction activities;
- To promote individual and collective responsibilities for nature, the environmental and economic sustainability, and human solidarity with the environment;
- Generate awareness of environmental protection among the workers, through the placement of educational messages in the common areas of the Project.

To mitigate the impact on wildlife during construction activities, an appropriate training program on wildlife conservation is proposed.

Hunting or destruction of wildlife that move within the property or its surrounding is prohibited during the entire execution of the project. Fishing is also prohibited in the sea.

Fauna Rescue

Before starting the construction, trained personnel will take a tour around the site trained to catch the fauna that inhabits in the place; this will be properly handled in appropriate cages and given to an NGO for relocation in appropriate sites.

If fauna is harmed or there are birds or other circumstances that require wildlife management during the site preparation, will proceed as follows:

- Cages for transporting fauna will be available on the Project site and on the personnel's transportation vehicles to the field. The collected specimens will be taken to the office in the Laydown area;
- From the Laydown area they will be taken to an appropriate organization like FUNZEL or other dedicated to recover affected animals and be able to reintegrate them to their environment, already recovered;
- A record of the affected animals and delivered to these institutions will be kept.

Specific activities

- Recognition of the main species of wildlife: fish, mammals, birds, etc; identified in the project area;
- Discussion on the concept of over-exploitation, extinction, sustainable use and other related topics. To encourage participation in the commitment to the care of the environment in general;
- Foundation of principles and attitudes of management of the environment occupied or inhabited, by means of environmental education;
- Training.

Training talks to construction workers, 1 hour once a month, at the general safety meeting, during the site preparation stage.

<u>Location of the Environmental Measure</u>
Laydown area.

Estimated Amount of Environmental Measure

Table 3-13 – Estimated Amount of Environmental Measure – Terrestrial Fauna Relocation Measure					
Description	**Qantity**	**Unit**	**Unit Price**	**Term (months)**	**Total**
Relocation of fauna	2.00	persons	$ 1,100.00	2.00	$ 4,400.00
Training for construction personnel	300.00	persons	$ 2.00	3.00	$ 1,800.00
				TOTAL	**$ 6,200.00**

Source: Elaboration by Consulting Team

3.2.11 Reforestation and Support to FIAES

Measure Type: Attenuation

Description of measure

To compensate for the loss of vegetation by the cutting of trees, as well as the loss of infiltration by waterproofing areas and the use of water from the well is proposed the following:

1. Revegetation in areas of the Project;
2. Revegetation on land of the Municipality of Acajutla; y
3. Donation to FIAES, for revegetation projects and other environmental projects.

Calculation of compensation for logging

Logging is summarized in the following Table 3-14:

Table 3-14 – Trees to Cut		
Location	**Common**	**Threatened**
Project Property	121	0
Pipeline right of way	112	0
Laydown area	284	2
Total of trees to cut down	**517**	**2**

Source: Elaboration by Consulting Team

The trees will be compensated according to the compensation requirements of the MARN, 10 trees for each tree cut, and 25 for each tree cut, for the trees in delicate state, totaling 5,220 trees to plant.

Calculation of compensation for water use and waterproofing

Table 3-16 and 3-17 summarizes the calculation of compensation for water use and for waterproofing, based on the water balance in Table 3-15

Table 3-15 – Hydric balance		
Concept	**mm**	**%**
Precipitation	1,754.00	100%
Evapotranspiration	1,182.00	67%
Infiltration	343.00	20%
Runoff	229.00	13%

Source: Hydrological Study

Table 3-16 – Compensation for use of water from the well		
Description	**Quantity**	**Unit**
Extraction Flow	4.5	L/S
Flow per minute	270	L/MIN
Conversion to:	16,200.00	L/H
Conversion to:	324,000.00	L/Day (20 h)
Litters per year:	118,206,000.00	L/YEAR
TO COMPENSATE	118,260.00	m^3/year
Rain	1,754.00	mm
% Infiltration	20%	
Having an infiltration	343.00	mm
Infiltration in m	0.34	m
To infiltrate	118,260.00	m^3 (B)
Needed:	344,781.34	m^2 (B into A)
In hectares	34.47	
Distancing	25.00	distance 5x5
Total Trees	**13,791.25**	

Source: Elaboration by Consulting Team

Table 3-17– Compensation for Loss of Infiltration		
Description	**Quantity**	**Formula**
Area to waterproof:	53,748.19	m^2 (B into A)
In hectares	5.37	
Distancing	25.00	distance 5x5
TOTAL	**1,774.73**	

Source: Elaboration by Consulting Team

Thus, the quantity of trees to be planted for compensation totals 20,787.

For the compensation the following has been considered:

1. Revegetation on Project grounds: 546 trees;
2. The remaining 20,241 trees will be donated in an equivalent amount to the Initiative Fund for the Americas (FIAES), distinguishing between compensation for felling and loss of infiltration, in relation to water consumption, given the temporal scope of the required measures.

3.2.11.1Reforestation in project grounds

Planting method

Preparation of the site to plant: The tree should be planted, making sure it is vertical, centered in the hole, and stable. When planting, roots must be extended with care and cut the broken or wilted parts, immediately place the soil in the hole in the form of layers.

Individuals to plant shall have at least 1m height. The suggested species for planting, has been selected mainly under the principles of adaptability in the area and considering native species of flora, the existence of the species in the project area, determine the adaptation to the site.

Soil fertility, water availability, soil inclination and planting (protection / recreation) will be taken into account in addition to the characteristics of the selected species to estimate the spacing between plants and rows. The recommended planting period is at the beginning of the rainy season, between the third week of May and the second week of June.

Species maintenance starts from the time they are planted (early winter or rainy season) or depending on construction activities according to program) and will last up to two years:

- Irrigation of planted species: the process must be repeated until the plant has been established for at least 2 years. Special care must be taken during dry days, during the heat stroke, rainy-dry and dry transitional season;
- Protection with cover (mulsh): it is advisable to place a dry plant material cover, with a thickness of 3 to 5 cm around the plant, to minimize the loss of water from the soil and avoid the possibility of the growth of weeds around the same;
- Tutoring: Some plants need the support of a tutor, to avoid lodging (tilt);
- Cleaning and replanting: this consists in the elimination of weeds that are competing with the ground, keeping the area clean on the crown (1m diameter) and the refitting of mulsh. When it is necessary to replace the malformed plants and of course the dead, with the aim of maintaining the appropriate density of vegetation cover. The developer as owner of the project

will have the responsibility of maintaining the planting until the end of the project and the delivery of planted to the corresponding institutions.

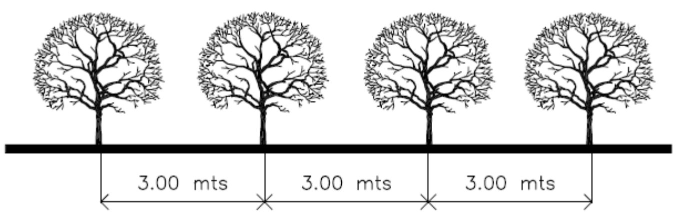
Methods of planting

For the implementation of the three planting, there are different methods for the settlement of the plantation, depending on the characteristics of the areas to revegetate and of selected species. Below is a brief description of the recommended planting methods according to the characteristics of each place.

Row Method

It is used in areas parallel to the roads (border), the distance between plants depends on the size reached by the species in its maturity, so that planting can vary between 3 to 5 meters, as presented in Figure 3-5. The species to be considered must also present characteristics of primary root deep, in order to prevent damage to the urban infrastructure to implement.

Figure 3-5 – Row Planting Method

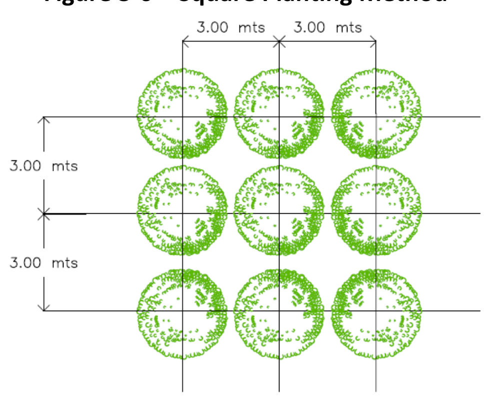


Source: Consulting Team Elaboration

Method of the square

In this method the plants are distributed in rows, formed a square, with a spacing between rows of 5.00 to 3.00m; Combining threads of different species. (See Figure 3-6)

Figure 3-6 – Square Planting Method



Source: Consulting Team Elaboration

Species

The total compensation of trees, is shown in Table 3-18, indicating, species, distance and number of individuals.

Table 3-18 – Table of trees			
Common name	**Scientific name**	**Distance**	**Quantity**
"anona poshte"	Annona cherimola	3.00	42.00
"coco"	Cocus nucifera	3.00	42.00
"limón persa"	Citrus latifolia	3.00	42.00
"limón indio"	Citrus aurantifolia	3.00	42.00
"mandarina"	Citrus reticulata	3.00	42.00
"marañón"	Anacardium occidentale	3.00	42.00
"naranja valencia"	Citrus sinensis var. Valencia	3.00	42.00
"naranja victoriana"	Citrus sinensis var. Tehuacan	3.00	42.00
"morro"	Crescentia alata	3.00	42.00
"madrecacao"	Gliricida sepium	3.00	42.00
"naranja"	Citrus sinensis	3.00	42.00
"achiote"	Bixa Orellana	3.00	42.00
"casco de cabro"	Bauhinla purpurea	3.00	42.00
		TOTAL OF TREES	**546.00**

Source: Consulting Team Elaboration

Estimated Amount of the Environmental Measure

The detail of the costs for the compensation measure associated to the sowing at the site, are presented in Table 3-19.

Table 3-19 – Compensation cost for 1781 trees				
Calculation of tree costs for FIAES, based on a MARN document				
Description	**Quantity**	**Unit**	**Unit Price**	**Total**
Cost per tree	546	each	$2.50	$1,365.00
Cost per shrub	0.00		$1.00	
Tracing and stacking at field level	0.36	day	$250.00	$90.97
Transportation, travel with 200 plants	2.73	Trip	$50.00	$136.50
PLANTING				
Digging 0.40x0.40x0.40	35.82	m^3	$1.50	$89.54
Fertilizing with 1 oz. of fertilizer per plant	0.34	quintal	$15.33	$5.23
Laboring with 20 plants per day	27.30	day	$4.00	$131.31
TOOLS				
Pickax	1.39	each	$15.00	$20.84

Table 3-19 – Compensation cost for 1781 trees				
Calculation of tree costs for FIAES, based on a MARN document				
Description	**Quantity**	**Unit**	**Unit Price**	**Total**
Duplex shovels	1.39	each	$25.00	$34.73
MAINTENANCE				
Maintenance personnel, weed removal, re-planting of lost or damaged plants, pest and disease control	546	trees	$1.82	$2,653.56
TOTAL DIRECT COSTS				**$4,527.69**
INDIRECT COSTS				
Cost of administration			12%	$543.32
Technical Assistance and field monitoring			25%	$1,131.92
Unforeseen			10%	$452.77
TOTAL INDIRECT COSTS				**$2,128.01**
TOTAL SOWING + MAINTENANCE				**$6,655.70**

Source: Consulting Team Elaboration

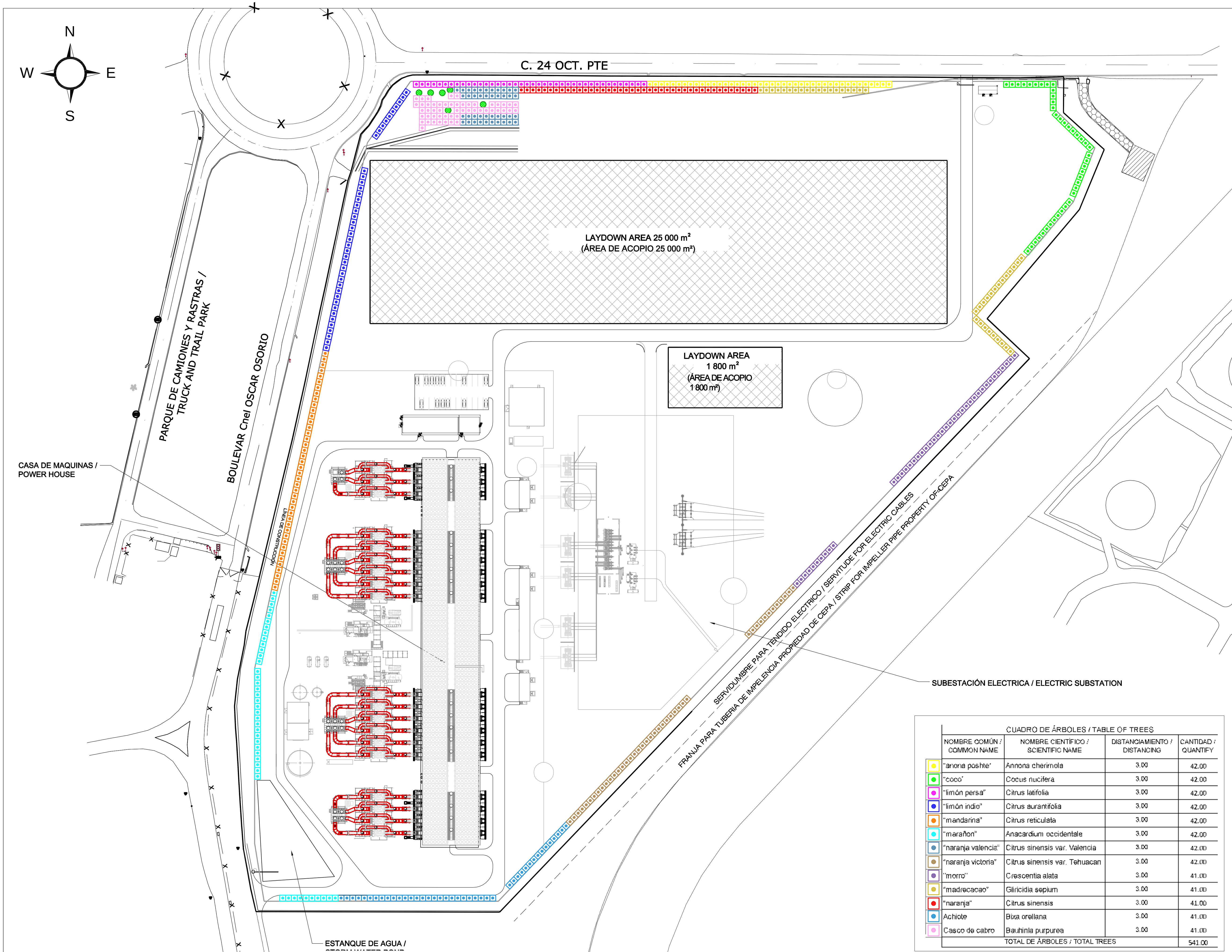
Location of the environmental measure

For the compensation for planting: Revegetation in the grounds of the Project: 546. As shown in Figure 3-7. (See Map in Appendix 3-A)

3.2.11.2Donation to FIAES for lost infiltration and tree cutting

FIAES is a non-profit organization that captures resources from governments, civil society and private sector, and assigns them to environmental conservation projects. Since 1993, FIAES has supported the conservation of ecosystems such as forests, wetlands, coastal areas, watersheds and agroecosystems, such as the Los Cóbanos conservation area, El Imposible-Barra de Santiago, Apaneca-Ilamatepec Biosphere Reserve, among others.

Compensation for: Logging of 474 trees (5,220 minus 546 to plant in the field), • Infiltration Loss 1,775 trees, For water use: 13,792 trees, Total: 20,241 trees.



	CUADRO DE ÁRBOLES / TABLE OF TREES			
	NOMBRE COMÚN / COMMON NAME	NOMBRE CIENTÍFICO / SCIENTIFIC NAME	DISTANCIAMIENTO / DISTANCING	CANTIDAD / QUANTIFY
	"anona poshte"	Annona cherimola	3.00	42.00
	"coco"	Cocus nucifera	3.00	42.00
	"limón persa"	Citrus latifolia	3.00	42.00
	"limón indio"	Citrus aurantifolia	3.00	42.00
	"mandarina"	Citrus reticulata	3.00	42.00
	"marañon"	Anacardium occidentale	3.00	42.00
	"naranja valencia"	Citrus sinensis var. Valencia	3.00	42.00
	"naranja victoria"	Citrus sinensis var. Tehuacan	3.00	42.00
	"morro"	Crescentia alata	3.00	41.00
	"madrecacao"	Gliricidia sepium	3.00	41.00
	"naranja"	Citrus sinensis	3.00	41.00
	Achiote	Bixa orellana	3.00	41.00
	Casco de cabro	Bauhinia purpurea	3.00	41.00
	TOTAL DE ÁRBOLES / TOTAL TREES			541.00

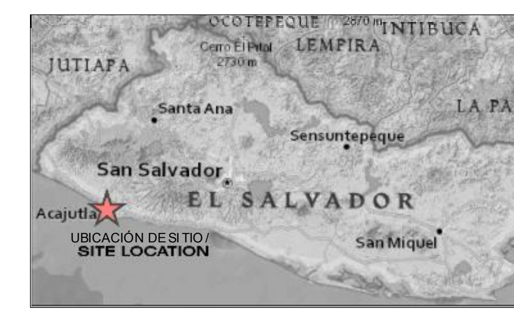
Energía del Pacífico

ENERGÍA DEL PACÍFICO

LNG TO POWER PROJECT

ARBORIZACIÓN EN EL PROYECTO / TREE PLANTING IN THE PROJECT

FIGURA 3.7 / FIGURE 3.7



0 10 20 30 40 50m

FUENTE / SOURCE:
PLANOS WARTSILA / WARTSILA SITE PLAN

MAPA CREADO POR / MAP CREATED BY: ECO INGENIEROS
MAPA REVISADO POR / MAP CHECKED BY: LF
PROYECCIÓN DE MAPA / MAP PROJECTION :
UTM ZONA 16 WGS84 / UTM ZONE 16 WGS84

ARCHIVO / FILE
C:/ECO,DRAWING 1, EL SALVADOR/ ECO INGENIEROS
C:/ECO,DIBUJO 1, EL SALVADOR/ ECO INGENIEROS

PROYECTO / PROJECT: 14-9114
ESTADO / STATUS : FINAL / FINAL
FECHA / DATE: 29/01/2018

DILLON CONSULTING

ECO INGENIEROS

Estimated Amount of the Environmental Measure

The calculation is as follows, for 6,449 trees, distancing 5x5m, 625 trees per hectare equals 10.32 Ha. Table 3-20 includes the total costs associated with planting and maintenance for three years.

Table 3-20 – FIAES Compensation Costs. Infiltration Loss and Logging. 10.32 Ha. Planting and Maintenance

DESCRIPTION	QUANTITY	UNIT	($USD/Ha)	TOTAL COST ($USD)
Planting Costs	10.32	Ha	$2,071.90	$21,378.69
Maintenance Costs (3 years)	10.32	Ha	$1,139.50	$11,757.82
Total direct costs				**$33,136.51**
Administration expenses			12%	$3,976.38
Technical Assistance			25%	$8,284.13
Incidentals			10%	$3,313.65
Total indirect costs				**$15,574.16**
Total				**$48,710.67**

Source: Consulting Team Elaboration

3.2.11.3Donation to FIAES for use of water from well

As compensation for water use, in addition to planting costs, maintenance costs are included for 20 years of project operation. As shown in Table 3-16 the compensation was estimated at 34.48 Ha. The cost estimate is presented in Table 3-21.

Table 3-21 – Compensation Costs for Use of Water. 34.48 Ha.

DESCRIPTION	($USD/Ha)	TOTAL COST ($USD)
Planting costs	$2,071.90	$71,435.25
Maintenance costs (3 years)	$1,139.50	$39,287.83
Total direct costs		**$110,723.08**
Indirect costs		
Administration expenses	12%	$13,286.77
Technical Assistance	25%	$27,680.77
Incidentals	10%	$11,072.31
Total indirect costs		**$52,039.85**
Total for planting and maintenance (3 years)		**$162,762.93**
Compensation for period 4-20 years	$20,199.74	**$696,449.34**
Total Costs		**$859,212.27**

Source: Consulting Team Elaboration

Three-year planting and maintenance costs sum **$ 162,762.93**, which are included as costs associated with the construction phase. The cost of maintenance for the period between years 4 to 20 is included as part of the measures for operations phase of the Project.

Table 3-22 presents the summary of costs for construction phase.

Table 3-22 – Estimated Amount for Environmental Measure – Revegetation Measure and Support to the Initiative Fund for America					
Description	**Quantity**	**Unit**	**Unit Price**	**Period (months)**	**Total**
Trees on Project Ground Planting + maintenance for 3 years (1,781 trees)	1	c/u	**$6,655.70**	1.00	**$6,655.70**
Initiative Fund for America. Logging + Infiltration Loss. Plantation + maintenance for 3 years (10.32 Ha)	1	c/u	$48,842.11	1.00	$48,842.11
Initiative Fund for America. Water use from well. (34.48 Ha)	1	c/u	$162,762.93	1.00	$162,762.93
				TOTAL	**$218,260.74**

Source: Consulting Team Elaboration

The cost of the consignments to be delivered to FIAES is not included in the summary of the Environmental Management Program, regarding the framework of the EDP - FIAES Agreement, the guarantees that support compliance with the environmental measure will be formalized.

3.2.12 Measurements during HDD drilling

Type of measure: Prevention

Description of the measure

HDD will be passed through a recycling system to separate water-clay and sediment materials, to reuse the water. El sistema se describe a continuación.

The additional mitigation that will be implemented during the HDD activity includes the following:

- Drilling fluid mixture will be appropriate for use near aquatic life.
- Drilling fluid to be sampled and analyzed for contaminants before disposal on site or off site; The material can be removed in a landfill or property
- Develop and follow a containment and contingency plan for involuntary release, in case an inadvertent release of drilling fluid to the surface of the ground or a body of water is identified or suspected;

- The contractor will control the volume, pressure and parameters of the drilling fluid to detect any loss during drilling operations. The rate of pumping of the drilling fluid and the rate of return of the drilling fluid to the surface will be constantly monitored by the Contractor;
- In the event of an inadvertent release of drilling fluid, the Contractor should consult the Inappropriate Drilling Flow Contingency Plan, temporarily cease drilling operations and notify the Construction Manager and the Environmental Manager immediately; And
- Hydrovac trucks will be mantained on site during drilling operations.

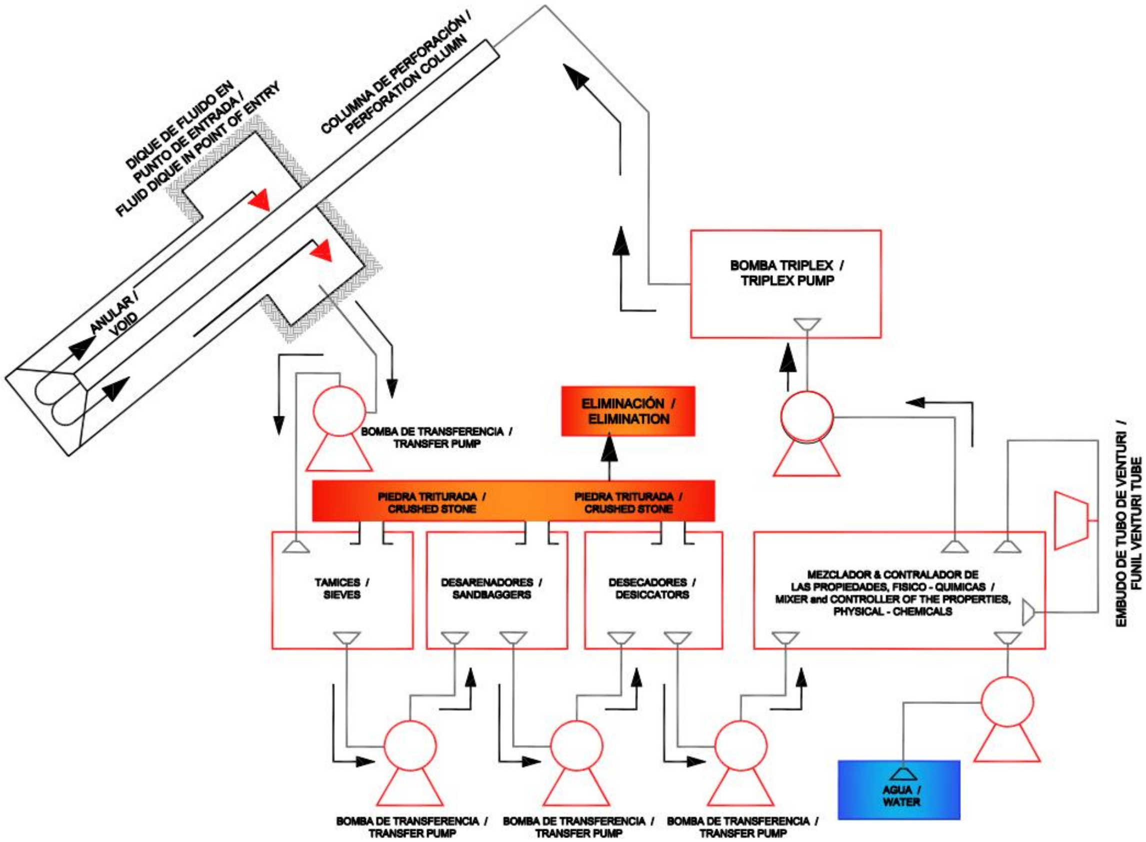
3.2.12.1Drilling fluid recycling system

The HDD contractor will use a recycling system to remove the extracted material (sediment) from the drilling fluid. This system is typically composed of three (3) different components: vibrating screens, sand traps and settlers, which progressively remove the sediment according to its grain size. The specification of a representative recycling system is provided below along with example diagrams. (Figure 3-8 and 3-9).

Figure 3-8 Recycling System- Copyright © DERRICK

Source: Acajutlan LNG Import, Tender Method Statement (HDD), Conducto/DrillTec, November 2017.

Figure 3-9 Diagram of Fluid Re-Circulation System



Source: Acajutlan LNG Import, Tender Method Statement (HDD), Conducto/DrillTec, November 2017.

<u>Location of the Environmental Measure</u>

Pipe route on seabed and temporary storage site.

<u>Estimated Amount of the environmental measure</u>

Table 3-23 – Estimated Amount of the Environmental Measure - Prevention of Fauna Interaction Measure

Departure	**Quantity**	**Unit**	**Unit price**	**Term (months)**	**Total**
Prevention plan	1.00	c/u	$1,000.00	1.00	$ 1,000.00
Recycling tank	1.00	c/u	$18,000.00	1.00	$18,000.00
				TOTAL	$ 19,000.00

Source: Consulting Team Elaboration

3.2.13 Prevention of Interaction with Fauna

Type of measure: Prevention

Description of measure

Avoid attracting fauna to the site by all wastes to be generated. It includes a description of each type of waste to be generated and the management proposal for each of these.

Disposal of waste and residues

There will be wastes from the construction of the works, consisting of gravel from the construction, carton from cement bags, reinforcing steel pieces, PVC pipes, among others. These wastes and residues should be separated and handled appropriately.

The recommended handling for the waste and residues produced during the construction stage and site preparation, is summarized in the **¡Error! No se encuentra el origen de la referencia.**.

Table 3-24– Wastes and Residues to be Generated in the Construction Stage

Disposal/Waste	Origin	Handling	Disposition
Fuel or used oil	Preparation of machinery and equipment daily	Storage in recyclable oil tank.	Sale to be used as fuel.
Used absorbent material (wipes, sawdust).	Preparation of machinery and equipment daily	Storage in closed containers or bags, properly closed and labeled as "hazardous waste"	Incineration through controlled methods, in sites with the authorization of the competent authority.
Wood or firewood	Cutting and logging	Collection in a designated area. The wood will be cut and placed in order.	Sale of wood or firewood
Leaves and branches	Cutting and logging	Collection in a designated site on every work front.	Eviction to authorized site, will be collected by the City Hall. (See Appendix 4E)
Paper	Office and packing	Store in signposted container	Sale for recycling
Domestic (cafeteria and offices)	Food, various	Storage in closed containers	Collected by municipal garbage truck (see Appendix 4E)
Glass	Bottles	Storage in closed container	Sale for reuse
Plastic	Packing material	Storage in closed container	Sale for recycling
Building Rubble	From own construction	Storage	Taken to an authorized rubble dump.
Metal pieces	Spare parts of support structures and metal pipes	Storage	Selling as scrap

Table 3-24– Wastes and Residues to be Generated in the Construction Stage			
Disposal/Waste	**Origin**	**Handling**	**Disposition**
Sterile earth moving material	Earth movements	Stacked in a defined area of land	Eviction to site defined for filling

Source: Elaborated by Consulting Team

Hazardous wastes include: empty deposits, used lubricating oil, solvents and other reagents, batteries and other consumables.

The construction rubble will be taken to an appropriate disposal site, authorized by the Municipality and by MARN.

Deposits to be used for domestic waste shall be fauna-proof and shall be emptied and cleaned regularly to avoid accumulation thereof.

At the end of the construction, the removal of all types of waste and residues should be verified at the site where the building material was located.

As a monitoring, a record of the amount of waste and waste generated, by type of waste or waste, of the transportation and delivery receipts of the waste and / or residue, and a photographic record of the storage site shall be kept, at least once a month.

Location of the Environmental Measure

Temporary storage sites, Laydown Area and work fronts within the site.

Estimated Amount of Environmental Measure

Table 3-25 – Estimated amount of the environmental measure - a measure preventing Interaction With fauna					
Description	**Quantity**	**Unit**	**Unit Price**	**Term (months)**	**Total**
Plastic containers	60.00	c/u	$40.00	1.00	$ 2,400.00
				TOTAL	**$ 2,400.00**

Source: Elaborated by Consulting Team

3.2.14 Construction lighting plan Offshore

Type of measure: Attenuation

Description of measure

Establish a management plan for the lighting, for works at sea, specifically to the installation of RCM and pipeline, so as not to affect the marine fauna. The plan is to:

- Reduce the lighting at night in non-essential areas, particularly during critical periods of the life cycle of the fauna, such as for example during the sea turtle nesting;
- Use screens to direct lighting to work areas;
- Direct all lighting to work areas without illuminating directly to the water, except for periodic safety inspections.
- Low light mounting where possible;
- Use of light shielding to reduce the amount of glare, as well as reduce visible light to animals, so there is less chance of them being trapped, repelled, or their day / night patterns altered;
- Installation of long wavelength lights (like amber and red lights) which makes visible light appear less intense for nocturnal animals (State of Florida 2014[1]).

Location of the Environmental Measure

Maritime Terminal and temporary dock

Estimated Amount of Environmental Measure

Table 3-26 – Estimated Amount of Environmental Measure - Measure Plan of Lighting of the construction Offshore

Description	Quantity	Unit	Unit Price	Term (months)	Total
TemporaryLighting Plan	1.00	s.g.	$1,000.00	1.00	$ 1,000.00
				TOTAL	**$ 1,000.00**

Source: Elaboration by Consulting Team

[1] State of Florida. 2014. "Wildlife Lighting - About Light Pollution" Florida Fish and Wildlife Conservation Commission. Online: http://myfwc.com/conservation/you-conserve/lighting/pollution/

3.2.15 Measures to Reduce Turbidity and Oyster Biomonitoring

Type of measure: Prevention

Description of measure

Temporarily suspend or reduce the activity of ditch excavation for pipeline in seabed if turbidity criteria are detected through supervision, to exceed the applicable limits.

The monitoring will be done using a portable turbidimeter on site, and will be carried out daily, at least 4 hours after starting the digging activities and two hours later, to verify the levels. With the data, an estimate of the average weekly and monthly levels will be made, to be compared with the reference standard.

Standard to be used for sediment suspension control: US EPA STANDARD PER STATE. California Standard, considering that is the same ocean and have developed port projects that are active. The standard establishes levels of 75 NTU, average of 30 days and 100 NTU average of 100 days.
To verify the impact of sediment trawling, biomonitoring will be carried out in oysters, when trenching activities are carried out for the installation of underground piping. Initial monitoring is proposed, to establish the baseline, a monitoring at the start of construction activities, midway through its execution, and at the end.

Biomonitoring in oysters will be carried out following the following steps:

1. Identification of the areas of concentration of oysters that are a source of collection.
2. Preparation and sterilization of glass containers for storage of samples.
3. Selection of 4 samples from different sites of 400 grams each.
4. Storage in containers and in cooling conditions for transport.
5. Delivery of the samples in the laboratory for analysis.
6. Sample processing and obtaining results (approximately 15 days)
7. The baseline will be established before starting, where the parameters with which they are to date will be kept, and the same parameters will be checked for subsequent sampling to verify if there is an increase in contamination.
8. If there are significant increases, the construction method will be modified, or other methods to reduce the increase of sediments in the soil.
9. Significant increases, will force adjust the construction method or timing, or other methods to reduce the increase of sediments in the soil.

Location of the Environmental Measure

Points M1 and M3 of sampling performed, M1 at coordinates 13 ° 35'3.10 "N and 89 ° 50'42.35" O and M2 at coordinates 13 ° 35'1.49 "N and 89 ° 50'42.19" W. See Table 3-27.

Table 3-27 – Turbidity Monitoring Point				
No	Date	Sample	Coordinate	
			Latitude	Length
1	17/08/2016	M01	13°34'50.59	89°50'10.80
23	24/08/2016	M03	13°35'28.37	89°51'3.10

Source: Elaboration by Consultation Team

Biomonitoring in an area identified as oyster banks in the place known as "La Pedrera".

Estimated Amount of Environmental Measure

Table 3-28 – Estimated Amount of Environmental Measure - Turbidity Reduction Measure					
Description	Quantity	Unit	Unit Price	Term (months)	Total
Turbidity Measurement	60	Unit	$55.00	1.00	$3,300.00
Oyster Biomonitoring	20	Sample	$ 150.00	1.00	$ 3,000.00
				TOTAL	**$ 6,600.00**

Source: Elaboration by Consultation Team, 2018

3.2.16 Environmental and Social Management Plan

Type of measure: Prevention

Description of measure

In addition to standard precautions for access control to unauthorized personnel. A communications plan must be established throughout the Project's execution, to be carried out by the project's social and environmental management office.

Objetives

This measure pursues the following objectives:

- Provide information to the local population and the general public on the progress, virtues and benefits of construction;
- Avoid collective speculation and rumours to prevent social and environmental conflicts;
- Notify ahead of time to the possible affected about the development of the Project;
- Prevent social conflicts and maintain a good relationship with the neighbours of the Project;
- Prevent inconvenience to the population residing in areas immediately to the project area;
- Serve the population that is affected in some way during construction.

Resources

The Office will have the following staff, as minimum:

1. Social Specialist: Will be responsible for all the social management of the project. The required profile for the person in charge of social management is as follows:

   Bachelor degree (BA) in Social Work, Sociology or Anthropology;
   - Experience in mediation of conflicts and processes of citizen participation;
   - Experience in social promotion of communal development projects.
2. Environmental Specialist: will be responsible for verifying the correct implementation of the project's environmental management plan. The required profile is as follows:
   - Graduated in Civil Engineering or similar, with specialization in environment;
   - Experience in implementing environmental measures in similar projects;
   - Experience in environmental impact assessments or environmental audits.

Functions of the office and its personnel

- Respond to queries and complaints from the population and answer or coordinate a response for them;
- Verify that the ENVIRONMENTAL MANAGEMENT PROGRAM is executed, as planned. Keep a record and prepare an annual report, which will be available when MARN carries out the environmental audits;
- Coordinate the environmental management of the Project related to activities outside the property;
- Conduct briefings. These meetings should include community leaders, representatives of the main institutions and the municipality. At least every six months;
- Talks to workers related to environmental protection, respect for customs and values, monthly, to different groups of 50 people;
- Organize campaigns to prevent health effects;
- Carry out communication campaigns of the Project;
- Prepare written informational documentation of the Project, in surrounding areas, municipality, schools.

Consideration should be given to the installation of 2 notices visible to passers-by and drivers, on the location of the Office of Social Management, in the perimeter walls of the Project.

Minimum requirements for operation

Must have at least three desks, a telephone, a computer and space for short meetings for at least five people, to serve small groups that might visit.

Location

The office will be established in the City of Acajutla.

Period of Office Operation

The office will be established before starting the construction process and will be in operation until the end of construction.

Guidelines for the Construction Stage

The responsibilities that the construction company acquires in the matter of social management of a project entails, giving full compliance with what is established within the technical conditions and of the contract that is subscribed, these responsibilities are framed in function of performing the following activities and / or actions:

a. To formulate an operational work plan, for which it will take as base the Social Management Program, which will require an update of the same if necessary, given that the period of time between the study and the execution of the Project can be broad, and the existence of changes in the environment thereof.
b. Incorporate the person in charge of social management into the monthly follow-up meetings.
c. Prepare monthly monitoring reports and a final report, which reflects the compliance with the measures and the processes implemented for it, these documents must have their respective support.
d. Inform and communicate to the communities about the proposed Project, impacts and compensation measures proposed.
e. Identify possible sources of local resources to cooperate in the implementation of mitigation measures and notify the Project holder so that it assesses the appropriateness of the sources and initiates the pertinent steps to formalize the cooperation.
f. Document properly (photographs, registration of participants and visits, reports, memory aids, etc.) activities implemented and / or followed up.

Location of the Environmental Measure

Municipality of Acajutla

Estimated Amount of Environmental Measure

Table 3-29– Estimated Amount of Environmental Measure - Environmental and Social Management Plan Measure

Description	Quantity	Unit	Unit Price	Term (months)	Total
Social Specialist	1.00	person	$800.00	33.00	$ 26,400.00
Environmental Specialist	1.00	person	$800.00	33.00	$ 26,400.00
Office and materials	1.00	Total	$950.00	33.00	$ 31,350.00
				TOTAL	**$ 84,150.00**

Source: Consulting Team Elaboration

3.2.17 Safety Offshore

Measure Type: Attenuation

Description of measure

In coordination with CEPA and the Port Authority, a safety plan will be established during construction, which will include at least:

- An irregularly shaped circle of exclusion of magenta that is presented in figure 1-38 around FSRU and areas of pipeline, in addition to zones for movement of boats. This area has been analyzed and preliminarily approved by the operational personnel of CEPA. This exclusion zone applies to all ships, including commercial port traffic. The Project will formalize this exclusion space with the Port Maritime Authority with the concurrence of CEPA.
- An additional security concession zone (shown in Figure 1-37) with a radius of 500 m will be established, applicable to ships of maritime terminals that are not CEPA, CENERGICA, ALBA, RASA or EDP.
- Signaling in the closest location of the CENERGICA pipe (60m in its closest area), Special care will be taken in the installation of anchors in the vicinity of the CENERGICA pipe, and installation will only be done when the pipeline is not in download operation.
- Reinforcement of CEPA patrols and security measures;
- Communication with fishermen and other people who use boats in the area; y
- Coordinate activities with CEPA.

Location of the environmental measure

RCM and Pipe installation area.

Estimated Amount of Environmental Measure

Table 3-30 – Estimated amount of the environmental measure - Safety on the Open Sea

Description	Quantity	Unit	Unit Price	Term (months)	Total
Development of the plan in coordination with CEPA	1.00	Total	$2,000.00	1.00	$ 2,000.00
Materials	1.00	Total	$3,500.00	1.00	$ 3,500.00
				TOTAL	**$ 5,500.00**

Source: Elaboration by Consulting Team

3.2.18 Traffic Plan

Type of measure: Attenuation

Description of measure

A traffic management plan will be developed, during construction, to coordinate the entry of materials, labor and equipment into the Project site. The plan will include at least:

- Use of collective transportation vehicles, provided by the company to reduce the effect on the public transportation of the city;
- Specify designated routes;
- Heavy vehicles will not be allowed to pass through city streets (See Figure 4.3 - Equipment and Materials Road for Project Construction);
- Driver training on the traffic management plan as well as good driving practices;
- Announce and schedule, if necessary, closure of the entrance street, for the movement of heavier equipment: motors, generators, etc.;
- Appropriate signs and traffic controllers; y
- Report to the municipality, local schools and communities the traffic plan and potential dangers or affectation.

Location of the environmental measure

Project's area of influence.

Estimated amount of the environmental measure

Table 3-31 – Estimated amount of the environmental measure - Traffic Plan Measure

Description	Quantity	Unit	Unit Price	Term (months)	Total
Signalling	1.00	Total	$500.00	1.00	$ 500.00
Driver Training	30.00	Person	$4.00	11.00	$ 1,320.00
				TOTAL	$ 1,820.00

Source: Elaboration by Consulting Team

3.2.19 Employment of local workers

Type of measure: Attenuation

Description of measure

To ensure that local workforce is used as possible, a person in charge of human resources will be hired, who will operate in the Project's communications office, to assist and coordinate with contractors the different elements of the Project specifically the identification of workers local. The unskilled workforce must be from the municipality of Acajutla, to the extent possible. Publicity will be made to inform the population of the assistance of personnel in the communications office of the Project. No work requests will be received in the main access of the Project site.

The measure includes:

- Human resources manager;
- Advertising material.

Location of the Environmental Measure
Project Communications Office and Project Access.

Estimated Amount of Environmental Measure

Table 3-32 – Estimated amount of the environmental measure - employment for local workers

Description	Quantity	Unit	Unit Price	Term (months)	Total
Human resources manager	1.00	person	$800.00	30.00	$ 24,000.00
Advertising material	1.00	Total	$1,500.00	1.00	$ 1,500.00
				TOTAL	$ 25,500.00

Source: Elaboration by Consulting Team

3.2.20 Prevention of Informal Stores near the Site

Type of measure: Prevention

Description of measure
Within the project site there will be a space for the construction workers for rest and feed, however, to prevent the proliferation of informal sales of food at the entrance of the project that would impede the passage of vehicles to the project and to the port, it will take the following measures:

1. Workers will be made aware through talks, flyers, about not to purchases food from informal sales;
2. Five signs will be installed on the perimeter fences of the Project prohibiting the establishment of street or informal sales;
3. When informal businesses are set up, they will coordinate with the Municipality for possible removal from the area.

Location of the Environmental Measure

Project Entry and Protection Fence

Estimated Amount of Environmental Measure

Table 3-33 – Estimated Amount of Environmental Measure - Informal Store Prevention Measure Nearthe Site

Description	Quantity	Unit	Unit Price	Term (months)	Total
Signs	5.00	m	$40.00	1.00	$ 200.00
Employee training	1.00	Total	$500.00	1.00	$ 500.00
				TOTAL	**$ 700.00**

Source: Elaboration by Consulting Team

3.2.21 Pipeline Safety Barrier

Type of measure: Prevention

Description of measure

A barrier will be installed to block and provide safety between the pipe construction site and recreational green areas of CEPA and employee housing, also from CEPA. The barrier will be temporary. It will be located on the entire south side of the pipe construction site. (See Figure 3-17)

Location of the Environmental Measure

South side of pipeline construction site.

Estimated Amount of Environmental Measure

Table 3-34 – Estimated Amount of Environmental Measure - Noise Barrier and Pipeline Safety

Description	Quantity	Unit	Unit Price	Term (months)	Total
Protection barrier	401.00	m	$22.00	1.00	$ 8,822.00
				TOTAL	**$ 8,822.00**

Source: Elaboration by Consulting Team

3.2.22 Compensation for Fishermen

Measure Type: Attenuation

Fishermen Measure Description

As a measure of compensation for the effects on the reduction of fishing zones and distance traveled by fishermen, the following environmental measures have been proposed, which were identified in the public consultation process of the Project:

Fishermen Cooperatives and independent fishers in general:

For the benefit of the fishermen of both cooperatives and independent fishers in general:

- Replacement of damaged winch; and,
- The installation of fish aggregating devices (FADs) near the artisanal dock - A FAD is an object that is used to attract fish. They usually consist of buoys or floats tied to the bottom of the ocean with concrete blocks. More than 300 species of fish gather around planted FADs.
- Installation of artificial reefs. The measure contemplates the rehabilitation of the marine coastal ecosystems by means of artificial reefs which constitute an efficient tool of ordering and protection not only of oysters but of variety of species. The implementation of the Artificial Reef will promote the sustainability of the resource and will be addressed to the beneficiary communities which must be committed to the guidelines of proper maintenance of the reefs.

In Appendix 3C profiles of these projects are presented, a list of fishermen and an analysis of the possible impacts of some of the elements to be installed.

These measures are considered equitable, in which all fishermen would benefit equally, and that these projects can be implemented effectively before the start of construction.

Oyster-catchers and tuberos

In addition to the benefit of the FAD and compensate even more oyster-catchers and tuberos for the loss of fishing sites, EDP will provide these fishermen with an option to receive support and training to remain in the fishing sector, or to make a change to an alternative way of livelihood.

The support will consist of the following:

1. Those who wish to remain in the fishing option
    a. Participate in building themselves a rowboat to replace the "Tubes ";
    b. Receive training on safety, fish marketing and food safety;
    c. Receive improved materials and equipment for fishing.

2. Leaving the fishing option:
    a. Receive support for training in an alternative line of job skills/employment; y
    b. Eligible for ongoing counselling related to finding a job.

It is expected that any of these options will provide opportunities for affected fishermen to improve their livelihoods compared to the existing situation.

Location of the Environmental Measure
Coastal area in front of the City of Acajutla. See Figure 3-10.

Estimated Amount of Environmental Measure

Table 3-35 – Estimated Amount of Environmental Measure - Fishermen's Compensation Measure

Description	Quantity	Unit	Unit Price	Term (months)	Total
Purchase of winch for artisanal dock	1.00	Unit	$1,500.00	1.00	$ 1,500.00
Fish aggregating device and accessories	15	Unit	$1,000.00	1.00	$ 15,000.00
Artificial Reefs for Oyster-catchers	1.00	Total	$10,650.90	1.0	$ 10,650.90
Support to "Tuberos" and Local Oyster-catchers	57.00	person	$500.00	1.00	$ 28,500.00
				TOTAL	**$55,650.90**

Source: Elaboration by Consulting Team

3.2.23 Construction of Wastewater Treatment Systems

Type of measure: Preventive

Description of the environmental measure
This measure includes the systems to treat wastewater from employees, cafeteria and cleaning to comply with the quality standard for waste water to be discharged to a receiving body in El Salvador. The treated effluent will be discharged to the CEPA drainage channel at the south-west corner of the site. The sludge from the domestic wastewater treatment plant will be sun dried and used as fertilizer in the green areas of the plant or removed by an authorized company.

A SBR "Sequencing Batch Reactor" process system will be installed. This process is divided into the following stages: During the initial loading phase (sludge damping and storage) the solids (sludge) settle and the sludge water from the upper layer is transferred to the second stage of the treatment (The bioreactor).

The draining water is aerated inside the bioreactor with fine bubbles of oxygen and this causes the microorganisms that consume the nutrients to increase. This can be seen in the aeration phase.

After aeration, which lasts for a relatively long time, there is a rest phase inside the bioreactor. During this phase the water rests completely and the rest of the sludge is set at the bottom of the tank and a zone of clear water is created.

The clear water is extracted for disinfection with Ultraviolet light, which kills e. coli bacteria. The settled sludge returns from the bioreactor to "Cushioning and sludge storage". After this the cycle starts again from the beginning.

The following figure 3-9 shows the different phases of the SBR process. The proposed system operation is the same, but may have different tanks or cameras.

Figure 3-10 – Treatment in the Wastewater Treatment Plant

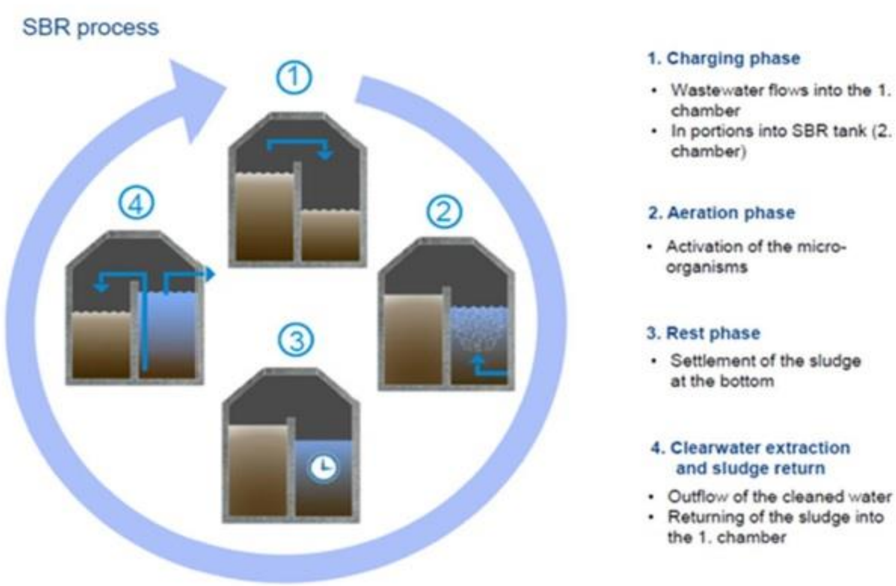
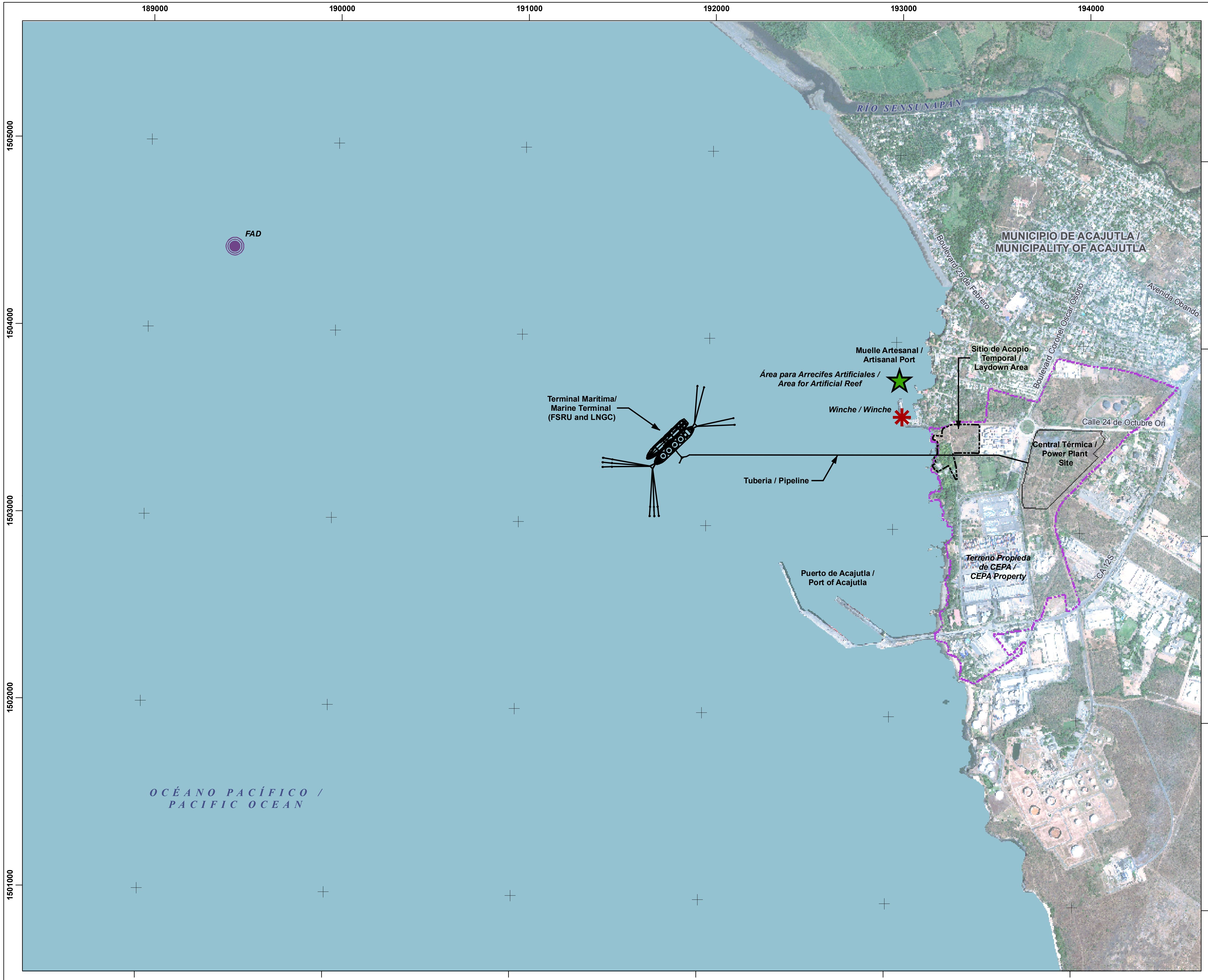


Figure 1 The different stages of the SBR process.

Source: Wärtsilä 2016



ENERGÍA DEL PACÍFICO

LNG TO POWER PROJECT

COMPENSACIÓN A PESCADORES / COMPENSATION TO FISHERS

FIGURA 3.9 / FIGURE 3.9

FAD

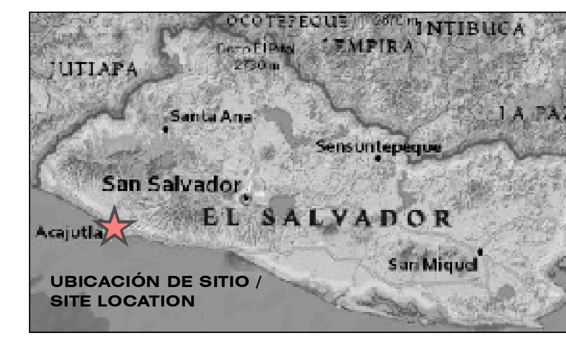
WINCHE UBICACIÓN / WINCHE LOCATION

ÁREA PARA ARRECIFES ARTIFICIALES / AREA FOR ARTIFICIAL REEF

SITIO DEL PROYECTO / PROJECT SITE

SITIO DE ACOPIO TEMPORAL / TEMPORARY LAYDOWN AREA

TERRENO PROPIEDA DE CEPA / CEPA PROPERTY



0 100 200 400 m

1:20,000

N W E S

FUENTE / REFERENCE
VISIÓN DEL MUNDO 2 IMÁGENES DE ALTA RESOLUCIÓN /
WORLDVIEW 2 HIGH RESOLUTION IMAGERY (2014-02-12)

MAPA CREADO POR / MAP CREATED BY: PFM
MAPA REVISADO POR / MAP CHECKED BY: MW
PROYECCIÓN DE MAPA / MAP PROJECTION: UTM ZONE 16 WGS84

ARCHIVO / FILE:
I:\GIS\163489 Acajutla\GIS\MXDs\Reporting - 2016\10-9 - Compensation to Fisheries REV.mxd

PROYECTO / PROJECT: 14-9114
ESTADO / STATUS: FINAL / FINAL
FECHA / DATE: 2/7/2018

DILLON CONSULTING

ECO INGENIEROS
LÍDERES EN CONSULTORÍA AMBIENTAL

The monitoring and control of the plant is presented in 3-1.24. The water to discharge will comply with what is established in the standard of "wastewater discharged to a recipient body" normative.

FSRU will have a sewage treatment unit suitable for the crew with 14 days of wastewater storage. According to the MARPOL Annex IV specification (Marine Environment Protection Committee Resolution 159 (55)) and comply with the local discharge requirements of El Salvador.

Monitoring and control

The physic and chemical characterization of the discharges with its corresponding flow measurement will be performed, to size the treatments for the reduction of levels of: COD, BOD, solids, sedimentary, suspended solids and fats and oils.

The standard of "WASTEWATER DISCHARGED TO A RECPIENT BODY" sets the following frequency of monitoring for domestic waste. In the case of the plant applies the less than 10 m^3 per day (Table 3-36).

Table 3-36 – Parameters and Sampling Frequency

Characteristics	Flow rate m^3 / day		
	< 10	10 a 100	> 100
Temperature, PH, Sedimentable Solids and Flow	Monthly	Weekly	Daily
Other mandatory parameters according to standard	Annual	Biannual	quarterly

Source: Salvadorian Normative

For discharges less than or equal to 5 m^3 / day they will be exempt from presenting operational reports; However, they must implement the necessary measures to comply with the maximum permissible values in this standard. Therefore it is recommended to keep the corresponding record.

However, the Temperature, pH, Sedimentable Solids and Flow, do not need to be performed by an accredited laboratory. Yet, should be included in the operational report.

It is recommended to acquire a pH meter, thermometer, several Imhoff cones and a flow meter to perform their respective monthly measurements of Temperature, PH, Sedimentable Solids and Flow.

At least once a year hire a certified laboratory to perform at least one analysis and make validation of data taken by plant personnel (Table 3-37).

Table 3-37 – Parameters to Monitor According to Standard		
Parameter	**Unit**	**Standard**
BOD5	mg/l	60
COD	mg/l	150
Ph	mg/l	5.5-9.0
Oils and grease	mg/l	20
Sedimentable solids	mg/l	1
Total Suspended Solids	mg/l	60

Source: Elaboration by Consulting Team

The minimum frequency of sampling and analysis is defined according to the flow rate of effluents from wastewater treatment systems of ordinary type, which for the plant is estimated to be between 3-84 and 25.43 m^3 per day. These shall be carried out as set out in Table 3-38)

Table 3-38 – Frequency of Monitoring according to Residual Water Flow in m3 per Day.			
Parameter	**Less than 50**	**between 50 and 00**	**Over 100**
PH, Sedimentable Solids and Flow	Monthly	Weekly	Daily
Oil and grease	Annual	By quarterly	Quarterly
$BOD_{5,20}$	Quarterly	Quarterly	Quarterly
Total Suspended Solids	Annual	Biannual	Quarterly
Coliforms	Quarterly	Quarterly	Quarterly

Source: Elaboration by Consulting Team

The costs of the analysis are detailed In Table 3-39)

Table 3-39 – Annual Cost of Analysis			
Analysis	**Price**	**Quantity**	**Total Cost**
Biochemical Oxygen Demand	$29.00	4	$116.00
Chemical oxygen demand	$19.40	4	$77.60
Hydrogen Potential	$7.80	12	$93.60
Oils and grease	$19.70	1	$19.70
Sedimentable solids	$7.80	12	$93.60
Total Suspended Solids	$15.50	1	$15.50
Chlorides	$11.00	1	$11.00
Coliforms	$11.00	1	$11.00
TOTAL			**$ 438.00**

Source: Elaboration by Consulting Team

The total cost is $ 438.00 per year of monitoring, per treatment plant.

The periodic operational reports should contain as minimum requirements the following information:

a) Flood record;
b) Record of laboratory analysis carried out by the holder and carried out by accredited laboratories, according to the pertinent legislation;
c) Registry of infrastructure damage, caused by accidental situations or accidents in the operation and operation of the system;
d) Fortuitous situations or accidents in the handling and operation of the system that generate discharges of waste water with levels of contaminants that contravene the limits allowed by the respective technical standards;
e) Evaluation of the current state of the system, and corrective and control actions.

<u>Location of the Environmental Measure</u>
South-west corner of the site of the Thermal Power Plant.

<u>Estimated Amount of Environmental Measure</u>

Table 3-40 – Estimated Cost of Environmental Measure - Construction of Wastewater Treatment Plant

Description	Quantity	Unit	Unit Price	Term (months)	Total
Package type wastewater plant	2.00	each	$ 35,000.00	1.00	$70,000.00
Transportation to the plant and taxes	1.00	each	$ 8,320.00	1.00	$8,320.00
Civil works for the installation of the plant	1.00	s.g.	$ 9,000.00	1.00	$9,000.00
Characterization of effluent (1 year and initial)	2.00	each	$ 438.00	3.00	$2,628.00
TOTAL					**$89,948.00**

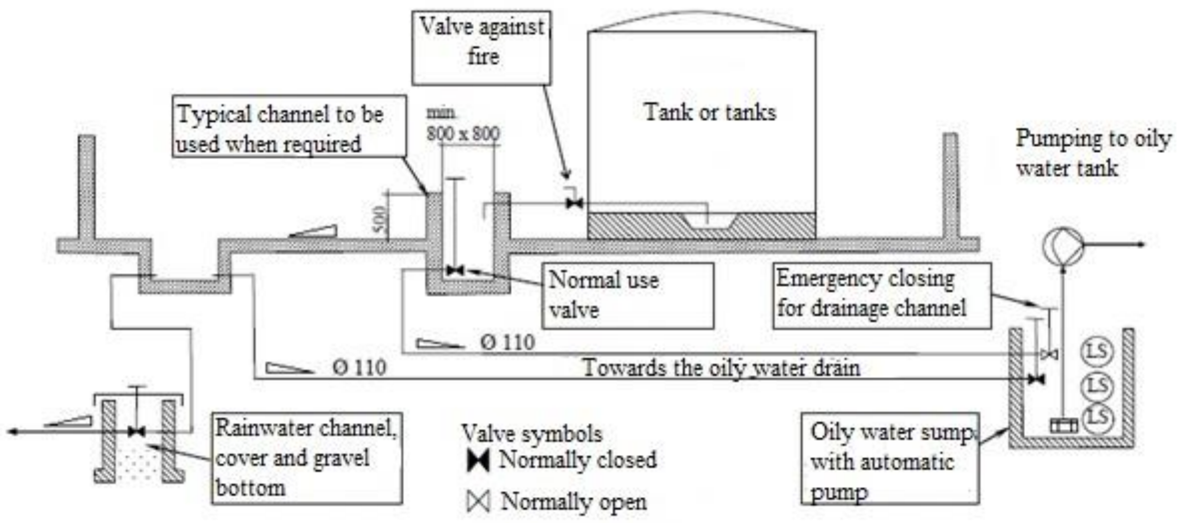
Source: Elaboration by Consulting Team

3.2.24 Oily Water Treatment System

Type of measure: Preventive

<u>Description of the environmental measure</u>
All tanks with oil content, will have a drainage system. The main purpose is to perform the collection of water and cleaning of the tank areas, resulting in a lower risk of rainwater contamination. The main diagram is shown below, in Figure 3-12.

Figure 3-12 – Diagram of the Oil/Water Separator System



Source*: Wärtsilä 2016*

The philosophy and the most important rules that prevent spills are the following

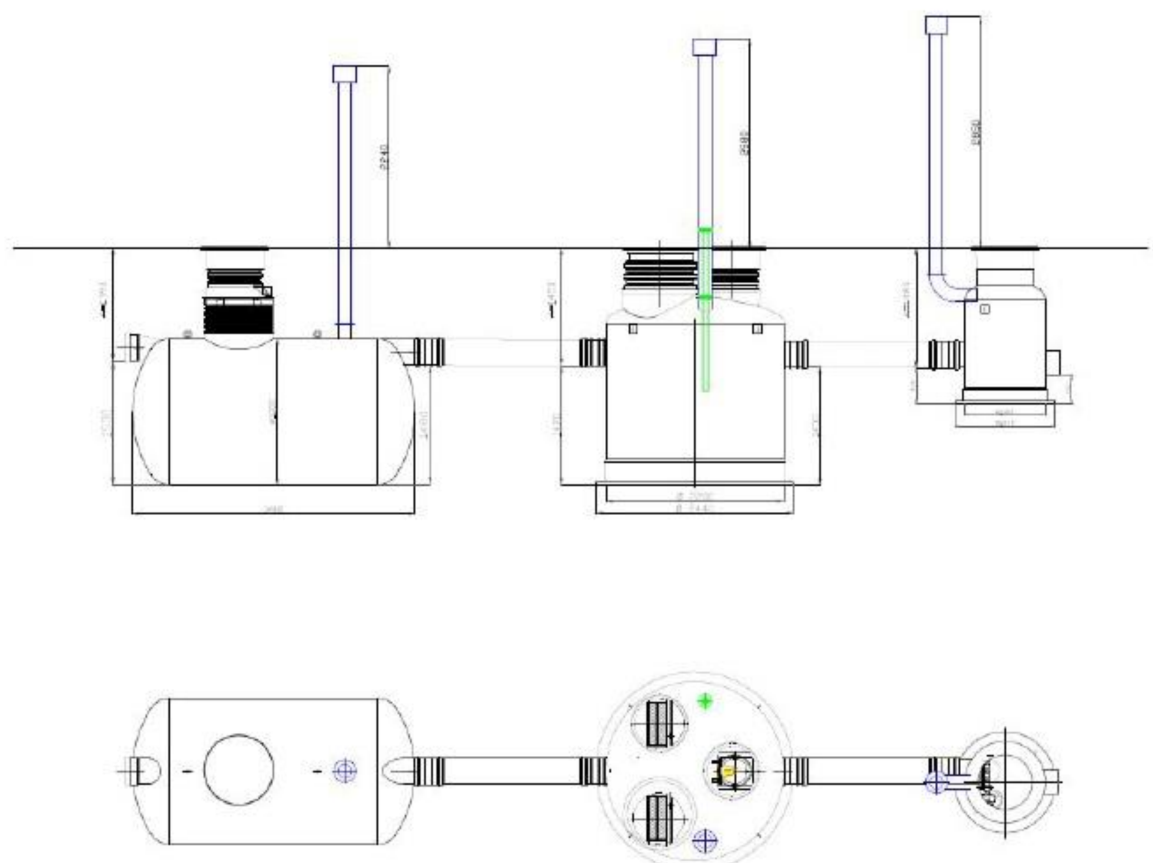
- Normally closed valves must only be opened under supervision.
- All tanks containing hydrocarbons (oily water, sludge, lubricating oil, fuel, etc.) will have an equivalent drainage system. The nearby tanks will use the same drainage channel. If funnels are used after the drain valves (in rows of small tanks, for example) they will be connected with a pipe to the common drainage channel of the tank.
- Drainage channels will be constructed with walls approximately 0.5 meters high to keep pure rainwater and oily waters separate. Rain that falls directly into the drainage channel (in smaller amounts) will be brought to the oily water collector. The minimum area of the bottom of the channel will be 800 x 800 mm to maintain valves and the channel. The drain channel valve will be equipped with an extension arm for easy operation.
- All drain lines will normally be closed to prevent oil dripping out of the area in case the tank spills.
- Pipelines will be separated from the drain channel of the tank and those from the rainwater channel to prevent direct spillage from the tank to the rainwater system.

The oily water management system will be responsible for collecting the oily waters and sludge produced in the plant to be stored in a tank for future disposal and transportation. The sludge will be delivered to a company that has environmental permission for its final treatment and transportation outside the plant.

There will be water oil separator systems to drain water that might have contact with the oils of the equipment.

Figure 3-13 shows the treatment system for the water potentially contaminated with oil. The rain water pass through the sand trap where the particles settle out. When they come out of the sand trap the water is carried to the oil trap where the content of the oil is removed with the help of a coalescer, which separates the oil from the water, the system also includes a container of sampling where samples of the treated water can be taken.

Figure 3-13 – Water-Oil Separator



Source: Wärtsilä 2016

During the operation of the plant, rainwater potentially contaminated with oil will pass through the oil trap to prevent contamination.

In general, contaminated cleaning water from the following areas will also be treated:

1. Powerhouse;
2. Switch control;
3. Turbines;
4. Heat recovery boilers;
5. Stack area;
6. Boiler washing water;
7. Heat recovery system;
8. Compressed air building;
9. External tanks.

The parameters to be measured will be oils and grease and hydrocarbons.

Location of the Environmental Measure

South-west corner of the site of the Thermal Power Station.

Estimated Amount of Environmental Measure

Table 3-41 – Estimated Cost of Environmental Measure - Water-Oil Treatment System

Description	Quantity	Unit	Unit Price	Term (months)	Total
Oil treatment system	1.00	s.g.	$16,000.00	1.00	$ 16,000.00
Monitoring	6.00	c/u	$80.00	1.00	$ 480.00
				TOTAL	**$ 16,480.00**

Source: Elaboration by Consulting Team

3.2.25 Sedimentation / Rain Water Control Pond

Type of measure: The measure is considered as Preventive

Description of measure

To reduce the impact from the generation of increase of rainwater flows in the project, it is necessary to build a detention pond to store the additional volume and discharge only the rain water in the conditions without project.

The calculated flow rate to the ground without project generated by the maximum intensity of rain, 0.17 mm/min, for a return period of 100 years is 179 l/s. The duration of storm used is 24 hours. It is used for the design storm return period of 100 years, according to regulations of the United States, at the request of the holder of the Project.

Within the project area, it generates a total flow of 210 L/s with project. The difference in flow rates between conditions with and without the project, is 0.193 m3/sec for the rest of the field, based on the approved original plan. The maximum daily rainfall data used in this study correspond to the station Acajutla, and are from the 1971-2011 period (41 years). There is no more recent data; however, the analyzed period includes catastrophic weather events, such as IDA (2009), AGHATA (2010) and 12E (2011).

Detention ponds consisting of a pond and a pumping system are proposed, since the point of discharge is at an upper level, in the CEPA drainage channel, on the Boulevard Coronel Oscar Osorio.

Preliminarily, it is expected that the retention pond will have minimum dimensions of 24 x 60 meters at the base and 1.95 meters in height, having a capacity of 2,812.32 m3. These dimensions will be confirmed during the final engineering stage, always maintaining the design criteria mentioned above. The emptying time of the tank will be double the filling, so that the criteria of zero hydrological impact is fulfilled.

The recommended pumping equipment is of submersible type, since it will be submerged inside the pond, Due to the low flow rate and the small hydraulic load that must overcome, a required power of 1.1 HP has been estimated, data to be confirmed in the final design phase. The water will be evacuated in 48 hours.

A solid trap will be installed in the entrance of the rainwater to the ponds, in order to prevent large solids from damaging the pump, it is recommended to use a submersible pump for wastewater, since these have the capacity to handle solid particles up to 2 inches in diameter.

The pond will be periodically inspected to verify that there are no obstructions or excessive sedimentation in the pond. The inspection should be daily in the rainy season, and should be cleaned or removed and sediments when necessary.

The final stormwater management system will consider "low impact development" (LID) techniques such as:

- Reduction of impermeable areas;
- Permeable paving
- currents and bio retention
- Landscaped vegetation

The discharge of the water after the pond will be to the channel of CEPA.

<u>Location of the Environmental Measure</u>
Before discharge in the CEPA Channel at the south of the property and the other pond at the south of the substation.

<u>Estimated Amount of Environmental Measure</u>

Table 3-42 – Estimated Amount of Environmental Measure - Rain Water Control Pond

Description	Quantity	Unit	Unit Price	Term (months)	Total
Pond fot Power House and rest of the property	1.00	total	$10,000.00	1.00	$ 12,000.00
				TOTAL	**$ 12,000.00**

Source: Elaboration by Consulting Team

3.2.26 Fire Protection System

Type of measure: Prevention.

<u>Description of measure</u>
To protect people, employees and the general population by possible events, especially in the handling of hazardous materials, such as LNG and other materials that will used in the project in the phase of operation.

Firefighting equipment will be detailed later, as specified in the design of the firefighting system.

<u>Location of the environmental measure</u>
Thermal Power Plant in General.

Estimated Amount of Environmental Measure

Table 3-43 – Estimated Amount of Environmental Measure - Fire Protection System					
Description	**Quantity**	**Unit**	**Unit Price**	**Term (months)**	**Total**
Portable fire extinguisher 5Kg, CO2	11	each	$35.00	1.00	$ 385.00
Portable fire extinguisher 20Kg, CO2	2	each	$90.00	1.00	$ 180.00
Portable fire extinguisher 12Kg, ABC	52	each	$60.00	1.00	$ 3,120.00
Portable fire extinguisher 6Kg, ABC	10	each	$35.00	1.00	$ 350.00
25 m hose	4	each	$300.00	1.00	$ 1,200.00
Blanket against fire	1	each	$60.00	1.00	$ 60.00
External hydrants	12	each	$1,850.00	1.00	$ 22,200.00
External hose enclosure	12	each	$450.00	1.00	$ 5,400.00
Valves for hydrant	12	each	$1,200.00	1.00	$ 14,400.00
Self-supporting hose enclosure	12	each	$500.00	1.00	$ 6,000.00
Foam mobile unit	6	each	$11,000.00	1.00	$ 66,000.00
				TOTAL	**$ 119,295.00**

Note: water tank, pipes and sprinkler systems are not included.

Source: Wärtsila 2016

Detailed information on the fire system is included in Appendix 10D.

3.2.27 Leak Detection System

Type of Measure: Prevention.

Description of measure

Installation of fixed equipment for detection of vapors

Gas detectors shall be installed within the facilities of the Thermal Power Plant, as established in Article 23, literal k) of the Regulation for the Application of the Law Regulating the Deposit, Transport and Distribution of Petroleum Products. These detectors will be of the intelligent, addressable type and with Infra-Red or Ultra Violet technology. The detectors send information to the control room permanently. The equipment that is detailed will be installed:

- 8 Around the Powerhouse
- 4 in CEPA dock;
- 4 on main land.

In total, 16 fixed vapor detectors will be installed.

The detectors send information to the control room permanently, and are reviewed and calibrated every six months.

Acquisition of portable equipment for detection of vapors
Another mechanism to detect LNG leaks will be by constant monitoring of pressure in tanks and pipes, which, upon detecting an uncontrolled pressure drop, will automatically close the affected equipment-section. In addition, periodic inspections will be carried out with portable explosive gas detection instruments and oxygen meters.

The acquisition of four explosive gas detectors and four oxygen meters will be made.

<u>Location of the Environmental Measure</u>
Thermal Power Plant in general (See Figure 3-17)

<u>Estimated Amount of Environmental Measure</u>

Table 3-44 – Estimated Amount of Environmental Measure - Leak Detection System

Description	Quantity	Unit	Unit Price	Term (months)	Total
Detection system	16.00	s.g	$500.00	1.00	$ 8,000.00
Explosive gas detectors and oxygen meter	4.00	each	$2,000.00	1.00	$ 8,000.00
				TOTAL	**$ 16,000.00**

Source: Elaboration by Consulting Team

3.2.28 Well Flow Monitoring Equipment and Monitoring Wells

Type of measure: Prevention

<u>Description of measure</u>
Objetive
Check the water flows extracted from the wells to be drilled to supply water to the plant.

Description
Installation of three water meters with flange of 2" and multi-jet standard pressure. To ensure the proper functioning of the macrometers installed, the maintenance described below will be performed.

- Preventive maintenance consists of suspending the supply, disassembling the meter and checking its parts to locate wear or burns that require its change. Proceed to adjust all its parts and if necessary calibrate to ensure its accuracy. Still, it is better to change the piece of measurement to another one that has been calibrated previously in the workshop, to guarantee its good functioning;
- The meters should be read at a frequency that allows to be aware of any irregularities such as backsliding or stoppages which may represent problems for the water supply. Every 1000 m3 is a figure that can serve as a guide and if the daily consumption is higher, then, reading every day will be recommended;
- The meter must be repaired, usually "in situ", it is immediately detected that it is failing or in bad condition.

Depending on the admissible flow registered, the following shall be done:

a. Maintenance must be done every two years when the meter registers 50% of the permissible flow per month. That is, we have Qn = Nominal flow rate, Qa = Permissible flow rate = Qn / 3

$$Q_t = Caudal\ total\ mes = \frac{Q_n}{3} \times 24 \times 30$$

When the total monthly consumption is half Qt or less, preventive maintenance can be done every two years.

b. When the total monthly consumption is between 50% and 75% of Qt, maintenance should be done every six months.
c. When it is above 75% it should be maintained every two months and presumably before, since at that rate it is expected to be damaged frequently. Consider placing another meter with a higher rated capacity. If the meter is frequently damaged, it is necessary to replace it with a higher nominal capacity.

The water quality of the well will also be monitored, in the well and in the monitoring wells. Parameters to be monitored include static level, temperature, conductivity and solids, as well as contaminants such as greases and oils (to determine hydrocarbons). As part of the salt intrusion control, the well will be monitored every six months for the following parameters: Calcium, magnesium, potassium, sodium, phosphates, sulfides and chlorides.

Monitoring Wells

In order to perform a continuous monitoring and verify that there is no risk of saline intrusion in the aquifer, it is proposed to construct two monitoring wells. The characteristics of each monitoring well to be drilled are as follows:

- Overall depth: 100 meters.
- Perforation Diameter: 10 inches.
- Coating Diameter: 6 inches
- Probable Static Level: 25 to 30 meters.

In the wells will be installed piezometric tubes for the monitoring of levels.

The chemical change in water will be reflected by an increase in the value of Electrical Conductivity, Total Dissolved Solids and Temperature.

It is possible to maintain control of these basic parameters by the installation of equipment with a continuous logging equipment known as Data Logger (Figure 3-14).

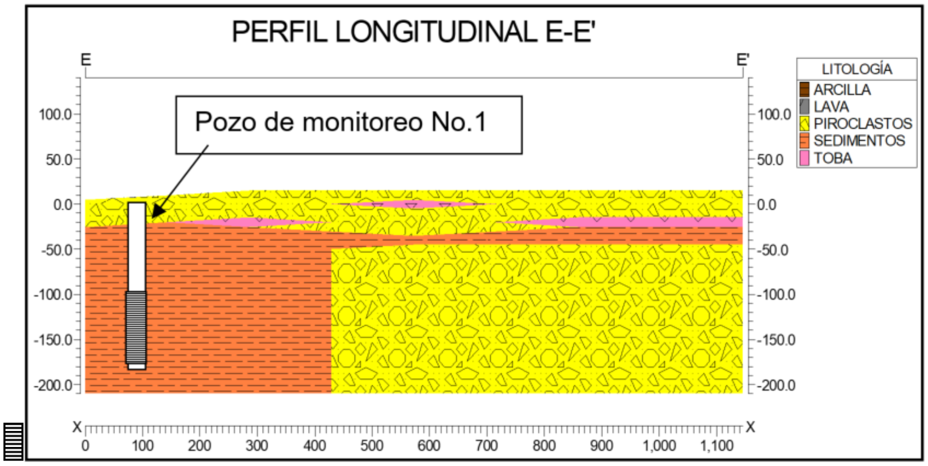
Figure 3-14– Data Logger

Source: http://www.solinst.com/products/dataloggers-and-telemetry/3001-levelogger-series/levelogger-junior-edge/datasheet.php

In any case, due to the increase in the volume of exploitation in the area, it will be beneficial for all to maintain a monitoring of the basic physico-chemical parameters of the groundwater of the aquifer used. The aquifer that should be monitored are the alluvial sediments that can be observed in the Profile E-E ' (

Figure 3-15).

Figure 3-15– Longitudinal profile E-E 'Location of monitoring well No.1



Perfil longitudinal = Longitudinal profile, Pozo de monitoreo = Monitoring well, Litología= Lithology, Arcilla= clay, lava=lava , piroclastios = pyroclstic, sedimentos=sediments, toba= tuff

Source: Hydrogeological Study of the Project

In this case, a piezometer nest is not required because the aquifer to be monitored is only one.

The electrical conductivity of seawater is very high compared to fresh water, it ranges from 50,000 µS / cm to 60,000 µS / cm. An increase in the electrical conductivity of water extracted from a well is not necessarily related to saline intrusion; however, in the case of coastal aquifers it is most likely.

The total dissolved solids of the seawater present a value close to 35,000 mg / L, evidently an increase of this parameter due to saline intrusion would be very easy to detect with a continuous monitoring.

The temperature in the groundwater will increase if the flows come from a greater depth. If there is an increase in the electrical conductivity of the water and an increase of the total dissolved solids, but if this variation is accompanied by an increase in the temperature of the extracted water; then, probably the explanation is that a deeper water flow has been induced by means of pumping and not necessarily an intrusion of sea water.

Therefore, it is evident that a constant monitoring of these basic parameters is required, any anomaly will be detected promptly and will facilitate the attenuation of the harmful effects of the phenomenon. On the other hand, as is to be expected, variations in water quality are very important for the evaluation of saline intrusion, there are ionic relations that serve to detect the phenomenon, and that can be used for assessment.

The main ones are the following:

- Chloride / Bicarbonate Ratio: rCl / rHCO3: In sea water, its values range from 20 to 50, while in fresh waters varies from 0.1 to 5.0. Therefore, monitoring of the chloride and bicarbonate ions must be carried.
- Sulphates / Chlorides ratio: rSO42- / rCl-: It is of great interest to identify the process of marine intrusion since it has a characteristic value (0.1) in sea water. An approximation of the values of this relation in the water of the aquifer can be an indication of contamination by sea water.
- Magnesium / Calcium Ratio: rMg2 + / rCa2 +: In sea water reaches values around 5, while in fresh water it is 0.3 to 1.5.

Therefore, it is considered basic that in the Project wells are monitored the following ions: Chlorides, Bicarbonates, Sulphates, Magnesium and Calcium.

The frequency of sampling should be at least once a month, so that any anomaly that may exist in the quality of the water extracted in the production Wells can be identified.

It is important to define the objectives of monitoring, basically it is necessary to know if the exploitation of wells in the area is producing the Saline Intrusion phenomenon. The control of marine intrusion, will be beneficial not only for the Project, but for the different uses in that area. Aquifer sector where there is several wells.

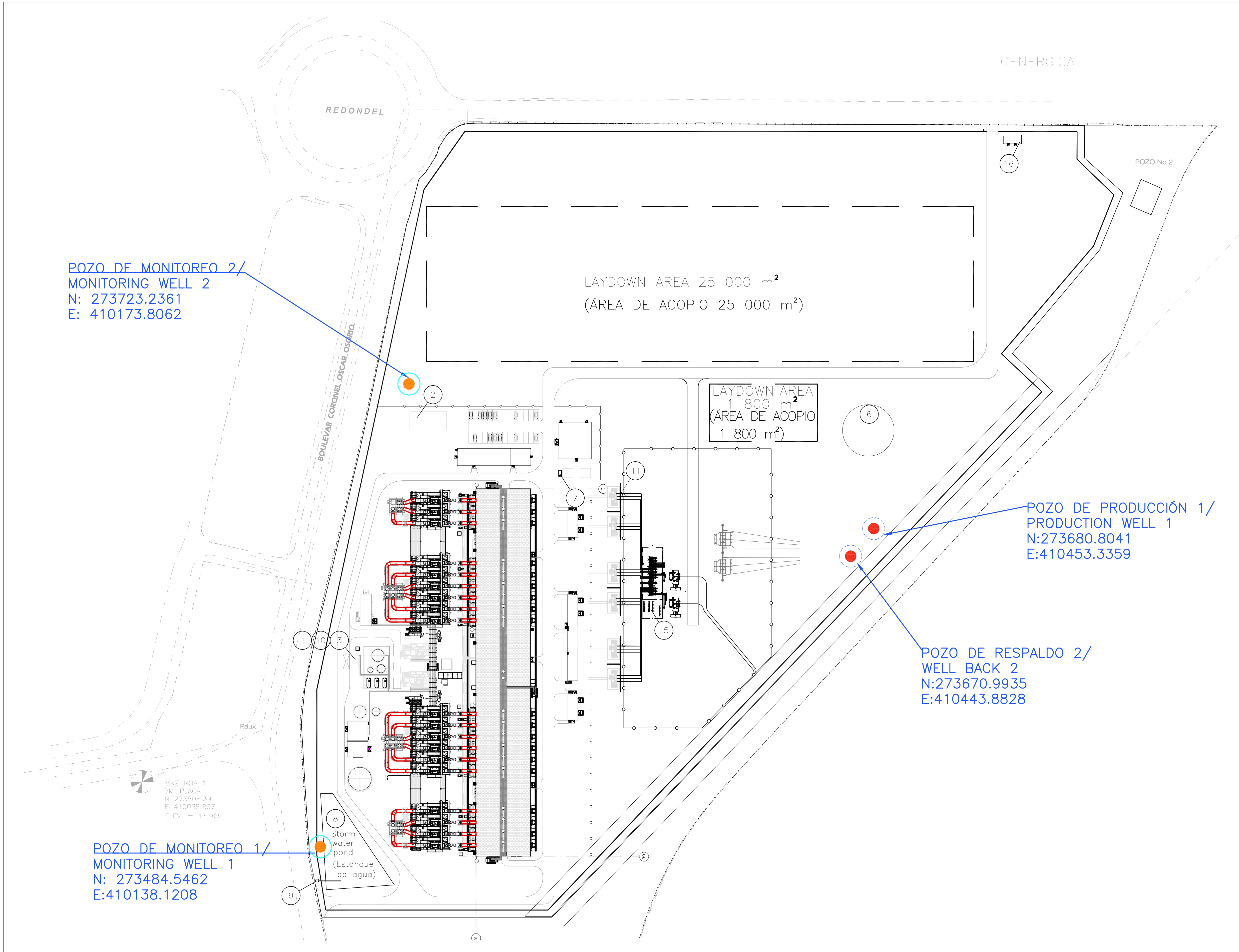
<u>Location of the Measure</u>
Figure 10-16 details the location of the extraction well and monitoring wells.

<u>Estimated Amount of Environmental Measure</u>

Table 3-45 – Estimated Amount of Environmental Measure - Well Flow Equipment Monitoring

Description	Quantity	Unit	Unit Price	Term (months)	Total
Installation of flow macrometers	2.00	each	$ 650.00	1.00	$ 1,300.00
Analysis to determine saline intrusion	1.00	each	$ 75.00	4.00	$ 300.00
Placement of piezometric tubes and monitoring	3.00	each	$ 100.00	5.00	$ 1,500.00
TOTAL					$ 3,100.00

Source: Elaboration by Consulting Team



Energía del Pacífico

ENERGÍA DEL PACÍFICO

LNG TO POWER PROJECT

UBICACIÓN DE POZOS DE EXTRACCIÓN Y POZOS DE MONITOREO / LOCATION OF EXTRACTION WELLS AND WELLS OF MONITORING

FIGURA 3.16 / FIGURE 3.16

0 10 20 30 40 50m

N W E S

FUENTE / SOURCE:
PLANOS WARTSILA / WARTSILA SITE PLAN

MAPA CREADO POR / MAP CREATED BY: ECO INGENIEROS
MAPA REVISADO POR / MAP CHECKED BY: LF
PROYECCIÓN DE MAPA / MAP PROJECTION :
UTM ZONA 16 WGS84 / UTM ZONE 16 WGS84

ARCHIVO / FILE
C:/ECO,DRAWING 1, EL SALVADOR/ ECO INGENIEROS
C:/ECO,DIBUJO 1, EL SALVADOR/ ECO INGENIEROS

PROYECTO / PROJECT: 14-9114
ESTADO / STATUS : FINAL / FINAL
FECHA / DATE: 20/12/2017

DILLON CONSULTING

ECO INGENIEROS

3.2.29 Disease Vector Minimization

Type of measure: Prevention

Description of measure

It is intended to prevent the proliferation of disease vectors. Efforts will be made to minimize / eliminate stagnant water areas and train employees to minimize vector sites.

Location of Measure

All lands of the Project

Estimated amount of the environmental measure

Table 3-46 – Estimated Amount of Environmental Measure – Disease Vector Minimization Measure

Description	Quantity	Unit	Unit price	Term (months)	Total
Employee training, a talk every three months	1	s.g	$200.00	12.00	$ 2,400.00
				TOTAL	**$ 2,400.00**

Source: Elaboration by Consulting Team

3.2.30 Marine Wildlife Rescue Center

Type of measure: Attenuation.

Description of Measure

A Marine Wildlife Rescue Center will be set up in collaboration with MARN for the recovery of marine animals that could be affected during the construction of the project.

A rescue center is dedicated to recovering, restoring, the health of stranded or sick animals. The fauna for which this type of facilities is required are: birds of aquatic habitats, dolphins, sea turtles and sea lions.

• Sea turtle zone.

An area under shade will be installed, where sea turtles will be kept. The material and equipment considered includes the installation of 3 fiberglass ponds of 2.0 m in diameter and a height of 1 meter with a pvc valve in the center to facilitate the replacement of sea water. It will have fresh and filtered seawater filling pipe of suspended particles. With a basic hydraulic system that allows the entrance of filtered sea water and filtered outlet (sand filter) of the same. (See photograph 3-2)

Photograph 3.2 Example of a Turtle Tank

At least 3 cylinders of fiberglass or plastic 1 m maximum diameter and 15 cm high, to treat turtles out of water. Tables for turtle cures will also be required, which may be the same table for curing other animals and small buckets to keep the turtles out of the water. (See Photograph 3.3) And the following supplies: 20 towels, ten 5 gallon buckets with lid, 5 plastic brushes with extension stick for cleaning.

Photograph 3.3 Example of a Tank for turtles out of water

• Dolphins

At least two ponds of greater volume than sea turtles are required. Preferably dug in the ground and roofed, with walls and insulated. Or glass fiber resistant to the volume of water. Dimensions: 1.10 m depth and 5 m long, 2.5 m wide, with a division in the middle, to accommodate two small dolphins. Or also circular ponds of 4 to 5 m in diameter. It must have evacuation valve and for filling with filtered sea water, and sand filter for the evacuation of the water. Cost: $ 6000 to 12,000 approx. (See photograph 3-4).

Dolphins require a larger pond, 6m in diameter. In addition to a stainless steel pushchair with canvas stretcher to move dolphins to and from the ponds. That can lift and carry 500 pounds of weight. A pressure hose wash system for ponds. And a sand filter at the water outlet as a purification method, to remove suspended solids from the water. As a monitoring, a register of treated animals will be kept.

Photograph 3.4 Example of tank for dolphins

Location of the Environmental Measure

Rented house near the coast.

Estimated Amount of Environmental Measure

Table 3-47 – Estimated Amount of the Environmental Measure – Fauna Rescue Center					
Description	**Quantity**	**Unit**	**Unit Price**	**Term (month)**	**Total**
Cylinders for turtles	3	c/u	$3,000.00	1	$9,000.00
Hydraulic system	1	Global sum	$3,000.00	1	$3,000.00
Working table	1	c/u	$100.00	1	$100.00
Towels, buckets, brushes	2	Global sum	$200.00	1	$400.00
Tank for dolphins	2	c/u	$6,000.00	1	$12,000.00
Stainless steel pushchair with canvas stretcher	2	c/u	$1,000.00	1	$2,000.00
Operations	18	months	$600.00	1	$10,800.00
				TOTAL	**$37,300.00**

Source: Consulting team

3.2.31 Corals Monitoring

Type of measure: Prevention.

Description of Measure

Due to the proximity of corals to the construction site, it is proposed to monitor the state of the corals in the area, specifically at the site of sunken ship, south of the location of FSRU and Pipeline.

The procedure is described:

1. The stony and soft corals of interest are located to monitor (one to two species maximum with three to five specimens of each species located and identified).
2. They will be photographed, and their physiognomy (coloration, herbivory, whitening%, habitat, surrounding species, sand or mud cover), perimeter, diameter and height will be registeres and measured, for individual hard corals and/or colonial. Size of base, width and height will be registered for soft corals.
3. Points one and two will be the baseline for monitoring.
4. The sites selected to be monitored must comply with the regulation requirement to avoid 100% fishing by trawlers, harpoons, chisel and hammer of the oysters.

Three sites of 100 m^2 each are proposed, prohibiting the access of people outside the monitoring. The closest sites to EDP project and where monitoring is proposed, comprise where the ships are sunk between the EDP project and the industrial pier.

Sampling will be performed:

1. Prior to the beginning of work at sea.
2. Prior to the start of dredging activities.
3. Half of dredging activities.
4. At the end of the dredging activities.
5. At the end of the construction at the sea

Location of the Environmental Measure

Points at sinking boats locations.

Estimated Amount of Environmental Measure

Table 3-48 – Estimated Amount of Environmental Measure– Corals Monitoring

Description	Quantity	Unit	Unit Price	Term (months)	Total
Monitoring of stone and soft corals	3.00	Monitoring points	$2,500.00	5.00	$ 12,500.00
				TOTAL	**$ 12,500.00**

Source: Consulting Team

3.2.32 Detailed Risk Assessment and Contingency Plan

Type of measure: Prevention.

Description of Measure

Objective

Prevent damage to people, employees in general for possible events occur.

Description

Carry out a detailed risk assessment as part of the detailed design work and the development of the Major Risk Contingency and Risk Planning Plan. Further details are given in Appendix 4B and summarize in Table 3-50.

Table 3-49 – Additional Security Studies to be carried out	
STUDY	**DESCRIPTION**
Detailed engineering	
Hazard and Operability study (HAZOP)	HAZOP evaluates the top processing systems to identify the risks to people (employees and public), the environment and assets. This workshop identifies potential risks with a primary focus on process systems. The top-level processes, cargo systems and main FSRU public service systems have been reviewed.
Analysis of fallen objects	It evaluates and quantitatively reviews the risk of fallen objects scenarios (e.g. material handling study) during normal operations for the marine terminal. The risk of fallen objects is reflected in the detailed QRA.
Fire and Explosion Analysis (FERA)	The possible fire and explosion scenarios identified in HAZID and HAZOP are detailed in the quantitative FERA study. The study will include gas dispersion analysis. In particular, for the explosion risk assessment, a 3D computational fluid dynamics (CFD) study is required in the detailed design taking into account design details and congestion. The FERA study confirms dimensional accidental loads (DAL) for critical targets to be taken into account in the detailed design to achieve ALARP risk for possible fire and explosion scenarios. The study can also model the effects of smoke, thermal radiation, and overpressure with respect to evacuation and escape routes from facilities.
Cryogenic spill analysis	In addition to the possible scenarios of cryogenic spillage (loss of containment) identified in HAZID and HAZOP, a detailed quantitative study is required for FSRU and load operations to analyze the risk of cryogenic spillage. This study confirms the dimensions required for the containment of accidental cryogenic spills that must be taken into account in the detailed design to achieve ALARP.

Table 3-49 – Additional Security Studies to be carried out	
STUDY	**DESCRIPTION**
Ventilation dispersion analysis	Ventilation dispersion analysis will model the effects of ventilating the process (natural gas) in the FSRU during an emergency, given the rates of operating scenarios in a range of weather conditions. Modeling of LNG vapor emissions enables the assessment of whether the respective LNG vapor cloud is compatible with the design of the FSRU / terminal.
Finite element for the collision of the ship	An analysis of finite elements was performed for the respective consequence of the impact of a potential collision on the LNGC and / or FSRU.
Detailed QRA	Evaluates the risk and impacts of hazardous events on staff, people (public) and the environment for the specific location of the project in El Salvador. All risks to the public and the environment must be within the ALARP range.
Escape, Evacuation and Rescue Analysis (EERA)	It evaluates qualitatively the effectiveness of the facilities, evacuation and rescue. In addition, the potential risk for the loss of integrity of the escape routes of the FSRU / marine facility is ALARP for the FERA scenarios are evaluated quantitatively. The FERA scenarios and the CFD calculations are used as input for this analysis to estimate the risk.
Contingency Planning	Plan the response to abnormal events when they occur.
As low as reasonably practicable (ALARP)	This study examines and discusses the main mitigation measures to achieve ALARP for marine facilities in normal operation (GNLC and FSRU). It assesses whether sufficient risk mitigation measures are in place to meet the least cost principle.
Port Facility Security Assessment (PFSA)	It ensures that the physical security infrastructure included with the project is the most appropriate and that all the detailed design features of the security systems are included as accurately as possible. Made for installations according to the ISPS code.
Operations	
Emergency preparedness/ contingency plan	Ensures that risk mitigation, preparedness, response and recovery are in place to lessen the impacts of abnormal events.
Performance Monitoring	Demonstrates that arrangements exist to monitor HSE performance.
Occupational safety / risk analysis	Identifies hazards of specific tasks to reduce the risk of injury to workers.
Spill prevention and control plan	Document the procedures to be followed to avoid spills and response in the occurrence of a spill.
Boats Safety Plan	It provides prevention and early detection of attacks and improved surveillance coverage, detection equipment, lighting use and crew responses.

Source: Contingency Plan, EDP

If after completing the detailed studies, it is determined that the Iso risk limits defined in the QRA for the FEED stage are exceeded, measures and actions should be defined to ensure that areas of public access, outside the property of (1 E-06 per year) "0 ALARP (as low as reasonably practicable), (1 E-06 per year <IR <1 E- 04 per year).

All studies will be presented to the Ministry of Environment and Natural Resources, with the results of the studies and the proposed measures to reduce the risk, if they are determined that these are necessary.

Location of the Environmental Measure

FSRU, pipeline and Thermal Power Plant.

Estimated Amount of Environmental Measure

Table 3-50 – Estimated Amount of Environmental Measure – Additional Risks Study

Description	Quantity	Unit	Unit Price	Term (months)	Total
Risk assessment and contingency plan, including training and drills	1.00	Global sum	$100,000.00	1.00	$ 100,000.00
				TOTAL	**$ 100,000.00**

Source: Elaboration by Consulting Team

3.2.33 Tsunami Alert system

Type of measure: Prevention.

Description of Measure

Objective

Prevent damage in general to people, employees, in case of tsunami.

Description of Measure

The project site is subject to tsunamis generated by both local and distant earthquakes. Information about a distant earthquake and possible tsunami is done through the Pacific Tsunami Warning Center (PTWC) administered by the National Oceanic and Atmospheric Administration (NOAA). This information will be provided approximately 90 minutes prior to arrival for the nearest distant source in North of South America. Distant source earthquakes are expected to produce current wave heights and speeds well below design levels.

Local earthquakes have the potential to generate large tsunamis. The initial tsunami at the site may be detectable 30 minutes after the earthquake. Design heights and maximum currents can occur as early as 60 minutes after the earthquake. The flow properties between the initial wave arrival time period and the maximum design conditions will be very variable, changing between relatively calm conditions to near design conditions for periods of 5-10 minutes. Warning of tsunami hazard potential at the project site should be based on the magnitude of the earthquake and location, the depth of the earthquake, the duration of the earthquake rupture, and the detection of tsunami at or near the sea. The fault zone in this region of Central America is known to produce "slow" tsunamigenes, with the implication that early magnitude estimates (within 30 minutes of the event) can be very poor. Therefore, initial decisions regarding tsunami-related responses should be based on the duration of the local earthquake, with information available on the depth of the earthquake, the location of the epicenter, the magnitude and the near tsunami observations used as secondary decision data.

The EDP's tsunami warning system, which will be independent of the PTWC, will consist of three main features: seismic detection instruments installed on the ground at the project site, national seismological information and a decision tree developed that will use the data mentioned to determine the seismic activity, and later the course of action, that is, the need for immediate preparations for the LNGC exit, etc.

EDP will request that it be added to the list of recipients of the MARN seismological monitoring and reporting system. The information of this system: the duration, magnitude, depth and epicenter of the earthquake will be processed in the decision tree of the EDP tsunami for local events. For additional information and confirmation of events, an seismic measurement instrument will be installed on an accelerometer on the ground at the project site. This seismic measurement instrument specific accelerometer of the project will provide estimates of the duration of the earthquake and will be used to determine the initial preparatory actions of the maritime terminals. It is important to note that this accelerometer measuring instrument local seismic accelerometer will provide the local duration of the shake, which will be greater than the duration of the earthquake rupture; The difference in these two values will depend on the distance between the earthquake and the project site. Other measures would be based on the information provided by MARN seismic surveillance, which will include a greater estimate of the duration of the breach of confidence.
A decision tree will be developed, based on the local duration of the agitation and the duration of the rupture. In conclusion:

- A tsunami detection system will be installed at the FSRU and onshore.
- Elaboration of an action protocol and connection of the project to the civil protection communications network.

Location of the Environmental Measure

FSRU control center and measuring instruments installed onshore at the project site.

Estimated Amount of Environmental Measure

Table 3-51 – Estimated Amount of Environmental Measure – Tsunami Alert System

Description	Quantity	Unit	Unit Price	Term (months)	Total
Installation of seismic detection instruments	1.00	Global sum	$0.00	1.00	$ 0.00 (Included within project costs)
Action Protocol	1.00	Global sum	$3,000.00	1.00	$3,000.00
				TOTAL	**$ 3,000.00**

Source: Consulting Team

3.2.34 Insulation Valve Installation

Type of measure: Prevention.

Description of Measure

Objective

Prevent damage to persons, employees in general due to possible leakage events, by decreasing the volume of gas leaking from the pipelines.

Description

Installation of ground isolation valve to reduce the inventory of piped gas that can be released in case of a leakage event.

The piping shall be provided with a high integrity emergency isolation valve, with fire safety and tight closure to minimize the release of hydrocarbons and prevent scaled damages.

Location of the Environmental Measure

Ground pipe inlet.

Estimated Amount of Environmental Measure

Table 3-52 – Estimated Amount of Environmental Measure – Insulation Valve Installation					
Description	**Quantity**	**Unit**	**Unit Price**	**Term (months)**	**Total**
Installation of Ground Insulation Valve	1.00	Global sum	$30,000.00	1.00	$ 30,000.00
				TOTAL	**$ 30,000.00**

Source: Consulting Team

3.2.35 Environmental Measures Plan

Figure 3-17 and Figure 3-18 present the location of environmental measures for the construction phase, for the Thermal Power Plant and the FSRU-Pipeline.

3.2.36 Summary of the Environmental Management Program during the Construction Phase

The Environmental Management Program (EMP) is to prevent, mitigate and compensate for the negative impacts that the Project activities will generate on the environment. The Environmental Management Program basically consists of:

Environmental Management Plan
A summary table 3-53 containing all the measures proposed above is presented, with the respective actions required for each one, including implementation costs.

Monitoring Program
In Table 3-54, provides an overview of identified impacts, both positive and negative, proposed mitigation measures for each impact and displays the Environmental monitoring required for the construction phase.

Schedule for the implementation of measures and investments.
The implementation of the measures has been programmed, according to the development of the Project.

The summary of the Environmental Management Plan, monitoring plan and timetable for the application of environmental measures, for the CONSTRUCTION PHASE are included in tables 3-53, 3-54 and 3-55. The environmental bond has been quantified for an investment cost of **EIGHT HUNDRED SEVENTY THREE TOUSAND AND SEVEN HUNDRED AND THIRTY TREE 60/100 DOLLARS ($ 873,733.60).**

Energía del Pacífico

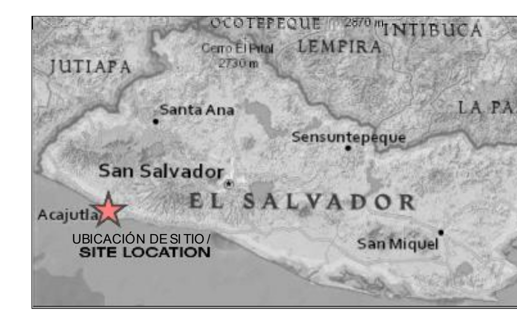
ENERGÍA DEL PACÍFICO

LNG TO POWER PROJECT

MEDIDAS AMBIENTALES EN CONSTRUCCIÓN / ENVIRONMENTAL MEASURES IN CONSTRUCTION

FIGURA 3.17 / FIGURE 3.17

SIMBOLOGÍA / SYMBOLS	UBICACIÓN DE MEDIDAS / MEASURES OF LOCATION	CONTENIDO DE MEDIDAS / CONTENT OF MEASURES
	MEDIDA 5 / MEASURE 5	MANEJO Y ALMACENAMIENTO DE MATERIALES PELIGROSOS / HANDLING AND STORAGE OF HAZARDOUS MATERIALS
	MEDIDA 6 / MEASURE 6	TRATAMIENTO DE AGUAS RESIDUALES DOMESTICAS / DOMESTIC WASTE WATER TREATMENT
	MEDIDA 11 / MEASURE 11	REFORESTACIÓN APOYO A FIAES / REFORESTATION SUPPORT FOR FIAES
	MEDIDA 21 / MEASURE 21	BARRERA DE SEGURIDAD DE TUBERÍA / BARRIER FOR SAFETY
	MEDIDA 23 / MEASURE 23	CONSTRUCCIÓN DE SISTEMA DE TRATAMIENTO DE AGUAS RESIDUALES / CONSTRUCTION OF WASTEWATER TREATMENT PLANT
	MEDIDA 24 / MEASURE 24	SEPARADOR DE AGUA – ACEITE / WATER – OIL SEPARATOR
	MEDIDA 25 / MEASURE 25	TANQUE SEDIMENTADOR/AMORTIGUADOR DE AGUA / SEDIMENTATION/BUFFER TANK FOR RAINWATER
	MEDIDA 26 / MEASURE 26	SISTEMA DE PROTECCIÓN CONTRA INCENDIOS / FIRE PROTECTION SYSTEM
	MEDIDA 27 / MEASURE 27	SISTEMA DE DETECCIÓN DE FUGAS / LEAK DETECTION SYSTEM
	MEDIDA 28 / MEASURE 28	EQUIPO DE MONITOREO DEL CAUDAL DEL POZO / MONITORING EQUIPMENT FOR THE WATER WELL AND MONITORING WELLS
	MEDIDA 34 / MEASURE 34	INSTALACIÓN DE VÁLVULA DE AISLAMIENTO (ENTRADA DE TUBERÍA A TIERRA) / INSULATION VALVE INSTALLATION (PIPE ENTRY TO GROUND)



0 10 20 30 40 50m

FUENTE / SOURCE:
PLANOS WARTSILA / WARTSILA SITE PLAN

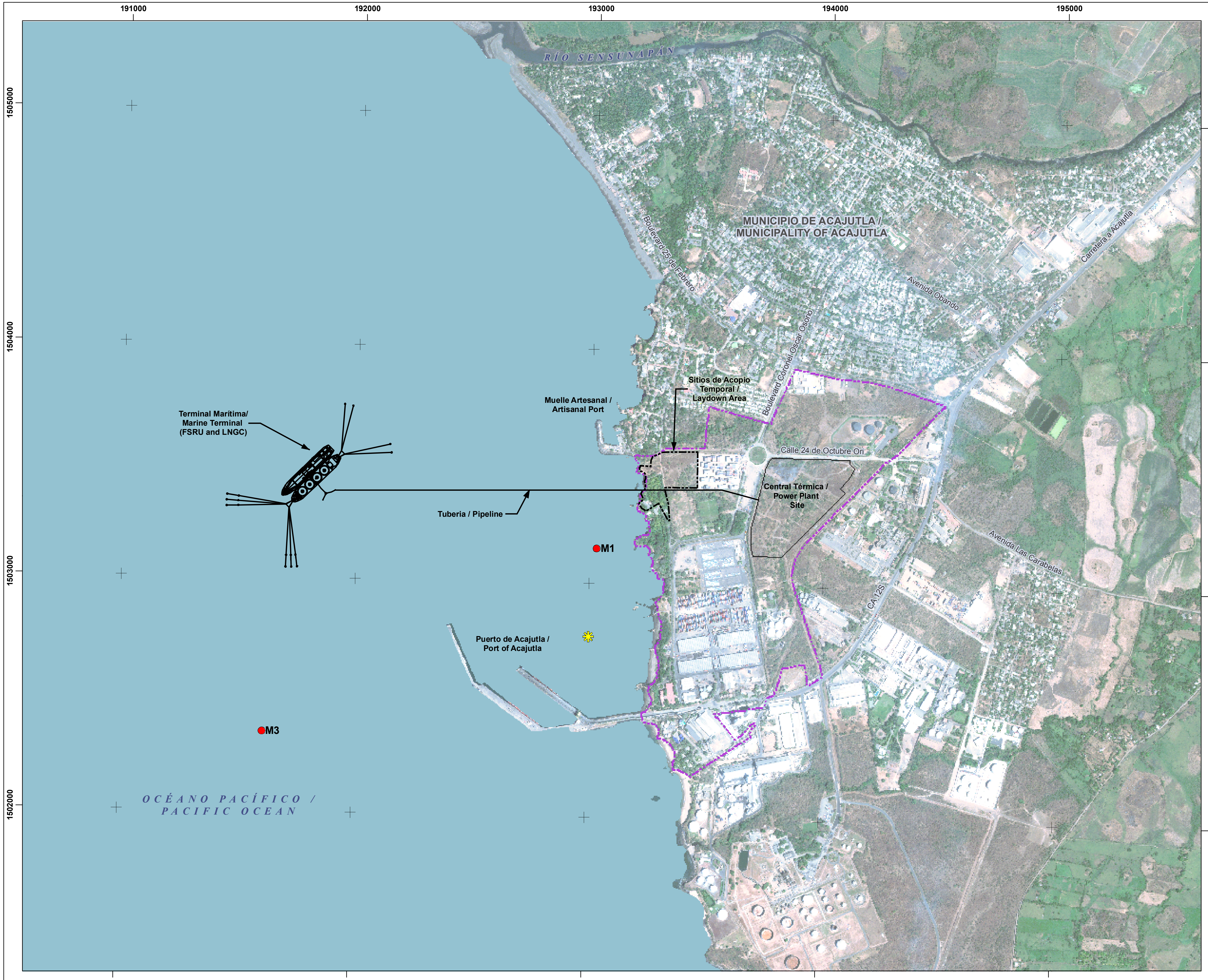
MAPA CREADO POR / MAP CREATED BY: ECO INGENIEROS
MAPA REVISADO POR / MAP CHECKED BY: LF
PROYECCIÓN DE MAPA / MAP PROJECTION :
UTM ZONA 16 WGS84 / UTM ZONE 16 WGS84

ARCHIVO / FILE
C:/ECO,DRAWING 1, EL SALVADOR/ ECO INGENIEROS
C:/ECO,DIBUJO 1, EL SALVADOR/ ECO INGENIEROS

PROYECTO / PROJECT: 14-9114
ESTADO / STATUS : FINAL / FINAL
FECHA / DATE: 02/02/2018

DILLON CONSULTING

ECO INGENIEROS



Energía del Pacífico

ENERGÍA DEL PACÍFICO

LNG TO POWER PROJECT

MEDIDAS AMBIENTALES/ ENVIRONMENTAL MITIGATION MEASURES

FIGURA 3.18 / FIGURE 3.18

- MONITORERO DEL LA TURBIDEZ AND BIOMONITOREO DE OSTRAS/TURBIDITY MONITORING AND OYSTER BIOMONITORING (MEDIDA 34)
- MONITOREO DE CORALES/ CORAL MONITORING (MEDIDA 34)
- SITIO DEL PROYECTO / PROJECT SITE
- SITIO DE ACOPIO TEMPORAL / TEMPORARY LAYDOWN AREA
- TERRENO PROPIEDA DE CEPA / CEPA PROPERTY

0 100 200 400 m

1:16,000

N W E S

FUENTE / REFERENCE
VISIÓN DEL MUNDO 2 IMÁGENES DE ALTA RESOLUCIÓN / WORLDVIEW 2 HIGH RESOLUTION IMAGERY (2014-02-12)

MAPA CREADO POR / MAP CREATED BY: PFM/SFG
MAPA REVISADO POR / MAP CHECKED BY: MW
PROYECCIÓN DE MAPA / MAP PROJECTION: UTM ZONE 16 WGS84

PROYECTO / PROJECT: 163489
ESTADO / STATUS: FINAL / FINAL
FECHA / DATE: 2/7/2018

DILLON CONSULTING

ECO INGENIEROS
LÍDERES EN CONSULTORÍA AMBIENTAL

ARCHIVO / FILE: I:\GIS\163489 Acajutla\GIS\MXDs\Reporting - 2016.10-18 - Environmental Mitigation Measures.mxd

Table 3-53 – Environmental Management Program, Construction Phase

Execution Phase	Project Activity	Description of Generated Environmental Impact	Environmental Measure (Prevention, Attenuation, Compensation)	Description of Proposed Measure	Location of the Environmental Measure	Responsible for its execution	Calculated Amount of Environmental Measure	Time of execution	Expected result
Site Preparation, Construction and Closing	• Operation of stationary generators • Operation of the mobile motorized equipment • Cutting and logging • Excavation work • General construction activities • Construction related to traffic	• Exposure of workers and the public to the emission of air pollutants • GHG emissions	**Attenuation** ***1.*** **Reduction of air emissions**	Develop a Maintenance Plan that considers: • Maintenance program, • Control / monitoring system • Location of stationary generators 50 m from the northern boundary of the site • Anti-shutdown protocol • Use of buses to transport workers from outside Acajutla to the site from the main cities	Project site area and transport and haul routes	EDP	$2,000.00	During construction	No significant impact on air quality and the reduction of emissions of greenhouse gases from the transport of workers
Site Preparation, Construction and Closing	• Clearance • Excavation works • General construction activities • Traffic related to construction	• Migration of dust emissions to off-site receptors	**Prevention** **2. Dust management plan**	Dust Management Plan including: • Irrigation of water in internal streets of the project during dry season • Site exit control (wheel washing, surface hardening) • Stabilize storage areas • Speed limits on internal roads • Truck covers	Project site, temporary storage site, main transport routes and material haulage	EDP	$54,012.00	During construction	Prevent short-term dust increase in the vicinity of the site
Site Preparation, Construction and Closing	• Construction of piles (on land) • Earthworks • Construction, use of equipment HDD drilling	• Disturbing noises for surrounding communities and residents	**Attenuation** **3. Noise management during construction**	Develop a Noise Management Plan that considers: • Type, number and location of the piles; • Use of low noise techniques for piles, if feasible (ex: vibratory piles, pressure piles) • Schedules for excavation of piles. • Schedule for use of primary routes and for hauling of materials	Project Site, Temporary Collection Site, and route of construction materials	EDP	$1,000.00	Duration of construction activities, in particular pile driving.	Short-term annoying noises at a project site radius during daylight hours.

Ing. Alejandro Alle, Apoderado Legal, **Energía del Pacífico Ltda. de C.V.**

Table 3-53 – Environmental Management Program, Construction Phase

Execution Phase	Project Activity	Description of Generated Environmental Impact	Environmental Measure (Prevention, Attenuation, Compensation)	Description of Proposed Measure	Location of the Environmental Measure	Responsible for its execution	Calculated Amount of Environmental Measure	Time of execution	Expected result
Site Preparation, Construction and Closing	• Cut and logging • Earthworks • Construction activities in general (on land)	• Loss of fertile soil/soil layers • Possible effects on flora and marine fauna for sediments entering the marine waters as a result of erosion of materials on land • Offsite flooding as a result of peak events for running surface waters	**Attenuation** **4. Soil and rainwater management during construction**	Apply the provisions for the management of earthworks and rainwater in "Instruction for quality and installation, earthworks, Power Plants" from Wärtilä, including: • Trenching and storage of organic soil separated from the subsoil • Use of berms and fencing to control erosion and sediment runoff • fences to prevent entry of machinery in sensitive areas. • Protect or stabilize exposed material (re-vegetation, geo-membranes, concrete, etc.) • Protect corners of ditches and curves with rocks or breakwater - installation of energy dissipation devices in outputs and download locations • settling ponds / or other system to remove the sediments of water before discharge and ponds to control • Ponds To control the discharge of rain water.	General Project Site, Laydown area, and shoreline areas that could be susceptible to erosion	EDP	$75,800.00	Before and during the duration of construction activities, including activities in the vicinity of the coast	Use of organic soil from the site's trace, removed for off-site use. Release of marine sediment for a short period, without significant effects on marine flora and fauna. There are no changes in the event of maximum flood
Site Preparation, Construction and Closing	Storage, handling, use and disposal of hazardous raw materials and hazardous wastes (on the project site and temporary storage area)	Accidental release of hazardous materials at the site with potential for: • pollution of the environment at the site (soil, surface and groundwater) • exposure of workers to toxic or irritant materials	**Prevention** **5. Handling and Storage of Hazardous Materials**	Use of the Best Practices of the International Industry for the handling, storage, use of hazardous materials, including: • Training to personal and protective equipment available • Overfilling and spill protection • Labeling and Inventory Control • Use of secondary containment • Incompatible materials stored in separate places • Spill response and cleaning of material • Fire extinguishers available	Laydown area and Construction Site	EDP	$12,200.00	During construction	Low risk of significant contamination of soil, ground or surface water as a result of construction
Site Preparation, Construction and Closing	Storage, handling, use and disposal of hazardous raw materials (onshore)	• Pollution of the environment through the inadequate disposal of human waste	**Prevention** **6. Sewage waste water treatment**	• Portable toilets with integrated tanks will be provided for workers • Material collected will be transported by truck for off-site treatment and disposal at an authorized facility	Construction Site and Laydown area.	EDP	$47,180.00	During construction	There is no contamination of human waste at the project site. Discharge of effluents to the off-site waste treatment plant.
Site Preparation, Construction and Closing	Storage, handling, use and disposal of raw materials, and hazardous waste (offshore)	• Pollution of marine waters or sediments by the accidental release of hazardous materials during construction activities • Possible contamination of the human food chain	**Prevention** ***7. Hazardous materials in construction of RCM and FSRU installation***	In addition to the general procedures for the storage and handling of hazardous materials defined in other sections, the following practices shall be used: • Storage of hazardous materials, including fuels and lubricants, in confined areas. • Spill equipment will be available for immediate deployment in case of a spill (absorbent booms, floating oil containment barriers, skimmers) • Workers will be trained in the prevention of marine spills and to provide response and cleaning during construction activities	Installation area of FSRU	EDP	$11,520.00	Duration during installation of FSRU and pipeline.	No significant environmental pollution as a result of sea spills is anticipated

Ing. Alejandro Alle, Apoderado Legal, **Energía del Pacífico Ltda. de C.V.**

Table 3-53 – Environmental Management Program, Construction Phase

Execution Phase	Project Activity	Description of Generated Environmental Impact	Environmental Measure (Prevention, Attenuation, Compensation)	Description of Proposed Measure	Location of the Environmental Measure	Responsible for its execution	Calculated Amount of Environmental Measure	Time of execution	Expected result
Site Preparation, Construction and Closing	• drilling of wells (onshore)	• Unsealed holes can allow the migration of contaminating material into groundwater	**Prevention** **8. Closing of perforations in soil**	Capping or sealing open holes with bentonite clay or other suitable material	Area where drilling may be required (powerhouse)	EDP	$1,000.00	Geotechnical exploration	There are no new pathways created for the migration of material to groundwater
Site Preparation, Construction and Closing	Cleaning of pipelines	• Contamination of the environment by the release of water from hydrostatic test and pipelines cleaning	**Prevention** **9. Discharge of test water**	• The water used for pressure test will be test to confirm the absence of contamination. Water free from contamination will be released to a local drain. If it is contaminated above the applicable criteria, the water will be treated before discharge. • Water for cleaning will be collected for proper disposal as needed.	Site for the discharge of water after the tests.	EDP	$3,000.00	Upon completion of hydrostatic testing of ships and pipelines	No significant contamination of wash effluent release / hydrostatic tests
Site Preparation, Construction and Closing	Cut and logging	• Elimination of vegetation resulting in the displacement of fauna to inadequate areas, which could cause mortality	**Attenuation** **10. Relocation of terrestrial fauna**	• Wildlife Relocation Program: before commencing works, relocate wildlife (ex: snakes) to an appropriate habitat with the support of an NGO • Keeping cage and training for construction workers from respecting and protecting wildlife during construction	The project site and Laydown Area	EDP	$6,200.00	Immediately prior to cleaning, and during logging activity	To reduce the mortality of fauna of great size. Reduce the migration of fauna in nearby areas not suitable
Site Preparation, Construction and Closing	Cut and logging	• Loss of habitat and increased habitat fragmentation	**Compensation** **11. Reforestation and support to FIAES**	Restoration of habitat, planting of 20,787 trees: • Plantation of 546 trees within the project property •The payment of $211,473.60 to FIAES for use in projects for improvement and protection of the environment in El Salvador	• Project site	EDP	$6,655.70	At the end of construction	The tree planting program will not result in the loss of tree numbers. Restoration works carried out as part of the FIAES program will compensate for the loss of habitat in the area
Site Preparation, Construction and Closing	Pipe installation using HDD method	• Possible discharge of water with sediments in gutter and seawater	**Prevention** **12. Measures during HDD drilling**	installation of a Recycling System to separate water-clay and sediments. As well as use of material that does not affect wildlife, volume monitoring for stoppage in case of discharges, handling of accidental discharges.	Temporary storage site and pipe route	EDP	$19,000.00	During HDD drilling	Avoid unnecessary discard of drilling fluid
Site Preparation, Construction and Closing	Storage, handling, use and disposal of hazardous raw materials, and common and / or hazardous waste	• inadequate storage and disposal of food waste attractive for wildlife	**Prevention** **13. Prevention of interaction with fauna**	• Food waste will be stored in wildlife-proof containers that are emptied and cleaned regularly • All waste will be disposed outside the properly	Project Site, Laydown Area,pipeline bondage, and temporary trestle.	EDP	$2,400.00	Duration of construction activities	There are no important attractants for wildlife related to the storage and handling of food and waste

Ing. Alejandro Alle, Apoderado Legal, **Energía del Pacífico Ltda. de C.V.**

Table 3-53 – Environmental Management Program, Construction Phase

Execution Phase	Project Activity	Description of Generated Environmental Impact	Environmental Measure (Prevention, Attenuation, Compensation)	Description of Proposed Measure	Location of the Environmental Measure	Responsible for its execution	Calculated Amount of Environmental Measure	Time of execution	Expected result
Site Preparation, Construction and Closing	General Installation Activities (offshore)	• Artificial lighting necessary for construction can affect the behaviour of marine fauna, including turtles	**Attenuation** **14. lighting plan offshore during construction**	Apply Lighting Management Plan: • Reduce lighting in non-essential areas, particularly during critical periods of life-cycle (ex: nesting of turtles) • Use of guards to direct lights to areas requiring lighting • Avoid direct light in water, exepting during safety inspections • Low light mounting where possible • Use of long wavelength lights (ex: amber) that make light less intense for nocturnal animals.	Area of FSRU and pipe.	EDP	$1,000.00	Duration of offshore activities	Reduce lighting that can disturb marine fauna behavior
Site Preparation, Construction and Closing	Dredging of marine sediment	• Dredging will increase the amount of suspended sediment in the water column, as well as turbidity	**Prevention** **15. Measures to Reduce Turbidity and Oyster Biomonitoring**	Stop or temporarily reduce dredging activities if excess turbidity limits are detected during monitoring. At the same time to perform biomonitoring of oysters.	Points M1 and M23 as well as oyster zone	EDP	$6,600.00	Establish prior to the start of dredging activities and maintain while dredging activities continue.	Temporal and localized with less impact to aquatic flora and fauna
Site Preparation, Construction and Closing	• Cutting and logging • Earthworks • General construction activities	•Risk of safety to the public by general construction activities, including the use of heavy machinery •Construction activities can cause disruption and inconvenience to local residents or businesses (complaints)	**Prevention** **16. Environmental and Social Management Plan**	Establish a community liaison program to be served by two relationship officers, whose responsibilities include: • Maintain the presence of an off-site community liaison office • Implement a communication plan that includes meetings, materials, interviews, including information / educational material for the municipality, schools and community. • Make the community aware of the existence of the Complaint Mechanism. To register and to solve the complaints that are presented by the stakeholders	Around communities, schools, municipality	EDP	$84,150.00	Establish before the start of construction and maintenance during construction	Broad knowledge of the project and the risks of the general public Low risk of unauthorized entry or public safety risk Respond to all valid complaints and complaints filed in the office
Site Preparation, Construction and Closing	General Installation Activities - offshore	• Safety risk for the public (seafarers and fishermen) operating in the vicinity of the temporary trestle, pipeline, and ships necessary for the installation of RCM and Pipeline	**Prevention** **17. Open sea safety**	Coordination with CEPA and the Port Maritime Authority (AMP), to develop a safety plan, during construction, including considerations for: • Formalize the exclusion zone during construction and operation with AMP in agreement with CEPA. This exclusion zone applies to all ships including commercial port traffic. According to Appendix G.An additional security zone. Approximately 500m radius, applicable for vessels that are not of CEPA, ALBA, RASA, CENERGICA or EDP.Security perimeter compliance plan. • Reinforcement of communication with/and education of local fishermen and other active navigators in the area	Project site in the sea	EDP	$5,500.00	Before the start of construction and during offshore construction activities	Low risk of significant safety incidents for navigators and fishermen

Ing. Alejandro Alle, Apoderado Legal, **Energía del Pacífico Ltda. de C.V.**

Table 3-53 – Environmental Management Program, Construction Phase									
Execution Phase	**Project Activity**	**Description of Generated Environmental Impact**	**Environmental Measure (Prevention, Attenuation, Compensation)**	**Description of Proposed Measure**	**Location of the Environmental Measure**	**Responsible for its execution**	**Calculated Amount of Environmental Measure**	**Time of execution**	**Expected result**
Site Preparation, Construction and Closing	Traffic related to construction	Project traffic on public roads can: • Create risk for public safety (collisions and accidents) • Cause traffic jams	**Prevention** **18. Traffic Plan**	Traffic Management Plan includes: • The use of collective transport for workers (buses) to reduce vehicle movements • Specification of designated haul routes • No heavy vehicles on local roads • Drivers will receive training on the Traffic Management Plan. • Inform closures or blockages and plan it in hours of little activity • appropriate traffic controller signals • Consultation with the municipality, local communities, and local schools on the traffic plan and traffic hazards	Project site, transport routes roads	EDP	$1,820.00	Duration of construction	There is no significant increase in the risk to the public safety of traffic related to the project less congestion of the main access road to the site
Site Preparation, Construction and Closing	Management of the construction workforce	•The influx of job seekers and the growing demand for social services and the possible disruption of peace and community security • Security and safety hazard, by the group of people who seek employment in the facilities	**Prevention/ attenuation** **19. Employment of local workers**	• Hire a local hiring officer to support EDP and contractors with the identification of qualified and unskilled local workers • Expand the off-site office in Acajutla for use by EDP and contractors as a local contracting center • Publish that the contracting will focus on local staff and that there will be no contracting at the doors of the facilities	• The entrance of the site • commercial area Acajutla • Project Office	EDP	$25,500.00	Before and during construction	Net profit expected from the local economy through the hiring and use of local service providers An influx of job seekers is expected, but with minimal changes to the local population base, demand for local services, peace and safety
Site Preparation, Construction and Closing	General construction activities	• Security problems due to the development of food stalls and informal merchants, near the entrance of the facilities.	**Prevention** **20. Prevention of informal stores near the site**	In addition to providing on-site cafeteria facilities, provide: • Communication to workers to discourage informal food • Signs prohibiting informal sales on the property's outdoor fence • Coordinate with the municipality to remove informal stores	Entrance to site	EDP	$ 700.00	Duration of construction	Reduce the incentive for informal traders to be located near entry to facilities
Site Preparation, Construction and Closing	• Cutting and logging • Earthworks • Pile driving • General Construction Activities - on land • Hydrostatic test	• Construction activities may pose a danger to the safety of CEPA workers and the public in the use of CEPA sports fields.	**Prevention / attenuation** **21. Pipeline Safety Barrier**	Provide a security barrier to ensure public safety.	• Temporary Laydown Area • Piping route	EDP	$8,822.00	During construction and testing activities in pipeline corridor	Prevention of access by CEPA and public workers to active construction areas

Ing. Alejandro Alle, Apoderado Legal, **Energía del Pacífico Ltda. de C.V.**

Table 3-53 – Environmental Management Program, Construction Phase									
Execution Phase	**Project Activity**	**Description of Generated Environmental Impact**	**Environmental Measure (Prevention, Attenuation, Compensation)**	**Description of Proposed Measure**	**Location of the Environmental Measure**	**Responsible for its execution**	**Calculated Amount of Environmental Measure**	**Time of execution**	**Expected result**
Site Preparation, Construction and Closing	• General offshore construction activity • Physical presence of the maritime terminal	The installation activities of FSRU pipeline will produce: • Restrict fishing areas for "oyster-catcher" and "tuberos" fishermen,	**Compensation** **22. Compensation for fishermen**	To compensate members of fishermen's cooperatives affected by longer distances of travel: • Installation of a new winch at the artisanal dock • Installation of 15 "Fish Aggregator Devices" (FAD) To compensate the fishermen "Oyster catchers" • Installing artificial reefs To compensate 57 fishermen known as "tuberos" and "Oyster-catchers", allow to choose among: • Participate in the construction of a boat, completing with safety training (product handling), and reception of basic fishing equipment, or, Receive training in an alternative line of work with the objective of leaving the fishing industry.	• FAD- Northwest Artisanal dock • Artificial Reefs- North of the Artisanal dock • Winche- Artisanal dock • Equipment and Training - To be defined (Artisanal dock)	EDP	$55,650.90	Complete installation of FAD, Reefs and winches, and start the training of oyster-catchers and tuberos, before the start of construction	The cost and longer navigation time for cooperatives will be compensated for improvements in the winch of the artisan pier, and the installation of the FADs. The livelihoods of local oysters will be enhanced by the development of the artificial reef. The livelihoods of the local pipelines will be compensated by equipment / training Improving the safety of fishermen
Site Preparation, Construction and Closing	Operations stage Wastewater Management	• Sewage generation	**Prevention** **23. Construction of wastewater treatment systems**	Installation of waste water treatment plant in the Thermal Power Plant (FSRU)	Power Plant: South-west of the property (See figure of location of environmental measures) Maritime Terminal:FSRU	EDP	$89,948.00	Installation during the construction phase	All process water and treated wastewater must comply with applicable standards
Site Preparation, Construction and Closing	Operations stage Increased surface runoff	• Generation of drainage of surface waters potentially contaminated by oils and grease	**Prevention** **24. Oily Water Treatment System**	Installation of a waste water treatment system to treat potentially contaminated water with oils from surface drainage	West of the property (See figure of location of environmental measures)	EDP	$16,480.00	Installation during the construction stage	All treated water must comply with applicable standards
Site Preparation, Construction and Closing	Physical presence of the facilities	• Off-site flooding as a result of increased flow of surface water	**Prevention** **25. Sedimentation / rainwater control pond**	Construction of two sedimentation ponds. The final stormwater management system will consider LID Low Impact Development techniques such as: • Reduction of impermeable areas, permeable paving, ditches and bio-retention, and with landscaping vegetation. Send the rest of the surface water flow of the permanent stormwater management system.	Sedimentation ponds will be located south of the Project Site	EDP	$12,000.00	Before starting operations	It was not expected to have a significant change in flood potential downstream of the site, by an increase in the maximum flow.
Site Preparation, Construction and Closing	Operation stage - general operating activities	• Operations stage Firefighting equipment	**Prevention** **26. Fire protection system**	• Installation of fire extinguishing equipment: fire extinguishers, hydrants, hoses, valves, mobile foam units, etc. • Provide training in fire extinguishing and drills	General facilities including Thermal Power Station and Marine Terminal	EDP	$119,295.00	Installation and training to be completed before the start of operations	International Good Practices of the Firefighting Industry

Ing. Alejandro Alle, Apoderado Legal, **Energía del Pacífico Ltda. de C.V.**

Table 3-53 – Environmental Management Program, Construction Phase

Execution Phase	Project Activity	Description of Generated Environmental Impact	Environmental Measure (Prevention, Attenuation, Compensation)	Description of Proposed Measure	Location of the Environmental Measure	Responsible for its execution	Calculated Amount of Environmental Measure	Time of execution	Expected result
Site Preparation, Construction and Closing	Operation stage - general operating activities	• Accidental release or leakage of natural gas	**Prevention** **27. Leak Detection System**	Leak detection equipment at the Thermal Power Plant (fixed), pipelines and CEPA Port, as well as portable gas meters for detecting leaks in the visual inspections of the facilities	NG, FSRU pipeline	EDP	$16,000.00	Buying meters before starting operations	Periodic inspections will help identify leaks
Site Preparation, Construction and Closing	Operation stage – Well Operation	• Groundwater use	**Prevention** **28. Well flow monitoring equipment and monitoring wells**	Installation of flow control equipment, and measure levels and parameters in monitoring wells.	Wells	EDP	$3,100.00	Installation before begining operations	The extraction of water must not exceed the limit established in the permit
Site Preparation, Construction and Closing	General construction activities - offshore	• Risk to the public and workers	**Prevention** **29. Disease Vectors Minimization**	Minimize / remove areas with water stagnation, and provide training to employees to minimize vector sites	Thermal Power Plant and Temporary Collecting Site	EDP	$2,400.00	During construction activities	Elimination of mosquito breeding habitats
Site Preparation, Construction and Closing	General construction activities - offshore	• Removal and disturbance of marine habitat	**Attenuation** **30. Marine wildlife rescue center**	To install a marine fauna rescue center in collaboration with MARN for the recovery of marine animals that could be affected during the construction of the project.	House near de coast	EDP	$37,300.00	During construction activities	Stranded animals or sickly assisted. Minimized disturbance to marine habitats
Site Preparation, Construction and Closing	General construction activities - offshore	• Disturbance of marine habitat	**Prevention** **31. Corals monitoring**	Monitoring of stony and soft corals	Points located at sunken ships (three sites of 100m^2 each)	EDP	$ 12,500.00	Prior to beginning works at sea, Prior to the start of offshore activities, During and after offshore activities	Record of the state of stony an soft corals
Site Preparation, Construction and Closing	LNG delivery, LNG storage, management and regasification	• Risk to the public and nearby industrial activities due to a catastrophic event (major LNG / NG spills, large fires, explosion)	**Prevention** **32. Detailed risk assessment and contingency plan**	Perform a detailed risk assessment as part of the final detailed design work. • Development of a Major Threat Risk Management Plan and Contingency Plan. • Training and drills	FSRU	EDP	$100,000.00	Prior to begin operations	Risks to public safety within Standards and Good International Practices for the Industry
Site Preparation, Construction and Closing	LNG Delivery, LNG storage, management and regasification of LNG	•Risk to the public and to the integrity of NG/LNG containment and transport facilities and systems in the face of near and distant tsunami threats	**Prevention** **33. Tsunami Alert System**	Installation of a PTWC-independent tsunami alert system consisting of ground-installed seismic measurement instruments at the project site, national seismic information and decision tree.	Marine terminal, and seismic measuring instruments installed on the ground at the project site	EDP	$3,000.00	Prior to begin operations	Establishment of a PWTC-independent tsunami alert system for immediate preparations.
Site Preparation, Construction and Closing	LNG Delivery, LNG storage, management and regasification of NG	•Risk to the public and to nearby industrial activities due to a NG/LNG leakage event	**Prevention** **34. Installation of isolation valve**	Installation of isolation valve in the ground to reduce the inventory of piped gas that can be released in the event of a leak.	Entrance of pipeline to land	EDP	$30,000.00	Prior to begin operations	Reduction of risk levels in case of leakage in the NG transport pipeline.
						TOTAL	**$873,733.60**		

Ing. Alejandro Alle, Apoderado Legal, **Energía del Pacífico Ltda. de C.V.**

Table 3-54– Monitoring Program, Construction Stage

Stage of Execution	Environmental Measure	Parameters to Consider	Place or Monitoring Point	Frequency of Monitoring	Method to Use	Responsible for Monitoring	Interpretation of results	Feedback	Reference in Impact Description Text
Site Preparation, Construction and Closing	**Attenuation** **1. Reduction of Gas Emissions**	Maintenance record	Project construction office	Monthly	Review the record	EDP	Verify that maintenance is performed in accordance with the plan	Improve maintenance according to program	Page 10-4
Site Preparation, Construction and Closing	**Prevention** **2. Dust Management Plan**	Excess of dust emissions	All active construction areas where there is uncovered land	Daily / Weekly	Weekly visual check for excessive dust emissions by site environmental monitoring Weekly inspection of dust mitigation measures	EDP	Confirm that dust controls are effective to prevent significant off-site migration of dust by air or vehicles	If excessive dust migration is carried out, the activity that causes it should be stopped and appropriate control measures applied at the site or until the weather changes (rain or wind reduction)	Page 10-5
Site Preparation, Construction and Closing	**Attenuation** **3. Noise management during construction**	Disturbing noise	Nearby residential areas	Non-applicable	Complaints from interested parties	EDP	All noise complaints should be investigated to identify the root cause	Introduce control measures to deal with noise nuisance complaints and follow up communication with the complainant	Page 10-7
Site Preparation, Construction and Closing	**Attenuation** **4. Soil and rainwater management during construction**	Physical soil conditions	Areas subject to earthworks and excavations	Weekly	Weekly inspection of exposed soils and drainage channels for excess erosion and sedimentation	EDP	Confirm that sediment controls are effective to avoid significant erosion / sedimentation	If there is excessive erosion introduce additional stabilization measures for control	Page 10-8
		Flood	Sites for discharge of rain water and channel of CEPA in point of discharge	Weekly during the rainy season - monthly during the dry season	Visual inspection of the stormwater management system to verify capacity and integrity, and any evidence or risk of flooding and erosion	EDP	Check for erosion, signs of flooding, damage to gutter	Take corrective actions by improving the pipeline infrastructure or retention pond	Page 10-8
Site Preparation, Construction and Closing	**Attenuation** **5. Management and Storage of Hazardous Materials**	Adequate handling: storage in fenced area, MSDS available, establishment secondary containment.	Hazardous Materials Storage Site	Monthly	Inspection of the site and photographic record	EDP	All hazardous materials must be stored according to their characteristics	Correct storage of materials and reinforcement of training to the person in charge of the area	Page 10-11
Site Preparation, Construction and Closing	**Prevention** **6. Domestic wastewater treatment**	Presence and use of portable toilets	In front of work place	Monthly	Visual inspection, rental registration, cleaning record	EDP	Compare number of toilets with registration of workers, there must be one per 25 workers. Toilets must be in good condition and cleaned periodically	Hire more portable toilets and request their cleaning and maintenance	Page 10-15

Table 3-54– Monitoring Program, Construction Stage									
Stage of Execution	**Environmental Measure**	**Parameters to Consider**	**Place or Monitoring Point**	**Frequency of Monitoring**	**Method to Use**	**Responsible for Monitoring**	**Interpretation of results**	**Feedback**	**Reference in Impact Description Text**
Site Preparation, Construction and Closing	**Prevention** **7. Hazardous materials in installation of RCM and FSRU**	Training and accident records, spill equipment and biodegradable oil	In construction site	Every six months	Staff interviews, purchase and photo record	Holder	Prevent damage to personnel, infrastructure and the environment	Update of training topics and purchase of equipment needed	Page 10-17
Site Preparation, Construction and Closing	**Prevention** **8. Closing of perforations in soil**	Presence of open holes in the property	Tank construction site and powerhouse	Finishing construction of foundations	Inspection of the site and photographic record	EDP	Check that all open holes in the ground are closed	Close the open holes in the soil	page 10-18
Site Preparation, Construction and Closing	**Prevention** **9. Test water discharge**	Sampling water test water	Before discharge point	Before discharge, at the end of construction	Sampling with local equipment: suspended sediment, oil and fats	EDP	Check that the parameters are according to the regulations	Treat the water before it is discharged	Page 10-19
Site Preparation, Construction and Closing	**Attenuation** **10. Relocation of fauna**	Presence of fauna on site	Project property, spread areas, and piping corridor	Once, before starting the eviction of the property	Inspection of the site and photographic record	EDP	Verify that there is no established fauna present on the site	Apply the relocation program	Page 10-19
Site Preparation, Construction and Closing	**Compensation** **11. Reforestation and Support (FIAES)**	Number of species planted, record of donations to FIAES	Green areas in the Project site and register of payments to FIAES	Weekly	Inspection of the site and photographic record Compliance of EDP-FIAES agreement	EDP	Verify planting establishment	Care and maintenance or replanting of damaged species	Page 10-21
Site Preparation, Construction and Closing	**Prevention** **12. Measurements during HDD drilling**	Turbidity in the water	Effluent system separator clay and sediments	Monthly	Sampling and analysis of suspended solids total and suspended solids	EDP	NSO 13.49.01: 09, settling solids 1 mg / L, total suspended solids 60 mg / L.	Improve system of retention or increase of time of concentration of effluent.	page 10-29
Site Preparation, Construction and Closing	**Prevention** **13. Prevention of interaction with fauna**	Deposits for solid waste	In front of work place and inside the facilities	Weekly	Visual inspection	EDP	Verify the installation of containers and their proper use	Ensure eviction and proper disposal	Page 10-30
Site Preparation, Construction and Closing	**Attenuation** **14. Lighting plan of construction in the sea**	Illumination at the FSRU site and pipeline	FSRU zone and pipe to be excavated	Monthly during construction	Inspection of the site and photographic record	EDP	Lighting should not be directed to seawater except for periodic safety observations	Correct the direction of lightning	Page 10-35
Site Preparation, Construction and Closing	**Prevention** **15. Measures to Reduce Turbidity and Oyster Biomonitoring**	Turbidity in water and metals in oysters	M1 (13 ° 35'3.10 "N and 89 ° 50'42.35" W) and M3 (13 ° 35'1.49 "N and 89 ° 50'42.19" W) and oyster beds	turbidity, Weekly and biomonitoring in oysters every two months	Work material and analysis in laboratory	EDP	Turbidity must meet 75NTU average 30 days and 100NTU average 7 days; Metals in oysters should not be above the baseline (first Measure before works)	Improve measures for sedimentation control	Page 10-36

Ing. Alejandro Alle, Apoderado Legal, **Energía del Pacífico Ltda. de C.V.**

Table 3-54– Monitoring Program, Construction Stage

Stage of Execution	Environmental Measure	Parameters to Consider	Place or Monitoring Point	Frequency of Monitoring	Method to Use	Responsible for Monitoring	Interpretation of results	Feedback	Reference in Impact Description Text
Site Preparation, Construction and Closing	**Prevention** **16. Environmental and Social Management Plan**	Verify the information of the population about the project and conflicts that arise	Record of meetings and complaints	Monthly	Review complaints and their resolution	EDP	Verify that project information and conflict resolution have been provided	Improve the media and the attention to complaints	page 10-38
Site Preparation, Construction and Closing	**Prevention** **17. Safety in the open sea**	Incidents and accidents	Around the FSRU site and pipeline excavation	Monthly	Review accident statistics and the cause of accidents	EDP	Review the cause of accidents	Install measures to prevent accidents and improve coordination	Page 10-40
Site Preparation, Construction and Closing	**Prevention** **18. Traffic plan**	Claims from population	Communications office	Monthly	Check for any community complaints or traffic-related accidents.	EDP	Review the cause of the complaint or accident	Improve training for personnel in charge of transporting materials or equipment	Page 10-41
Site Preparation, Construction and Closing	**Prevention/ attenuation** **19. Local workers employment**	Number of people from the community hired for the project	Communications office	Monthly	Review of Statistics of the people hired for the project	EDP	Compare current hiring with the target of 100% unskilled local area workers	Improve the mechanism for hiring staff to incorporate more people from Acajutla	Page 10-42
Site Preparation, Construction and Closing	**Prevention** **20. Prevention of informal stores around the site**	Informal stores around the project site	Within the perimeter of the area of the project	Monthly	Site inspection and photographic record	EDP	Stores should not be installed	Improve measures with workers	Page 10-43
Site Preparation, Construction and Closing	**Prevention / attenuation** **21. Pipe safety barrier**	Presence of barrier	Coast in the corridor for the pipe	Monthly	Site inspection and photographic record	EDP	The barrier must be installed	Install the barrier, if it is not installed correctly or missing parts	Page 10-44
Site Preparation, Construction and Closing	**Compensation** **22. Compensation to fishermen**	Installation of winch, in the artisanal dock, artificial reefs and FDAs	Artisanal dock	6 months and 1 year after completion of installation	Site inspection and photographic record Interview to verify the effectiveness of the FAD	EDP	The winch must be installed. FAD and reefs must be installed	Install equipment	Page 10-44
		Compensation program for independent fishermen	NA	Before starting the program to establish the baseline, then 6 months, 1 year and 2 years after completion of the compensation program	Interview each independent fisherman on the status of his livelihood	EDP	Compare the baseline values	Provide corrective assistance for all fishermen whose livelihoods worsen as a result of the project	Page 10-46

Table 3-54– Monitoring Program, Construction Stage									
Stage of Execution	**Environmental Measure**	**Parameters to Consider**	**Place or Monitoring Point**	**Frequency of Monitoring**	**Method to Use**	**Responsible for Monitoring**	**Interpretation of results**	**Feedback**	**Reference in Impact Description Text**
Site Preparation, Construction and Closing	**Prevention** **23. Construction of wastewater treatment systems**	Water quality Analysis: BOD5, COD, pH, Oils and Fats Sedimentable solids Total Suspended Solids, Total Coliforms (CT)	Treatment plant effluent outlet point	Quarterly (4 times a year)	Individual samples subjected to laboratory NSO standards.	EDP	NSO 13.49.01:09, BOD5, 60 mg/L COD 60 mg/l, pH, fat and oils 20 mg/L, solid sedimentary 1 mg/L total suspended solids, 60 mg/L, Temperature 20-35°C, chlorides (report, there is no standard), flow (point "a" or "b")	If the monitoring detects contamination related to the project, corrective measures must be taken to avoid further contamination	Page 10-4
Site Preparation, Construction and Closing	**Prevention** **24. Water-oil separator**	Sampling of water quality: oil and fats and hydrocarbons	Before discharge in CEPA channel	Quarterly (4 times a year)	Individual samples for laboratory analysis	EDP	Comparison of the applicable surface water quality criteria: fats and Oils 20 mg / L, there should be no presence of hydrocarbons	If the monitoring detects contamination related to the project, corrective measures must be taken to avoid further contamination	Page 10-52
Site Preparation, Construction and Closing	**Prevention** **25. Sedimentary tank / rain damper**	Flood	Characteristics of surface water management	Weekly during the rainy season - monthly during the dry season	Visual inspection of the storm water management system to verify capacity and integrity, and any evidence or risk of flooding and erosion	EDP	Comparison with system design specifications	If inspections indicate a risk of flooding or erosion take corrective actions	Page 10-55
Site Preparation, Construction and Closing	**Prevention** **26. Fire protection system**	Installation of all equipment and operation test	Tank yards, cargo rack and bottling plant	Biannual	Equipment operations report	EDP	The equipment must operate according to the specifications thereof	Replacement of defective equipment	Page 10-57
Site Preparation, Construction and Closing	**Prevention** **27. Leak detection system**	Installation of all equipment and operation test	Tank yards, cargo rack and bottling plant	Biannual	Equipment operations report	EDP	The equipment must operate according to the specifications thereof	Replacement of defective equipment	Page 10-58
Site Preparation, Construction and Closing	**Prevention** **28. Well flow monitoring equipment and well monitoring**	Flow rate of extraction and piezometric levels and parameters which are indicative of saline intrusion	Monitoring wells groundwater up and down the gradient of the well and the well project	Quarterly (4 times a year)	Individual samples submitted for laboratory analysis	EDP	Comparison to baseline conditions	If monitoring detects contamination related to the project, corrective measures must be taken to avoid further contamination and to seek for the necessary corrective measures	Page 10-59
Site Preparation, Construction and Closing	**Prevention** **29. Disease vector minimization**	The presence of mosquito larvae	Areas of deposition areas of stagnant water (for example, a storm water pond) site in general	2 times a week (can be reduced in the dry season)	Visual inspection	EDP	Presence of breeding habitat, presence of larvae in water	Eliminate reproduction habitat whenever possible. Otherwise, if larvae persist, treat with larvicide	Page 10-64

Table 3-54– Monitoring Program, Construction Stage

Stage of Execution	Environmental Measure	Parameters to Consider	Place or Monitoring Point	Frequency of Monitoring	Method to Use	Responsible for Monitoring	Interpretation of results	Feedback	Reference in Impact Description Text
Site Preparation, Construction and Closing	**Attenuation** **30. Fauna Rescue Center**	Installation and equipment of the Wildlife Rescue Center	• House near the coast	Quarterly (4 times a year)	Inspection on the site	EDP	Operation of the Wildlife Rescue Center	Define assistance capacity. If necessary, identify alternative rescue centers	
Site Preparation, Construction and Closing	**Prevention** **31. Corals monitoring**	Individual and/or colonial hard corals: registry of physiognomy (coloration, herbivory, % bleaching, habitat, species that surround it, sand or mud cover) perimeter, diameter and height. Soft corals: Size of base, width and height	Points at sunken ships sites (three sites of 100m² each one)	Prior to beginning works at sea, Prior to the start of dredging activities, During dredging activities, When finishing dredging activities At the end of construction at sea	Verification of monitoring reports and photographic record	EDP	Identification of alterations in relation to baseline	Comparison of results in relation to baseline	Page 10-73
Site Preparation, Construction and Closing	**Prevention** **32. Detailed risk assessment and contingency plan**	Establishment of the plan	• Thermal Power Plant, Pipeline and FSRU	1 time before the start of the operations phase.	Verify that the plan is established, coordinate with authorities and train employees	EDP	This plan must contain all the aspects established in chapter 9	Complete or justify what is needed	
Site Preparation, Construction and Closing	**Prevención** **33. Tsunami Alert system**	Installation of seismic measuring instruments, access to national seismological information and decision tree	FSRU, and seismic measuring instruments installed on the ground at the project site	1 time Prior to operations phase	Registry of purchase and installation of seismic measuring instruments and decision tree	EDP	Decision tree linked to contingency plan	Enhanced Contingency Plan	Page 10-77
Site Preparation, Construction and Closing	**Prevention** **34. Installation of isolation valve**	Installation of ESD valve	Entrance of pipeline to land	1 time Prior to operations phase	Registry of purchase and installation of valve	EDP	Definition of response time of the valve	Future adjustments to risk studies according to specifications of the valve	Page 10-78

Ing. Alejandro Alle, Apoderado Legal, **Energía del Pacífico Ltda. de C.V.**

Table 3-55– Execution Schedule of the Environmental Management Program, Construction Stage

Execution stage	Environmental measure	2017												MONTHS / COST YEAR 1	2018												MONTHS / COST YEAR 2	2019												2020				MONTHS / COST YEAR 3 (2019+2020)	Calculated Amount of Environmental Measure
		1	2	3	4	5	6	7	8	9	10	11	12		1	2	3	4	5	6	7	8	9	10	11	12		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4		
Site Preparation, Construction, Closing	Attenuation					1	1	1	1	1	1	1	1	8	1	1	1	1	1	1	1	1	1	1	1	1	12	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	16	$2,000.00
	1. Reduction of Gas Emissions													$444.44													$666.67																	$888.89	
Site Preparation, Construction, Closing	Prevention											1	1	2	1	1	1	1							1	1	6	1	1	1	1							1	1	1	1	1	1	10	$54,012.00
	2. Dust Management Plan													$6,001.33													$18,004.00																	$30,006.67	
Site Preparation, Construction, Closing	Attenuation					1	1	1	1	1	1	1	1	8	1	1	1	1	1	1	1	1	1	1	1	1	12	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	16	$1,000.00
	3. Noise management during construction													$222.22													$333.33																	$444.44	
Site Preparation, Construction, Closing	Attenuation					1	1	1	1	1	1	1	1	8	1	1	1	1	1	1	1	1	1	1	1	1	12	1	1	1	1													4	$75,800.00
	4. Soil and rainwater management under construction													$25,266.67													$37,900.00																	$12,633.33	
Site Preparation, Construction, Closing	Prevention					1	1	1	1	1	1	1	1	8	1	1	1	1	1	1	1	1	1	1	1	1	12	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	16	$12,200.00
	5. Handling and Storage of Hazardous Materials													$2,711.11													$4,066.67																	$5,422.22	
Site Preparation, Construction, Closing	Prevention					1	1	1	1	1	1	1	1	8	1	1	1	1	1	1	1	1	1	1	1	1	12	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	16	$47,180.00
	6. Domestic wastewater treatment													$10,484.44													$15,726.67																	$20,968.89	
Site Preparation, Construction, Closing	Prevention																	1	1	1							3																		$11,520.00
	7. Hazardous materials in construction of Maritime Terminal and temporary dock																										$11,520.00																		
Site Preparation, Construction, Closing	Prevention													0										1	1	1	3																	0	$1,000.00
	8. Closing of perforations in soil													$ -													$1,000.00																	$ -	

Ing. Alejandro Alle, Apoderado Legal, **Energía del Pacífico Ltda. de C.V.**

Table 3-55– Execution Schedule of the Environmental Management Program, Construction Stage

Execution stage	Environmental measure	2017												MONTHS / COST YEAR 1	2018												MONTHS / COST YEAR 2	2019												2020				MONTHS / COST YEAR 3 (2019+2020)	Calculated Amount of Environmental Measure
		1	2	3	4	5	6	7	8	9	10	11	12		1	2	3	4	5	6	7	8	9	10	11	12		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4		
Site Preparation, Construction, Closing	Prevention													0													0														1	1	1	3	$3,000.00
	9. Test water discharge													$ -													$ -																	$3,000.00	
Site Preparation, Construction, Closing	Attenuation					1	1	1						3				1	1	1							3																	0	$6,200.00
	10. Relocation of fauna													$3,100.00													$3,100.00																	$ -	
Site Preparation, Construction, Closing	Compensation					1	1	1	1	1	1	1	1	8	1	1	1	1	1	1	1	1	1	1	1	1	12	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	16	$6,655.70
	11.Reforestation and Support to (FIAES)													$1,479.05													$2,218.57																	$2,958.09	
Site Preparation, Construction, Closing	Prevention																	1	1	1							3																		$19,000.00
	12. Measures during HDD perforation																										$19,000.00																		
Site Preparation, Construction, Closing	Prevention					1	1	1	1	1	1	1	1	8	1	1	1	1	1	1	1	1	1	1	1	1	12	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	16	$2,400.00
	13. Prevention of interaction with fauna													$533.33													$800.00																	$1,066.67	
Site Preparation, Construction, Closing	Attenuation					1	1	1	1	1	1	1	1	8	1	1	1	1	1	1	1	1	1	1	1	1	12	1	1	1	1	1	1	1	1	1								9	$1,000.00
	14. Lighting Plan for Maritime Terminal and Temporary dock													$275.86													$413.79																	$310.34	
Site Preparation, Construction, Closing	Prevention																				1	1					2																	0	$6,600.00
	15. Measures to Reduce Turbidity and Oyster Biomonitoring																										$6,600.00																	$ -	
Site Preparation, Construction, Closing	Prevention				1	1	1	1	1	1	1	1	1	9	1	1	1	1	1	1	1	1	1	1	1	1	12	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	16	$84,150.00
	16. Environmenta and Social Management Plar													$20,468.92													$27,291.89																	$36,389.19	
Site Preparation, Construction, Closing	Prevention					1	1	1	1	1	1	1	1	8	1	1	1	1	1	1	1	1	1	1	1	1	12	1	1	1	1	1	1	1	1	1								9	$5,500.00
	17. Safety in the open sea													$1,517.24													$2,275.86																	$1,706.90	
Site Preparation, Construction, Closing	Prevention					1	1	1	1	1	1	1	1	8	1	1	1	1	1	1	1	1	1	1	1	1	12	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	16	$1,820.00
	18. Traffic Plan													$404.44													$606.67																	$808.89	
Site Preparation,	Prevention / attenuation					1	1	1	1	1	1	1	1	8	1	1	1	1	1	1	1	1	1	1	1	1	12	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	16	$25,500.00

Table 3-55– Execution Schedule of the Environmental Management Program, Construction Stage

Execution stage	Environmental measure	2017												MONTHS / COST YEAR 1	2018												MONTHS / COST YEAR 2	2019												2020				MONTHS / COST YEAR 3 (2019+2020)	Calculated Amount of Environmental Measure
		1	2	3	4	5	6	7	8	9	10	11	12		1	2	3	4	5	6	7	8	9	10	11	12		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4		
Construction, Closing	**19. Employment of Local Workers**													$5,666.67													$8,500.00																	$11,333.33	
Site Preparation, Construction, Closing	**Prevention**					1	1	1	1	1	1	1	1	8	1	1	1	1	1	1	1	1	1	1	1	1	12	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	16	**$700.00**
	20. Prevention of informal stores around the site													$155.56													$233.33																	$311.11	
Site Preparation, Construction, Closing	**Prevention / attenuation**													0	1	1	1	1	1	1							6																	0	**$8,822.00**
	21. Pipe Safety Barrier													$ -													$8,822.00																	$ -	
Site Preparation, Construction, Closing	**Compensation**		1	1	1	1	1	1						6													0																	0	**$55,650.90**
	22. Compensation to Fishermen													$55,650.90													$ -																	$ -	
Site Preparation, Construction, Closing	**Preventive**													0													0								1	1	1							3	**$89,948.00**
	23. Construction of sewage treatment systems													$ -													$ -																	$89,948.00	
Site Preparation, Construction, Closing	**Preventive**													0													0						1	1	1									3	**$16,480.00**
	24. Water-oil separator													$ -													$ -																	$16,480.00	
Site Preparation, Construction, Closing	**Prevention**					1	1	1						3													0																	0	**$12,000.00**
	25. Settling tank / rain damper													$12,000.00													$ -																	$ -	
Site Preparation, Construction, Closing	**Preventive**													0													0											1	1	1	1	1	1	6	**$119,295.00**
	26. Fire Protection System													$ -													$ -																	$119,295.00	
Site Preparation, Construction, Closing	**Preventive**													0													0														1	1	1	3	**$16,000.00**
	27. Leak Detection System													$ -													$ -																	$16,000.00	
Site Preparation, Construction, Closing	**Preventive**					1	1	1						0													0																	3	**$3,100.00**
	28. Wellflow monitoring equipment and monitoring wells													$3,100.00													$ -																	$ -	
Site Preparation, Construction, Closing	**Preventive**					1	1	1	1	1	1	1	1	8	1	1	1	1	1	1	1	1	1	1	1	1	12	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	16	**$2,400.00**
	29. Minimization of Disease Vectors													$533.33													$800.00																	$1,066.67	
	Attenuation													6																															**$37,300.00**

Ing. Alejandro Alle, Apoderado Legal, **Energía del Pacífico Ltda. de C.V.**

Table 3-55– Execution Schedule of the Environmental Management Program, Construction Stage

Execution stage	Environmental measure	2017												MONTHS / COST YEAR 1	2018												MONTHS / COST YEAR 2	2019												2020				MONTHS / COST YEAR 3 (2019+2020)	Calculated Amount of Environmental Measure
		1	2	3	4	5	6	7	8	9	10	11	12		1	2	3	4	5	6	7	8	9	10	11	12		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4		
Site Preparation, Construction, Closing	**30. Marine Wildlife rescue center**													$37,300.00																															
Site Preparation, Construction, Closing	**Preventive**					1	1	1	1	1	1	1	1	8	1	1	1	1	1	1	1	1	1	1	1	1	12	1	1	1	1	1	1	1	1	1								9	**$12,500.00**
	31. Corals monitoring													$3,448.28													$5,172.41																	$3,879.31	
Site Preparation, Construction, Closing	**Preventive**									1	1	1	1	4	1	1	1	1									4																	0	**$100,000.00**
	32. Detailed risk assessment and contingency plan													$50,000.00													$50,000.00																	$ -	
Site Preparation, Construction, Closing	**Preventive**													0													0											1	1	1	1	1	1	6	**$3,000.00**
	33. Tsunami alert system																																											$3,000.00	
Site Preparation, Construction, Closing	**Preventive**													0													0											1	1	1	1	1	1	6	**$30,000.00**
	34. Isolation valve instalation																																											$30,000.00	
TOTAL PER YEAR AND TOTAL PMA														**$240,763.79**													**$225,051.86**																	**$407,917.94**	**$873,733.60**

3.3 Description of Environmental Measures for Operation Phase

3.3.1 Emissions Monitoring

Type of measure: Preventive

Description of the Measure

Air emissions of combustion gases will be measured after the start-up of the engines. Sampling will be carried out by an independent laboratory selected by EDP and authorized by MARN. MARN staff will be invited to witness its execution.

Methods of measurement shall be US EPA[2] reference methods. The air emissions program is summarized in Table 3-56 below.

Table 3-56 – Stack Emission Monitoring Summary	
Sampling Site:	4-engine stacks, selected at random.
Frequency:	Annual, for three years; Note: After the first three years, during the life of the Project if the results comply with the normative, the monitoring will be done every two or three years, not annually.
Parameters to be determined:	NOx; PTS; O2; CO; CO2; Gas flow, composition, production (MW)
Methods to use	NOx: US EPA Method 7, o 7C, o 7E
	PTS: US EPA Method 17
	O2: US EPA Method 3A o 3B
	CO: US EPA Method 10
	Gas flux: US EPA Method 2
	Gas Humidity: US EPA Method 4
	Fuel consumption: Load measurement.
	CO2 emissions will be calculated based on the fuel analysis and the measured O2
Number of tests:	3 consecutive for each parameter
Duration of sampling:	≥1 hour at ≥90% Maximum continuous load
Standard to be met:	World Bank Guidelines, 2007

Source: Elaboration by Consulting Team

[2] [2] US 40 CFR 60 Appendix A, Reference Method.

The environment air quality will be measured after the start-up of the equipment. Sampling will be carried out by a laboratory selected by EDP. MARN staff will be invited to witness its execution.

Methods of measurement shall be US EPA[2] reference methods and ASTM methods. The air emissions program is summarized in Table 3-57.

For environment, air is detailed as follows:

Table 3-57 – Summary of Environment Air Quality Program (atmospheric emissions)	
Sampling Site:	A point in the critical area determined in the dispersion model.
Frequency:	Continuous monitoring for twenty days
Parameters to be determined:	NO_x, during the text period the heat rate, fuel consumption, and production (MW) will be measure.
Methods to Use:	Continuous measurement with electrochemical analyzer equipment similar to that used for the base line
Number of tests:	Continuous
Sampling time:	continuous
Standard to be met	NSO 13.11.01:01, Table 1 Nitrogen dioxide: 150 µg/Nm^3, for 24 hours.

Source: Elaboration by Consulting team

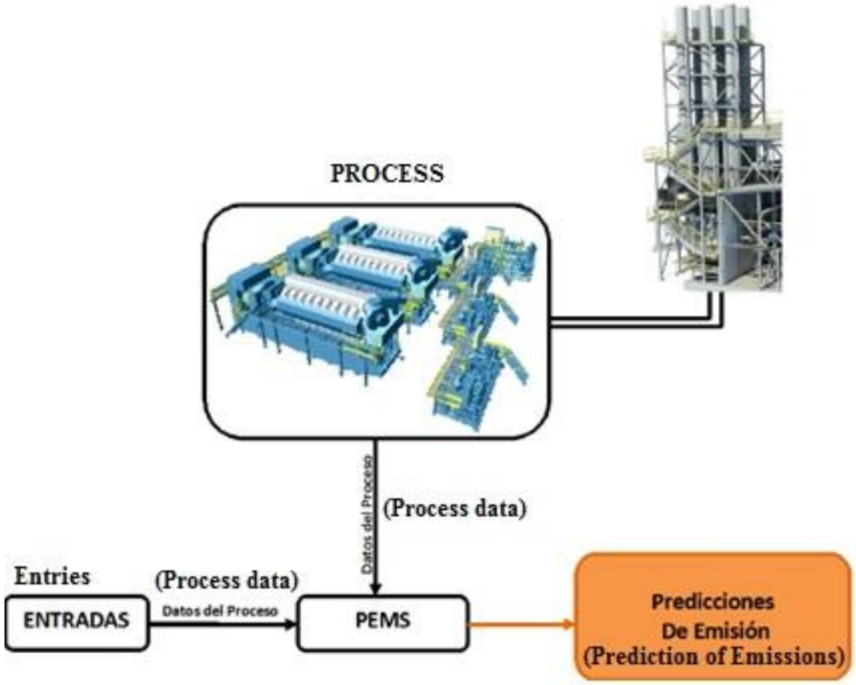
The results will be commented with the meteorological data obtained from the meteorological station to be installed.

Emission prediction monitoring system

Since NOx is the main pollutant produced in the combustion of natural gas, the NOx gas detector allows the reading of the NOx levels in the chimney in real time, so when detecting non-standard levels during the tests will proceed with the system shutdown.

In addition, an EMISSION PREDICTION MONITORING (PEM) SYSTEM will be installed. These systems calculate emissions using models that use real data of different parameters, use robust instrumentation and can be verified by reference measurements. These systems have been tested in the United States and are used in more than one hundred facilities worldwide to report emissions. The USEPA No. 16 standard gives the requirements for this equipment. See Figure 3-19.

Figure 3-19– Emission Prediction Monitoring System Operation Scheme



Source: Wärtsilä, 2014

Meteorology

A permanent weather station will be operated and maintained to the purpose of:

a) Facilitate the interpretation of monitoring data of NO_2;
b) evaluating air quality events (for example, possible odor observations);
c) construct a local database for a more precise application of dispersion models.

A meteorological station will be installed to record the following parameters:

- Wind direction (degrees, from the north = 0, from the east = 90);
- Wind speed (m/s);
- Relative humidity (%, calculated dew point ^{o}C);
- Temperature (^{o}C);
- Rain (total mm, mm/h);
- Solar radiation (W/m^2).

The wind sensors shall be located to comply with the following guidelines [3]:

- The standard height is 9-10 m on uneven flat ground;
- Keep a distance ≥10 times the height of the nearest buildings or trees;
- If the sensor was installed on a building, do it on a mast of ≥ 6 m above the highest part of the building; and
- If the sensor is installed on a tower (ex: chimneys) on a horizontal support of a length equal to twice the diameter of the tower and install this extension where the wind comes most of the time.

A summary of the local meteorological data will be included in the annual reports that EDP submits to MARN, where the results of the air quality measurements will be reported. This summary shall include for each sampling period the number of hours in which the passive monitoring station was in the leeward of the Thermal Power Station (± 11.25 degrees), and the average wind speed. That is, if the monitor is located exactly to the west of the Thermal Power Station (270 degrees) it would count the time in which the direction of the wind was in the interval (78.75 to 101.25 degrees). The production of this meteorological summary will be facilitated with the use of software or a spreadsheet to classify wind directions, with respect to the orientation of each of the air quality monitoring stations. (See Table 3-58)

Table 3-58– Meteorology	
Sampling site:	EDP Communications Office.
Frequency:	Continuous, schedule data file.
Parameters to determine:	Wind direction and wind speed, solar radiation, temperature, humidity.
Methods to be used.	NOAA guidelines for meteorological stations. (NOAA, guidelines for meteorological station reconnaissance and meteorological sensors height measurements, April 2008).
Number of tests:	Continuous
Duration of sampling:	Continuous

Source: Elaboration by Consulting Team

The data obtained from the weather station to install will be used to check on future data, since it does not have sufficient information during a time that lasts the sampling in chimneys, or 24 hour on ambient air. Note the atmospheric data during the tests of emission and emission levels, to comment on the results obtained.

[3] Source: NOAA, Guidelines for Meteorological Station Reconnaissance and Meteorological Sensor Height Measurements, Abril 2008.

Location of the Environmental Measure

Stacks and Communications Office.

Estimated Amount of Environmental Measure

Table 3-59 – Estimated Amount of Environmental Measure - Emissions Monitoring					
Activity	**Quantity**	**Unit**	**Unit Price**	**Term (months)**	**Total**
Stack monitoring	12.00	c/u	$2,000.00	1.00	$ 24,000.00
Ambient Air monitoring	6.00	c/u	$1,500.00	1.00	$ 9,000.00
				TOTAL	**$ 33,000.00**

Source: Elaboration by Consulting Team

3.3.2 Noise Monitoring

Type of measure: Preventive

Description of the Measure

The noise will be measured after the start of the equipment. An independent contractor selected by EDP will carry out sampling.

Methods of measurement shall be US EPA reference methods and ASTM methods. The noise measurement to be performed is detailed: (See Table 3-60).

Table 3-60 – Summary of the Noise Testing Program	
Sampling site:	4 points in sensitive receptors, sampled for the baseline of the project and boundary of the property.
Frequency:	Annual, 3 tests at each point
Parameters to determine:	dB(A) during the day and night
Methods to use:	Measurement with sound meter
Number of tests:	3
Duration of sampling:	Timely
Standard to be met	The noise in the residential areas where the points are located should be less than 55 dB (A) during the day and no more than 3 dB (A) of the noise measured at the baseline, at night: L1 50 dB (A), L2 54 dB (A), L3 56 dB (A) and L4 45 dB (A). 70 dB (A) on the edge of the property.

Source: Elaboration by Consulting Team

In addition, EDP should respond to the concerns of the community if there are any complaints regarding noise by the operations of the facility.

Location of the Environmental Measure

Baseline Noise Measurement Points (Figure 5.9)

- L1: 193799E, 1503738N
- L2: 194277E, 1503885N
- L3: 194760E, 1503024N
- L4: 193286E, 1503558N

In addition, the noise measurements to be taken in the boundary of the property of the Thermal Power Plant.

Estimated amount of the environmental measure

Table 3-61 – Estimated Amount of Environmental Measure - Noise Monitoring

Activity	Quantity	Unit	Unit Price	Term (months)	Total
Five Point Noise Measurement	1.00	Total	$ 1,000.00	3.00	$ 3,000.00
				TOTAL	$ 3,000.00

Source: Elaboration by Consulting Team

3.3.3 Protective Equipment for Personale and Spill

Type of measure: Prevention.

Description of the Measure

Objective

Prevent damages to employees and visitors for possible events, especially for the handling of hazardous materials, such as LNG and other hazardous materials in the Thermal Power Plant.

Description

The holder will acquire an industrial and personal safety equipment.
Personal protective equipment will be available, at least the following:

- Neoprene gloves;
- Helmets;
- Bucket shoes;
- Suits against fire 12.00;
- Breathing equipment 4.00.

Acquisition of portable equipment for detection of vapors

Constant monitoring of pressure in the tank will help monitoring possible LNG leaks in pipes, which, upon detecting a pressure drop, will automatically, close the affected equipment-section. In addition, periodic inspections with portable explosive gas detection instruments and oxygen meters.

Location of the Environmental Measure

Power Plant in general.

Estimated Amount of Environmental Measure

Table 3-62 – Estimated Amount of Environmental Measure – Spill and Personal Protective Equipment

Description	Quantity	Unit	Unit Price	Term (months)	Total
Suits Against Fire	12.00	each	$200.00	1.00	$ 2,400.00
Breathing Equipment	4.00	each	$200.00	1.00	$ 800.00
a set of gloves, shoes and helmet	60.00	each	$111.00	1.00	$ 6,660.00
Spill Kit	5.00	each	$300.00	1.00	$ 1,500.00
				TOTAL	**$ 9,860.00**

Source: Elaboration by Consulting Team

3.3.4 Training on Environment, Hygiene and Safety

Type of Measure: Prevention.

Description of the Measure

One of the most important measures to take is to provide the necessary information to the staff about the materials to be used and the safety measures to be taken in addition to the risks to which they would be exposed. Instruct staff about the likelihood of incidents during operations and maintenance activities, training them in safety standards for the type of work and the proper handling of equipment and tools.

This will be achieved by implementing training in safety and hygiene standards, with reinforcement at least every three months. Should include:

a. Introduction to environmental management: importance and understanding of environmental management;

b. Occupational health and safety aspects;

- First aid;
- Fire prevention and control;
- Handling of hazardous chemicals or materials;

- Signals used;
- Use and importance of personal protective equipment;
- Contingency plan: knowledge and training about it; and
- Provide safety equipment and personal protection.

Location of the Environmental Measure

To all the staff in the Thermal Power Plant.

Estimated Amount of Environmental Measure

Table 3-63 – Estimated Amount of Environmental Measure - Training in Environment, Hygiene and Safety

Description	Quantity	Unit	Unit Price	Term (months)	Total
Training	60.00	each	$50.00	1.00	$ 3,000.00
				TOTAL	**$ 3,000.00**

Source: Elaboration by Consulting Team

3.3.5 Environment, Hygiene and Safety Plans and Procedures

Type of measure: Prevention

Description of the measure

Objective

Prevent contamination of soil and water by poor management of waste from the operation of the Project.

Description

The best practices of the international industry will be used for the handling, storage, use of hazardous materials, including:

- Personal protective equipment;
- Overfilling and spill protection;
- Signals, labelling and inventory control;
- The use of secondary containment;
- Incompatible materials stored in separate places;
- Spill response material and easy-to-clean cleaning; and
- Fire extinguishers available.

In addition, a Solid Waste Management Plan will be implemented. This plan consists of the classification and separation of solid wastes according to their nature (packaging, domestic, organic and dangerous).

Also, stored temporarily in plastic containers with lid located inside the property, for later withdrawal by the service collection, to a dump authorized to receive non-hazardous waste (domestic, organic), recycling (packaging wastes). This prevention measure is considered as part of the Project, and will operate from the beginning of activities.

The use of chemicals (like, pesticides) for site landscaping management has the potential to affect the health of the community. The use of chemicals for gardening purposes will be minimized and used within local regulatory requirements.

Generation of common solid waste
Solid waste generated during the operating stage will be removed at least 3 times a week, by the garbage truck of the City Hall.

A set of containers will be provided to keep the waste separated in the following manner: Household Waste "and" Recyclable Material "(cans, plastic bottles, and others).

Generation of special type waste
Oil contamination
Regarding the oil residues that will be obtained from the oil separation trap, they will be separated during the cleaning activities of the trap (every 6 months) and stored in plastic barrels for their treatment, through companies dedicated to it, such as Geocycle company.

- Temporary storage

"Hazardous wastes" (wipes and paper contaminated with oil, empty containers of oil), generated in the different areas of customer service, will be stored temporarily in plastic containers properly covered and labeled. These will be properly disposed of through recycling companies.

Location of the Environmental Measure
Power Plant (See Figure 3-20).

Estimated Amount of Environmental Measure

Table 3-64 – Estimated Amount of Environmental Measure - Environment, Hygiene and Safety Plans and Procedures

Description	Quantity	Unit	Unit Price	Term (months)	Total
Treatment of waste with oils	1.00	Total	$350.00	36.00	$ 12,600.00
Containers for solid waste	12.00	Each	$45.00	1.00	$ 540.00
				TOTAL	**$ 13,140.00**

Source: Elaboration by Consulting Team

3.3.6 Relation with the Community

Type of measure: prevention

<u>Description of the Measure</u>

A communications plan must be established during the first three years of the Project's operation, to be carried out by the project's social and environmental management office.

Objectives

This measure pursues the following objectives:

- Provide information to the local citizens in relation of the operation of the Project;
- Preventing social conflicts and maintaining a good relationship with Project's neighbors;
- Prevent discomfort to the population residing in areas immediate to the Project site;
- Serve the population that is affected in some way during the operation, attention of complaints or discomfort of the community;
- Contact with fishermen, boats personnel, and schools; and
- Safety-related meetings.

Resources

The office will have at least the following staff:

Social Specialist: Will be responsible for all social management of the Project. The profile required for the manager of social management is as follows:

- Bachelor's Degree in Social Work, Sociology or Anthropology;
- Experience in mediation of conflicts and stakeholder engagement processes; y,
- Experience in social promotion of community development projects;

Functions of the office and its personnel

- Respond to queries and complaints from the population and respond or coordinate a response for them;
- Verify that the ENVIRONMENTAL MANAGEMENT PROGRAM is executed, as planned. Keep a record and prepare an annual report, which will be available when MARN carries out the environmental audits;
- Coordinate the environmental management of the Project;
- Hold informative meetings. These meetings should include community leaders, representatives of the main institutions and the corresponding municipality. At least every six months;

- Talks to workers related to environmental protection, respecting customs and values, monthly, to different groups of 20 people;
- Prepare written informational documentation of the Project, in surrounding areas, municipality, and schools.

Location of the Environmental Measure

The office will be installed within the administrative facilities of the Project. (See Figure 3-20)

Consideration should be given to the placement of 2 notices visible to pedestrians and drivers, on the location of the Social Management Office, on the project's site walls.

Estimated Amount of Environmental Measure

Table 3-65 – Estimated Amount of Environmental Measure - Relationship with the Community

Description	Quantity	Unit	Unit Price	Term (months)	Total
Social and environmental specialist	1.00	Person	$800.00	36.00	$ 28,800.00
Premises and materials	1.00	Total	$150.00	33.00	$ 4,950.00
				TOTAL	**$ 33,750.00**

Source: Elaboration by Consulting Team

3.3.7 FSRU Lightning Plan

Type of measure: Attenuation

Description of measure

Establish a lightning management plan, for the activities at sea in the operation phase, so it does not affect the marine fauna. The plan consists of:

- Reduce lighting at night hours in non-essential areas, except as required by the safety plan, particularly during critical periods of the life cycle of the fauna, such as during turtle nesting;
- Use screens to direct lighting to work areas;
- Direct all lighting to work areas and do not directly illuminate water.
- Low beam mounting;

- Use of light shielding to reduce the amount of glare, as well as reduce visible light to animals, so there is less chance of them being trapped, repelled, or their day / night patterns result altered;
- Installation of long wavelength lights (like amber and red lights) makes visible light appear less intense for nocturnal animals (State of Florida 2014[4]).

Location of the Environmental Measure

FSRU (See Figure 3-20)

Estimated Amount of Environmental Measure

Table 3-66 – Estimated Amount of Environmental Measure - Temporal Dock Lightning Plan					
Description	**Quantity**	**Unit**	**Unit Price**	**Term (months)**	**Total**
Marine Terminal Lighting Plan	1.00	Total	$1,000.00	1.00	$ 1,000.00
				TOTAL	**$ 1,000.00**

Source: Elaboration by Consulting Team

3.3.8 Revegetation Maintenance and Support to FIAES

Type of measure: compensation

Description of the measure

To compensate for the loss of vegetation by cutting trees, as well as the loss of infiltration, environmental measures were defined for the construction phase, considering planting and maintenance for three years.

To compensate for the exploitation of water resources during the operation stage, the donation to the Initiative Fund for the Americas has been considered, for revegetation projects and other environmental projects, equivalent to maintenance.

[4] State of Florida. 2014. "Wildlife Lighting - About Light Pollution" Florida Fish and Wildlife Conservation Commission. Online: http://myfwc.com/conservation/you-conserve/lighting/pollution/

Location of the environmental measure.

For planting compensation: Donation to the FIAES, to invest in environmental projects, the amount of $ 696,449.34.

Estimated Amount of Environmental Measure

The cost of planting and maintenance are included in the construction stage and for the operating stage, the maintenance cost for the period from 4 to 20 years is taken up, which totals $ 696,449.34, as shown in Table 3-67.

Table 3-67 – Estimated Amount of Environmental Measure - Revegetation Maintenance and Support to FIAES

Description	($USD/Ha)	Total Cost ($USD)
Plantation costs	$2,071.90	$71,435.25
Maintenance costs (3 years)	$1,139.50	$39,287.83
Total direct costs		**$110,723.08**
Indirect costs		
Administration expenses	12%	$13,286.77
Technical assistance	25%	$27,680.77
Incidentals	10%	$11,072.31
Total indirect costs		**$52,039.85**
Total planting and maintenance for 3 yeas		**$162,762.93**
Compensation for period 4-20 years	$20,199.74	**$696,449.34**
Total costs		**$859,212.27**

Source: Elaboration by Consulting Team

Table 3-68 presents a proposal for a breakdown of the measure in the Environmental Management Program

Table 3-68 – Proposal for Measure's Breakdown - Revegetation Maintenance and Support To FIAES

Breakdown in PMA		
Maintenance 04-07	Operations	$122,902.83
Maintenance 07-10	Operations	$122,902.83
Maintenance 10-13	Operations	$122,902.83
Maintenance 13-16	Operations	$122,902.83
Maintenance 16-19	Operations	$122,902.83
Maintenance 19-20	Operations	$81,935.22
		$696,449.34

Source: Elaboration by Consulting Team

3.3.9 Flow Monitoring Equipment and Monitoring of Wells

Type of Measure: Prevention

Objective: Prevention

Verify the water flows extracted from the well to be drilled for the supply of drinking water.

Description of the measure

Monitoring of water meters of 2 "with flange and standard pressure multi-jet, in the discharge shaft.

As described in measure 3.1.30 on the construction phase, the operation phase is followed up to ensure the correct operation of the installed equipment according to the conditions described in measure 3.1.30 including maintenance every 6 months to the equipment during the operation of the Thermal Power Plant (for 20 years).

Location of the Environmental Measure

Same as detailed in construction stage.

Estimated Amount of Environmental Measure

Table 3-69 – Estimated Amount of Environmental Measure - Flow Monitoring and Salt Intrusion Detection Equipment

Description	Quantity	Unit	Unit Price	Term (months)	Total
Analysis to determine saline intrusion	1.00	Each	$ 75.00	**36.00**	**$ 2,700.00**
Monitoring of levels with piezometric tubes	2.00	Each	$ 100.00	**4.00**	**$ 800.00**
				TOTAL	**$ 3,600.00**

Source. Elaboration by Consulting Team

3.3.10 Acquisition of Tugboats

Type of measure: Prevention

Objective

Respond to FSRU emergencies such as fire..

Description

A tugboat will be acquired to respond to emergencies.

Location of the Environmental Measure

FSRU.

Estimated Amount of Environmental Measure

Table 3-70 – Estimated Amount of Environmental Measure – Acquisition of Tugboats					
Description	**Quantity**	**Unit**	**Unit Price**	**Term (months)**	**Total**
Acquisition of Tugboats	1.00	c/u	$ 5,000,000.00	**1.00**	**$ 5,000,000.00**
				TOTAL	**$ 5,000,000.00**

Source. Elaboration by Consulting Team

3.3.11 Marine Wildlife Rescue Center

Type of measurement: Attenuation.

Description of the measure

Maintenance of a Marine Wildlife Rescue Center in collaboration with the MARN for the recovery of marine animals that could be affected during the operation of the project.

A rescue center is dedicated to recovering, restoring, the health of stranded or sick animals. The fauna for which this type of facilities is required includes: birds from aquatic habitats, dolphins, sea turtles and sea lions.

Location of the Environmental Measure

Will rent a house near the coast.

Estimated Amount of Environmental Measure

Table 3-71– Estimated Amount of Environmental Measure – Marine Wildlife Rescue Center					
Description	**Quantity**	**Unit**	**Unit Price**	**Term (month)**	**Total**
Operations	36	months	$600.00	**1**	$21,600.00
				TOTAL	**$21,600.00**

Source. Elaboration by Consulting Team

3.3.12 Environmental Measures Layout for Operation Phase

Figure 3-20 on the next page, presents the layout of environmental measures for operation phase.

3.4 Summary of the Environmental Management Program

The Environmental Management Program (PMA) aims to prevent, mitigate and compensate the negative impacts that the Project activities will generate on the environment. The Environmental Management Program basically consists of:

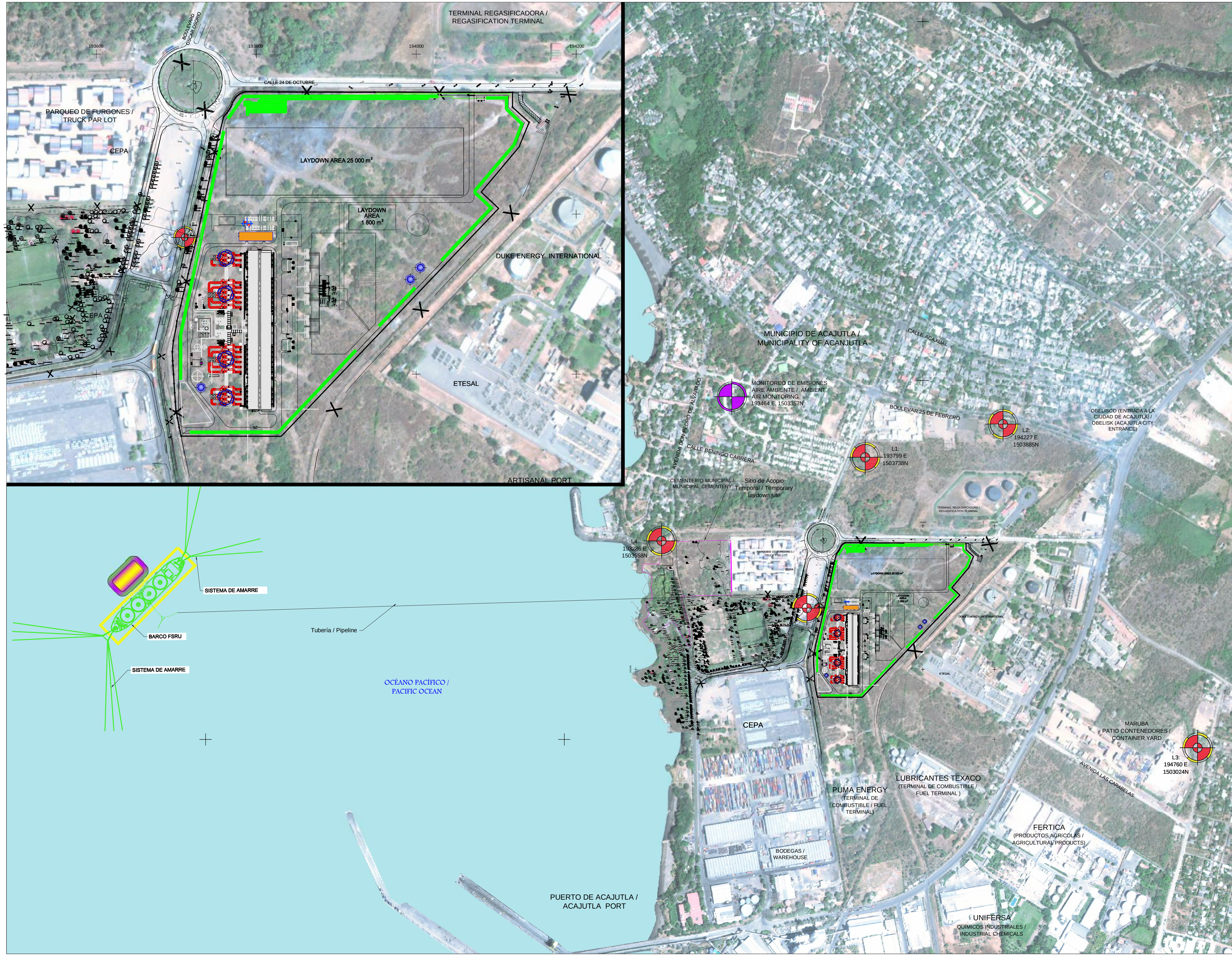
Measures and environmental investments to implement.
A summary Table containing all the measures proposed above is provided, with the respective actions required for each one, including implementation costs.

Monitoring program
Control and monitoring to verify the implementation and effectiveness of measures and investments.

Included in the monitoring program are other monitoring measures to be carried out for the project not associated with any environmental measure.

Schedule for the implementation of measures and investments.
The implementation of the measures has been programmed to be finalized by the end of the second year of operations, in accordance with the development of the Project.

The summary of the environmental management plan, monitoring plan and timetable for the application of environmental measures are included in the following Tables. The environmental bail has been quantified at an investment cost for **FIVE MILLION ONE HUNDRED TWENTY-ONE THOUSAND, NINE HUNDRED AND FIFTY 00/100 DOLLARS ($5,121,950.00)** for the measures to be implemented during the operational phase.



Energía del Pacífico

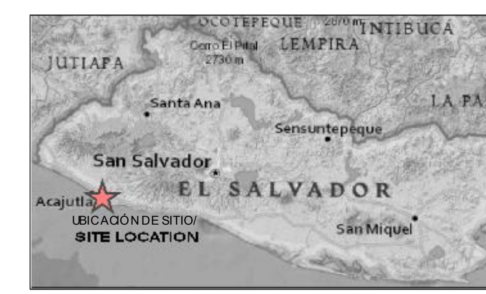
Energía del Pacífico

LNG TO POWER PROJECT

MEDIDAS AMBIENTALES EN ETAPA DE OPERACIÓN / ENVIRONMENTAL MEASURES IN STAGE OF OPERATION

FIGURA 3.20 / FIGURE 3.20

SIMBOLOGÍA / SYMBOLS	UBICACIÓN DE MEDIDAS / LOCATION OF MEASURES	CONTENIDO DE MEDIDAS / CONTENT OF MEASURES
	MEDIDA 1 / MEASURE 1	MONITOREO DE EMISIONES EN CHIMENEA / STACK EMISSIONS MONITORING
		MONITOREO DE EMISIONES AIRE AMBIENTE / AMBIENT AIR MONITORING
	MEDIDA 2 / MEASURE 2	MONITOREO DE RUIDO / NOISE MONITORING
	MEDIDA 3 / MEASURE 3	EQUIPO DE PROTECCIÓN PERSONAL Y DE DERRAMES / SECURITY EQUIPMENT AND SPILL RESPONSE
	MEDIDA 4 / MEASURE 4	ENTRENAMIENTO EN MEDIOAMBIENTE, HIGIENE Y SEGURIDAD / WORKER EHS TRAINING
	MEDIDA 5 / MEASURE 5	PLANES, PROCEDIMIENTOS, MEDIOAMBIENTE, HIGIENE SEGURIDAD / EHS PLANS AND PROCEDURES
	MEDIDA 6 / MEASURE 6	RELACIÓN CON LA COMUNIDAD / COMMUNITY LIAISON
	MEDIDA 7 / MEASURE 7	PLAN DE ILUMINACIÓN DEL FSRU / LIGHTING PLAN ON FSRU
	MEDIDA 8 / MEASURE 8	MANTENIMIENTO A REFORESTACIÓN / MAINTENANCE OF REFORESTATION
	MEDIDA 9 / MEASURE 9	EQUIPO DE MONITOREO DEL CAUDAL DEL POZO Y POZOS DE MONITOREO / WATER FLOW MONITORING MONITORING EQUIPMENT AND MONITORING WELLS
	MEDIDA 10 / MEASURE 10	ADQUISICIÓN DE REMOLCADOR / ACQUISITION OF TUGBOAT



0 50 100 150m

1:8,000

N E S W

FUENTE / SOURCE:
PLANOS WARTSILA / WARTSILA SITE PLAN

MAP CREATED BY / MAPA CREADO POR: ECO INGENIEROS
MAP CHECKED BY / MAPA REVISADO POR: LF
MAP PROJECTION / PROYECCIÓN DE MAPA:
UTM ZONE 16 WGS84/ UTM ZONA 16 WGS84

FILE / ARCHIVO
C:/CAP 10,ECO,DIBUJO 1, EL SALVADOR/ ECO INGENIEROS
C:/CAP 10,ECO,DRAWING 1, EL SALVADOR/ ECO INGENIEROS

PROJECT / PROYECTO: 14-9114
STATUS / ESTATUS: FINAL / FINAL
DATE / FECHA: 02/02/2018

DILLON CONSULTING

ECO INGENIEROS

Table 3-72 – Environmental Management Program Operation Phase

Execution Stage	Project Activity	Description of Generated Environmental Impact	Environmental Measure	Description of Proposed Measure	Location of the Environmental Measure	Responsible for its execution	Calculated Amount of Environmental Measure	Time of execution	Expected result
Operations	NG burning to produce power in the engines	Emissions to the atmosphere	**1. Emission Monitoring**	Conduct emission measurements every year for the first three years, install a PEM (Emission Prediction Monitoring) and measure ambient air quality for nitrogen dioxide (NO2) for 20 continuous days	4 motors chimneys selected randomly, and Communications office (environment air)	EDP	$33,000.00	Annual	Emissions and ambient air levels below benchmarks
Operations	NG burning to produce power in the engines	Noise	**Prevention** **2. Noise Monitoring**	Measuring of noise levels during three years, annually. If there are major changes in equipment / operations that could produce an increase in noise, more would be needed.	The noise must be monitored at baseline points and at the plant property boundary.	EDP	$3,000.00	Annual	Noise in residential areas shall be less than 55 dB (A) during the day and not more than 3 dB (A) of the noise measured at baseline, at night: L1 50 dB (A), L2 54 dB (A), L3 56 dB (A) and L4 45 dB (A). 70 dB (A) on property boundary.
Operations	Storage, handling, use and disposal of raw materials, waste and hazardous waste	Accidental dumping of hazardous materials at the site with potential for: • Pollution of the environment (soil, surface waters, groundwater, sea water) • Exposure of workers to toxic or irritant materials • • Possible contamination of the human food chain (by contamination of sea water)	**Prevention** **3. Protective Equipment for personal and spills**	Use the Best Practices of the International Industry for the handling, storage, use of hazardous materials, including: • Overfilling and spill protection • Inventory Labeling and Control • The use of secondary containment • Incompatible materials stored in separate places • Easily accessible spill response and cleaning material (onshore and offshore) • Personal protective equipment available	All the plant and FSRU	EDP	$9,860.00	Duration of operations	Low risk of significant environmental pollution from operations Low risk of significant exposure of workers or the human food chain to hazardous materials
Operations	Storage, handling, use and disposal of raw materials, waste and hazardous waste	Accidental dumping of hazardous materials at the site with potential for: • Pollution of the environment (soil, surface water, groundwater, sea water) The exposure of • workers with toxic or irritant substances • The potential contamination of the human food chain (from marine water pollution)	**Prevention** **4. Training environment, hygiene and safety**	Provide training on the environment, hygiene and safety for workers appropriate for their role and position Provide advanced training for workers handling hazardous materials	Project's site	EDP	$3,000.00	During operations	All workers will receive appropriate training for handling and management of hazardous materials

Ing. Alejandro Alle, Apoderado Legal, **Energía del Pacífico Ltda. de C.V.**

Table 3-72 – Environmental Management Program Operation Phase

Execution Stage	Project Activity	Description of Generated Environmental Impact	Environmental Measure	Description of Proposed Measure	Location of the Environmental Measure	Responsible for its execution	Calculated Amount of Environmental Measure	Time of execution	Expected result
Operations	Storage, handling, use and disposal of raw materials and hazardous waste	Accidental dumping of hazardous materials at the site with potential for: • Pollution of the environment (soil, surface water, groundwater, sea water) • Exposure of workers to toxic or irritant substances • The potential contamination of the human food chain (from marine water pollution)	**Prevention** **5. Environment, health and safety plans and procedures**	Use the Best Practices of the International Industry for the handling, storage, use of hazardous materials, including: • Personal protective equipment available • Avoid overfilling and spill protection • Signaling, labeling and inventory control • Use of secondary containment • Incompatible materials stored in separate places • Spill response and cleaning material available • Fire extinguishers available	Hazardous materials storage areas	EDP	$13,140.00	During operations	Low risk of significant environmental media pollution as a result of operations Low risk of significant exposure of workers or the human food chain from hazardous materials
Operations	• LNG delivery • Physical presence of facilities • General Operations Activities	• potential safety for artisanal fishermen and the general navigating public • The general relationship with the public and interested parties	**Prevention** **6. Relation with the community**	• Continue Community Liaison Program initiated during construction, including: • safety brochures for fishermen and boaters and for schools • security meetings • Response to complaints from stakeholders	Non-applicable	EDP	$33,750.00	Comprehensive safety disclosure prior to operations. Liason and assistance with the program as needed during operations	General knowledge of the risks of maritime safety, safety of navigation and navigation behaviour, and the danger of unauthorized entry. All complaints must be legitimately addressed.
Operations	General operations	Artificial lighting around the FSRU can affect the behavior of marine fauna, including turtles.	**Attenuation** **7. FSRU Lightning Plan**	Apply Lighting Management Plan: • Reduce lighting in non-essential areas, particularly during critical periods of life-cycle (ex: nesting of turtles) • Use guards to direct lights to areas requiring lighting • Direct light away from water, excepting for safety inspections	Areas of operation at sea	EDP	$1,000.00	During operations	Eliminate unnecessary lighting
Operations	Eviction	Loss of habitat and increased habitat fragmentation	**Compensation** **8. Maintenance to reforestation and Support to FIAES**	Maintenance: • Payment of $ 696,449.34 to FIAES for use in works to improve and protect the environment in El Salvador	• Areas identified by FIAES	EDP	$0.00	For 17 years	Establishment of the plantation. The work of restoration will be undertaken by FIAES which will compensate for the local loss of habitat.
Operations	Monitoring of water meters and physico- chemical characteristics.	The decrease of water flow and contamination by saline intrusion.	**Prevention** **9. Flow monitoring equipment and monitoring of wells**	•Monitoring of water flows from the potable water supply. •Monitoring of physicochemical parameters of the extracted water.	• Water extraction well • Monitoring of wells	EDP	$ 3,600.00	During operation time, well exploitation.	The groundwater flow rate and the quality of the groundwater will be kept at the appropriate level.

Ing. Alejandro Alle, Apoderado Legal, **Energía del Pacífico Ltda. de C.V.**

Table 3-72 – Environmental Management Program Operation Phase									
Execution Stage	**Project Activity**	**Description of Generated Environmental Impact**	**Environmental Measure**	**Description of Proposed Measure**	**Location of the Environmental Measure**	**Responsible for its execution**	**Calculated Amount of Environmental Measure**	**Time of execution**	**Expected result**
Operations	Operation del FSRU	Risk to the public and the facilities	**Prevention** **10. Acquisition of tugboats**	Acquisition of one tug boat to facilitate FSRU exit from the maritime terminal in emergency or other situations.	• FSRU	EDP	$ 5,000,000.00	During operations	Support in emergency care
Operations	General offshore activities	Disturbance of Marine habitat	**Attenuation** **11. Marine Wildlife Rescue Center**	Installation of a Marine Wildlife Rescue Center in collaboration with MARN for the recovery of marine animals that could be affected during the construction of the project.	• Rented house near the coast	EDP	$21,600.00	During operation activities	Stranded animals or sickly assisted. Minimized disturbance to marine habitats
						Total	**$5,121,950.00**		

Table 3-73 – Monitoring Program Stage of Operations

Execution stage	Environmental Activity	Parameters to consider	Place or Monitoring Point	Frequency of Monitoring	Method to Use	Responsible for Monitoring	Interpretation of Results	Feedback	Reference in Impact Description Text
Operations	**Prevention** **1. Monitoring of Emission**	NOx; PTS; O2; CO; CO2; Flow of gases; Composition; Production (MW) emissions when starting operations, the next two years only NOx sampling.	Sampling in port, in chimney of 4 motors chosen at randomly	Annually for the first three years; Then, during the life of the project, if the results are favorable, the monitoring will be done every three years.	Isocinetic Method, EPA Methods	EDP	Comparison to the World Bank Guide Issue Limits Project, 200 mg / Nm3	Perform diagnostic and maintenance for any engine that is emitting excess concentrations of NOx	Page 10-87
		Predictive emission monitoring	Engines in plant	Continuous	PEM equipment	EDP	Comparison to the Project Fuel cell Emission Limits	Perform diagnostic and maintenance for any engine that is emitting excess NOx	Page 10-87
		NO2 Soil Concentrations	Off-site, permanent monitoring site	Continuous 20 days for one year	According to NSO 13.11.01: 01, Table 1, electrochemical analyzer or similar	EDP	Comparison NSO 13.11.01: 01, Nitrogen Dioxides: 150 µg / Nm3, for 24 hours	Apply measures to reduce the concentration in the ambient air	Page 10-87
Operations	**Prevention** **2. Noise Monitoring**	(Off-site) Environmental noise, including low-frequency noise	In the four points in near residential areas, used for the baseline and in boundary	Annual and thereafter only if complaints are received from the population	Monitoring to be performed according to Acoustics international standard 9613-2	EDP	Noise in residential areas shall be less than 55 dB (A) during the day and not more than 3 dB (A) of the noise measured at baseline, at night: L1 50 dB (A), L2 54 dB (A), L3 56 dB (A) and L4 45 dB (A). 70 dB (A) on property boundary.	If the excess noise identified after analysis determines potential sources and remedial measures	Page 10-91
Operations	**Prevention** **3. Spills and Personal Protective Equipment**	Installation of all equipment and operation test	Tank yards, cargo rack and bottling plant	Biannual	Equipment Operations Report, Preventive Maintenance and Inventory of Spill and Containment Equipment	EDP	Preventive maintenance and inventory of spill and containment equipment	Replacement of defective equipment	Page 10-92
Operations	**Prevention** **4. Environment, hygiene and safety training**	Training and accident records	In offices to staff	Biannual	Interviews to personnel	EDP	Prevent damage to personnel, infrastructure and the environment	Updating of training topics	Page 10-93
Operations	**Prevention** **5. Environmental, Hygiene and Safety Plans and Procedures**	Containers for solid waste and handling of hazardous materials	Waste collection site	Monthly	Visual Inspection and Photographic Record	EDP	Prevent contamination of soil and water	Ensure transport and proper disposal and proper use of latrines	Page 10-94
Operations	**Prevention** **6. Relationship with the community**	Verify the information of the population about the project and conflicts that arise	Record of meetings and complaints	Monthly	Review complaints and their resolution	EDP	Verify that project information and conflict resolution have been provided	Improve the media and attention to complaints	Page 10-96

Ing. Alejandro Alle, Apoderado Legal, **Energía del Pacífico Ltda. de C.V.**

Table 3-73 – Monitoring Program Stage of Operations

Execution stage	Environmental Activity	Parameters to consider	Place or Monitoring Point	Frequency of Monitoring	Method to Use	Responsible for Monitoring	Interpretation of Results	Feedback	Reference in Impact Description Text
Operations	**Attenuation** **7. FSRU lightning Plan**	Lighting on the FSRU	FSRU	Monthly during construction	Visual Inspection and Photographic Record	EDP	Lighting should not be directed to sea water except for periodic safety observations	Correct the lighting direction	Page 10-97
Operations	**Compensation** **8. Revegetation Maintenance and Support to FIAES**	Donation record	Office	Anual	Compliance with the EDP-FIAES agreement	EDP	Verify Donation	Care and maintenance	Page 10-98
Operations	**9. Well Flow Monitoring Equipment and Monitoring Wells**	Well water	Water from extraction well and monitoring of wells	Biannual (2 times a year) for physicochemical parameters. Monthly (12 times a year) piezometer inspection.	Laboratory analysis method according to NSO 13.11.01: 01	EDP	Comparison with baseline conditions and water quality criteria	If the monitoring detects signs of intrusion, the project should review the consumption and look for alternative sources	Page 10-100
Operations	**Prevention** **10. Acquisition of tugboats**	Acquisition of two tug boats	Marine Terminal	Monthly	Visual Inspection and Reports	EDP	No incidents, expedite FSrU exit from the maritime terminal in emergency or other situations.	Effective displacement of the FSRU	
Operations	**Attenuation** **11. Marine Wildlife Rescue Center**	Installation of a Marine Wildlife Rescue Center, collaboration from MARN	Rented house near the coast	Monthly	Reports and Photographic Record	EDP	Stranded animals or sickly assisted.	Minimized disturbance to marine habitats	
Operations	**12. Surface water quality**	Oils and Fats, Hydrocarbons	Wastewater discharge points, prior to discharge	Quarterly (4 times per year)	Laboratory analysis method according to NSO 13.11.01: 01	EDP	Comparison with standards	If monitoring detects project-related pollution, then take corrective action to stop additional pollution and investigate the need for corrective action	Non-applicable
Operations	**13. Water quality of effluent from domestic wastewater treatment system**	BOD 5, COD, pH, Oils and Fats Sedimentary solids Total Suspended Solids, Total Coliforms (CT)	Domestic wastewater from the treatment plant of Central Thermal Power Plant, and FSRU.	Quarterly (4 times per year)	Laboratory analysis method according to NSO 13.11.01: 01	EDP	Comparison with standards	If monitoring detects project-related pollution, then take corrective action to stop additional pollution and investigate the need for corrective action	Non-applicable
Operations	**14. Presence of disease vectors**	Presence of mosquito larvae	Areas of stagnant water, such as rainwater ponds and the site in general	Twice a week during the rainy season. Monthly during dry season	Visual inspection	EDP	Presence of breeding habitat, presence of larvae in water	If larvae are detected, corrective actions should be taken to solve the problem	Non-applicable

Ing. Alejandro Alle, Apoderado Legal, **Energía del Pacífico Ltda. de C.V.**

Table 3-73 – Monitoring Program Stage of Operations									
Execution stage	**Environmental Activity**	**Parameters to consider**	**Place or Monitoring Point**	**Frequency of Monitoring**	**Method to Use**	**Responsible for Monitoring**	**Interpretation of Results**	**Feedback**	**Reference in Impact Description Text**
Operations	**15. Marine Fauna**	Presence of marine biota in the FSRU water intake. Quantity and type of fish caught	FSRU	Weekly for one year and monthly after first year	Visual inspection	EDP	A significant number of species, particularly those considered significant, should not be trapped in water intake or captured through water intake.	Replace the grid in the openings of the breakwater and in the water intake openings, consideration of displacement screens/meshes if necessary	Non-applicable
Operations	**16. Water discharge from and FSRU**	Temperature	Water discharge points	Monthly	Temperature sensor	EDP	Should not be greater than 5ºC of the body temperature recipient	Take corrective actions to reduce temperature, prior to discharge	Non-applicable

Ing. Alejandro Alle, Apoderado Legal, **Energía del Pacífico Ltda. de C.V.**

Table 3-74 – Schedule of the Environmental Management Program, Operation Phase

Stage of Execution	Environmental Measure	Execution Time (Quarters since Start of Operations)												Estimated Amount of Environmental Measure
		YEAR 1				YEAR 2				YEAR 3				
		1	2	3	4	5	6	7	8	9	10	11	12	
Operations	**Prevention** **1. Emission Monitoring**													$33,000.00
Operations	**Prevention** **2. Noise Monitoring**													$3,000.00
Operations	**Prevention** **3. Spills and Personal Protective Equipment**													$9,860.00
Operations	**Prevention** **4. Environment, hygiene and safety training**													$3,000.00
Operations	**Prevention** **5. Environmental, health and safety plans and procedures**													$13,140.00
Operations	**Prevention** **6. Relationship with the community**													$33,750.00
Operations	**Attenuation** **7. FSRU Lightning Plan**													$1,000.00
Operations	**Compensation** **8. Maintenance for reforestation and Support to FIAES**													$0.00
Operations	**Prevention** **9. flow monitoring equipment and monitoring of wells**													$ 3,600.00
Operations	**Prevention** **10. Acquisition of tugboats**													$5,000,000.00
Operations	**Attenuation** **11. Marine Wildlife Rescue Center**													$21,600.00
TOTAL AMOUNT OF ENVIRONMENTAL MEASURES OPERATIONS PHASE														**$5,121,950.00**

Ing. Alejandro Alle, Apoderado Legal, **Energía del Pacífico Ltda. de C.V.**

Energía del Pacífico

Project: LNG to Power
Addendum to EsIA
Chapter 4: Risk Assessment and Contingency Plan

February 2018 – 16-3489

ECO INGENIEROS
LÍDERES EN CONSULTORÍA AMBIENTAL

DILLON CONSULTING

Table of Contents Chapter 4

List of Figures Chapter 4

List of Charts Chapter 4

List of Charts Chapter 4

4. Risk Assessment and Contingency Plan

The project is its Front End Engineering Design (FEED) stage related to the maritime terminal, which will consist of a Floating Storage Regasification Unit (FSRU) fixed in place by means of the RCM mooring system formed by mooring lines that act as an extended mooring system (Spread Mooring). The FSRU will be a Liquefied Natural Gas Carrier (LNG) adapted with a regasification plant. The RCM mooring system will allow the LNGC to be moored by means of a boat-to-boat system alongside the FSRU.

The Project is still under development through a world-class best practice approach seeking to ensure the safety of the facility. All activities carried out during the Front End Engineering Design have demonstrated that the characteristics of the project will be within the acceptable safety scope. The thoroughness applied to the risk identification and analysis activities carried out to date have been in accordance with international standards for projects at this stage of development.

During the FEED stage, several studies have been carried out to establish a preliminary design basis in order to identify the technological challenges and feasibility. Technical requirements have been developed in terms of anchorage and mooring using computing methods that, based on current climatic and dynamic ocean conditions, maneuvers have been identified for these conditions. The navigation maneuvers previously studied are still applicable since the FSRU's location is maintained in the previous FSU's proposed location, resulting in the LNGC being docked at the terminal in the same location previously studied. The risks related to the Project, such as the collision of ships due to climatic conditions, have been analyzed at this stage. In addition, a quantitative risk study has been conducted to assess the risks of the Project that could affect people or the environment.

After obtaining financing and building permits, the detailed design stage begins. This stage focuses on establishing a complete definition of all aspects of the project. The design and engineering of the FEED stage are fine-tuned. Safety and risk studies, such as the detailed QRA, will be undertaken, taking into consideration all the detailed characteristics of the Project that will be defined at this stage. These characteristics include aspects such as piping and instrumentation diagrams. Fire and explosion risks will be analyzed in greater depth and modeled in order to assess the impact on both, the public and the environment. Evacuation routes will be defined later and the final detailed contingency plan will be developed.

Thereafter, the construction, installation and starting-up stage begins. At this stage, infrastructure inspections and marine classification begin. Following is a detailed update of the risk identification and quantitative assessment of the preliminary / high-level risk, which assessed aspects such as the process risk, the potential hazards, navigation, location, tsunamis, earthquakes, heavy rains and anthropogenic threats at the project's site.

The global firm Lloyd's Registry (LR) contracted to identify and to conduct risk studies associated with the project and the modifications proposed in this study.

The process is detailed as follows:

1. **Risk Identification:** Workshops were held, including a Hazard Identification Update Workshop (Hazard Identification, HAZID) in December 2017, which contributed to the quantitative risk analysis.
2. **Quantitative risk analysis:** the workshop results, as well as international standards in risk management, were taken into account.
3. **Conceptual plan of contingencies**. The conceptual-level contingency plan drafted in November 2016, outlines the content and requirements of a future Detailed Contingency Plan (which will be developed as part of the detailed project design) continues to be applicable.

In the risk identification (HAZID) and quantitative risk analysis (QRA), the scenarios requested in the project's terms of reference were assessed.

- To identify the risks present therein
- To assess the frequency and probability of its occurrence, and
- To determine the magnitude and impact they would have on the public in general, on the environment and on material goods

The elements assessed include spill scenarios from different points/locations and plant operations, the probability of occurrence, the environmental conditions and the risks in addition to their potential consequences. The results of the workshops held before 2017, were included in the EIA submitted in 2016, and those that remained applicable were retaken.

The results obtained are described below.

4.1 Risk Identification (Hazard Identification, HAZID)

In the HAZID risk industry, workshops are widely used to incorporate local knowledge and the key areas of focusing on risk and project assessments. HAZID's main objective is to identify the main potential hazards associated with the marine project, the possible causes/consequences, the frequency, the possible risk mitigation measures and its recommendations.

The following describes the issues discussed and the results of the HAZID workshops conducted.
In addition to the workshops held before December 2016, and included in the EIA submitted, a HAZID

workshop was held in December 2017. The purpose was to review and update the types of risks, causes and consequences associated with the new characteristics of the Project, mainly:

- FSU Removal
- The removal of the cofferdam structure (perimetral breakwater) which surrounded the re-gasifying barge.
- The use of the RCM mooring system
- LNG transfer between LNGC and FSRU. (Previously the transfer was between the LNGC and the FSU)
- Increased delivery pressure of natural gas from FSRU to the thermal plant from 13 bar to 80 bar.

The attendees to the HAZID workshop were the technical teams from Lloyd's Register, Energía del Pacífico, and Exmar (designers of the regasification plant and the modifications on the LNGC methane carrier).

4.2 HAZID Recommendations

As already mentioned, the twenty-six recommendations identified in the HAZID workshops in 2016, and Hazid Update in 2017, continue to be applicable and are listed in the chart 4-1, with the exception of the recommendations for the FSU that are no longer applicable which were deleted from the chart. The recommendations will be further studied and will be considered during the design and development stage of the final procedures.

<table>
<tr><th colspan="3">Chart 4-1 - HAZID Recomendations</th></tr>
<tr><th>ID</th><th>Recommendation</th><th>Risk classification (after mitigation)</th></tr>
<tr><td>1.1</td><td>Consider the operational procedures to ensure proper piloting and tugboat assistance to approach the LNGC to avoid collisions.</td><td>M</td></tr>
<tr><td>1.1</td><td>Establish the points where any towing assistance should be in place before continuing to the final destination.</td><td>M</td></tr>
<tr><td>1.1</td><td rowspan="2">Identify the needs for navigation aids.</td><td>M</td></tr>
<tr><td>1.5</td><td>L</td></tr>
<tr><td>1.2</td><td rowspan="3">Examine the exclusion and/or security areas for the transit of the LNGC</td><td rowspan="3">M</td></tr>
<tr><td>2.1</td></tr>
<tr><td>8.2</td></tr>
<tr><td>1.2</td><td>Establish by the procedure the requirement to have an escort of the pull for LNGC</td><td>M</td></tr>
</table>

Chart 4-1 - HAZID Recomendations

ID	Recommendation	Risk classification (after mitigation)
1.2	Consider establishing designated pilot boarding area (s).	M
	Consider regulating a formal transport lane for ships sailing to/from the Port of Acajutla in the southwest and validate through marine simulations. Make sure that the formal proposal has sufficient supporting documents (like, marine simulations) when it is submitted to the Maritime Authorities.	
1.2	It is recommended to arrange a meeting involving all parties affected by the change of location of the canal (shipping lane) (AMP, CEPA pilots, Cenérgica's mooring master). It is recommended that the shipping lane be marked with visual signs. Make sure that access to other terminals remains safe under the new scheme.	M
1.2 2.1	Identify the turning circle for the GNLC maneuver and approachment to the Maritime Terminal, and coordinate with AMP and the Port Authority. Consider the PIANC and SIGTTO regulations to determine the turning radius.	M
1.4 3.5	Bathymetry studies are recommended for navigation areas.	M M
1.5	Consider the possibility of assessing the operational procedures to ensure an appropriate piloting service and towing assistance to approach the LNGC and avoid any collision.	L
3.1 3.2 3.3	Assess towing requirements (such as requirements and procedures) Passage of the ships to the sea, ships that enter/exit the port.	M M M
3.4 5.1	Develop pipeline protection as part of the design. It is recommended to include a restricted area around the pipe route.	M M
3.4	Develop the protection of the lifting pipe as part of the design.	M
3.5	Investigate the composition of the seabed in the geophysical study.	M
5.1	Consider a visual marking to indicate the physical location of the pipe. Make sure that pipeline area (through a nautical chart indication and direct communication with fishermen).	M
6.1	Consider limiting the approach/departure of a vessel at a time from or to the CENÉRGICA'S mooring area, the Port of Acajutla, or the LNG Terminal.	
6.1	It is recommended that local pilots and tugboat operators be provided with the acquaintance and training necessary to operate the LNGC.	L
6.2	It is recommended to start mooring and maneuvering operations for the LNG terminal during daytime. The overnight outings will be simulated to determine the preliminary acceptability.	-
6.3	The distance between the bottom of a ship and the seabed needs to be analyzed for moored ships.	-

Chart 4-1 - HAZID Recomendations		
ID	**Recommendation**	**Risk classification (after mitigation)**
7.1	When the terminal is operating and powered on, fishing activity will be attracted to the terminal. Ensure that safety and exclusion areas are proposed and instituted regarding fishing and traffic near the terminal.	M
7.1	The International Ship and Port Facility Security (ISPS) for the terminal should take into account local safety concerns.	M
7.1	It is recommended that the project is committed with the national government to ensure that the government provides security measures for external threats to this international investment project.	M
7.2	Quantitative Risk Analysis (QRA) for the project will address the risk to third parties and coastal communities (nearby populations).	-
9.1	Consider stopping the LNG transfer from LNGC to FSRU in the event of showers.	L
9.1	Include showers in marine simulation scenarios.	L
9.2	It is recommended to clearly define the environmental limits	L

Source: HAZID Marine Report, Project LNG to Power, Acajutla, El Salvador

4.3 SIMOPS Recommendations

During the HAZID workshops carried out in 2016, the risks associated with possible simultaneous operations (SIMOPS) of maritime terminals in the area were assessed. As a result of SIMOPS, the following comments were obtained which remain applicable. These comments will be studied and, if applicable, will be considered during the design and development stage of the final procedures.

- With the current resources available (pilot and tugboats) and the requirement to assist tankers/LNGCs entering from the pilot's embarkation area with one pilot and two tugboats, the tankers will not be approaching or leaving the Cenérgica area while an NLGC is in transit heading to the embarkation pilot or to the marine terminal.
- Normal operations in the Port of Acajutla can be carried out at the same time when there is NLGC activity or normal operations undertaken in the LNG terminal. As an example, while the NLGC is approaching or leaving the LNG terminal it is transferred through a ground pipeline. The normal operations at the Port of Acajutla, such as unloading or material handling, may continue.
- If a LNG leak or fire occurs in the Maritime Terminal, all incoming and outgoing traffic must be stopped. Operations in the Port of Acajutla should be planned in detail if they are to be continued in the event of any LNG leak or a fire at the Maritime Terminal.

- The discharge of hydrocarbons at the Alba Petróleos terminal or RASA terminal can be carried out at the same time as the normal operations at the Maritime Terminal and at the same time as the LNGC approaches or exits.

The following recommendations produced from SIMOPS, included in Chart 4.2, will also be studied and, if applicable, will be considered during the design and development stage of the final procedures.

Chart 4-2 - SIMOPS Recommendations

ID	Recommendations[R] / Comments[C]
2	[R] It is recommended that the project is determines whether it is necessary to increase the anchoring/scene area or to allocate specific anchoring areas before the NLGC enters the area.
3	[R] It is recommended that the project is obtains the operating manual and emergency preparedness procedures from the port and other terminals.
8	[R] It is recommended to determine whether the resources at the Port of Acajutla are enough in terms of emergency response capacity for the occurrence of two incidents at the same time. For example, 1) LNG leakage at the LNG Terminal and oil leakage at the Cenérgica mooring area; 2) LNG leakage at the LNG Terminal and a fire at the Port of Acajutla. Among the mitigation measures could be stopping the transferring and the production to avoid two incidents at the same time.
9	[R] It is recommended to run a simulation in the QRA to address the consequences of a natural gas vapor leak.
10	[R] It is recommended to assess the frequency of scenarios that have an outcome in the port's operations and potentially determine a contingency planning for these situations.

Source: HAZID Marine Report, Project LNG to Power, Acajutla, El Salvador

4.4 Quantitative Risk Analysis Study (QRA Study)

The Quantitative Risk Study (QRA) took into account the observations and comments made by the participants of the Risk Identification workshops.

Lloyd's Register (LR) was contracted to conduct the Quantitative Risk Analysis (QRA) of the new project set-up/layout. Although initially a plant with two production trains of 70 million standard cubic feet per day (MMSCFD) of natural gas (NG) was planned to be installed, the QRA study was further developed based on a production rate of 280 MMSCFD of natural gas. 280 MMSCFD is the maximum delivery rate for future development, which could be achieved with two additional regasification trains of 70 MMSCFD each. The scope of the QRA performed for the new set-up includes the LNG import terminal up to the isolation valve on the ground pipe (also referred to in this report as emergency ground shutdown valve). The Study is included in Appendix 4A.

4.5 Objective

The main objective of the QRA conducted in the Front-End Engineering Design (FEED) stage is to assess the potential risks to the environment and the public as a result of significant, serious, and credible events in the LNG import terminal and associated infrastructure in addition to supporting the Environmental Impact Assessment (EIA) project.

4.6 Methodology

The risk posed by the project was assessed in the FEED basing on the major and worst, and credible scenarios identified in HAZID sessions prior to the QRA. For each scenario, the following was discussed

- Scenario description
- Frequency anal
- Assessment of the consequence
- Risk assessment as a combination of frequency and consequence
- Risk assessment with risk criteria and risk mitigation recommendations

The risk acceptance criteria used in the QRA are shown in Chart 4-3.

Chart 4-3 - QRA Criterion for Criteria Acceptance

Region at risk	Description	Average Public Individual Risk (IR) Criteria (Annually)
Unacceptable risk	Authority requirements, corporate requirements, international standards and recommended practices jointly define a higher level of risk above which risk is considered unacceptable. The unacceptable risk cannot be justified except in unusual circumstances.	≥ 1E-04
Tolerable/acceptable risk, whenever the risk is ALARP *(As Low As Reasonably Practicable)*	Recognised and accepted focuses/approaches through the sector show that an adequate level of scrutiny and mitigation have been applied to risks arising from identified hazards and that the residual risk to the public and the environment is as low as reasonably practicable (ALARP).	1E-06 < IR < 1E-04
Widely acceptable risk	These risks are generally considered as insignificant and adequately controlled.	≤ 1E-06

Source: Quantitative Risk Analysis

The individual Iso-risk curves (LSIRs) are often used in the early stages of the project planning and are considered conservative in estimating risk for the public. The LSIR measures the risk in nearby areas (industrial or public areas) and is used in this QRA to measure project risk to the public and, indirectly, to the environment. The LSIR is calculated for two locations: the LNG import terminal (synonymous with Marine Terminal) and the ground location.

The ALARP methodology for assessing risk reduction and mitigation is applied in conjunction with good engineering practices, legislative requirements, codes, and standards. The ALARP principle is widely recognized in the industry to prove that the appropriate scrutiny and mitigation level are applied in identifying risks and that the residual risk to workers in the site, the public, and the environment is ALARP.

The requirements of authorities, international standards, and best practices jointly define the level of risk considered as unacceptable. In the unacceptable region, the risk cannot be justified except under extraordinary circumstances.

4.7 Results

The results of individual risk (IR) by process release location are provided in Chart 4-4.

Chart 4-4 - Individual Risk (IR) Results

Location of the launching process	IR by Year	Region for Public
FSRU bridge	1.7.E-04	Not applicable to the public
Thermal Plant Center	7.37E-07	Widely acceptable

Source: Quantitative Risk Analysis

Risk Level for Public Members

The results show that the risk to members of the public found within the tolerable risk region (zone 10E-06 outlined in orange) is located on the southeastern edge of the town of Acajutla, some industrial zones and part of the port of Acajutla. This represents an area where residual risk to the public is as low as reasonably practicable. Beyond this area, the risk to the public is widely acceptable, regarded as insignificant and adequately controlled.

Level of Risk at the Ground Generating Plant

The risk to the public is widely acceptable, widely considered as insignificant and adequately controlled.

LNG Import Terminal

A risk area of 10E-04 per year (blue outline) around the FSRU/LNGC has been identified in the QRA; however, there will be no public presence in this area.

Access Channel

Risk Levels along the access channel, as it is currently defined, are partially in a tolerable/acceptable risk region (>10E-6 per year), and partially within the widely acceptable risk region (<10E-6 per year)

LSIR's Iso-risk outlines of these locations are shown in Figure 4-1.

Figure 4-1 - LSIR's Iso-Risk Outlines for LNG Import Terminal and Ground Location

Source: Quantitative Risk Analysis

4.8 Comparison with the previous QRA Study

This study follows the previous QRAs for the proposed facility, and the main changes are:

- Operation of high pressure natural gas production using pipe pressure at 80 bar instead of 11 bar; and,
- Removal of the Floating Storage Unit (FSU) and a lifting platform surrounding the FSRU.

Because of these changes and the revised assumptions considered in the previous QRAs, there are clear differences between the QRA results at 80 bar and 11 bar as explained below:

- NG releases at 80 bar will have higher risk ranges than those released at 11 bar. As a result, the risk outlines at 80 bar can be extended for distances greater than 11 bar.
- Previously, it was assumed that all surface pipeline emissions would occur at the center of the generating plant. This was a conservative approach which was valid for the 11 bar operation, but is not considered valid for the 80 bar operation in the sense that it would give an unrealistic risk perception. For the 80 bar operation, emission locations have been modeled along the buried

underground pipeline route. This changes the risk perception on the ground and eliminates the risk outline at the center of the generation plant that previously existed.

- The FSU overfill frequency considered in the previous QRAs was based on the amount of time (year fraction) in which the FSU was being filled. A fault tree, based on that mode of operation, was used. The approach adopted in this QRA was based on the number of times that the transfer between the LNGC and FSRU is carried out rather than the duration of the transfer and which, subsequently, produces higher calculated risk values for this scenario. It is recognized that the overfill failure tree requires a review to incorporate additional protection that will be in place for the transferring between the LNGC and the FSRU. The transfer flows between the GNLC and the FSRU are also higher than those for the FSU filling, which result in larger consequential ranges. As a result, this QRA shows that the overfill scenario contributes significantly to the risk perception and a hidden effects, that is, scenarios having lower risk outcomes.

4.9 Overfill Scenario Sensitivity Analysis

Lloyd's Register explains that this QRA shows that the overfill scenario during the boat- to-boat transfer significantly contributes to the risk outline/curve/image and, consequently, hides scenarios that have lower risk outcomes. It is also important to note that a very conservative approach was taken to calculate the FSRU overfilling frequency. To show the sensitivity of the results on this scenario, an assessment of the risk level with a reduction in flooding/overfilling frequency by a factor of 10 was made. The results are shown in Figure 4-2 below.

Figure 4-2 - LSIR Iso-risk outlines (with a reduced overfilling frequency).

Fuente: Quantitative risk analysis

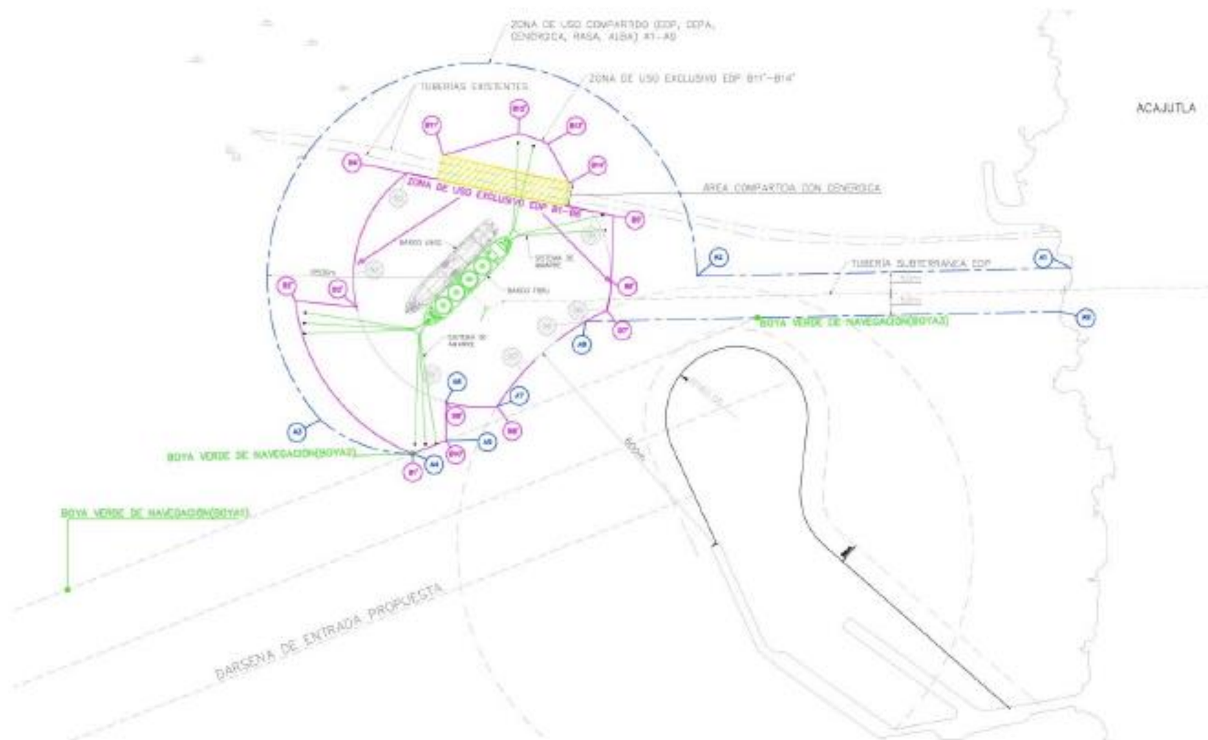
It can be seen that by reducing the frequency of the overfilling scenario by a factor of 10, the expansion of the risk outline is significantly reduced. There is no 10E-04 risk profile per year and the only non-marine area with a risk greater than 10E-6 per year is in the port area.

Lloyd's Register recommends a detailed review of the overfilling scenario to check both, the possible overfilling frequency and its consequences. If it can be demonstrated that the overfilling protection systems are robust, for what it is expected that there will be a reduction in the risk of producing similar results to those shown in Figure 4-2 above.

4.10 Conclusions

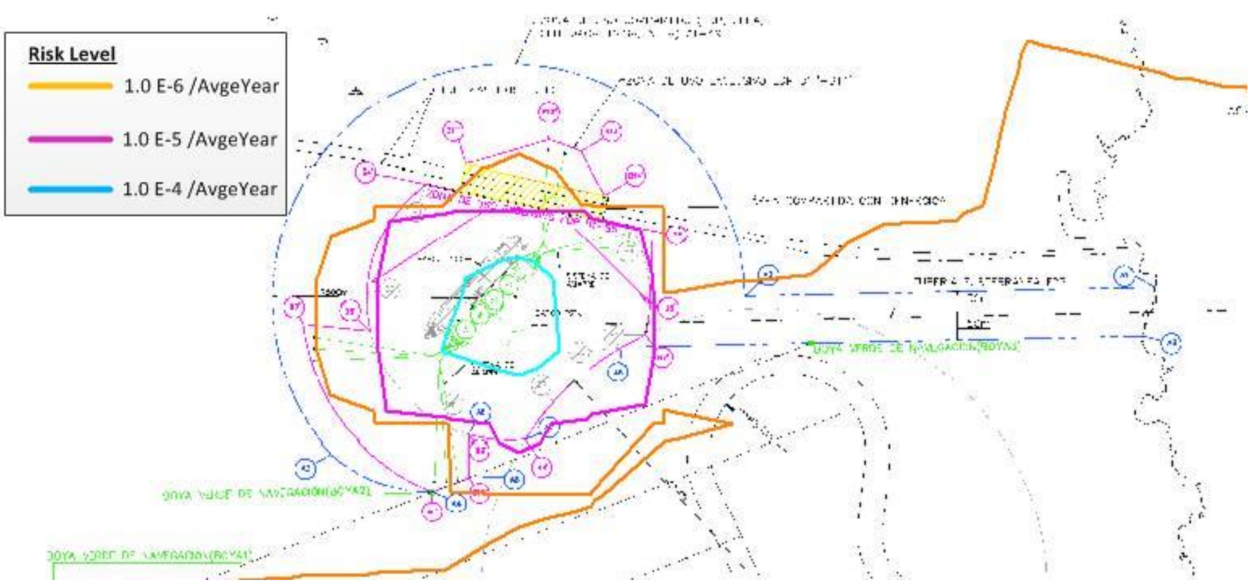
In summary, the QRA Study conducted in the FEED stage did not identify LSIR in the region of unacceptable risk for the public according to the risk acceptance criteria. The public and the environment are not exposed to an unacceptable risk caused by the EDP project. During the detailed design stage, another detailed QRA Study will be developed which will take into account advanced design considerations such as Piping and Instrumentation Diagrams (P&IDs). It should be noted that under the final design considerations the ISO risk LSIR outlines might change in range. The project will be designed to ensure that the risk region is ALARP by implementing all measures detailed in Section 4.24 and others that might result from the detailed design stage. The QRA shows that the risk of the LNG import terminal exposing the current inlet dock (which runs strictly from west to east) is within the region of tolerable and widely acceptable risk. In general, the current inlet dock is acceptable as it is defined. However, the project has proposed. In addition, AMP and CEPA have verbally approved to rotate the entry dock in a "clockwise" direction in order to establish it as shown in Figure 4-3 and Figure 4-4 below.

Figure 4-3 - Proposed Inlet Dock



Source: EDP, 2018

Figure 4-4 - Superimposed risk in New General Arrangement



Source: EDP, 2018

The project remains committed to installing an ESD valve on the plant grounds. Additionally, within the updated QRA provided in this chapter, a sensitivity analysis was performed in order to understand the possible risk reduction associated with the inclusion of a remotely activated ESD valve in the PLEM. However, the results indicated that the inclusion of this ESD valve in the PLEM had no effect on the overall risk levels.

The detailed design stage will analyze the design of shelters and process equipment facilities at the LNG import terminal to minimize the confined spaces in order to reduce explosion occurrences. Explosion scenarios were not analyzed through the FEED stage. Explosion events will be analyzed in more detail through a detailed engineering review as it is typically done.
Incidents at the LNG import terminal and power plant area can affect the nearest adjacent industry. Active fire protection will be installed such as gas detectors around the facility, and an emergency response plan that will provide a procedure for notifying people at the neighboring facilities and at the LNG import terminal during a LNG or NG emergency event.

4.11 Gas Detection

Gas detectors will be placed at the port of Acajutla if they are not already installed. An alarm system and an emergency response plan will be coordinated, including the port in case of an incident at the LNG import terminal. Appropriate gas detectors will be provided by ultraviolet (UV), infrared (IR), electro-catalytic or other types of detectors based on their suitability for the site and in terms of cost-effectiveness. For areas near the marine terminal, the project will use point-type gas detectors for alerts (IR or catalytic) / off-site directions. The type of instrument and the level of completeness will be similar to that of marine facilities. These will be independent gas detector packages with a certified panel/ detectors/light/alarm / basic interface and communications. The typical layout is as follows:

- 2 gas detectors integrated into a certified panel with red stroboscopic light and an audible alarm.
- The panels only require an external power supply and means of communication with the control rooms.
    a) The functionality is typically as follows:
    b) The signal reception in 1 out of 2 instruments will indicate a possible gas detection, the unit, then, will notify the Control Room and possibly the Fire Department in case of a possible problem.
- The signal reception of 2 out of 2 instruments is a confirmed gas detection and starts the stroboscopic light and the audible alarm, alerting the Operator and possibly the Fire Department. The signaling scheme 2 of 2 is used to avoid false alarms that disturb the public.
- Independent fire and gas specialists will certify the panel and recertify the installation on a regular, typically on an annual basis.

4.12 Safety zones

The QRA did not identify IR in the unacceptable risk region. Therefore, based on the risk acceptance criteria, the public and the environment are not exposed to an unacceptable risk. Widely accepted risk regions and ALARP regions have also been identified.

4.13 Ground Power Plant

The ground generating plant is beyond the outline 10E-6 per year and, therefore, it is within the widely acceptable risk region. No additional measures are required for the protection of the public in this area.

4.14 LNG Import Terminal, Port of Acajutla and Acajutla Residential Areas

There are 10E-4 and 10E-5 outlines per year around the terminal. These are areas where members of the public would not normally be present, so no additional measures are required to protect the public in these areas.

A risk area within 10E-5 per year is located on the wharf of the Port of Acajutla. This is a tolerable/acceptable risk area for members of the public.
Outline 10E-6 covers some industrial and residential areas on land that are within the tolerable/acceptable risk region. No additional measures will be required for public protection in this area, as long as the terminal and pipelines pose a controlled ALARP risk.

It is worth noting that it is considered that the frequency review of overfill scenarios, as discussed previously, will significantly reduce the scope of the areas described earlier.

4.15 Project's safety objective

The Project's Industrial Health and Safety objective will always seek to protect the community. EDP is committed to working only under conditions that are safe for the employees, the public, and the environment during construction and operations. During the detailed design stage, a series of detailed safety studies will be conducted with the aim of studying all potential risks and determining whether they are acceptable or, in its case, to establish mitigation measures. To manage the project's potential risks to public safety, EDP is committed to undertaking a number of initiatives and studies as part of future project planning and design work. These initiatives and studies are described in Section 9.3.2.

4.16 High-Level Contingency Plan

The High-Level Contingency Plan dated November 18, 2016, remains applicable except that since the FSU's need for the project has been removed, the recommendations associated with the FSU are also excluded from the contingency plan.

Lloyd's Register (LR) has been contracted by the project to develop a high-level contingency plan for EDP's liquefied natural gas (LNG) import terminal in Acajutla, El Salvador. This version was developed early in the initial Front-End Engineering (FEED) stage of the project with limited information. The purpose was to ensure that a preliminary course of action is prepared and that the various stakeholders are prepared to respond to abnormal events when these occur.

A conceptual-level contingency plan and an emergency response plan have been prepared for defining the content of a more detailed future Contingency Plan that will be developed as part of the detailed project design. This conceptual-level plan specifically describes the risk events that should be considered in the detailed Contingency Plan. The plan was developed to take all necessary measures in order to address events or emergencies that may cause public, environmental and material effects due to the project's operations.

This plan provides a high-level review of contingencies for the project at an early stage. A detailed contingency plan will be developed later in the project, during the detailed engineering stage by EDP and other stakeholders. To begin the contingency plan at the early stage of the project and update it as the work progresses through its life cycle is the best practice.

4.17 Contingency Planning Workshop

As part of the methodology for preparing the plan, a team of competent personnel/staff conducted a contingency planning workshop during the FEED stage of the project. The purpose of the workshop was to review the project's contingencies and contingency/emergency responses in the occurrence of an abnormal event. The workshop results remain applicable, with the exception of those related to the FSU. The information was provided in the document submitted in 2016.

The main conclusions resulting from the workshop to be considered for the project are listed below:

- A detailed contingency plan for the LNG import terminal will be developed through the detailed engineering. It will include the major hazards as discussed in the workshop, such as LNG leakage, fire, and explosion. Refer to Section 4.18;
- The main risks identified in the workshop sessions on hazard identification (HAZID), were analyzed in order to identify risks for the people, the environment, and the assets. Refer to section 4.22;
- The project will assess the need for the LNG carrier (LNGC) to leave the LNG import terminal in the event of a tsunami or surge;
- The port of Acajutla is equipped with firefighting capacity, including firefighters, a fire engine tug, and an ambulance. However, the port will give priority to assisting its own facilities and commercial vessels. Therefore, the project's contingency plan will complement the response and rescue of the port;

- A spill response plan for the LNG import terminal will be developed in the detailed engineering stage to address contingencies for the release of other hydrocarbons such as diesel; and
- The Port Facility Security Assessment (PFSA) shall include risks related to port security and the contingency management in the occurrence of a security-threatening situation.

4.18 Contingency Plan Contents

Due to the LNG nature, it is necessary to prevent and to control the following events:

- Spill
- Gas cloud generation
- Fragile fracture when in contact with the deck plates
- Quick heating
- Power on
- High heat radiation fires, and pressure
- Explosion (Steam cloud explosions are not relevant due to open areas and there is no confined gas trapping under the defined the spill scenarios.

The contingency plan shall include mitigation measures and measures to prevent the escalation of these events. Examples of mitigation measures include not allowing any ship to enter the port when a loss of containment has been identified at the LNG import terminal in order to prevent an escalation of fires. Some of the safety equipment to control and prevent escalation include:

- Deck water spraying system on the tanker
- Dry chemical system in the ship or terminal;
- High expansion foams and dual-agent systems to suppress and to control LNG vapor clouds in the tanker or terminal; and
- Water monitors on the tanker or terminal.

Appendix 4B describes the risks and worksheet of the preliminary developed plan. This includes each event considered:

1) Defined risk and incident scenario. Normal operating hazards, as identified by the HAZID[1] or marine HAZID;
2) Scenario description. Scenario description and possible scenario escalation;
3) Consequences. Consequences for personnel/staff, environment and third parties (public);
4) Main focusing areas for emergency response. A general response to the incident scenario, such as securing/evacuating the incident scene for emergency alert authorities and ensuring asset protection;
5) Response Procedure/Main Strategy. Response regarding the following, where applicable, the

description of the response timeline during an emergency:

1) Alert the corresponding authorities
2) Fighting the incident
3) Personnel/Staff rescuing
4) Evacuation of personnel/staff or population
5) Normalization: Action to return to safe normal operation

6) Response equipment. Equipment involved in the incident response, including on board equipment or in port equipment, when applicable;
7) Response staff/team. Staff involved in the incident response, which can include LNG import terminal staff or firefighters;
8) Interfaces and requirements. Actions taken by authorities, including port authorities;
9) Comments and recommendations; and
10) Comments and recommendations indicated in this column.

Chart 4-5 provides a sketch of the main risk events and initiatives that EDP will undertake to address these events. Chart 4-6 lists and explains each of the initiatives and studies undertaken.

Chart4-5 - Activities to be undertaken as part of the Contingency Plan				
#	**Defined Risks and Incident Scenario**	**Scenario Description**	**Prevention and Management Plans**	**Initiatives**
1	**Main events**			
1.1	Hydrocarbon leakage (LNG) / Gas dispersion	Large spill of LNG into the environment (spill on water) reaching the port. Non-ignition event/case.	Fire and Explosion Analysis -Hazard and Operational Studies (HAZOP) -Contingency plan -ESD System	A detailed assessment will be carried out to verify the extent of the leakage, the ability to isolate the leak, the gas cloud, climatic conditions and, as a result, which areas are at risk. The recommendation to the port (like evacuation, traffic management stop) will be made accordingly. The project will assess the need to remove the LNGC. - This risk and corresponding action will be addressed in the Contingency Plan, which will be submitted for approval to the Civil Protection Authorities. - An action protocol will be established, endorsed by CEPA and AMP, in case the defined risk areas require a shutdown of operations in the Port of Acajutla. - The Contingency Plan shall establish procedures for emergency notification, port evacuation, when necessary, shutdown/traffic management in the affected area. - Fire and gas detection and protection will be included in the detailed engineering fire and explosion analysis.
1.2	Fire (if LNG is ignited)	Leakage of LNG into the environment (discharged into water). Fire if the ignition source lits the gas cloud.	-Fire and Explosion Analysis -Operations Plan -Contingency Plan -ESD System	- This risk and corresponding action will be addressed in the Contingency Plan, which will be submitted for approval to the Civil Protection Authorities. - An action protocol will be established, endorsed by CEPA and AMP, in case the defined risk areas require a shutdown of operations in the Port of Acajutla. - The Contingency Plan shall establish procedures for emergency notification, port evacuation, when necessary, shutdown/traffic management in the affected area. - There will be a boat, which will have firefighting capacities -The terminal / FSRU will have fire detectors and preventive measures according to international standards. - Fire and gas detection and protection shall be part of the fire and explosion analysis in the detailed engineering stage.

Chart4-5 - Activities to be undertaken as part of the Contingency Plan

#	Defined Risks and Incident Scenario	Scenario Description	Prevention and Management Plans	Initiatives
1.3	Rapid Phase Transition (RPT)	There is a major leakage of LNG into the sea and conditions for RPT. Escalation: a possible explosion of cold. The consequences depend on the composition of LNG, water temperature, the number of spills and flow rate in the water. With the right conditions to have RPT, the probability is very low for a well-designed facility	- Fire and Explosion Analysis -Hazard and Operational Studies (HAZOP) - Contingency Plan	- This risk and corresponding action will be addressed in the Contingency Plan, which will be submitted for approval to the Civil Protection Authorities. - Port authority: Emergency notification, port evacuation if necessary, stop/traffic management in affected area. - Fire and gas detection and protection shall be part of the fire and explosion analysis in the detailed engineering stage.
1.4	Chemical, toxic or flammable leaks	Diesel stored in the FSRU is flammable and can lead to the possibility of fire in case of ignition. Escalation: Fire if the ignition source ignites the diesel.	-Hazard and Operational Studies (HAZOP) -Contingency Plan -ESD System	- This risk and corresponding action will be addressed in the Contingency Plan, which will be submitted for approval to the Civil Protection Authorities. - An action protocol will be established, endorsed by CEPA and AMP, in case the defined risk areas require a shutdown of operations in the Port of Acajutla. - The Contingency Plan shall establish procedures for emergency notification, port immunization if necessary, shutdown /traffic management in the affected area. - There will be a boat, which will have firefighting capacities - The terminal / FSRU will have fire detectors and preventive measures according to international standards - Fire and gas detection and protection shall be part of the fire and explosion analysis in the detailed engineering stage.
1.5	Explosion	Explosion	-Fire and Explosion Analysis -Hazard and Operational Studies(HAZOP) - Contingency Plan - ESD System	- This risk and corresponding action will be addressed in the Contingency Plan, which will be submitted for approval to the Civil Protection Authorities. - Port authority: Emergency notification, port evacuation if necessary, shutdown /traffic management in affected area. - The Contingency Plan will establish the conditions under which it would be recommended to evacuate the surrounding population and the coordination of these activities.

Chart4-5 - Activities to be undertaken as part of the Contingency Plan				
#	**Defined Risks and Incident Scenario**	**Scenario Description**	**Prevention and Management Plans**	**Initiatives**
1.6	Fire or Explosion in the Thermoelectric Plant	Fire or explosion	-The plant will be designed following the NFPA (National Fire Protection Agency) guidelines for fire and explosion prevention. -Contingency Plan	- This risk and corresponding action will be addressed in the Contingency Plan, which will be submitted for approval to the Civil Protection Authorities. - Port authority: Emergency notification, port evacuation if necessary, shutdown /traffic management in affected area. - The Contingency Plan will establish the conditions under which it would be recommended to evacuate the surrounding population and the coordination of these activities.
2	**Natural Risks**			
2.1	Short-term maritime movement	Local atmospheric conditions, such as cyclones, can lead to marine movements for a short period, forming waves up to 3.6 m high. Escalation: This can lead to an excessive movement of the LNGC	-Operations Plan - Contingency Plan	-Activate the Contingency Plan and notify, including VTS to ensure maritime safety communications (including coordination with rescue resources), notify the Civil Protection entity if necessary.
2.2	Long-term surge	The weather, the storms and hurricane activity can lead to long-term surge with waves up to 2.4 m high. Escalation: This can lead to excessive LNGC movement	-Operations Plan - Contingency Plan	- Activate the Contingency Plan and notify, including VTS to ensure maritime safety communications.
2.3	Tsunami, near ground	The weather, the subduction zone off the coast of El Salvador, or the seismic activity can result in a tsunami. Advanced warning not provided and/or exceeds the event design	-Berthing System Design -Hazard and Operational Studies (HAZOP) -Contingency Plan' -ESD System	- This risk and corresponding action will be addressed in the Contingency Plan, which will be submitted for approval to the Civil Protection Authorities. - Port authority: Emergency notification, port evacuation if necessary, stop/traffic management in affected area. - There will be a boat, which will have firefighting capacities

Chart4-5 - Activities to be undertaken as part of the Contingency Plan

#	Defined Risks and Incident Scenario	Scenario Description	Prevention and Management Plans	Initiatives
2.4	Tsunami, far from the ground	The climate, the subduction zone off the coast of El Salvador, or seismic activity can result in a tsunami. Escalation: LNGC may leave the terminal with an advanced warning. Other ships may collide in LNGC, leading to containment loss (only if the impact energy is > 28 mJ).	-Berthing System Design -Hazard and -Operational Studies (HAZOP) -Contingency Plan -ESD System	- This risk and corresponding action will be addressed in the Contingency Plan, which will be submitted for approval to the Civil Protection Authorities - Port authority: Emergency notification, port evacuation if necessary, shutdown /traffic management in affected area. - Tug dedicated to the project - A redundant warning system, in addition to the Pacific Tsunami Warning System (PTWC) will be considered during the detailed design stage.
2.5	Seismic activity, earthquake	Weather. Subduction zone off the coast of El Salvador may result in seismic activity or earthquake. Escalation: Other ships may collide in the FSRU; potential fire.	- Maritime Terminal Design -Hazard and Operational Studies (HAZOP) -Contingency Plan -ESD System	- Notify the Port and Civil Protection Authorities, as necessary and activate the Contingency Plan.
2.6	Thunderstorm	Rain showers in the region can cause thunderstorms. Escalation: This can cause damage to infrastructure and possible deaths.	- Maritime Terminal Design -Hazard and Operational Studies (HAZOP) -Contingency Plan -ESD System	- The facility shall be designed so that operations can continue safely in the event of thunderstorms (for example, ventilation mitigation measures).
2.7	Strong wind	Rain showers in the region can cause strong winds. Escalation: This can lead to tearing of mooring lines.	- Maritime Terminal Design -Hazard and Operational Studies (HAZOP) -Contingency Plan -ESD System	[C] The LNG import terminal facility must be designed to withstand strong winds and continue operations in the event of high wind conditions.

Chart4-5 - Activities to be undertaken as part of the Contingency Plan

#	Defined Risks and Incident Scenario	Scenario Description	Prevention and Management Plans	Initiatives
3	**Falling of objects**			
3.1	Falling objects during crane lifting on the FSRU	N/A	-Analysis of Fallen Objects	-The Port or Civil Protection Authorities will be alerted if an emergency occurs.
3.2	A fallen object in the underwater pipeline on shore.	Anchor dragging and/or casting from another boat in the underwater pipeline. Escalation: Damage to the underwater pipeline. Potential loss of containment potential.	- Maritime Terminal Design - Analysis of Fallen Objects - Contingency Plan	- The Port or Civil Protection Authorities will be alerted if an emergency occurs. - Along with AMP, work will be undertaken to establish a non-anchoring area along the underwater pipeline route.
4	**Vertical and Underwater Tubing**			
4.1	Gas leakage to the environment, underwater source (underwater pipe or underwater rise)	Underwater vertical pipe rupture. Escalation: Release of gas to the environment. Ignition Case/event	-Terminal design - Fire and Explosion Analysis -Hazard and Operational Studies (HAZOP) -Contingency Plan ESD System	A detailed assessment of the extent of the leakage, the ability to isolate the leak, the gas cloud, climatic conditions and, as a result, which areas are at risk will be conducted. The recommendation to the port (for example, evacuation, and traffic management stop) will be undertaken accordingly. The project will assess the need to remove the LNGC. - This risk and corresponding action will be addressed in the Contingency Plan, which will be submitted for approval to the Civil Protection Authorities - Port authority: Emergency notification, port evacuation if necessary, shutdown /traffic management in affected area. - Fire and gas detection and protection shall be part of the fire and explosion analysis in the detailed engineering stage.

Chart4-5 - Activities to be undertaken as part of the Contingency Plan

#	Defined Risks and Incident Scenario	Scenario Description	Prevention and Management Plans	Initiatives
4.2	Gas leakage to the environment, upper side source (connection to FSRU, part of the vertical pipe above the sea)	Breakage of the vertical tubing due to collision of a ship with the tubing. Escalation: Release of gas to the environment. Potential fire jet if the high-pressure gas is ignited.	-Terminal design -Fire and Explosion Analysis -Hazard and Operational Studies (HAZOP) -Layers of Protection Analysis (LOPA) Study -Contingency Plan -ESD System	-A detailed assessment of the extent of the leakage, the ability to isolate the leak, the gas cloud, climatic conditions and, as a result, which areas are at risk will be conducted. The recommendations for the port (for example, evacuation, and traffic management shutdown) will be undertaken accordingly. The project will assess the need to withdraw the LNGC. - This risk and corresponding action will be addressed in the Contingency Plan, which will be submitted for approval to the Civil Protection Authorities. - Port authority: Emergency notification, port evacuation if necessary, shutdown /traffic management in affected area. - Fire and gas detection and protection shall be part of the fire and explosion analysis in the detailed engineering stage.
5	**Security**			
5.1	Security threats	Local security threats can have an impact on the staff's security and on assets and production.	-Port Facility Security Assessment (PFSA)	- PFSA will be developed in conjunction with Civil Protection Authorities. - This study will establish the most appropriate physical security infrastructure to be included in the project and to ensure that the specifications of the detailed design of the security systems are included as accurately as possible. Designed for the facilities according to ISPS code. - The contingency plan will establish protocols for third-party entering restricted areas. These measures will be identified throughout the PFSA and will be endorsed by CEPA and AMP.
6	**Other**			

Chart4-5 - Activities to be undertaken as part of the Contingency Plan

#	Defined Risks and Incident Scenario	Scenario Description	Prevention and Management Plans	Initiatives
6.1	Leakage of hydrocarbons by fire on another ship (for example, while sailing or starting in the Port of Acajutla, moored at the Cenérgica terminal, moored at the Rasa terminal, or moored at the Alba terminal)	Leakage of hydrocarbons from a ship. Escalation: Potential fire if ignited.	Contingency Plan	- Due to the distance between the LNG import terminal and the port / Cenérgica terminal / Rasa terminal / Alba terminal, it is not expected that a localized fire would affect the LNG import terminal. - Nevertheless, this eventuality will be analyzed through the contingency plan

Source: Quantitative Risk Assessment

Chart 4-6 - Additional Safety Studies to be conducted

STUDY	DESCRIPTION
Detailed Engineering	
Hazard and Operational Studies (HAZOP)	HAZOP assesses the above-mentioned process systems in order to identify risks to people (staff and public), the environment, and the assets. This workshop identifies potential risks with a primary focus on the process systems. The processes above-mentioned, the cargo systems and the main FSRU utility systems have been reviewed.
Fallen Objects Analysis	Quantitatively assess and review the risk of falling object scenarios (for example, the material handling study) during normal operations for the marine terminal. The risk of falling objects is shown in the detailed QRA.
Fire and Explosion Risk Analysis (FERA)	The possible fire and explosion scenarios identified in HAZID and HAZOP are detailed in the quantitative FERA study. The study will include gas dispersion analysis. In particular, for an explosion risk assessment, a 3D Computational Fluid Dynamics (CFD) study is required in the detailed design considering design details and congestion. The FERA study confirms Dimensioning Accidental Load (DAL) for critical objectives that must be taken into account in the detailed design to achieve ALARP risk for possible fire and explosion scenarios. The study can also model the effects of smoke, thermal radiation and overpressure on evacuation and facility evacuation routes.

Chart 4-6 - Additional Safety Studies to be conducted	
STUDY	**DESCRIPTION**
Cryogenic spill analysis	In addition to the possible cryogenic spill (containment loss) scenarios identified in HAZID and HAZOP, it is necessary to conduct a detailed quantitative study for FSRU, and load operations to analyze cryogenic spill risk. This study confirms the dimensions required for containment of accidental cryogenic spills that must be considered in the detailed design for achieving ALARP.
Ventilation dispersion analysis	The ventilation dispersion analysis will model the effects of the ventilating process (natural gas) in the FSRU during an emergency given operational scenario rates within a range of meteorological conditions. The modeling of LNG vapor emissions makes it possible to assess whether the respective LNG vapor cloud is compatible with the FSRU/terminal design.
Finite Element Analysis of Ship Collisions	Finite Element Analysis of Ship Collisions was conducted for a related consequence of the impact of a potential collision on the LNGC.
Detailed QRA	Assesses the risk and impacts of hazardous events on staff, people (public) and the environment for the specific project location in El Salvador. All risks to the public and to the environment must be within the ALARP range.
Evacuation, Escape and Rescue Analysis (EERA)	Qualitatively assess the effectiveness of facilities, and evacuation and rescue. In addition, the potential risk for loss of completeness of the FSRU escape routes/marine facility is ALARP for the FERA scenarios are assessed quantitatively. FERA scenarios and CFD calculations are used as an input for this analysis in order to estimate the risk.
Contingency planning	Plan response to abnormal events when they occur.
As Low As Reasonably Practicable (ALARP)	This study reviews and discusses the main mitigation measures for achieving ALARP for marine facilities under normal operation (LNGC and FSRU). It assesses whether sufficient risk reduction measures are in place to comply with the lowest reasonable cost principles.
Port Facility Security Assessment (PFSA)	To ensure that the physical security infrastructure included within the project is the most appropriate and that all detailed design features of the security systems are included as accurately as possible. Designed for facilities according to the ISPS code.
Operations	
Emergency/ contingency preparedness plan	To ensure that risk mitigation, preparedness, response and recovery are in place in order to reduce the impacts of abnormal events.
Performance monitoring	Shows that there are arrangements to monitor HSE performance.
Occupational safety / risk analysis	To identify hazards arising from specific tasks to reduce the risk of injury to workers.
Spill prevention and control plan	To document the procedures to be followed to prevent spills and to respond in the event of a spill.
Ship Safety Plan	To provide prevention and early detection of attacks and enhanced surveillance coverage, equipment detection, lighting usage, and crew response.

Source: EDP 2016

4.19 Summary of Commitments

EDP's project marine facilities and natural gas pipelines are expected to provide fuel to the power plant with a reliable supply in a safe and environmentally acceptable manner. The objective of the safety, health and environmental plan shall be to provide a safe environment for the public and for the project's personnel/staff.

In order to ensure that this objective is fulfilled, EDP is committed to conducting a risk management process along with an extremely rigorous technical safety program consistent with the industry best practices and the most onerous international codes and standards. The following is a summary of the main commitments to manage potential risks within the project, including the contingency planning.

4.20 Starting with Safer Facilities

The processes involving hydrocarbon handling have great potential for the occurrence of abnormal events, incidents or accidents. A responsible development of these projects includes an extensive hazard identification, a risk analysis, and hazard management activities to ensure that the risk is tolerable/acceptable for the public, the facilities, and the operators.

In EDP's mitigation and abnormal (hazard) events assessment, preference is given to hazard elimination to produce an inherently safe design. The risk reduction measures are being prioritized in the following order:

1. **Prevention is on the first place**– Achieving an inherently safe design by eliminating hazards, reducing plant complexity, decreasing hydrocarbon inventory, lowering operating pressure, and decreasing process fluids, etc.
2. **Control is next** – Controlling hazards through active methods in the Distributed Control System (DCS) and through training.
3. **Finally, Mitigation** – Risk mitigation through active and passive measures such as the firefighting system.

This approach is already reflected through key project decisions such as locating LNG storage facilities at sea.

4.21 Technical Safety

EDP is carrying out a rigorous process to ensure the technical safety of the facilities. The FEED stage considers, as far as possible, the potential for major accident/incident hazards, the risks associated, and the identification of potential risk mitigation measures. This work is well-headed through the completion of HAZID, the preliminary QRA Study, and the preliminary Contingency workshop in which the majority of those involved in the development of the project participated.

These inputs will be incorporated into the design package, which, at a minimum, will include basic safety studies, documents, and activities, including:

- HAZIDs Marine and General Arrangement (Layout)
- HAZOP and LOPA Studies;
- ALARP Study and Report;
- QRA which will reflect the results of extensive studies, including at least:
    - FERA, which will include a probabilistic explosion risk analysis based on Computational Fluid Dynamics (CFD);
    - Analysis of smoke and gas dispersion (including combustion units and pressure relief);
    - Cryogenic spill analysis;
    - EERA Study;
    - Ship collision analysis ;
    - Study of fallen objects; y
    - Personnel/Staff Transport Study.

The technical studies and workshops of HAZID, QRA, and Preliminary Contingencies were Supported and completed by Lloyd's Register which is an independent consulting organization, well recognized in the industry, and which is also a Classification Society.

The preliminary QRA results included limited vapor dispersion trials, radiation analysis, and a preliminary quantitative risk assessment of the project (marine facilities, pipeline, and gas supply to the power plant). This indicates that EDP's project risks are manageable and within the ALARP region. These results will be refined as the project engineering stage progresses.

4.22 Safety Commitments

EDP has conducted workshops and assessments on hazards, QRA, and preliminary contingency studies, as well as other safety activities during the FEED stage.

The hazard management and approach design will continue when the project is at its detailed design stage where the project is committed to undertaking activities that address hazards to ensure that they are acceptable. Safety commitments are shown in Chart 4-7.

Chart 4-7 - EDP's Safety Commitments

POTENTIAL/POSSIBLE EVENT	EDP' S COMMITMENT TO SAFETY

Chart 4-7 - EDP's Safety Commitments	
POTENTIAL/POSSIBLE EVENT	**EDP' S COMMITMENT TO SAFETY**
POTENTIAL/POSSIBLE EVENT	The release of hydrocarbons is an extremely serious potential event and, therefore, the facility will include extensive measures to detect and mitigate the risk associated with the release of hydrocarbons. • **Robust design:** The marine terminal and gas pipeline will be designed using best practices and international codes to ensure that the release of hydrocarbons is minimized. The control system shall ensure that processes operate within the appropriate range. The control system will alert operators when conditions approach the operating limits and will shut down processes before the system can operate beyond its designed conditions. • **Gas detection:** Marine facilities shall be equipped with an extensive gas detection system to ensure that hydrocarbon release is identified quickly and the appropriate response is taken. The gas detection system shall be highly complex and independent from the main control system. • **Emergency isolating valves:** Equipment and piping containing hydrocarbons shall be provided with highly complex, fire-safe and tightly closed emergency isolating valves to minimize the release of hydrocarbons to ensure the prevention of escalated damage. • **ESD System:** The marine facilities will be equipped with an Emergency Shutdown System (ESD) which, when activated, will automatically alert the operator, and set the plant in a safe status (de-energize engines and close isolation valves to minimize the amount of leakage). This system will be highly complex and regularly tested to verify that it will operate when necessary.

Fire	A fire is possible in a marine facility under various scenarios, such as a fire in the galley of the accommodation block, fire in the engine room or more seriously, by ignition of released hydrocarbons. Protective measures will be included in the EDP's marine facilities to manage potential scenarios:
	• **Fire and smoke detection:** Marine facilities will be equipped with extensive fire and smoke detection systems to ensure that fire is promptly identified and the appropriate response is taken.
	• **Portable Fire Fighting Equipment:** Facilities will be equipped with a portable fire-fighting equipment such as fire extinguishers, fire blankets, etc.
	• **Passive Fire Protection:** Passive Fire Protection (PFP) will be applied to the main structures and the equipment identified as susceptible for preventing unacceptable escalation events.
	• **Fixed Firefighting Equipment:** The marine facilities shall be equipped with fixed firefighting equipment which shall include:
	  o Water for firefighting systems based on pumps that operate with diesel engines. This system will be implemented periodically to ensure its operation.
	  o Dry powder and chemical systems in machinery spaces, galley, and other areas.
	• N1 or CO2 systems for emergency relief to ensure that these fires can be extinguished.

Chart 4-7 - EDP's Safety Commitments	
POTENTIAL/POSSIBLE EVENT	**EDP' S COMMITMENT TO SAFETY**
LNG Release	The release of unnoticed LNG may result in a number of hazards given the physical properties of LNG and the flammability of the associated vapor cloud. The design will incorporate features to mitigate the risks associated with cryogenic spills. These will include: • **Detection.** The detection of LNG spills will be facilitated by a CCTV system, which will monitor LNG transfer operations, operator presence during the connection and the transfer start-up, and gas or cooling detection at the marine terminal. • **Water curtain.** During the transfer operations, a water curtain shall be placed to ensure that an unnoticed release of LNG is quickly vaporized and it does not damage the adjoining steel due to such low LNG temperatures. • **Cryogenic spill management strategy:** LNG management facilities systematically consider and address the risks associated with LNG operations. Depending on the area, the LNG release protection measures include: o **Minimization of leakage potential.** Potential LNG leakage points will be minimized and, where required, shall be installed close to each other to facilitate handling. o **Containment and capturing areas** with high probability of LNG leakage points and routes towards a safe place o **Passive cooling protection** is similar to the PFP but designed to prevent LNG from damaging steel, carbon or plate structures. It shall be applied, where necessary, based on a detailed study. o **Water curtain and flooding.** It will be an integral part of the LNG leakage strategy related to the location and size of the potential leakage.
Fallen objects in the facility	Equipment, supplies, and waste are transferred between the marine facilities and supplying ships through permanent crane lifting operations. This means that the launched objects suggest a risk for which EDP is rigorously committed to handling as follows: • The berth of supply and operational ships are located far from the gas riser to prevent objects from being launched and impacting this sensitive area. • The upper parts of the FSRU do not allow lifting operations on active process equipment. • Fixed rails and gantry cranes are included at the upper part of the FSRU and within machinery spaces to facilitate maintenance with limited possibilities for falling objects. As a final measure, protection against falling objects will be applied to the equipment handling hydrocarbons having an unacceptable risk of falling objects.

Chart 4-7 - EDP's Safety Commitments	
POTENTIAL/POSSIBLE EVENT	**EDP' S COMMITMENT TO SAFETY**
Objects thrown over the pipeline	Dragging anchors or ships that can damage the underwater pipeline have a low probability of occurrence, but with serious possible damages in the event that it occurs. Some measures to mitigate this situation include: • The pipeline shall be protected and installed on a route in which the nautical charts show a non-anchoring area. • The pipe's inlet and outlet shall be equipped with an emergency stop valve that will minimize the volume that can escape from it.
Port Facility Security	An independent company specializing in Port Facility Security conducted a Port Facility Security Assessment (PFSA) during the FEED stage. The assessment included a review of the power plant perimeter, storage area, and marine terminal area. The PFSA process was conducted in accordance with the International Ship and Port Security Code (ISPS). The assessment covered the following items: 1. Identification and evaluation of important assets and infrastructure; 2. Identification of possible threats to these and their occurrence probability; 3. Identification, selection, and prioritization of counter-measures and procedural interventions, and an estimation of their level of effectiveness in vulnerability reduction; 4. Identification of tenuousness, including human factors, in infrastructure and procedures. The assessment methodology used was taken from the American National Standards Institute (ANSI) and Standard 780 of the American Petroleum Institute (API). The methodology included five sequential steps: 1. Characterization; 2. Hazard assessment; 3. Vulnerability Assessment; 4. Risk Assessment 5. Risk prevention.

Source: EDP 2016

EDP foresees a level/degree of detail regarding the above-mentioned safety commitments. New commitments, if necessary, will be included as the project progresses in the detailed design and where the risks and the facilities are better defined.

4.23 Contingency Plan

EDP's contingency plan is in the process, starting with preliminary safety studies and a contingency workshop in San Salvador in June 2016. The contingency plan is of great importance in mitigating the effects of potential risks for the project, as it will help in ensuring that stakeholders are prepared to respond to extraordinary events when these occur.

The contingency plan is an ongoing activity that will have a detailed contingency and emergency response plan as its final product before the facilities become operational.

- Early in the design stages of the project, the contingency plan relies on risk identification and subsequent risk analysis in order to identify abnormal events and plan contingency planning in the case of such events.
- In the operational stage of the project, the contingency plan should take into account other sources of information such as incident/accident reports and inspections to keep the plan updated at all times.

EDP is currently in Front End Engineering Design (FEED) stage and the contingency plan is preliminary, but it enables us to establish that the project, the community, and the Port of Acajutla will be able to respond effectively to a wide range of events such as tsunamis, loss of hydrocarbon containment, or fire at the marine LNG terminal.

As EDP progresses to define the risks associated with facilities, the contingency plan will be streamlined and the level/degree of detail will increase. Finally, the contingency plan will help to ensure that EDP is prepared to respond to any accidental/incidental or abnormal events and that the contingency plan is consistent with the existing emergency procedures. It will also help to ensure an integrated response plan with other key stakeholders such as port authorities (AMP, CEPA) and the Ministry of Environment and Natural Resources (MARN).
The final contingency plan shall include at least the following events:

A. Controllable emergency response procedures, including alerting personnel and appropriate use of emergency response equipment, isolation of certain parts of the equipment, and other applicable safety actions to ensure that a gas or liquid leak is stopped or reduced in the shortest possible time.
B. Procedures to identify an uncontrollable emergency and measures to take in assuring that damage to personnel at the facility and to the public is reduced as well as ensuring that flammable mixture does not spread outside the emergency area and that thermal radiation from a fire does not exceed the acceptable values of applicable regulations.
C. Procedures for immediate notification of the emergency to the corresponding local authorities, including possible evacuation of personnel to the surrounding areas.
D. Coordination procedures with local authorities, during the development of the emergency evacuation plan, which shall set out the steps necessary to protect the public and its proper care in health facilities, if required.

The contingency plan shall include or refer to the design documents that describe the measures for mitigating potential emergency events, covering at least:

E. Leakage, flammable gas, flame, smoke and cooling detection systems;
F. Alarm systems;
G. Overpressure protection, releasing systems, hydrocarbon venting and purging systems;
H. Definition of emergency exit measures, emergency care;
I. Active and passive fire management and fire extinguishing systems for marine facilities; and
J. Contingency measures for:
    a. Natural gas storage operations.
    b. LNG regasification operations, and
    c. Thermoelectric plants based on natural gas

4.24 Measures to be Included within the Environmental Management Program

The measures to be included in the environmental management program in chapter 10 are listed below:

1) Fire Protection System: Installation of fire extinguishing equipment: fire extinguishers, hydrants, hoses, valves, mobile foam units, etc. Includes providing firefighting training and drills
2) Leak Detection System. In-Plant leak detection equipment (fixed) and portable gas meters to detect leaks during visual inspections of facilities.
3) Detailed risk assessment and contingency plan. Conduct a detailed risk assessment as part of the detailed design work. Development of the Contingency Plan and Major Risk Planning. In which procedures, organization, resources, communications, etc. will be described in greater detail. Refer to Section 4.23.

Appendix 1A–
Environmental Permit

MINISTRY OF ENVIRONMENT AND ENVIRONMENTAL RECOURSES

RESOLUTION M A R N -No.20250-1104-2017

Ministry of Environment and Environmental Recourses, San Salvador, in the twenty-one days of the month of December of two thousand seventeen. Considering the diligences promotes by the engineer Alejandro Gustavo Alfe, acting as General Administrative representative of the society ENERGÍA DEL PACÍFICO, LIMITADA DE CAPITAL VARIABLE, holder of the "LNG TO POWER" project, located in Calle 24 de Octubre y boulevard Osear Osorio, Acajutla Industrial zone, municipality of Acajutla, Sonsonate department, which it consists in the installation of a Thermal Power Plant for the generation of electric power with a net capacity of 378 MW, using a natural gas as fuel and a Maritime Terminal to receive the Liquefied Natural Gas (LNG) and turn it into Natural Gas (GN). The power generation plant will consist of 19 Wartsila 18V50SG internal combustion engines with a capacity of 18.3 MW each, for a generation of 348 MW each, for a generation of 348 MW, and a 30.0 MW steam turbine that will take advantage of the exhaust gases of the engines to close a combined cycle. Additionally, the plant will be provided with a power substation and support facilities. The Maritime Terminal will consist of a barge or Storage and Regasification Unit (FSRU) within a breakwater structure of cellular cofferdam type or of concrete caissons; the same protection structure will serve for the berthing of a floating storage unit (FSU) and for the methane tanker (LNGC); EL ORGANO EJECUTIVO in the Environment and Natural Resources Branch.

CONSIDERING THAT:

I. The Project Owner, in compliance with articles 22 of the Environmental Law and 19 of the General Regulation of the Law, PRESENTED THE Environmental Form, the scope and the nature of the execution of said project has been evaluated.

II. In compliance with articles 22 of the Environmental Law and 19 of the General Regulation of the Law, this Ministry categorized the aforementioned project, determining that it is included in Group B, Category 2, so it was concluded that the project it required the preparation of an Environmental Impact Study, so the Reference Terms were provided for the preparation of the same.

III. On the twenty-third days of December of two thousand and fourteen, the Environmental Impact Study was received in this Ministry accompanied, among other aspects, by the Environmental Management Program of the aforementioned project, which was evaluated by this Secretary of State, in compliance with the provisions of articles 19 and 33 of the General Regulations of the same.

IV. The Environmental Impact Study was made public knowledge in compliance with the provisions of articles 25 letter a), the Environmental Law and 32 of the General Regulations of the same; in this regard, there were no opinions or observations in writing by any natural or legal person.

MINISTERIO DE MEDIO AMBIENTE Y RECURSOS NATURALES DIRECCIÓN GENERAL DE EVALUACIÓN Y CUMPLIMIENTO AMBIENTAL El Salvador, C.A.

V. To ensure compliance with the Environmental Permit, regarding the execution of the Environmental Management Program corresponding to the Location and Construction Stage, the Environmental Compliance Bond was received in this Ministry, which is established in articles 29 of the Environmental Law, 19 AND 34 OF THE General Regulation of the Law, quantified in NINE HUNDRED TWENTY-FOUR THOUSAND ONE HUNDRED THIRTY-EIGHT 48/100 DOLLARS OF THE UNITED STATES OF AMERICA ($924,138.48), for a term of FORTY MONTHS, counted from of the eighteenth of October, two thousand an seventeen.

VI. In accordance with the provisions of Articles 18, 19, 20, 21, 22, 23, 25 and 29 of the Law on the Environment and Arts. 18, 19, 20, 22, 23, 24, 25, 26, 27, 28, 29, 30, 32, 33 and 34 of the General Regulation of the law on the Environment, it is appropriate to issue this Resolution;

VII. On November 30, two thousand and seventeen, according to Agreement No. 643, the President of the Republic, Salvador Sánchez Cerén, agreed to order the Environment and Natural Resources Office, on an ad-honorem basis, during the period from 17 to 21 of December of two thousand and seventeen, to the Vice Minister of the Branch, Doctor Angel María !barra Turcios, and in that sense, has the faculty to sign Resolutions such as this one.

SO,

In accordance with the previous recitals;

RESOLVE:

1. GRANT THE ENVIRONMENTAL PERMIT OF LOCATION AND CONSTRUCTION to society ENERGÍA DEL PACÍFICO, LIMITADA DE CAPITAL VARIABLE, represented by the engineer Alejandro Gustavo Alle, in his capacity as General Administrative Attorney. This company is the owner of the “”LNG TO POWER"", project, located in Calle 24 de Octubre y boulevard Osear Osorio, Acajutla Industrial zone, municipality of Acajutla, Sonsonate department, which consists of the installation of a Thermal Power Plant for the generation of electric power with a net capacity of 378 MW, using natural gas as a fuel and a Maritime Terminal to receive the Liquefied Natural Gas (LNG) AND TURN IT INTO Natural Gas (NG). The power generation plant will consist of 19 Wartsila 18V50SG internal combustion engines with a capacity of 18.3 MW, and a 30.0 MW steam turbine that will take advantage of the exhaust gases of the engines to close a combined cycle. Additionally, the plant will be provided with a power substation and support facilities. The Maritime Terminal will consist of a barge or Storage and Regasification Unit (FSRU) within a breakwater structure of cellular cofferdam type or of concrete caissons; the same protection structure will serve for the docking of a floating storage unit (FSU) and for the methane tanker (LNGC).

2. They are an integral part of this Resolution and, therefore, of mandatory compliance for the project owner, the following documents: The Favorable Technical Opinion, the

MINISTERIO DE MEDIO AMBIENTE Y RECURSOS NATURALES DIRECCIÓN GENERAL DE EVALUACIÓN Y CUMPLIMIENTO AMBIENTAL El Salvador, C.A.

MINISTERIO DE MEDIO AMBIENTE Y RECURSOS NATURALES

Environmental Impact Study and its addenda, which among other aspects, contains the Environmental Management Program. These documents will be used as a basic to carry out the Environmental Assessment Audit.

3. Any extension, rehabilitation or reconversion that the project intends to carry out, the owner must submit the relevant Environmental Form, in accordance with Article 22 of the Environmental Law and may not take any action to implement it, until this Ministry issue the corresponding Resolution. Otherwise, this State Portfolio will initiate the administrative procedures established in the Environmental Law.

4. It shall be the responsibility of the owner to correct any significant negative impact caused by the activities not contemplated in the Environmental Impact Study and its related documentation.

5. This Environmental Permit does not exempt the project owner from obtaining the other authorizations established by the laws of our State, as requirements for the execution of this project.

6. This ENVIRONMENTAL LOCATION AND CONSTRUCTION PERMIT does not grant the right to the owner of the aforementioned project to start its operation.

7. Once the environmental measures for the location and construction have been completed, the owner must request this Ministry, at least two months before the expiration of said Bond, the environmental evaluation audit according to Art. 27 of the Law of the Environment and articles 35, 36, 36-A, 37, 38 and 39 of its General Regulations.

8. Failure to comply with this Resolution by the owner of the aforementioned project, empowers this Ministry to initiate the administrative procedures established in the Environmental Law.

This Resolution will become effective as of the day of its notification. COMMUNICATE: ANGEL MARÍA !BARRA TURCIOS, VICE-MINISTER OF ENVIRONMENT AND NATURAL RESOURCES, OFFICE MANAGER --

MINISTERIO DE MEDIO AMBIENTE Y RECURSOS NATURALES DIRECCIÓN GENERAL DE EVALUACIÓN Y CUMPLIMIENTO AMBIENTAL El Salvador, C.A.

MINISTERIO DE MEDIO AMBIENTE Y RECURSOS NATURALES REPUBLICA DE EL SALVADOR EN LA AMERICA CENTRAL

Licda. Vilma Celina García de Monterrosa
Directora General de Evaluación y Cumplimiento Ambiental

Appendix 1B–

Stakeholder Engagement

Appendix 1A- Stakeholder Engagement

Energía del Pacífico

Project: LNG to Power

Stakeholder Engagement for EIA Addendum

January 2018 – 16-3489

TABLE OF CONTENT

List of Tables

List of Photos

Stakeholder Engagement for Addendum to the "LNG to Power Project" ESIA

1.0 Introduction and Background

As part of the follow-up that Energía del Pacífico wants to give to stakeholder engagement and continue strengthening community relations as well as keeping key stakeholders informed about the development of the project, it was considered necessary to carry out additional activities to those previously developed as part of the initial evaluation process concerning the Environmental Impact Study, and subsequent to the Public Consultation Process administered by the Ministry of Environment and Natural Resources of El Salvador (MARN) during the process of approval of the environmental permit for the project. In this regard, it should be noted that the "LNG TO POWER" project has already obtained a favorable technical opinion and environmental permit from MARN, issued on December 21st, 2017 with resolution number "MARN-N ° .20250- 1104-2017 ".

During 2017, the technical team of Energía del Pacífico continued working on the project's final engineering and evaluating the possibilities for the final execution of the Project. As part of this process, new options were developed for the final design of the Project, which made it necessary to share these new options with the key actors through additional activities of community participation. This consultation process developed after the admission of the EsIA to MARN, has been identified as "Reactivation Meetings", whose objective is to keep informed the key actors of the locality and obtain their opinions on the development and progress of the project before its execution.

Energía del Pacífico has carried out a series of citizen consultation and informative activities since the development of the EIA and after its preparation, in order to maintain constant communication with key stakeholders and keep the population from the municipality Acajutla informed about the status and progress of the "LNG to Power" project, allowing the adequate and inclusive development of the project.

Among the key actors for the development of the project, the social group of fishermen from the municipality of Acajutla is of special interest, since it is one of the most participatory actors involved and with the potential to be affected both positively and negatively by the execution of the project. Another key player is the municipality of Acajutla, represented by the city Mayor and council members. For this reason, Energía del Pacífico has held reactivation meetings with these two groups.

The main modifications due to the final engineering design, and which have been shared with the key actors, are related to:

- Design and technology for the marine terminal: Mooring system for FSRU.
- Definition of HDD construction technology for underwater pipeline installation.
- Minor changes in the final design and location of marine terminal elements (FSRU and pipeline) as well as restriction zones.

2.0 Objetives

2.1 General Objective

The general objective of the reactivation meetings was to keep key stakeholders informed about the development and possibilities of changes in the final design of the "LNG to Power" project.

2.2 Key Objetives

- Update the groups of fishermen cooperatives and Municipality, on the progress and components of Energía del Pacífico "LNG TO POWER" project.

- Present the changes that have been generated since the last participatory meeting held in 2016, in order to optimize its design and to achieve a better integration of its elements with the environment.

- Obtain the opinions from key actors on the proposed changes in the construction of the project.

- Acquire suggestions and recommendations from the social actors, with the purpose of identifying environmental and social aspects to be considered in the execution of the Project.

3.0 Methodology for the Development of the Activities

In the first place, for the appropriate development of stakeholder reactivation activities the two main groups of actors identified to be included in the activities are:

- Groups of fishermen from Acajutla; Cooperatives, "tuberos"[1] and oystercatchers.
- Representatives from the municipality of Acajutla: municipal mayor and city council.

The methodology for the development of the activities is described below.

3.1 Key Actors Update

Contacts information was confirmed, particularly for directors from the cooperatives and key representatives of fishermen's groups, as well as representatives from the municipality, to ensure their permanence and that the same records of the last meeting remain for the subsequent delivery of invitations. In the following Table 3-1, contacts are detailed.

Table 3-1 List of Contacts of Representatives of each Fishermen's Group

No	Name of Representative	Cooperative	No. of members
1	Oscar Orlando Cortez	ACOOPPAC	30
2	José Antonio Cordero	ACPRA	25
3	José Bonilla	ACOPESCA	16
4	Oscar Armando García Pacheco	OSTREROS	5
5	Raúl Escobar	TUBEROS	50
6	David Antonio Henríquez	ACPETAMAR	29

Source: Consulting Team, December 2017.

With respect to the representatives from municipality, the updated contacts are presented in Table 3-2 below.

Table 3-2 List of Contacts of Representatives of the municipality

No	Name	Working Area
1	Mario Edgardo Pérez	Mayor
2	Manuel Méndez	municipal councillor
3	José Ángel Suriano	municipal councillor
4	Silvia Ventura	municipal councillor
5	José Joaquín Moreira	municipal councillor
6	Dinora Guadalupe Mejía	municipal councillor

[1] Group of fishermen that do not belong to any cooperative and have no access to appropriate fishing equipment or boat and use a float as a resource for their fishing activities.

Table 3-2 List of Contacts of Representatives of the municipality		
No	**Name**	**Working Area**
7	José Luis Escobar	municipal councillor
8	Wilber Hernán Soriano	municipal councillor
9	Saúl Hernández	municipal councillor
10	Darío Guadrón	municipal councillor
11	Silvano Madrid	municipal councillor
12	Julio Cabrera	municipal councillor
13	José Alberto Ramírez	municipal councillor
14	Salvador López	municipal councillor
15	Julio Arriola	municipal councillor

Source: Consulting Team, December 2017.

3.2 Delivery of Invitations

After updating the contacts of the representatives of each group of social actors, invitations were given to each of the key stakeholders, directing the invitation to the director or chief representative of each group, and extending it to more interested representatives of each group. *Annex 1* presents a record of the invitations delivered with signature of reception by the representative of each group.

3.3 Preparation of Informative Material

As part of the preparations for each of the meetings, informative material was developed by means of a POWERPOINT presentation *(See Annex 2)*, in which the following topics are exposed:

The October presentation included the following topics:

- **a)** Summary of the concept of the project, need and its components in order to refresh it in the memory of the social actors;
- **b)** Account on the latest progress in the development of the project from 2016 to 2017;
- **c)** Presentation of possibilities of changes to the project and evaluation of pipeline location;
- **d)** Characteristics of submarine natural gas pipelines.
- **e)** Summary of the current compensations intended for the fishing sector;
- **f)** Proposal for possible additional support to the fishing sector;

g) Summary of the social investment mechanism for the municipality and record of the social investment projects that have already been executed.

The December presentation included the following topics:

a) Introduction
b) Previous proposal: Breakwater (cofferdam);
c) New proposal: Catenary Anchoring System;
d) Floating Storage and Regasification Unit (FSRU);
e) Characteristics of the pipeline installation;
f) Advantages of the new proposals for the marine terminal;
g) Conclusions and Next Steps.

4.0 Development of the Activities

4.1 Reactivation meeting in October with the Fishermen's Group

The first participatory reactivation meeting with the different groups of actors belonging to the fishing sector of the municipality of Acajutla took place in the facilities of the Acajutla Restaurant, located in the municipality of the same name, department of Sonsonate, on Wednesday, October 11 of the year 2017.

This meeting had as main topics: the presentation of the advances, changes and benefits concerning the "LNG TO POWER" project. Representatives of all groups of fishermen identified in the area of influence of the project were invited to the meeting *(See Annex 1.1)*, and finally had the participation of representatives of the cooperatives ACOOPPAC, ACPETAMAR, group of tuberos and group of Oystercatchers *(See Annex 3.1: Attendance List to the Event)*. Also, representatives of Energía del Pacífico and the technical team of ECO INGENIEROS were present at the meeting. Only missing the presence of representatives of ACOOPESCA who were invited to the event but did not send any member in representation of the group.

During this meeting the components of the Project were resumed and updated informative material was delivered to the attendees about the latest advances and possible alternatives to the location of the natural gas pipeline.

The participatory meeting was successfully developed, the representatives of each of the groups of fishermen started arriving at 9:00 a.m. to the conference room of Acajutla Restaurant, where the first phase of the activities which consisted in a presentation of informative material and discussion with all the actors was developed. The second phase of the participatory activities consisted of a visit to the facilities of the artisanal pier accompanied by representatives of each group of fishermen.

The agenda of the meeting was developed in the following order of activities:

Phase 1:

a) Attendance list in writing;
b) Distribution of material (triptych with project summary);
c) Welcoming speech and presentation of each of the attendees;
d) Objective of the meeting;
e) Presentation of project update;
f) Open space for participation: questions, comments, concerns.
g) Breakfast;
h) Appreciation for assistance.

Phase 2:

a) Visit to the artisanal pier with representatives of all the entities present;
b) Meeting agreement with each cooperative for the following week.

4.1.1 Phase 1: Participatory Meeting

Representatives of the different groups of fishermen attended the event, only missing the presence of representatives of ACOOPESCA who were invited to the event, but did not attend, also had the presence of three representatives of "Energía del Pacífico" and two representatives of "Eco Ingenieros".

Next, the detail of the assistants, *(See in Annex 3.1, a copy of the attendance list to the event):*

a) Representatives of ACOOPPAC Cooperative.
b) Representatives of ACPETAMAR Cooperative.
c) Representatives of the Tuberos group.
d) Representatives of the Ostreros group.
e) Representative of the project owner, "LNG TO POWER- Energía del Pacífico".
f) Representatives of the consulting firm for the preparation of the EsIA and baseline studies, ECO INGENIEROS, S.A. DE C.V.

As part of the methodology applied, the visual presentation prepared in PowerPoint containing a complete description of the Project was carried out, and an informative summary of the "LNG TO POWER Project" was also given to the attendees *(See Annex 4).*

During the activity, they were updated about the latest developments of the project and the changes that have arisen as part of the more detail engineering, with the purpose that fishermen in the area acquire a global vision of the development of the project. An important part of the presentation was to present the alternative location of the natural gas pipeline that is currently being evaluated. Likewise, as part of the presentation, the stages of preparation of the project were presented and current project timeline.

In addition, the main activities that will be carried out to compensate this sector and the possibility of additional support were announced. As a final part of the presentation, the social investment component that is part of the project was recalled, regarding the social projects already executed and in the mechanism that exists for the participation of those interested in seeking support for social development projects.

In general, the participants presented their comments, doubts, suggestions and different situations that they considered necessary to clarify with respect to the project, taking advantage of the activity. In the following section the results are presented in detail of the events of the meeting, as well as the comments made.

4.1.1.1 Results of the participatory meeting with Acajutla fishermen

Through this meeting it was possible to explain the project progress, the possibility of some changes especially concerning the alternative pipeline location, in addition to the compensatory measures for the fishing sector, as well as the possibility of providing additional support because they are a key sector with respect to the development of the project.

Likewise, through the presentation, it was possible to publicize the social investment projects that have already been carried out thanks to the support of Energía del Pacífico through the fund destined for the municipality of Acajutla *(See Annex 2.1: Project Update Presentation).*

At the beginning of the presentation, a brief introduction was made about the importance of this group being together since they are considered key actors for the proper development of the project, which is why they have been taken into account with greater recurrence due to the effects that the project could mean for the sector, as well as the importance of their comments which have been incorporated into the decision making of the project.

As part of the presentation the generalities of the project, the need to build such a plant, advantages of natural gas, location, process of obtaining permits, benefits, compensations, social investment already made, and particularly, the alternative of location of the pipeline nearer the artisanal pier, among other topics, were taken up again.

As a central theme, it was explained that in view of the possibility of some modifications that could be made to the "LNG TO POWER" project, it is of great interest for Energía del Pacífico to have first hand views and concerns from the fishing sector, as well as knowing the level of acceptance in particular in relation to the alternative location of the pipeline south of the artisanal pier.

Continuing with the issue of the pipeline, during the exposition it was explained that gas pipelines are quite common in other parts of the world and that the industry has extremely high safety and emergency response standards, it was clarified that it is a pipeline that transports GAS and not liquids (petroleum), and that all the prevention measures required will be taken so that a risk scenario is quite low.

The representatives of the different groups of fishermen and cooperatives participated in an open manner during the activity, presenting some comments, proposals and suggestions on the actions, especially in what comprises the compensation that the project will give. Likewise, it should be noted that several of the opinions expressed were directed towards the possibility that the fishing sector receives greater support from Energía del Pacífico.

Within the possibilities of support to the sector, a subject of interest was the possibility of dredging the artisanal pier as part of compensation measures or investment projects, to which representatives of Energía del Pacífico opportune responded that unfortunately, this proposal would not be possible because its execution requires permits from MARN, and since EDP is a responsible company could not intervene in a project that does not have the endorsement of that institution.

Always in relation to the issue of dredging the artisanal pier, some representatives said that there is already a pre-approval of the project apparently with IDB funds, however, has not been formalized by the municipality.

Finally, the fishing sector expressed its acceptance of the changes presented in relation to the alternative location of the pipeline near the artisanal pier, stating their interest in being compensated for any negative impact, as well as supported to overcome some problems that they currently face in the development of their economic activity, and deficiencies in the infrastructure of the pier, such as lack of lighting. Afterwards, a visit was made with all the entities represented together, to see first-hand the current state of the artisanal pier facilities and that the representatives could express their needs directly.

Among the opinions issued by the actors, the following stand out:

<u>Mr. Oscar Orlando representative of ACOOPPAC:</u>

- He made a point about the need of dredging the artisanal wharf and that this activity is the one that has greater importance in his opinion and should be a priority at the time of the compensatory measures in the fishing sector.

- He also consulted about the possibility of helping to do the pertinent procedures both in MARN and in the Mayor's Office of Acajutla.
- He expressed his commitment to Energía del Pacífico to help with the unification of the fishing sector and thus facilitate the dredging process of the pier.
- He expressed his agreement with the new location of the gas pipeline, since "it will generate employment and compensatory measures have been presented".

Mr. Alberto Cuellar representative of ACPETAMAR:

- Asked about other compensatory measures that will be given, since dredging is something that transcends the authority that Energía del Pacifico has for such activity. It was also explained that apparently there is a proposal for dredging that is under review by the IDB and the Acajutla Mayor's Office.
- He expressed his disagreement with the municipality of Acajutla, since the groups (fishermen) are not taken into account and their projects are not guaranteed to be part of the social investment.
- Suggested that individual meetings be held with each of the cooperatives, for EDP to be able to listen to their proposals separately and specifically since they could vary the needs of each of them (Energía del Pacífico committed to hold such meetings the next Thursday, 19th or Friday, October 20 of this year).
- Suggested that the aforementioned meetings be held within the facilities of each of the cooperatives.

Mr. David Henríquez representative of ACPETAMAR:

- He expressed his solidarity with the TUBEROS, since he expressed that this type of fishing is the most complicated and requires a very slow mobilization within the sea, since it is carried out by non-motorized means.
- He expressed his agreement with the location of the pipeline and also with the compensatory way that it would be to provide the local people of Acajutla with employment while the power generation plant is being built.
- He added that they should make a diagram of the fishing routes that are most affected during the construction of the marine terminal, and thus be able to reformulate the compensatory activities they would receive.
- He proposed that the electrical system infrastructure of the pier and the lighthouse could be improved, since they are currently being guided by the light from a local restaurant close to where the pier is located, and that it is very important to have a lighthouse.

<u>Mr. Juan Carlos Gonzales, representative and manager of APECTAMAR:</u>

- He made some comments regarding the rejection to the proposals presented to the municipality by the fishing sector. Also remarked that the mayor was not supportive of this sector, for which, they knew that they could not count on them for the dredging and electrical installation of the pier among other activities.
- He commented that there are more approaches where aid could be given to the fishing sector, which is not precisely the artisanal pier.
- He is satisfied with the location of the pipeline since it will generate employment.
- He stated that it could be a viable proposal to be able to talk with each of the institutions, separately, to see the alternatives that each of them has for the compensatory means to the fishing sector.
- He Proposed dates for such personal visits with each cooperative.
- He stated that the lighthouse and the electrical system, previously mentioned, must have a special infrastructure due to the salinity and its outdoor location.

4.1.1.2 Final Comments

Responding to some of the concerns expressed previously, the representatives of ECO Ingenieros and Energía del Pacífico made some comments in relation to the compensatory measures that will be considered:

- It was explained that the pipeline could be located close to the artisanal pier, but that the probability of leakage is next to nil. And that it does not transport any liquid (such as oil), but gas, and that the industry has international safety standards.

- The infrastructure already built within the municipality of Acajutla was manifested through the presentation. As well as the compensations established particularly for the fishing sector, by means of the installation of artificial reefs and the fish aggregating devices.

- It was stated that the dredging of the artisanal pier is outside the scope of Energía del Pacífico compensations, since EDP cannot be committed to this activity because entities such as MARN and Acajutla Municipality have not facilitated the granting of the permit, and the company must comply with the applicable legislation. It was also explained that the dredging of the pier was a topic that EDP tried to promote at the beginning of the project and that this measure was rejected by MARN.

- It was detailed to the cooperatives that they can be supported in some other way to promote the dredging proposal that they mentioned is under review by the IDB and the Acajutla Municipality, but as previously mentioned, EDP cannot commit to the execution of that activity as a compensatory measure.

- EDP showed its interest in the possibility of supporting the sector if there are other proposals for the sustenance and development of the sector, being willing to listen to the proposals and encouraging them to submit them to the municipal government to be considered in the selection of social projects.

- Energía del Pacífico agreed to hold individual meetings with each cooperative, and they would be scheduled for next Thursday, October 19 or Friday, October 20, where they could present the projects feasibility of execution each one of them have in mind to be taken into consideration. After these meetings, all the cooperatives would be informed so that there will be no misunderstandings among them.

- The artisanal pier was visited to show the problems with the electric light in the site, so Energía del Pacífico attended to their suggestions for the project, as well as the situation that now exists with the lighthouse.

- Regarding the employment that will occur when the project is in the construction phase, Energía del Pacifico said that there is a plan to hire labor from local inhabitants, provided they have the proper training to carry out the work positions that will be available.

And as a general conclusion it was stated that the location of the pipeline near the pier is not in any way badly accepted within the fishing sector, the most mentioned recommendations to be considered by the project owner are the following:

- Generation of employment for local people, especially jobs aimed at the fishing sector so that they can be compensated for the interruption of fishing during the construction of the pipeline.

- Support with additional compensatory measures regarding improvements in infrastructure where they have some difficulty to continue doing their work.

- Possibility of support from Energía del Pacífico with government institutions to promote their project proposals as part of EDP's social investment component.

4.1.2 Phase 2: Visit to Artisanal Pier

As a second part of the activity, representatives of the fishing groups from the cooperatives of ACOOPPAC (Represented by Oscar Orlando Cortez) and ACPETAMAR (Represented by David Antonio Henríquez), as well as representatives of Energía del Pacífico (Alejandro Alle, Javier Mina, Horacio Larios, Patricia Cerón and Brenda Lovato), together with the consulting team of Eco Ingenieros (Represented by Lisbia Jarquín and Oscar Molina) visit the installations of the artisanal pier, which is used by both cooperatives, so that the cooperatives could show at first hand some related needs, and at the same time get an idea in the field of the proposed location for the natural gas pipeline.

During the meeting, photographs were taken of the main facilities of the pier, as well as of the exposed needs, among them the installation of a lighthouse since they currently don'thave lighting when they return from fishing during at night.

Likewise, the cooperatives exposed other needs of the pier related to its deterioration. At the end of the visit, the representatives of both cooperatives were grateful with the interest shown of behalf of the company in knowing the facilities and listening to their requests. On the other hand, Energía del Pacífico explained that the petitions will be evaluated with the purpose of collaborating in the future.

4.2 December Reactivation Meeting with Fishermen's Group

The second reactivation and consultation meeting with the different groups of actors belonging to the fishing sector of the municipality of Acajutla was carried out in the facilities of the Acajutla Restaurant, located in the municipality of the same name, department of Sonsonate, on Wednesday, December 20th, 2018.

This meeting presented in a more detailed and concrete means the final engineering changes proposed for the "LNG TO POWER" project, especially the mooring system of the marine terminal and the construction system of the submarine pipeline and its final location. These changes would be included in the project modification addendum.

Many representatives of all the fishermen groups identified in the area of influence of the project were invited to the meeting *(See Annex 1.2: Invitations to the Event),* finally counting with the participation of representatives of the cooperatives ACOOPPAC, ACPETAMAR, ACPRA, representatives from the group of "tuberos" and representatives of the oystercatchers group *(see Annex 2.1: Event Assistance Lists).* No ACOOPESCA representative attended, even though they were invited to the event. Also, representatives of Energía del Pacífico and the technical team of ECO Ingenieros were present at the meeting.

The participatory meeting was successfully carried out, the representatives of each of the groups of fishermen were present at 9:00 a.m. in the conference room of Acajutla Restaurant, where the activities that were carried out consisted in the first place, in the presentation of informative material about the proposed changes, and finally a discussion of the material with all of the actors.

The agenda of the meeting was carried out in the following order of activities:

a) Written attendance taking;
b) Welcome and presentation of each of the attendees;
c) Objective of the meeting;
d) Presentation of update and proposed changes to the maritime terminal and installation technology of the submarine pipeline project;
e) Consclusions, advantages and next steps;
f) Open space of participation for questions, comments, concerns;
g) Breakfast;
h) Appreciation for assistance.

4.2.1 Results of the December participatory meeting with Acajutla fishermen

At the beginning of the presentation a brief introduction was made about the importance of this group being reunited since they are considered key actors for the adequate development of the project, reason for which they have been taken into account with greater recurrence due to the effects that the project could have for the sector; as well as, the importance of their comments which have been incorporated into the decision making process of the project.

On this occasion the presentation focused on the proposed changes as part of the final engineering of the project, referring to the mooring system of the FSRU at the marine terminal, and in explaining the system to be used for the installation of the submarine pipeline consisting of HDD. The differences between the previous proposal consisting of the construction of a breakwater and the new catenary type anchoring proposal were explained, detailing the advantages that these changes mean in the final proposed engineering, both for the environment and for the successful development of the project since it implies less alteration of the environment, and easier installation that implies a shorter execution time for the works.

The representatives of the different groups of fishermen and cooperatives participated in an open way during the activity, explaining some comments. In general, they expressed themselves positively in relation to the changes and the development of the project. They also appreciated that they are being taken into account throughout the process and that they will be informed first hand about the changes.

The fishing sector expressed its acceptance of the changes presented, concerning the mooring system alternative, the HDD installation system for the pipeline, and the location of the pipeline, only expressing its interest in making the project a reality and how it could benefit the municipality.

On another note, comments were received at the same time directed towards the possibility that the fishing sector could receive greater support from Energía del Pacífico, and their interest in being compensated for any negative impact, as well as supported to overcome some problems they currently face in the carrying out of their economic activity, especially in terms of shortages in the infrastructure of the craft dock.

Among the opinions issued by the actors, the following stand out:

<u>Mr. Oscar Orlando, representative of ACOOPPAC, asked in relation to the location of the pipeline, expressing the following:</u>

- Asked about the final location of the pipes since they had previously been presented with the possibility of locating the pipe nearer to the craft dock at the previous meeting.
- He expressed that there are many people who are asking about the certainty of the location of the pipe.
- And because they had been told they would be notified about the location of the pipe before construction.
- Suggested that they be informed about the location of the pipeline and discuss the manner of personal safety.
- Previously they had not been given security if they will pass close to the CENERGICA pipes.
- The most appropriate and best practice is to give security about the location of the pipeline and to go underground.

<u>Other representatives also expressed the following opinion regarding the location of the pipeline:</u>

- They expressed that they consider the option of underground pipeline the best since there is less risk of contamination and accidents.

<u>Javier Mina from Energía del Pacífico explained in relation to the location of the pipeline:</u>

- They were told at the previous meeting that they were looking at options, but after these last few weeks the designers have advanced with the construction of the pipeline. With a new technology, the pipeline is going to be pushed underground from the land where the plant will be located, until the maritime terminal, so there will be no greater impact of approaching it..

Lisbia Jarquín from Eco Ingenieros, expanded on the topic of the location of the pipeline by adding:

- She understands the confusion in relation to the location since in the previous meeting they had been presented with the possibility of moving the pipeline farther north (which was being evaluated), but that at the moment the location that was initially discussed (further south of artisanal pier) is being maintained.

Jose Antonio Cordero, representative of ACPRA expressed the following:

- He appreciates that they have been taken into account throughout the process and congratulates EDP for maintaining this relationship with fishermen.

Wilfredo Molina, representative of ACOOPAC, expressed himself in general about the proposed changes to the maritime terminal:

- He expressed familiarity with this type of anchoring, having worked outside the country in Mexico, where he said that they have been using it for years.

4.2.2 Final comments

It can be concluded that the meeting was quite positive since the following objectives were achieved:

- Doubts and questions were clarified regarding the location of the pipeline.

- It was corroborated that the fishing sector includes the new catenary anchoring system and that the industry has international safety standards.

- The fishing sector was reminded of the compensatory measures that are already part of the "Environmental Management Program" and that these will be kept, even if there are changes in the design of the project, such as artificial reefs and fish aggregators.

- It was explained again that the dredging of the Artisanal Pier is outside the scope of Energía del Pacífico, since they cannot commit to this activity because entities such as MARN and the Acajutla Municipality have not facilitated the granting of the permit, and the company must comply with the applicable legislation. However, it was stated that EDP provide give support in following up with the municipality, which is currently in the process of initiating the environmental assessment process on the MARN platform regarding that project.

- The fishermen sector expressed themselves positively on the design changes presented, as well as the system for installing the pipeline underground.

- It was concluded that they should continue to be informed prior to the construction stage of the project.

4.3 December Reactivation Meeting with Municipality

The meeting to reactivate the consultation with actors belonging to the Acajutla municipality, was held in the facilities of the City Hall on Monday, December 18th, 2017. The meeting was convened through the Mayor's office, with the purpose of having his presence, as well as that of all the members of the municipal council, a space was requested during one of the council meetings.

This meeting presented in a more detailed and concrete way the final engineering changes proposed for the "LNG TO POWER" project, especially the mooring system of the FSRU of the marine terminal and to present the construction system of the submarine pipeline and its final location. Same that would be included in the project modification addendum.

Representatives of city council and other representatives who showed interest on behalf of the municipality were invited to the meeting *(see Annex 2.3: Event Assistance Lists).* Also, several representatives of Energía del Pacífico and the technical team of ECO Ingenieros were present at the meeting.

The participatory meeting was successfully developed, firstly, with the presentation of the informative material about the proposed changes, and finally in the discussion with all the actors.

The agenda of the meeting was developed in the following order of activities:

a) Taking of assistance in writing.
b) Welcome and presentation of each of the attendees.
c) Objective of the meeting.
d) Presentation of project update.
e) Open space of participation for questions, comments, concerns.
f) Coffee Break
g) Appreciation for assistance.

4.3.1 Results of the December participatory meeting with Acajutla City Hall

At the beginning of the presentation there was a brief introduction about the importance of keeping the municipality constantly informed as they are the main reference and responsible for the administration of the locality, so they are considered key actors for the proper development of the project. Due to the above, your comments are considered of great importance, which at the same time have been considered in the decision-making process of the project.

On this occasion the presentation focused on the proposed changes as part of the final engineering of the project, referring to the mooring system of the FSRU at the maritime terminal, and explaining the system to be used for the installation of the submarine pipeline consisting of HDD. The differences between the previous proposal consisting of the construction of a breakwater and the new catenary type anchoring proposal were explained, detailing the advantages that these changes mean in the final proposed engineering, both for the environment and for the successful development of the project since it implies less alteration of the environment, and greater ease of installation which means a shorter execution time of the works.

Some representatives of the municipal council participated in an open manner during the activity, explaining some comments. In general, they expressed positively in relation to the changes and the development of the project, mainly expressing their interest in the project being developed in the best possible way. They also appreciated being informed of these changes and that they continue to be taken into account during the entire process prior to and during the construction of the project.

The changes related to the mooring system alternative, as well as the HDD installation system for the pipeline, and the location of it, did not receive greater observations from the representatives of the municipality, only showing their interest in the project to be a reality and to benefit the municipality.

On the other hand, a comment was received relating to the interest that the breakwater infrastructure was going to be in the area.

Among the opinions issued by the actors, the following stood out:

<u>The main comments expressed by some councilors of the municipality were:</u>

- One of the councilors only regretted that the breakwater was not built because it considered that this would be a greater investment that would remain for the municipality, and how important investment was in the area.

- Other members of the council agreed that the project is already bringing many benefits with the works that have already been done, and the municipality is grateful to the company because the commitments acquired are being fulfilled.
- They also appreciated the information provided, having knowledge of what will be developed in the area. Así mismo, algunos concejales expresaron que consideran que habría menor impacto ambiental con la nueva propuesta.

For his part, the Mayor thanked that they are being kept informed and that the project can finally be developed.

4.3.2 Final Comments

It can be concluded that the meeting was quite positive since the following objectives were achieved:

- The municipality expressed itself in a positive way to the design changes presented, as well as to the pipeline installation system underground.

- It was concluded that they should continue to be informed prior to the construction stage of the project.

- In general, the overall feeling of the municipality is that of full support for the implementation of the project and appreciation of being kept informed.

5.0 Conclusions

As a general conclusion, it is possible to determine that the perception of the project by the different actors is quite favorable. Both the municipality and the actors of the fishing sector expressed themselves in a positive way that they had been contacted for the different informative activities and citizen participations carried out. As a reflection of this conclusion, most of the participants expressed themselves positively about the project.
The positive impacts are more mentioned by the actors, which are mostly related to the expectations of the local population in which employment opportunities are generated, and local and general development in the municipality. On the other hand, most local actors expressed no disadvantages or negative impact because of the development of the project, or the proposed changes, but rather give their support to make the project a reality.

In the two meetings with the fishermen, the support of this sector was perceived towards the project, only doubts were clarified that arose in relation to the location of the pipeline since it had been asked during the first meeting, the possibility of moving it, to which there wasn't any objection; rather, they expressed their interest in being informed opportunely before the construction of it.

Regarding the changes to the mooring system of the FSRU, in general all the actors, both from the Municipal Mayor's Office and from the fishing sector, expressed familiarity with said system, in a general way the majority compared it with the anchoring system that the freighters of the maritime terminal of CENÉRGICA, and particularly some of the members of the cooperatives, who have worked outside the country, expressed their knowledge of the system when it was used in other countries, and passed on their knowledge of the catenary anchoring system to other members during the meeting.

Likewise, the fishing sector expressed its needs and the expectation of generating employment during the construction and maintenance of the plant.

The general feeling of all the actors was of total support in the execution of the project since they want this to be a reality for the municipality. Likewise, it was possible to perceive that all the actors have great confidence in Energia del Pacífico, and that they are trying to develop the project in the best way and trust that the proposed changes are all for the benefit and better execution of the project.

As a final point, it is highlighted that the citizen participation activities carried out as part of the present analysis, have served to inform and educate the population about the changes in the final engineering of the project and the technology to be used for the construction stage. . Likewise, during the participation activities, other doubts or concerns among the actors were solved.

6.0 Photographic Record

Next, a photographic record is presented that shows the development of the main activities that took place during the reactivation meetings with the fishing sector.

6.1 Photographic Record of Reactivation Meeting with Fishermen in October-2017

Photo 6-1 Arq. Lisbia Jarquín from Eco Ingenieros, explaining about the advances and changes that have arisen in the project

Source: Consulting Team, October of 2017.

Photo 6-2 Actors of the different fishermen cooperatives during the presentation

Source: Consulting Team, October of 2017.

Photo 6-3 General view of the participants

Source: Consulting Team, October of 2017.

Photo 6-4 Representative of ACPETAMAR exposing his concerns during the space for questions on the presentation

Source: Consulting Team, October of 2017.

Photo 6-5 Representative of ACOOPPAC exposing his concerns

Source: Consulting Team, October of 2017.

Photo 6-6 Representatives of Energía del Pacífico

Source: Consulting Team, October of 2017.

Photo 6-7 Representatives of Cooperatives in conversation with Patricia Cerón and Brenda Lovato from Energía del Pacífico

Source: Consulting Team, October of 2017.

Photo 6-8 Representatives of ACOOPAC and ACPETAMAR in Company with representatives of Energía del Pacífico during visit to the Artisanal Pier

Source: Consulting Team, October of 2017.

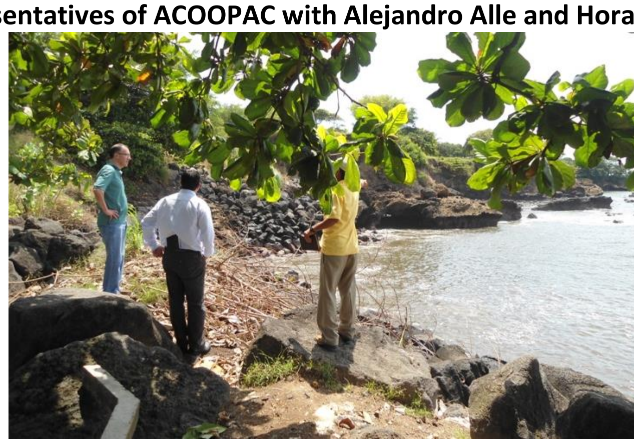
Photo 6-9 Visit to the Artisanal Pier with representatives of ACOOPAC and ACPETAMAR exposing their needs to Alejandro Alle, in company with Oscar Molina from Eco Ingenieros

Source: Consulting Team, October of 2017.

Photo 6-10Representatives of ACPETAMAR expressing to Alejandro Alle from EDP, their needs during the Visit to Artisanal Pier

Source: Consulting Team, October of 2017.

Photo 6-11 Representatives of ACOOPAC with Alejandro Alle and Horacio Larios from EDP



Source: Consulting Team, October of 2017.

Photo6-12 Representatives of ACOOPAC with Alejandro Alle and Horacio Larios from EDP

Source: Consulting Team, October of 2017.

6.2 Photographic Record of Reactivation Meeting with Fishermen in December-2017

Photo 6-13 View of attendees to the meeting with fishermen of December 2017

Source: Consulting Team, December of 2017.

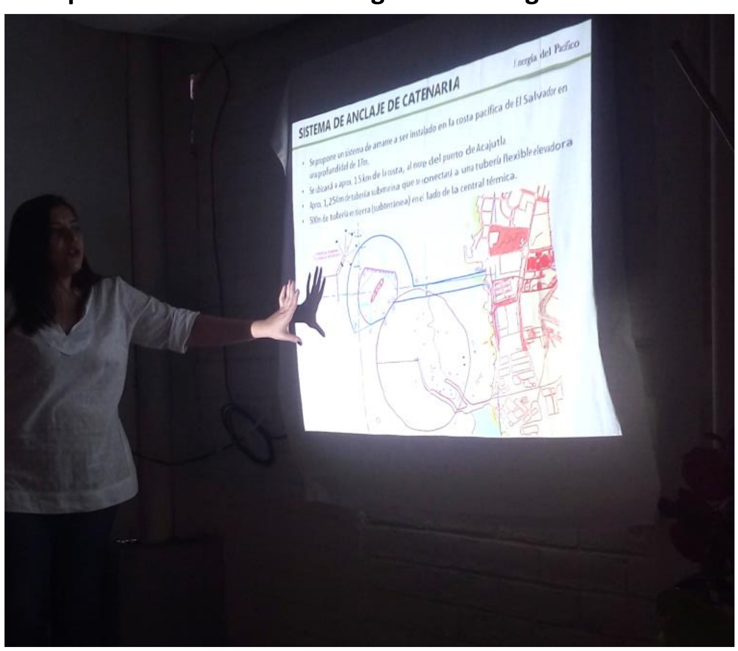
Photo 6-14 View of attendees to the meeting with fishermen of December 2017

Source: Consulting Team, December of 2017.

Photo 6-15 View of the presentation made during the meeting with fishermen of December 2017

Source: Consulting Team, December of 2017.

Photo6-16- View of the presentation made during the meeting with fishermen of December 2017



Source: Consulting Team, December of 2017.

Photo6-17- View of the presentation made during the meeting with fishermen of December 2017

Source: Consulting Team, December of 2017.

Photo6-18- View of the attendees to the meeting with fishermen of December 2017

Source: Consulting Team, December of 2017.

Photo6-19- Representatives of the fishing sector during the meeting of December 2017

Source: Consulting Team, December of 2017.

Photo6-20- Representatives of the fishing sector during the meeting of December 2017

Source: Consulting Team, December of 2017.

Photo6-21- Representatives of the fishing sector during the meeting of December 2017

Source: Consulting Team, December of 2017.

Photo6-22- Representatives of the fishing sector during the meeting of December 2017

Source: Consulting Team, December of 2017.

6.3 Photographic Record of Reactivation Meeting with Municipality on December-2017

Photo6-23- Municipal mayor and council representatives during the meeting

Source: Consulting Team, December of 2017.

Photo6-24- Representatives of the city council during the meeting

Source: Consulting Team, December of 2017.

Photo6-25- Representative of the council expressing his opinion on the changes

Source: Consulting Team, December of 2017.

7.0 Anexxes

Anex
1- Register of Invitations

Annex
1.1
October

Energía del Pacífico

Acajutla, 09 de octubre de 2017

Señores ACPPRA
Presente

Con Atención a:
José Antonio Cordero
Presidente

Reciban un cordial saludo en nombre de Energía del Pacífico, Ltda. de C.V.

En esta ocasión nos dirigimos a ustedes para invitar a **4 representantes** de su sector, a la **"Reunión Informativa"** sobre los avances del proyecto de generación de energía eléctrica que se está desarrollando en esta ciudad, la cual tiene como objetivo presentar:

1. **Actualización de los avances del proyecto.**

2. **Propuesta para cambios al proyecto.**

La asamblea se llevará a cabo:

Día: Miércoles 11 de octubre de 2017

Hora: 9:00 A.M.

Lugar: Salón de Conferencias Restaurante Acajutla.

Si desea obtener más información puede visitar nuestra oficina ubicada en la Colonia RASA 1, Calle Circunvalación, casa #44, Acajutla, Sonsonate, llamar al teléfono 2452-6313 o escribirnos al correo electrónico info@edp.com.sv

Energía del Pacifico, Ltda. de C.V. reitera la importancia de su participación y suscomentarios en esta **"Reunión Informativa"**, ya que todas las opiniones recibidas serán consideradas y analizadas como parte del proceso de evaluación ambiental y social.

Agradecemos su atención a la presente.

Atentamente,

Energía del Pacífico, Ltda. de C.V.

7479-1672

Edificio Avante, Oficina 709, Calle Llama del Bosque,
Antiguo Cuscatlán, La Libertad, El Salvador.
(503) 2133-0700

Energía del Pacífico

Acajutla, 09 de octubre de 2017

Señores ACOPESCA
Presente

Con Atención a:
José Bonilla
~~Representante de Tuberos~~

Reciban un cordial saludo en nombre de Energía del Pacífico, Ltda. de C.V.

En esta ocasión nos dirigimos a ustedes para invitar a **4 representantes** de su sector, a la **"Reunión Informativa"** sobre los avances del proyecto de generación de energía eléctrica que se está desarrollando en esta ciudad, la cual tiene como objetivo presentar:

1. **Actualización de los avances del proyecto.**
2. **Propuesta para cambios al proyecto.**

La asamblea se llevará a cabo:

Día: Miércoles 11 de octubre de 2017

Hora: 9:00 A.M.

Lugar: Salón de Conferencias Restaurante Acajutla.

Si desea obtener más información puede visitar nuestra oficina ubicada en la Colonia RASA 1, Calle Circunvalación, casa #44, Acajutla, Sonsonate, llamar al teléfono 2452-6313 o escribirnos al correo electrónico info@edp.com.sv

Energía del Pacifico, Ltda. de C.V. reitera la importancia de su participación y suscomentarios en esta **"Reunión Informativa"**, ya que todas las opiniones recibidas serán consideradas y analizadas como parte del proceso de evaluación ambiental y social.

Agradecemos su atención a la presente.

Atentamente,

Energía del Pacífico, Ltda. de C.V.

78582274.

Edificio Avante, Oficina 709, Calle Llama del Bosque,
Antiguo Cuscatlán, La Libertad, El Salvador.
(503) 2133-0700

Energía del Pacífico

Acajutla, 09 de octubre de 2017

Señores
Sector Tuberos de Acajutla
Presente

Con Atención a:
Raúl Escobar
Representante de Tuberos

Reciban un cordial saludo en nombre de Energía del Pacífico, Ltda. de C.V.

En esta ocasión nos dirigimos a ustedes para invitar a **4 representantes** de su sector, a la **"Reunión Informativa"** sobre los avances del proyecto de generación de energía eléctrica que se está desarrollando en esta ciudad, la cual tiene como objetivo presentar:

1. **Actualización de los avances del proyecto.**
2. **Propuesta para cambios al proyecto.**

La asamblea se llevará a cabo:

Día: Miércoles 11 de octubre de 2017

Hora: 9:00 A.M.

Lugar: Salón de Conferencias Restaurante Acajutla.

Si desea obtener más información puede visitar nuestra oficina ubicada en la Colonia RASA 1, Calle Circunvalación, casa #44, Acajutla, Sonsonate, llamar al teléfono 2452-6313 o escribirnos al correo electrónico info@edp.com.sv

Energía del Pacifico, Ltda. de C.V. reitera la importancia de su participación y suscomentarios en esta **"Reunión Informativa"**, ya que todas las opiniones recibidas serán consideradas y analizadas como parte del proceso de evaluación ambiental y social.

Agradecemos su atención a la presente.

Atentamente,

Energía del Pacífico, Ltda. de C.V.

RUEUL ESCOVAR 74·99·06·23

Edificio Avante, Oficina 709, Calle Llama del Bosque,
Antiguo Cuscatlán, La Libertad, El Salvador.
(503) 2133-0700

Acajutla, 09 de octubre de 2017

Señores
Sector Ostreros de Acajutla
Presente

Con Atención a:
Oscar Armando García Pacheco
Representante de Ostreros

Reciban un cordial saludo en nombre de Energía del Pacífico, Ltda. de C.V.

En esta ocasión nos dirigimos a ustedes para invitar a **4 representantes** de su sector, a la **"Reunión Informativa"** sobre los avances del proyecto de generación de energía eléctrica que se está desarrollando en esta ciudad, la cual tiene como objetivo presentar:

1. **Actualización de los avances del proyecto.**

2. **Propuesta para cambios al proyecto.**

La asamblea se llevará a cabo:

Día: Miércoles 11 de octubre de 2017

Hora: 9:00 A.M.

Lugar: Salón de Conferencias Restaurante Acajutla.

Si desea obtener más información puede visitar nuestra oficina ubicada en la Colonia RASA 1, Calle Circunvalación, casa #44, Acajutla, Sonsonate, llamar al teléfono 2452-6313 o escribirnos al correo electrónico info@edp.com.sv

Energía del Pacifico, Ltda. de C.V. reitera la importancia de su participación y suscomentarios en esta **"Reunión Informativa"**, ya que todas las opiniones recibidas serán consideradas y analizadas como parte del proceso de evaluación ambiental y social.

Agradecemos su atención a la presente.

Atentamente,

Energía del Pacífico, Ltda. de C.V.

7689-4637

Acajutla,09deoctubre de 2017

Señores ACOOPPAC
Presente

<u>Con Atención a:</u>
Oscar Orlando Córtez
Presidente

Reciban un cordial saludoen nombre de Energía del Pacífico, Ltda. de C.V.

En esta ocasión nos dirigimos a ustedes para invitar a **4 representantes** de su sector, a la **"Reunión Informativa"** sobre los avances del proyecto de generación de energía eléctrica que se está desarrollando en esta ciudad, la cual tiene como objetivo presentar:

1. **Actualización de los avances del proyecto.**

2. **Propuesta para cambios al proyecto.**

La asamblea se llevará a cabo:

Día: Miércoles 11 de octubre de 2017

Hora: 9:00 A.M.

Lugar: Salón de Conferencias Restaurante Acajutla.

Si desea obtener más información puede visitar nuestra oficina ubicada en la Colonia RASA 1, Calle Circunvalación, casa #44, Acajutla, Sonsonate, llamar al teléfono 2452-6313 o escribirnos al correoelectrónico info@edp.com.sv

Energía del Pacifico, Ltda. de C.V. reitera la importancia de su participación y suscomentarios en esta **"Reunión Informativa"**, ya que todas las opiniones recibidas serán consideradas y analizadas como parte del proceso de evaluación ambiental y social.

Agradecemos su atención a la presente.

Atentamente,

Energía del Pacífico, Ltda. de C.V.

71 02-97 66

Annex 1.2-

Register of invitations for December meeting with Fisehrmen

Antiguo Cuscatlán, 15 de diciembre de 2017

Señor
HUGO ARRIOLA
Alcalde Municipal
Alcaldía de Acajutla
Presente

Estimado Sr. Arriola,

Reciba un cordial saludo en nombre de Energía del Pacífico, Ltda. de C.V.

Tal como es de su conocimiento, Energía del Pacífico, Ltda. de C.V. (EDP) se encuentra en el proceso de desarrollo del proyecto de generación de Energía Eléctrica LNG-to-Power, ubicado en Acajutla, departamento de Sonsonate.

Como parte del proceso de diseño del Proyecto, deseamos hacerle la amable solicitud a Usted y su Concejo Municipal para que nos concedan un espacio en su agenda **el día lunes 18 de diciembre de 2017**, para desarrollar una breve presentación sobre los avances del proyecto en general y presentar los cambios en el diseño de la Terminal Marítima y Tubería de Gas Natural.

Estos cambios en el diseño se han realizado para minimizar el impacto ambiental y para EDP es de vital importancia conocer la opinión que la Alcaldía de Acajutla tiene ante estas modificaciones y poder así evaluar de mejor forma el componente social y ambiental del Proyecto.

Agradeciendo su atención a la presente, y a la espera de su confirmación de disponibilidad y el horario asignado, me suscribo.

Atentamente,

ENERGIA DEL PACIFICO, LTDA. DE C.V.

Alejandro G. Alle
Apoderado General Administrativo
Energía del Pacífico, Ltda. de C.V.

Antiguo Cuscatlán, 15 de diciembre de 2017

Señor
MARDOQUEO MACHUCA
Síndico Municipal
Alcaldía de Acajutla
Presente

Estimado Sr. Machuca,

Reciba un cordial saludo en nombre de Energía del Pacífico, Ltda. de C.V.

Tal como es de su conocimiento, Energía del Pacífico, Ltda. de C.V. (EDP) se encuentra en el proceso de desarrollo del proyecto de generación de Energía Eléctrica LNG-to-Power, ubicado en Acajutla, departamento de Sonsonate.

Como parte del proceso de diseño del Proyecto, deseamos hacerle la amable solicitud a Usted y su Concejo Municipal para que nos concedan un espacio en su agenda **el día lunes 18 de diciembre de 2017**, para desarrollar una breve presentación sobre los avances del proyecto en general y presentar los cambios en el diseño de la Terminal Marítima y Tubería de Gas Natural.

Estos cambios en el diseño se han realizado para minimizar el impacto ambiental y para EDP es de vital importancia conocer la opinión que la Alcaldía de Acajutla tiene ante estas modificaciones y poder así evaluar de mejor forma el componente social y ambiental del Proyecto.

Agradeciendo su atención a la presente, y a la espera de su confirmación de disponibilidad y el horario asignado, me suscribo.

Atentamente,

ENERGIA DEL PACIFICO,
LTDA. DE C.V.

Alejandro G. Alle
Apoderado General Administrativo
Energía del Pacífico, Ltda. de C.V.

Sector Tuberos de Acajutla
Presente

Con Atención a:
Raúl Escobar
Representante de Tuberos

Reciban un cordial saludo en nombre de Energía del Pacífico, Ltda. de C.V.

En esta ocasión nos dirigimos a ustedes para invitar a **4 representantes** de su sector, a la **"Reunión Informativa"** sobre los avances del proyecto de generación de energía eléctrica que se está desarrollando en esta ciudad, la cual tiene como objetivo presentar:

1. **Actualización de los avances del proyecto.**
2. **Presentación de la tecnología definitiva que EDP utilizará para la terminal marítima.**

La reunión se llevará a cabo:

Día: Miércoles 20 de diciembre de 2017

Hora: 9:00 A.M.

Lugar: Salón de Conferencias Restaurante Acajutla.

Si desea obtener más información puede visitar nuestra oficina ubicada en la Colonia RASA 1, Calle Circunvalación, casa #44, Acajutla, Sonsonate, llamar al teléfono 2452-6313 o escribirnos al correo electrónico info@edp.com.sv

Energía del Pacifico, Ltda. de C.V. reitera la importancia de su participación y sus comentarios en esta **"Reunión Informativa"**, ya que todas las opiniones recibidas son consideradas y analizadas como parte del proceso de evaluación ambiental y social.

Agradecemos su atención a la presente.

Atentamente,

Energía del Pacífico, Ltda. de C.V.

Acajutla, 17 de diciembre de 2017.

Señores ACOPESCA
Presente

Acajutla, 17 de diciembre de 2017.

Señores ACOOPPAC
Presente

Con Atención a:
Oscar Orlando Córtez
Presidente

Reciban un cordial saludo en nombre de Energía del Pacífico, Ltda. de C.V.

En esta ocasión nos dirigimos a ustedes para invitar a **4 representantes** de su sector, a la **"Reunión Informativa"** sobre los avances del proyecto de generación de energía eléctrica que se está desarrollando en esta ciudad, la cual tiene como objetivo presentar:

1. **Actualización de los avances del proyecto.**
2. **Presentación de la tecnología definitiva que EDP utilizará para la terminal marítima.**

La reunión se llevará a cabo:

Día: Miércoles 20 de diciembre de 2017

Hora: 9:00 A.M.

Lugar: Salón de Conferencias Restaurante Acajutla.

Si desea obtener más información puede visitar nuestra oficina ubicada en la Colonia RASA 1, Calle Circunvalación, casa #44, Acajutla, Sonsonate, llamar al teléfono 2452-6313 o escribirnos al correo electrónico info@edp.com.sv

Energía del Pacifico, Ltda. de C.V. reitera la importancia de su participación y sus comentarios en esta **"Reunión Informativa"**, ya que todas las opiniones recibidas son consideradas y analizadas como parte del proceso de evaluación ambiental y social.

Agradecemos su atención a la presente.

Atentamente,

Energía del Pacífico, Ltda. de C.V.

Acajutla, 17 de diciembre de 2017.

Energía del Pacífico

Señores ACPPRA
Presente

Con Atención a:
José Antonio Cordero
Presidente

Reciban un cordial saludo en nombre de Energía del Pacífico, Ltda. de C.V.

En esta ocasión nos dirigimos a ustedes para invitar a **4 representantes** de su sector, a la **"Reunión Informativa"** sobre los avances del proyecto de generación de energía eléctrica que se está desarrollando en esta ciudad, la cual tiene como objetivo presentar:

1. **Actualización de los avances del proyecto.**
2. **Presentación de la tecnología definitiva que EDP utilizará para la terminal marítima.**

La reunión se llevará a cabo:

Día: Miércoles 20 de diciembre de 2017

Hora: 9:00 A.M.

Lugar: Salón de Conferencias Restaurante Acajutla.

Si desea obtener más información puede visitar nuestra oficina ubicada en la Colonia RASA 1, Calle Circunvalación, casa #44, Acajutla, Sonsonate, llamar al teléfono 2452-6313 o escribirnos al correo electrónico info@edp.com.sv

Energía del Pacifico, Ltda. de C.V. reitera la importancia de su participación y sus comentarios en esta **"Reunión Informativa",** ya que todas las opiniones recibidas son consideradas y analizadas como parte del proceso de evaluación ambiental y social.

Agradecemos su atención a la presente.

Atentamente,

Energía del Pacífico, Ltda. de C.V.

Acajutla, 17 de diciembre de 2017.

Edificio Avante, Oficina 709, Calle Llama del Bosque,
Antiguo Cuscatlán, La Libertad, El Salvador.
(503) 2133-0700

Sector Tuberos de Acajutla
Presente

Con Atención a:
Raúl Escobar
Representante de Tuberos

Reciban un cordial saludo en nombre de Energía del Pacífico, Ltda. de C.V.

En esta ocasión nos dirigimos a ustedes para invitar a **4 representantes** de su sector, a la **"Reunión Informativa"** sobre los avances del proyecto de generación de energía eléctrica que se está desarrollando en esta ciudad, la cual tiene como objetivo presentar:

1. **Actualización de los avances del proyecto.**
2. **Presentación de la tecnología definitiva que EDP utilizará para la terminal marítima.**

La reunión se llevará a cabo:

Día: Miércoles 20 de diciembre de 2017

Hora: 9:00 A.M.

Lugar: Salón de Conferencias Restaurante Acajutla.

Si desea obtener más información puede visitar nuestra oficina ubicada en la Colonia RASA 1, Calle Circunvalación, casa #44, Acajutla, Sonsonate, llamar al teléfono 2452-6313 o escribirnos al correo electrónico info@edp.com.sv

Energía del Pacifico, Ltda. de C.V. reitera la importancia de su participación y sus comentarios en esta **"Reunión Informativa"**, ya que todas las opiniones recibidas son consideradas y analizadas como parte del proceso de evaluación ambiental y social.

Agradecemos su atención a la presente.

Atentamente,

Energía del Pacífico, Ltda. de C.V.

Acajutla, 17 de diciembre de 2017.

Señores ACOPESCA
Presente

Con Atención a:
José Bonilla
Representante de Tuberos

Reciban un cordial saludo en nombre de Energía del Pacífico, Ltda. de C.V.

En esta ocasión nos dirigimos a ustedes para invitar a **4 representantes** de su sector, a la **"Reunión Informativa"** sobre los avances del proyecto de generación de energía eléctrica que se está desarrollando en esta ciudad, la cual tiene como objetivo presentar:

1. **Actualización de los avances del proyecto.**
2. **Presentación de la tecnología definitiva que EDP utilizará para la terminal marítima.**

La reunión se llevará a cabo:

Día: Miércoles 20 de diciembre de 2017

Hora: 9:00 A.M.

Lugar: Salón de Conferencias Restaurante Acajutla.

Si desea obtener más información puede visitar nuestra oficina ubicada en la Colonia RASA 1, Calle Circunvalación, casa #44, Acajutla, Sonsonate, llamar al teléfono 2452-6313 o escribirnos al correo electrónico info@edp.com.sv

Energía del Pacifico, Ltda. de C.V. reitera la importancia de su participación y sus comentarios en esta **"Reunión Informativa"**, ya que todas las opiniones recibidas son consideradas y analizadas como parte del proceso de evaluación ambiental y social.

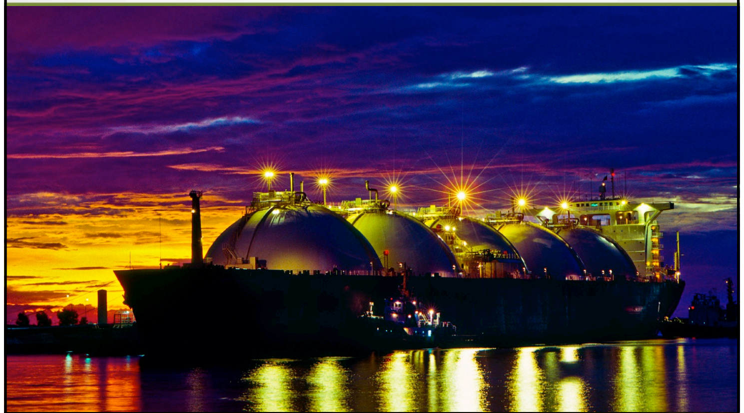
Agradecemos su atención a la presente.

Atentamente,

Energía del Pacífico, Ltda. de C.V.

Annex 2-
Presentatios of the Project

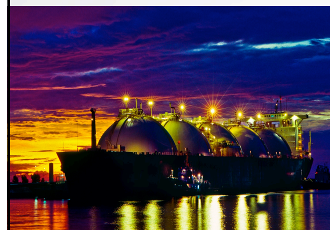
Energía del Pacífico



Energía limpia para nuestro futuro

Energía del Pacífico

OBJETIVO DE LA REUNIÓN



Informar a la población y al público en general las **actividades que se continúan desarrollado** para el proyecto de **GENERACIÓN DE ENERGÍA CON GAS NATURAL** de ENERGÍA DEL PACÍFICO.

Se ha trabajado en conjunto

DISEÑADORES – TITULARES DEL PROYECTO – CONSULTORES AMBIENTALES

Para buscar la configuración óptima del proyecto

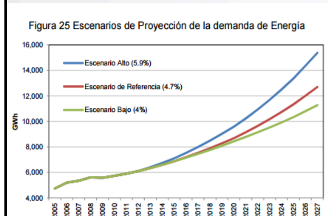
Energía del Pacífico

GENERALIDADES DEL PROYECTO

- Se instalará una planta de generación de **380 MW de Potencia.**
- La Planta suministrará electricidad a las siete distribuidoras de El Salvador.
- Se utilizará **gas natural**, el combustible más limpio disponible para la generación de electricidad en plantas térmicas.

Energía del Pacífico

NECESIDAD DEL PROYECTO

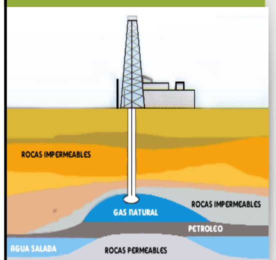


El Salvador requiere ampliar su producción de energía eléctrica para contribuir al desarrollo económico y social que el crecimiento del país y su población demandan.

- Energía del Pacífico ganó un contrato para generar electricidad durante 20 años.
- Esto ayudará a mejorar la forma en que se genera electricidad y garantizar un abastecimiento de energía al país y sus habitantes.

Energía del Pacífico

VENTAJAS DEL GAS NATURAL



El gas natural es un combustible fósil que se encuentra en la naturaleza. Se extrae de la tierra.

Es seguro

Se dispersa fácilmente en el ambiente, mas liviano que el aire.

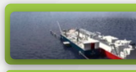
Se requiere una menor cantidad para generar más electricidad.

Es limpio

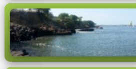
- Tiene menos carbono, generando menos CO2 al ambiente.
- Contiene menor cantidad de azufre comparado con otros combustibles como el Bunker

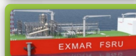
Energía del Pacífico

ACTIVIDADES EN 2016-2017


Rediseño del proyecto buscando la mejor alternativa


Estudios de calidad de aire complementarios


Análisis de agua, sedimentos y biota marina



Estudio de riesgos del proyecto


Consulta y reuniones con instituciones: MARN, ANDA, MINISTERIO DE ECONOMÍA, AMP, CEPA.


El proyecto se encuentra en **proceso final** de validación y **obtención de aprobación de permiso** medioambiental

Energía del Pacífico

ELEMENTOS DEL PROYECTO

CENTRAL TÉRMICA en tierra

Unidad de regasificación y almacenamiento flotante en el mar.

Energía del Pacífico

POSIBILIDADES DE CAMBIOS EN EL PROYECTO

Energía del Pacífico

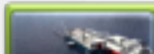
ALTERNATIVA DE UBICACIÓN DE TUBERÍA

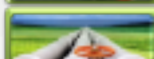
Energía del Pacífico

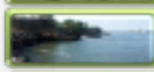
EVALUACIÓN Y MINIMIZACIÓN DE POSIBLES IMPACTOS

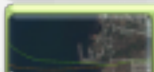
Energía del Pacífico

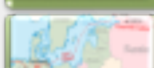
SEGURIDAD DE LA TUBERÍA

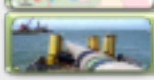

La industria del gas natural en su conjunto invierte constantemente en investigación, evaluación, prevención de daños, para asegurar la seguridad de las tuberías.


Como mayor reaseguro, el sistema de tuberías de gas natural está regulado bajo numerosos estándares y vigilancia agencias internacionales.


Desde el diseño y la construcción hasta las operaciones y el mantenimiento, se mantienen estándares altos para que no ocurran incidentes.


Las fugas y los incidentes en las tuberías de Gas Natural ocurren RARAMENTE, y este no genera derrames líquidos ya que la tubería transporta Gas NO petróleo.
De presentarse una fuga se detectará de forma inmediata y se cortará el suministro desde la terminal marina


Existen tuberías de gas natural de larga extensión en todo el mundo que pasan por varios países, la más larga está construida bajo el mar entre Rusia y Alemania tiene 1,224 km de longitud


El impacto ambiental que producen los gasoductos se centra en la fase de construcción de la tubería y es remediable en corto plazo.
El impacto se compensará adecuadamente a los actores más afectados

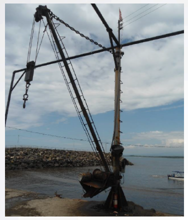
Energía del Pacífico

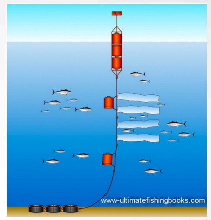
BENEFICIOS Y COMPENSACIÓN

Energía del Pacífico

COMPENSACIONES SECTOR PESQUERO

1. Sustitución de winche
2. Instalación de dispositivos agregadores de peces (FAD por sus siglas en inglés) en las proximidades del muelle artesanal .
3. Instalación de arrecifes artificiales para rehabilitación de los ecosistemas costero marinos.





Energía del Pacífico

POSIBLE APOYO ADICIONAL AL SECTOR PESQUERO

SE REVISARÁN LAS PROPUESTAS QUE SEAN MÁS VIABLES ALGUNOS EJEMPLOS PUEDEN RELACIONARSE CON:

1. Posible apoyo en fortificar al sector pesquero con aperos de pesca
2. Posibles capacitaciones dirigidas a incentivar al sector.
3. Posibilidad de mejora de instalaciones de apoyo al muelle. Ej.: oficinas, instalaciones eléctricas

Energía del Pacífico

OTROS BENEFICIOS

- Se requerirá un aproximado máximo de cerca de **1.000 trabajadores de la construcción** - y unos 60 trabajadores para la fase de operaciones.
- EDP se compromete a la **contratación de personas locales** que cuenten con las habilidades adecuadas.

Energía del Pacífico

INVERSIÓN SOCIAL

Energía del Pacífico
Energía limpia para nuestro futuro

Ciudad Portuaria
Acajutla

FISDL

Energía del Pacífico (EDP) se ha comprometido a contribuir con el desarrollo social del municipio de Acajutla.

Las comunidades pueden presentar sus propuestas para proyectos de desarrollo social a la Alcaldía de Acajutla, quien apoyada por el FISDL aprobará y presentará todos los proyectos a EDP para su ejecución.

INVERSIÓN SOCIAL

A continuación se detallan los pasos para la aprobación y ejecución de Proyectos de Inversión Social:

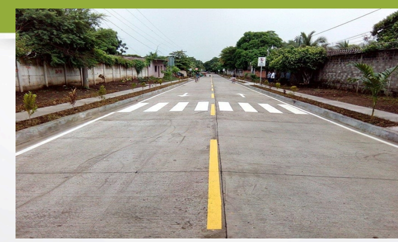
1. EVALUACIÓN DE PROYECTOS
Las obras serán propuestas, evaluadas y priorizadas, tomando en cuenta las necesidades de las comunidades, por el Fondo de Inversión Social para el Desarrollo Local (FISDL) y la Alcaldía de Acajutla

2. APROBACIÓN DE PROYECTOS
Las obras que sean acordadas por el FISDL y la Alcaldía pasarán a aprobación del CONCEJO MUNICIPAL

3. EJECUCIÓN DE LAS OBRAS
Energía del Pacífico realizará las obras autorizadas. Invirtiendo 530 mil dólares aproximadamente cada año

INVERSIÓN SOCIAL

EDP invertirá la cantidad de $ 532,500.00 , de forma anual durante un período de 23 años, en OBRAS DE DESARROLLO SOCIAL en el MUNICIPIO DE ACAJUTLA, iniciado desde el año 2015.



INVERSIÓN SOCIAL

2016

Se realizó la construcción de las **Calles Benigno Carrera y RASA**, ambas ubicadas en la Ciudadela CEPA en Acajutla, con lo cual se benefició a más 2 mil familias y se generaron 75 empleos directos dentro de las comunidades. Se construyeron 613 metros de largo entre ambas calles.

INVERSIÓN SOCIAL

2017

Se han aprobado tres proyectos sociales que mejorarán la calidad de vida de los habitantes de varias comunidades de la zona:

- **Techado de cancha de basketball y mejoras del Complejo Educativo Hacienda Metalío** (Creación de: Un nuevo módulo de baños, Sector de juegos para parvularia, Estacionamiento para bicicletas, además de pintura general en todo el complejo, renovación de banda de paz y renovación en pizarras, escritorios con sus sillas y archiveros en cada una de las aulas).
- **Introducción de energía Eléctrica en Caserío Los Abetos.**
- **Introducción de energía Eléctrica en Caserío Miramar.**

Energía del Pacífico

Techado de cancha de básquet y mejoras del Complejo Educativo Hacienda Metalío

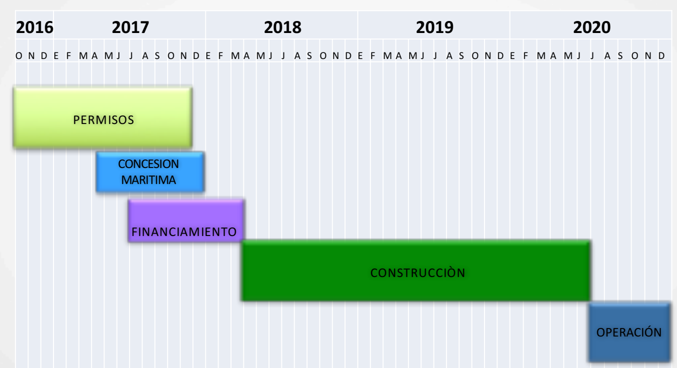
Energía del Pacífico

Energía del Pacífico

Introducción de energía eléctrica Los Abetos y Miramar

Energía del Pacífico

PROGRAMA



Energía del Pacífico

MEDIOS PARA OBTENER MAYOR INFORMACIÓN

Oficina de comunicaciones del Proyecto:
Colonia RASA 1, Calle Circunvalación, casa #44, Acajutla, Sonsonate

Línea Telefónica de Atención:
2452-6313

Correo Electrónico: info@edp.com.sv
Página Web:
http://www.energiadelpacifico.com/

Energía del Pacífico

GRACIAS POR SU ATENCIÓN

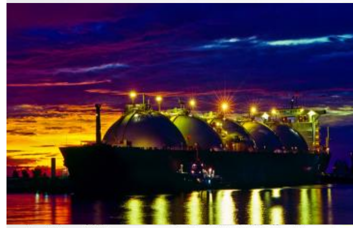
Annex 2.1-

Updated Presentation of the Project

Energía del Pacífico

Acajutla, diciembre de 2017

OBJETIVO DE LA REUNIÓN



- Realizar una breve introducción de la tecnología que EDP utilizará para la terminal marítima
- Exponer las ventajas de la tecnología a utilizar

TEMAS:

1. **Propuesta anterior:** Rompeolas (cajones)
2. **Propuesta nueva:** Sistema de Anclaje de Catenaria
3. **Unidad de Regasificación Flotante** (FSRU)
4. **Tubería**
5. **Ventajas nueva propuesta** para terminal marítima
6. **Conclusiones y Próximos Pasos**

1- PROPUESTA ANTERIOR: ROMPEOLAS

PROPUESTA ANTERIOR: ROMPEOLAS

Energía del Pacífico

La propuesta anterior estaba compuesta por los siguientes elementos:

- Barcaza de almacenamiento y regasificación
- Estructura rompeolas (cofferdam)
- Almacenamiento Flotante (FSU)
- Tubería Submarina

Energía del Pacífico

2- PROPUESTA NUEVA: SISTEMA DE ANCLAJE DE CATENARIA

SISTEMA DE ANCLAJE DE CATENARIA

Energía del Pacífico

La tecnología posee los siguientes componentes principales:

- Buque de Almacenamiento y Regasificación (FSRU)
- Sistema de Amarre (Líneas de amarre y restrictor)
- Anclas en el fondo marino
- Tubería Submarina

SISTEMA DE ANCLAJE DE CATENARIA

Energía del Pacífico

- Se propone un sistema de amarre a ser instalado en la costa pacífica de El Salvador en una profundidad de 17m.
- Se ubicará a aprox. 1.5 km de la costa, al norte del puerto de Acajutla.
- Aprox. 1,250m de tubería submarina que se conectará a una tubería flexible elevadora
- 500m de tubería en tierra (subterránea) en el lado de la central térmica.

COMPONENTES CLAVE

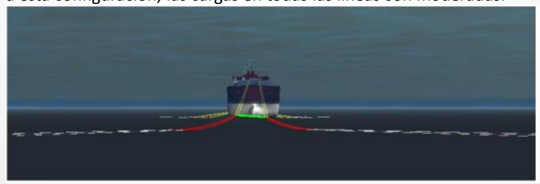
- **Sistema de amarre en proa**
  - Cuerdas de poliéster y cadenas, ordenadas desde la popa y una barra de restricción para sostener las líneas de amarre juntas.
- **Barra de restricción**
  - Mantiene las líneas de amarre juntas para evitar interferencia con el casco de la embarcación.
- **Tubería elevadora y cable umbilical**
- **Colector final de tubería (PLEM)**
- **Líneas de amarre en popa**
  - Líneas de amarre se instalan en la popa por medio de retenedores de cadenas.
- **Tubería**
  - Una tubería de 20-24" y de 1,250m de longitud va desde el PLEM hasta el punto de conexión en la costa.

SISTEMA DE AMARRE EN PROA

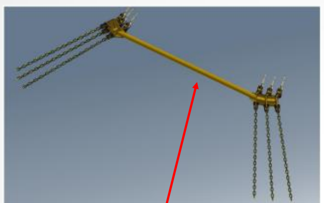
- Final de la línea de amarre a la altura de cubierta
- Líneas de amarre, 3+3 con anclas de uñas
- La restricción de amarre (El Restrictor) cercano a la proa
- Una tubería elevadora con un PLEM para la tubería de gas hacia la costa y un sistema umbilical para el control del PLEM

La restricción en la parte superior del sistema de amarre permite el uso de una barra horizontal en la parte inferior del sistema de restricción y una muy pequeña estructura en voladizo

Debido a esta configuración, las cargas en todas las líneas son moderadas.



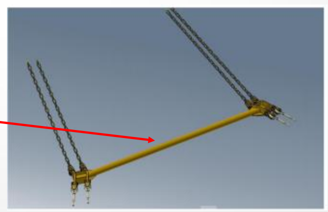
BARRA DE RESTRICCIÓN (RESTRICTOR)



La barra de restricción consiste básicamente en una viga tubular reforzada y grilletes en cada uno de sus extremos. Las líneas de amarre son enlazadas mediante terminales en tipo-H.

Barra de restricción en proa 3+3

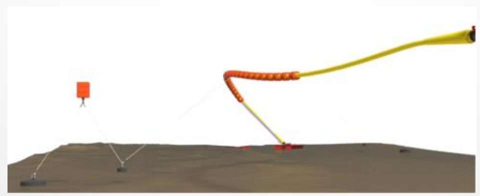
Barra de restricción en popa 2+2



TUBERÍA ELEVADORA (RISER)

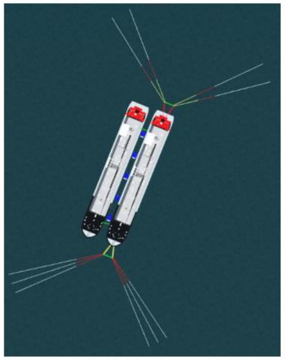
El "riser" irá desde el "PLEM" hasta un costado del FSRU. Será ubicado antes de la válvula ESD y de la tubería rígida.

Se realiza una atadura entre el barco y la tubería elevadora con una brida mediante dos abrazaderas especiales. La parte superior termina con un ángulo con el objetivo de proveer suficiente holgura con el casco de la embarcación.



Energía del Pacífico

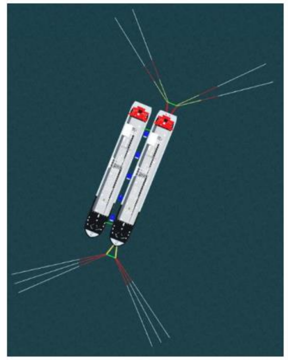
SISTEMA DE AMARRE EN POPA



- Compuesto de un sistema de cadenas/poliéster en configuración 2+2
- 4 Anclas de uñas
- Dichas cadenas son las encargadas de evitar la rotación del FSRU

Energía del Pacífico

TRANSFERENCIA DE COMBUSTIBLE BARCO-BARCO



Energía del Pacífico

CONCEPTO PROBADO Y EN OPERACIÓN

Buque “Sendje Berge” en el Campo Petrolero Okwari, Nigeria

Energía del Pacífico

UNIDAD DE ALMACENAMIENTO Y REGASIFICACIÓN (FSRU)

Energía del Pacífico

FSRU

- Capacidad de 138,000 m^3
- Los parámetros de variación de temperatura de agua marina para regasificación se mantendrán en cumplimiento con la norma NSO 13.49.01:09 y Reglamento Especial de Normas Técnicas de Calidad Ambiental

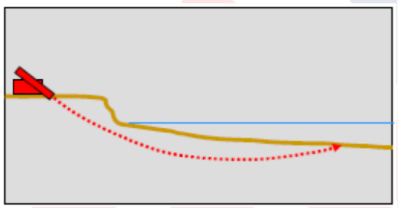
Energía del Pacífico

TUBERÍA

Energía del Pacífico

PERFORACIÓN HORIZONTAL DIRIGIDA (HDD)

- Dado a la complejidad que presentan las características naturales del sitio, EDP ha estado desarrollado y profundizado el concepto de Taladrado Horizontal direccional (HDD por sus siglas en inglés) directamente con contratistas expertos en este rubro.
- Estos contratistas especializados están en el proceso de presentar a EDP un plan de trabajo el cual incluirá los siguientes temas :
  - Manejo de seguridad medioambiental
  - Evaluación de riesgos y mitigación



Energía del Pacífico

VENTAJAS NUEVO SISTEMA

Energía del Pacífico

VENTAJAS

- Presenta menor complejidad y su instalación es más simple respecto al caso base
- No se requieren obras civiles
- No se requiere dragado y por tanto se eliminan los efectos asociados (dispersión de sedimentos, turbidez, movimiento de material del suelo marino)
- Las anclas pueden instalarse de forma sencilla sin perturbar el medio ambiente
- A diferencia del cofferdam las anclas no generan bloqueo al oleaje
- Puede ser ubicado en el mismo sitio del caso base
- No genera bloqueo al canal de acceso a CEPA
- Es un sistema probado y en funcionamiento para aplicaciones similares

Energía del Pacífico

CONCLUSIONES Y PROXIMOS PASOS

CONCLUSIONES

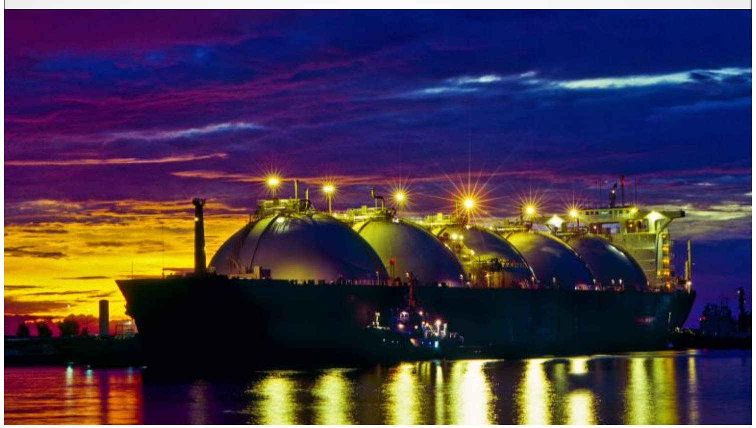
- La nueva configuración propuesta presenta diversas ventajas sobre la configuración del caso base: Técnicas, económicas y en tiempo de construcción
- Al no necesitar de obras civiles complejas se reducirán los impactos ambientales, tanto en la construcción como en la fase de operación.

PRÓXIMOS PASOS:

- Finalizar los aspectos técnicos requeridos para la definición completa de la tecnología
- **Evaluar los impactos ambientales de la nueva tecnología, aunque se prevén mucho menores impactos ambientales.**
- Preparar el documento de Modificación del EIA
- Taller de presentación de Resultados de la evaluación ambiental de la nueva configuración al MARN
- Presentar el documento de Modificación al EIA

Energía del Pacífico

GRACIAS POR SU ATENCIÓN



Annex 3-

List of attendance to the Meeting

ASISTENCIA REUNIÓN PROYECTO "LNG TO POWER" 11/Oct/2017

	Nombre	DUI	Cooperativa	Nº Contacto	Firma
1	Oscar Orlando		acooppac.	7102-9766	
2	David A Henriquez		acpetamar	74952789	
3	Rosa alberto cuellar		"	73142120	RHEC
4	RUBEL ESCOVAR		REPRENTE DE TUVER	74.99.06.23	RvèvESCOVAR
5	Ricardo Perez	02478702-4	Tuveros	63226550	
6	Gustavo A Delg Diaz		tuvero		
7	Alcides Alexander	04100649-7	Tuvero	03777583.0	
8	ARMANDO GARSIA PH.	0377583.0			
9			REPRESENTA DEL		
10			SECTOR OSTRERO		
11	Brenda Lovato.		Energía del Pacífico.	2452-6313	BR.
12	Patricia Cerón		EDP	2133-0700	
13	Oscar Molina	00932660-7	Ecoingenieros	2272-4148	
14	HORACIO LARIOS		EDP	2133-0700	
15	JAVIER MINA		EDP	2133-0700	
16	Alejandro ALLE	CR: 41,304	EDP	2133-0700	
17	Santos Victoriano Luc	01387580-4	Ostrero.	71518965	
18	Hebert Chávez. /			24523421	
19	julio jovel			7625-0922	

ASISTENCIA REUNIÓN PROYECTO 11/OCT/2017
"LNG TO POWER"

	Nombre	DUI	Cooperativa	N° de contacto	Firma
20	Juan Carlos García	00697442-7	ACPETAMAR de R.L.	70284547	
21					
22					

AcPetamar
70284547
Juan carlos Gonzalez
Gerente

Annex 3.1-

List of attendance to the December meeting with Fishermen

LISTA DE ASISTENCIA

REUNION INFORMATIVA CON GRUPOS DEL SECTOR PESQUERO DE ACAJUTLA

PROYECTO: "LNG TO POWER" DE ENERGÍA DEL PACÍFICO

FECHA: MIÉRCOLES 20 DE DICIEMBRE DEL 2017

N°	Nombre	Sexo	Nombre de la institución social o comunidad de la cual proviene	Teléfono de contacto	Correo electrónico	Firma
1	JULIAN TOVAR		TUVEROS	72.81.89.28		JULIANTOVAR
2	LUIS Antoni alegria		tuveros	79595153		[firma]
3	Gustavo A dalgo Diaz					Gustavo A Diaz
4	Ricardo Antonio tobar		TUVero	63226550		[firma]
5	Alcides Alexander Tobar		Tuvero			[firma]
6	WILFREDO MOLINA GONZALES		ACOOPAC			[firma]
7	Oscar Orlando Cortez		Durca Acoopac.	72220454		[firma]
8	Juan Carlos González		ACPETAMAR	70284547		[firma]
9	Isabel Cuellar Hercules		APETAMAR	74039491		Cuellar H
10	Fredy E. Serrano Castaneda		Acpetamar	76981145		[firma]
11	ARMANDO GARCIA PACHECO		OSTRERO	7689-4697		[firma]
12						
13	Julio Nelson Jovel		Flores	7625-0922		[firma]
14	Brenda Lovato.		Energia del Pacifico	7840-9635		B. L.
15	Javier Mina		ENERGÍA DEL PACÍFICO	2133-0700	fmina@edp.com.sv	[firma]
16	Jose Antonio cordero		APPRA	7479-7672		[firma]
17	Santos Victorion Luc			71548965		[firma]
18	Oscar Molina		ECOINGENIEROS	2272-4148		[firma]
19						
20						
21						

Annex 3.2-

List of attendance to the meeting in December

LISTA DE ASISTENCIA

REUNION INFORMATIVA CON CONCEJO DE ALCALDIA MUNICIPAL DE ACAJUTLA

PROYECTO: "LNG TO POWER" DE ENERGÍA DEL PACÍFICO | **FECHA:** LUNES 18 DE DICIEMBRE DEL 2017

N°	Nombre	Sexo	Nombre de la institución social o comunidad de la cual proviene	Teléfono de contacto	Correo electrónico	Firma
1	Mario Edgardo Perez		alcaldia			[firma]
2	Manuel Melendez		AMA			[firma]
3	Jose Angel Soriano		AMA			[firma]
4	Silvia Ventura de Buruca		AMA			[firma]
5	José Joaquin Moreira		AMA			[firma]
6	Dinora Guadalupe Mejia		AMA.			[firma]
7	José Luis Escobar O.		concejo AMA.			[firma]
8	Wilber Hernan Soriano M.		AMA			[firma]
9	Saul Hernandez		Concejal		saul.hernandez.acajutla@gmail.com	[firma]
10	Dario Guzman		Alcaldia	7749-3546		[firma]
11	Silvano Madrid		concejal			[firma]
12	Julio Cabrera		Alcaldia			[firma]
13	Jorge Alberto Ramirez M	M.	Alcaldia	7747-9774.	jorgeramirez1975@gmail.com	[firma]
14	Salvador A. López	m	Alcaldia	7602-1071		[firma]
15	Hugo Antonio Arriola		alcaldia	7747 2490		[firma]
16						
17						
18						
19						
20						
21						

Annex 4- information of the project

"LNG TO POWER de Energía del Pacífico"

En 2016 se realizó la construcción de las Calles Benigno Carrera y RASA, ambas ubicadas en la Ciudadela CEPA en Acajutla, con lo cual se benefició a más de 2 mil familias y se generaron 75 empleos directos dentro de las comunidades, así como la construcción de un total de 613 metros de largo entre ambas calles.

En 2017, se han aprobado tres proyectos sociales que mejorarán la calidad de vida de los habitantes de varias comunidades de la zona, entre ellos se encuentra el techado de una cancha de basketball y la mejora del Complejo Educativo Hacienda Metalío.

El objetivo de estos proyectos es mejorar las condiciones que permitan al sector educativo del lugar, que sobrepasa los 800 estudiantes, desarrollar actividades que beneficien la convivencia y el desarrollo de las comunidades cercanas a la escuela, mediante el esparcimiento deportivo, artes escénicas y demás reuniones, entre otros.

También se aprobaron dos proyectos de introducción de energía eléctrica en los caseríos Los Abetos y Miramar, ubicados en el municipio de Acajutla.

Oficina Central

Edificio Avante, Oficina 709,
Calle Llama del Bosque,
Antiguo Cuscatlán,La Libertad, El Salvador.
Teléfono: (503)2133-0700
Email: info@edp.com.sv

Oficina Acajutla

Colonia Rasa N° 1,
Acajutla,Sonsonate, El Salvador.
Teléfono: (503)2452-6313
Email: info@edp.com.sv

www.energiadelpacifico.com

Energía del Pacífico

Energía limpia para nuestro futuro

Energía del Pacífico, Ltda. de C.V. (EDP) es la empresa propietaria de un proyecto de generación de energía eléctrica a base de Gas Natural Licuado (GNL), con el cual se suministrarán 355 MW de nueva potencia y su energía asociada al mercado eléctrico de El Salvador. Este megaproyecto representa una inversión de aproximadamente USD $800 millones y estará ubicado en el Puerto de Acajutla, departamento de Sonsonate.

ETAPAS DEL PROYECTO

ETAPA DE DESARROLLO

↓

ETAPA DE CONSTRUCCIÓN

↓

ETAPA DE OPERACIÓN

El Proyecto de EDP es de interés nacional ya que producirá múltiples beneficios entre los que se destaca la diversificación de la matriz energética debido a la introducción del Gas Natural, un combustible limpio, seguro y que rápidamente será adoptado por la industria, tal como ocurre en muchos países del mundo.

Etapa de desarrollo (2014-2017)

A la fecha, dentro de los avances técnicos del proyecto tenemos la realización de los Estudios de Impacto Ambiental (EIA), la optimización del diseño de la Terminal Marítima de Almacenamiento y Regasificación de GNL, La identificación y contratación de los derechos de vía sobre los inmuebles en donde cruzará la línea de transmisión con que EDP inyectará la energía eléctrica generada al sistema nacional de transmisión, la aprobación de los estudios de interconexión por parte de ETESAL y la CRIE, entre otros; por otro lado, se firmó el contrato de suministro de GNL con la empresa Shell y los contratos de montaje de la planta generadora y provisionamiento de equipo con la empresa finlandesa Wärtsilä.

Esta etapa también incluye el cierre financiero con la Corporación Financiera Internacional (IFC por sus siglas en inglés), brazo del Banco Mundial que financia proyectos de inversión privados, el cual aún se encuentra en negociación.

Etapa de construcción (2017-2020)

La etapa de construcción contempla los siguientes componentes:

- La Planta de Generación Térmica de 378 MW de capacidad instalada, para cumplir con los Contrato de Abastecimiento de 355 MW de nueva potencia y su energía asociada firmados con las distribuidoras;
- La Terminal Marítima de Almacenamiento y Regasificación de GNL;
- La Tubería submarina de Gas Natural (GNL ya regasificado), la cual irá desde la Terminal Marítima hasta la Planta de Generación; y
- La Línea de Transmisión de 45 km para inyectar la energía generada al sistema nacional de transmisión, mediante la Subestación de Ahuachapán.

La construcción del proyecto generará hasta 1,000 empleos temporales en su etapa de construcción y aproximadamente 100 empleos permanentes una vez inicie operaciones.

Etapa de operación (a partir del año 2021)

Firma de contrato con Shell

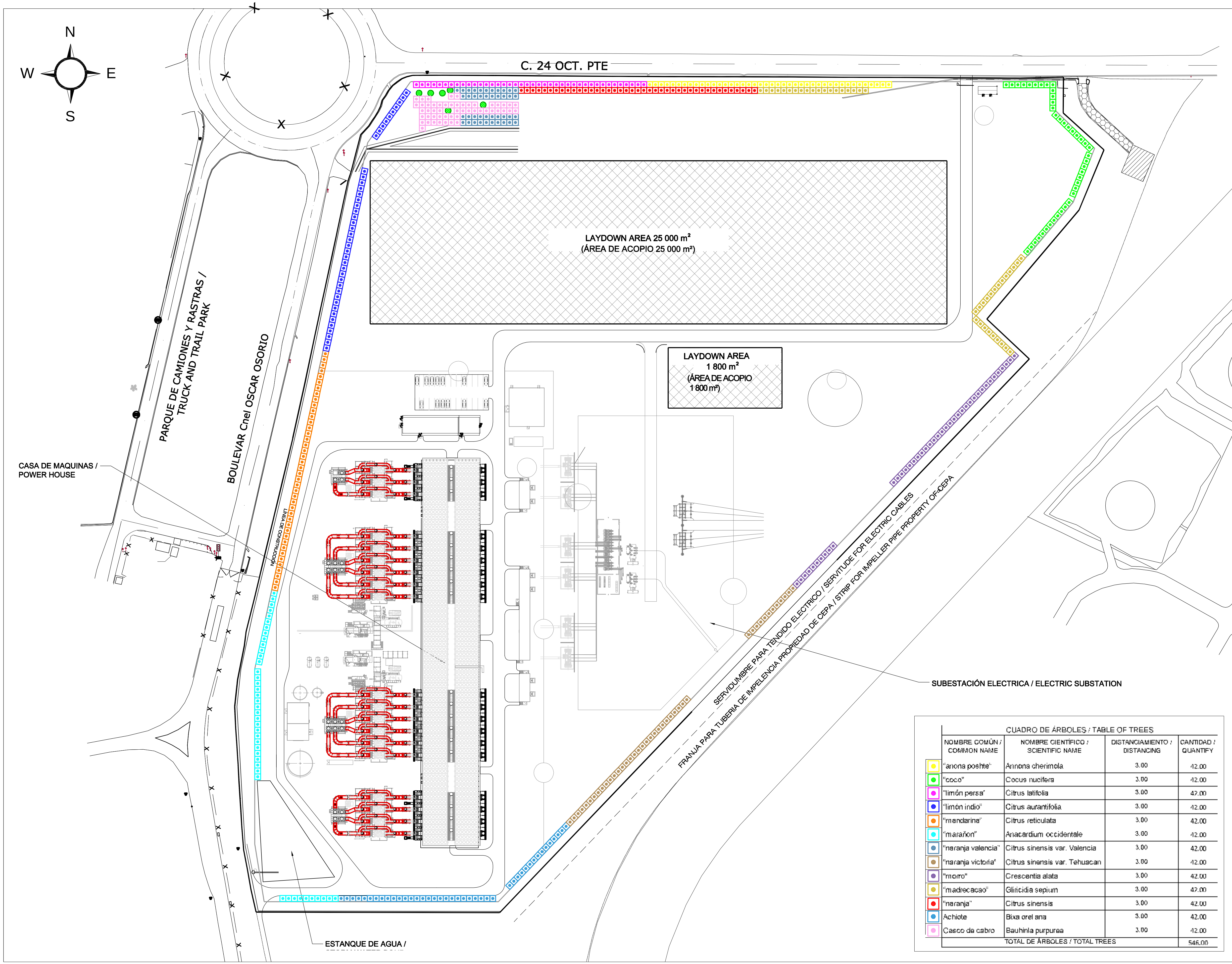
EDP ha firmado Contratos de Abastecimiento por ún término de 20 años con las distribuidoras eléctricas de El Salvador. Asimismo, se firmó un Contrato de Compra y Venta de GNL con la empresa Shell International Trading Middle East Limited, para el suministro del combustible que utilizará la planta de generación que se construirá y operará en el Puerto de Acajutla.

La firma de estos contratos es un paso decisivo en el proceso de diversificación de la matriz energética, tanto para El Salvador como para Centro América, al permitir la introducción del GNL como combustible.

Componente Social

EDP es una compañía comprometida con el desarrollo económico y social del municipio de Acajutla, y con ese objetivo ejecutará obras sociales por un monto que asciende a USD $ 530,000 anuales, aproximadamente. La decisión de qué proyectos serán ejecutados por EDP es tomada anualmente por la Alcaldía Municipal de Acajutla, en coordinación con el Fondo de Inversión Social para el Desarrollo Local (FISDL).

Appendix 3A–
Revegetation Layout



CUADRO DE ÁRBOLES / TABLE OF TREES

NOMBRE COMÚN / COMMON NAME	NOMBRE CIENTÍFICO / SCIENTIFIC NAME	DISTANCIAMIENTO / DISTANCING	CANTIDAD / QUANTIFY
"anona poshte"	Annona cherimola	3.00	42.00
"coco"	Cocus nucifera	3.00	42.00
"limón persa"	Citrus latifolia	3.00	42.00
"limón indio"	Citrus aurantifolia	3.00	42.00
"mandarina"	Citrus reticulata	3.00	42.00
"marañon"	Anacardium occidentale	3.00	42.00
"naranja valencia"	Citrus sinensis var. Valencia	3.00	42.00
"naranja victoria"	Citrus sinensis var. Tehuacan	3.00	42.00
"morro"	Crescentia alata	3.00	42.00
"madrecacao"	Gliricidia sepium	3.00	42.00
"naranja"	Citrus sinensis	3.00	42.00
Achiote	Bixa orel ana	3.00	42.00
Casco de cabro	Bauhinia purpurea	3.00	42.00
TOTAL DE ÁRBOLES / TOTAL TREES			546.00

Energía del Pacífico

ENERGÍA DEL PACÍFICO
LNG TO POWER PROJECT

ARBORIZACIÓN EN EL PROYECTO / TREE PLANTING IN THE PROJECT

FIGURA 3.7 / FIGURE 3.7

0 10 20 30 40 50m

FUENTE / SOURCE:
PLANOS WARTSILA / WARTSILA SITE PLAN

MAPA CREADO POR / MAP CREATED BY: ECO INGENIEROS
MAPA REVISADO POR / MAP CHECKED BY: LF
PROYECCIÓN DE MAPA / MAP PROJECTION:
UTM ZONA 16 WGS84 / UTM ZONE 16 WGS84

ARCHIVO / FILE
C:/ECO,DRAWING 1, EL SALVADOR/ ECO INGENIEROS
C:/ECO,DIBUJO 1, EL SALVADOR/ ECO INGENIEROS

PROYECTO / PROJECT: 14-9114
ESTADO / STATUS : FINAL / FINAL
FECHA / DATE: 29/01/2018

DILLON CONSULTING

ECO INGENIEROS

Appendix 3B–

Proposed Project Profiles for Fishermen

Energía del Pacífico

Project: LNG to Power
Appendix 3B: Summary of Compensation Projects for the Fishermen

December 2016 – 16-3489
14-9114

Project LNG to Power
Appendix 3B: Summary of Compensation Projects for Fishermen

December 2016
Project Reference: 16-3489

Prepared for:
ENERGÍA DEL PACÍFICO, S.A. DE C.V.
El Salvador

Prepared by:

DILLON CONSULTING LIMITED	ECO INGENIEROS, S.A. DE C.V.
Canadá	El Salvador

CONTENT TABLE

Figures List

Pictures List

Tables List

1.0 Compensation Projects Summary

The construction activities, and finally, the presence of the dock, could generate the following impacts:

- Loss of fishing areas located nearby the coast and interference with artisanal fishing activities, both cooperative as well as independent (oyster and “tubero” fishermen).
- Make the fishermen from the artisanal pier, travel longer distances when they move to other fishing zones located near Punta Remedios.

Therefore, the following compensation measures have been determined to mitigate the impacts on this group, and the selected measures are listed below.

To benefit all fishermen in general and to compensate the members of the cooperatives affected by an increase in the distance of their journey:

• Installation of fish aggregating devices (FAD- "Fish Aggregating Device").
• Installation of a new winch.
• Artificial oyster reefs.

To compensate independent fishermen (oyster and “tubero” fishermen) they will be allowed to choose between:

• Participating in the construction of a cayuco (small canoe), complete safety training (including fishing methods), and receiving necessary implements and equipment for fishing.

• Receive training in an alternative line of work with the aim of leaving the fishing industry.

Below we describe the projects.

1.1 Installation of Fish Aggregating Devices

1.1.1 Background

With the installation of fish aggregating devices, new habitats are generated, allowing the fish to feed, develop and reproduce, which also increases catching possibilities in the area, thus generating higher incomes for the families of local fishermen. The installation of aggregators also protects the environment, as fishing is not allowed with illegal methods and fishing is carried out by hook.

At present, the capture levels of the marine resources have been reduced, not only in this local area, but also in all the coastal zone of El Salvador, due to climatic factors, disorderly exploitation of resources and pollution. These are the main causes in the reduction of the fishing and extraction of marine organisms, which contributes to the levels of poverty in many of the communities of fishermen, since in the majority of the cases, fishing is their only source of economic income. In the search of solutions to poverty levels, to the reductions in catches, and high costs of resources needed for fishing activities, the installation of Fish Aggregating Devices serves as a tool to increase fish population, which is reflected in the Increase of catches and economic incomes.

As of now, the use of Aggregating Devices, to increase marine production, provides substrate for algae and invertebrate settlement and growth, increases shelter and protection for juveniles during growth and development, as well as provides areas suitable for adults during reproduction time.

1.1.2 General Objective for the Project

- Create proper conditions for the reproduction, growth and development of fish with the installation of Fish Aggregating Devices (FAD).

1.1.3 Specific Objectives

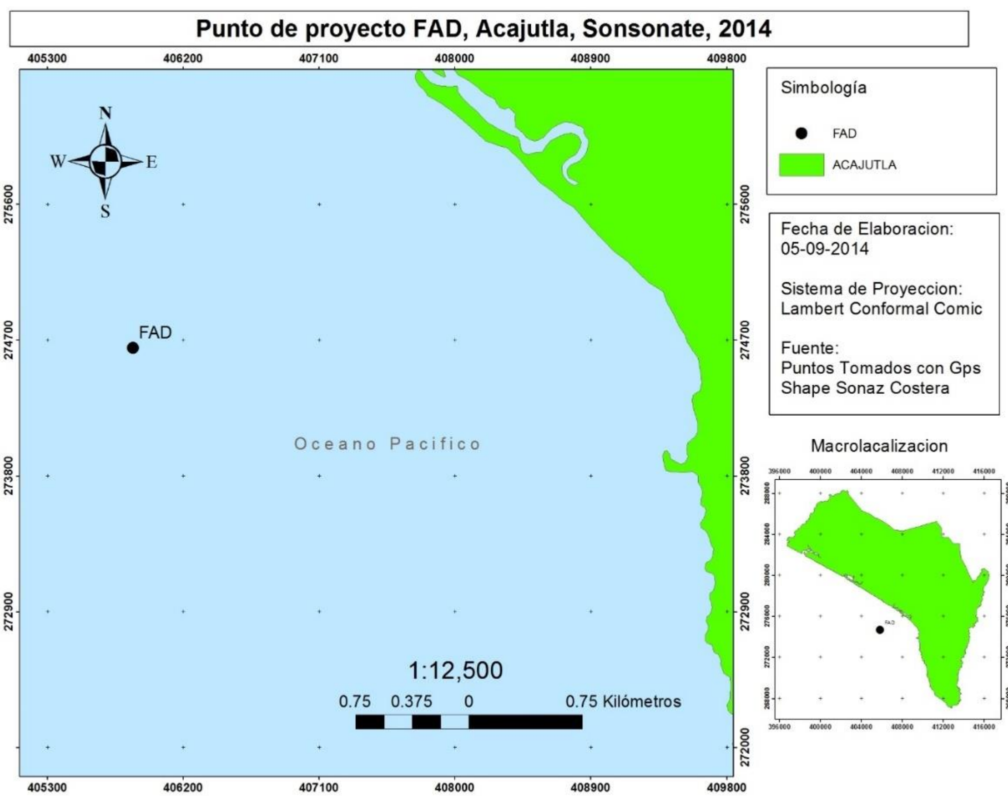
- Contribute to the recovery of fishing in the area, with the installation of floating aggregators.
- Reduce the current pressure in fish population, by installing hook-type fishing aggregators.
- Develop fishing and tourism activities by implementing the environmental regulations.

1.1.4 Project Description

The project will be located in Acajutla, Sonsonate, the area has the following coordinates: 13 ° 20'42.34¨LN 88 ° 58'26.99¨LO and 13 ° 20'46.55¨LN 88 ° 58'34.31¨LO, at an average depth of 10 to 20 meters, with a sand substrate and a mixture of small rock particles (Fig. 1: Project Location). In order to contribute to the creation of own habitats for fish reproduction and development, in communities interested in this type of project, especially in open sea areas, the use of FAD (Fish Aggregating Device) work best there (Figre 1.2: Design of Floating Fish Aggregating Device).

The total of Aggregators that are intended to be installed for this project are 15, and they are made of polyduct materials split in half through longitudinal cuts and will be fastened with ¾ silk lanyard as these provide longer life and their design does not cause potentially negative impact on the surrounding areas by the effect of currents and carry a concrete base (60 lb. Gramaquin) to keep them anchored vertically towards the float.

Figure1.1 – Proposed Location for FAD Project

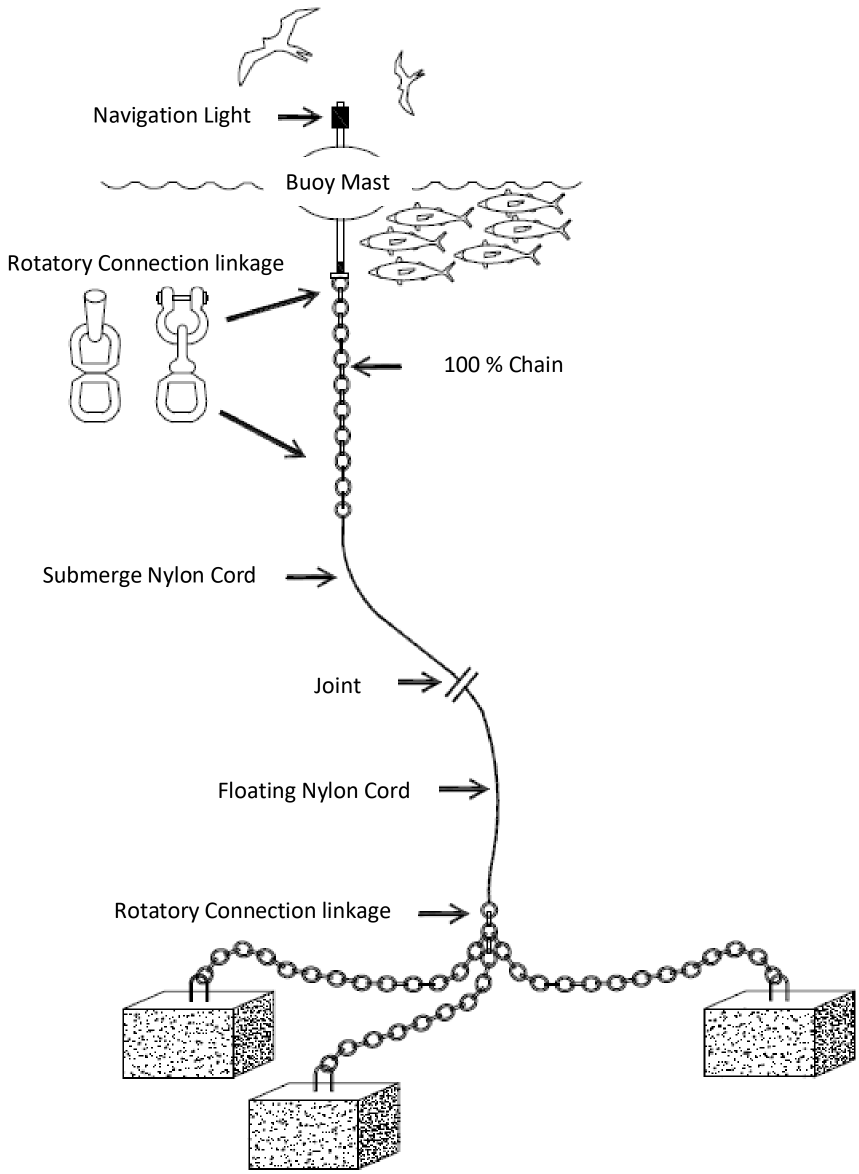


Source: Own elaboration

1.1.5 Components

- Floating fish aggregating devices
- Hooks
- Signs that signal de FAD zone

Figure 1.2 – FAD Device Design



Source: Own elaboration

Within the measures of restoration and rehabilitation of coastal ecosystems, the devices are used as open sea fishing tools. There are numerous examples worldwide where these devices have been used to perform important functions such as: physical protection of sensitive and fragile ecosystems and the replacement of a socio-economic resource. One of the important features is the protection and/or restoration of natural marine habitats, which is why they represent a great potential for habitat improvement.

1.2 Installation of new winch in artisanal dock

1.2.1 Background

There are two winches at the artisanal dock. One of them is completely rusty and needs to be replace. This one is located in the southwest, and there is only one working at the moment, which is located in the northeast. Below you can appreciate some images of both winches:

Photo 1-1– Image of only winch in use

Source: Picture taken by the consulting team

Photo 1-2– Image of the deteriorated winch

Source: Picture taken by the consulting team

1.2.2 Objectives

Installation of new winch to replace the deteriorated one, located southwest of the artisanal dock.

1.2.3 Description

Next, there is a detail of the components of the new winch that will be installed:

Table 1.1 – Detail of the components of new winch that will be installed

Quantity	Description
2	H beams 6 meter long by 16 inches tall
4	Sheets of 1/2 inch thick of 1 by 2 meters
8	Carbon Steel Pulleys
150	Meters of steel wire of 5/8
4	Schackles of 1 inch thick
1	Stringer Steel wire
1	Hook Cashew shaped of 1 1/2 inches for 12 Tons
2	Adjustable tensioners 1 inch thick
1	Diesel engine of 28 HP and 1800 RPM
1	Motor reducer of 28 HP
1	Battery Diesel Engine 90 amps

Table 1.1 – Detail of the components of new winch that will be installed	
Quantity	**Description**
1	Diesel Engine Ignition Battery Cable
6	Sheets of 1/8 Tear Strips of 3 Meters
5	Tubes of 5-in. 1/4-inch thick
2	Tubes of 6.5-inch of carbon steel of 6 meters long
2	Tubes of Carbon Steel of 12 inches of diameter by 1/2-inch thick
19	Cutting Iron Discs of 9-inch
19	Polishing Iron Discs 9-inch
100	Pounds of Sweet Iron Electrode
50	Pounds of Stainless Steel Electrode
80	Pounds of electrode for Pipe 6010
8	Angles of 3-inch and 1/4 in thickness
1	Sprocket type pinch with 57 3/4 pitch teeth
1	3.5 Inch Sprocket of Step 3/4
1	Steel bar for 2-inch shaft
1	1 1/2 inch steel shaft bar
12	Gallons of Anticorrosion paint and plastic paint or FAST DRY paint
12	Gallons of strong thinner to dissolve paint
8	Gallons of Gray colored of MINIO Paint
	Other materials to use (oxigen and acetylene)
	Lathe Work Pay for the parts to be used
NOTES: * This crane does not include any electrical system because its design is for a Diesel Engine.	

Source: Own elaboration

1.3 Installation of artificial reefs nearby the area to Acajutla's oyster bank near the artisanal dock

An artificial reef is a submerged structure placed deliberately on the sea bed to imitate some of the characteristics of a natural reef. They may be partially exposed in some tide movements.

It is a fact that the deliberate sinking of objects in the sea by man, with a different objective than to get rid of them, is something that historically has been carried out with multiple purposes. From the recreation of habitats that could have a favorable effect in fish resources, to the defense of the coast against the erosive action of the sea, through the installation of structures that protect sensitive ecosystems against aggressive fishing practices, such as trawling, or disposition in the bottom, of elements that can be attractive for recreational diving, the reasons that can motivate the creation of an artificial reef are diverse, and in many cases, complementary.

Within the measures of protection, restoration and rehabilitation of marine-coastal ecosystems, artificial reefs appear as management and protection tools from a social and ecological perspective. There are numerous global examples where these structures have been used to perform various functions, for example: the physical protection of sensitive and fragile ecosystems, the addition or replacement of habitat complexity, the creation of new substrates, or the replacement of a socioeconomic resource. One of the most important functions of artificial reefs is the protection and/or restoration of natural marine habitats, mainly in the face of the danger posed by illegal fishing techniques (fishing tools prohibited by national regulations), which threaten to reduce critically the biodiversity of species within the continental shelf.

The main purposes of the use of artificial reefs have been, in this order, increased production of species associated with hard substrates (macroalgae, invertebrates and fishes) and to favor or increasethe species catches associated with reefs. There are many possible materials to achieve the same purpose. Concrete blocks of different morphology, breakwater dikes, ship hulls, simple or complex structures, branched, ceramic, PVC, mesh, etc. are some of the structures used as artificial reefs.

1.3.1 Main Objective of the Project

- Promote fishing with enviromentally friendly practices and improve the economy and quality of life of its beneficiaries.

1.3.2 Specific Objectives

- To achieve efficiency in the use of marine resources with the implementation of fishing techniques appropriate to the ecosystem.
- Protect biodiversity with the implementation of environmentally friendly practices.
- Search for new forms of fishing that guarantee economic sustainability.

1.3.3 Project Justification

- Low productivity, increased the operating costs deficiencies in the market due to lack of product on critical dates.
- The natural resource (oysters), has decreased in quantity and quality, loss of genetic diversity. The production is delivered to toponeros or is auction in the market due to the lack of constancy in the quantity and quality of products; the greatest profit is obtained by

the intermediary for reasons such as the absence of installed capacity to process or to refrigerate the production.
- Improvement of the livelihoods of the local population.
- Regulation of water flows, maintenance and increase of hydrological resources.
- Protect the country's food security.

The activity carried out by the project is justified by the social and economic situation that dominates the area. The activity aims to contribute to improving the living conditions of the population and the natural reproduction of marine species.

The fundamental criteria:
- Technical and scientific basis
- Active participation of users and stakeholders and normative-based attachment
- The regulation that allows the harmonious use of resources.

The project is located in Acajutla, department of Sonsonate, and is located at an average depth of 6 meters at low tide, with a substrate of talpetate. In order to contribute to the creation of adequate habitats for the reproduction of marine fish, in each community we intend to install 100 artificial concrete reefs in the form of a cube (Fig. 2). The artificial reefs that are intended to be installed are concrete because they provide longer life and its design does not impact the surrounding areas by the effect of the currents.

Needs of the Project (Economic and Social Justification):
Economic:
- Shortage of job sources for income generation.
- Low profitability in fishing activities and agriculture.
- Decrease in population subject to artisanal fisheries exploitation during some times of the year.

Social:
- Lack of job opportunities.
- High rates of poverty and illiteracy that generate low levels of human development.
- Lack of technical advice for the sustainable use of fishery resources.

Impact:
- Implementation of alternative methods of sustainable extraction of fishery resources.
- Creation of opportunities to improve the beneficiary’s family income levels.
- Strengthening local capacities on sustainable management of fishery resources.

Expected benefits from project's execution/implementation:

Artificial reefs are used as management and protection tools from an ecological perspective. They have been used to perform important functions such as: physical protection of sensitive and fragile ecosystems, addition or replacement of habitat complexity, creation of new substrates, or replacement of a socioeconomic resource. One of the important features of artificial reefs is the protection and / or restoration of natural marine habitats (oyster beds). They represent a great potential for habitat improvement and contribute to three important factors: (i) Restoration, which consists in returning a habitat to its original condition; Ii) rehabilitation, returning a habitat to another state; Iii) improvement, by adding something different to the ecosystem.

The shape and materials used for the construction of artificial reefs, due to management and placement issues, are important to consider due to the size and shape of the artificial reefs to be placed. Immediately after the artificial reefs are placed the fish are the first to colonize them and later the algae and small organisms like mollusks and crustaceans. For artificial reefs to be an important tool, it is necessary to develop and implement a management plan in the area of artificial reefs, as a tool for the management of fisheries from the following points of view: commercial, sporting and scientific.

One of the important features of artificial reefs is the protection and / or restoration of natural marine habitats, which is why they represent a great potential for habitat improvement and contribute to four important factors, such as:

• Restoration, which consists in returning a habitat to its original condition;
• Rehabilitation, returning a habitat to another state;
• Improvement, by adding something different to the habitat.
• Pressure, reducing the pressure of use towards a particular species (oyster bank), through new adaptive practices of environmentally friendly fishing (handline or hook fishing).

In many countries artificial reefs are built of wood, which can be bamboo, dry mangrove trees, or washed by the currents at the mouths of the rivers, forming trunks. In some cases it is observed that many fishermen in view of the limitation of dry mangrove trees, cut them green to dry them and thus to be able to use them, creating with this a problem in the search of a solution. This time, it is intended to install concrete reefs which are widely used for the creation of artificial ecosystems, because in addition to not being harmful to the environment, they are very effective and have a longer life (between 15 to 20 years).

All of the above, will give back to increase production, improve economic conditions of those involved in the project, increase purchasing power, solidification and business equipment, incursion into new markets, improvement of supply and demand and increase in the price of its products, experiences in the management and distribution of resources and local development.

1.3.4 Reasoning (Backgrounds and Expected Results)

Artificial reefs are used to increase populations of marine organisms because they create habitats that provide them with food and shelter in their stages of growth, development and reproduction. In addition to contributing to the recovery of the marine populations, because they protects areas of trawling; artificial reefs also contribute to fisheries organization and management by facilitating the implementation of resource management plans.

The fish in their juvenile stages are the first to arrive and little by little, others of greater size incorporate until they become colonized by adult individuals.

With the installation of artificial reefs in these communities, it is intended to expand habitats for marine organisms, which will allow them to feed, develop and reproduce. This will increase catches in the area, generating better economic income for the families concerned. In addition, fishing will be reduced with illegal methods, such as bombs, since in the area of the artificial reef, fishing will only be possible with a hook, which ensures an adequate and sustainable management in the area and an increase in catch sizes, increased productivity and diversity of species.

1.3.4.1 Product Extraction

In the artificial reef only the members of each beneficiary community will be able to fish and the commitments for the implementation of the use and management of this artificial ecosystem will be the following:

a) Only fishing with hand line (hook);
b) Nets or traps, floating or deep, with a maximum of FIVE per boat, regardless of size;
c) Fishing rods of any kind floating and deep;
d) Underwater fishing is only permitted without oxygen tanks, using harpoons without explosive tips; and
e) Diving with eco-diving equipment is allowed, provided that no extraction is carried out,

Inside the artificial reef area, the following won't be allowed:

a) To carry out extractions of organisms whose sizes are smaller than those authorized
b) To carry out trawling fishing within the area of artificial reefs;
c) Execute fishing using explosives;
d) Use in their extractive activities, no fishing gear made by netting, except for traps.

1.3.4.2 Commitments

- Fishermen who in the act of their activities catch live species with sizes smaller than those authorized by CENDEPESCA, must return them to their natural habitat.
- Any other art and method of unauthorized fishing that fishermen intend to implement in their days of extraction, must be previously evaluated and authorized by CENDEPESCA.
- In order to assess hydrobiological resources from reefs, each group will keep a record of fisheries, in order to monitor the productivity and effectiveness of artificial reefs in increasing fish stocks (populations).

Any violation to the previously stated agreements will be sanctioned according to the General Law of Management and Promotion of Fishing and Aquaculture.

1.3.5 Design

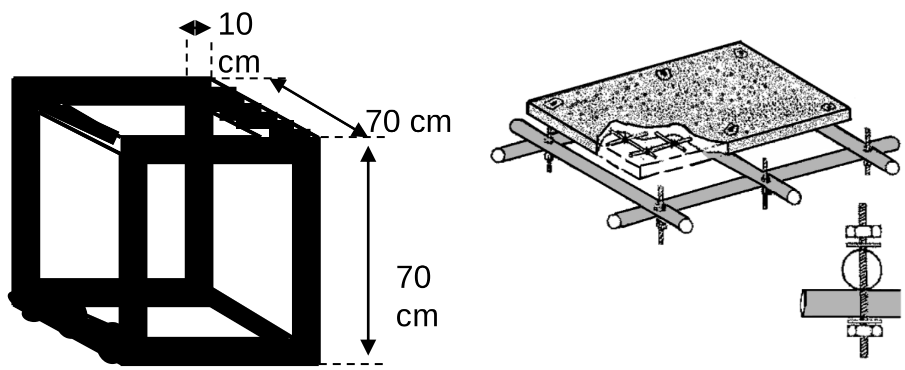
The objectives and characteristics of the reefs mainly respond to habitat protection, ecological restoration, control of fishing access, protection of marine reserves, and as a bonus, they improve fishing, separate conflicts between fishermen, protect breeding habitats and environmental mitigation.

Every AA must follow these 4 conditions:

- Functionality: related to the suitability of the chosen material in terms of being able to meet the desired goal.
- Compatibility: in relation to its possible toxicity and contamination of the environment.
- Durability: over the average lifetime of the material, which must be in line with the time it is intended to remain submerged and with the ability to perform its function.
- Stability: to maintain the structure in place and with the desired configuration.

This time, the most suitable material for this project are concrete blocks, which are composed of reinforced concrete materials and solid in various morphologies normally cubic, although there also exist cylindrical and pyramidal designs. These structures, due to their mass and design, tend to be very stable. For this project cubic forms will be installed.

Figure1.3 – Artificial concrete reefs for the restoration and settlement of species of commercial interest.



Source: Consulting team's drawing

1.3.6 Project Budget

Project's budget, detailing its main components:

Execution time: Fourth months.

Project amount: $ 10,650.90

Table 1.2 – General Budget for the Project				
No	**Description**	**Units**	**Unit Value**	**Total**
1	Purchase of artificial reefs			
1.1	Cube shaped reefs	100	60.00	6,000.00
1.2	Polyethylene rope roll 1" to install the reefs on the seabed.	1.00	265.00	265.00
1.3	1/2" polyethylene rope roll for buoy placement.	4.00	78.00	312.00
1.4	Signaling buoys for the area of artificial reefs	12.00	25.00	300.00
1.5	Installation of advertising poster in the area of artificial reefs	1.00	125.00	125.00
1.6	Construction of raft for transfer of artificial reefs1	1.00	200.00	200.00
1.7	Purchase of 12 plastic barrels	12.00	27.00	324.00
1.8	6-sided scantlings	40.00	1.70	68.00
1.9	6-rod flat ruler	6.00	1.40	8.40
1.10	1/2 " polyethylene rope roll to moor barrels	3.00	78.00	234.00
1.11	Construction of metallic support to install the artificial reefs in the bottom of the sea	1.00	200.00	200.00
1.12	Resin for sealing barrel plugs	1.00	15.00	15.00

Table 1.2 – General Budget for the Project				
No	**Description**	**Units**	**Unit Value**	**Total**
1.13	Fiberglass for sealing barrel plugs	5.00	1.50	7.50
1.14	Construction of supports for buoys	12.00	5.00	60.00
1.15	Construction of anchors for the raft	4.00	75.00	300.00
2	Supplies			
2.1	Boat rental	8.00	50.00	400.00
3	Facilitation			
3.1	Training on the importance of artificial reefs	3.00	50.00	150.00
3.2	Training to establish a regulation for fishing in the artificial reefs	4.00	50.00	200.00
3.3	D / H raft construction	12.00	10.00	120.00
3.4	Installation of D / H reefs	120.00	10.00	1,200.00
3.5	D / H buoy installation	4.00	10.00	40.00
3.6	Training on fishing logging (registry keeping) on artificial reefs	1.00	50.00	50.00
3.7	Construction of raft to transfer artificial reefs D / H	9.00	8.00	72.00
			TOTAL	10,650.90

Source: Own elaboration

1.4 Manufacturing of boats and training for independent fishermen

1.4.1 Backgrounds

Independent fishermen currently have very few opportunities to improve their situation and the methods they use to obtain the products they sell are rudimentary, because due to their economic situation they can not purchase their own fishing vessel and equipment.

These uses float and swim to obtain their products, mainly oysters and lobsters, which they take out manually with chisel or harpoon. They usually swim in an approximate area of up to 3km offshore. They are attracted to buoys like the one for CENÉRGICA to have a point to which to tie to. The activities they carry out are more dangerous. This group fishes in the proposed area for the pier, south of the craft (artisanal) pier, so its activity would be restricted due to the project.

1.4.2 Objetives

- Provide independent fishermen (oysters, tuberos who do not belong to any of the local cooperatives) with the necessary tools to carry out their activities in a more efficient and low risk way, through the contribution of a boat and equipment, and proper training.
- Provide another option for some of them to change their source of income, through training in other tasks.

1.4.3 Description

To the independent fishermen identified during the process of citizen participation carried out for the present EsIA (See also appendix on small-scale fisheries in Chapter 5), they will be given two options described below:

a) Ship delivery, safety training and fishing techniques:

A local company dedicated to the field of boat manufacturing will be hired to manufacture boats or canoes, in which process the beneficiaries will actively participate, as well as adequate training in the different fishing methods, as well as safety. They will also receive equipment and implements necessary to put all the fishing techniques learned into practice.

b) Training in an alternative line of work:

For fishermen who no longer want to continue to dedicate themselves to this industry, they will be offered the option of training in other jobs or trades, possibly related to activities during the construction and operation stages of the Project. Having the opportunity to apply to some of the jobs that could be opened for the Project or for other industries that require the same type of services. The following are examples of potential training that could be included or trades that fishermen could learn.

- ⇒ Surveillance Training
- ⇒ Gardening
- ⇒ Maintenance Activities
- ⇒ Masonry, carpentry, and others related to construction.
- ⇒ Literacy
- ⇒ Among others to define in the future, due to previous analysis

2.0 List of Fishermen

Next, we list the fishermen by groups in tables 2.2 to 2.7.

2.1 Cooperativa de Rederos de Acajutla (ACPPRA) (Cooperative of Net Fishermen of Acajutla)

Table 2.1 – Cooperativa de Rederos de Acajutla (ACPPRA) 2016			
No.	**First Name**	**Last Name**	**Age**
1	MIGUEL ANTONIO	MARTÍNEZ RAMÍREZ	39
2	MANUEL ANTONIO	NAVARRETE	41
3	VICTOR JOEL	ESPINOZA ÁVILA	34
4	GUILLERMO	GONZÁLEZ CORDERO	38
5	SAMUEL	LÓPEZ MEJÍA	38
6	EMMER CRUZ	GALLARDO	47
7	FIRMO ANTONIO	ÁVALOS RAUDA	47
8	JOSÉ MAURICIO	CANALES	36
9	RENÉ ERNESTO	CORDERO	35
10	JUAN FRANCISCO	BONILLA PÉREZ	39
11	JUAN PABLO	MANCÍA ARGUETA	27
12	JUAN MOISÉS	MEJÍA BERNARDINO	41
13	HENRY SALVADOR	OSORIO	33
14	WILBER ALBERTO	CANDELARIO ALVARADO	32
15	CARLOS NAPOLEÓN	JOVEL RODRÍGUEZ	25
16	ESWIN ALEXANDER	ARGUERA GALLARDO	29
17	ELMER RICARDO	JOVEL RODRÍGUEZ	32
18	JUAN ANTONIO	GONZÁLEZ ROSA	55
19	RUPERTO AURELIO	GARCÍA MELÉNDEZ	49
20	JOSÉ MARÍA	GONZÁLEZ CORDERO	32
21	ALFREDO	DUBÓN LÓPEZ	54
22	BYRON ALEXANDER	MEMBREÑO ASTRO	35
23	FRANCISCO	ÁLVAREZ	72
24	GUILLERMO EDWIN	RIVAS POLANCO	47
25	JESÚS ALFREDO	HERNÁNDEZ	48
26	JOSÉ ANTONIO	CORDERO	43
27	JOSÉ MARÍA	VARGAS PÉREZ	44
28	JOSÉ SANTOS	VANEGAS MENJÍVAR	65
29	JULIO NELSON	JOVEL FLORES	48

Table 2.1 – Cooperativa de Rederos de Acajutla (ACPPRA) 2016			
No.	First Name	Last Name	Age
30	MANUEL DE JESÚS	REYES	54
31	MIGUEL ÁNGEL	RODRÍGUEZ MENJÍVAR	65
32	SANTOS INOCENTE	FLORES	52
33	WILLIAM ALEXANDER	CASTELLANOS MUNGUÍA	32
34	YANIRA DEL CARMEN	SÁNCHEZ MORALES	29

Source: Own elaboration

2.2 Asociación Cooperativa de Producción Pesquera del Puerto de Acajutla (ACOOPPAC) (Cooperative Association of Fishing Production for Acajutla Harbor)

Table 2.2 – Asociación Cooperativa de Producción Pesquera del Puerto de Acajutla (ACOOPPAC) 2016			
N°	NAME	LAST NAME	AGE
1	PEDRO	AGUILAR	67
2	ANDRÉS	AGUILAR AGUILAR	62
3	MIGUEL ÁNGEL	ALVARENGA	67
4	MAGDIEL	ASCENCIO CONTRERAS	66
5	JOSÉ ROBERTO	AYALA	67
6	GONZALO	BERNAL CASTRO	56
7	JOSÉ ÁNGEL	CARBAJAL GONZÁLEZ	77
8	EUGENIO	CASTELLANOS	78
9	OSCAR ORLANDO	CORTEZ RIVERA	50
10	JORGE	CRUZ	69
11	MARIO NELSON	CUÉLLAR MARTÍNEZ	54
12	PABLO DE JESÚS	DERAS HUEZO	29
13	MANUEL NAPOLEÓN	DHEMING JUÁREZ	79
14	JOSÉ IGNACIO	FLORES	54
15	JUAN CARLOS	GARCÍA	48
16	KELVIN ALEXANDER	GARCÍA JOVEL	26
17	JESÚS	GARRIDO ZALDAÑA	84
18	VICENTE	GARRIDO ZALDAÑA	76
19	MARCOS HILARIO	GONZÁLEZ NAJARRO	66
20	JOSÉ DAVID	HERNÁNDEZ VELÁSQUEZ	58
21	MANUEL OSCAR	HERRERA	57
22	NICOLÁS ANTONIO	HERRERA GODOY	44
23	RICARDO NAPOLEÓN	JOVEL FLORES	54

Table 2.2 – Asociación Cooperativa de Producción Pesquera del Puerto de Acajutla (ACOOPPAC) 2016			
N°	NAME	LAST NAME	AGE
24	JULIÁN	LÉMUS	70
25	JOSÉ SALVADOR	LÓPEZ	50
26	JOSÉ ADÁN	LÓPEZ FUNES	55
27	MIGUEL ÁNGEL	MENJÍVAR MADRID	80
28	JUAN REINALDO	MERCADO HERNÁNDEZ	54
29	WILFREDO	MOLINA GONZÁLEZ	54
30	RICARDO	MERLOS	57
31	WILFREDO	MOLINA GONZÁLEZ	54
32	PEDRO ERNESTO	MORALES MORÁN	60
33	ANDRÉS	MORALES RAMOS	60
34	SALVADOR	OSORIO BONILLA	67
35	CARLOS ERNESTO	PINEDA	53
36	EDWIN ORLANDO	RAMÍREZ MOLINA	30
37	NICOLÁS	REINADO	73
38	JESÚS JORGE	REYNALDO ÁBREGO	72
39	ADRIÁN	RIVAS BARCO	56
40	CARLOS SANTOS	RODRÍGUEZ	54
41	LUIS ARNOLDO	RODRÍGUEZ	52
42	ISABEL	RODRÍGUEZ MORALES	41
43	MATILDE	TREJO	80
44	JORGE ALBERTO	VELÁSQUEZ	48
45	JOSÉ ANTONIO	VELÁSQUEZ ALVAYERO	61
46	ELIGIO ANDRÉS	TIJERINO	28
47	RICARDO ANTONIO	URÍAS TIJERINO	28
48	EDUARDO ENRIQUE	TIJERINO GUERRA	24
49	MAURICIO ALEXANDER	JOVEL RAMÍREZ	40
50	FRANKLIN ALBERTO	CORTEZ RAMÍREZ	25
51	JOSÉ UTIEL	ALFARO ELÍAS	49
52	JULIO	LEMUS	
53	FERNANDO GALINDO	LEMUS	
54	VANESSA	JOVEL	
55	SILVIA	ENRIQUEZ	
56	MAYRA GUADALUPE	GUILLÉN	
57	PATRICIA	RAMOS MORÁN	

Source: Own elaboration

2.3 List of Asociación Cooperativa de Producción Pesquera Tiburoneros de Alta Mar Responsabilidad Limitada

Table 2.3 – List of Asociación Cooperativa de Producción Pesquera Tiburoneros de Alta Mar de Responsabilidad Limitada, 2016						
#	**Name and Last Name**	**Place of Birth**	**Date of Birth**	**Age**	**Sex**	**Personal ID #**
1	Ricardo Obdulio Escalante Ruano	Acajutla, Sonsonate	04/07/1968	45	M	01359226-0
2	Ciro Rosembel Andrade	Sociedad, Morazán	24/07/1941	72	m	01589713-7
3	Juan Carlos González	Nahuilingo, Sonsonate	26/04/1973	41	m	00697447-7
4	Erick Osman Mazariego Alas	Acajutla, Sonsonate	01/10/1975	39	m	01821596-0
5	Rosa Humberto Hércules Cuellar	Acajutla, Sonsonate	30/08/1976	37	m	01556115-0
6	José lsrael Martínez	El porvenir, Santa Ana	22/07/1966	47	m	01654798-9
7	Felipe de Jesús Pérez	Sacacoyo, La libertad	25/03/1965	49	m	02580186-1
8	David Antonio Henríquez	Concepción Batres, Usulutan	23/08/1950	63	m	02604862-8
9	Isabel Cuellar Hércules	Acajutla, Sonsonate	05/11/1966	47	m	00664844-0
10	Alfonzo Cortez Huezo	Nejapa, San salvador	02/08/1965	48	m	01601363-9
11	Jorge Mario Contreras Renderos	Ciudad Arce, La Libertad	13/12/1955	58	m	01128600-9
12	José Albedo Ramírez	Sonsonate, Sonsonate	19/03/1951	63	m	00740100-3
13	José Santos Escobar	Colon, La libertad	01/01/1964	50	m	01083162-3
14	José Vidal Santiago Zetino	Acajutla, Sonsonate	15/05/1964	50	m	00912737-0
15	Vicente Antonio Guerra	Acajutla, Sonsonate	15/10/1977	36	m	02075025-1
16	Juan Francisco Pleitez Hércules	Acajutla, Sonsonate	24/05/1961	53	m	01218942-0
17	Juan Alberto Najarro Cárdenas	Acajutla, Sonsonate	27/12/1968	45	m	02943172-3
18	Rafael Antonio Sánchez Rivas	Acajutla, Sonsonate	23/01/1977	37	m	00898621-8
19	Oscar Ovidio Recinos	Armenia, Sonsonate	17/04/1966	48	m	00726653-4
20	Rafael Ãntonio Contreras Gálvez	Acajutla, Sonsonate	19/11/1966	47	m	00948949-7
21	Pedro Albedo Ortiz varez	Santa Ana, Santa Ana	27/04/1975	39	m	02837848-5

#	Name and Last Name	Place of Birth	Date of Birth	Age	Sex	Personal ID #
22	Karen Elizabeth Hernández Aquino	Acajutla, Sonsonate	27/02/1974	40	m	02796248-5
23	Rufino Cuellar Vázquez	Jujutla, Ahuachapán	03/12/1960	53	m	00054575-9
24	Ana Victoria Pleitez Benitez	Acajutla, Sonsonate	12/07/1985	28	F	03496576-1
25	Maryuri Griselda Medrano Arrué	Acajutla, Sonsonate	26/04/1989	25	F	04085827-3
26	Miguel ngel Villeda	Acajutla, Sonsonate	22/09/1962	51	m	00162556-0
27	Karla María Domínguez Codez	Acajutla, Sonsonate	11/01/1988	26	F	04010212-7
28	Juan Carlos Ortega Moran	Juayua, Sonsonate	04/03/1979	35	m	02961721-7
29	Fredy Ernesto Serrano Castaneda	Acajutla, Sonsonate	26/10/1982			

2.4 List of Asociación Cooperativa de Producción Agropecuaria y Pesquera Camaroneros de Acajutla Responsabilidad Limitada

Table 2.4 – List of Asociados de la Cooperativa de Producción Agropecuaria y Pesquera Camaroneros de Acajutla de R.L. 2016						
#	Name and Last Name	Place of Birth	Date of Birth	Age	Sex	Personal ID #
1	Pedro Alfonso Cardona Orellana	Nueva Concepción, Chalatenango	28/07/1943	72	M	03011321-1
2	Margarito Antonio Guardado	La Unión, La Unión	10/06/1946	69	M	0186357-6
3	Pedro Antonio Quijada Contreras	Nueva Concepción, Chalatenango	07/05/1947	68	M	00992793-3
4	Neftalí de Jesús Figueroa Palma	Acajutla, Sonsonate	10/06/1985	30	M	03298220-4
5	Israel Portillo	Zacatecoluca, La Paz	05/12/1951	63	M	02375230-9
6	Godofredo Núñez	Acajutla, Sonsonate	07/08/1967	48	M	02221539-6
7	José Bonillo Trigueros	Sonsonate, Sonsonate	26/08/1957	58	M	01702175-8
8	José Roberto Rivas Moreno	Zacatecoluca, La Paz	26/05/1963	52	M	00303522-4
9	Juan Ángel Miranda Acosta	Coatepeque, Santa Ana	01/04/1958	57	M	00744342-9
10	Fernando Transito Delgado	San Juan Opico, La Libertad	29/05/1936	79	M	01162985-9

Table 2.4 – List of Asociados de la Cooperativa de Producción Agropecuaria y Pesquera Camaroneros de Acajutla de R.L. 2016						
#	**Name and Last Name**	**Place of Birth**	**Date of Birth**	**Age**	**Sex**	**Personal ID #**
11	Genaro Ernesto Navarrete Pleitez	Acajutla, Sonsonate	10/07/1969	46	M	03392543-9
12	Marta Angélica Bonilla Salinas	Acajutla, Sonsonate	20/08/1989	26	F	04144851-8
13	Patricia Figueroa de Miranda	Acajutla, Sonsonate	01/08/1989	29	F	03808562-4
14	Patricia Elisabeth de Recinos	Acajutla, Sonsonate	22/12/1971	43	F	01065298-8
15	Mónica Beatriz Molina	Acajutla, Sonsonate	30/12/1980	34	F	03285334-2
16	Lorena Elisabeth	San Antonio del Monte, Sonsonate	09/08/1981	34	F	05609829-3

Source: Own elaboration

2.5 List of Oyster Catchers

Table 2.5 – List of Oyster Catchers for Project LNG to Power, Acajutla, 2016				
#	**Name**	**Personal ID #**	**# of Family Members**	**School Grade**
1	Juan Ramón Ortiz Rivera	03295698-6	6	7th GRADE
2	Jorge Alberto Vasquez	02985971-9	9	2nd GRADE
3	Pedro Antonio Estrada	03405125-3	4	3rd GRADE
4	Santos Victoriano Lue	01387580-4	9	HIGH SCHOOL GRADUATE/ 2nd YEAR OF ACCOUNTING
5	Oscar Armando García Pacheco	03777583-0	7	5th GRADE
6	Modesto Saravia			

Source: Own elaboration

2.6 List of Tuberos

Table 2.6 – List of Tube Catchers for Project LNG to Power, Acajutla, 2016				
#	**Name**	**Personal ID Number**	**# of Family Members**	**School Grade**
1	Mario Salvador Aguilar Rodríguez	0400978-9	7	3°
2	Julio Cesar Hernández	Menor de edad	9	5°
3	Miguel ängel López Rodríguez	03870450-7	6	5°
4	Kevin Javier Martinez Roman	Menor de edad	5	8°
5	Josue Alexander Recinos R.	04909831-7	5	4°
6	José Alexander Canales Román	04676057-5	4	7°
7	Julio Cesar Portillo Perez	01808967-8	6	4°
8	José Andrés Somoza Melara	04286196-3	5	7°
9	Miguel Ortiz Barahona	04493560-3	5	2°
10	Julio Cesar Echeverria Arevalo	00549931-9	4	5°
11	Santos Inocente Flores	03819178-8	3	0°
12	Juan Antonio trigueros H.	00725042-8	5	9°
13	Alexander Arriola Fuentes	01940801-1	4	4°
14	Fredis Erasmo Arriola Puentes	02190239-8	5	9°
15	Ernesto Pinto Ponce	Menor de edad	5	3°
16	Andrés Francisco Guardado	Menor de edad	5	9°
17	Herber Adonay Flores Hercules	04403059-2	4	5°
18	Josue Alberto Flores Hercules	04777158-3	4	9°

Table 2.6 – List of Tube Catchers for Project LNG to Power, Acajutla, 2016				
#	**Name**	**Personal ID Number**	**# of Family Members**	**School Grade**
19	Carlos david Flores Hercules	Menor de edad	3	8°
20	Jorge Elias Somosa Melara	04859747-3	5	7°
21	Juan Carlos Ortyega Morán	02961721-4	4	2°
22	José Antonio Pinto Pozo	04805180-9	5	9°
23	Josué Alexander Sibrian Guerra	05247922-1	3	4°
24	Juan Reynaldo Mercado Hernández	02114124-3	4	6°
25	Edín René Abarca Areválo	00311426-4	4	8°
26	Ronaldo Antonio Chávez Jímenez	02933574-9	2	3°
27	Carlos Alberto Ramirez	Menor de edad	8	6°
28	Ricardo Antonio Urias Tijerinos	03665074-4	3	1°
29	Erick Guadalupe Osorto	04472360-8	4	5°
30	Roberto Arturo Morales Sahavedra	04803819-4	4	7°
31	Adrian Antoio Rivas Aguilar	02791129-8	4	6°
32	Alfredo Dubón López	03295713-6	2	0°
33	Sandro Geovani Ardon Peraza	03929326-1	6	7°
34	Roberto Ardón Arias	01075506-3	5	8°
35	Julio Cesar García Hernández	00935356-5	4	3°
36	Carlos Antonio Campos Henriquez	02732911-6	5	3°
37	José Utici Alfaro Elias	02691830-2	4	7°
38	Reyes Canjura Menjívar	03276783-2	3	0°
39	Eduardo Luis Flores Hércules	05179850-9	1	7°
40	Victor Manuel Molina H.	05173043-8	6	0°
41	Juan José Henriquez Tijerino	Menor de edad		3°
42	Eugenio de Jesús Somoza M.	03746335-2	5	0°
43	Luis Alonso Alegría Pérez	04577619-1	2	8°
44	Luis Antonio Alegría	03216419-9	2	0°
45	Bayron Enrique Alegría	04740997-8	3	9°
46	Oscar Mauricio Mejía Guerra	03529186-3	3	9°
47	Santiago Flores Valle	05106810-8	3	9°
48	José Noe Rodríguez	05216961-4	7	High School Graduate
49	Miguel Ángel Mejía Cuéllar	05145347-0	8	High School Graduate
50	Julián Tovar			
51	Santos Jesús Alegría			

Source: Own elaboration

3.0. Environmental Considerations

Artificial reefs and FADs do not have basic regulations that cover the full spectrum of possible uses and purposes under which they can be conceived. It is part of the concept of areas for marine conditioning and fishing protection areas, which aim to promote the protection and regeneration of living marine resources.

Increasing biomass and biodiversity as a usable resource is one of the main objectives (production-concentration or fish aggregating devices) and will be used to enhance tourism and recreational activities such as diving, fishing, etc.

Both structures present the purpose of promoting recreational diving where they will provide the surrounding communities with new leisure spaces. It aims to improve areas where the practice of recreational diving is tradition, and even, it can be achieved to enhance this sport in places considered as not usual with regard to its practice.

Both structures are built or assembled on land:

For artificial reefs

1. Artificial reefs require the use of a platform to move the structures to the open sea, using a boat, which moves the floating platform, from the sailing sites (craft dock of Acajutla), which facilitates its transfer and installation.

2. At the moment of bringing the blocks to the anchoring site, it should be launched one by one by means of slings or loops and supported by SCUBA equipment for proper placement in the bottom, proper management of structures is required, since generally in this one step is when the blocks usually break or become damaged.

3. It is recommended to place them in groups of 5 forming units of 10 blocks maximum, ordering them in pyramidal form and distancing the groups 50 m from a central group of blocks.

4. Once placed, loops should be removed and structures should be marked with buoys and labels.

5. It is important to leave mooring sites for boats, that is to say, special places marked with buoys that allow the anchoring of boats to perform the fishing operations better.

For FADs

1. The FADs require the use of a boat of at least 30 feet in length, to move the structures armed or assembled on land, to placement, which facilitates their installation.
2. At the moment of carrying the armed structures (one by boat), to the anchoring site, the float must first be thrown, then with a minimum carrying speed, the silk lanyard is slowly launched with its branches spaced from PVC pipes and finally, the concrete grid is launched, so that it pulls and vertically places the structure.
3. It is recommended to place them apart at a distance of at least 20 meters, since the depth of the site is 15 meters.
4. Once placed, structures should be marked with buoys and labels.
5. It is important to leave mooring sites for boats, that is to say, special places marked with buoys that allow the anchoring of boats to perform better the fishing operations.

2.7 Special Recommendations

Both structures are far from:

- Incubation and hatching pens of sea turtle eggs.
- Beaches with high turtle nestings (more than 200 turtles per season).
- Locations identified as foraging areas for sea turtles.
- Adjacent or nearby human settlements, docks, restaurants and hostels.
- Over very soft seabeds and communities of marine phanerogams (seagrass).

2.8 Environmental effects

Water quality

Water contamination will be minimal as artificial reef mooring will be by flotation and scuba and FADs during the placement work and the volume of the concrete grid will produce a minimum resuspension of the sediments. These effects can be considered specific and reversible (it is assumed by natural means), manifesting directly on water quality and indirectly on biota, especially affecting organisms with little or no movement capacity (benthic flora and fauna).

Sound levels and vibrations

The affectation derived from the increase of sound levels and vibrations will only be manifested during the anchoring work of the structures, not detecting differential or cumulative effects.

Appendix 3D–
Fire Protection System

A2.10 FIRE PROTECTION SYSTEM

General

The specification below is for Wartsila standard fire protection based on NPFA. Local codes may require changes to this specification. Specific requirements, if any, of the Owner's insurance company will be considered. Deviations in local or insurance requirements may require an amendment to the scope of supply. Such changes will be subject to the appropriate provisions in the Agreement.

The stand pipe system inside the power house follows "NFPA14 class II stand pipe system" requirements. Additionally, mobile foam units are provided. For immediate action against small local fires, the power house is equipped with a number of 6 kg and 12 kg dry powder extinguishers at strategic locations, and 5 kg CO_2 extinguishers for electrical fires (spacing as per NFPA10).

The fire main is built using "NFPA24 Private fire service main" as a design guideline.

The tank area design — concerning e.g. the safety distances — is based on NFPA30, with cooling water streams for exposure protection.

The fire pump capacity is chosen according to specific protection requirements, and will be not less than 1890 l/min (approx 120 m^3/h), which is the minimum hose stream requirement by NFPA850.

Although the protection system philosophy is based on widely recognized NFPA standards, piping and equipment may still follow standards used by the fire protection equipment supplier.

Fire areas should be separated from each other by fire barriers, spatial separation, or other approved means.

The design philosophy described above aims for avoiding interruption of power generation due to false alarms and failures in automation system — and is based on the following assumptions:

- Competent personnel attend the Power Plant 24 hours a day.
- The personnel operating and maintaining the plant are trained in correct operation procedures on regular basis, and are trained in fire prevention and response
- The plant, including installed fire protection equipment, is well maintained and kept in good order. The equipment is periodically tested.
- Maintenance work, including welding and cutting, shall be done with appropriate precautions and instructions

Fire detection system

The fire alarm system typically includes the following main components (see **¡Error! No se encuentra el origen de la referencia.** below):

- **a fire alarm centre** including a supervision unit, a display unit, input and output terminal units, a power supply unit, and a message transfer unit
- fire detectors and manual call points connected to the fire alarm centre
- **alarm devices** (bells, sirens, flashing lights) connected to the fire alarm centre

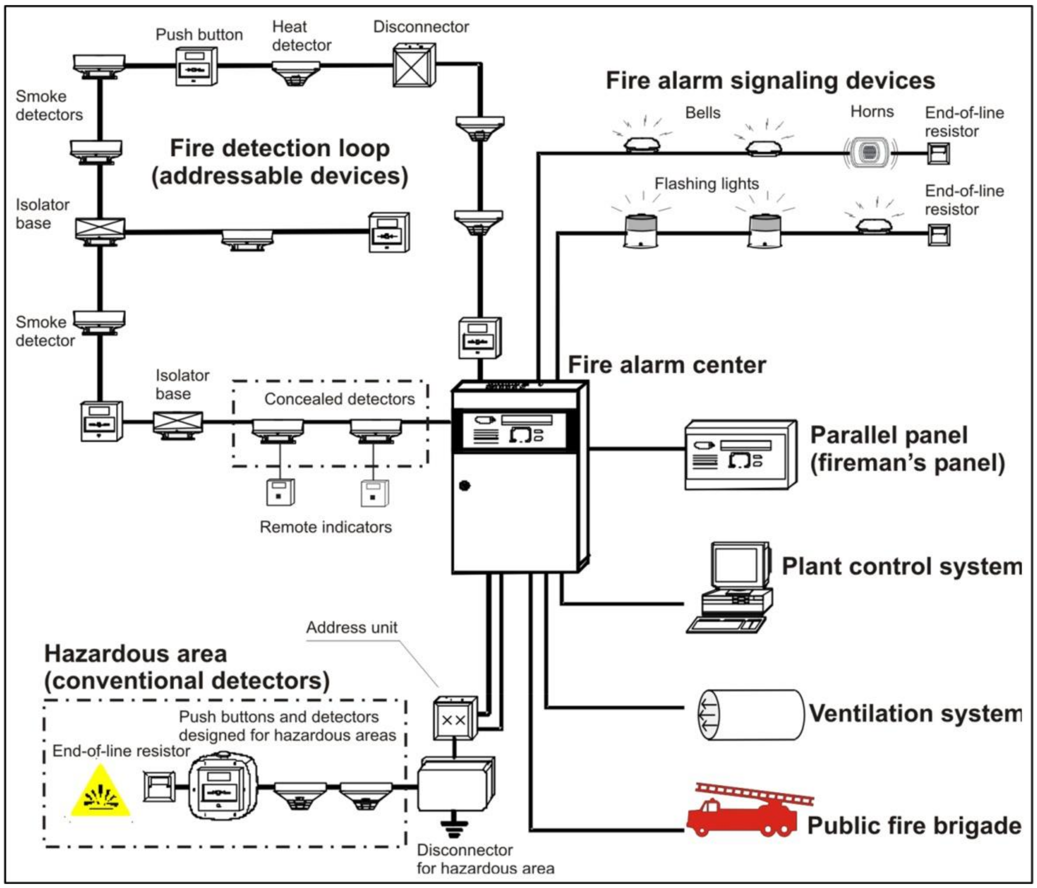


Figure 1 Typical setup of an addressable system

The fire alarm system is designed considering the following basic principles:

- The fire alarm centre shall be placed in a continuously manned room (the control room).
- The supervised rooms will be divided into alarm zones to ease locating the fire.
- Every room/zone is provided with an adequate amount and type of detectors.
- Alarm bells, sirens and flashing lights shall be situated so that they can easily be heard or seen.

Fire alarm zones

The purpose of fire alarm zones is to group the fire detectors in order to ease the fire location at an alarm.

At least the following areas will defined as separate fire alarm zones:

- Separate buildings
- Separate floors (except stairways which may encompass several floors)
- Rooms separated by fire walls
- Areas of different fire classes
- Rooms or areas of essentially different heights
- Rooms that cannot be accessed without passing through other zones

Type of detectors

The basic principle is to install the type and amount of fire detectors that detects fires without causing false alarms during normal operation conditions.

Optical smoke detectors are used in the engine room, auxiliary space, switchgear rooms, offices, stores and control rooms. In workshops and similar rooms, where smoke may appear as a result of normal use of the room, differential maximum heat detectors are used.

Manual call points

In a manual alarm device, the fire alarm is activated with a push button, protected with a cover that can be crushed.

Push buttons for manually activating fire alarms manually should be placed close to each exit route and close to the fire alarm panel or alarm centre. Each fire detection loop has at least one push button. There is at least one manual call point within 30 meters from any spot in the buildings.

Fire detection loops

The fire detectors and fire call buttons are located along one or more closed loops, starting and ending in the fire alarm centre. Each detection loop will be partitioned by a number of disconnecting devices. At a possible line break or short circuit on the loop, the faulty section is isolated at the two closest disconnecting devices — while the other detectors on the loop will stay in contact with the fire centre.

Alarm signaling system

The following types of alarm signaling devices are used:

- Alarm bells
- Flashing lights (mandatory in engine hall and auxiliary space)
- Alarm sirens (where feasible)

Principles for placing the alarm signal devices:

Engine hall	Visual alarm devices (flashing light) are placed so that they can be seen in all locations where people stay more than temporarily
Control room	One audible alarm device (alarm bell).
Other rooms	Audible alarm devices are placed so that they can be heard in all rooms where people stay more than temporarily.
Outdoors	One audible alarm device on each side of the power house is installed. Additional alarm devices shall be provided when there are other buildings or other obstructions which may limit the hearing of the alarm.

Fire alarm signaling loops

All alarm devices in the plant should be activated at a fire alarm. (Exception: alarms clearly meant only for separated area or building not having immediate impact on plant operation).

The fire alarm loops are arranged so that a fault message is obtained at cable break or short circuit.

Fire alarm centre power supply

There will be at least two independent power supplies:

- AC taken from the LV switchgear (or public grid)
- One or more batteries (generally 24 VDC) with battery charger.

Each of them must be able to feed the power required when the system is in alarm state and the current for 30 minutes in alarm state.

Connecting to other systems

Available potential free contacts are arranged to open at a fire alarm or fault (normally closed). The contacts can be used for transferring alarm and fault signals to the plant control system.

A2.10.1 FIRE PROTECTION, COMMON

1 Fire water system building (combined with water treatment building)

The fire water building contains a fire fighting pump main unit and its control system. The fire water pump main unit supplies water from the water tank for fire hydrants and hose reels. There are two centrifugal type fire pumps, one diesel engine driven and one electric motor driven. Each pump is capable of delivering the total quantity of water for firefighting purposes.

Minimum pressure at rated flow is 8 bar. The indicative volume flow rate demand is 300 m^3/h.

Included in the fire water system building:

1	Diesel engine driven pump unit
1	Electric motor driven pump unit
1	Jockey pump
1	Control system
1	Sprinklers (set)
1	Portable fire extinguisher
1	Piping (set)

1 Fire water tank

The total fire water tank volume is dimensioned for approximately 2 hours operation with full fire water pump capacity. 400m^3 capacity is allocated to raw water storage but the full volume can be used for fire fighting if needed.

Volume	1,000	m^3

In the combined raw water tank the raw water for plant service is taken from the top part of the tank in a manner that the fire water capacity cannot be affected by the raw water consumption.

1 Set tank equipment (valves, fittings, level indicators and alarms, inspection ports if applicable, ladders if applicable)

1 Lot Outdoor hydrants

The plant is equipped with exterior hydrants which are located on the site area outside the powerhouse. The outlet connections are typically 2 x 2.5".

1 Lot Outdoor hose cabinets

A hose cabinet is a painted steel cabinet with two folded hoses in a hose rack. The hose length is 20 m, diameter 2.5" and designed for 16 bar pressure. The hoses are equipped with quick couplings. An adjustable water fog nozzle is included in the hose cabinet.

1 Lot Portable fire extinguishers (dry powder type)

The capacity of each portable dry powder fire extinguisher is 12.0 kg. ABC type.

1 Piping and valves fire water system inside engine hall

This includes pipes, valves, flanges and gaskets for the fire water system up to the interconnection point.

1 Underground piping and valves fire water system outside engine hall

This includes pipes, valves, flanges and gaskets for the fire water system up to the interconnection point.

A2.10.2 FIRE PROTECTION, ENGINE HALL

1 Sprinkler system

The engine room is protected with a wet pipe sprinkler system utilising minimum 93°C temperature bulbs to prevent accidental release due to occasionally elevated temperature areas which may occur below the roof.

The sprinkler piping will be also placed below the exhaust and intake air ducts above the piping modules.

The required flow is based on NFPA 13, Area density method and NFPA37 recommendation for the application rate and area:

A design basis using "Extra hazard group 1" with a density (0.3 gpm/ft^2) 12.2 l/min/m^2 for area 232 m^2 (2500 ft^2) shall be used. Hose allowance of 1900 lit/min (NFPA 850).

Maximum Flow = 2830 l/min + 1900 l/min fire hose demand = 5000 l/min = 300 m^3/h.

1 Lot Hydrant valve pairs

The engine hall is equipped with fire pipe network called a standpipe system. From this network there will be outlets for pairs of 1½" hydrant valves with couplings for the fire hoses in vicinity of the hose cabinets inside the engine hall.

1 Lot Standpipe hose cabinets

A hose cabinet is a painted steel cabinet with folded hose in a hose rack. The hose length is 20 m, diameter 1½" and designed for 16 bar pressure. The hose is equipped with quick coupling and an adjustable water combination fog/spray nozzle.

1 Lot Portable fire extinguishers (dry powder type)

The capacity of each portable dry powder fire extinguisher is 12.0 kg. ABC type.

6 Mobile foam units

Each mobile foam unit consists of a low expansion foam branch pipe, inductor, foam concentrate tank and two fire hoses with couplings suitable to be connected to the fire hydrants. Foam can be used to suppress an oil based fire. The foam unit has wheels and can be moved to the location of a fire. Capacity 200 l/min water flow, 100 l foam concentrate tank.

A2.10.4 FIRE PROTECTION, MV/CONTROL BUILDING

1 Lot Portable fire extinguishers (CO2 type)

The plant is equipped with portable carbon dioxide type fire extinguishers which are located in electrical spaces and control room. The capacity of each extinguisher is 5.0 kg.

1 Lot Portable fire extinguishers (CO2 type)

The plant is equipped with portable carbon dioxide type fire extinguishers which are located in electrical spaces and control room. The capacity of each extinguisher is 20.0 kg.

1 Lot Portable fire extinguishers (dry powder type)

The capacity of each portable dry powder fire extinguisher is 12.0 kg. ABC type.

A2.10.4 FIRE PROTECTION, MV BUILDING

1 Lot Portable fire extinguishers (CO2 type)

The plant is equipped with portable carbon dioxide type fire extinguishers which are located in electrical spaces and control room. The capacity of each extinguisher is 5.0 kg.

1 Lot Portable fire extinguishers (CO2 type)

The plant is equipped with portable carbon dioxide type fire extinguishers which are located in electrical spaces and control room. The capacity of each extinguisher is 20.0 kg.

1 Lot Portable fire extinguishers (dry powder type)

The capacity of each portable dry powder fire extinguisher is 12.0 kg. ABC type.

A2.10.8 FIRE PROTECTION, FIRE FIGHTING PUMP HOUSE / WATER TREATMENT BUILDING

1 Wet pipe sprinkler system serving only the fire pump house side

The sprinkler system is equipped as follows:

1	Alarm valve with flow alarm connected to the fire detection/alarm system
1	Fire department connection with locally accepted couplings to facilitate the system feed alternatively from the fire truck
1	Sign plate for fire department connection
1	Closing valve with position indication for system maintenance purposes (normally locked open)
1	Set of sprinkler nozzles
1	Set of galvanized steel piping

1 Lot Portable fire extinguishers (dry powder type)

The capacity of each portable dry powder fire extinguisher is 6.0 kg. ABC type.

A2.10.13 FIRE PROTECTION, GUARD HOUSE

1 Lot Portable fire extinguishers (dry powder type)

The capacity of each portable dry powder fire extinguisher is 6.0 kg. ABC type.

A2.10.16 FIRE PROTECTION, WORKSHOP AND WAREHOUSE

1 Lot Portable fire extinguishers (CO2 type)

The plant is equipped with portable carbon dioxide type fire extinguishers which are located in electrical spaces and control room. The capacity of each extinguisher is 5.0 kg.

1 Lot Portable fire extinguishers (dry powder type)

The capacity of each portable dry powder fire extinguisher is 6.0 kg. ABC type.

1 Lot Portable fire extinguishers (dry powder type)

The capacity of each portable dry powder fire extinguisher is 12.0 kg. ABC type.

2 Hose reels

The hoses are equipped with adjustable water fog nozzles. The hose length is 25 m and diameter 19 mm.

A2.10.17 FIRE PROTECTION, ADMINISTRATION / SOCIAL BUILDING

1 Lot Portable fire extinguishers (dry powder type)

The capacity of each portable dry powder fire extinguisher is 6.0 kg. ABC type.

2 Hose reels

The hoses are equipped with adjustable water fog nozzles. The hose length is 25 m and diameter 19 mm.

1 Fire blanket

A2.10.22 1 FIRE PROTECTION, STEP UP TRANSFORMERS

1 Deluge sprinkler system for step-up transformers.

The step up transformers are equipped with a deluge type fire fighting system using water provided by the main fire pump. The step up transformers will be separated by fire walls

Appendix 3E–

Waste Collection Letter

ASUNTO: AUTORIZACION Y APROBACION DE DETALLE DE LUGARES A REFORESTAR DE MANERA PARCIAL Y TOTAL DENTRO DEL MUNICIPIO DE ACAJUTLA.

ACTA NÚMERO UNO. **FECHA:05-ENERO-2015.**

ACUERDO NUMERO VEINTINUEVE: el Concejo Municipal de la Ciudad de Acajutla, en uso de las facultades legales que le confiere el artículo 203 y 204 de la Constitución de la República de El Salvador y artículos 30 numeral 4, y 34 del Código Municipal, **CONSIDERANDO**: **I.-)** Que visto escrito presentado por el Encargado de la Unidad Ambiental Municipal en el cual presenta detalle de lugares a Reforestar Parcialmente y total dentro del Municipio de Acajutla, a la Empresa **ENERGIA DEL PACIFICO, S.A. DE C.V.,** por lo que después de analizada la situación expuesta, por todos los miembros del Concejo Municipal, **POR MAYORIA ACORDAMOS: I. AUTORIZAR Y APROBAR:** Que la Empresa **ENERGIA DEL PACIFICO, S.A. DE C.V.,** en coordinación con el Encargado de la Unidad Ambiental Municipal, realicen Reforestar Parcialmente y total dentro del Municipio de Acajutla, los siguientes lugares: **a.- Cantón El Suncita, Caserío La Brecha: 100% a reforestar de mangle**, área total a verificar en plano, dicha zona ha sido deforestada de manera intencional por los lugareños, irrespetando los mojones que definen el área del manglar. **b.- Cantón El Suncita, Las Tres RRR: 100% a reforestar de mangle**, área total a verificar en plano dicha zona ha sido deforestada de manera intencional por los lugareños, irrespetando los mojones que definen el área del manglar. **c.- Cantón Punta Remedios Los Cobanos**, Zona Verde a medir, 100% a reforestar con árboles frutales. **d.- Cantón El Coyol, Lot. El Milagro, Centro Escolar El Milagro**, área a reforestar 40% del área total, con árboles de sombra y ornamentales. **e.-** Cantón El Coyol, Lot. **El Milagro, Cancha El Milagro**, área total a reforestar, con árboles de sombra. **f.- Cantón Metalio, Caserío Monzón**, área a reforestar 40% de 8 Manzanas dicha zona ha sido deforestada de manera intencional por

los lugareños, irrespetando los mojones que definen el área del manglar. **g.- Cantón Metalio, Puente de Bocana San Juan**, área a reforestar 30% de 10 Manzanas dicha zona ha sido deforestada de manera intencional por los lugareños, irrespetando los mojones que definen el área del manglar. **h.- Cantón Metalio, Playa Costa Azul, poniente de antena Claro**, área a reforestar 100% de 8 Manzanas, dicha zona ha sido deforestada de manera intencional por los lugareños, irrespetando los mojones que definen el área del manglar. **i.- Barrio La Playa, Acajutla a Reforestar 40% de 6 Manzanas**, dicha zona ha sido deforestada de manera intencional por los lugareños, irrespetando los mojones que definen el área del manglar. **II.-** Que José Arturo Flores, Decimo Regidor Propietario, Vilma Estela Alvarenga de Alemán, Tercer Regidora Propietaria, Iris Ivette Carolina Godoy de Ramírez, Sexto Regidora Propietaria y Julio Cesar Cabrera Guardado, Cuarto Regidor Propietario, se abstienen de votar; haciendo uso del derecho que le asiste, según el artículo 45 del Código Municipal, salvan su voto por no estar de acuerdo en la decisión tomada. CERTIFIQUESE Y COMUNIQUESE para los demás efectos administrativos y legales consiguientes. Y no habiendo más que hacer constar se cierra la presente que firmamos.///////D.G.A./////W.A.P.Calderón//
/J.E.J.L/E.D.I.HPB//varengadeAleman/JCC/DGMA//IICGR/JAOrtega//E.A.
G.B/B.N.M.C.//J.Arturo//MTCastaneda//A.O//VHSorianoM//BE.Contreras/
/Sria.//
""RUBRICADAS""

DADO EN EL SALON DE SESIONES DE LA ALCALDIA MUNICIPAL DE ACAJUTLA, A LOS CINCO DÍAS DEL MES DE ENERO AÑO DOS MIL QUINCE.

ES CONFORME CON SU ORIGINAL CON EL CUAL SE CONFRONTO.----------

DARIO ERNESTO GUADRON AGREDA,
ALCALDE MUNICIPAL.

BLANCA ESTELA CONTRERAS,
SECRETARIA MUNICIPAL.

Appendix 4A–
Quantitative Risk Analysis

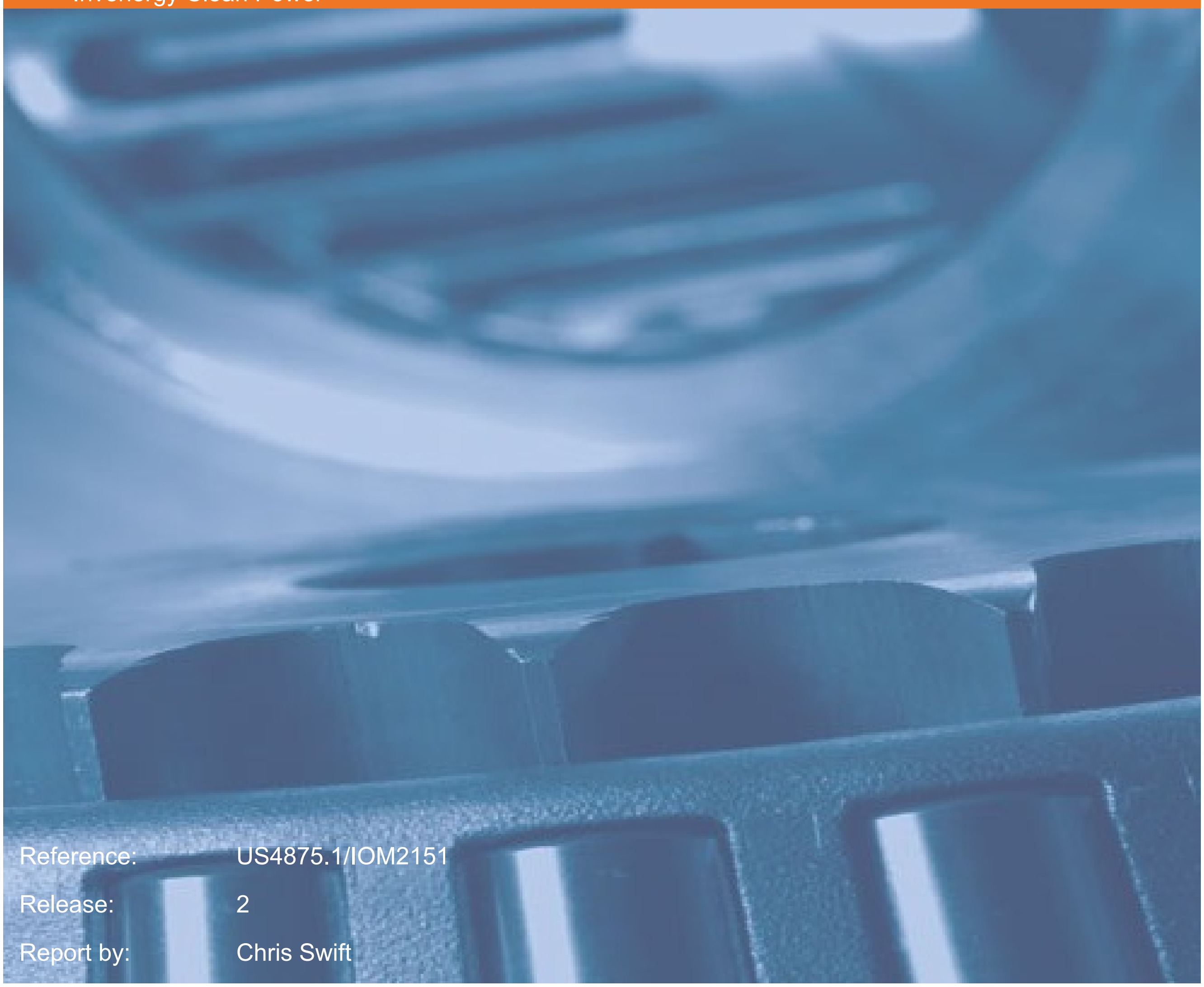
Lloyd's Register Energy

Working together
for a safer world

EDP LNG Power to Shore Project, Acajutla, El Salvador

Quantitative Risk Analysis (80 Barg Operation)

Report for
Invenergy Clean Power



Reference: US4875.1/IOM2151

Release: 2

Report by: Chris Swift

Summary

EDP LNG Power to Shore Project, Acajutla, El Salvador		
Quantitative Risk Analysis (80 Barg Operation)		
Date of Issue	01 February 2018	
Administrative Review	N/A	
Report by Chris Swift Principal Consultant	**Reviewed by** Danielle Chrun Senior Consultant	**Approved by** Robert Hall Technical Operations Manager – Americas
Our Contact Danielle Chrun +1 281 649 2795 danielle.chrun@lr.org	Lloyd's Register Drilling Integrity Services, Inc. 1330 Enclave Parkway, Suite 200 Houston, Texas 77077 United States of America	
Client Contact Horacio Larios / Rupal Soni +1 414 779 1213 hlarios@invenergyllc.com / rsoni@invenergyllc.com	Invenergy Clean Power 1 South Wacker Drive, #1800 Chicago, IL 60606 United States of America	

Document History

Release	Date	Description	Contributors
1	23 January 2018	Initial release	**Report by:** Chris Swift **Reviewed by:** Danielle Chrun **Approved by:** Robert Hall
2	01 February 2018	Updated following client review	**Report by:** Chris Swift **Reviewed by:** Danielle Chrun **Approved by:** Robert Hall

Table of Contents

Abbreviations

ALARP	as low as reasonably practicable
BOG	boil-off gas
CAMS	Central American Marine Services
CEPA	Comisión Ejecutiva Portuaria Autónoma
EDP	Energía del Pacífico
EIA	environmental impact assessment
ESD	emergency shutdown
FEED	front-end engineering design
FERC	Federal Energy Regulatory Commission
FRSU	floating regasification storage unit
HAZID	hazard identification
HDD	horizontal directional drilling
IR	individual risk
LFL	low flammable limit
LR	Lloyd’s Register
LNG	liquefied natural gas
LNGC	liquefied natural gas carrier
LSIR	location-specific individual risk
MARN	Ministerio de Medio Ambiente y Recursos Naturales (Ministry of Environment and Natural Resources)
MMSCFD	million standard cubic feet per day
NG	natural gas
NFPA	National Fire Protection Association
OGP	Oil and Gas Producers
P&ID	piping and instrumentation
PLEM	pipeline end manifold
QRA	quantitative risk analysis
RCM	Restricted Catenary Mooring
RPT	rapid phase transition
STS	ship-to-ship
UFL	upper flammability limit

1 Executive Summary

Scope of Work

Lloyd's Register (LR) has been engaged by Invenergy Clean Power (Invenergy) to carry out a quantitative risk assessment (QRA) for the Energía del Pacífico (EDP) liquefied natural gas (LNG) import terminal in Acajutla, El Salvador, for the front-end engineering design (FEED) phase. The EDP LNG import terminal will receive LNG from an LNG carrier (LNGC). The LNGC will offload LNG to a floating storage regasification unit (FSRU). A production rate of 280 million standard cubic feet per day (MMSCFD) of natural gas (NG) (base case) will be sent by pipeline to a power plant and power to end consumers in El Salvador. The scope of the QRA includes the LNG import terminal up to the inlet to the power plant. Marine transportation risk is not included in the scope of work.

Objectives

The regulatory regime in El Salvador is focused on preventing the occurrence of accidents and/or malfunctions from new industrial developments and their respective activities. The main objective of the QRA performed in FEED is two-fold: 1) examine the potential risks to the environment and the public as a result of major and worst-case, credible events from the LNG import terminal and associated infrastructure; and 2) support the Environmental Impact Assessment (EIA) and subsequent application process to fulfill the requirements applicable to the project as part of the requirements from Ministerio de Medio Ambiente y Recursos Naturales (MARN - Ministry of Environment and Natural Resources).

Methodology

The risk posed by the project is evaluated in the FEED based on an identification of 18 major and worst-case, credible scenarios as identified in the HAZID sessions that were conducted prior to the QRA. For each scenario, the following is analyzed:

- Scenario description
- Frequency analysis
- Consequence assessment
- Risk assessment as a combination of frequency and consequence
- Risk evaluation against the risk criteria and recommendations to reduce risk

The risk acceptance criteria used in the QRA are shown in Table 1.1.

Table 1.1: **QRA Risk Acceptance Criteria for Members of the Public [1]**

Risk Region	Description	Average Public Individual Risk (IR) Criteria (per annum)
Intolerable risk	Authority requirements, corporate requirements, international standards, and recommended practices together define an upper level of risk above which risk is considered to be unacceptable. Intolerable risk cannot be justified except in extraordinary circumstances.	≥ 1E-04

Risk Region	Description	Average Public Individual Risk (IR) Criteria (per annum)
Tolerable risk, provided risk is ALARP	Recognized, industry-wide accepted approaches demonstrate that an appropriate level of scrutiny and mitigation has been applied to risks from identified hazards, and that the residual risk to the public and the environment is as low as reasonably practicable (ALARP).	1E-06 < IR < 1E-04
Broadly acceptable risk	These risks are generally regarded as insignificant and adequately controlled.	≤ 1E-06

The location-specific individual iso-risk (LSIR) curves are often used early in the project planning phases and are deemed conservative to estimate the risk to the public. The LSIR measures the risk to the nearby areas (industrial or public areas) and is used in this QRA to measure the risk from the project to the public and indirectly to the environment. The LSIR is calculated for two locations: FSRU bridge and the center of the power plant.

Results

The individual risk (IR) results per location are provided in Table 1.2 for the FSRU bridge and the center of the power plant.

Table 1.2: IR Results

Process Release Location	IR per Year	Risk to Public
FSRU bridge	1.7E-04	Not applicable to the public
Center of power plant	7.37E-7	Broadly acceptable

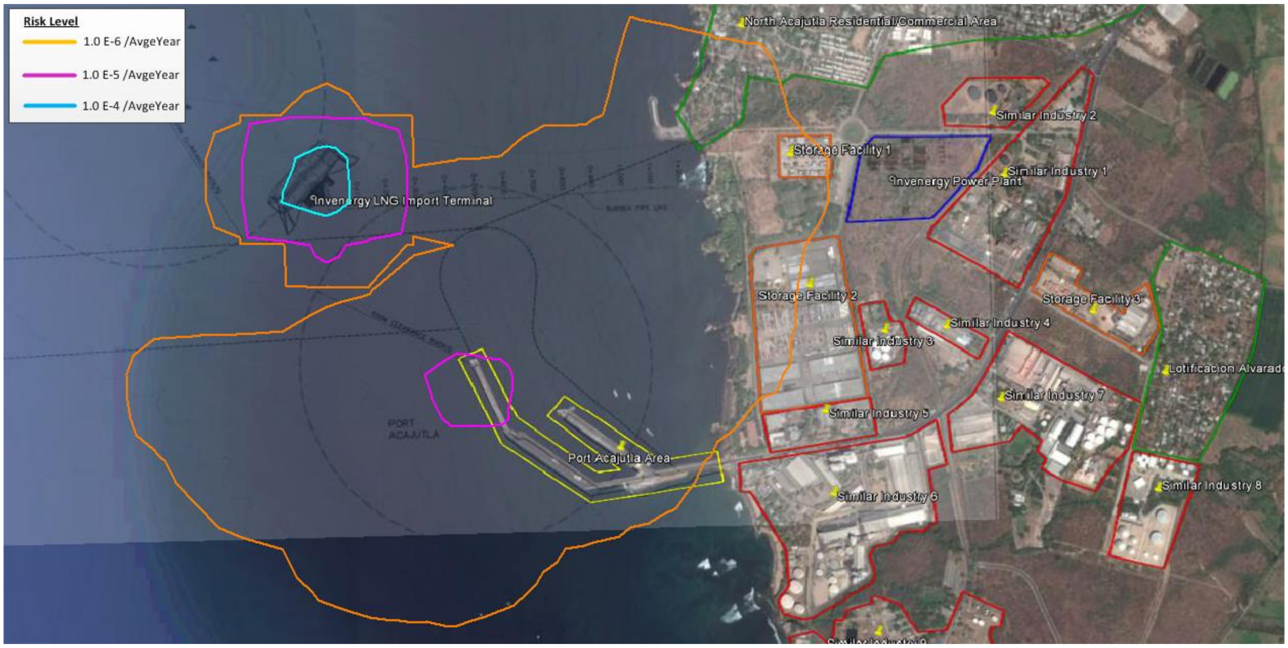


Figure 1.1: LSIR iso-risk contours for LNG import terminal and onshore location.

Risk Levels to Members of the Public

The results show that risks to members of the public are in the tolerable risk region (within the 10E-7 orange contour) in the southern edge of Acajutla, some industrial areas and part of Acajutla port. This represents an area where the residual risk to the public is as low as reasonably practicable. Beyond this area, the risks to the public are broadly acceptable, generally regarded as insignificant, and adequately controlled.

Risk Levels at the Onshore Power Plant

Risk to the public is in the broadly acceptable region, generally regarded as insignificant, and adequately controlled.

Risk Levels at the LNG Import Terminal

The QRA identifies an area of risk of 10E-4 per year (blue contour) around the FSRU/LNGC. However, this is an area where members of the public will not be present.

Risk Levels along the Shipping Lane

Risk levels along the shipping lane, as it is currently defined, are partially in the tolerable risk area (>10E-6 per year) and partially in the broadly acceptable risk area (<10E-6 per year).

Sensitivity Assessment Results

Sensitivity analyses have been performed to understand possible risk reduction with the installation of a remotely activated ESD valve on the PLEM. The analysis of this option shows that the installation of the valve has no effect on the overall level of risk.

Recommendations

Based on the analysis, the following general recommendations are suggested:

- It is recommended, if possible, to analyze the design of process equipment shelters and buildings within the LNG import terminal and power plant limit to minimize confined spaces and to reduce explosion events. No explosion scenarios were analyzed for the design at the FEED stage. Explosion events will be further studied in detailed engineering.
- The LSIR is one input to define the extent of the marine exclusion zone. However, other considerations can justify a larger marine exclusion zone, e.g ship collision that do not result in LNG release and security risks.
- Overfill of an LNG tank on the FSRU during transfer from the LNGC has been shown to contribute the most to the overall offshore risk and produces an area of risk around the FSRU/LNGC (≥10E-4). While this level of risk is not relevant for members of the public, risk reduction options should be considered for this scenario, which should include a detailed review of the FSRU overfill scenario. In addition to the possible formation of fires/explosions, the release of large quantities of LNG at an elevated level on the vessel from an overfill could lead to extensive structural failure due to low temperature embrittlement.
- The installation of an ESD valve on the PLEM shows no risk reduction benefits and does not appear to be required on this basis. However it is recognized that an ESD valve could be used to isolate the pipeline rapidly if required due to operational issues or external threats and should not be omitted purely from a risk point of view.

2 Introduction

2.1 Background

LR has been engaged by Invenergy to carry out a QRA for the EDP LNG import terminal in Acajutla, El Salvador, for the FEED phase. The EDP LNG import terminal will receive LNG from an LNGC. The LNGC will offload LNG to an FSRU and re-gasified. The NG will be sent by pipeline to an onshore power plant, creating power to end consumers in El Salvador. The project is expected to begin in 2020.

The regulatory regime in El Salvador is focused on preventing the occurrence of hazards and accidents by supporting the application of good international practices for new industrial developments and their respective activities.

2.2 Objective

The main objective of the FEED QRA is to examine the potential risks to operating personnel, the environment and the public as a result of major and worst-case, credible events from the LNG import terminal and associated infrastructure.

The QRA is also to act as supporting information for the Environmental Impact Assessment and subsequent application process to fulfill the requirements applicable to the project as part of the MARN [2] requirements.

2.3 Scope

The scope of the QRA includes the LNG import terminal and associated project infrastructure up until the onshore power plant with natural gas production rate of 280 MMSCFD (base case). Marine transportation risk is not included in the scope of work.

2.4 Conditions and Limitations

It should be recognized that this is a FEED QRA addressing the global safety issues and that it focuses on the major and worst-case, credible scenarios to identify the maximum effect of the hazards in terms of hazard distances that may affect population and/or the environment.

The QRA performed in the FEED phase is based on preliminary information provided by the engineering partners, and conservative assumptions are taken to compensate for the lack of engineering details reached at this stage. The QRA is aiming at providing feasibility data and mitigation measures at an early stage. Engineering parameters are to be further updated at a later stage, along the development of the project.

2.5 Assumptions

QRA assumptions are provided in Appendix A and have been validated by EDP and partners.

3 System Description – Base Case

The EDP LNG import terminal will be located in the area of the port of Acajutla, El Salvador (see Figure 3.1). It will supply NG to an adjacent 380 MW power plant and to other energy consumers in El Salvador.

Figure 3.1: Site location.

The following operations will be performed (see Figure 3.2):

- An FSRU of capacity 138,000 - 174,000 m^3 will be permanently moored approximately 1,250 to the West of shore, near Acajutla.
- An LNGC of capacity 165,000 m^3 will offload LNG to an FSRU approximately 32 times per year.
- LNG will be regassified in the FSRU to produce high-pressure (HP) NG at 80 bara and a production rate of 280 MMSCFD.
- The NG will be transferred from the FSRU to the onshore plant via a 12"-diameter riser and a 24"-diameter subsea/onshore pipeline at 80 bara.
- The pressure of NG will be reduced to 11 bara where the pipeline reaches the power plant.

Figure 3.2: LNG import terminal.

The process flow diagram for the FSRU process is shown in Figure 3.3. Details of the FSRU/LNGC and pipeline are also shown in Figure 3.4.

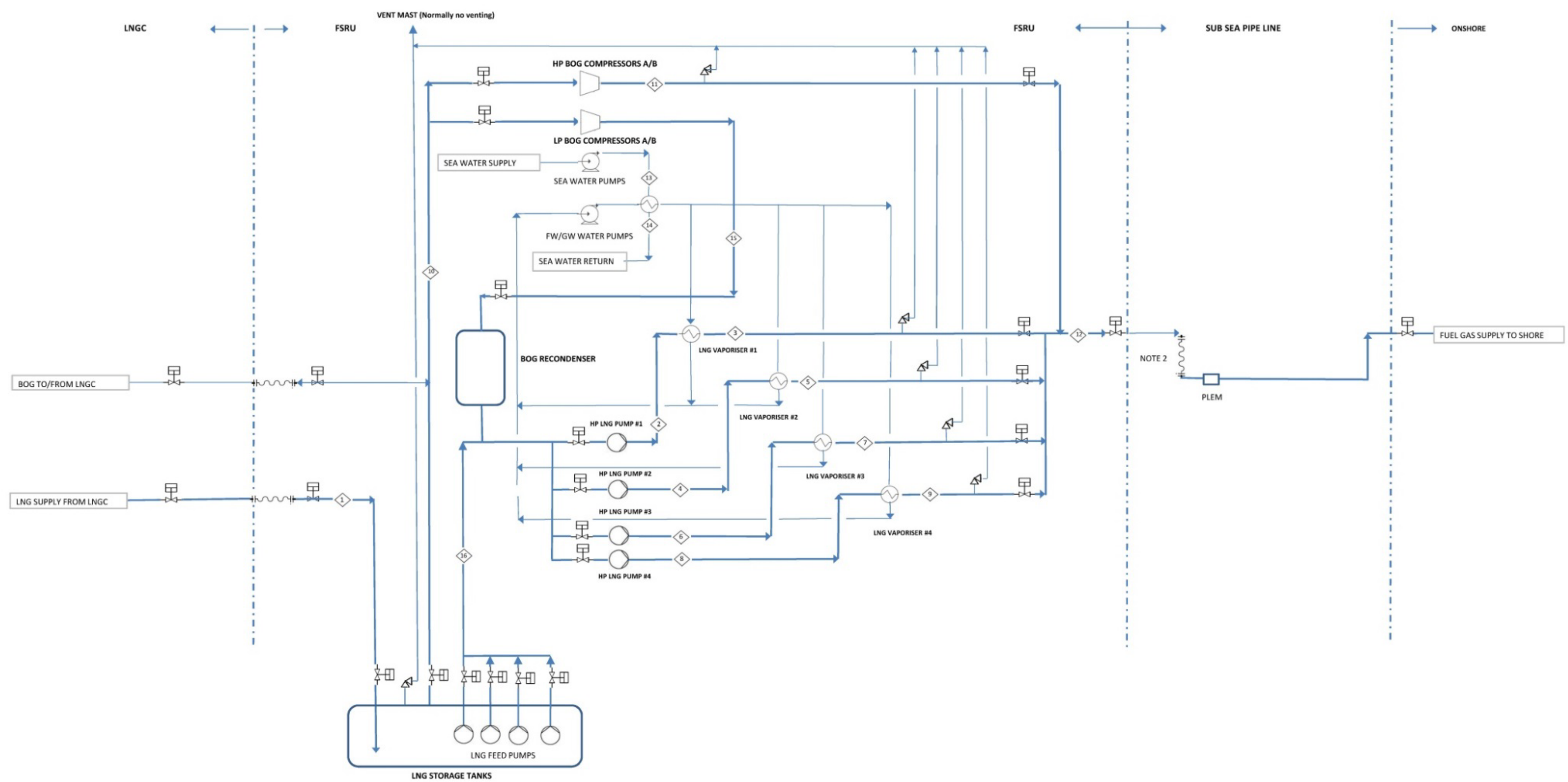


Figure 3.3: LNG Import process flow diagram.

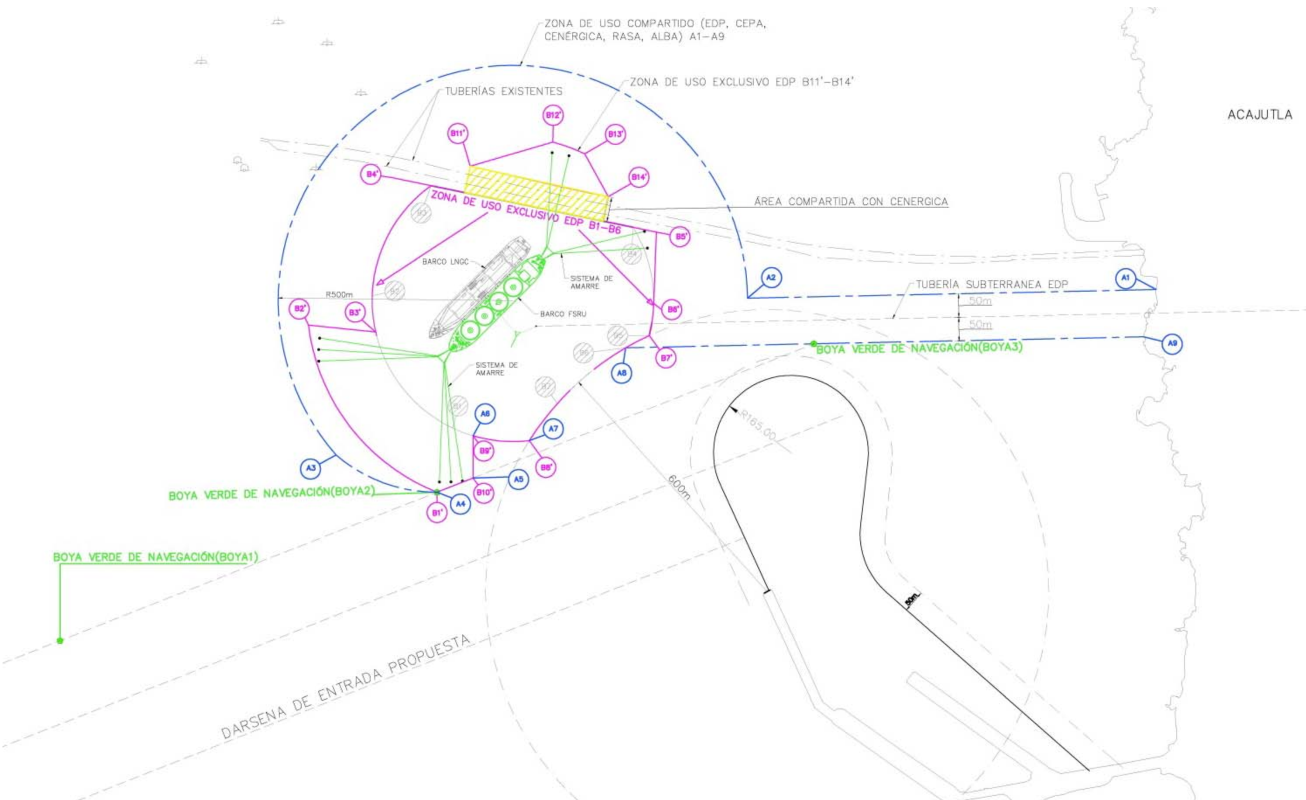


Figure 3.4: LNG terminal area layout applicable to this report.

3.1 LNGC

The LNG transfer between the LNGC and FSRU will be performed via STS transfer and will rely on six hoses for LNG and two hoses for vapor. The total transfer rate will be approximately 6,000 m^3/hr. A total of 32 LNGC offloading operations have been conservatively estimated per year and approved by EDP and partners.

3.2 FSRU

The FSRU will be used for LNG storage and perform the regasification of LNG into NG. The FSRU will be floating and safely moored using Restricted Catenary Mooring (RCM). The RCM can withstand all identified environmental loads. There will be a single flexible riser from the FSRU to the subsea PLEM. The FSRU process comprises four parallel LNG vaporizer trains, each with a high pressure (HP) LNG pump and a vaporizer. There are two low pressure (LP) boil-off-gas (BOG) compressors that return BOG to the LNG system via a BOG recondenser. Two HP BOG compressors are installed and will operate if the required gas supply to shore is low. The NG send-out rate to the onshore power plant is estimated to be 280 MMSCFD at 80 bara.

3.3 PLEM and Subsea Pipeline

NG will be continuously sent out from the FSRU via a riser and a 24″ pipeline. The pipeline will run subsea from the LNG import terminal to onshore, as shown in Figure 3.2, with installation using Horizontal Directional Drilling (HDD) or trenching with backfill and additional protection where required. A total length of 1,910 meters is used for the pipeline/PLEM and includes:

- 10 m of PLEM piping;
- 1,400 meters from the riser platform to onshore; and,
- 500 meters of buried onshore pipeline.

3.4 Onshore Pressure Reduction

The NG pressure will be reduced at the power plant from 80 bara to 11 bara. Piping lengths used for the pressure reducing system are:

- 15 m high pressure piping; and,
- 30 m low pressure piping.

The location of the pressure reducing system is assumed to be at the boundary of the power plant as shown in Figure 3.2. It is assumed that the pressure reduction system is fitted with an ESD valve.

4 Methodology

The QRA performed in FEED follows good industry practice for risk analysis and the QRA methodology is illustrated in Figure 4.1.

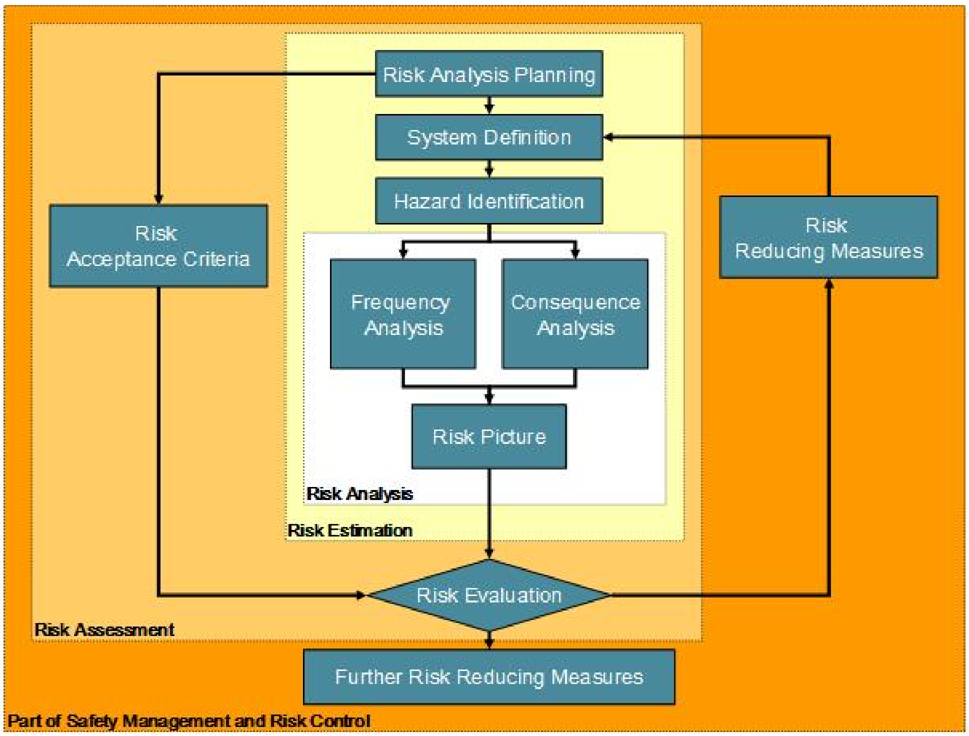


Figure 4.1: Risk analysis methodology.

This QRA was performed based on preliminary information provided by the engineering partners, and conservative assumptions were taken to compensate the lack of engineering details reached at this stage. Assumptions for the QRA are provided in Appendix A. The FEED QRA is based on the major and worst-case, credible scenarios as identified in the HAZID sessions [14], [15], [3].

<u>For each scenario the following is described:</u>

- Scenario description;
- Frequency analysis;
- Consequence assessment;
- Risk assessment to the public/other industry area if applicable; and,
- Risk evaluation and risk recommendations to reduce risk if applicable.

<u>The QRA performed in FEED is based on the following recognized regulations and standards as guidelines:</u>

- NFPA 59A, Standard for the Production, Storage, and Handling of LNG by the National Fire Protection Association [4];
- The US Energy Regulatory Commission (FERC), US risk based proposed guideline [1];

- EN 1473: Installation and Equipment for Liquefied Natural Gas – Design of Onshore Installations [5];
- UK HSE, UK risk based regulatory framework for HSE in Oil and Gas industry [6];
- NORSOK Z-013, Norway risk based regulatory framework for HSE in Oil and Gas industry [7]; and,
- OGP, Risk Assessment Data, Report No. 434 [8].

4.1 Risk Acceptance Criteria

The risk acceptance criteria for individual risk (IR) used in the QRA is shown in Table 4.1 and graphically represented in Figure 4.2. The risk is split into three categories:

- **Intolerable risk:** Authority requirements, corporate requirements, international standards, and recommended practices together define an upper level of risk above which the risk is considered to be unacceptable. Intolerable risk cannot be justified except in extraordinary circumstances.
- **Tolerable risk:** Recognized, industry-wide accepted approaches demonstrate that an appropriate level of scrutiny and mitigation has been applied to risks from identified hazards, and that the residual risk to the public and the environment is as low as reasonably practicable (ALARP).
- **Broadly acceptable risk:** These risks are generally regarded as insignificant and adequately controlled.

Table 4.1: Risk Acceptance Criteria

Description	Average Public IR Criteria (per annum)
Intolerable risk	≥ 1E-04
Tolerable risk, provided risk is ALARP	1E-06 < IR < 1E-04
Broadly acceptable risk	≤ 1E-06

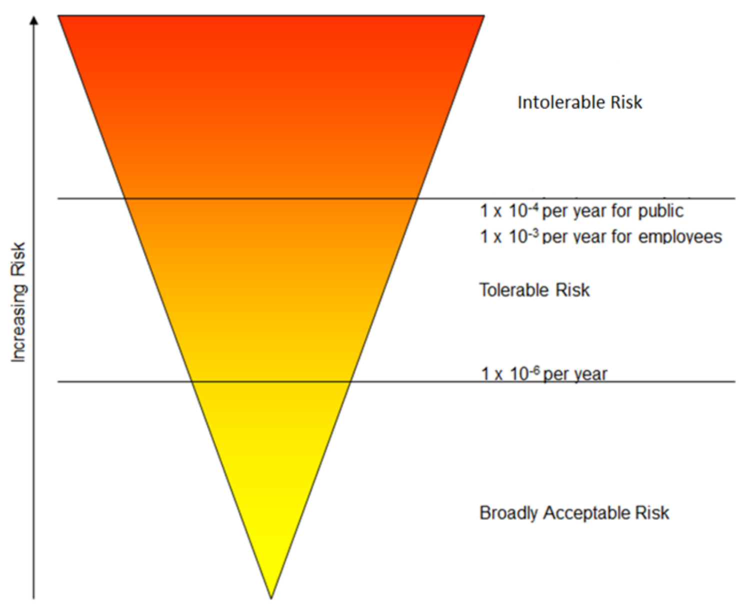


Figure 4.2: Risk regions.

It should be noted that Figure 4.2 which is taken from the United Kingdom HSE shows the intolerable risk criteria for employees as being 1E-03 per year. This criteria is used for assessing risk to employees in and is not applicable to members of the public. This QRA only assesses the risk to the public; risk to employees will be assessed in the detailed engineering phase.
The LSIR curves are often used early in the project planning phases and are deemed conservative to estimate the risk to the public. The LSIR measures the risk to the nearby areas (industrial or public areas). In this QRA, the LSIR is a conservative approach and measures the risk from the project to the public and indirectly to the environment.

For LSIR, a continuous exposure of the receptor is assumed, which means that an individual at a specific location is always present (24 hours per day, 7 days per week, and 52 weeks per year). This value does not include an 'actual' presence factor to account for the 'actual' amount of time a person would be reasonably expected to be in a given area and as such is considered conservative.

The LSIR is presented with iso-risk contour plots on an actual map of the location. The iso-risk contour is independent of the time a person is actually exposed and thus is a conservative measure to help guide the project risk levels and the facility safety zone in the planning phase. The facility safety zone should be within the tolerable iso-risk contour (IR ≤ 1E-4 per year). The LSIR iso-risk contours for the FEED QRA are provided in Section 8.

4.2 System Definition

The system to be analyzed should be defined, including geographical, operational, and logical limits as well as the relevant time periods. Topography and surface type relevant to the local conditions in Acajutla area are provided in Assumption Sheet 3 in Appendix A. In addition, weather data from the Metocean report prepared by Moffatt & Nichol [9] were used as input to the QRA to best model the local conditions in El Salvador (Assumption Sheet 2 in Appendix A). The scope for the QRA includes the LNG import terminal and associated project infrastructure up until the inlet valve at the power plant and is based on the project documentation available at the time of the analysis.

4.3 Hazard Identification

The major hazards, which are associated with the activities, were identified and analyzed in the HAZID workshop in October 2015 at Invenergy's offices in Chicago [8] and in a separate marine HAZID session in January 2016 in El Salvador [9]. The HAZIDS were both updated in December 2017 [3]. Key stakeholders were present during all reviews.

4.4 Frequency Analysis

The frequency analysis was performed to select and define the scenarios that represent the risk posed by the LNG import system and associated infrastructure. Event tree methodology was used to establish the end event frequencies for each scenario. The frequency analysis is described in Section 6.

LR's experience from similar projects and generic data were used and aligned with available project-specific data such as transfer time for LNGC offloading, major equipment, and size of piping to determine leak frequencies. Probabilities for immediate and delayed ignition were calculated and entered into the event trees for each scenario to determine the end event frequencies.

The estimation of the risk to the operating personnel and members of the public assessed in the QRA was based on the major and worst-case, credible scenarios and a range of leak sizes. Hole sizes of 750 mm and 250 mm were modeled for the ship collision scenarios between LNGC and FSRU based on the floating storage study by Pitblado [10]. Traffic data registered for the port of Acajutla from 16 August 2014 to 15 August 2015 [11] was used to determine the ship collision frequency.

Leak frequencies are based on available data, generic data, and LR's best practice. The recognized software tool Phast Risk/Safeti version 6.7 was used to determine the frequency of each end event for each scenario with use of event trees. Figure 4.3 shows an event tree example. Note that for this project, due to the open, flat surface as well as anticipated low FSRU congestion levels where gas cannot accumulate, explosion scenarios were deemed not relevant at this stage of the FEED design.

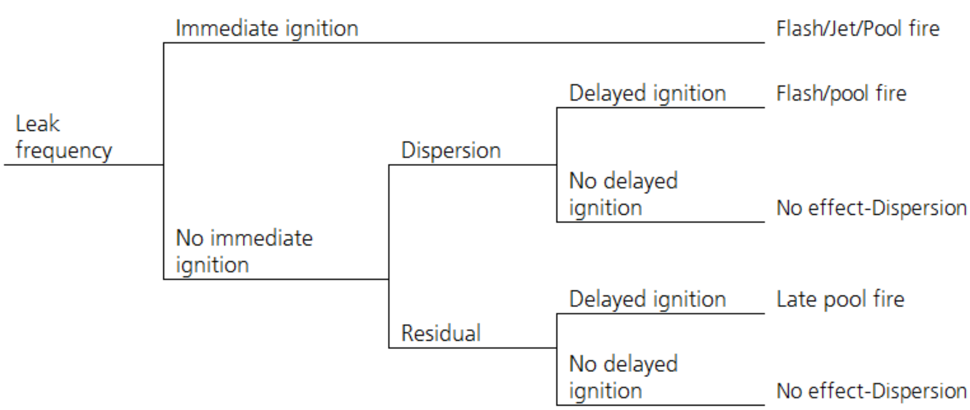


Figure 4.3: Example event tree.

4.5 Consequence Analysis

For each identified scenario a consequence assessment was performed either qualitatively or quantitatively. The consequences were assessed quantitatively for all hazardous scenarios involving release of LNG or natural gas.

The recognized software tool Phast Risk/Safeti version 6.7 was used to perform the quantitative consequence calculations for unignited releases, jet fires, pool fires, flash fires, and vapor cloud explosions. The results of the consequence analysis are provided in Section 7. The following sections describe the acceptance criteria used to assess the consequences.

4.5.1 Gas Dispersion

The lower flammable limit (LFL) and the upper flammable limit (UFL) are respectively the minimum and maximum volume fraction at which a gas/air mixture is flammable. In a flash-fire scenario, the flame front moves through the cloud consuming at least the proportions of the cloud within the flammability limits. The dispersion of the vapor is dependent on atmospheric conditions. It is used as a basis for determining flash-fire hazard distances. A flash fire is relatively short in duration and the flame spreads at subsonic velocity; thus, the overpressure damage to equipment and structures is usually negligible. Damage of equipment and structures is often caused by heat radiation of secondary fires. However, inhalation of the hot air within a flash fire can cause fatal damage to tissue and lungs. For a flash-fire scenario, Phast Risk/Safeti simulates a flash fire for the area between LFL and UFL. The contours represent the maximum distance that can be affected by a flash fire. A ½ LFL is shown as a buffer and uncertainty zone for the flammable zone.

4.5.2 Thermal Radiation

The distances to safe levels of radiant heat flux values were used in the risk calculations for fatalities. Thermal radiation from fires could damage the property, exposed personnel, and the public. NFPA 59A [4] and OGP [8] are used as guidance for the thermal radiation criteria, which are listed in Table 4.2. The effect zones of the thermal radiation of 32, 12.5, and 5 kW/m^2 were modeled in the study. The ignition model and criteria for vulnerability followed the guideline provided by the "Purple Book" [12] and LR's best practice [13].

Table 4.2: Heat Radiation Levels to the Public per NFPA 59A [4] and OGP [8]

Permissible Design Level K (kW/m^2)	Exposure
5	The nearest point located outside the owner's property line that, at the time of plant siting, is used for outdoor assembly by groups of 50 or more persons, for a fire over an impounding area.
12.5	Significant chance of fatality for extended exposure. High chance of injury. Extended exposure may cause the temperature of wood to rise to a point where it may be readily ignited by a naked flame. Thin steel with insulation on the side away from the fire may reach a thermal stress level high enough to cause structural failure.
32	Loss of strength of structural steel exposed to the fire to an extent that is primary load-bearing capacity is reduced significantly over the duration of LNG fire being analyzed.

4.5.3 Explosion/Overpressure

Overpressure/explosion criteria use the blast damage criteria shown in NFPA 59A, Table 15.8.4.3 [4] (see Table 4.3). The hazard distances and effect zone to the lower overpressure limit of 5000 N/m^2 (0.05 bar), 15,000 N/m^2 (0.15 bar), and 25,000 N/m^2 (0.25 bar) are modeled in the study. The ignition model and criteria for vulnerability follow the guideline provided by the "Purple Book" [12] and Lloyd's Register's best practice [13]. Due to the open, flat surface as well as anticipated low FSRU congestion levels where gas cannot accumulate, explosion scenarios were deemed not relevant in the FEED design. In detailed engineering, explosion events will be analyzed further in the fire and explosion analysis. Confined spaces will be limited but may not be completely eliminated.

Table 4.3: Overpressure Level per NFPA 59A, Table 15.8.4.3 [4]

NFPA 59A Blast Damage Criteria	Reflected Damage Overpressure (N/m^2)	
	Lower Limit	Upper Limit
Window glass damage	250	4,000

NFPA 59A Blast Damage Criteria	Reflected Damage Overpressure (N/m^2)	
Damage to doors, cladding, and persons	5,000	10,000
Severe structural damage to building	15,000	20,000
Severe injury to people	25,000	50,000*

* Complete demolition of building

4.6 Risk Picture

The risk is the combination of the results from the frequency analysis and the consequence analysis for all evaluated scenarios (Risk = Frequency x Consequence). The risk picture uses consequences that are vulnerable to people as provided in the Purple Book [12] and areas between LFL and UFL where flash fire could occur. The risk is measured by LSIR and presented by iso-risk contours on the project site map. The risk picture is provided in Section 8. The ignition model and criteria for vulnerability follow the guideline provided by the "Purple Book" [12] and Lloyd's Register's best practice [13].

4.7 Risk Evaluation

The resulting risk picture was evaluated against the risk acceptance criteria defined in Section 4.1.

4.8 Risk-Reducing Measures

Risk-reducing measures are presented as recommendations for mitigation where there is a risk of undesired impact to the operating personnel and/or members of the public. If there are no significant impacts, mitigating measures may still be suggested to improve the design and document to ALARP. Risk-reducing measures are provided in Section 12.

5 Hazards Identification

The major hazards, which are associated with the activities, were identified and analyzed in the HAZID workshop in October 2015 at Invenergy's offices in Chicago [14] and in a separate marine HAZID session in January 2016 in El Salvador [15]. Key stakeholders from Invenergy, Exmar, Moffatt & Nichol, Dillon Consulting, EDP, Shell, Central American Marine Services (CAMS), Comisión Ejecutiva Portuaria Autónoma (CEPA), MARN and LR were present.

An additional review of the HAZID was held in December 2017 [3] during which changes to the proposed design made following the previous studies were considered.

The hazards that were identified as medium or high risks in the HAZID or marine HAZID were further investigated. They are listed in Table 5.1.

Table 5.1: HAZID Summary

Reference	Hazards	Comments
HAZID items 1.2, 1.3, 1.4	Natural hazards such as long-period swells, tsunamis	This is discussed in Section 10.2.
HAZID items 2.1, 2.2, 2.3, 2.4, 2.5 Marine HAZID items 1.1, 1.2, 1.3, 2.1, 3.1, 3.2, 3.3	Ship collisions	This is discussed in Section 10.1.
HAZID items 3.1, 3.2, 3.3, 4.1, 4.2, 4.3, 5.1, 5.2, 5.3, 6.1, 6.2, 6.3, 7.1, 7.2, 7.3 Marine HAZID items 3.4, 5.1, 7.1, 7.2	Release of LNG/NG, which can lead to fire if ignited or explosion	Major and worst-case, credible scenarios are further analyzed in the QRA, as detailed in Table 5.2.
Marine HAZID item 6.1	Security issues in Acajutla	This is discussed in Section 10.3.
Marine HAZID item 7.3, 7.4	Other emergency situations originating at port of Acajutla, Cenérgica mooring area, Albapetroleos terminal, or Rasa terminal	Situations will be handled by the port or terminal when appropriate, per relevant contingency planning. Simultaneous operations have been discussed in the marine HAZID.

In the QRA, the major and worst-case, credible events that could have an impact on the environment or affect the public have been considered. The flammable materials present in the processing, storage, and offloading operation include NG, BOG, and LNG. The selection of the major and worst-case, credible scenario for each flammable materials release is based on the process conditions (pressure, temperature, inventory, flow rate, etc.). In addition, a release from a large inventory and/or high-pressure segment usually results in a worse consequence, which has also been accounted for in the scenarios selected.

The following major flammable releases (loss of containment) scenarios have been identified and analyzed in the QRA. The scenarios are summarized in Table 5.2.

Table 5.2: QRA Scenarios

Location	Scenario	Description	Scenario ID
LNG storage, import, regasification and BOG	LNG release	The scenarios of LNG release at the LNG storage, import and regasification are when releases occur at the inlet segments (hose/storage arm) or at the LNG storage tanks / piping because the inlet segments have large inventories and high pressure and the LNG storage tanks have high inventories and volumes of LNG. The representative scenarios of LNG release at LNG storage and import include: - LNG release from LNGC to FSRU offloading hoses (6x) and piping	1, 2, 3
		- LNG release from LNGC storage (250 mm and 750 mm	4
		- LNG release from FSRU storage (250 mm and 750 mm)	5
		- FSRU LNG tank overfill	19
	NG release	The scenarios of vapor release from LNG storage and import due to large inventories and high pressure are the following: - NG release from BOG system - NG release from regasification system - NG release from the flexible riser	6, 7, 8, 9, 10, 16, 17, 18
Subsea pipeline and PLEM	NG release	The scenarios of NG release from the PLEM and subsea pipeline occur due to large inventories and high pressure. They include the - Release of NG from the flexible riser - Release of NG from the subsea pipeline	11
Onshore pipeline	NG release	The scenarios for NG release onshore are from the buried pipeline	12,
Pressure reducing system	NG release	The scenario for NG release onshore are from the high pressure and low pressure piping systems	14, 15,

If a very large LNG spill or leak followed by a vaporization event were to occur in or near water, then water in contact with the spilled LNG can accelerate the vaporization process and increase the concentration of vapor in the immediate area. This is known as one of the risks of LNG called rapid phase transition (RPT). This is also called cold explosion or physical explosion. During such an event, there is no combustion (flameless) but rather, a high amount of energy is transferred in the form of heat from the water to the LNG at a large temperature difference. Although the consequences of RPT will not cause ignition, it could be severe. It will be highly localized within the spill area and could potentially damage equipment or the installation. This event was discussed in both HAZID sessions [14], [15], [3] and based on the layout and design is not deemed to pose a hazard to the public or environment. As a result, RPT is not further assessed in the QRA.

6 Frequency Analysis

6.1 Leak Frequency

The likely frequencies of occurrence for the process scenarios were estimated based on pipe lengths provided by Exmar and Invenergy [16] and generic failure frequencies detailed in the assumptions register (Appendix A).

These generic failure frequencies are deemed appropriate for the QRA.

For the LNG release from the LNGC tank (scenario 4) and for the LNG release from FSRU tank (scenario 5), two cases were considered: 250 mm hole size and 750 mm hole size. Loss of containment from these scenarios is assumed to release the total volume of the tank.

For the other scenarios (1 - 4 and 7 - 18), a range of failures were considered ranging from catastrophic rupture to small leaks. The hole sizes selected are those defined in the frequency data and vary depending on factors such as pipe diameter and equipment type. Consequently there is a range of hole sizes varying from scenario to scenario.

ESD failures are defined as scenarios where the ESD system fails to close the ESD valve within the required response time (60 seconds) and fails to keep a tight shut-off/seal from the loss of containment. The upset is detected by a flow or a pressure transmitter signal that is sent to the ESD system or directly to the valve to shut in. Details on frequency assumptions are listed in Assumption Sheet 4 in Appendix A.

Overfilling of LNG tank on the FSRU (scenario 19) frequency takes into account both operator error and high-level shutdown failure and is derived using a fault tree analysis as presented in Assumption Sheet 7.

A 20% increase of frequency per scenario was added to account for smaller equipment, pipelines, and instrumentation. This is seen as a conservative approach. The selected scenarios (with ESD response/with ESD failure) and their frequencies are presented in Table 6.1.

Table 6.1: QRA Scenarios Leak Frequency per Annum

ID	Scenario	QRA Tag No.	Hole diameter (mm)	ESD operates (Yes/No)	Frequency (per year)	Return period (years)
1	LNGC Piping up to hose manifold	1-LNGC-L-600-I	600	Yes	2.39E-06	418,407
		1-LNGC-L-600-U	600	No	9.98E-09	100,160,256
		1-LNGC-L-200-I	200	Yes	1.20E-05	83,681
		1-LNGC-L-200-U	200	No	4.99E-08	20,032,051
		1-LNGC-L-50-I	50	Yes	2.39E-05	41,841
		1-LNGC-L-50-U	50	No	9.98E-08	10,016,026
		1-LNGC-L-25-I	25	Yes	4.78E-05	20,920

ID	Scenario	QRA Tag No.	Hole diameter (mm)	ESD operates (Yes/No)	Frequency (per year)	Return period (years)
		1-LNGC-L-25-U	25	No	2.00E-07	5,008,013
2	LNGC/FSRU transfer line (6x)	2-STS-L-200-I	200	Yes	3.11E-05	32,136
		2-STS-L-200-U	200	No	1.30E-07	7,692,800
		2-STS-L-67-I	67	Yes	5.74E-05	17,434
		2-STS-L-67-U	67	No	2.40E-07	4,173,344
		2-STS-L-50-I	50	Yes	2.22E-05	44,990
		2-STS-L-50-U	50	No	9.29E-08	10,769,920
		2-STS-L-25-I	25	Yes	1.00E-04	9,962
		2-STS-L-25-U	25	No	4.19E-07	2,384,768
3	Inlet line to FSRU storage tank	3-FSRU-L-600-I	600	Yes	2.39E-06	418,407
		3-FSRU-L-600-U	600	No	9.98E-09	100,160,256
		3-FSRU-L-200-I	200	Yes	1.20E-05	83,681
		3-FSRU-L-200-U	200	No	4.99E-08	20,032,051
		3-FSRU-L-50-I	50	Yes	2.39E-05	41,841
		3-FSRU-L-50-U	50	No	9.98E-08	10,016,026
		3-FSRU-L-25-I	25	Yes	4.78E-05	20,920
		3-FSRU-L-25-U	25	No	2.00E-07	5,008,013
4	LNGC Storage Tank failure	4-LNGC-L-750-U	750	n/a	1.78E-08	56,067,588
		4-LNGC-L-250-U	250	n/a	5.95E-09	168,202,765
5	FSRU Storage Tank failure	5-FSRU-L-750-U	750	n/a	1.16E-07	8,602,151
		5-FSRU-L-250-U	250	n/a	3.88E-08	25,806,452
6	Common header from FSRU Cargo Pumps)	6-FSRU-L-250-I	250	Yes	3.59E-05	27,894
		6-FSRU-L-250-U	250	No	1.50E-07	6,677,350
		6-FSRU-L-83-I	83	Yes	7.17E-05	13,947
		6-FSRU-L-83-U	83	No	3.00E-07	3,338,675
		6-FSRU-L-25-I	25	Yes	1.25E-04	7,970
		6-FSRU-L-25-U	25	No	5.24E-07	1,907,814
7	LNG from Booster	7-FSRU-L-150-I	150	Yes	4.78E-05	20,920

ID	Scenario	QRA Tag No.	Hole diameter (mm)	ESD operates (Yes/No)	Frequency (per year)	Return period (years)
	Pumps to Vaporizers	7-FSRU-L-150-U	150	No	2.00E-07	5,008,013
		7-FSRU-L-50-I	50	Yes	9.56E-05	10,460
		7-FSRU-L-50-U	50	No	3.99E-07	2,504,006
		7-FSRU-L-25-I	25	Yes	1.67E-04	5,977
		7-FSRU-L-25-U	25	No	6.99E-07	1,430,861
8	NG from vaporizer to NG header (four parallel trains) Includes Vaporizer	8-FSRU-G-300-I	300	Yes	4.06E-05	24,612
		8-FSRU-G-300-U	300	No	1.70E-07	5,891,780
		8-FSRU-G-100-I	100	Yes	4.78E-05	20,920
		8-FSRU-G-100-U	100	No	2.00E-07	5,008,013
		8-FSRU-G-50-I	50	Yes	9.56E-05	10,460
		8-FSRU-G-50-U	50	No	3.99E-07	2,504,006
		8-FSRU-G-25-I	25	Yes	1.20E-04	8,368
		8-FSRU-G-25-U	25	No	4.99E-07	2,003,205
		8-FSRU-G-10-I	10	Yes	4.78E-04	2,092
		8-FSRU-G-10-U	10	No	2.00E-06	500,801
9	Combined NG Export Header	9-FSRU-G-300-I	300	Yes	3.59E-06	278,938
		9-FSRU-G-300-U	300	No	1.50E-08	66,773,504
		9-FSRU-G-100-I	100	Yes	1.79E-05	55,788
		9-FSRU-G-100-U	100	No	7.49E-08	13,354,701
		9-FSRU-G-50-I	50	Yes	3.59E-05	27,894
		9-FSRU-G-50-U	50	No	1.50E-07	6,677,350
		9-FSRU-G-25-I	25	Yes	7.17E-05	13,947
		9-FSRU-G-25-U	25	No	3.00E-07	3,338,675
10	Riser and associated pipework	10-PIPE-G-300-I	300	Yes	1.70E-03	587
		10-PIPE-G-300-U	300	No	7.12E-06	140,423
		10-PIPE-G-100-I	100	Yes	2.39E-06	418,407
		10-PIPE-G-100-U	100	No	9.98E-09	100,160,256
		10-PIPE-G-50-I	50	Yes	8.57E-04	1,167

ID	Scenario	QRA Tag No.	Hole diameter (mm)	ESD operates (Yes/No)	Frequency (per year)	Return period (years)
		10-PIPE-G-50-U	50	No	3.58E-06	279,415
		10-PIPE-G-25-I	25	Yes	5.98E-06	167,363
		10-PIPE-G-25-U	25	No	2.50E-08	40,064,103
		10-PIPE-G-10-I	10	Yes	5.40E-03	185
		10-PIPE-G-10-U	10	No	2.25E-05	44,366
11	Subsea Pipeline and PLEM	11-PIPE-G-100-I	100	Yes	7.64E-04	1,309
		11-PIPE-G-100-U	100	No	3.19E-06	313,314
		11-PIPE-G-50-I	50	Yes	5.73E-04	1,745
		11-PIPE-G-50-U	50	No	2.39E-06	417,752
		11-PIPE-G-10-I	10	Yes	1.77E-03	566
		11-PIPE-G-10-U	10	No	7.38E-06	135,487
12	Onshore gas pipeline (buried)	12-PIPE-G-600-I	600	Yes	1.37E-05	73,084
		12-PIPE-G-600-U	600	No	5.72E-08	17,495,241
		12-PIPE-G-200-I	200	Yes	2.95E-05	33,948
		12-PIPE-G-200-U	200	No	1.23E-07	8,126,593
		12-PIPE-G-13-I	13	Yes	5.37E-05	18,637
		12-PIPE-G-13-U	13	No	2.24E-07	4,461,481
13	Not used	-	-	-	-	-
14	Gas Regulator System (HP)	14-REG-G-600-I	600	Yes	3.59E-07	2,789,382
		14-REG-G-600-U	600	No	1.50E-09	667,735,043
		14-REG-G-200-I	200	Yes	1.79E-06	557,876
		14-REG-G-200-U	200	No	7.49E-09	133,547,009
		14-REG-G-50-I	50	Yes	3.59E-06	278,938
		14-REG-G-50-U	50	No	1.50E-08	66,773,504
		14-REG-G-25-I	25	Yes	7.17E-06	139,469
		14-REG-G-25-U	25	No	3.00E-08	33,386,752
15	Gas Regulator	15-REG-G-600-I	600	Yes	7.17E-07	1,394,691

ID	Scenario	QRA Tag No.	Hole diameter (mm)	ESD operates (Yes/No)	Frequency (per year)	Return period (years)
	System (LP)	15-REG-G-600-U	600	No	3.00E-09	333,867,521
		15-REG-G-200-I	200	Yes	3.59E-06	278,938
		15-REG-G-200-U	200	No	1.50E-08	66,773,504
		15-REG-G-50-I	50	Yes	7.17E-06	139,469
		15-REG-G-50-U	50	No	3.00E-08	33,386,752
		15-REG-G-25-I	25	Yes	1.43E-05	69,735
		15-REG-G-25-U	25	No	5.99E-08	16,693,376
16	Feed to BOG Compressors	16-BOG-G-600-I	600	Yes	3.59E-06	278,938
		16-BOG-G-600-U	600	No	1.50E-08	66,773,504
		16-BOG-G-200-I	200	Yes	1.79E-05	55,788
		16-BOG-G-200-U	200	No	7.49E-08	13,354,701
		16-BOG-G-50-I	50	Yes	3.59E-05	27,894
		16-BOG-G-50-U	50	No	1.50E-07	6,677,350
		16-BOG-G-25-I	25	Yes	7.17E-05	13,947
		16-BOG-G-25-U	25	No	3.00E-07	3,338,675
17	HP BOG Compressors and Pipework	17-BOG-G-250-I	250	Yes	3.93E-05	25,435
		17-BOG-G-250-U	250	No	1.64E-07	6,088,769
		17-BOG-G-100-I	100	Yes	3.47E-06	288,557
		17-BOG-G-100-U	100	No	1.45E-08	69,076,039
		17-BOG-G-83-I	83	Yes	7.17E-05	13,947
		17-BOG-G-83-U	83	No	3.00E-07	3,338,675
		17-BOG-G-50-I	50	Yes	3.23E-04	3,099
		17-BOG-G-50-U	50	No	1.35E-06	741,928
		17-BOG-G-25-I	25	Yes	1.45E-02	69
		17-BOG-G-25-U	25	No	6.04E-05	16,549
18	LP BOG Compressor and Recondenser	18-BOG-G-200-I	200	Yes	4.53E-05	22,080
		18-BOG-G-200-U	200	No	1.89E-07	5,285,502
		18-BOG-G-100-I	100	Yes	3.47E-06	288,557

ID	Scenario	QRA Tag No.	Hole diameter (mm)	ESD operates (Yes/No)	Frequency (per year)	Return period (years)
		18-BOG-G-100-U	100	No	1.45E-08	69,076,039
		18-BOG-G-83-I	83	Yes	7.17E-05	13,947
		18-BOG-G-83-U	83	No	3.00E-07	3,338,675
		18-BOG-G-50-I	50	Yes	3.23E-04	3,099
		18-BOG-G-50-U	50	No	1.35E-06	741,928
		18-BOG-G-25-I	25	Yes	1.45E-02	69
		18-BOG-G-25-U	25	No	6.04E-05	16,549
		18-BOG-G-10-I	10	Yes	1.20E-04	8,368
		18-BOG-G-10-U	10	No	4.99E-07	2,003,205
19	LNG Tank overfilling scenario	19-OFIL-G-n/a-I	n/a	n/a	3.54E-03	282
		19-OFIL-G-n/a-U	n/a	n/a	1.48E-05	67,560

Note that scenario 12 was for an overground section of the onshore pipeline is not included in this assessment as the entire pipeline will be buried.

The total leak frequency is 4.68E-02 per year (once in 21 years). It should be noted that this frequency is relatively high as it includes 'small' releases. If only 'large' releases were considered (defined as those with release diameters over 50 mm diameter), the leak frequency would be 3.17E-03 per year (once in 315 years).

The major contributors to the total leak frequency are leak (non-rupture) scenarios with a shutdown within the 60-second ESD response (90.1%). The ESD system is a crucial safety measure to protect a process by stopping flow upon detection of a dangerous event such as a leak. The high contribution of the scenario where an ESD successfully shuts down the process is explained by the following:

- Small leaks have a higher probability of occurrence than large leaks such as ruptures. Hence, small leak scenarios have a higher contribution to the total frequency than rupture scenarios.
- The probability of an ESD valve successfully shutting down the process is significantly higher than the probability of an ESD failure. As a result, the frequency of having a leak and no ESD failure is greater than the frequency of having a leak and an ESD failure.

6.2 Ignition Probabilities

The consequence of a given leak is dependent on ignition probabilities of either immediate or delayed events. An internal event tree was analyzed in Phast Risk/Safeti to determine the frequency of each end event for each scenario.

The three ignition scenarios were characterized by three different ignition probabilities:

- Probability of immediate ignition.

- Probability of delayed ignition inside the LNG import terminal and power plant.
- Probability of delayed ignition outside the LNG import terminal and power plant.

6.2.1 Immediate Ignition Probability

Immediate ignition is related to the cause of a leak and the release rate. The probability for immediate ignition is based on LR's data dossier [17]. Table 6.2 shows the probability of immediate ignition based on release rate.

Table 6.2: Immediate Ignition Probability

Release Rate (kg/s)	Immediate Ignition Probability
0.05–1	0.001
1–10	0.001
10–30	0.003
> 30	0.03

6.2.2 Delayed Ignition Probability inside the LNG Import Terminal and Power Plant

Delayed ignition is the result of a buildup of a flammable vapor cloud which is ignited by a source remote from the release point. The delayed ignition probability was calculated based on the model of UKOOA look-up correlations and release rate provided in the Oil and Gas Producers (OGP) Risk Assessment Data Directory [18]. Based on the review of OGP Risk Assessment Data Directory and LR's experience, scenario 24 is found to be the most adequate to represent the EDP LNG import terminal with respect to process conditions and was chosen to calculate delayed ignition probability. The overall ignition probability based on release rate used in the QRA is presented in Table 6.3. This probability will be subtracted by the immediate ignition probability to determine the delayed ignition probability.

Table 6.3: OGP Ignition Probability Correlation

Release Rate (kg/s)	Ignition Probability
0.1	0.0010
0.2	0.0011
0.5	0.0012
1	0.0013
2	0.0030
5	0.0092
10	0.0213
20	0.0493
50	0.1500
100	0.1500
200	0.1500
500	0.1500

Release Rate (kg/s)	Ignition Probability
1,000	0.1500

6.2.3 Delayed Ignition Probability outside the LNG Import Terminal and Power Plant

A gas cloud originating from the LNG import terminal and power plant that was not ignited within the installation boundary or is dissipated into the air could propagate and be ignited outside the installation boundary. Phast Risk/Safeti calculates each release and dispersion scenario in discrete time steps, and if a combustible gas cloud covers an ignition source in a time step, the probability of ignition is calculated according to the formula:

$$P_{i,t} = f_i(1-e^{-\omega_i t})$$

$P_{i,t}$ Probability of ignition by source *i* in the duration of time step *t*
f_i Operating probability of source *i* (e.g., if the ignition source is only present part of the time)
ω_i Effectiveness factor for ignition source *i*
t Duration of time step

Assuming LNG and natural gas operating probabilities and effectiveness factor (probability of ignition in 60s) for ignition sources in the Acajutla surrounding area, the calculated delayed ignition probability outside the installation boundary over a 600-meter squared area is 0.20. Detailed calculations and results of immediate and delayed ignition probabilities are provided in Appendix B.

7 Consequence Analysis

The consequence analysis was performed with Phast Risk/Safeti version 6.7. Phast Risk/Safeti is commonly used for modeling gas cloud dispersion and heat radiation from fires for the onshore industry. The geometry and topography for the LNG import terminal location was considered by selecting a surface roughness parameter for both sea (0.2 mm open water) and land (10 cm low crops; occasional large obstacles) in the calculations. LNG and BOG were modeled using methane. The initial temperature of a release was set to –163ºC for liquid (LNG) streams and −140ºC for vapor streams (BOG). Natural gas was modeled as shown in Table 7.1 [19].

Table 7.1: Natural Gas Composition

Natural Gas Composition	mol%
methane	>85.00%
ethane	<15.00%
propane	<5.00%
butane	<2.50%
pentane	<0.25%
nitrogen	<1.00%

The scenario process conditions shown in Table 7.2 are in accordance with Invenergy and Exmar's input for the QRA [16].

Table 7.2: Scenario Process Conditions

ID	Scenario	Modeled as	Pressure (barg)	Temp (°C)	Flow Rate (kg/s)	Density (kg/m^3)	Pipe Size (in.)	Pipe Lgth. (m)	Release Height (m)
1	LNGC Piping up to hose manifold	LNG	7	-163	750	450	24	100	1
2	LNGC/FSRU transfer line (6x)	LNG	1	-163	750	450	8	20	5
3	Inlet line to FSRU storage tank	LNG	1	-163	750	450	24	100	1
4	LNGC Storage Tank failure	LNG	0.1	-163	n/a	450	n/a	n/a	5
5	FSRU Storage Tank failure	LNG	0.1	-163	n/a	450	n/a	n/a	5
6	Common header from FSRU Cargo Pumps)	LNG	5	-163	750	450	10	150	1
7	LNG from Booster Pumps to Vaporizers (4x)	LNG	84	-163	187.5	450	6	50	1

ID	Scenario	Modeled as	Pressure (barg)	Temp (°C)	Flow Rate (kg/s)	Density (kg/m^3)	Pipe Size (in.)	Pipe Lgth. (m)	Release Height (m)
8	NG from vaporizer to NG header (four parallel trains) Includes Vaporizer	NG	79	5	187.5	55.4	12	50	1
9	Combined NG Export Header	NG	79	5	187.5	55.4	12	50	1
10	Riser Failure and associated pipework	NG	79	5	750	55.4	12	10	1
11	Subsea Pipeline and PLEM	NG	79	5	750	55.4	24	1310	1
12	Onshore gas pipeline (buried)	NG	79	5	750	55.4	24	160	1
13	Onshore gas pipeline (above ground)	NG	79	5	750	55.4	24	340	5
14	Gas Regulator System (HP)	NG	79	5	750	55.4	24	15	1
15	Gas Regulator System (LP)	NG	10	5	750	7.62	24	30	1
16	Feed to BOG Compressors	LNG	0.1	-140	3.2	1.0	24	150	1
17	HP BOG Compressors and Pipework	LNG	79	5	3.2	55.40	10	150	1
18	LP BOG Compressor and Recondenser	LNG	5	20	3.2	55.4	8	150	1
19	LNG Tank overfilling scenario	LNG	0.1	-163	750	450	n/a	n/a	17

The ignition model and criteria for vulnerability follow the guideline provided by the "Purple Book" [12] and LR's best practice [13]. The consequence analysis includes releases of LNG and natural gas, followed by gas dispersion and possibility of ignition, which can lead to pool fires, jet fires, flash fires, and/or explosions. Due to the open, flat surface as well as anticipated low FSRU congestion levels where gas cannot accumulate, explosion scenarios are deemed not relevant in the FEED design. For more details on modeling assumptions such as process conditions, Phast Risk/Safeti inputs, and atmospheric conditions, see Appendix A.

7.1 Gas Dispersion Results

Details of the distances to the ULF, LFL, and ½ LFL hazard distances for gas dispersion of each scenario at different weather conditions are tabulated in Appendix C. In the presence of a delayed ignition, the area between UFL and LFL concentrations could result in a flash fire.

The 750 mm releases from either the LNGC or FSRU LNG storage tanks result a large dispersion hazard distances due to the LNG inventory dispersing into air (UFL – 66.6 m, LFL – 1,716.7 m, ½ LFL – 4,468.5 m for

1.5/F weather condition). However, a hole of 750 mm in the LNGC tank resulting in an LNG release is at a very low leak frequency as detailed in Section 6.1.

For the same weather condition, the loss of containment of natural gas from the FSRU transfer line also results in large dispersion hazard distances. The leak frequency for rupture of a transfer arm is 3.40E-07 per year. The risk picture for these events is further detailed in Section 8.

As an example, Figure 7.1 shows the contour of gas dispersion maximum hazard distances from any direction of the release point by a rupture to the LNGC to FSRU transfer hose (Scenario 2) when isolated after 60 seconds. This illustrates that the ½ LFL (blue curve) gas cloud could reach a significant part of the Acajutla area, the LFL (green risk curve) gas cloud is approximately 950 meters away from the LNG import terminal, just reaching the and the UFL (yellow curve) is approximately 30 meters from the LNG import terminal. The results of this scenario are due to the process conditions, LNG volume spilled and meteorological conditions. It should be noted that this is based on the major and worst-case, credible scenario. Even though the hazardous distance reaches land, the frequency of the scenario is 3.11E-05 per year (once in 32,154 years). Given that the ½ LFL contour reaches the port, it is recommended to install gas detectors at the port, if not already installed, and to coordinate an alarm system and emergency response plan that includes the port in case of incident at the LNG import terminal.

Figure 7.1: Gas dispersion from an LNGC transfer hose rupture (isolated).

7.2 Jet Fire Results

Details of the distances to the maximum hazard distances for the jet fire radiation values (5 kW/m^2, 12.5 kW/m^2, and 32 kW/m^2) for each scenario are shown in Appendix C.

Figure 7.2 shows the contour of jet fire maximum hazard distances from any direction from the release location by a rupture of the high pressure section of the gas regulator system. For the 1.5/F weather condition, the NG discharge from the system results in a large jet fire radiation hazard distances (e.g., isolated 600 mm case: 5 kW/m^2 – 830 m, 12.5 kW/m^2 – 635 m, and 32 kW/m^2 – 495 m).

The jet fire radiation curves from this scenario can reach defined populated areas, however the frequency of the release is very low at 3.59E-07 per year (once in 2,785,515 years for an isolated release).

Figure 7.2: Jet fire hazard distances from HP gas regulator system failure.

7.3 Pool Fire Results

In the event of a leak, the amount of LNG spilled from the pipeline or equipment will rapidly vaporize due to the large change in temperature (from –163°C to 27°C). When there is a significant amount of LNG released, a portion of the LNG located inside the volume released will stay liquid. This situation creates a potential for a pool. The scenarios for which a pool fire is possible are the scenarios that can create a large release of LNG based on the flow rate and volume of inventory within its containment. Only three scenarios have been identified as potential scenarios for pool fires. These scenarios and the maximum hazard distances for the pool fire radiation values (5 kW/m^2, 12.5 kW/m^2, and 32 kW/m^2) are shown in Appendix C.

The 750 mm releases from either the LNGC or FSRU LNG storage tanks result in relatively small radiation hazard distances. These scenarios are expected to have hazard distances due to the volume of LNG released but are unlikely to occur at 1.78E-08 per year (once in 56,179,755 years) for the LNGC and 1.16E-07 per year (once in 8,602,689 years) for the FSRU.

As a graphical example, Figure 7.3 shows the contour of pool fire maximum hazard distances from any direction by a 750 mm release from the LNGC tanker. Pool fires do not reach any defined public areas. If the shipping lane (not defined) reaches the area the thermal radiation regions, the release could potentially affect people traveling through this area at radiation levels of 5 kW/m^2 and 12.5 kW/m^2, at 278 m and 173 m respectively. Radiation levels of 32 kW/m^2 would only affect personnel within a 90 m radius of the LNG import terminal.

Figure 7.3: Pool fire hazard distances from a release of LNGC or FSU LNG storage tanks.

The tables showing consequence extent distances in Appendix C are not included in the Release 1 of this Report. As these tables only provide additional information, the overall results of the QRA are not affected by their absence.

8 QRA Risk Picture

In this QRA, the main areas of concern are the risk exposure to a third party and indirectly the risk to the environment. A third party corresponds to people off-site not directly involved in the activities within the site (general public and neighboring industries). LSIR iso-risk curves are presented to show the risk picture to the public (see Section 4.1).

8.1 LSIR Iso-Risk Contours

The IR for the LNG import terminal, pipeline and onshore location are shown in Figure 8.1.

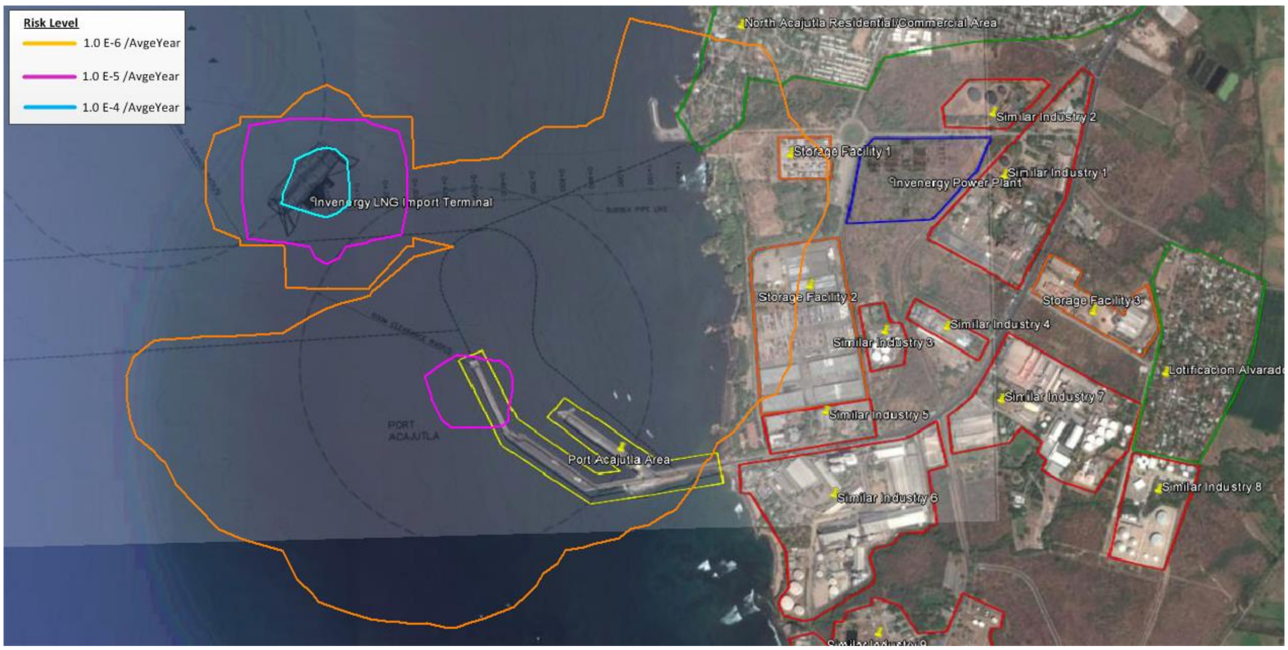


Figure 8.1: LSIR iso-risk contours

From Figure 8.1, it can be seen that there is an IR contour of 1E-04 per year (blue) in the area around the FSRU and LNGC. However, this is an area where no members of the public will be present.

The 1E-05 per year contour (purple) lies over the FSRU/LNGC, and part of the harbor wall at the Port of Acajutla. The 1E-06 per year contour (orange) lies over industrial and storage areas, part of the Port of Acajutla and the southern part of Acajutla. The area between the 1E-05 per year and 1E-6 per year contours are in the tolerable ALARP region.

Beyond the 1E-06 per year (orange), contour risks are broadly acceptable.

Review of the model results shows that the FSRU overfill scenario contributes significantly to the 1E-04 level of risk around the terminal.

A very conservative approach has been taken for calculating the overfill frequency for the FSRU. To show the sensitivity of the results to this scenario, an assessment of the level of risk with an overflow at a lower frequency (a factor of 10) has been undertaken, The results from this are shown in Figure 8.2 below.

Figure 8.2: LSIR iso-risk contours (with reduced overfill frequency).

It can be seen that by reducing the overfill scenario frequency by a factor of 10 the extent of the risk contours is significantly reduced; there is no 10E-04 per year risk contour and the only onshore area with a risk greater than 10E-6 per year is in the port harbor area.

It is recommended that a detailed review of the overfill scenario is undertaken, reviewing both the possible frequency of overfill and consequences of overfill. If it can be shown that the systems for protection against overfill are robust then it is expected that there will be a reduction in risk producing results similar to those shown in Figure 8.2.

8.2 Risk Contribution Breakdown

A specific assessment of LSIR at two locations has been undertaken in order to identify which scenarios contribute the most to risk. The points selected are the FSRU Bridge and the center of the Power Plant.

FSRU Bridge

The total LSIR at this location is 1.7E-04 per year. A breakdown of the individual risk contribution for scenarios that contribute over 1% at this point given in Table 8.1 below.

Table 8.1: FRSU LSIR Breakdown

ID	Scenario	LSIR Contribution (per year)	LSIR Contribution (%)
19	Isolated overfill on the FSRU	1.0E-4	60.8
10	Isolated failure of the subsea riser (300 mm diameter hole).	5.1E-5	30.0
17	Isolated NG release from the HP BOG Compressors and pipework on the FSRU (25 mm diameter hole)	3.7E-6	2.2
7	Isolated LNG release from the LNG booster pumps on the FSRU (50 mm diameter hole)	3.0E-6	1.8

It can be seen that overfill of the LNGC contributes to over 60% of the overall risk in this area and the FSRU riser to 30%. In both cases, these are isolated releases with a relatively high frequency.

Power Plant

The total LSIR at the center of the power plant is 7.37E-07 per year which is in the broadly acceptable risk region. A breakdown of the individual risk contribution for scenarios that contribute to over 1% at this point is provided in Table 8.2 below.

Table 8.2: Power Plant LSIR Breakdown

ID	Scenario	LSIR Contribution (per year)	LSIR Contribution (%)
19	Isolated overfill on the FSRU	6.92E-7	93.9
6	Isolated failure of the common header from FSRU Cargo Pumps (250 mm diameter hole)	1.79E-8	2.4

It can be seen that overfill of the LNGC contributes to over 93% of the overall risk in this area.

9 PLEM Isolation ESD Sensitivity Analysis

A sensitivity analysis has been performed to understand possible risk reduction for installation of a remotely activated ESD valve on the PLEM.

The installation of a remotely activated ESD valve on the PLEM allows rapid isolation of the flexible riser from the subsea pipeline. This significantly reduces the quantity of NG from the isolated section that could be released in the event of flexible riser failure as shown below in Table 9.1.

Table 9.1: Release Inventories with/without PLEM ESD Valve

Isolated section	Without PLEM ESD isolated mass (kg)	With PLEM ESD isolated mass (kg)
Flexible Riser	28,783	431
24" Pipeline	28,783	28,352

The change in inventory in the 24" pipeline is not significantly changed.

The IR for the LNG import terminal, pipeline, and onshore location with the PLEM ESD valve are shown in Figure 9.1 below.

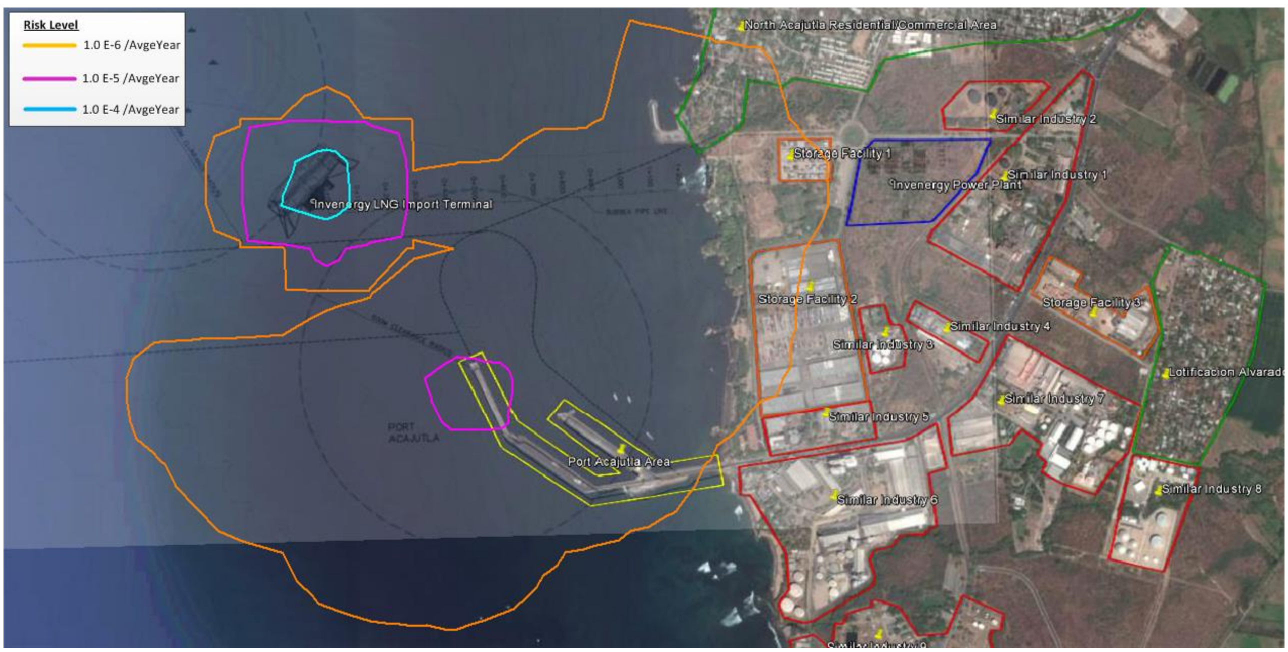


Figure 9.1: LSIR iso-risk contours (PLEM ESD valve)

From comparison of the risk contours without the PLEM ESD valve in Figure 8.1 against those in Figure 9.1, one can be see that the installation of an ESD valve on the PLEM has no effect on the overall levels of risk.

10 Other Risks

The following other risks for the project are discussed qualitatively at this stage in the QRA performed in FEED and are not included in the risk contour, except for ship collisions, which have been quantified:

- Ship collisions
- Tsunamis
- Security

10.1 Ship Collision Risk

A ship collision risk analysis has been completed [15]. Based on the HAZID [14], the following ship collision scenarios involving the LNG import terminal were identified for further analysis in the ship collision risk analysis:

- The potential collision of the LNGC with the LNG import terminal
- The potential collision of an oil tanker en route to the Cenérgica mooring area with the LNG import terminal, and
- The potential collision of merchant vessels to/from the port of Acajutla with the LNG import terminal.

Collision of the LNGC in the LNG import terminal will result in minor structural damage of the FSRU with low impact energy. When the approaching speed of the LNGC is higher than 1.3 knots, causing impact energy greater than 28 mJ, the powered collision has the potential to cause LNG release from the FSRU. However, the collision of the LNGC in the FSRU is unlikely to cause a spill from the FSRU due to the low approaching speed of the LNGC. In addition, the most severe collision of the LNGC with the FSRU is a head-on collision, which is not likely to cause loss of containment from the LNGC tank due to location of tank in the hull.

Collisions of oil tankers in the LNG import terminal will only cause local or minor damage to the FSRU and are not likely to cause an LNG leak from the FSRU due to the light weight, low speed, and low impact energy of the oil tanker.

Since collisions of the LNGC or oil tankers in the LNG import terminal are not likely to cause an LNG leak given the low impact energies, only the collision of merchant vessels with the LNG import terminal is considered a risk for collisions. There were 742 vessel entries (341 unique vessels callings) to the port of Acajutla registered from 16 August 2014 to 15 August 2015 [20]. The vessel distribution to the port of Acajutla and the vessel distribution based on vessel type are provided in Table 10.1 and Figure 10.1, respectively. Assuming mitigated measures like mandatory pilotage and tugboats accompanying larger vessels, most of these collisions will cause only local or minor damage to the FSRU due to the low impact energy and are not likely to cause an LNG release from the FSRU. In extreme weather conditions, the high speed of the drifting vessel could result in a collision with large impact energy. This collision has the potential to cause a leak from the FSRU and LNGC. Based on the QRA, the ship collision risk is found to be 2.61E-09 per year and falls in the broadly acceptable region.

Table 10.1: Vessel Distribution to the Port of Acajutla

	Deadweight Tonnage (ton)					Number of Entries	Percentage
	0–1,499	1,500–4,999	5,000–14,999	15,000–39,999	>40,000		
Bulk Carrier	0	0	8	57	77	142	19%
Tanker	0	4	4	40	198	246	33%
Container	0	0	28	225	0	253	34%
Carriers (Vehicles)	0	0	18	44	0	62	8%
General Cargo	0	1	5	8	21	35	5%
Other Vessels	2	1	0	0	1	4	1%
Total	2	6	63	374	297	742	100%
Percentage	0%	1%	8%	50%	40%	100%	

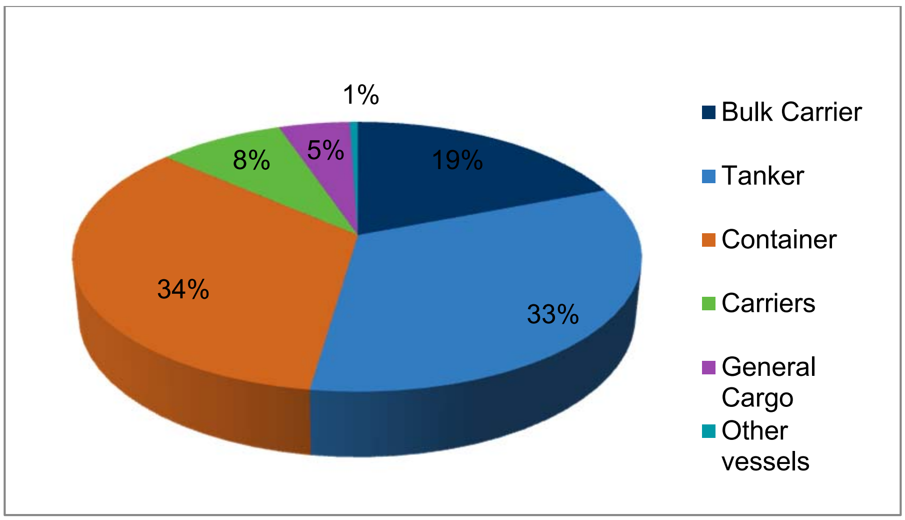


Figure 10.1: Vessel distribution based on vessel type.

10.2 Tsunamis Risk

El Salvador is located on the west coast of Central America, which has a reasonably well-documented history of subduction zone earthquakes that have produced tsunamis near the terminal site. Large eddies created by earthquakes can lead to major consequences in the vicinity of the site. Therefore, tsunami risk is a realistic potential hazard, as identified in the HAZID [14]. A tsunami study was performed by Moffatt & Nichol and results of the simulations are provided in the report [21]. This study is currently being updated.

Although tsunamis are rare events, they have been identified as potential hazards, given the magnitude of the consequences (damage to asset, environment, and people). The mooring system has been designed for the FSRU that can withstand a tsunami for which the conditions do not exceed the tsunami conditions chosen in the design criteria.

In the event of a distant earthquake, advance notice will be provided to evacuate personnel from the LNG import terminal and to ensure the LNGC, if present, is leaving the LNG import terminal to reach a safe area.

In the event of long-period swells, which can be predicted in advance, the LNGC will leave the terminal and the personnel will be evacuated.

10.3 Security Risk

Violence and crime are critically high in El Salvador. Local security threats have been identified as high risk for the project in the marine HAZID [15]. To deal with potential security threats, the port of Acajutla is currently committed to safe and efficient movement of goods and passengers through the port. The addition of the LNG import terminal in the area and its high profile as an international investment project may increase the security risk. The following recommendations should be considered for the project:

- Restricted access to the LNG import terminal
- Video surveillance of the LNG import terminal installation and surrounding marine area
- Lighting of the installation at night
- Marine exclusion/safety zone around the LNG import terminal
- Patrol/Security vessels enforcing the marine exclusion/safety zone
- Incident reporting program to track suspicious activity
- International Ship and Port Security (ISPS) plan for the LNG import terminal taking into account local security concerns.

11 Previous QRA Studies

This study follows previous QRAs for the proposed installation, with the main changes being:

- Operation of the natural gas production at high pressure with a pipeline pressure at 80 bara instead of 11 bara; and,
- Removal of a Floating Storage Unit (FSU) and riser platform surrounding the FSRU from the design.

As a result of these changes and review of assumptions made in previous QRAs, there are clear differences between the QRA results at 80 bara and 11 bara as discussed below.

- Releases of NG at 80 bara will give higher hazard ranges than those at 11 bara. As a result the risk contours at 80 bara extend for greater distances than those at 11 bara.
- It had previously been assumed that all releases from the overground pipeline would occur at the center of the power plant, this was a conservative approach, that was valid for 11 bara operation but is not considered to be valid for 80 bara as it would give an unrealistic risk picture. For 80 bara operation the locations of releases have been modelled as being along the route of the buried onshore pipeline. This changes the onshore risk picture and removes risk contours in the center of the power plant that were previously present.
- The FSU overfill frequency considered in previous QRAs was based on the amount of time (fraction of the year) that filling of the FSU was taking place and used a fault tree that had been based on that mode of operation. The approach taken in this QRA is based on the number of times transfer takes place between the LNGC and FSRU rather than the transfer duration and subsequently produces higher calculated risk values for this scenario. It is recognized that the overfill fault tree requires revision to incorporate additional safeguards that will be in place for transfer between the LNGC and FSRU. Transfer flowrates between the LNGC and FSRU are also higher than they were for FSU filling, resulting in larger consequence distances. As a result, this QRA shows that the overfilling scenario contributes significantly to the risk picture and a consequence hides scenarios that have lower risk contributions.

12 Recommendations and Discussions

12.1 Safety Zones

Onshore Power Plant

The onshore power plant lies beyond the 10E-6 per year contour and is therefore in the broadly acceptable risk region. No additional measures are required for protection of the public in this area.

LNG Import Terminal

There are 10E-4 and 10E-5 per year contours around the terminal. These are areas where members of the public would not normally be present so no additional measures are required for protection of the public in these areas.

Port of Acajutla

An area of risk within 10E-5 per year lies over the jetty area of the Port of Acajutla. This is a tolerable risk area for members of the public.

Onshore Areas

The 10E-6 contour covers some industrial and residential onshore areas which are therefore in the tolerable risk region. No additional measures for public protection will be required in this area as long as the terminal and pipelines have controlled risk to ALARP.

It should be noted that it is considered that review of the overfill scenario frequency as discussed in Section 8.1 will reduce the extent of the zones described above significantly.

12.2 Shipping Lane

The shipping lane, as it is currently defined, with risk contours is shown in Figure 12.1. It can be seen that the 10E-5 per year level of risk reaches the shipping lane and the lanes are partially in the tolerable risk area (>10E-6 per year) and partially in the broadly acceptable risk area (<10E-6 per year).

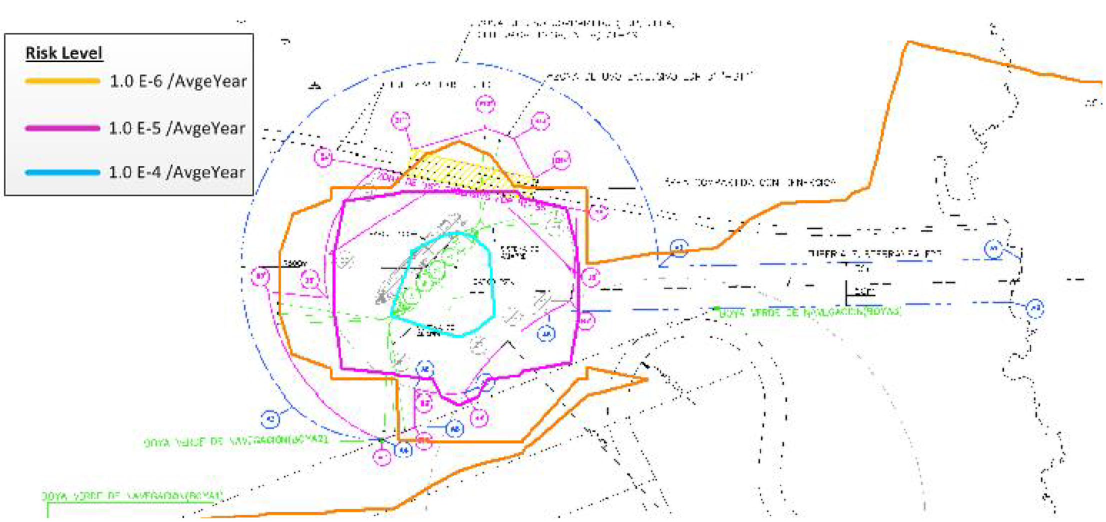


Figure 12.1: Shipping Lane Risk Contours

The LSIR contour is one input to define the acceptability of the shipping lane. However, there are other inputs not included in the LSIR contour, such as security risk, required turning radius for ships, or traffic control that may require the shipping lane to be moved.

12.3 Recommendations

Based on the analysis, the following general recommendations are suggested:

- It is recommended, if possible, to analyze the design of process equipment shelters and buildings within the LNG import terminal and power plant limit to minimize confined spaces and to reduce explosion events. No explosion scenarios were analyzed for the design at the FEED stage. Explosion events will be further studied in detailed engineering.
- The LSIR is one input to define the extent of the marine exclusion zone. However, other considerations can justify a larger marine exclusion zone, e.g ship collision that do not result in LNG release and security risks.
- Overfill of an LNG tank on the FSRU during transfer from the LNGC has been shown to contribute the most to the overall offshore risk and produces an area of risk around the FSRU/LNGC (≥10E-4). While this level of risk is not relevant for members of the public, risk reduction options should be considered for this scenario, which should include a detailed review of the FSRU overfill scenario. In addition to the possible formation of fires/explosions, the release of large quantities of LNG at an elevated level on the vessel from an overfill could lead to extensive structural failure due to low temperature embrittlement.
- The installation of an ESD valve on the PLEM shows no risk reduction benefits and does not appear to be required on this basis. However it is recognized that an ESD valve could be used to isolate the pipeline rapidly if required due to operational issues or external threats and should not be omitted purely from a risk point of view.

13 References

[1] FERC Risk-Informed Decision Making Guidelines, Chapter 3 – Risk Assessment, Federal Energy Regulatory Commission, Version 4.1, March 2016.

[2] Ley del Medio Ambiente, Decreto No. 233, Diario Official No. 79, Tomo No. 339, 28 May 2015.

[3] Lloyd's Register, "Invenergy Power to Shore Project, LaPaz, El Salvador – HAZID Report,2017" [HOLD].

[4] NFPA 59A, Standard for the Production, Storage, and Handling of LNG, 2016 Edition.

[5] British Standards BS EN 1473, Installation and equipment for liquefied natural gas — Design of onshore installations, 2007.

[6] Offshore Division Fire, Explosion and Risk Assessment Topic Guidance, HSE, June 2003.

[7] NORSOK Standard Z-013 – Risk and Emergency Preparedness Analysis, Revision 2, 2001.

[8] Risk Assessment Data Report, OGP, report no. 434, March 2010.

[9] Moffatt & Nichol, Metocean and numerical modelling for LNG import terminal Acajutla, El Salvador, Rev. A, 11/02/2015.

[10] Consequences of LNG Marine Incidents, R. M. Pitblado, Center for Chemical Process Safety (CCPS) Conference, July 2004.

[11] http://www.sadfiweb.gob.sv:8090/ConsultasEnLinea/HistoricoBuques/index.php

[12] "Reference Manual Bevi Risk Assessments version 3.2 – Module C", 01.07.2009.

[13] Lloyd's Register "Best Practice – Scenario selection for onshore QRA," 13 May 2011.

[14] Lloyd's Register, "Invenergy Power to Shore Project, LaPaz, El Salvador – HAZID Report," Report no. US4122.1, Rev. Final B, 03 March 2016.

[15] Lloyd's Register, "Invenergy Power to Shore Project, LaPaz, El Salvador – Marine HAZID Report," Report no. US4122.2, Rev. Final, 03 March 2016.

[16] Lloyd's Register, Exmar, Invenergy, and Moffatt & Nichol, "Questions_El Salvador QRA" Spreadsheet, Rev 3., 30 March 2016.

[17] Lloyd's Register Data Dossier, Appendix F: Ignition probability calculation, 2011.

[18] Oil and Gas Producers (OGP) risk assessment Data directory- Ignition Probability, Report No. 434-6.1, March 2010.

[19] QRA comments from H. Larios, 14 April 2016.

[20] http://www.sadfiweb.gob.sv:8090/ConsultasEnLinea/HistoricoBuques/index.php

[21] Moffatt & Nichol, "EDP LNG Import Terminal, Acajutla, El Salvador – Tsunami Simulation Report – FEED Phase," Revision No. A, 18 May 2016.

Appendix A

QRA Assumptions

Table of contents

Page

1 Introduction

The proposed FSRU near the Acajutla Port, El Salvador, will provide natural gas to an onshore power plant. A quantitative risk analysis (QRA) is performed to estimate the project risk towards the public and the environment. Appendix A documents the relevant assumptions for the QRA.

2 Assumptions

All assumptions sheets are listed in the following table.

Assumption Sheet No.	Subject	Rev.	Date	Notes
1	Scope of Work	1	January 8, 2018	
2	Atmospheric Conditions	1	January 8, 2018	
3	Topography and Ground Surface Type	1	December 21, 2018	
4	Frequency Analysis	1	December 21, 2017	
5	Consequence Analysis	1	January 4, 2018	
6	Risk Criteria	1	April 21, 2016	
7	Tank Overfilling Fault Tree Analysis	1	June 22, 2017	

Lloyd's Register Energy

Assumption Sheet 1

Sheet No.:	**1**	**Assumption Rev.:**	**1**
Subject:	**QRA**	**Date:**	**January 8, 2018**
Topic:	**Scope of Work**		

Assumption Description

The QRA will include LNGC offloading to FSRU, regasification process on the FSRU, gas send out to the subsea pipeline, onshore pipeline and pressure reduction system / isolation at the entrance into the power plant. Selected scenarios based on the HAZID and process flow diagrams are listed in Table 2.1.

Table 2.1 – Selected scenarios

ID	Scenario	Location
1	LNGC Piping up to hose manifold	LNGC
2	LNGC/FSRU transfer line (6x)	LNGC/FSRU
3	Inlet line to FSRU storage tank	FSRU
4	LNGC Storage Tank failure	LNGC
5	FSRU Storage Tank failure	FSRU
6	Common header from FSRU Cargo Pumps)	FSRU
7	LNG from Booster Pumps to Vaporizers	FSRU Regas
8	NG from vaporiser to NG header (four parallel trains) Includes Vaporizer	FSRU Regas
9	Combined NG Export Header	FSRU
10	Riser Failure and associated pipework	Riser
11	Subsea Pipeline and PLEM	Subsea Pipeline
12	Onshore gas pipeline (burried)	Onshore Pipeline
13	Not used	-
14	Gas Regulator System (HP)	Power Plant
15	Gas Regulator System (LP)	Power Plant
16	Feed to BOG Compressors	FSRU BOG
17	HP BOG Compressors and Pipework	FSRU BOG
18	LP BOG Compressor and Recondenser	FSRU BOG
19	LNG Tank overfilling scenario	FSRU

References

1. Lloyd's Register, Marine HAZID Report: Invenergy Power to Shore Project, Acajutla, El Salvador," Rev final, 03 March 2016.
2. Acjutla Terminal Project Process Flow Diagram – Regasification Plant FSRU, 5/12/2017, Updated for New Mooring System, Rev E.

Client comments/ approval:

Lloyd's Register Energy

Assumption Sheet 2			
Sheet No.:	**2**	**Assumption Rev.:**	**1**
Subject:	**QRA**	**Date: January 8, 2018**	
Topic:	**Atmospheric Conditions**		

Assumption Description

Weather information used in this study is obtained from the Metocean report prepared by Moffatt & Nichol, Ref. /1/.

Temperature

The ambient temperature is assumed to be 27°C, which is the annual average temperature for Acajutla port, Ref. /2/.

Humidity

The average ambient relative humidity is assumed to be 80%, Ref. /2/.

Wind speed and wind direction

The wind rose is shown in Figure 2.1. The dominating wind direction is the wind from north and northeast sector to the South and southwest sector, followed by winds from the south to north.

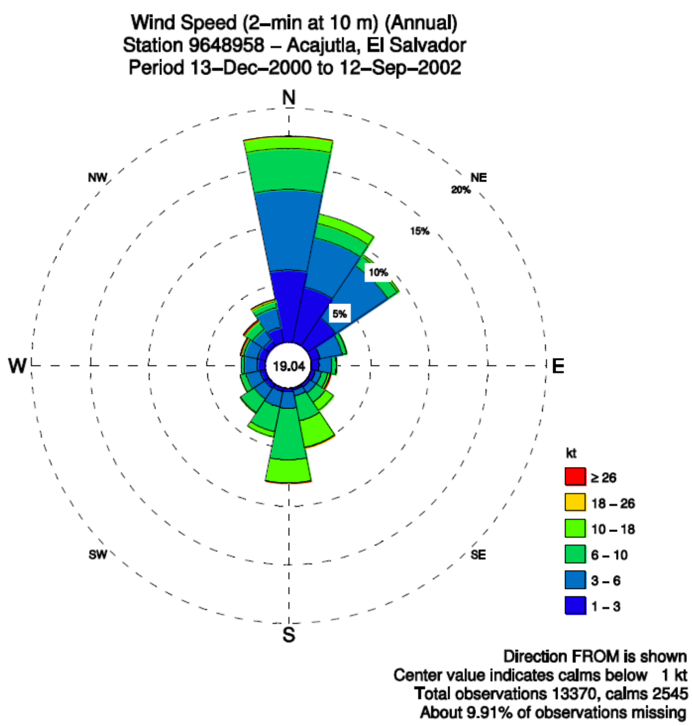


Figure 2.1 - Wind Rose Data at Acajutla

Stability class

Pasquil stability class is a measure of turbulence in the atmosphere and defined in Table 2.2, Ref. /2/. It is dependent on the wind speed, time of the day, and other conditions, as shown in

Table 2.3.

Table 2.2 Pasquil Stability Classes

Pasquill Class	Stability
A	Extremely unstable
B	Moderately unstable
C	Slightly unstable
D	Neutral
E	Slightly stable
F	Moderately stable

Table 2.3 Stability Class from Wind speed and Solar Radiation

Wind speed (m/s)	Daytime insolation			Night-time conditions	
	Strong	Moderate	Slight	Thin overcast or > 4/8 low cloud	<=4/8 cloudiness
0-2	A	A-B	B	E	F
2-3	A-B	B	C	E	F
3-5	B	B-C	C	D	E
5-6	C	C-D	D	D	D
>6	C	D	D	D	D

Four weather conditions will be used to represent weather conditions in this study; namely 1.5F, 3D, 5D and 9D.

Solar radiation will be 0.5 kW/m^2. The surface of water and soil temperatures will be assumed to be the same as the average ambient temperature of 27°C.

References

1. Moffatt & Nichol, EDP LNG Import Terminal Pre-FEED for Marine Infrastructure Basis of Design / Conceptual Engineering Studies Job No. 9017, 2015-12-16 Revision B.
2. https://weather-and-climate.com/average-monthly-Humidity-perc,Acajutla,El-Salvador.

Client comments/ approval:

Assumption Sheet 3

Sheet No.:	**3**	**Assumption Rev.:**	**1**
Subject:	**QRA**	**Date:**	**January 26, 2018**
Topic:	**Topography and Surface Type**		

Assumption Description

- The FSRU is located on the Pacific coast of El Salvador and the topography is flat in the Acajutla area. For consequence modelling, the Table 2.4 below shows the surface roughness for sea and on land.

Table 2.4 – Surface roughness (the lengths marked with * are used in the analysis)

Type of Surface	Roughness Length (m)
Open water, at least 5 km	0.0002*
Mud flats, snow; no vegetation, no obstacles	0.005
Open flat terrain; grass, few isolated objects	0.03
Low crops; occasional large obstacles, x/h > 20	0.10
High crops; scattered large obstacles, 15 < x/h < 20	0.25
Parkland, bushes; numerous obstacles, x/h < 15	0.5
Regular large obstacle coverage (suburb, forest)	1*
City center with high- and low-rise buildings	3

- The FSRU is in the Pacific Ocean about 1,400 meters west of the shoreline. . The onshore gas pressure regulation system is located about 500 meters from shoreline at the inlet of the power plant surrounded by other storage facilities and similar industry businesses.
- Storage tanks and hose releases when transferring LNG between the LNGC and FSRU are assumed to be discharge to the sea surface (water).
- Other process releases on-board the LNGC/FSRU are assumed to be collected and to leak to a cryogenic spill collection system on the LNGC/FSRU surface.
- Process releases on the FSRU are also protected by the FSRU hull which will protect and prevent leakages from leaving outside the FSRU area to the sea.
- Any leak from the onshore pipelines and piping systems are assumed to be released directly to air.

References

Client comments/ approval:

Lloyd's Register Energy

Assumption Sheet 4

Sheet No.:	**4**	**Assumption Rev.:**	**1**
Subject:	**QRA**	**Date: December 21, 2017**	
Topic:	**Frequency Analysis**		

Assumption Description

- The ESD response time is assumed to be 1 minute (60 seconds). The ESD will also stop the transfer pumps.
- The probability of failure on demand for an ESD valve is determined to be 4.16E-03 Ref. /1/.
- A leak from a hole is defined as a leak with an effective diameter of 10% of the nominal diameter.
- Loss of containment from LNGC and FSRU storage tanks is assumed to release the total volume of the tank. There is no ESD for these systems. Transfer times for the LNGC and FSRU are presented in Table 2.5. The transfer times are based on Ref. /2/.

Table 2.5 – LNGC and FSRU Annual Transfer time

Description	LNGC to FSRU	FSRU to onshore
Ship Size (m^3)	165,000	138,000-174,000
Density (kg/m^3)	460	9.6
LNG Transfer Rate (m^3/hour)	6000	n/a
NG Rate (MMSCFD)	n/a	280
Transfer Time (hours/ship)	28	n/a
Transfers (ships/year)	32	n/a
Transfer Time (hours/year)	880	8766
Transfer Time (Proportion)	0.1	1.00

References

1. OREDA Offshore Reliability Data, 5th Edition 2009.
2. Exmar, Acajutla LNG Terminal Project Process Flow Diagram, Rev F, 15/01/2018.
3. US DOT PHMSA and FERC, “LNG Facility Nominal Failure Rate Table,” February 11, 2015.

Client comments/ approval:

Lloyd's Register Energy

Assumption Sheet 5

Sheet No.:	**5**	**Assumption Rev.:**	**1**
Subject:	**QRA**	**Date:**	**January 4, 2018**
Topic:	**Consequence Analysis**		

Assumption Description

A consequence analysis will be performed with Phast Risk/Safeti version 6.7 with the scenarios listed in Table 2.6. Table 2.6 shows each scenario's process conditions. Process conditions are determined by the hydrocarbon inventory volume between two isolation valves.

Table 2.6 – Scenario Process Conditions, Ref. /1,2/

ID	Scenario	Fluid/Gas Type	Pressure (barg)	Temperature (°C)	Volume (m^3)	Flow rate (m^3/s)	Density (kg/m^3)	Mass Flowrate (kg/s)	Pipe Size (inch)	Pipe length (m)	ESD Time (s)
1	LNGC Piping up to hose manifold	LNG	7	-163	29.19	1.667	450	750	24	100	60
2	LNGC/FSRU transfer line (6x)	LNG	1	-163	0.65	1.667	450	750	8	20	60
3	Inlet line to FSRU storage tank	LNG	1	-163	29.19	1.667	450	750	24	100	60
4	LNGC Storage Tank failure	LNG	0.1	-163	50000	-	450	-	n/a	n/a	n/a
5	FSRU Storage Tank failure	LNG	0.1	-163	32000	-	450	-	n/a	n/a	n/a
6	Common header from FSRU Cargo Pumps)	LNG	5	-163	7.60	1.667	450	750	10	150	60
7	LNG from Booster Pumps to Vaporizers	LNG	84	-163	0.91	0.417	450	187.5	6	50	60
8	NG from vaporiser to NG header (four parallel trains) Includes Vaporizer	NG	79	5	3.65	3.384	55.4	187.5	12	50	60
9	Combined NG Export Header	NG	79	5	10.94	13.538	55.4	750	12	150	60
10	Riser Failure and associated pipework	NG	79	5	519.54	13.538	55.4	750	12	10	60
11	Subsea Pipeline and PLEM	NG	79	5	519.54	13.538	55.4	750	24	1310	60
12	Not used	-	-	-	-	-	-	-	-	-	-
13	Onshore gas pipeline (above ground)	NG	79	5	519.54	13.538	55.4	750	24	0	60
14	Gas Regulator System (HP)	NG	79	5	4.38	13.538	55.4	750	24	15	60
15	Gas Regulator System (LP)	NG	10	5	8.76	98.457	7.62	750	24	30	60
16	Feed to BOG Compressors	LNG	0.1	-140	43.78	3.200	1.00	3.2	24	150	60

ID	Scenario	Fluid/Gas Type	Pressure (barg)	Temperature (°C)	Volume (m^3)	Flow rate (m^3/s)	Density (kg/m^3)	Mass Flowrate (kg/s)	Pipe Size (inch)	Pipe length (m)	ESD Time (s)
17	HP BOG Compressors and Pipework	LNG	79	5	7.60	0.058	55.40	3.2	10	150	60
18	LP BOG Compressor and Recondenser	LNG	5	20	4.9	0.058	55.40	3.2	8	150	60
19	LNG Tank overfilling scenario	LNG	0.1	-163	n/a	1.667	450	750	16	n/a	60

Notes:

1 - Mass balance is based on 280 MMSCFD natural gas transfer to the power plant. Equivalent to 69.8 kg/s for 100% methane at STP (density 0.761 kg/Sm^3).

2 – Vapour flowrates are stated as Actual m^3/s (Am^3/s).

3 – Volumes stated for scenarios 11, 12 and 13 are for the combined riser, PLEM, subsea pipeline and buried/over ground onshore pipeline.

4 – The scenarios detailed do not include an ESD at the PLEM. This will be considered in a sensitivity analysis and will reduce the isolated volumes for scenarios 11, 12 and 13.

- The LNG and LNG Boil Off Gas (BOG) are modelled using methane. The initial temperature of a release is set to -163 ºC for LNG streams and -140 ºC for LNG BOG streams. Process conditions are given Table 2.6 above.
- The gas fraction will be modelled based on the following:
    - Methane: 85.00mol% minimum
    - Ethane: 15.00 mol% maximum
    - Propane: 5.00 mol% maximum
    - Butanes: 2.50 mol% maximum
    - Pentanes and heavier: 0.25 mol% maximum
    - Nitrogen: 1.0 mol% maximum

The ESD response times are assumed to be 1 minute (60 seconds) in Ref. /2/. The release rates and durations are modelled as follows:

1. Rupture: The total volume released from pipe diameter in a specified time (ESD or 10 min.) with flow rate and pressure as specified in process conditions table.
2. Hole: A leak from a 10 % of nominal diameter hole during specified time (ESD or 10 min.) with flow rate and pressure as specified in process conditions table.

- Releases from piping are assumed to be 1 meter above main deck of FSRU, except the offloading arm/hose(s) which are assumed to be at 5 meters above deck.
- Process releases onboard the FSRU is assumed to be collected and leak to a cryogenic spill collection system on the FSRU surface.

Consequences will calculate distances for various types of hazards such as gas dispersion, radiation, and overpressure. Gas dispersion has been modelled in order to investigate the distances that the lower flammability limits (LFL) (volume concentration value 5 percent), upper flammability limit (UFL), and ½ LFL can reach from the release point, Ref. /1/.

The distances to safe levels of radiant heat flux values will be used in the risk calculations for fatalities. The thermal radiation from fires could damage the property, expose personnel and the public. NFPA 59A [3] and OGP [6] are used as guidance for the thermal radiation criteria which are listed in the following table. Refer to QRA Methodology for more details. The effect zones of the thermal radiation of 32, 12.5, and 5 kW/m^2 are modeled in the study. The heat radiation of 12.5 kW/m2 will be used as the fatality limit in this study, i.e. a heat radiation greater than 12.5 kw/m^2 is fatal for persons present inside an exposed area.

Table 2.7 - Heat radiation levels to the public per NFPA 59A and OGP [2,3]

Permissible Design level (kW/m2)	Exposure
5	• At least 10 persons would suffer second-degree skin burns on at least 10% of their bodies within 30 seconds of exposure to the fire. Maximum Modified Dosage Unit is 500 ((kW/m2)4/3t). • At least one person inside the building would suffer second-degree skin burns on at least 10% of the body within 30 seconds of exposure to the fire. Maximum Modified Dosage Unit is 300 ((kW/m2)4/3t) • Impairment of escape routes and survival craft embarkation areas • The nearest point located outside the owner's property line that, at the time of plant siting, is used for outdoor assembly by groups of 50 or more persons, for a fire over an impounding area.
12.5	• Significant chance of fatality for extended exposure. High chance of injury.

	• Extended exposure may cause the temperature of wood to rise to a point where it may be readily ignited by a naked flame. Thin steel with insulation on the side away from the fire may reach a thermal stress level high enough to cause structural failure
32	• Loss of strength of structural steel exposed to the fire to an extent that is primary load-bearing capacity is reduced significantly over the duration of LNG fire being analyzed • Immediate fatality (100% lethality)

Explosion/overpressure

Overpressure/explosion criteria use the blast damage criteria shown in NFPA 59A Table 15.8.4.3. The hazard distances and effect zone to the lower overpressure limit of 5000 N/m^2 (0.05 bar), 15,000 N/m^2 (0.15 bar), 25,000 N/m^2 (0.25 bar) are modeled in the study.

Table 2.8 - Overpressure level per NFPA 59A (Table 15.8.4.3)

NFPA 59A Blast Damage Criteria	Reflected Damage Overpressure (N/m^2)	
	Lower Limit	Upper Limit
Window glass damage	250	4,000
Damage to doors, cladding, and persons	5,000	10,000
Severe structural damage to building	15,000	20,000
Severe injury to people	25,000	50,000*

*complete demolition of building

The overpressure of 15, 000 N/m^2 (0.15bar) will be used as the fatality limit for explosion.

References

1. Exmar, Acajutla LNG Terminal Project Process Flow Diagram, Rev F, 15/01/2018.
2. NFPA 59A, Standard for the Production, Storage, and Handling of LNG, 2016 Edition.
3. OGP, Vulnerability of Humans, report No. 434-14, March 2010.

Client comments/ approval:

Lloyd's Register Energy

Assumption Sheet 6

Sheet No.:	**6**	**Assumption Rev.:**	**1**
Subject:	**QRA**	**Date: April 21, 2016**	
Topic:	**Risk Criteria**		

Assumption Description

The individual risk criterion will be calculated to measure the risk towards the public as a conservative measure early in the project planning phases. The risk criteria for the QRA performed in FEED phase is presented in the following table. Refer to QRA Methodology for more details.

Description	Average Public IR Criteria [per annum]
Intolerable risk	⩾ 10E-4
Tolerable risk, provided risk is ALARP	10E-4 > IR > 10E-6
Broadly acceptable risk	⩽ 10E-6

References

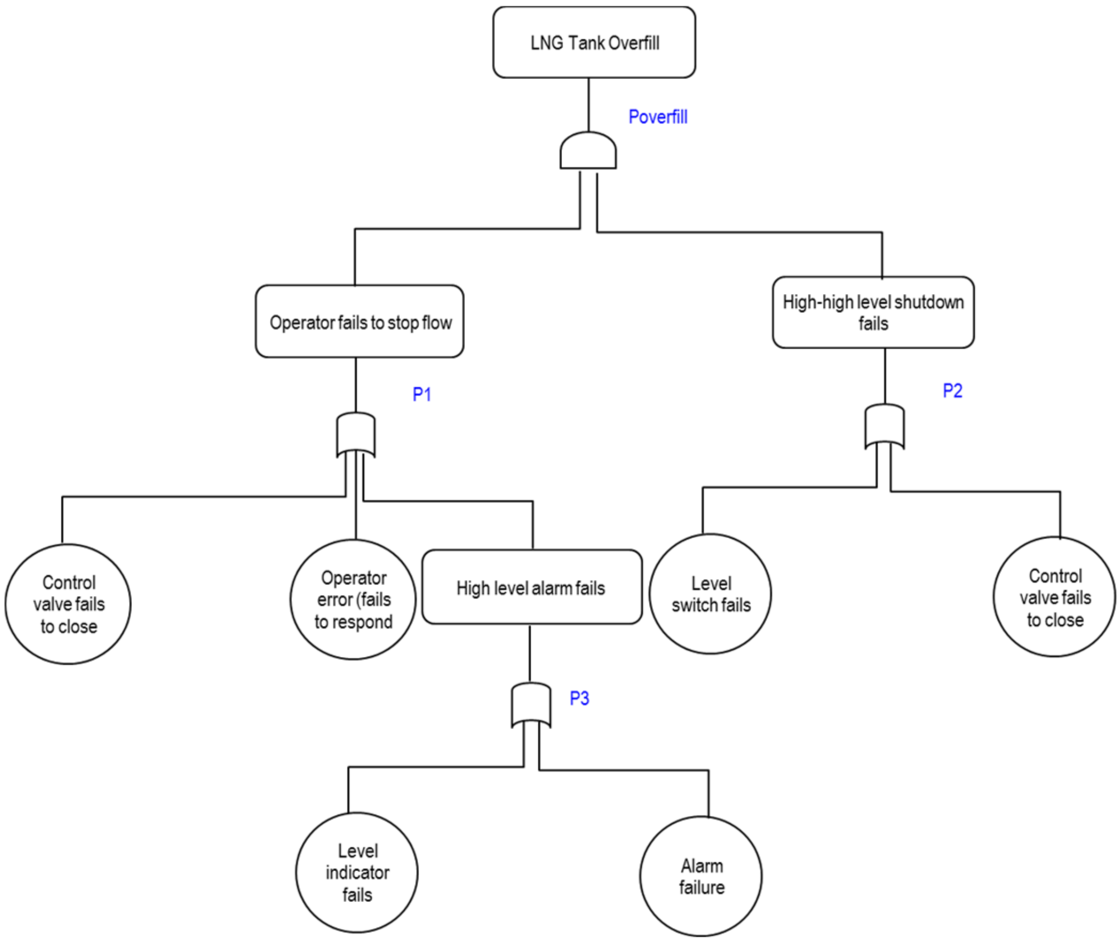
Client comments/ approval:

Assumption Sheet 7

Sheet No.:	7	Assumption Rev.:	1
Subject:	QRA	Date:	June 22, 2017
Topic:	Tank Overfilling Fault Tree Analysis		

Assumption Description

LNG tank overfilling frequency is estimated using the Fault Tree Analysis method as shown below. The Probability of Failure on Demand (PFD) for each node is given in the table below.



Component	PFD
Control valve fails to close	4.16E-03
Operator error (fails to respond to alarm)	1.00E-04
Level indicator fails	4.38E-03
High level alarm fails	4.38E-03

Level switch failure rate	4.38E-03
Solenoid failure rate	4.16E-03

References

1. OREDA Offshore Reliability Data, 5th Edition 2009

Client comments/ approval:

Appendix B

Ignition Probabilities

Table of contents

Page

1. Introduction

This Appendix gives the details on ignition probabilities for Invenergy QRA of the LNG Import Terminal. The three ignition scenarios are characterized by three different ignition probabilities:

- Probabilities of immediate ignition
- Probabilities of delayed ignition inside the LNG import terminal and power plant
- Probabilities of delayed ignition outside the LNG import terminal and power plant.

These ignition probabilities are used as inputs to Phast Risk software where an internal event tree would determine the frequency of each hazard end event for each scenario.

2. Immediate Ignition Probability

The immediate ignition is related to the cause of the leak and the release rate. The probability for immediate ignition is based on the LR data dossier [1]. Table 2.1 shows the probability of immediate ignition based on release rate.

Table 2.1: Immediate Ignition Probability Look up Table

Release Rate (kg/s)	Immediate Ignition Probability
0.05 - 1	0.001
1 - 10	0.001
10 - 30	0.003
> 30	0.03

The immediate ignition probability is determined by rupture and leak release rate of each scenario. The release rate is determined by each scenarios process condition in Phast Risk. Table 2.2 shows the release rate and immediate ignition probability.

Table 2.2: Scenarios Immediate Ignition Probability

ID	Scenario	Rupture Release Rate (kg/s)	Rupture Immediate Ignition Prob.	Leak Release Rate (kg/s)	Leak Immediate Ignition Prob.
1	LNG release from LNGC to FSU offloading hoses (6x)	128	0.03	2.46	0.001
2	Vapor release from LNGC to FSU offloading hoses (2x)	4	0.001	0.03	0.001
3	LNG Release from LNGC storage (250mm & 750mm)	> 30*	0.03	> 30*	0.03
4	LNG release from FSU to FSRU platform loading arms (1x with 1 spare)	192	0.03	12.42	0.003
5	Vapor release from FSU to FSRU platform loading arms (1x)	4	0.001	0.14	0.001
6	LNG Release from FSU storage (250mm & 750mm)	> 30*	0.03	> 30*	0.03
7	LNG feed to vaporizers (2x)	19	0.003	3.39	0.001
8	BOG line to compressors	4	0.001	0.05	0.001
9	Compressors and BOG line from compressors (2 x)	31	0.03	0.60	0.001
10	LNG vaporizers and line from the LNG vaporizers (2 x)	206	0.03	3.44	0.001

ID	Scenario	Rupture Release Rate (kg/s)	Rupture Immediate Ignition Prob.	Leak Release Rate (kg/s)	Leak Immediate Ignition Prob.
11	Total NG pipeline between process equipment shelter & gas send out manifold	367	0.03	5.60	0.001
12	Overfilling of LNG tank during transfer process	192	0.03	12.42	0.003
13	Pipelines (including 2 hose connections from FSRU), pig launcher/receiver, and ESD valve	367	0.03	5.60	0.001
14	Above ground release from the ESD Valve onshore at power plant.	367	0.03	5.60	0.001

*750mm release parameters are in the rupture case column and 250mm release parameters are in the leak case column.

3. Probability of Delayed Ignition Inside LNG Import Terminal and Power Plant)

The delayed ignition is the result of the build-up of a flammable vapor cloud which is ignited by a source remote from the release point. The delayed ignition probability is calculated based on the model of UKOOA look-up correlations and release rate, provided in Oil and Gas Producers (OGP) Risk Assessment Data Directory, [2]. The offshore FPSO gas scenario (24) was chosen to calculate delayed ignition probability. Figure 3.1 gives the overall ignition probability based on release rate. This probability will be subtracted by the immediate ignition probability to determine the delayed ignition probability.

Data Sheet 8: Scenarios 24 – 26

24 – Offshore FPSO Gas

Releases of flammable gases, vapour or liquids significantly above their normal (NAP) boiling poin from within offshore process modules or decks on FPSOs. See curve No. 25"offshore FPSO Gas Wall" if the release is from an area downwind of a transverse wall across the FPSO deck.

Release Rate (kg/s)	Ignition Probability
0.1	0.0010
0.2	0.0011
0.5	0.0012
1	0.0013
2	0.0030
5	0.0092
10	0.0213
20	0.0493
50	0.1500
100	0.1500
200	0.1500
500	0.1500
1000	0.1500

25 – Offshore FPSO Gas Wall

Releases of flammable gases, vapour or liquids significantly above their normal (NAP) boiling poin from within offshore process modules or decks on FPSOs. This correlation applies if the release is from an area downwind of a transverse wall acros the FPSO deck.

Release Rate (kg/s)	Ignition Probability
0.1	0.0010
0.2	0.0015
0.5	0.0038
1	0.0088
2	0.0207
5	0.0639
10	0.1500
20	0.1500
50	0.1500
100	0.1500
200	0.1500
500	0.1500
1000	0.1500

26 – Offshore FPSO Liquid

Releases of flammable liquids that do not have any significant flash fraction (10% or less) if released from within offshore process modules or decks on FPSOs

Release Rate (kg/s)	Ignition Probability
0.1	0.0010
0.2	0.0014
0.5	0.0022
1	0.0030
2	0.0042
5	0.0066
10	0.0092
20	0.0129
50	0.0200
100	0.0280
200	0.0280
500	0.0280
1000	0.0280

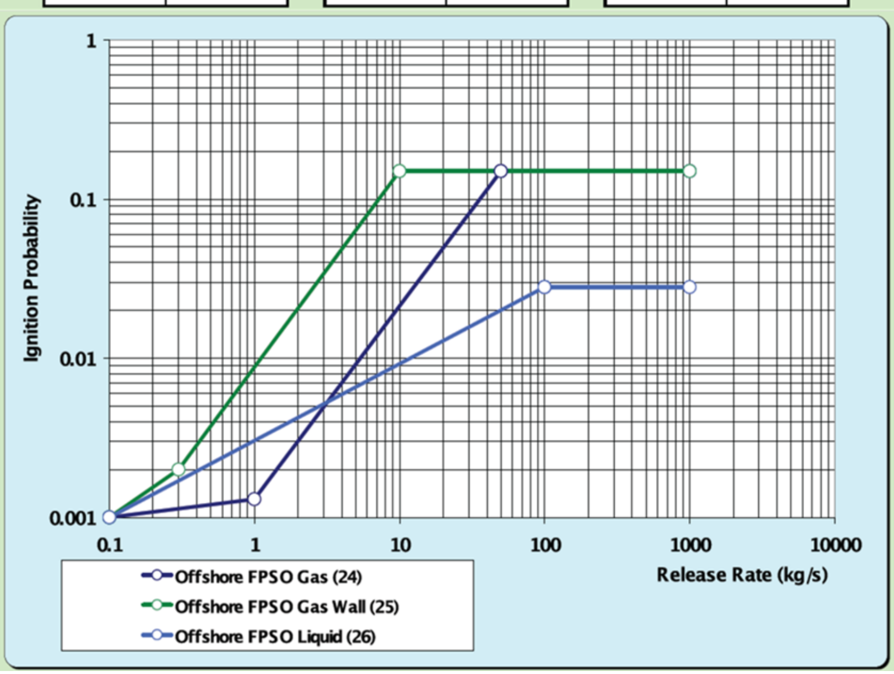


Figure 3.1: OGP Ignition Probability Correlation

Using the correlation in Figure 3.1, the delayed ignition probability is analyzed. Table 3.1 shows the results for the rupture cases and 750mm release of the LNGC and FSU. Table 3.2 shows the results for the leak cases and 250mm release of the LNGC and FSU.

Table 3.1: Rupture Scenarios Delayed Ignition Probability

ID	Scenario	Rupture Release Rate (kg/s)	Rupture Total Ignition Prob.	Rupture Immediate Ignition Prob.	Rupture Delayed Ignition Prob.
1	LNG release from LNGC to FSU offloading hoses (6x)	128	0.1600	0.03	0.130
2	Vapor release from LNGC to FSU offloading hoses (2x)	4	0.0070	0.001	0.006
3	LNG Release from LNGC storage (750mm)	> 30*	0.1600	0.03	0.130
4	LNG release from FSU to FSRU platform loading arms (1x with 1 spare)	192	0.1600	0.03	0.130
5	Vapor release from FSU to FSRU platform loading arms (1x)	4	0.0070	0.001	0.006
6	LNG Release from FSU storage (750mm)	> 30*	0.1600	0.03	0.130
7	LNG feed to vaporizers (2x)	19	0.0500	0.003	0.047
8	BOG line to compressors	4	0.0070	0.001	0.006
9	Compressors and BOG line from compressors (2 x)	31	0.0800	0.03	0.050
10	LNG vaporizers and line from the LNG vaporizers (2 x)	206	0.1600	0.03	0.130
11	Total NG pipeline between process equipment shelter & gas send out manifold	367	0.1600	0.03	0.130
12	Overfilling of LNG tank during transfer process	192	0.1600	0.03	0.130
13	Pipelines (including 2 hose connections from FSRU), pig launcher/receiver, and ESD valve	367	0.1600	0.03	0.130
14	Above ground release from the ESD Valve onshore at power plant.	367	0.1600	0.03	0.130

*750mm release parameters are in the rupture case column .

Table 3.2: Leak Scenarios Delayed Ignition Probability

ID	Scenario	Leak Release Rate (kg/s)	Leak Total Ignition Prob.	Leak Immediate Ignition Prob.	Leak Delayed Ignition Prob.
1	LNG release from LNGC to FSU offloading hoses (6x)	128	0.0030	0.001	0.002
2	Vapor release from LNGC to FSU offloading hoses (2x)	4	0.0010	0.001	0.000
3	LNG Release from LNGC storage (250mm)	> 30*	0.1600	0.03	0.130
4	LNG release from FSU to FSRU platform loading arms (1x with 1 spare)	192	0.0213	0.003	0.018
5	Vapor release from FSU to FSRU platform loading arms (1x)	4	0.0010	0.001	0.000
6	LNG Release from FSU storage (250mm)	> 30*	0.1600	0.03	0.130
7	LNG feed to vaporizers (2x)	19	0.0540	0.001	0.053
8	BOG line to compressors	4	0.0010	0.001	0.000
9	Compressors and BOG line from compressors (2 x)	31	0.0012	0.001	0.000
10	LNG vaporizers and line from the LNG vaporizers (2 x)	206	0.0020	0.001	0.001
11	Total NG pipeline between process equipment shelter & gas send out manifold	367	0.080	0.001	0.079
12	Overfilling of LNG tank during transfer process	192	0.0213	0.003	0.018
13	Pipelines (including 2 hose connections from FSRU), pig launcher/receiver, and ESD valve	367	0.0800	0.001	0.079
14	Above ground release from the ESD Valve onshore at power plant.	367	0.0800	0.001	0.079

* 250mm release parameters are in the leak case column.

4. Probability of Delayed Ignition Outside LNG Import Terminal and Power Plant

A gas cloud originating from the LNG import terminal and power plant that were not ignited within the installation boundary or is dissipated into the air could propagate and be ignited outside the installation boundaries. Phast Risk calculates each release and dispersion scenario in discrete time steps, and if a combustible gas cloud covers an ignition source in a time step, the probability of ignition is calculated according to the formula:

$$P_{i,t} = f_i(1-e^{-\omega_i t})$$

Where,

$P_{i,t}$ Probability of ignition by source *i* in the duration of time step *t*

f_i Operating probability of source *i* (e.g. if the ignition source is only present part of the time)

ω_i Effectiveness factor for ignition source *i*

t Duration of time step.

Assuming LNG and natural gas operating probabilities and effectiveness factor (probability of ignition in 60s) for ignition sources in the Acajutla surrounding area, the calculated delayed ignition probability is 0.20 per 600 meter squared area.

5. References

[1] LR Data Dossier, Appendix F: Ignition probability calculation, 2011.

[2] Oil and Gas Producers (OGP) risk assessment Data directory- Ignition Probability, Report No. 434-6.1, March 2010.

Appendix C

Consequence Results

Table of contents

Page

1 Discharge Results / Vapour Cloud Explosion Results

ID	Scenario	Hole Size (mm)	Flammability Levels	Max Distance for Isolated release (m)				Max Distance for unisolated release (m)			
				F1.5 m/s	D3 m/s	D5 m/s	D9 m/s	F1.5 m/s	D3 m/s	D5 m/s	D9 m/s
1	LNGC Piping up to hose manifold	600	UFL	41.0	120.6	146.3	129.6	92.8	200.5	265.1	271.7
			LFL	1127.3	466.6	425.9	344.0	2194.2	1006.8	953.4	798.1
			½ LFL	2614.5	821.1	702.5	552.9	6327.3	2013.4	1707.1	1351.8
		200	UFL	71.3	166.7	222.9	207.3	53.6	141.6	178.3	152.3
			LFL	1799.1	787.5	743.5	604.0	1440.5	608.1	556.4	439.4
			½ LFL	4767.0	1503.2	1295.3	1008.8	3541.9	1109.2	942.2	721.3
		50	UFL	50.6	62.5	58.5	37.6	48.8	62.5	58.4	37.5
			LFL	573.0	182.9	152.7	106.6	571.0	182.5	152.2	106.3
			½ LFL	1117.0	299.4	242.9	173.6	1112.9	298.7	242.1	173.0
		25	UFL	58.0	37.0	31.2	18.6	58.0	37.0	31.2	18.6
			LFL	355.0	97.9	78.6	54.4	356.6	97.9	78.9	54.5
			½ LFL	640.2	154.9	122.4	86.4	642.0	155.1	122.7	86.4
2	LNGC/FSRU transfer line (6x)	200	UFL	33.3	103.9	116.1	91.5	35.7	110.0	123.0	92.8
			LFL	948.8	368.5	326.7	251.0	1025.4	401.4	354.9	267.3
			½ LFL	2087.6	632.9	531.4	403.8	2302.5	700.1	585.4	436.2
		67	UFL	54.8	53.8	49.2	31.5	54.3	54.5	49.5	30.8
			LFL	490.1	150.9	124.5	88.2	502.9	153.8	126.6	88.4
			½ LFL	934.0	244.4	197.1	141.3	957.2	249.5	200.9	142.5
		50	UFL	57.1	43.2	37.8	23.1	57.2	43.6	38.0	22.9

ID	Scenario	Hole Size (mm)	Flammability Levels	Max Distance for Isolated release (m)				Max Distance for unisolated release (m)			
				F1.5 m/s	D3 m/s	D5 m/s	D9 m/s	F1.5 m/s	D3 m/s	D5 m/s	D9 m/s
			LFL	405.1	116.5	95.2	66.2	409.3	118.0	96.2	66.4
			½ LFL	745.8	186.1	148.7	104.9	756.1	188.8	150.5	105.8
		25	UFL	56.2	24.5	19.6	11.6	56.1	24.5	19.6	11.6
			LFL	252.0	62.8	49.6	33.6	253.2	63.0	49.7	33.7
			½ LFL	433.0	96.8	76.3	53.6	434.7	97.0	76.4	53.7
3	Inlet line to FSRU storage tank	600	UFL	58.0	146.4	196.7	191.8	96.5	203.3	275.4	287.8
			LFL	1503.7	656.2	618.3	521.4	2254.1	1029.2	1004.0	857.3
			½ LFL	3787.1	1206.3	1049.6	844.0	6533.7	2072.5	1815.3	1455.2
		200	UFL	41.4	121.0	141.7	109.5	35.7	110.0	122.9	92.8
			LFL	1160.9	467.7	415.5	316.5	1028.7	402.0	354.7	268.2
			½ LFL	2690.6	824.8	693.2	516.7	2305.1	700.7	585.3	437.1
		50	UFL	57.3	43.4	37.9	22.8	57.2	43.6	38.0	22.8
			LFL	408.8	117.7	96.0	66.3	409.2	118.0	96.1	66.4
			½ LFL	754.8	188.4	150.4	105.7	755.6	188.7	150.5	105.8
		25	UFL	56.2	24.6	19.7	11.6	56.2	24.6	19.7	11.6
			LFL	253.5	63.3	49.9	33.8	253.5	63.3	49.9	33.8
			½ LFL	435.7	97.4	76.7	53.8	435.7	97.4	76.7	53.8
4	LNGC Storage Tank failure	750	UFL	-	-	-	-	66.6	161.1	212.6	196.6
			LFL	-	-	-	-	1716.7	749.4	697.2	568.0
			½ LFL	-	-	-	-	4468.5	1410.3	1209.9	944.5
		250	UFL	-	-	-	-	28.8	89.3	92.1	65.3
			LFL	-	-	-	-	819.5	295.8	255.7	187.0
			½ LFL	-	-	-	-	1728.3	501.9	413.8	303.4

ID	Scenario	Hole Size (mm)	Flammability Levels	Max Distance for Isolated release (m)				Max Distance for unisolated release (m)			
				F1.5 m/s	D3 m/s	D5 m/s	D9 m/s	F1.5 m/s	D3 m/s	D5 m/s	D9 m/s
5	FSRU Storage Tank failure	750	UFL	-	-	-	-	66.6	161.1	212.6	196.6
			LFL	-	-	-	-	1716.7	749.4	697.2	568.0
			½ LFL	-	-	-	-	4468.5	1410.3	1209.9	944.5
		250	UFL	-	-	-	-	28.8	89.3	92.1	65.3
			LFL	-	-	-	-	819.5	295.8	255.7	187.0
			½ LFL	-	-	-	-	1728.3	501.9	413.8	303.4
6	Common header from FSRU Cargo Pumps)	250	UFL	58.6	147.1	198.7	194.7	60.5	149.6	197.1	178.0
			LFL	1518.8	664.8	628.1	530.3	1592.9	682.8	632.3	504.7
			½ LFL	3841.7	1226.5	1067.1	857.9	4039.8	1269.6	1083.6	838.1
		83	UFL	37.1	83.7	84.5	59.8	32.7	83.0	83.7	57.6
			LFL	765.2	270.2	229.3	166.5	756.8	266.5	228.2	164.4
			½ LFL	1585.6	453.0	369.5	270.5	1565.8	446.7	367.1	266.6
		25	UFL	58.1	34.4	28.7	17.1	57.8	34.5	28.8	17.1
			LFL	334.7	90.0	73.0	49.9	335.4	9.2	73.2	50.0
			½ LFL	597.3	142.4	112.8	79.3	598.9	142.8	113.0	79.5
7	LNG from Booster Pumps to Vaporizers (4x)	150	UFL	28.0	85.6	89.8	69.2	45.5	128.7	155.2	124.0
			LFL	767.4	277.1	241.6	185.0	1266.1	522.3	466.9	358.6
			½ LFL	1599.9	465.1	388.9	293.9	3000.8	932.3	780.9	589.0
		50	UFL	29.1	90.7	96.8	72.8	30.1	93.4	98.1	70.2
			LFL	826.9	303.8	266.4	199.4	858.5	317.1	274.3	200.9
			½ LFL	1751.9	514.2	429.1	320.6	1835.1	538.7	445.3	327.7
		25	UFL	52.8	58.5	54.8	35.6	51.8	59.2	55.1	34.7
			LFL	535.6	168.2	140.4	99.7	547.2	170.9	142.4	99.7

ID	Scenario	Hole Size (mm)	Flammability Levels	Max Distance for Isolated release (m)				Max Distance for unisolated release (m)			
				F1.5 m/s	D3 m/s	D5 m/s	D9 m/s	F1.5 m/s	D3 m/s	D5 m/s	D9 m/s
			½ LFL	1029.9	274.0	222.0	159.7	1054.3	279.7	226.2	161.0
8	NG from vaporiser to NG header (four parallel trains) Includes Vaporizer	300	UFL	87.0	86.7	87.7	89.7	87.0	86.7	87.7	89.7
			LFL	428.1	434.0	452.8	485.3	428.0	434.0	452.8	485.3
			½ LFL	916.6	940.5	1004.4	1121.9	916.6	940.5	1004.4	1121.9
		100	UFL	24.8	24.9	25.0	25.2	24.8	24.9	25.0	25.2
			LFL	132.4	134.6	138.7	146.9	132.4	134.6	138.7	146.9
			½ LFL	292.0	302.4	321.2	356.6	292.0	302.4	321.2	356.6
		50	UFL	11.5	11.4	11.4	11.2	11.5	11.4	11.4	11.2
			LFL	60.4	61.6	63.3	65.9	60.4	61.6	63.3	65.9
			½ LFL	137.0	142.6	150.4	164.6	137.0	142.6	150.4	164.6
		25	UFL	5.6	5.6	5.6	5.5	5.6	5.6	5.6	5.5
			LFL	27.3	27.5	27.6	27.5	27.3	27.5	27.6	27.5
			½ LFL	62.5	64.8	67.2	70.7	62.5	64.8	67.2	70.7
		10	UFL	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2
			LFL	9.7	9.5	9.3	8.9	9.7	9.5	9.3	89
			½ LFL	21.3	21.1	20.3	18.4	21.3	21.1	20.3	18.4
9	Combined NG Export Header	300	UFL	87.0	86.7	87.7	89.7	87.0	86.7	87.7	89.7
			LFL	428.1	434.1	452.8	485.3	428.1	434.1	452.8	485.3
			½ LFL	916.6	940.5	1004.4	1121.9	916.6	940.5	1004.4	1121.9
		100	UFL	24.8	24.9	25.0	25.2	24.8	24.9	25.0	25.2
			LFL	132.4	134.6	138.7	146.9	132.4	134.6	138.7	146.9
			½ LFL	292.0	302.4	321.2	356.6	292.0	302.4	321.2	356.6
		50	UFL	11.5	11.4	11.4	11.2	11.5	11.4	11.4	11.2

ID	Scenario	Hole Size (mm)	Flammability Levels	Max Distance for Isolated release (m)				Max Distance for unisolated release (m)			
				F1.5 m/s	D3 m/s	D5 m/s	D9 m/s	F1.5 m/s	D3 m/s	D5 m/s	D9 m/s
			LFL	60.4	61.6	63.3	65.9	60.4	61.6	63.3	65.9
			½ LFL	137.0	142.6	150.4	164.6	137.0	142.6	150.4	164.6
		25	UFL	5.6	5.6	5.6	5.5	5.6	5.6	5.6	5.5
			LFL	27.3	27.5	27.6	27.5	27.3	27.5	27.6	27.5
			½ LFL	62.5	64.8	67.2	70.7	62.5	64.8	67.2	70.7
10	Riser Failure and associated pipework	300	UFL	200.7	204.8	214.5	240.6	200.7	204.8	214.5	240.6
			LFL	687.0	720.8	771.6	1478.9	687.0	720.8	771.6	1478.9
			½ LFL	1204.0	1337.1	1362.5	2849.9	1167.4	1281.2	1362.5	2849.9
		100	UFL	69.4	69.3	73.1	79.6	69.4	69.3	73.1	79.6
			LFL	283.6	308.1	408.1	499.1	283.6	308.1	408.1	499.1
			½ LFL	530.1	615.2	858.1	960.1	530.1	615.2	858.1	960.1
		50	UFL	35.2	34.8	36.5	39.6	35.2	34.8	36.5	39.6
			LFL	156.6	181.6	203.6	248.3	156.6	181.6	203.6	248.3
			½ LFL	305.1	380.0	452.6	500.5	305.1	380.0	452.6	500.5
		25	UFL	17.6	17.4	18.2	19.7	17.6	17.4	18.2	19.7
			LFL	83.0	90.7	101.2	123.7	83.0	90.7	101.2	123.7
			½ LFL	168.2	198.5	236.0	261.7	168.2	198.5	236.0	261.7
		10	UFL	7.1	7.0	7.3	7.9	7.1	7.0	7.3	7.9
			LFL	34.4	36.0	40.2	48.9	34.4	36.0	40.2	48.9
			½ LFL	73.1	82.8	98.3	110.8	73.1	82.8	98.3	110.8
11	Subsea Pipeline and PLEM	600	UFL	390.8	403.1	330.8	364.0	390.8	403.1	330.8	364.0
			LFL	1187.7	1196.4	1511.5	1886.0	1187.7	1183.9	1511.5	1886.0
			½ LFL	1778.0	1915.1	3100.3	3977.6	1718.1	1955.3	3514.3	4560.4

ID	Scenario	Hole Size (mm)	Flammability Levels	Max Distance for Isolated release (m)				Max Distance for unisolated release (m)			
				F1.5 m/s	D3 m/s	D5 m/s	D9 m/s	F1.5 m/s	D3 m/s	D5 m/s	D9 m/s
		100	UFL	69.4	69.3	73.1	79.6	69.4	69.3	73.1	79.6
			LFL	283.6	308.1	408.1	499.1	283.6	308.1	408.1	499.1
			½ LFL	530.1	615.2	858.1	960.1	530.1	615.2	858.1	960.1
		50	UFL	35.2	34.8	36.5	39.6	35.2	34.8	36.5	39.6
			LFL	156.6	181.6	203.6	248.3	156.6	181.6	203.6	248.3
			½ LFL	305.1	379.9	452.6	500.5	305.1	379.9	452.6	500.5
		10	UFL	7.1	7.0	7.3	7.9	7.1	7.0	7.3	7.9
			LFL	34.4	36.0	40.2	48.9	34.4	36.0	40.2	48.9
			½ LFL	73.1	82.8	98.3	110.8	73.1	82.8	98.3	110.8
12	Onshore gas pipeline (buried)	600	UFL	45.3	3.7	5.2	6.9	45.3	3.7	5.2	6.9
			LFL	3025.4	41.6	49.5	56.2	3025.4	41.6	49.5	56.2
			½ LFL	5464.7	108.8	125.2	145.0	6673.9	108.8	125.2	145.0
		200	UFL	0.9	1.1	1.5	2.0	0.9	1.1	1.5	2.0
			LFL	30.3	12.5	15.1	17.5	30.3	12.5	15.1	17.5
			½ LFL	442.4	33.8	38.6	44.2	442.4	33.8	38.6	44.2
		13	UFL	0.0	0.0	0.1	0.1	0.0	0.0	0.1	0.1
			LFL	0.4	0.6	0.8	0.9	0.4	0.6	0.8	0.9
			½ LFL	1.3	1.8	2.0	2.3	1.3	1.8	2.0	2.3
13	Onshore gas pipeline (above ground)	600	UFL	154.1	154.8	155.0	155.3	154.1	154.8	155.0	155.3
			LFL	816.5	856.4	894.0	968.8	816.5	856.4	894.0	968.8
			½ LFL	1757.4	1890.4	2054.7	2331.6	1757.4	1890.4	2054.7	2331.6
		100	UFL	22.2	21.9	21.4	20.6	22.2	21.9	21.4	20.6
			LFL	10.1	99.2	94.6	84.8	10.1	99.2	94.6	84.8

ID	Scenario	Hole Size (mm)	Flammability Levels	Max Distance for Isolated release (m)				Max Distance for unisolated release (m)			
				F1.5 m/s	D3 m/s	D5 m/s	D9 m/s	F1.5 m/s	D3 m/s	D5 m/s	D9 m/s
			½ LFL	243.1	245.0	245.5	237.6	243.1	245.0	245.5	237.6
		50	UFL	11.2	11.0	10.9	10.6	11.2	11.0	10.9	10.6
			LFL	46.5	42.8	39.8	35.6	46.5	42.8	39.8	35.6
			½ LFL	104.2	94.9	84.9	67.4	104.2	94.9	84.9	67.4
		25	UFL	5.6	5.6	5.5	5.4	5.6	5.6	5.5	5.4
			LFL	23.3	22.2	20.9	19.2	23.3	22.2	20.9	19.2
			½ LFL	44.3	39.2	35.4	30.9	44.3	39.2	35.4	30.9
14	Gas Regulator System (HP)	600	UFL	205.7	200.1	202.8	208.6	205.7	200.1	202.8	208.6
			LFL	997.7	1010.2	1071.7	1191.5	997.7	1010.2	1071.7	1191.5
			½ LFL	1970.2	2080.6	2299.7	2654.6	2036.0	2146.9	2386.0	2654.6
		200	UFL	59.7	57.2	57.6	58.3	59.7	57.2	57.6	58.3
			LFL	326.8	320.7	337.9	373.1	326.8	320.7	337.9	373.1
			½ LFL	708.3	733.3	813.8	900.3	708.3	733.3	813.8	900.3
		50	UFL	11.3	11.0	10.7	10.2	11.3	11.0	10.7	10.2
			LFL	66.0	63.7	64.8	66.7	66.0	63.7	64.8	66.7
			½ LFL	156.9	156.6	168.0	190.3	156.9	156.6	168.0	190.3
		25	UFL	5.5	5.4	5.3	5.1	5.5	5.4	5.3	5.1
			LFL	27.8	26.6	25.8	24.1	27.8	26.6	25.8	24.1
			½ LFL	68.1	66.6	68.3	69.8	68.1	66.6	68.3	69.8
15	Gas Regulator System (LP)	600	UFL	60.9	58.0	58.4	59.4	60.9	58.0	58.4	59.4
			LFL	315.4	310.3	323.8	347.2	315.4	310.3	323.8	347.2
			½ LFL	666.3	680.7	725.6	809.2	666.3	680.7	725.6	809.2
		200	UFL	15.9	15.5	15.3	14.7	15.9	15.5	15.3	14.7

ID	Scenario	Hole Size (mm)	Flammability Levels	Max Distance for Isolated release (m)				Max Distance for unisolated release (m)			
				F1.5 m/s	D3 m/s	D5 m/s	D9 m/s	F1.5 m/s	D3 m/s	D5 m/s	D9 m/s
			LFL	95.1	92.3	94.8	99.3	95.1	92.3	94.8	99.3
			½ LFL	220.9	221.6	239.5	275.0	220.9	221.6	239.5	275.0
		50	UFL	3.7	3.6	3.5	3.4	3.7	3.6	3.5	3.4
			LFL	17.1	16.1	15.0	13.2	17.1	16.1	15.0	13.2
			½ LFL	41.9	40.1	39.3	36.7	41.9	40.1	39.3	36.7
		25	UFL	1.9	1.8	1.8	1.8	1.9	1.8	1.8	1.8
			LFL	7.8	7.3	6.7	6.0	7.8	7.3	6.7	6.0
			½ LFL	16.8	14.9	13.0	10.3	16.8	14.9	13.0	10.3
16	Feed to BOG Compressors	600	UFL	28.8	29.4	29.8	30.4	28.8	29.4	29.8	30.4
			LFL	121.7	130.1	137.0	151.2	121.7	130.1	137.0	151.2
			½ LFL	208.3	236.3	259.0	296.9	208.3	236.3	259.0	296.9
		200	UFL	8.3	8.2	8.0	7.6	8.3	8.2	8.0	7.6
			LFL	40.6	41.9	41.8	39.2	40.6	41.9	41.8	39.2
			½ LFL	85.9	97.5	103.6	106.6	85.9	97.5	103.6	106.6
		50	UFL	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1
			LFL	8.1	7.8	7.4	6.8	8.1	7.8	7.4	6.8
			½ LFL	17.0	13.9	12.2	10.9	17.0	13.9	12.2	10.9
		25	UFL	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
			LFL	4.1	4.2	4.0	3.8	4.1	4.2	4.0	3.8
			½ LFL	7.4	7.3	6.8	6.2	7.4	7.3	6.8	6.2
17	HP BOG Compressors and Pipework	250	UFL	70.7	70.4	71.2	72.8	70.7	70.4	71.2	72.8
			LFL	331.8	334.5	343.4	361.7	331.8	334.5	343.4	361.7
			½ LFL	670.2	678.2	709.3	770.2	670.2	678.2	709.3	770.2

ID	Scenario	Hole Size (mm)	Flammability Levels	Max Distance for Isolated release (m)				Max Distance for unisolated release (m)			
				F1.5 m/s	D3 m/s	D5 m/s	D9 m/s	F1.5 m/s	D3 m/s	D5 m/s	D9 m/s
		100	UFL	24.8	24.8	25.0	25.2	24.8	24.8	25.0	25.2
			LFL	127.7	129.6	133.5	140.5	127.7	129.6	133.5	140.5
			½ LFL	276.1	285.1	301.1	331.0	276.1	285.1	301.1	331.0
		83	UFL	20.1	20.1	20.1	20.2	20.1	20.1	20.1	20.2
			LFL	104.1	105.8	109.0	114.7	104.1	105.8	109.0	114.7
			½ LFL	227.9	235.9	249.2	273.7	227.9	235.9	249.2	273.7
		50	UFL	11.4	11.4	11.3	11.1	11.4	11.4	11.3	11.1
			LFL	59.0	60.0	61.5	64.1	59.0	60.0	61.5	64.1
			½ LFL	132.8	138.2	145.5	158.7	132.8	138.2	145.5	158.7
		25	UFL	5.6	5.6	5.5	5.5	5.6	5.6	5.5	5.5
			LFL	26.8	27.0	27.0	26.8	26.8	27.0	27.0	26.8
			½ LFL	61.2	63.5	65.8	69.0	61.2	63.5	65.8	69.0
18	LP BOG Compressor and Recondenser	200	UFL	11.3	11.2	11.1	11.0	11.3	11.2	11.1	11.0
			LFL	59.1	60.0	61.5	64.0	59.1	60.0	61.5	64.0
			½ LFL	128.0	131.3	136.7	147.0	128.0	131.3	136.7	147.0
		100	UFL	5.5	5.5	5.4	5.4	5.5	5.5	5.4	5.4
			LFL	26.9	27.1	27.1	26.9	26.9	27.1	27.1	26.9
			½ LFL	60.6	62.3	64.2	67.1	60.6	62.3	64.2	67.1
		83	UFL	4.5	4.5	4.5	2.5	4.5	4.5	4.5	2.5
			LFL	21.7	21.7	21.5	20.8	21.7	21.7	21.5	20.8
			½ LFL	49.1	50.4	51.6	52.7	49.1	50.4	51.6	52.7
		50	UFL	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7
			LFL	12.2	11.9	11.5	10.7	12.2	11.9	11.5	10.7

ID	Scenario	Hole Size (mm)	Flammability Levels	Max Distance for Isolated release (m)				Max Distance for unisolated release (m)			
				F1.5 m/s	D3 m/s	D5 m/s	D9 m/s	F1.5 m/s	D3 m/s	D5 m/s	D9 m/s
			½ LFL	27.4	27.5	27.1	25.6	27.4	27.5	27.1	25.6
		25	UFL	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
			LFL	5.9	5.9	5.8	5.6	5.9	5.9	5.8	5.6
			½ LFL	12.2	11.5	10.8	10.1	12.2	11.5	10.8	10.1
		10	UFL	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
			LFL	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
			½ LFL	4.8	4.8	4.6	4.4	4.8	4.8	4.6	4.4
19	LNG Tank overfilling scenario	NA	UFL	85.2	409.3	413.2	201.8	76.4	376.0	430.4	182.7
			LFL	1240.6	790.1	816.4	769.1	1221.2	751.2	831.5	778.8
			½ LFL	3193.5	1195.0	1163.4	1039.1	3103.4	1210.9	1212.0	1062.7

2 Jet Fire Results

ID	Scenario	Hole Size (mm)	Radiation Levels (kW/m²)	Max Distance for Isolated release (m)				Max Distance for unisolated release (m)			
				F1.5 m/s	D3 m/s	D5 m/s	D9 m/s	F1.5 m/s	D3 m/s	D5 m/s	D9 m/s
1	LNGC Piping up to hose manifold	600	5.0	0.9	1.0	1.0	1.0	0.9	1.0	1.0	1.0
			12.5	NR	NR	NR	NR	NR	NR	NR	NR
			32.0	NR	NR	NR	NR	NR	NR	NR	NR
		200	5.0	NR	NR	NR	NR	NR	NR	NR	NR
			12.5	NR	NR	NR	NR	NR	NR	NR	NR
			32.0	NR	NR	NR	NR	NR	NR	NR	NR
		50	5.0	NR	NR	NR	NR	NR	NR	NR	NR
			12.5	NR	NR	NR	NR	NR	NR	NR	NR
			32.0	NR	NR	NR	NR	NR	NR	NR	NR
		25	5.0	NR	NR	NR	NR	NR	NR	NR	NR
			12.5	NR	NR	NR	NR	NR	NR	NR	NR
			32.0	NR	NR	NR	NR	NR	NR	NR	NR
2	LNGC/FSRU transfer line (6x)	200	5.0	NR	NR	NR	NR	NR	NR	NR	NR
			12.5	NR	NR	NR	NR	NR	NR	NR	NR
			32.0	NR	NR	NR	NR	NR	NR	NR	NR
		67	5.0	NR	NR	NR	NR	NR	NR	NR	NR
			12.5	NR	NR	NR	NR	NR	NR	NR	NR
			32.0	NR	NR	NR	NR	NR	NR	NR	NR
		50	5.0	NR	NR	NR	NR	NR	NR	NR	NR
			12.5	NR	NR	NR	NR	NR	NR	NR	NR
			32.0	NR	NR	NR	NR	NR	NR	NR	NR
		25	5.0	NR	NR	NR	NR	NR	NR	NR	NR

ID	Scenario	Hole Size (mm)	Radiation Levels (kW/m²)	Max Distance for Isolated release (m)				Max Distance for unisolated release (m)			
				F1.5 m/s	D3 m/s	D5 m/s	D9 m/s	F1.5 m/s	D3 m/s	D5 m/s	D9 m/s
			12.5	NR	NR	NR	NR	NR	NR	NR	NR
			32.0	NR	NR	NR	NR	NR	NR	NR	NR
3	Inlet line to FSRU storage tank	600	5.0	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
			12.5	NR	NR	NR	NR	NR	NR	NR	NR
			32.0	NR	NR	NR	NR	NR	NR	NR	NR
		200	5.0	NR	NR	NR	NR	NR	NR	NR	NR
			12.5	NR	NR	NR	NR	NR	NR	NR	NR
			32.0	NR	NR	NR	NR	NR	NR	NR	NR
		50	5.0	NR	NR	NR	NR	NR	NR	NR	NR
			12.5	NR	NR	NR	NR	NR	NR	NR	NR
			32.0	NR	NR	NR	NR	NR	NR	NR	NR
		25	5.0	NR	NR	NR	NR	NR	NR	NR	NR
			12.5	NR	NR	NR	NR	NR	NR	NR	NR
			32.0	NR	NR	NR	NR	NR	NR	NR	NR
4	LNGC Storage Tank failure	750	5.0	NR	NR	NR	NR	NR	NR	NR	NR
			12.5	NR	NR	NR	NR	NR	NR	NR	NR
			32.0	NR	NR	NR	NR	NR	NR	NR	NR
		250	5.0	NR	NR	NR	NR	NR	NR	NR	NR
			12.5	NR	NR	NR	NR	NR	NR	NR	NR
			32.0	NR	NR	NR	NR	NR	NR	NR	NR
5	FSRU Storage Tank failure	750	5.0	NR	NR	NR	NR	NR	NR	NR	NR
			12.5	NR	NR	NR	NR	NR	NR	NR	NR
			32.0	NR	NR	NR	NR	NR	NR	NR	NR

ID	Scenario	Hole Size (mm)	Radiation Levels (kW/m^2)	Max Distance for Isolated release (m)				Max Distance for unisolated release (m)			
				F1.5 m/s	D3 m/s	D5 m/s	D9 m/s	F1.5 m/s	D3 m/s	D5 m/s	D9 m/s
		250	5.0	NR	NR	NR	NR	NR	NR	NR	NR
			12.5	NR	NR	NR	NR	NR	NR	NR	NR
			32.0	NR	NR	NR	NR	NR	NR	NR	NR
6	Common header from FSRU Cargo Pumps)	250	5.0	0.5	0.6	0.7	0.7	0.5	0.6	0.7	0.7
			12.5	NR	NR	NR	NR	NR	NR	NR	NR
			32.0	NR	NR	NR	NR	NR	NR	NR	NR
		83	5.0	NR	NR	NR	NR	NR	NR	NR	NR
			12.5	NR	NR	NR	NR	NR	NR	NR	NR
			32.0	NR	NR	NR	NR	NR	NR	NR	NR
		25	5.0	NR	NR	NR	NR	NR	NR	NR	NR
			12.5	NR	NR	NR	NR	NR	NR	NR	NR
			32.0	NR	NR	NR	NR	NR	NR	NR	NR
7	LNG from Booster Pumps to Vaporizers (4x)	150	5.0	NR	NR	NR	NR	NR	NR	NR	NR
			12.5	NR	NR	NR	NR	NR	NR	NR	NR
			32.0	NR	NR	NR	NR	NR	NR	NR	NR
		50	5.0	NR	NR	NR	NR	NR	NR	NR	NR
			12.5	NR	NR	NR	NR	NR	NR	NR	NR
			32.0	NR	NR	NR	NR	NR	NR	NR	NR
		25	5.0	NR	NR	NR	NR	NR	NR	NR	NR
			12.5	NR	NR	NR	NR	NR	NR	NR	NR
			32.0	NR	NR	NR	NR	NR	NR	NR	NR
8	NG from vaporiser to NG	300	5.0	445.1	449.3	450.3	439.1	445.1	449.3	450.3	439.1
			12.5	331.5	340.2	347.8	353.6	331.5	340.2	347.8	353.6

ID	Scenario	Hole Size (mm)	Radiation Levels (kW/m²)	Max Distance for Isolated release (m)				Max Distance for unisolated release (m)			
				F1.5 m/s	D3 m/s	D5 m/s	D9 m/s	F1.5 m/s	D3 m/s	D5 m/s	D9 m/s
	header (four parallel trains) Includes Vaporizer		32.0	263.2	266.9	269.5	294.5	263.2	266.9	269.5	294.5
		100	5.0	165.2	165.6	165.3	162.0	165.2	165.6	165.3	162.0
			12.5	127.5	130.1	132.8	136.4	127.5	130.1	132.8	136.4
			32.0	99.4	101.3	107.6	118.2	99.4	101.3	107.6	118.2
		50	5.0	88.6	89.0	89.4	89.8	88.6	89.0	89.4	89.8
			12.5	70.8	72.3	74.2	77.5	70.8	72.3	74.2	77.5
			32.0	55.9	57.7	61.9	68.5	55.9	57.7	61.9	68.5
		25	5.0	45.7	46.0	46.3	46.8	45.7	46.0	46.3	46.8
			12.5	37.5	38.3	39.3	41.1	37.5	38.3	39.3	41.1
			32.0	30.3	31.2	32.9	36.7	30.3	31.2	32.9	36.7
		10	5.0	17.7	17.8	17.8	17.8	17.7	17.8	17.8	17.8
			12.5	14.8	15.1	15.3	15.8	14.8	15.1	15.3	15.8
			32.0	12.0	12.3	10.3	13.4	12.0	12.3	10.3	13.4
9	Combined NG Export Header	300	5.0	445.1	449.3	450.3	439.1	445.1	449.3	450.3	439.1
			12.5	331.5	340.2	347.8	353.6	331.5	340.2	347.8	353.6
			32.0	263.2	269.5	269.5	294.5	263.2	269.5	269.5	294.5
		100	5.0	165.2	165.6	165.3	162.0	165.2	165.6	165.3	162.0
			12.5	127.5	130.1	132.8	136.4	127.5	130.1	132.8	136.4
			32.0	99.4	101.3	107.6	118.2	99.4	101.3	107.6	118.2
		50	5.0	88.6	89.0	89.4	89.8	88.6	89.0	89.4	89.8
			12.5	70.8	72.3	74.2	77.5	70.8	72.3	74.2	77.5
			32.0	55.9	57.7	61.9	68.5	55.9	57.7	61.9	68.5
		25	5.0	45.7	46.0	46.3	46.8	45.7	46.0	46.3	46.8

ID	Scenario	Hole Size (mm)	Radiation Levels (kW/m²)	Max Distance for Isolated release (m)				Max Distance for unisolated release (m)			
				F1.5 m/s	D3 m/s	D5 m/s	D9 m/s	F1.5 m/s	D3 m/s	D5 m/s	D9 m/s
			12.5	37.5	38.3	39.3	41.1	37.5	38.3	39.3	41.1
			32.0	30.3	31.2	32.9	36.7	30.3	31.2	32.9	36.7
10	Riser Failure and associated pipework	300	5.0	299.0	300.6	302.3	305.0	299.0	300.6	302.3	305.0
			12.5	189.5	192.5	195.5	199.0	189.5	192.5	195.5	199.0
			32.0	113.9	115.3	119.5	125.5	113.9	115.3	119.5	125.5
		100	5.0	109.5	109.9	110.3	111.1	109.5	109.9	110.3	111.1
			12.5	69.1	69.5	69.9	70.4	69.1	69.5	69.9	70.4
			32.0	39.7	40.3	43.3	48.9	39.7	40.3	43.3	48.9
		50	5.0	56.4	56.4	56.5	56.6	56.4	56.4	56.5	56.6
			12.5	35.2	35.2	35.2	34.9	35.2	35.2	35.2	34.9
			32.0	21.7	22.6	24.7	28.0	21.7	22.6	24.7	28.0
		25	5.0	27.3	27.2	27.1	26.7	27.3	27.2	27.1	26.7
			12.5	16.8	16.7	16.8	17.7	16.8	16.7	16.8	17.7
			32.0	11.6	12.0	12.8	14.6	11.6	12.0	12.8	14.6
		10	5.0	8.7	8.5	8.3	7.7	8.7	8.5	8.3	7.7
			12.5	5.9	6.0	6.1	6.3	5.9	6.0	6.1	6.3
			32.0	3.8	4.0	3.0	4.4	3.8	4.0	3.0	4.4
11	Subsea Pipeline and PLEM	600	5.0	553.5	556.0	558.5	562.3	553.5	556.0	558.5	562.3
			12.5	354.4	357.3	364.6	373.0	354.4	357.3	364.6	373.0
			32.0	218.1	222.7	226.0	240.3	218.1	222.7	226.0	240.3
		100	5.0	109.5	109.9	110.3	111.1	109.5	109.9	110.3	111.1
			12.5	69.1	69.5	69.9	70.4	69.1	69.5	69.9	70.4
			32.0	39.7	40.3	43.3	48.9	39.7	40.3	43.3	48.9

ID	Scenario	Hole Size (mm)	Radiation Levels (kW/m^2)	Max Distance for Isolated release (m)				Max Distance for unisolated release (m)			
				F1.5 m/s	D3 m/s	D5 m/s	D9 m/s	F1.5 m/s	D3 m/s	D5 m/s	D9 m/s
		50	5.0	56.4	56.4	56.5	56.6	56.4	56.4	56.5	56.6
			12.5	35.2	35.2	35.2	34.9	35.2	35.2	35.2	34.9
			32.0	21.7	22.6	24.7	28.0	21.7	22.6	24.7	28.0
		10	5.0	8.7	8.5	8.3	7.7	8.7	8.5	8.3	7.7
			12.5	5.9	6.0	6.1	6.3	5.9	6.0	6.1	6.3
			32.0	3.8	4.0	3.0	4.4	3.8	4.0	3.0	4.4
12	Onshore gas pipeline (buried)	600	5.0	426.2	484.3	477.2	488.6	426.2	484.3	477.2	488.6
			12.5	154.1	235.0	252.7	292.4	154.1	235.0	252.7	292.4
			32.0	NR	NR	73.0	96.7	NR	NR	73.0	96.7
		200	5.0	145.8	173.4	189.4	123.8	145.8	173.4	189.4	123.8
			12.5	NR	73.7	100.1	200.4	NR	73.7	100.1	200.4
			32.0	NR	NR	21.1	42.0	NR	NR	21.1	42.0
		13	5.0	7.8	12.4	14.6	15.8	7.8	12.4	14.6	15.8
			12.5	NR	NR	6.3	10.1	NR	NR	6.3	10.1
			32.0	NR	NR	NR	NR	NR	NR	NR	NR
13	Onshore gas pipeline (above ground)	600	5.0	828.4	841.9	854.4	848.9	828.4	841.9	854.4	848.9
			12.5	633.8	631.2	652.8	671.7	633.8	631.2	652.8	671.7
			32.0	494.0	505.5	509.3	548.2	494.0	505.5	509.3	548.2
		100	5.0	164.8	165.5	165.6	163.1	164.8	165.5	165.6	163.1
			12.5	126.0	128.9	132.0	136.4	126.0	128.9	132.0	136.4
			32.0	98.0	100.2	103.4	116.4	98.0	100.2	103.4	116.4
		50	5.0	88.4	89.0	89.7	90.6	88.4	89.0	89.7	90.6
			12.5	69.1	70.9	73.1	77.1	69.1	70.9	73.1	77.1

ID	Scenario	Hole Size (mm)	Radiation Levels (kW/m²)	Max Distance for Isolated release (m)				Max Distance for unisolated release (m)			
				F1.5 m/s	D3 m/s	D5 m/s	D9 m/s	F1.5 m/s	D3 m/s	D5 m/s	D9 m/s
			32.0	53.8	55.6	58.1	64.6	53.8	55.6	58.1	64.6
		25	5.0	45.3	45.7	46.2	47.1	45.3	45.7	46.2	47.1
			12.5	35.1	36.1	37.3	39.7	35.1	36.1	37.3	39.7
			32.0	25.6	26.9	28.5	31.8	25.6	26.9	28.5	31.8
14	Gas Regulator System (HP)	600	5.0	829.5	842.7	854.8	848.3	829.5	842.7	854.8	848.3
			12.5	634.3	632.7	653.8	671.7	634.3	632.7	653.8	671.7
			32.0	496.0	506.7	509.4	549.0	496.0	506.7	509.4	549.0
		200	5.0	308.5	310.2	309.2	299.2	308.5	310.2	309.2	299.2
			12.5	231.8	237.0	241.4	244.6	231.8	237.0	241.4	244.6
			32.0	182.1	184.4	189.6	206.6	182.1	184.4	189.6	206.6
		50	5.0	88.6	89.0	89.4	89.8	88.6	89.0	89.4	89.8
			12.5	70.8	72.3	74.2	77.5	70.8	72.3	74.2	77.5
			32.0	55.9	57.7	61.9	68.5	55.9	57.7	61.9	68.5
		25	5.0	45.7	46.0	46.3	46.8	45.7	46.0	46.3	46.8
			12.5	37.5	38.3	39.3	41.1	37.5	38.3	39.3	41.1
			32.0	30.3	31.2	32.9	36.7	30.3	31.2	32.9	36.7
15	Gas Regulator System (LP)	600	5.0	317.2	319.1	318.0	308.0	317.2	319.1	318.0	308.0
			12.5	238.2	243.6	248.1	251.5	238.2	243.6	248.1	251.5
			32.0	187.2	189.6	194.6	212.1	187.2	189.6	194.6	212.1
		200	5.0	118.1	118.5	118.7	118.1	118.1	118.5	118.7	118.1
			12.5	92.9	43.0	97.1	100.9	92.9	43.0	97.1	100.9
			32.0	72.7	35.0	80.1	88.5	72.7	35.0	80.1	88.5
		50	5.0	31.3	31.4	31.6	31.9	31.3	31.4	31.6	31.9

ID	Scenario	Hole Size (mm)	Radiation Levels (kW/m²)	Max Distance for Isolated release (m)				Max Distance for unisolated release (m)			
				F1.5 m/s	D3 m/s	D5 m/s	D9 m/s	F1.5 m/s	D3 m/s	D5 m/s	D9 m/s
			12.5	26.0	26.5	27.1	28.3	26.0	26.5	27.1	28.3
			32.0	21.3	22.0	22.8	24.6	21.3	22.0	22.8	24.6
		25	5.0	15.1	15.1	15.1	15.0	15.1	15.1	15.1	15.0
			12.5	12.5	12.7	12.9	13.1	12.5	12.7	12.9	13.1
			32.0	NR	NR	NR	NR	NR	NR	NR	NR
16	Feed to BOG Compressors	600	5.0	93.9	87.1	95.3	104.8	93.9	87.1	95.3	104.8
			12.5	73.1	77.7	87.2	97.3	73.1	77.7	87.2	97.3
			32.0	56.9	71.9	81.8	92.2	56.9	71.9	81.8	92.2
		200	5.0	34.0	30.5	34.8	37.4	34.0	30.5	34.8	37.4
			12.5	26.6	28.5	33.0	35.6	26.6	28.5	33.0	35.6
			32.0	20.2	26.9	31.6	34.3	20.2	26.9	31.6	34.3
		50	5.0	8.5	9.4	9.3	9.3	8.5	9.4	9.3	9.3
			12.5	5.7	8.2	NR	NR	5.7	8.2	NR	NR
			32.0	NR	NR	NR	NR	NR	NR	NR	NR
		25	5.0	NR	4.3	NR	NR	NR	4.3	NR	NR
			12.5	NR	NR	NR	NR	NR	NR	NR	NR
			32.0	NR	NR	NR	NR	NR	NR	NR	NR
17	HP BOG Compressors and Pipework	250	5.0	361.7	364.4	363.5	352.9	361.7	364.4	363.5	352.9
			12.5	270.3	277.0	282.4	286.9	270.3	277.0	282.4	286.9
			32.0	213.3	216.3	220.4	241.1	213.3	216.3	220.4	241.1
		100	5.0	158.3	158.8	158.5	155.5	158.3	158.8	158.5	155.5
			12.5	122.3	124.9	127.6	131.3	122.3	124.9	127.6	131.3
			32.0	95.4	97.3	103.5	114.0	95.4	97.3	103.5	114.0

ID	Scenario	Hole Size (mm)	Radiation Levels (kW/m²)	Max Distance for Isolated release (m)				Max Distance for unisolated release (m)			
				F1.5 m/s	D3 m/s	D5 m/s	D9 m/s	F1.5 m/s	D3 m/s	D5 m/s	D9 m/s
		83	5.0	134.0	134.4	134.4	132.9	134.0	134.4	134.4	132.9
			12.5	104.5	106.7	109.2	113.1	104.5	106.7	109.2	113.1
			32.0	81.6	83.6	89.4	98.8	81.6	83.6	89.4	98.8
		50	5.0	84.9	85.4	85.8	86.3	84.9	85.4	85.8	86.3
			12.5	67.9	69.5	71.3	74.7	67.9	69.5	71.3	74.7
			32.0	53.7	55.5	59.5	66.1	53.7	55.5	59.5	66.1
		25	5.0	43.8	44.1	44.4	44.9	43.8	44.1	44.4	44.9
			12.5	36.0	36.8	37.7	39.5	36.0	36.8	37.7	39.5
			32.0	29.1	30.0	31.4	35.3	29.1	30.0	31.4	35.3
18	LP BOG Compressor and Recondenser	200	5.0	86.0	86.5	86.9	87.3	86.0	86.5	86.9	87.3
			12.5	68.8	70.3	72.2	75.6	68.8	70.3	72.2	75.6
			32.0	54.3	56.1	60.2	66.9	54.3	56.1	60.2	66.9
		100	5.0	44.4	44.7	45.0	45.5	44.4	44.7	45.0	45.5
			12.5	36.5	37.2	38.2	40.1	36.5	37.2	38.2	40.1
			32.0	29.5	30.4	31.8	35.7	29.5	30.4	31.8	35.7
		83	5.0	36.8	37.0	37.3	27.7	36.8	37.0	37.3	27.7
			12.5	30.4	31.0	31.8	33.3	30.4	31.0	31.8	33.3
			32.0	24.7	24.9	26.6	29.6	24.7	24.9	26.6	29.6
		50	5.0	21.8	21.9	22.0	22.1	21.8	21.9	22.0	22.1
			12.5	18.2	18.5	19.0	19.7	18.2	18.5	19.0	19.7
			32.0	15.0	15.4	16.0	17.3	15.0	15.4	16.0	17.3
		25	5.0	10.3	10.3	10.2	10.0	10.3	10.3	10.2	10.0
			12.5	8.4	8.4	8.5	8.4	8.4	8.4	8.5	8.4

ID	Scenario	Hole Size (mm)	Radiation Levels (kW/m^2)	Max Distance for Isolated release (m)				Max Distance for unisolated release (m)			
				F1.5 m/s	D3 m/s	D5 m/s	D9 m/s	F1.5 m/s	D3 m/s	D5 m/s	D9 m/s
			32.0	NR	NR	NR	NR	NR	NR	NR	NR
		10	5.0	NR	NR	NR	NR	NR	NR	NR	NR
			12.5	NR	NR	NR	NR	NR	NR	NR	NR
			32.0	NR	NR	NR	NR	NR	NR	NR	NR
19	LNG Tank overfilling scenario	NA	5.0	271.4	304.8	331.1	308.6	271.4	304.8	331.1	308.6
			12.5	146.2	198.5	223.2	205.6	146.2	198.5	223.2	205.6
			32.0	24.6	79.3	125.8	130.6	24.6	79.3	125.8	130.6

3 Pool Fire Results

ID	Scenario	Hole Size (mm)	Radiation Levels (kW/m^2)	Max Distance for Isolated release (m)				Max Distance for unisolated release (m)			
				F1.5 m/s	D3 m/s	D5 m/s	D9 m/s	F1.5 m/s	D3 m/s	D5 m/s	D9 m/s
1	LNGC Piping up to hose manifold	600	5.0	295.0	311.8	323.0	333.2	295.0	311.8	323.0	333.2
			12.5	184.2	209.0	225.6	238.1	184.2	209.0	225.6	238.1
			32.0	95.3	116.4	136.0	161.4	95.3	116.4	136.0	161.4
		200	5.0	227.7	240.7	249.9	257.5	227.7	240.7	249.9	257.5
			12.5	142.1	162.1	175.0	184.4	142.1	162.1	175.0	184.4
			32.0	72.8	89.0	104.4	124.8	72.8	89.0	104.4	124.8
		50	5.0	64.9	68.8	72.0	74.0	64.9	68.8	72.0	74.0
			12.5	40.3	47.2	51.2	54.1	40.3	47.2	51.2	54.1
			32.0	18.8	23.1	26.8	32.1	18.8	23.1	26.8	32.1
		25	5.0	28.5	30.4	32.0	33.0	28.5	30.4	32.0	33.0
			12.5	17.3	20.8	23.0	24.6	17.3	20.8	23.0	24.6
			32.0	7.2	8.7	9.9	11.4	7.2	8.7	9.9	11.4
2	LNGC/FSRU transfer line (6x)	200	5.0	154.0	162.7	169.5	174.3	154.0	162.7	169.5	174.3
			12.5	96.1	110.4	119.2	125.8	96.1	110.4	119.2	125.8
			32.0	48.3	59.6	69.5	83.1	48.3	59.6	69.5	83.1
		67	5.0	52.2	55.4	58.1	59.7	52.2	55.4	58.1	59.7
			12.5	32.3	38.1	41.5	43.9	32.3	38.1	41.5	43.9
			32.0	14.7	17.9	20.8	24.5	14.7	17.9	20.8	24.5
		50	5.0	36.9	39.3	41.2	42.5	36.9	39.3	41.2	42.5
			12.5	22.6	26.9	29.5	31.5	22.6	26.9	29.5	31.5
			32.0	9.8	11.9	13.6	15.9	9.8	11.9	13.6	15.9

ID	Scenario	Hole Size (mm)	Radiation Levels (kW/m²)	Max Distance for Isolated release (m)				Max Distance for unisolated release (m)			
				F1.5 m/s	D3 m/s	D5 m/s	D9 m/s	F1.5 m/s	D3 m/s	D5 m/s	D9 m/s
		25	5.0	15.0	16.2	17.0	17.7	15.0	16.2	17.0	17.7
			12.5	8.7	10.8	12.2	13.3	8.7	10.8	12.2	13.3
			32.0	3.3	3.8	4.1	4.6	3.3	3.8	4.1	4.6
3	Inlet line to FSRU storage tank	600	5.0	295.0	311.8	323.0	333.2	295.0	311.8	323.0	333.2
			12.5	184.2	209.0	225.6	238.1	184.2	209.0	225.6	238.1
			32.0	95.3	116.4	136.0	161.4	95.3	116.4	136.0	161.4
		200	5.0	154.0	162.7	169.6	174.3	154.0	162.7	169.6	174.3
			12.5	96.1	110.4	119.2	125.8	96.1	110.4	119.2	125.8
			32.0	48.3	59.6	69.5	83.1	48.3	59.6	69.5	83.1
		50	5.0	36.9	39.3	41.2	42.5	36.9	39.3	41.2	42.5
			12.5	22.6	26.9	29.5	31.5	22.6	26.9	29.5	31.5
			32.0	9.8	11.9	13.6	15.9	9.8	11.9	13.6	15.9
		25	5.0	15.0	16.2	17.0	17.7	15.0	16.2	17.0	17.7
			12.5	8.7	10.8	12.2	13.3	8.7	10.8	12.2	13.3
			32.0	3.3	3.8	4.1	4.6	3.3	3.8	4.1	4.6
4	LNGC Storage Tank failure	750	5.0	-	-	-	-	278.3	294.2	304.9	314.5
			12.5	-	-	-	-	173.8	197.4	213.0	224.8
			32.0	-	-	-	-	89.7	109.7	128.3	152.1
		250	5.0	-	-	-	-	112.8	119.2	125.5	127.9
			12.5	-	-	-	-	70.4	81.4	87.9	92.9
			32.0	-	-	-	-	34.6	42.8	49.9	59.7
5	FSRU Storage Tank failure	750	5.0	-	-	-	-	278.3	294.2	304.9	314.5
			12.5	-	-	-	-	173.8	197.4	213.0	224.8

ID	Scenario	Hole Size (mm)	Radiation Levels (kW/m²)	Max Distance for Isolated release (m)				Max Distance for unisolated release (m)			
				F1.5 m/s	D3 m/s	D5 m/s	D9 m/s	F1.5 m/s	D3 m/s	D5 m/s	D9 m/s
			32.0	-	-	-	-	89.7	109.7	128.3	152.1
		250	5.0	-	-	-	-	112.8	119.2	125.5	127.9
			12.5	-	-	-	-	70.4	81.4	87.9	92.9
			32.0	-	-	-	-	34.6	42.8	49.9	59.7
6	Common header from FSRU Cargo Pumps)	250	5.0	253.6	268.1	278.1	286.7	253.6	268.1	278.1	286.7
			12.5	158.3	180.2	194.5	205.1	158.3	180.2	194.5	205.1
			32.0	81.4	99.8	116.4	138.8	81.4	99.8	116.4	138.8
		83	5.0	100.3	106.0	110.8	113.7	100.3	106.0	110.8	113.7
			12.5	62.5	72.5	78.3	82.8	62.5	72.5	78.3	82.8
			32.0	30.4	37.6	44.0	52.2	30.4	37.6	44.0	52.2
		25	5.0	25.6	27.4	28.8	29.7	25.6	27.4	28.8	29.7
			12.5	15.4	18.7	20.7	22.2	15.4	18.7	20.7	22.2
			32.0	6.3	7.6	8.6	9.9	6.3	7.6	8.6	9.9
7	LNG from Booster Pumps to Vaporizers (4x)	150	5.0	171.3	181.1	188.5	193.8	171.3	181.1	188.5	193.8
			12.5	106.9	122.6	132.2	139.6	106.9	122.6	132.2	139.6
			32.0	54.0	66.5	77.8	92.8	54.0	66.5	77.8	92.8
		50	5.0	120.8	127.6	133.2	136.8	120.8	127.6	133.2	136.8
			12.5	75.3	87.0	93.9	99.3	75.3	87.0	93.9	99.3
			32.0	37.2	45.9	53.8	64.1	37.2	45.9	53.8	64.1
		25	5.0	59.9	63.6	66.6	68.4	59.9	63.6	66.6	68.4
			12.5	37.2	43.6	47.4	50.1	37.2	43.6	47.4	50.1
			32.0	17.2	21.2	24.5	29.0	17.2	21.2	24.5	29.0
8	NG from	300	5.0	NA	NA	NA	NA	NA	NA	NA	NA

ID	Scenario	Hole Size (mm)	Radiation Levels (kW/m^2)	Max Distance for Isolated release (m)				Max Distance for unisolated release (m)			
				F1.5 m/s	D3 m/s	D5 m/s	D9 m/s	F1.5 m/s	D3 m/s	D5 m/s	D9 m/s
	vaporiser to NG header (four parallel trains) Includes Vaporizer		12.5	NA	NA	NA	NA	NA	NA	NA	NA
			32.0	NA	NA	NA	NA	NA	NA	NA	NA
		100	5.0	NA	NA	NA	NA	NA	NA	NA	NA
			12.5	NA	NA	NA	NA	NA	NA	NA	NA
			32.0	NA	NA	NA	NA	NA	NA	NA	NA
		50	5.0	NA	NA	NA	NA	NA	NA	NA	NA
			12.5	NA	NA	NA	NA	NA	NA	NA	NA
			32.0	NA	NA	NA	NA	NA	NA	NA	NA
		25	5.0	NA	NA	NA	NA	NA	NA	NA	NA
			12.5	NA	NA	NA	NA	NA	NA	NA	NA
			32.0	NA	NA	NA	NA	NA	NA	NA	NA
		10	5.0	NA	NA	NA	NA	NA	NA	NA	NA
			12.5	NA	NA	NA	NA	NA	NA	NA	NA
			32.0	NA	NA	NA	NA	NA	NA	NA	NA
9	Combined NG Export Header	300	5.0	NA	NA	NA	NA	NA	NA	NA	NA
			12.5	NA	NA	NA	NA	NA	NA	NA	NA
			32.0	NA	NA	NA	NA	NA	NA	NA	NA
		100	5.0	NA	NA	NA	NA	NA	NA	NA	NA
			12.5	NA	NA	NA	NA	NA	NA	NA	NA
			32.0	NA	NA	NA	NA	NA	NA	NA	NA
		50	5.0	NA	NA	NA	NA	NA	NA	NA	NA
			12.5	NA	NA	NA	NA	NA	NA	NA	NA
			32.0	NA	NA	NA	NA	NA	NA	NA	NA

ID	Scenario	Hole Size (mm)	Radiation Levels (kW/m²)	Max Distance for Isolated release (m)				Max Distance for unisolated release (m)			
				F1.5 m/s	D3 m/s	D5 m/s	D9 m/s	F1.5 m/s	D3 m/s	D5 m/s	D9 m/s
		25	5.0	NA	NA	NA	NA	NA	NA	NA	NA
			12.5	NA	NA	NA	NA	NA	NA	NA	NA
			32.0	NA	NA	NA	NA	NA	NA	NA	NA
10	Riser Failure and associated pipework	300	5.0	NA	NA	NA	NA	NA	NA	NA	NA
			12.5	NA	NA	NA	NA	NA	NA	NA	NA
			32.0	NA	NA	NA	NA	NA	NA	NA	NA
		100	5.0	NA	NA	NA	NA	NA	NA	NA	NA
			12.5	NA	NA	NA	NA	NA	NA	NA	NA
			32.0	NA	NA	NA	NA	NA	NA	NA	NA
		50	5.0	NA	NA	NA	NA	NA	NA	NA	NA
			12.5	NA	NA	NA	NA	NA	NA	NA	NA
			32.0	NA	NA	NA	NA	NA	NA	NA	NA
		25	5.0	NA	NA	NA	NA	NA	NA	NA	NA
			12.5	NA	NA	NA	NA	NA	NA	NA	NA
			32.0	NA	NA	NA	NA	NA	NA	NA	NA
		10	5.0	NA	NA	NA	NA	NA	NA	NA	NA
			12.5	NA	NA	NA	NA	NA	NA	NA	NA
			32.0	NA	NA	NA	NA	NA	NA	NA	NA
11	Subsea Pipeline and PLEM	600	5.0	NA	NA	NA	NA	NA	NA	NA	NA
			12.5	NA	NA	NA	NA	NA	NA	NA	NA
			32.0	NA	NA	NA	NA	NA	NA	NA	NA
		100	5.0	NA	NA	NA	NA	NA	NA	NA	NA
			12.5	NA	NA	NA	NA	NA	NA	NA	NA

ID	Scenario	Hole Size (mm)	Radiation Levels (kW/m²)	Max Distance for Isolated release (m)				Max Distance for unisolated release (m)			
				F1.5 m/s	D3 m/s	D5 m/s	D9 m/s	F1.5 m/s	D3 m/s	D5 m/s	D9 m/s
			32.0	NA	NA	NA	NA	NA	NA	NA	NA
		50	5.0	NA	NA	NA	NA	NA	NA	NA	NA
			12.5	NA	NA	NA	NA	NA	NA	NA	NA
			32.0	NA	NA	NA	NA	NA	NA	NA	NA
		10	5.0	NA	NA	NA	NA	NA	NA	NA	NA
			12.5	NA	NA	NA	NA	NA	NA	NA	NA
			32.0	NA	NA	NA	NA	NA	NA	NA	NA
12	Onshore gas pipeline (buried)	600	5.0	NA	NA	NA	NA	NA	NA	NA	NA
			12.5	NA	NA	NA	NA	NA	NA	NA	NA
			32.0	NA	NA	NA	NA	NA	NA	NA	NA
		200	5.0	NA	NA	NA	NA	NA	NA	NA	NA
			12.5	NA	NA	NA	NA	NA	NA	NA	NA
			32.0	NA	NA	NA	NA	NA	NA	NA	NA
		13	5.0	NA	NA	NA	NA	NA	NA	NA	NA
			12.5	NA	NA	NA	NA	NA	NA	NA	NA
			32.0	NA	NA	NA	NA	NA	NA	NA	NA
13	Onshore gas pipeline (above ground)	600	5.0	NA	NA	NA	NA	NA	NA	NA	NA
			12.5	NA	NA	NA	NA	NA	NA	NA	NA
			32.0	NA	NA	NA	NA	NA	NA	NA	NA
		100	5.0	NA	NA	NA	NA	NA	NA	NA	NA
			12.5	NA	NA	NA	NA	NA	NA	NA	NA
			32.0	NA	NA	NA	NA	NA	NA	NA	NA
		50	5.0	NA	NA	NA	NA	NA	NA	NA	NA

ID	Scenario	Hole Size (mm)	Radiation Levels (kW/m²)	Max Distance for Isolated release (m)				Max Distance for unisolated release (m)			
				F1.5 m/s	D3 m/s	D5 m/s	D9 m/s	F1.5 m/s	D3 m/s	D5 m/s	D9 m/s
			12.5	NA	NA	NA	NA	NA	NA	NA	NA
			32.0	NA	NA	NA	NA	NA	NA	NA	NA
		25	5.0	NA	NA	NA	NA	NA	NA	NA	NA
			12.5	NA	NA	NA	NA	NA	NA	NA	NA
			32.0	NA	NA	NA	NA	NA	NA	NA	NA
14	Gas Regulator System (HP)	600	5.0	NA	NA	NA	NA	NA	NA	NA	NA
			12.5	NA	NA	NA	NA	NA	NA	NA	NA
			32.0	NA	NA	NA	NA	NA	NA	NA	NA
		200	5.0	NA	NA	NA	NA	NA	NA	NA	NA
			12.5	NA	NA	NA	NA	NA	NA	NA	NA
			32.0	NA	NA	NA	NA	NA	NA	NA	NA
		50	5.0	NA	NA	NA	NA	NA	NA	NA	NA
			12.5	NA	NA	NA	NA	NA	NA	NA	NA
			32.0	NA	NA	NA	NA	NA	NA	NA	NA
		25	5.0	NA	NA	NA	NA	NA	NA	NA	NA
			12.5	NA	NA	NA	NA	NA	NA	NA	NA
			32.0	NA	NA	NA	NA	NA	NA	NA	NA
15	Gas Regulator System (LP)	600	5.0	NA	NA	NA	NA	NA	NA	NA	NA
			12.5	NA	NA	NA	NA	NA	NA	NA	NA
			32.0	NA	NA	NA	NA	NA	NA	NA	NA
		200	5.0	NA	NA	NA	NA	NA	NA	NA	NA
			12.5	NA	NA	NA	NA	NA	NA	NA	NA
			32.0	NA	NA	NA	NA	NA	NA	NA	NA

ID	Scenario	Hole Size (mm)	Radiation Levels (kW/m²)	Max Distance for Isolated release (m)				Max Distance for unisolated release (m)			
				F1.5 m/s	D3 m/s	D5 m/s	D9 m/s	F1.5 m/s	D3 m/s	D5 m/s	D9 m/s
		50	5.0	NA	NA	NA	NA	NA	NA	NA	NA
			12.5	NA	NA	NA	NA	NA	NA	NA	NA
			32.0	NA	NA	NA	NA	NA	NA	NA	NA
		25	5.0	NA	NA	NA	NA	NA	NA	NA	NA
			12.5	NA	NA	NA	NA	NA	NA	NA	NA
			32.0	NA	NA	NA	NA	NA	NA	NA	NA
16	Feed to BOG Compressors	600	5.0	NA	NA	NA	NA	NA	NA	NA	NA
			12.5	NA	NA	NA	NA	NA	NA	NA	NA
			32.0	NA	NA	NA	NA	NA	NA	NA	NA
		200	5.0	NA	NA	NA	NA	NA	NA	NA	NA
			12.5	NA	NA	NA	NA	NA	NA	NA	NA
			32.0	NA	NA	NA	NA	NA	NA	NA	NA
		50	5.0	NA	NA	NA	NA	NA	NA	NA	NA
			12.5	NA	NA	NA	NA	NA	NA	NA	NA
			32.0	NA	NA	NA	NA	NA	NA	NA	NA
		25	5.0	NA	NA	NA	NA	NA	NA	NA	NA
			12.5	NA	NA	NA	NA	NA	NA	NA	NA
			32.0	NA	NA	NA	NA	NA	NA	NA	NA
17	HP BOG Compressors and Pipework	250	5.0	NA	NA	NA	NA	NA	NA	NA	NA
			12.5	NA	NA	NA	NA	NA	NA	NA	NA
			32.0	NA	NA	NA	NA	NA	NA	NA	NA
		100	5.0	NA	NA	NA	NA	NA	NA	NA	NA
			12.5	NA	NA	NA	NA	NA	NA	NA	NA

ID	Scenario	Hole Size (mm)	Radiation Levels (kW/m²)	Max Distance for Isolated release (m)				Max Distance for unisolated release (m)			
				F1.5 m/s	D3 m/s	D5 m/s	D9 m/s	F1.5 m/s	D3 m/s	D5 m/s	D9 m/s
			32.0	NA	NA	NA	NA	NA	NA	NA	NA
		83	5.0	NA	NA	NA	NA	NA	NA	NA	NA
			12.5	NA	NA	NA	NA	NA	NA	NA	NA
			32.0	NA	NA	NA	NA	NA	NA	NA	NA
		50	5.0	NA	NA	NA	NA	NA	NA	NA	NA
			12.5	NA	NA	NA	NA	NA	NA	NA	NA
			32.0	NA	NA	NA	NA	NA	NA	NA	NA
		25	5.0	NA	NA	NA	NA	NA	NA	NA	NA
			12.5	NA	NA	NA	NA	NA	NA	NA	NA
			32.0	NA	NA	NA	NA	NA	NA	NA	NA
18	LP BOG Compressor and Recondenser	200	5.0	NA	NA	NA	NA	NA	NA	NA	NA
			12.5	NA	NA	NA	NA	NA	NA	NA	NA
			32.0	NA	NA	NA	NA	NA	NA	NA	NA
		100	5.0	NA	NA	NA	NA	NA	NA	NA	NA
			12.5	NA	NA	NA	NA	NA	NA	NA	NA
			32.0	NA	NA	NA	NA	NA	NA	NA	NA
		83	5.0	NA	NA	NA	NA	NA	NA	NA	NA
			12.5	NA	NA	NA	NA	NA	NA	NA	NA
			32.0	NA	NA	NA	NA	NA	NA	NA	NA
		50	5.0	NA	NA	NA	NA	NA	NA	NA	NA
			12.5	NA	NA	NA	NA	NA	NA	NA	NA
			32.0	NA	NA	NA	NA	NA	NA	NA	NA
		25	5.0	NA	NA	NA	NA	NA	NA	NA	NA

ID	Scenario	Hole Size (mm)	Radiation Levels (kW/m²)	Max Distance for Isolated release (m)				Max Distance for unisolated release (m)			
				F1.5 m/s	D3 m/s	D5 m/s	D9 m/s	F1.5 m/s	D3 m/s	D5 m/s	D9 m/s
			12.5	NA	NA	NA	NA	NA	NA	NA	NA
			32.0	NA	NA	NA	NA	NA	NA	NA	NA
		10	5.0	NA	NA	NA	NA	NA	NA	NA	NA
			12.5	NA	NA	NA	NA	NA	NA	NA	NA
			32.0	NA	NA	NA	NA	NA	NA	NA	NA
19	LNG Tank overfilling scenario	NA	5.0	247.2	258.6	265.8	280.6	247.2	258.6	265.8	280.6
			12.5	154.0	174.2	189.3	209.6	154.0	174.2	189.3	209.6
			32.0	78.9	95.6	114.3	145.4	78.9	95.6	114.3	145.4

Appendix 4B–

Contingency Planning

Lloyd's Register

Working together
for a safer world

EDP LNG Power to Shore Project, Acajutla, El Salvador

Contingency Planning

Report for
Invenergy Clean Power

Reference: US4280.1/R2

Release: 2

Report by: Danielle Chrun

Summary

EDP LNG Power to Shore Project, Acajutla, El Salvador		
Contingency Planning		
Date of Issue	18 November 2016	
Administrative Review	Margaret Bush	
Report by Danielle Chrun Senior Consultant/Team Manager	**Reviewed by** Therese L. Baas for Operations Manager	**Approved by** Robert Hall Technical Operations Manager – Americas
D. Chrun		

Our Contact Danielle Chrun +1 281 649 2795 danielle.chrun@lr.org	Lloyd's Register Drilling Integrity Services, Inc. 1330 Enclave Parkway, Suite 200 Houston, Texas 77077 United States of America
Client Contact Horacio Larios/Diego Canal +1 414 779 1213 hlarios@invenergyllc.com/ dcanalsaez@invenergyllc.com	Invenergy Clean Power 1 South Wacker Drive, #1800 Chicago, IL 60606 United States of America

Document History			
Release	**Date**	**Description**	**Contributors**
1	01 September 2016	Initial Release	**Report by:** Danielle Chrun **Reviewed by:** Rhey Lee/Varsha Pedhireddy **Approved by:** Kyle Wingate
2	18 November 2016	Final Release—Comments from Invenergy are implemented.	**Report by:** Danielle Chrun **Reviewed by:** Therese L. Baas **Approved by:** Robert Hall

Table of Contents

Abbreviations

AMP	Autoridad Marítima Portuaria (Maritime Port Authority)
CAMS	Central American Marine Services
CEPA	Comisión Ejecutiva Portuaria Autónoma (Port Authority Executive Commission)
EDP	Energía del Pacífico
EIA	environmental impact assessment
ESD	emergency shutdown
FEED	front end engineering design
FERC	Federal Energy Regulatory Commission
FSRU	floating storage and regasification unit
FSU	floating storage unit
HAZID	hazard identification
LNG	liquefied natural gas
LNGC	liquefied natural gas carrier
LR	Lloyd's Register
M&N	Moffatt & Nichol
MARN	Ministerio de Medio Ambiente y Recursos Naturales (Ministry of Environment and Natural Resources)
MINEC	Ministerio de Economía (Ministry of Economy)
PFSA	Port Facility Security Assessment
PTWC	Pacific Tsunami Warning Center
RPT	rapid phase transition
SNET	Servicio Nacional de Estudios Territoriales (National System of Territorial Studies)
STPP	Secretaría Técnica y de Planificación de la Presidencia (Secretary of Technical and Planning)
VTS	Vessel Traffic Service

Definitions

Abnormal event: Event deviating from the normal and usual operating conditions as defined by the project.

Accident: Unplanned event that resulted in death, injury, or ill health of people, or damage to property or the environment.

Contingency plan: Plan that defines the actions to undertake in the event of an abnormal event or accident.

Emergency situation: Situation that poses an immediate risk to health, life, property, or environment.

Escalation: Increase in the consequence of a hazard.

Hazard: Situation that poses threat to people, property, or environment.

Mitigation: Action of reducing the consequence of a hazard.

Project: Energía del Pacífico’s (EDP’s) initiative to develop an LNG import terminal in the port of Acajutla, El Salvador.

1 Executive Summary

Lloyd's Register (LR) has been engaged by Invenergy to carry out a high-level review of the contingency plan for the EDP liquefied natural gas (LNG) import terminal in Acajutla, El Salvador. This review was developed early in the front-end engineering (FEED) phase of the project with limited information. The purpose of the review is to ensure a preliminary course of action designed for EDP and different stakeholders be prepared and to ensure EDP and stakeholders are prepared to respond to abnormal events when they occur. This plan provides a high-level review of contingencies for the project, early in the project. A detailed contingency plan will be developed later in the project, in detailed engineering, by EDP and other stakeholders. It is best practice to begin contingency planning early in the project's life and update it as the work progresses through the project's life cycle.

A contingency planning workshop was conducted in San Salvador, El Salvador, on 15 June 2016. The intent of the workshop was to discuss contingencies for the project. Discussions included the current contingency in place in the port of Acajutla and contingencies that will be in place at the LNG import terminal. The participants included the following: key regulatory bodies, stakeholders, and project participants from the Maritime Port Authority (Authoridad Marítima Portuaria – AMP), Government, Port of Acajutla Executive Commission (Commission Ejecutiva Portuaria Autonoma – CEPA), Invenergy, Moffatt & Nichol (M&N), Exmar, EDP, and Lloyd's Register. Main conclusions from the workshop are listed below:

- A detailed contingency plan for the LNG import terminal will be developed in detailed engineering. It will include the major hazards as discussed in the workshop, such as an LNG leak, fire, and explosion.
- Major hazards, as identified in the hazard identification (HAZID) workshop sessions [1] [2], were discussed to analyze the risks to people, environment, and assets.
- The project will evaluate the need for the LNG carrier (LNGC) and floating storage unit (FSU) to leave the LNG import terminal in the event of a tsunami or swells. The project will consider a self-powered FSU or dedicated tugs to move the FSU in the event where the FSU needs to be moved to a safe location.
- In the event of an emergency at the port, an early warning is provided by a loud audible alarm and the port authority will inform the civil protection group. The civil protection group will assess the situation and decide whether to evacuate or muster in place. Municipalities will be notified in case of evacuation and will coordinate the evacuation of people to safety. The project's contingency plan will be submitted to the civil protection group through the fire department for approval in order to ensure timely notification.
- The port of Acajutla is equipped with firefighting capabilities, including firefighters, a firefighting tug, and ambulance. However, the port will prioritize assistance to its own facilities and to commercial vessels; therefore, the project's contingency plan will complement the port's response and rescue.
- A port contingency plan that addresses remedial actions at the port in the occurrence of an abnormal event, has been developed by the port. At the time of the contingency planning workshop, the plan was being reviewed by firefighters and AMP.
- A spill response plan for the LNG import terminal will be developed in detailed engineering to cover contingency in the event of a release of other hydrocarbons such as diesel.
- The port facility security assessment (PFSA) will include security related risks at the port and address contingency in the occurrence of a security threat.

2 Introduction

2.1 Background

LR has been engaged by Invenergy to carry out a high-level review of the contingency plan for the LNG import terminal in Acajutla, El Salvador, in the FEED phase.

The EDP LNG import terminal is designed to receive LNG from an LNGC and supply natural gas to a power plant and power to end consumers in El Salvador. The following operations will be performed:

- An LNGC will offload LNG to an FSU.
- The FSU will transfer LNG to a floating storage regasification unit (FSRU) where LNG will be processed into high-pressure natural gas.
- The natural gas will be transferred from the FSRU to the onshore plant via riser and pipeline.

The project was announced in November 2013 and is expected to start the first quarter of 2020.

2.2 Objective

This objective of this report is to review contingencies for the project based on the information available at the FEED phase of the project. The intent of the review is to ensure contingencies and possible emergency scenarios are addressed at an early stage of the project. This report will be included of the Environmental Impact Assessment (EIA) application.

The contingency plan for the project will be developed in detailed engineering, by EDP and other stakeholders.

2.3 Scope of Work

The scope includes the LNG import terminal and does not address contingencies at the plant onshore. A workshop methodology was employed to review contingencies at the LNG import terminal and those currently in place at the port.

The contingency planning workshop was conducted in San Salvador, El Salvador, on 15 June 2016. The participants included key regulatory bodies, stakeholders, project participants from the Maritime Port Authority, Government, Port of Acajutla, Invenergy, M&N, Exmar, Energía del Pacífico, and Lloyd's Register.

3 Contingency Planning

3.1 Objective

EDP, at a later stage of the project development, will develop a contingency plan that addresses the contingencies for the hazards related to the LNG import terminal installation.

The primary purpose of contingency planning for a project is to be prepared to respond to abnormal events when they occur. Contingency planning is usually based on several inputs such as risk analyses, and allows for emergency preparedness, as depicted in Figure 3.1. In the early design phase of a project, contingency planning is based on risk analysis to identify abnormal events and plan on contingency in the occurrence of such events. In the operational phase of the project, contingency planning should also include other sources of information such as accident reports and inspections to keep the plan updated at all times. It is best practice to begin contingency planning early in a project's life and continue to evolve as the work progresses through the project's life cycle. Figure 3.1 also shows that contingency planning is input to emergency preparedness. The effectiveness of the plan depends on the personnel regularly exercising their respective roles and responsibilities through training and exercises. Contingency planning will also allow the proponent to harmonize with existing emergency operation procedures, and to ensure an integrated and coordinated response with other key authorities such as the port authorities (AMP, CEPA) and the Ministerio de Medio Ambiente y Recursos Naturales (Ministry of Environment and Natural Resources – MARN).

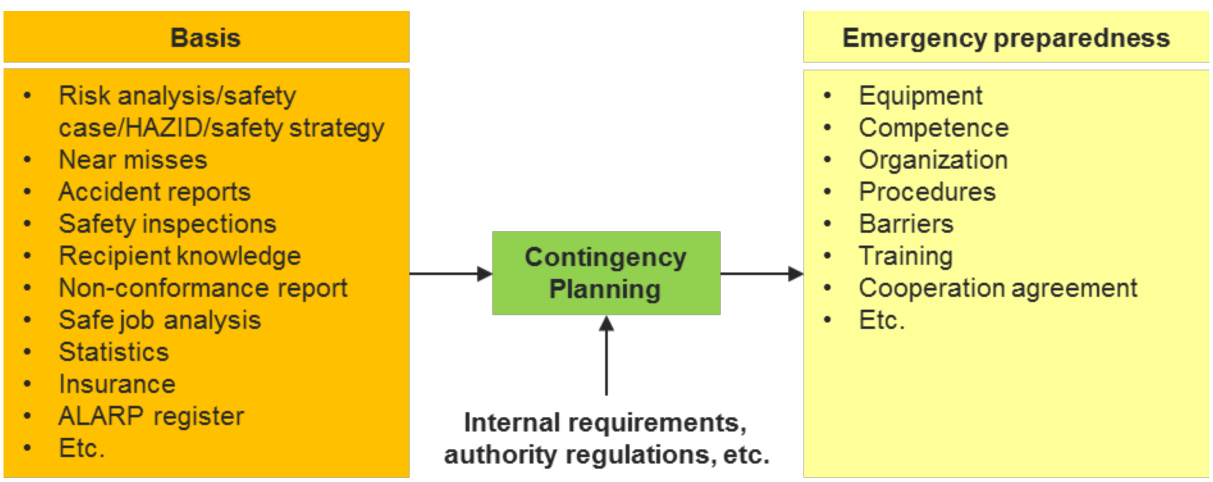


Figure 3.1: Contingency planning basis.

3.2 Contingency Planning Workshop

3.2.1 Methodology

A contingency planning workshop was carried out in the FEED phase of the project by a team of competent personnel. The purpose of the workshop was to review the contingency/emergency response in the occurrence of an abnormal event. The hazards assessed in the workshop are taken from the HAZID [1] and marine HAZID [2] and are listed in Table 3.1. Consequences to personnel, simultaneous operations at the port, environment, and third party, including the proper emergency response, were discussed and captured in a worksheet. The complete worksheet can be found in Appendix A.

Table 3.1: Critical Hazards

#	Defined Hazard and Accident Scenario
1	**Major Events**
1.1	Hydrocarbon leakage (LNG)/Gas dispersion
1.2	Fire (if LNG is ignited)
1.3	Rapid phase transition (RPT)
1.4	Toxic or flammable chemical leakage
1.5	Explosion
2	**Natural Hazards**
2.1	Short period sea movement
2.2	Long period swells
2.3	Tsunami, near field
2.4	Tsunami, far field
2.5	Seismic activity, earthquake
2.6	Electrical storm
2.7	High wind
3	**Dropped Objects**
3.1	Dropped objects during crane lifting or while transferring cargo from supply vessel to FSRU
3.2	Dropped objects during crane lifting on FSU
3.3	Dropped object on subsea pipeline to shore
4	**Riser and Subsea Pipeline**
4.1	Gas leakage to environment, subsea source (subsea pipeline or riser underwater)
4.2	Gas leakage to environment, topside source (connection to FSRU, riser part above sea)
5	**Security**
5.1	Security threats
6	**Other**
6.1	Leak of hydrocarbons of fire from another ship (e.g., sailing or berthed in port of Acajutla, berthed in Cenérgica terminal, berthed in Rasa terminal, or berthed in Alba terminal)

3.2.2 Participants List

A contingency planning workshop was conducted at the Hilton Princess Hotel in San Salvador, El Salvador, on 15 June 2016. Key participants at the workshop included personnel from regulatory bodies, stakeholders, and project participants from the Maritime Port Authority, Government, CEPA, Invenergy, M&N, Exmar, Energía del

Pacífico, and LR. The expertise of the team, both with respect to technical engineering and maritime operational experience, was considered appropriate and adequate for the workshop.

Representatives from LR facilitated and scribed the review. A list of workshop participants is presented in Table 3.2.

Table 3.2: Workshop Participants

	Name	Company	Discipline	E-mail Address
1	Captain Marco Aguirre	CAMS	Marine advisor	marcoernestoa@yahoo.es
2	Captain John E. Keon	CAMS	Local marine advisor	elsalmar1@msn.com
3	Alonso Valdemar Sarania	STPP	Electrical engineer	asarania@presidencia.gob.sv
4	Ernesto Mendez	STPP	Electrical engineer	amendez@ presidencia.gob.sv
5	Mario Chavarría	MINEC	Legal advisor	mchavarria@minec.gob.sv
6	Manuel Aicides Mejía Valiente	MINEC	Inspector	mmejia@minec.gob.sv
7	Salvador Eliú Avendaño Vásquez	MINEC	Inspector	savendano@minec.gob.sv eliuaven@gmail.com
8	Jesús Ricardo Andrade Hernández	MINEC	Technical coordinator, supervision and control	jandrade@minec.gob.sv
9	José E. Hernández	CEPA	Pilot	josehernandez_67@hotmail.com
10	Roberto Mendoza	CEPA	Manager of port of Acajutla	roberto.mendoza@cepa.gob.sv
11	Tatiana Chacón	AMP	Port infrastructure	echacon@amp.gob.sv
12	Yid Zelada Quán	MARN	Environmental evaluation	yzelada@marn.gob.sv
13	Lisbia Teresa Jarquin	Eco Ingenieros	Consultant, environmental management	l.jarquin@eco-ingenieros.com
14	Luc Saerens	Exmar	HSE	luc.saerens@exmar.be
15	Ashwini Kumar	Exmar	Project manager	ashwini.kumar@exmar.be
16	Eric Smith	M&N	Coastal, navigation engineering	esmith@moffattnichol.com
17	Bob Beasley	M&N	Project manager	rbeasley@moffattnichol.com
18	Horacio Larios	EDP	Project manager	hlarios@invenergyllc.com
19	Javier Mina	EDP	Engineering	lmina@edp.com.sv
20	Rupal Soni	Invenergy	Engineering	rsoni@invenergyllc.com
21	Diego Canal Sáez	Invenergy	Project engineer	dcanalsaez@invenergyllc.com
22	Felipe Mazzini	Invenergy	Project director	fmazzini@invenergyllc.com
23	Rhey Lee	LR	Technical safety/risk	rhey.lee@lr.org
24	Danielle Chrun	LR	Facilitator	danielle.chrun@lr.org

3.2.3 Contingency Planning Worksheet

The worksheet is attached in Appendix A. The worksheet columns are described in Table 3.3.

Table 3.3: Contingency Planning Worksheet Fields Description

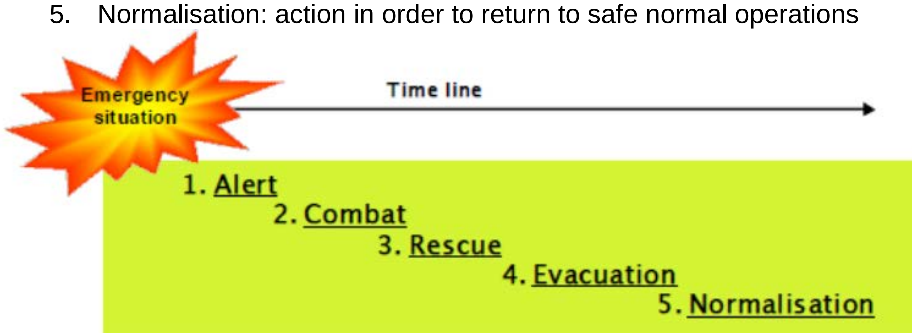
<table>
<tr><th>Worksheet Field</th><th>Description</th></tr>
<tr><td>ID</td><td>Unique identification number for each item discussed.</td></tr>
<tr><td>Defined Hazard and Accident Scenario</td><td>Hazards normal operation, as identified in the HAZID [1] or marine HAZID [2].</td></tr>
<tr><td>Description of Scenario</td><td>Description of scenario and of potential escalation of the scenario.</td></tr>
<tr><td>Consequences</td><td>Consequences to personnel, environment, and third party (public).</td></tr>
<tr><td>Main Focus Areas for the Emergency Response</td><td>General response to accident scenario, such as securing/evacuating accident scene, alerting authorities, and ensuring asset integrity.</td></tr>
<tr><td>Response Procedure/Main Strategy</td><td>Response as it relates to the following, when applicable (see Figure 3.2, which presents the timeline for the response to an emergency situation):
1. Alerting relevant authorities
2. Combating accident
3. Rescuing personnel
4. Evacuating personnel or population
5. Normalisation: action in order to return to safe normal operations


Figure 3.2: Response to an emergency situation.</td></tr>
<tr><td>Response Equipment</td><td>Equipment involved in the response to accident, including equipment on board or at the port, when applicable.</td></tr>
<tr><td>Response Personnel</td><td>Personnel involved in the response to accident and can include LNG import terminal personnel or firefighters.</td></tr>
<tr><td>Interfaces and Requirements</td><td>Actions by authorities, including port authority.</td></tr>
<tr><td>Comments [C]/ Recommendations [R]</td><td>Comments and recommendations are stated in this column.</td></tr>
</table>

4 LNG

The EDP LNG import terminal will be the first installation in the port of Acajutla to handle and process LNG. This chapter presents general description of LNG, for an understanding of its properties and the hazards associated with it.

LNG is liquefied natural gas (predominantly methane) that is odorless, colorless, and nontoxic. It will be transported by an LNGC in a liquid form and delivered to the LNG import terminal. The liquid form of LNG allows for easier and safer storage and transportation than its form as a gas. The LNG will then be processed into natural gas at the LNG import terminal: its volume increases by a factor of 600 as it changes from liquid to gas form. Natural gas will be transferred from the LNG import terminal to the power plant onshore via riser and pipeline.

Given LNG is stored at a very low temperature (approximately -160°C) in its liquid form, it can cause frostbite as it enters in contact with the skin. In gas form, LNG can cause asphyxiation and damage to the eyes. LNG vapors mixed with air are flammable and could be explosive in confined spaces.

Due to the nature of LNG, the following events need to be prevented and controlled:

- Spill
- Gas cloud formation
- Brittle fracture when in contact with deck plating
- Fast warm-up
- Ignition
- Fires—high-heat radiation, and pressure
- Explosion (Vapor cloud explosions are not found relevant due to open areas and no confined entrapment of gas from the defined spill scenarios.)

For the project, hazards are identified and documented in the HAZID and marine HAZID reports [1] [2]. Contingency planning includes mitigation measures and measures to prevent escalation of the occurrence of these events. Examples of mitigation measures include not permitting any ship to enter the port when a loss of containment has been identified at the LNG import terminal to prevent a fire escalation. Some of the safety equipment to control and prevent escalation includes the following:

- Deck water spray system on the tanker
- Dry chemical system on the tanker or terminal
- High-expansion foams and dual agent systems to suppress and control LNG vapor clouds on the tanker or at the terminal
- Water monitors on the tanker or at the terminal

5 LNG Import Terminal-Oriented Contingency Planning

The contingency plan for the LNG import terminal will be developed in detailed engineering. The contingency plan should provide guidance on response organization and procedures to enable the organization to efficiently respond in a coordinated manner to any accident involving the LNG import terminal. Accidents covered by the contingency plan should address, at a minimum, the following hazards:

- Loss of life
- Serious injury
- Tsunami
- Seismic activity
- LNG leakage
- Fire if LNG is ignited
- Explosion if found relevant
- Collision with another vessel
- Grounding if found relevant
- Spill of other hydrocarbons such as diesel
- Security threats
- Leak of hydrocarbons or fire from another ship

Contingencies at the LNG import terminal were discussed during the contingency planning workshop. The main discussions are summarized below:

- <u>Communication system:</u> The Vessel Traffic Service (VTS) system will ensure that the accident is broadcasted to other ships and to the port.
- <u>Emergency response team:</u> At a later stage, key roles in the emergency response team will be identified and assigned. For example, a salvage master may be appointed.
- <u>Tsunami/Swells/Seismic activity:</u> The project will evaluate the need for the LNGC and FSU to leave the LNG import terminal in the event of a tsunami, swells, or seismic activity. The project will consider a self-powered FSU or dedicated tugs to move the FSU in the event where the FSU needs to be moved to a safe location.
- <u>Fire on board LNG import terminal:</u> A fire on board the LNG import terminal may escalate to other areas. The LNG import terminal will be equipped with firefighting capabilities. Fire and gas detection and protection will be part of fire and explosion analysis in detailed engineering.
- <u>Hydrocarbon (other than LNG) spill:</u> A spill response plan will be developed at a later stage of the project to cover contingency in the event of a release of other hydrocarbons such as diesel.
- <u>Security threats:</u> A port facility security assessment (PFSA) will be developed in detailed engineering. The PFSA will cover security issues at the port and address contingency in the occurrence of a security threat.
- <u>Emergency shutdown (ESD) system:</u> The ESD system will be one of the main response equipment to isolate a leakage of LNG and mitigate the consequences quickly.
- <u>Evacuation of personnel on board:</u> Evacuation of personnel will depend on the situation.
- <u>Normalization:</u> After the accident, if operations at the LNG import terminal were stopped, operations will resume in accordance with international standards, local requirements, and operating permit.

6 Port Contingency Planning

The port of Acajutla has developed a contingency plan for the port's current operations that defines procedures to follow in the occurrence of an accident for all traffic entering, approaching, or exiting the port. During the workshop, it was discussed that the plan should define the actions to undertake in the occurrence of such events, including alerting, combatting the event, rescuing personnel on board or onshore, and evacuating. The plan should also define all the parties to be involved. It is a joint effort between the port authority, firefighters, and AMP. At the time of the contingency workshop (June 2016), the plan was not available for review. It was, however, submitted to and was being reviewed by the fire department and AMP. Once the project evolves, its operations will be included in the port contingency plan. Current contingency at the port is discussed below.

In the event of an accident, such as fire on board a vessel, the port authority will be alerted via the VTS system. The port will decide the remedial actions at the port, such as alerting firefighters, putting tugs on standby, adjusting ongoing operations, stopping operations, or evacuating to the port of refuge. The port of Acajutla will prioritize port traffic and coordinate the firefighting support. Given that the LNG import terminal will most likely be the last on the priority list, dedicated, adequate, standalone firefighting capabilities, such as a dedicated security/firefighting tug, are currently being evaluated for the project.

Currently, in the occurrence of an abnormal event at the port, the warning from a loud audible alarm is provided to the port. The port authority will inform the civil protection group. The civil protection group will assess the situation and decide whether to evacuate or muster in place. Municipalities will be notified in the case of evacuation and will coordinate the evacuation of people to safety. The project's contingency response will be approved by the civil protection group through the fire department to ensure timely notification and coordination.

In the event of a fire, CEPA will coordinate the effort at the port. Currently, the port of Acajutla has firefighting crew and ambulance available. The city of Acajutla does not have firefighting capabilities and ambulance. In an emergency, firefighters and ambulance from Sonsonate (15-20 minutes away from the port) could also respond to assist onshore.

The control tower at the port of Acajutla uses aids to be kept informed on the sea and weather conditions. The National System of Territorial Studies (Servicio Nacional de Estudios Territoriales – SNET) is used to monitor the weather conditions such as the speed of current and the Pacific Tsunami Warning Center (PTWC) in Hawaii is used to alert and warn authorities. In the event of a tsunami, the control tower and the port operations receive notification to evacuate to a safe location.

In the event of an evacuation, the port will coordinate the effort to leave to a safe location. The port will prioritize traffic and ensure all vessels reach a safe location. Current movement in the port is limited to one vessel at a time due to current pilot and tug capabilities.

7 Recommendations from Contingency Planning Workshop

Recommendations that were identified in the workshop are listed in Table 7.1. All recommendations should be followed up and closed out by the responsible party.

Table 7.1: Recommendations

ID	Recommendations	Responsible
1.1	It is recommended that the project is plugged into the civil protection communication network.	EDP
2.4	Consider dedicated tugs for the project.	EDP
2.4	Consider additional thrusters to allow FSU to move away from LNG import terminal upon tsunami warning.	EDP
2.4	Consider implementing a redundant warning system, in addition to the Pacific Tsunami Warning Center (PTWC) system.	EDP

8 References

[1] Lloyd's Register, "Invenergy Power to Shore Project, LaPaz, El Salvador – HAZID Report", Report No. US4122.1, Rev. Final B, 03 March 2016.

[2] Lloyd's Register, "Invenergy Power to Shore Project, LaPaz, El Salvador – Marine HAZID Report", Report No. US4122.2, Rev. Final, 03 March 2016.

Appendix A

Contingency Planning Worksheet

#	Defined Hazard and Accident Scenario	Description of Scenario	Consequences	Main Focus Areas for the Emergency Response	Response Procedure/Main Strategy	Response Equipment	Response Personnel	Interfaces and Requirements	Comments [C]/Recommendations [R]
1	**Major Events**								
1.1	Hydrocarbon leakage (LNG) / Gas dispersion	Large leakage of LNG to the environment (spill on water) reaching the port. Case of no ignition.	- **Personnel:** Potential fatalities. - **Environment:** LNG is non toxic, odorless; local, short-term impact to the marine environment. - **Public:** Possible consequences primarily from gas dispersion to 3rd parties and population in the proximity.	- Secure accident scene - Evacuate personnel from exposed area - Medical assistance - Control release - Asset integrity	- **Alert:** Activate emergency response plan, VTS to ensure marine safety communications incl. coordination with rescue resources, notify civil protection entity. - **Combat:** According to emergency response plan - **Rescue:** If necessary - **Evacuation:** If necessary - **Normalization:** In accordance with international standards, local requirements, and operating permit.	- First aid equipment - Transport vessel if necessary - Fire and gas detection - Fire and gas protection - Firefighting tugs - ESD system	- Emergency response team - LNG import terminal crew - Salvage master if required - Fire fighters/first responders from port of Acajutla if necessary - Tug operators	- **Port authority:** Notification of emergency, evacuation of port if necessary, stop/manage traffic in the effected area. - **Other terminals:** N/A - **Power plant:** If necessary, notification / communication to the power plant.	[C] An assessment will evaluate the extent of the leak, ability to isolate the leak, gas cloud, weather condition and as a result, which areas are at risk. Recommendation to the port will be made accordingly. Project will evaluate the need to move out LNGC or FSU and the need for thruster for FSU, pending availability of tugs to assist LNG import terminal on demand. [C] Currently, port of Acajutla has fire fighting crew and ambulance available in the event of an emergency situation. The city of Acajutla does not have fire fighters and ambulance. If more resources are required in an emergency event (e.g. two simultaneous emergency events), fire fighters and ambulance from Sonsonate could respond (15-20 minutes away from the port) to assist onshore. [R] It is recommended that the project is plugged into the civil protection communication network [EDP]. [C] In the event of an emergency, the port of Acajutla will prioritize port traffic and coordinate the firefighting support. Given the LNG import terminal will most likely be the last on the priority list, dedicated, adequate, standalone firefighting capabilities should be considered for the project. Dedicated security/firefighting tug is currently being evaluated. [C] Fire and gas detection and protection will be part of fire and explosion analysis in detailed engineering.
1.2	Fire (if LNG is ignited)	Leakage of LNG to the environment (spill on water). Fire if ignition source ignites gas cloud.	- **Personnel:** Potential fatalities. - **Environment:** LNG is non toxic, odorless; local, short-term impact to the marine environment. - **Public:** Possible consequences primarily only from flash fire (not pool or jet fire) to 3rd parties and population in the proximity.	- Secure accident scene - Evacuate personnel from exposed area - Medical assistance - Control release - Control/extinguish release and/or fire - Asset integrity	- **Alert:** Activate emergency response plan, VTS to ensure marine safety communications incl. coordination with rescue resources - **Combat:** According to emergency response plan - **Rescue:** If necessary - **Evacuation:** If necessary - **Normalization:** In accordance with international standards, local requirements, and operating permit.	- First aid equipment - Transport vessel if necessary - Fire and gas detection - Fire and gas protection - Firefighting tugs - ESD system	- Emergency response team - LNG import terminal crew - Salvage master if required - Fire fighters/first responders from port of Acajutla if necessary - Tug operators	- **Port authority:** Notification of emergency, evacuation of port if necessary, stop/manage traffic in the effected area. - **Other terminals:** N/A - **Power plant:** If necessary, notification / communication to the power plant.	[C] Currently, port of Acajutla has fire fighting crew and ambulance available in the event of an emergency situation. The city of Acajutla does not have fire fighters and ambulance. If more resources are required in an emergency event (e.g. two simultaneous emergency events), fire fighters and ambulance from Sonsonate will respond (15-20 minutes away from the port). [C] Dedicated security/firefighting tug is currently being evaluated. [C] Fire and gas detection and protection will be part of fire and explosion analysis in detailed engineering.
1.3	Rapid phase transition (RPT)	Large leak of LNG to sea and conditions for RPT are present. **Escalation:** Potential cold explosion. Consequence depends on LNG composition, water temperature, spill amount and flow rate into water. The right conditions to be present to have RPT, likelihood is very low for a well designed facility	- **Personnel:** Potential fatalities. - **Environment:** LNG is non toxic, odorless; local, short-term impact to the marine environment. - **Public:** None anticipated due to local effects.	- Secure accident scene - Evacuate personnel from exposed area - Medical assistance - Control release - Asset integrity	- **Alert:** Activate emergency response plan, VTS to ensure marine safety communications incl. coordination with rescue resources - **Combat:** According to emergency response plan - **Rescue:** If necessary - **Evacuation:** If necessary - **Normalization:** In accordance with international standards, local requirements, and operating permit.	- First aid equipment - Transport vessel if necessary - Fire and gas detection - Fire and gas protection - Firefighting tugs - ESD system	- Emergency response team - LNG import terminal crew - Salvage master if required - Fire fighters/first responders from port of Acajutla if necessary - Tug operators	- **Port authority:** Notification of emergency, evacuation of port if necessary, stop/manage traffic in the effected area. - **Other terminals:** N/A - **Power plant:** If necessary, notification / communication to the power plant.	[C] Currently, port of Acajutla has fire fighting crew and ambulance available in the event of an emergency situation. The city of Acajutla does not have fire fighters and ambulance. If more resources are required in an emergency event (e.g. two simultaneous emergency events), fire fighters and ambulance from Sonsonate will respond (15-20 minutes away from the port).
1.4	Toxic or flammable chemical leakage	Diesel stored at the FSRU is flammable and can lead to potential fire if ignited. **Escalation:** Fire if ignition source ignites diesel	- **Personnel:** Potential fatalities due to fire. - **Environment:** Diesel spill; impact to the marine environment. - **Public:** None anticipated due to local effects.	- Secure accident scene - Evacuate personnel from exposed area - Medical assistance - Control release - Control/extinguish release and/or fire - Asset integrity	- **Alert:** Activate emergency response plan, VTS to ensure marine safety communications incl. coordination with rescue resources - **Combat:** According to emergency response plan and to spill response plan - **Rescue:** If necessary - **Evacuation:** If necessary - **Normalization:** In accordance with international standards, local requirements, and operating permit.	- First aid equipment - Transport vessel if necessary - Fire and gas detection - Fire and gas protection - Firefighting tugs - ESD system	- Emergency response team - LNG import terminal crew - Salvage master if required - Fire fighters/first responders from port of Acajutla if necessary - Tug operators	- **Port authority:** Notification of emergency, evacuation of port if necessary, stop/manage traffic in the effected area. - **Other terminals:** N/A - **Power plant:** If necessary, notification / communication to the power plant.	[C] Currently, port of Acajutla has fire fighting crew and ambulance available in the event of an emergency situation. The city of Acajutla does not have fire fighters and ambulance. If more resources are required in an emergency event (e.g. two simultaneous emergency events), fire fighters and ambulance from Sonsonate will respond (15-20 minutes away from the port). [C] Dedicated security/firefighting tug is currently being evaluated. [C] Fire and gas detection and protection will be part of fire and explosion analysis in detailed engineering.
1.5	Explosion	N/A	N/A	N/A	N/A	N/A	N/A	N/A	[C] Based on the FEED design, the structure will be open; hence, there are no confined areas and no potential for explosions. No potential for explosions are considered in FEED. In Detailed Engineering, explosion events will be analyzed further in fire explosion analysis. Confined spaces will be limited but may not be completely eliminated.
2	**Natural Hazards**								
2.1	Short period sea movement	Local atmospheric conditions such as cyclones can lead to sea movement for a short period of time, creating waves of up to 3.6 m high. **Escalation:** This can lead to excessive movement of the LNGC and/or FSU.	- **Personnel:** Potential injuries depending on magnitude of the waves. - **Environment:** No anticipated consequence. - **Public:** No anticipated consequence.	- Medical assistance - Asset integrity	- **Alert:** Activate emergency response plan, VTS to ensure marine safety communications incl. coordination with rescue resources - **Combat:** According to emergency response plan - **Rescue:** For medical emergency only - **Evacuation:** For medical emergency only - **Normalization:** In accordance with international standards, local requirements, and operating permit.	- First aid equipment - Transport vessel if necessary - Tugs potentially - ESD systems	- Emergency response team - LNG import terminal crew - Salvage master if required - Tug operators	- **Port authority:** Notification of emergency if applicable, coordination of resources. - **Other terminals:** N/A - **Power plant:** N/A	[C] Coordination of emergency response resources (ambulance, fire fighters, etc..) to be determined at a later stage.
2.2	Long period swells	Climate, storms and hurricane activity can lead to long period swells with waves of up to 2.4 m high. Advanced warning not provided. **Escalation:** This can lead to excessive movement of the LNGC and/or FSU	Refer to item 1.1						
2.3	Tsunami, near-field	Climate, subduction zone outside coast of El Salvador, or seismic activity can result in a tsunami. Advanced warning not provided and/or exceeds design event **Escalation:** This can lead to excessive movement of the LNGC and/or FSU. Worst case scenario FSU breaks away and collides with LNG terminal or Cenérgica mooring buoys leading to loss of containment (only if impact energy >28 mJ).	- **Personnel:** Potential injuries depending on magnitude of the waves. - **Environment:** LNG is non toxic, odorless; local, short-term impact to the marine environment. - **Public:** No anticipated consequence.	- Medical assistance - Asset integrity	- **Alert:** Activate emergency response plan, VTS to ensure marine safety communications incl. coordination with rescue resources - **Combat:** According to emergency response plan - **Rescue:** For medical emergency only - **Evacuation:** For medical emergency only - **Normalization:** In accordance with international standards, local requirements, and operating permit.	- First aid equipment - Transport vessel if necessary - Tugs potentially - ESD systems - Anchors	- Emergency response team - LNG import terminal crew - Salvage master if required - Tug operators	- **Port authority:** Notification of emergency if applicable, coordination of resources. - **Other terminals:** Alerted via emergency channel. - **Power plant:** N/A	

#	Defined Hazard and Accident Scenario	Description of Scenario	Consequences	Main Focus Areas for the Emergency Response	Response Procedure/Main Strategy	Response Equipment	Response Personnel	Interfaces and Requirements	Comments [C]/Recommendations [R]
2.4	Tsunami, far-field	Climate, subduction zone outside coast of El Salvador, or seismic activity can result in a tsunami. **Escalation:** LNGC and FSU may leave the terminal upon advanced warning. Other vessels can collide in LNGC/FSU, leading to loss of containment (only if impact energy >28 mJ). No anticipated damage to FSRU given cofferdam structure. Potential damage to cofferdam structure.	- **Personnel:** Potential injuries depending on magnitude of the waves. - **Environment:** LNG is non toxic, odorless; local, short-term impact to the marine environment. - **Public:** No anticipated consequence.	- Medical assistance - Asset integrity	- **Alert:** Activate emergency response plan, VTS to ensure marine safety communications incl. coordination with rescue resources - **Combat:** According to emergency response plan - **Rescue:** For medical emergency only - **Evacuation:** LNGC and FSU may leave - **Normalization:** In accordance with international standards, local requirements, and operating permit.	- First aid equipment - Transport vessel if necessary - Tugs potentially - ESD systems - Anchors	- Emergency response team - LNG import terminal crew - Salvage master if required - Tug operators	- **Port authority:** notification of emergency if applicable, coordination of resources. - **Other terminals:** alerted via emergency channel. - **Power plant:** N/A	[C] In the situation where vessels need to leave to safe location, port will assist departure of vessels at the port first. [R] Consider dedicated tugs for the project [EDP]. [R] Consider additional thrusters to allow FSU to move away from LNG import terminal upon tsunami warning [EDP]. [R] Consider implementing a redundant warning system, in addition to the Pacific Tsunami Warning Center (PTWC) system [EDP].
2.5	Seismic activity, earthquake	Climate, subduction zone outside coast of El Salvador can result in seismic activity or earthquake. **Escalation:** Other vessels can collide in FSRU; no anticipated damage to FSRU given cofferdam structure. Potential damage to cofferdam structure , pipeline, fixed equipment/infrastructure. Potential fire.	- **Personnel:** Potential injuries depending on magnitude of seismic activity. - **Environment:** LNG is non toxic, odorless; local, short-term impact to the marine environment. - **Public:** Possible consequences primarily from gas dispersion from onshore pipeline to 3rd parties and population in the proximity.	- Medical assistance - Asset integrity	- **Alert:** Activate emergency response plan, VTS to ensure marine safety communications incl. coordination with rescue resources - **Combat:** According to emergency response plan - **Rescue:** For medical emergency only - **Evacuation:** None - **Normalization:** In accordance with international standards, local requirements, and operating permit.	- First aid equipment - Transport vessel if necessary - ESD systems	- Emergency response team - LNG import terminal crew - Salvage master if required	- **Port authority:** notification of emergency if applicable, coordination of resources. - **Other terminals:** N/A - **Power plant:** If necessary, notification / communication to the power plant.	[C] Emergency Response Plan will be developed by the project.
2.6	Electrical storm	Chubascos in the region can cause electrical storms. **Escalation:** This can lead to damage to the infrastructure and potential fatalities.	- **Personnel:** Potential injuries depending on magnitude of the waves. - **Environment:** No anticipated consequence. - **Public:** No anticipated consequence.	- Medical assistance - Asset integrity	- **Alert:** Activate emergency response plan, VTS to ensure marine safety communications incl. coordination with rescue resources - **Combat:** According to emergency response plan - **Rescue:** For medical emergency only - **Evacuation:** For medical emergency only - **Normalization:** In accordance with international standards, local requirements, and operating permit.	- First aid equipment - Transport vessel if necessary	- Emergency response team - LNG import terminal crew - Salvage master if required	- **Port authority:** Notification of emergency if applicable, coordination of resources. - **Other terminals:** N/A - **Power plant:** N/A	[C] The LNG import terminal installation should be designed such that operations can be continued safely in the occurrence of electrical storms (e.g. mitigating measures venting)
2.7	High wind	Chubascos in the region can cause high winds. **Escalation:** This can lead to breakage of mooring lines.	- **Personnel:** No anticipated consequence. - **Environment:** No anticipated consequence. - **Public:** No anticipated consequence.	N/A	N/A	N/A	N/A	N/A	[C] The LNG import terminal installation should be designed to withstand high wind and continue operations in the occurrence of high wind conditions
3	**Dropped Objects**								
3.1	Dropped objects during crane lifting or while transferring cargo from supply vessel to FSRU	N/A	N/A	N/A	N/A	N/A	N/A	N/A	[C] Design of the installation should be such that no objects will be lifted over live equipment.
3.2	Dropped objects during crane lifting on FSU	Dropped objects during crane lifting due to human error or mechanical failure. **Escalation:** Damage to LNG transfer system or topside equipment on FSU.	- **Personnel:** Potential injuries - **Environment:** No anticipated consequence. - **Public:** No anticipated consequence.	- Medical assistance - Asset integrity	- **Alert:** Activate emergency response plan, VTS to ensure marine safety communications incl. coordination with rescue resources - **Combat:** According to emergency response plan - **Rescue:** For medical emergency only - **Evacuation:** For medical emergency only - **Normalization:** In accordance with international standards, local requirements, and operating permit.	- First aid equipment - Transport vessel if necessary - ESD systems	- Emergency response team - FSU crew - Salvage master if required	- **Port authority:** Notification of emergency if applicable, coordination of resources. - **Other terminals:** N/A - **Power plant:** N/A	[C] Design of the installation should be such that no objects will be lifted over live equipment.
3.3	Dropped object on subsea pipeline to shore	Dragged and/or dropped anchor from another vessel on the subsea pipeline. **Escalation:** Damage to subsea pipeline. Potential loss of containment.	- **Personnel:** None anticipated. - **Environment:** LNG is non toxic, odorless; local, short-term impact to the marine environment. - **Public:** Potential effect due to gas dispersion nearby shore.	- Secure accident scene - Control release - Asset integrity	- **Alert:** Activate emergency response plan, VTS to ensure marine safety communications incl. coordination with rescue resources - **Combat:** According to emergency response plan - **Rescue:** For medical emergency only - **Evacuation:** None - **Normalization:** In accordance with international standards, local requirements, and operating permit.	- ESD systems	- Emergency response team - LNG import terminal crew - Salvage master if required	- **Port authority:** Notification of emergency, evacuation of port if necessary, stop/manage traffic in the effected area. - **Other terminals:** N/A - **Power Plant:** If necessary, notification / communication to the LNG import terminal.	[C] Pipeline should be protected by design. [C] No anchoring zones are shown on nautical charts.
4	**Riser and Subsea Pipeline**								
4.1	Gas leakage to environment, subsea source (subsea pipeline or riser under water)	Rupture of riser subsea. **Escalation:** Release of gas to the environment. Case of no ignition	- **Personnel:** None anticipated. - **Environment:** LNG is non toxic, odorless; local, short-term impact to the marine environment. - **Public:** Potential effect due to gas dispersion nearby shore.	- Secure accident scene - Control release - Asset integrity	- **Alert:** Activate emergency response plan, VTS to ensure marine safety communications incl. coordination with rescue resources - **Combat:** According to emergency response plan - **Rescue:** For medical emergency only - **Evacuation:** None - **Normalization:** In accordance with international standards, local requirements, and operating permit.	- ESD systems	- Emergency response team - LNG import terminal crew - Salvage master if required	- **Port authority:** Notification of emergency, evacuation of port if necessary, stop/manage traffic in the effected area. - **Other terminals:** N/A - **Power Plant:** If necessary, notification / communication to the LNG import terminal.	[C] Pipeline should be protected by design. [C] No anchoring zones are shown on nautical charts.
4.2	Gas leakage to environment, topside source (connection to FSRU, riser part above sea)	Rupture of riser due to ship collision in riser. **Escalation:** Release of gas to the environment. Potential jet fire if high pressure gas is ignited.	- **Personnel:** Potential fatalities due to fire. - **Environment:** LNG is non toxic, odorless; local, short-term impact to the marine environment. - **Public:** None anticipated due to the distance between the LNG import terminal and 3rd parties/population.	- Secure accident scene - Evacuate personnel from exposed area - Medical assistance - Control release - Asset integrity	- **Alert:** Activate emergency response plan, VTS to ensure marine safety communications incl. coordination with rescue resources, notify civil protection entity. - **Combat:** According to emergency response plan - **Rescue:** If necessary - **Evacuation:** If necessary - **Normalization:** In accordance with international standards, local requirements, and operating permit.	- First aid equipment - Transport vessel if necessary - Fire and gas detection - Fire and gas protection - Firefighting tugs - ESD system	- Emergency response team - LNG import terminal crew - Salvage master if required - Fire fighters/first responders from port of Acajutla if necessary - Tug operators	- **Port authority:** Notification of emergency, evacuation of port if necessary, stop/manage traffic in the effected area. - **Other terminals:** N/A - **Power plant:** If necessary, notification / communication to the power plant.	[C] Design of the riser will be such that collision of a small vessel and the riser is prevented.
5	**Security**								
5.1	Security threats	Local security threats can have impact on safety of personnel and on assets and production.	- **Personnel:** Potentially, depending on situation. - **Environment:** None anticipated. - **Public:** None anticipated.	As needed: - Secure accident scene - Evacuate personnel from exposed area - Medical assistance	- **Alert:** Activate emergency response plan, VTS to ensure marine safety communications incl. coordination with rescue resources - **Combat:** According to security plan - **Rescue:** If needed - **Evacuation:** If needed - **Normalization:** In accordance with international standards, local requirements, and operating permit.	- First aid equipment - Transport vessel if necessary	- Emergency response team - Port of Acajutla - Military/police	- **Port authority:** N/A - **Public agency:** Depending on initial emergency situation. - **Other terminals:** If necessary, notification / communication to the LNG import terminal.	[C] Security threats at the LNG import terminal will be addressed in the Port Facility Security Assessment (PFSA), which will be developed in the detailed engineering phase of the project.

#	Defined Hazard and Accident Scenario	Description of Scenario	Consequences	Main Focus Areas for the Emergency Response	Response Procedure/Main Strategy	Response Equipment	Response Personnel	Interfaces and Requirements	Comments [C]/Recommendations [R]
6	**Other**								
6.1	Leak of hydrocarbons of fire from another ship (e.g. sailing, or berthed in port of Acajutla, berthed in Cenérgica terminal, berthed in Rasa, terminal, berthed in Alba terminal)	Leakage of hydrocarbons from a ship. **Escalation**: Potential fire if ignited.	- **Personnel:** Potentially, depending on situation. - **Environment:** Potentially from other vessel, depending on situation. - **Public:** Potentially from other vessel, depending on situation.	As needed: - Secure accident scene - Evacuate personnel from exposed area - Medical assistance - Asset integrity	- **Alert:** Activate emergency response plan, VTS to ensure marine safety communications incl. coordination with rescue resources, notify civil protection entity. - **Combat:** According to emergency response plan - **Rescue:** If necessary - **Evacuation:** If necessary - **Normalization:** In accordance with international standards, local requirements, and operating permit.	- First aid equipment - Transport vessel if necessary - Fire and gas detection - Fire and gas protection - Firefighting tugs - ESD system	- Emergency response team - LNG import terminal crew - Salvage master if required - Fire fighters/first responders from port of Acajutla if necessary - Tug operators	- **Port authority:** Notification of emergency, evacuation of port if necessary, stop/manage traffic in the effected area. - **Other terminals:** N/A - **Power plant:** If necessary, notification / communication to the power plant.	[C] Due to the distance between the LNG import terminal and the port / Cenérgica terminal / Rasa terminal / Alba terminal, localized fire not expected to impact the LNG import terminal.