ENVIRONMENTAL IMPACT ASSESSMENT

48” GAS PIPELINE
CAPACITY INCREASE TO SUR

PETROLEUM DEVELOPMENT OMAN

SULTANATE OF OMAN

AUTHORISED FOR RELEASE BY:
DATE: 24th June 2003

Petroleum Development Oman

48" Gas Pipeline
Capacity Increase to Sur
Environmental Impact Assessment

Final Report

HMR Environmental Engineering Consultants
P.O. Box: 1295, Seeb
Postal Code: 111
Sultanate of Oman

Tel: (968) 502506
Fax: (968) 502616
email: hmrenv@omantel.net.om

June 2003

48” Gas Pipeline Capacity Increase to Sur
Environmental Impact Assessment

FINAL REPORT

on behalf of

Petroleum Development Oman

Prepared by

HMR Environmental Engineering Consultants
PO Box 1295, Seeb
Postal Code 111
Sultanate of Oman

Tel: (968) 502506
Fax: (968) 502616
email:hmrenv@omantel.net.om

EXECUTIVE SUMMARY: SAIH RAWL CPP - QALHAT GAS PIPELINE

Introduction

On behalf of the Government of Oman, Petroleum Development Oman LLC (PDO) has been given approval to construct a natural gas pipeline running from the Saih Rawl Central Processing Plant (CPP) to the Oman Liquefied Natural Gas (OLNG) plant in Qalhat, near Sur. The development of three new projects in the Sur area are reliant upon this additional gas. These projects include the 3rd train of the OLNG plant and export facility, a urea plant (currently under construction) and a power station.

PDO commissioned HMR Environmental Consultants (HMR) to prepare an EIA report for the proposed project based on an earlier Integrated Impact Assessment (IIA) study, March 2003 [ref. 1] conducted by PDO.

Project Description

In order to allow for the required increase in gas delivered to the OLNG plant, two options were under consideration by the ministry of Oil and Gas (MOG) at the time of this study. They are termed "full loop" and "partial loop". The "full loop" option would entail a second pipeline running alongside, and essentially duplicating, an existing pipeline running from the Saih Rawl CPP to the OLNG plant covering a distance of 358 km. The "partial loop" option would entail a second pipeline running along side the existing pipeline from Saih Rawl up to Block Valve Station (BVS) 9, approximately 68 km from the OLNG Plant. **As the loop option has yet to be decided, this EIA covers the full extent of the route so as to cover both the partial and full loop option.**

The existing 48" pipeline currently delivers less than 44 million m^3/day. It is expected that with the proposed expansion, delivery would increase to up to 64 million m^3/day or even 82 million m^3/day for the partial loop or full loop, respectively.

The IIA study was undertaken for the full loop option between October 2002 and March 2003. The study team included HMR staff and so most data required for the EIA was readily available. This EIA, therefore, is comprised mainly of desk research and consultations with pipeline engineers. The EIA report is prepared in accordance with both PDO (GU-195) and MRME&WR guidelines on EIA. The report discusses the existing baseline conditions, impact prediction and mitigation to the human and natural

environments.

Existing Environmental Conditions along Route

Saih Rawl to BVS 7:

The pipeline commences at Saih Rawl where it crosses gravel plain in an easterly direction to Saih Nihayda. From Saih Nihayda the route heads almost in a direct line in a northeastern direction to BVS 7, which is located to the northwest of the Wahiba Sands. The right of way (RoW) of the existing gas pipeline, which the new pipeline will likely follow, traverses a landscape of sand and gravel flats with occasional low gravel hills and rocky outcrops. Salt domes are visible at various points along the pipeline route, but none are close to the pipeline.

Because the area is a hot arid desert with scarce rainfall, vegetation tends to be restricted to depressions and wadi beds. Rainfall in the Hajar Mountains to the north occasionally flows south through the wadi systems that flow towards the south. There are no sources of good quality groundwater or afalaj suitable as a potable supply in the region. As a result, there are few villages or Bedouin settlements along this section of the pipeline route, although there are some small Bedouin settlements near the residential camps associated with the oilfield activities. No farms are located along the pipeline route until approaching the Wahiba sands.

BVS 7 to Al Saleel Nature Reserve:

This area is a hot semi-arid desert with low humidity during most of the year. Rainfall is inconsistent and limited. Villages and towns have developed close to groundwater resources and aflaj. Aflaj systems arising from groundwater occur in the vicinity of Ibra, Bidiyah and Mintrib that cross the pipeline route. There are also groundwater extraction wells at Mintrib, where the pipeline passes through the well-field protection zone, and at Al Kamil. To meet the demands of agriculture, industry and population, water supplies across the region are extracted to near unsustainable levels, leading to depletion in quantity and deterioration to water quality. Disposal of wastes and sewage may have already led to organic, inorganic and bacteriological contamination of some groundwater resources.

Acacia dominates the plant community across this region. Of conservation importance in the area is the Arabian gazelle. Many camels and goats are also seen throughout this area.

Due to the broad spectrum of habitats to be found along the RoW, avifauna are diverse. The pipeline route passes through the Al Saleel Nature Reserve whose border reaches the foothills of the East Hajar Mountains approximately 30 km beyond BVS-9 that is close to Al Kamil power station. The RoW passes, in a direct line, through the Park and should be wide enough to allow the construction of the new pipeline without further significant widening. Species of note in the park include Arabian gazelle, the sand cat, wolves and the red fox. Plans exist for the introduction of the Arabian Oryx and the sand gazelle to the park, and for the fencing of the park following removal of domestic animals and relocation of a small number of farms. The park has been earmarked for wildlife tourism and education, as well as providing revenue to the local economy. Most of the Bedouin settlements along this section of the route are between Sanaw and Mintrib.

There is a municipal waste dump located adjacent to the RoW in Hawiyah just before Al Saleel Park. Burning garbage was observed during the IIA field reconnaissance.

Al Saleel Nature Reserve to LNG Plant:

From the boundary of the Al Saleel Nature Reserve, the pipeline route passes through a narrow wadi for a distance of approximately 5 km before entering a plateau area of sand and gravels cut by deep, wide wadis. The right of way passes through a residential area to the north of Sur, where there is a school and a teacher training college close to the route, before crossing the narrow coastal plain to the OLNG Plant at Qalhat.

The groundwater is shallow to the west of Sur, and overuse of the groundwater in recent years has resulted in saline intrusion and resulted in declining water quality. Demand is higher than local public supply, and thus currently 20% of the demand is being provided from the desalination plant at OLNG and one million gallons per month by road transport from Al Kamil. There are surface aflaj at Sur where the water sources occur as springs. The pipeline route is not known to cross any afalaj in this section of the pipeline.

The decline in water supply and water quality in recent years has resulted in the simultaneous decline in farming in the wadi areas. Palm trees and vegetation in farms at the sides of wadis generally appear to be in a poor state, and there are numerous abandoned farms and cultivated areas. Vegetation is sparse through the mountains and across the plateau area where Acacia dominates the plant community in the wadis.

There are the remains of six tombs immediately adjacent to the pipeline route in the wadi

that passes through the East Hajar Mountains immediately to the east of the Al Saleel Nature Reserve. The RoW will require widening through this wadi by constructing cuttings that would destroy one or more of the tombs.

In recent years the supply of electricity has been extended to many communities and a new grid distribution line has been constructed from Al Kamil power station to the Sur Industrial Area where the OLNG plant is located. These various power lines cross the pipeline right of way in numerous locations and the construction of the new pipeline would require these to be temporarily disrupted or relocated.

Construction Methodology

The standard method for construction of cross-country pipelines is the "spread" technique. A spread is defined as the manpower and equipment necessary to carry out construction from surveying of the route at the start of construction through to restoration at the end of construction. The work is conducted on a moving assembly-line basis with each sequential activity maintaining a consistent rate of progress. The construction work is carried out by a pipeline contractor under the supervision of experienced pipeline management personnel representing PDO.

Significant Impacts and Mitigation for Project

The potential environmental impacts from the construction and operation activities and the mitigation measures planned are summarized below. The contractor shall implement all of the proposed mitigations listed below during the construction phase:

CONSTRUCTION PHASE	
POTENTIAL ADVERSE IMPACT	MITIGATION MEASURES
• Land take for the construction of labour camps may cause displacement and adversely affect the land use if not properly selected	a. Select land in compliance with town planning and avoidance of "high value" areas for labour camps.
• Steep cuttings will degrade aesthetics	a. Use of gentler slopes in sensitive areas
• Windrow may cause obstruction to people living near windrow, livestock and wildlife	a. Insert gaps at sufficient intervals in windrow

• Obstruction or damage to wadi or aflaj may cause impeded water flow, loss of water supply and pollution.	a. Locate camps away from aflaj and wadis b. Liaise with falaj Wakils and MRME&WR to create acceptable Aflaj Crossing, Monitoring and Restoration Plan. c. Ensure pipeline is at a minimum depth of 1.5 m when crossing wadis
• Use of groundwater for construction and domestic use may put stress on local groundwater resources	a. Water should not be taken from a community water supply b. Plan water usage with MRME&WR c. Use low grade water (not from local community supply) for dust suppression d. Use local companies to truck in water e. Use RO plants where available f. Minimise water consumption through conservation measures
• Chemical handling and fuel storage may lead to contamination of water and soil	a. Ensure chemicals are stored in accordance with MSDS/SHOC regulations b. Ensure regulations for handling and use of chemicals and toxic substances are followed (RD 46/95 and MD 248/97) c. Place fuel storage tanks in bunded areas outside of camps d. Monitor soil quality of chemical storage area e. Create and follow a Spill Contingency Plan
• Radioactive testing may be hazardous to both employees and surrounding populations	a. Ensure regulations for control and management of radioactive materials substances are followed (MD 249/97)
• Exposed holes may cause injuries to communities, livestock and wild fauna	a. Ensure borrow pits and trenches are fenced where practical
• Exposed holes may lead to health risk (spread of mosquito breeding ground leading to increase in malaria risk)	a. Ensure all exposed hold are covered if water is present b. Collaborate with MOH c. Monitor camp for increase in malaria amongst employees d. Report incidents of malaria to MOH immediately
• Hydrostatic testing may cause soil and groundwater degradation. Evaporation ponds may be hazardous to wildlife and livestock	a. Ensure hydrotest water is disposed of in line with MRME&WR regulations b. Ensure water disposal does not take place within ESAs c. Should evaporations ponds be used, they should be lined and fenced

• Disposal of solid wastes and liquid effluents and hazardous wastes generated from construction site as well as from labour camps may cause land and ground water pollution	a. Follow MRME&WR and PDO regulations for waste management b. Segregate and dispose of solid wastes according to MD 17/93 and MD 18/93 c. Collect sewage in septic tanks for appropriate disposal to an STP. Ensure MRME&WR regulations are followed (MD 421/98) d. Locate camps away from aflaj and wadis e. Segregate any contaminated runoffs (due to accidental oil or chemical spills) from normal runoffs, and their treatment or disposal as directed by DGEA f. Remediate any contaminated areas within the work sites and labour camps
• Stress on local infrastructure (power, water, roads, hospitals etc.) and impacts on public health due to large scale deployment of workforce for construction	d. Consult with local bodies and other contractors of concurrent project to develop and implement effective strategies e. Ensure that all expatriate workers are cleared by the labour ministry (medically screened for communicable diseases) f. Provide proper induction course to any first time expatriates on local culture and lifestyle
• Generation of dust and gaseous emissions from construction activities and the transport vehicles may degrade ambient air quality	a. Spray low grade water on unpaved roads and work sites for dust suppression b. Avoid over-speeding of transport vehicles on unpaved roads c. Ensure that the engine emissions for all construction equipment and transport vehicles comply with applicable emission standards d. Monitor air quality at and around work sites periodically e. Site camps away from ESAs f. Maintain efficient exhaust filters on equipment
• Generation of noise from the construction equipment and the transport vehicles may cause nuisance to local people and wildlife and be hazardous to employees	a. Minimise night time construction activities and vehicular traffic b. Ensure good maintenance of construction equipment and transport vehicles c. Inform residents of construction 2 weeks prior to start d. Monitor noise levels periodically e. Avoid construction during breeding/migration season for wildlife in Al Saleel Nature Reserve f. Ensure CRO investigates noise complaints within 24 hrs g. Avoid blasting and excessive noise during prayer times h. Use efficiently silenced equipment i. Ensure protective ear equipment is provided to and used by employees

• Vibrations from excavation and explosives may cause structural damage to archaeological sites, falaj systems and buildings	a. Obtain letter of no objection from Ministry of Heritage and Culture to allow construction to take place near archaeological sites b. Avoid unnecessary off-road driving c. Ensure controlled blasting is undertaken in sensitive areas d. Offer fair compensation for damage e. Control vehicle movements within ESAs
• Vegetation cutting/clearing in order to build camps or during trenching may lead to a decrease in forage for wildlife	a. Minimise vegetation cutting and clearing when creating access roads b. Minimise widening of RoW within boundary of Al Saleel Nature Reserve c. Locate camps and storage areas away from ESAs
• Artificial light generated at night during construction may cause nuisance to communities and wildlife	a. Ensure no construction during the night in populated areas or Al Saleel Nature Park
• Increased traffic flow due to transportation of materials by road may lead to traffic congestion and adversely affect public safety and health	a. Develop traffic management plan to reduce traffic congestion on public access roads
• Aesthetic deterioration and impacts to landscape and topography may result from abandonment of construction materials and camps.	a. Ensure site is fully restored after completion of construction. Ensure all waste and materials are removed and the site be leveled. b. Unused material extracted during excavation shall be kept and used in remediation and leveling ground surface.
• Lack of public engagement may deteriorate PDO-community relationship	a. Ensure local short term staff are employed from surrounding areas whenever possible b. Ensure the above stipulation is mentioned in the EPC tender document. c. Ensure Ministry of Labour Omanisation quotas are followed d. Clear communication between CROs and communities to ensure their awareness of noise, dust and hazards to them and their livestock
OPERATIONAL PHASE	
POTENTIAL ADVERSE IMPACT	PROPOSED MITIGATION MEASURES
• Increase in traffic along RoW may cause damage to pipeline, injury to users of RoW and disturbance to wildlife in sensitive areas	a. Clear signs need to posted stating RoW is not to be used by public b. Ensure RoW is inconvenient in usability at Al Saleel Nature Reserve and that usage is strictly forbidden by users other than those maintaining pipeline

• Maintenance vehicles in Al Saleel Park may cause disturbance to fauna.	a. Ensure special care and low speeds are taken when maintenance is being conducted within Al Saleel Park.
• Soil and groundwater contamination may occur from pigging sludge	b. Ensure PDO specifications and MRME&WR regulations are followed for sludge management
• Explosion/fire hazard from accidental gas leak may cause injuries and death among pipeline employees and neighboring communities. • Strain on local health facilities, and emergency services.	a. Ensure pipeline is maintained in accordance with regulations in place. b. Carry out QRA and implement the necessary mitigations measures. c. Municipal waste dump at Hawiyah should be moved away from the RoW d. RoW should not be used for everyday traffic e. Prepare emergency response plan with nearby health facilities f. Engage in regular emergency exercises with local hospitals

Conclusion

Although parts of the Saih Rawl-Qalhat pipeline is routed across a sensitive and fragile landscape the impacts associated with the project are such that they will occur mainly during its construction. The EIA study did not determine any impacts which are of such significance that would require re-routing of the pipeline. The study has not revealed any insurmountable constraints to the project implementation.

The routing and operation of the pipeline, if carried out in accordance with the recommendations of this EIA report, is such that environmental degradation of the area will be minimised. Any adverse environmental impacts associated with the project should be considered against the substantial economic benefits the construction and operation of the pipeline will bring to the region and to the nation.

ABBREVIATIONS

^{o}C	degrees Centigrade
BVS	block valve station
CEMP	construction environmental management plan
COD	chemical oxygen demand
CP	cathodic protection
CPP	central processing plant
CRO	community relations officer
dB(A)	decibel
DGEA	Directorate General of Environmental Affairs
E	Easting
EIA	environmental impact assessment
EPC	engineering, procurement and construction
ESA	environmentally sensitive area
GU	guideline
HGV	heavy goods vehicle
HMR	HMR Environmental Consultants
HSE	health, safety and environment
IIA	integrated impact assessment
km	kilometer
LC	Lethal Concentration
LGV	Light goods vehicle
m	meter
m3	cubic meter
m3d	meter cubed per day
MD	Ministerial Decision
mm3/d	millimeter cubed per day
MOG	Ministry of Oil and Gas
MOH	Ministry of Health
MRME&WR	Ministry of Municipalities, Environment and Water Resources
MSDS	material data sheets
MW	mega-Watt
N	Northing
NAAQ	National Fire Protection Agency of United States of America

OLNG	Oman Liquefied Natural Gas
PCES	pipeline construction environmental specification
PCS	pipeline construction specification
PDO	Petroleum Development Oman LLC.
RD	Royal Decree
RO	reverse osmosis
ROP	Royal Oman Police
ROW	right of way
RTA	road traffic accidents
SHOC	safe handling of chemicals
SP	specification
STP	sewage treatment plant
UeR	Umm er Rhadhuma
USEPA	United States (of America) Environmental Protection Agency
UTM	universal transverse merkator

TABLE OF CONTENTS

LIST OF APPENDICES

LIST OF TABLES

LIST OF FIGURES AND PLATES

1 INTRODUCTION

1.1 Project Background

In January 2003, Petroleum Development Oman LLC (PDO) were given approval to construct a 48" natural gas pipeline using the "partial loop" option along side the already existing 48" Central Oman gas pipeline. The existing pipeline supplies gas from Saih Rawl Central Processing Plant (CPP) to the Oman Liquified Natural Gas (OLNG) Plant in Qalhat. The partial loop would entail the new pipeline to run from Saih Rawl to Block Valve Station (BVS) 9, which is approximately 68 km away from Qalhat. In total, the new pipeline would be approximately 290 km long.

In May 2003 the Ministry of Oil and Gas (MOG) approved PDO to explore the "full loop" as an option. This option would entail constructing the new pipeline alongside, and essentially duplicating, the existing pipeline running from the Saih Rawl CPP to the OLNG plant, covering a distance of 358 km.

As the loop options are yet to be decided at the time of this study, the EIA covers the full loop option so that it will be valid regardless of the option chosen.

The existing 48" pipeline currently delivers less than 44 million m^3/day. It is expected that with the proposed expansion, delivery would increase to up to 64 million m^3/day or 82 million m^3/day for the full loop or partial loop, respectively.

The engineering, procurement and construction (EPC) contract for this project has yet to go to tender and it is therefore unknown at the time of this study who the EPC contractor will be. The EPC contractor will be responsible for the detail design and construction of the pipeline. PDO, who developed the conceptual design of the project for the MOG is responsible for supervision of design and construction of the project.

PDO has selected HMR Environmental Consultants (HMR) to prepare the environmental impact assessment (EIA) report of the conceptual design of the full loop option.

An integrated impact assessment (IIA) [Ref. 1] was undertaken for the full loop option between October 2002 and March 2003. The IIA study team included HMR staff and so

much data was readily available. This EIA, therefore, is comprised mainly of desk research and consultations with pipeline engineers. The EIA was conducted in accordance with both PDO (GU-195) and MRME&WR guidelines on EIA. The study established existing baseline conditions, impact prediction and mitigation to the human and natural environments.

1.2 Objective and Scope of EIA Study

The overall objective of the EIA study is to identify and evaluate all significant impacts from the project activities on the environment and to develop appropriate management plans for the mitigation of all potential adverse impacts. The project activities cover all the phases of the project, *viz.*, construction, operation and decommissioning.

The scope of work for the EIA of this project is defined in line with both Omani regulatory requirements, as specified in the "Guideline on Environmental Impact Assessment" issued by the Directorate General of Environmental Affairs (DGEA) in the Ministry of Regional Municipalities, Environment and Water Resources (MRME&WR); and PDO Environmental Assessment Guidelines (GU-195) [Ref. 13]. Together, these guidelines include the following elements:

- EIA scoping with DGEA to obtain approval for the means and methods used for baseline studies and impact assessment of the project;
- Environmental review of the project for quantification and characterisation of wastes generated from the project during its construction, operation and decommissioning;
- Environmental analysis of alternatives for the processes, technologies and approaches associated with the project development;
- Desktop reviews and field studies for describing the current status of the environment at project site;
- Identification of potential environmental impacts from the project activities during its construction, operation and decommissioning;

- Assessment of significant environmental impacts from the project activities during its construction, operation and decommissioning;

- Development of suitable environmental management plans including mitigation measures and monitoring programmes;

- Preparation of the EIA report for review by DGEA.

1.3 Method of Study

An integrated impact assessment (IIA) [Ref.1] carried out from October 2002 – March 2003 included assessments of environmental, health and social impacts of the proposed project. HMR was part of the IIA study team. This stand-alone EIA study was carried out in May 2003 and uses assessments made in the IIA report as its basis. The overall methodology was based on the general principles and procedures outlined in MRME&WR's "Guideline on Environmental Impact Assessment" published in 2000 and PDO's "Environmental Assessment Guideline" published in 1999 [Ref. 13]. In addition, guidance was taken from the World Bank Group guidelines on "Environmental Analysis and Review of Projects". The overall study was carried out in phases as described below:

- **EIA Scoping:**

Scoping was carried out at the beginning of the IIA study to get DGEA's approval for the means and methods used. Ministry officials were involved with the conducting of the IIA and Ministry concerns were included into the scope of the study. This EIA includes the same scope used for the EIA section of the IIA.

- **Document/Report Review**

The main report used to prepare this EIA is the 'Integrated Impact Assessment of the Central Oman Gas Expansion Project' March 2003 [Ref. 1]. This report was reviewed to identify the environmental hazards associated with the project construction and operational activities, and to characterise and quantify the various wastes that would be generated from the project. Consultations were held with PDO to determine design and pipeline specifications.

- **Environmental Data Gathering**

The majority of the environmental baseline information has been taken from the IIA report. Information such as topography, meteorology, geology, hydro-geology, ecology, socio-cultural aspects, socio-economics etc. was sourced from several government departments, non-governmental institutions and previous recently conducted EIA studies for this region. This included the preliminary EIA of the existing pipeline conducted by WS Atkins in 1993 [Ref. 26] and a comprehensive EIA conducted by Penspen International in 1996 [Ref. 12]. Site-specific field investigations were carried out during the IIA to augment the database and to determine the current environmental quality along the project route. The baseline details are presented in Chapter 4.

- **Impact Assessment**

Based on the above, all significant environmental aspects and impacts from the proposed project activities are identified in this report using checklists and matrices. Qualitative predictive techniques are used to determine the magnitude of these impacts. The importance of each impact is determined based on the nature of impact and taking into consideration the existing environmental quality. The details are presented in Chapter 5.

- **Development of Environmental Mitigation and Monitoring Plan**

Appropriate and effective mitigation measures are developed to reduce and mitigate all significant adverse environmental impacts to acceptable levels. The mitigation / monitoring plan covers all the phases of the project *viz*., construction phase, operation phase and decommissioning (site abandonment and restoration) phase. The necessary environmental monitoring systems are identified and monitoring programmes are developed. An effective environmental mitigation and monitoring plan is proposed in Chapter 6.

1.4 Structure of EIA Report

The main report is divided into six chapters. Succeeding this introductory chapter, the applicable environmental legislative and institutional requirements are presented in Chapter 2. The project description and specifications are presented in Chapter 3. The detailed description of the existing environment along the project route is presented in Chapter 4. In Chapter 5, the environmental aspects and potential impacts are discussed.

The environmental mitigation and monitoring is presented in Chapter 6. The conclusion is presented in Chapter 7.

An executive summary of the EIA is presented ahead of the main report. All other information that is not included in the main report is presented in appendices.

The organisation and the individuals responsible for the preparation of this report are listed in Appendix 1.

2 REGULATORY FRAMEWORK

2.1 Overview

The standards and codes for the construction of the project will be specified in the EPC contract documents issued by PDO.

With regard to the environmental specifications, PDO's contractual conditions to the EPC contractor will require that all local rules and regulations shall be complied with.

It is most likely that the environmental regulations and standards applicable for this project will be solely governed by Omani legislation. These are discussed in detail in Sections 2.2 and 2.3.

2.2 Environmental Legislation in Oman

The Omani regulations on environmental protection, control and management are covered under two basic laws *viz*., the "Law for the Conservation of the Environment and Prevention of Pollution" first promulgated in 1982 as Royal Decree (RD) 10/82 and superseded in November 2001 as RD 114/2001 and the "Law on Protection of Sources of Potable Water from Pollution" promulgated in November 2001 as RD 115/2001. The responsibility for the implementation of this law rests with MRME&WR, which issues regulations, standards and guidelines through "ministerial decisions (MDs)". Within MRME&WR, the authority responsible for environmental permitting, inspection and control in the Sultanate of Oman is DGEA. The current Omani environmental laws and regulations are listed in Table 2.1 in chronological order.

Table 2.1: Environmental Laws and Regulations in Oman

(Presented in Chronological Order)

Description	Reference Number
Protection of certain species of fauna	MD 4/76
Law on the development of water resources and its amendments	RD 76/77, RD 82/88, RD 29/00
Law on national heritage protection	RD 2/80, RD 6/80
Law for the conservation of the environment and prevention of pollution and its amendments	RD 10/82 (superseded), RD 63/85, MD 5/86, RD 71/89, MD 2/90, RD 31/93, RD 114/2001
Regulations concerning the disposal of liquid effluents to marine environment	MD 7/84
Regulations for the discharge of industrial and commercial effluents	MD 8/84
Regulations for septic tanks and holding tanks	MD 5/86 (superseded), MD 421/98
Regulations for air pollution control from stationary sources	MD 5/86
Regulations for the registrations of existing wells and new well permits	MD 2/90
Regulations for the management of the solid non-hazardous wastes	MD 17/93
Regulation for the management of hazardous wastes	MD 18/93
Regulations for wastewater re-use and discharge	MD 145/93, RD 115/2001
Regulating issuance of environmental permits	MD 300/93
Regulation on the removal of vegetation	MD 128/93
Regulation on hunting, capture or firing at wild animals	MD 207/93
Regulations for noise pollution in public environment	MD 79/94
Regulations for noise pollution in the working environment	MD 80/94
Law on handling and use of chemicals	RD 46/95
Designation of Al Saleel Nature Reserve	RD 50/97
Regulations for the handling of toxic substances	MD 248/97
Regulations for control and management of radioactive materials substances	MD 249/97
Regulation on the use of desalination units on wells	MD 342/97
Law on protection of potable water sources from pollution	RD 115/2001

2.3 Omani Environmental Standards

2.3.1 Emissions from Stationary Sources

The industry-wise Omani standards for maximum permissible concentrations or emission rates in stack emissions issued under MD 5/86 are summarised in Table 2.2 below:

Table 2.2: Stack Emission Standards

Type of Industry	Pollutant	Maximum Permissible Value
General	Dust	50 mg/Nm^3
Aggregate works	Particulates	50 mg/Nm^3
Asbestos	Crocidolite (10 minute average)	0.2 fibers /mL
	Chrysotile and amosite (4 hour average)	0.5 fibers/mL
	Chrysotile and amosite (10 minute average)	12 fibers/mL
	Total particulates	50 mg/Nm^3
Asphalt works	Bitumen fume	30 mg/Nm^3
	Total particulates	50 mg/Nm^3
Cement works	Particulates	100 mg/Nm^3
	Hydrogen sulphide	None
Ceramic works	Particulates	50 mg/Nm^3
Copper works	Total particulates	200 mg/Nm^3
	Zinc (concentration)	100 mg/Nm^3
	Zinc (mass rate)	1 kg/h
	Cadmium (concentration)	200 mg/Nm^3
	Cadmium (mass rate)	3 kg/h
	Lead	30 mg/Nm^3
Incinerator works	Hydrogen chloride	200 mg/Nm^3
	Hydrogen fluoride	100 mg/Nm^3
	Oxides of nitrogen as NO_2	200 mg/Nm^3
	Phosphous as P_2O_5	50 mg/Nm^3
	Hydrogen sulphide	5 ppmv
	Total particulates	100 mg/Nm^3
Lead works	Lead (concentration)	30 mg/Nm^3
	Lead (mass rate)	3 kg/h
	Total particulates	50 mg/Nm^3
Lime works	Particulate from kiln	100 mg/Nm^3
	Particulate from slaking	100 mg/Nm^3
	Particulate from Ancillary process	50 mg/Nm^3
Petroleum works	Particulates from catalytic crackers	100 mg/Nm^3
	Carbon monoxide from catalytic crackers	0.5 % by volume
	Sulphur recovery unit efficiency	95 % (minimum)

	Hydrogen sulphide	5 ppmv
Power plants – coal or oil fired	Particulate from coal or oil firing	100 mg/Nm^3 at 12% CO_2
Di-isocyanates	Volatile di-isocyanates	0.1 ppmv
	Particulate di-isocyanates	1 mg/Nm^3

Presently, for other industries not listed above, MRME&WR specifies standards on case-by-case basis.

2.3.2 Ambient Air Quality

Presently, there are no Omani standards for ambient air quality. In their absence, MRME&WR recommends the use of USEPA's national ambient air quality (NAAQ) standards. The NAAQ standards are shown in Table 2.3 below.

Table 2.3: Ambient Air Quality Standards

Pollutant (µg/m^3)	**Averaging Period**	**USEPA NAAQ Standards**
Particulates (PM_{10})	24-hour average	150 µg/m^3
	Annual arithmetic mean	50 µg/m^3
Sulphur dioxide (SO_2)	3-hour average	1300 µg/m^3
	24-hour average	365 µg/m^3
	Annual arithmetic mean	80 µg/m^3
Nitrogen oxides (as NO_2)	1-hour average	None
	24-hour average	None
	Annual arithmetic mean	100 µg/m^3
Carbon monoxide (CO)	1-hour average	40,000 µg/m^3
	8-hour average	10,000 µg/m^3
Ozone (O_3)	1-hour average	235 µg/m^3
	8-hour average	157 µg/m^3
Lead (Pb)	3-month average	1.5 µg/m^3
	Annual arithmetic mean	None

Note: The USEPA's NAAQ standards are presently the default standards of MRME&WR.

2.3.3 Noise

The Omani ambient noise standards for industrial sources issued under MD 79/84 are summarised in Tables 2.4 below:

Table 2.4: Ambient Noise Standards

Type of District	Maximum Permissible Noise Level [as L_{eq} in dB (A)]		
	Day Time (7AM –6PM): Workdays	Evening Time (6AM –11PM): Workdays	Night Time (11PM- 7AM) on Workdays and All Times on Holidays
Rural, residential, recreational	45	40	35
Suburban residential	50	45	40
Urban residential	55	50	45
Urban residential with some workshops or business	60	55	50
Industrial and commercial	70	70	70

MD 80/94 specifies the regulations for noise pollution control in working environment. These regulations state that no employee shall be exposed to noise levels exceeding 85 dB(A). If the workplace noise level exceeds 85 dB(A), suitable noise protection devices shall be provided. The attenuation of such noise protection devices shall reduce the noise level to 80 dB(A) or lower.

2.3.4 Wastewater Discharge and Re-use

The Omani standards for wastewater discharge and re-use on land are issued under MD145/93. These are re-inforced under RD 115/2001. There are two types of standards, based on the crops grown on the land where the wastewater is applied, as described below in Table 2.5A.

Table 2.5A: Wastewater Discharge and Re-use Standards - Part A: Categories

Specification	Standard A-1	Standard A-2
Crops	• Vegetables likely to be eaten raw • Fruit likely to be eaten raw and within 2 weeks of any irrigation	• Vegetables to be cooked or processed • Fruit if no irrigation within 2 weeks of cropping • Fodder, cereal and seed crops
Grass and ornamental areas	• Public parks, hotel lawns recreational areas • Areas with public access. • Lakes with public contact (except place which may be used for praying and hand washing)	• Pastures • Areas with no public access

The maximum permissible concentrations of various pollutants in the treated wastewater are as specified in Table 2.5B below.

Table 2.5B: Wastewater Discharge and Re-use Standards - Part B: Specifications

Parameter	Units	Standard A	Standard B
Biochemical oxygen demand (BOD) - after 5 days @ 20^0C	mg/L	15	20
Chemical oxygen demand (COD)	mg/L	150	200
Suspended solids (SS)	mg/L	15	30
Total dissolved solids (TDS)	mg/L	1500	2000
Electrical conductivity (EC)	µS/cm	2000	2700
Sodium absorption ratio (SAR)	-	10	10
pH	-	6 - 9	6 -9
Aluminium (as Al)	mg/L	5	5
Arsenic (as As)	mg/L	0.100	0.100
Barium (as Ba)	mg/L	1	2
Beryllium (as Be)	mg/L	0.100	0.300
Boron (as B)	mg/L	0.500	1.000
Cadmium (as Cd)	mg/L	0.010	0.010
Chloride (as Cl)	mg/L	650	650
Chromium (total as Cr)	mg/L	0.050	0.050
Cobalt (as Co)	mg/L	0.050	0.050
Copper (as Cu)	mg/L	0.500	1.000
Cyanide (total as CN)	mg/L	0.050	0.100
Fluoride (as F)	mg/L	1	2

Iron (total as Fe)	mg/L	1	5
Lead (as Pb)	mg/L	0.100	0.200
Lithium (as Li)	mg/L	0.070	0.070
Magnesium (as Mg)	mg/L	150	150
Manganese (as Mn)	mg/L	0.100	0.500
Mercury (as Hg)	mg/L	0.001	0.001
Molybdenum (as Mo)	mg/L	0.010	0.050
Nickel (as Ni)	mg/L	0.100	0.100
Nitrogen: Ammoniacal (as N) : Nitrate (as NO_3) : Organic (Kjeldahl) (as N)	mg/L	5 50 5	10 50 10
Oil and grease (total extractable)	mg/L	0.500	0.500
Phenols (total)	mg/L	0.001	0.002
Phosphorus (total as P)	mg/L	30	30
Selenium (as Se)	mg/L	0.020	0.020
Silver (as Ag)	mg/L	0.010	0.010
Sodium (as Na)	mg/L	200	300
Sulphate (as SO_4)	mg/L	400	400
Sulphide (total as S)	mg/L	0.100	0.100
Vanadium (as V)	mg/L	0.100	0.100
Zinc (as Zn)	mg/L	5	5
Faecal coliform bacteria	Number per 100 mL	200	1000
Viable nematode ova	Number per L	<1	<1

The following are Omani standards for re-use or disposal of sludge resulting from sewage treatment. The sludge generated from wastewater treatment may be applied on land for agricultural use, subject to the conditions given in Table 2.5C below.

Table 2.5C: Sewage Sludge Re-use Standards

Metal	**Maximum Permissible Concentration (mg/kg dry solid)**	**Maximum Application Rate (kg/ha/yr)**	**Maximum Permissible Concentration in Soil (mg/kg dry solid)**
Cadmium	20	0.150	3
Chromium	1000	10	400
Copper	1000	10	150
Lead	1000	15	30
Mercury	10	0.100	1
Molybdenum	20	0.100	3
Nickel	300	3	75

Selenium	50	0.150	5
Zinc	3000	15	300

After spreading the sludge, there must be at least a three-week period before any grazing or harvesting of forage crops. Sludge application on land is prohibited in the following cases:

- on soils while fruits or vegetable crops are growing or being harvested;
- for six months preceding the harvesting of fruit or vegetables that are normally eaten raw, and grown in contact with the soil;
- on soils with pH less than 7.

Any sludge containing metal concentrations above the following prescribed limits shall be disposed in sanitary landfills or to other facilities with MRME&WR's approval.

2.3.5 Hazardous Wastes

MD 18/93 specifies the Omani regulations on hazardous waste management. Hazardous waste is defined as "any liquid or solid waste, which because of its quantity, physical, chemical or infectious characteristics can result in hazards to human health or the environment when improperly handled, stored, transported, treated or disposed of." Some of the major requirements specified with respect to handling, storage, transport and disposal of hazardous wastes are listed below:

- Licence shall be obtained from MRME&WR for handling, storage, transport and disposal of hazardous wastes;
- No hazardous waste shall be mixed with any other type of waste;
- All hazardous waste shall be appropriately packed, labelled and shall have a waste consignment note when transported out;
- Hazardous waste shall be transported through MRME&WR licensed transporters only;
- Hazardous waste shall be disposed at MRME&WR licensed treatment or disposal sites only.

3 PROJECT DESCRIPTION

3.1 Introduction

It has been determined that the existing 358 km long 48" pipeline, put into operation in 1999, will require modification to deliver adequate gas for future developments such as the 3rd train of the OLNG plant and export facility, a urea plant (currently under construction) and a power station.

The addition of a new 40" or 48" gas pipeline along the existing one will substantially increase the supply of gas from the central gas processing plant (CPP) at Saih Rawl to the OLNG plant in Qalhat, north of Sur. Figure 3.1 shows the existing pipeline route.

3.2 Pipeline Loop Options

There are two possibilities for the pipeline loop and the decision will soon be made by the MOG. At the time of this study the option was still undecided.

3.2.1 Existing Pipeline

The existing 48" pipeline began operation in 1999 and runs from Saih Rawl CPP to the OLNG plant in Qalhat. It is 358 km long and delivers approximately 44 million m^3/day.

3.2.2 Partial Loop

In January 2003, PDO were given approval to construct a "partial loop" 48" pipeline along side the already existing 48" Central Oman gas pipeline. The partial loop would entail the new pipeline to run from Saih Rawl to Block Valve Station (BVS) 9 of the existing pipeline, which is approximately 68 km away from Qalhat. In total, the new pipeline would be approximately 290 km long and deliver approximately 64 million m^3/day. The tie-in at BVS 9 would need a minor extension to cater for the tie-in piping with valves and pig receiving facilities.

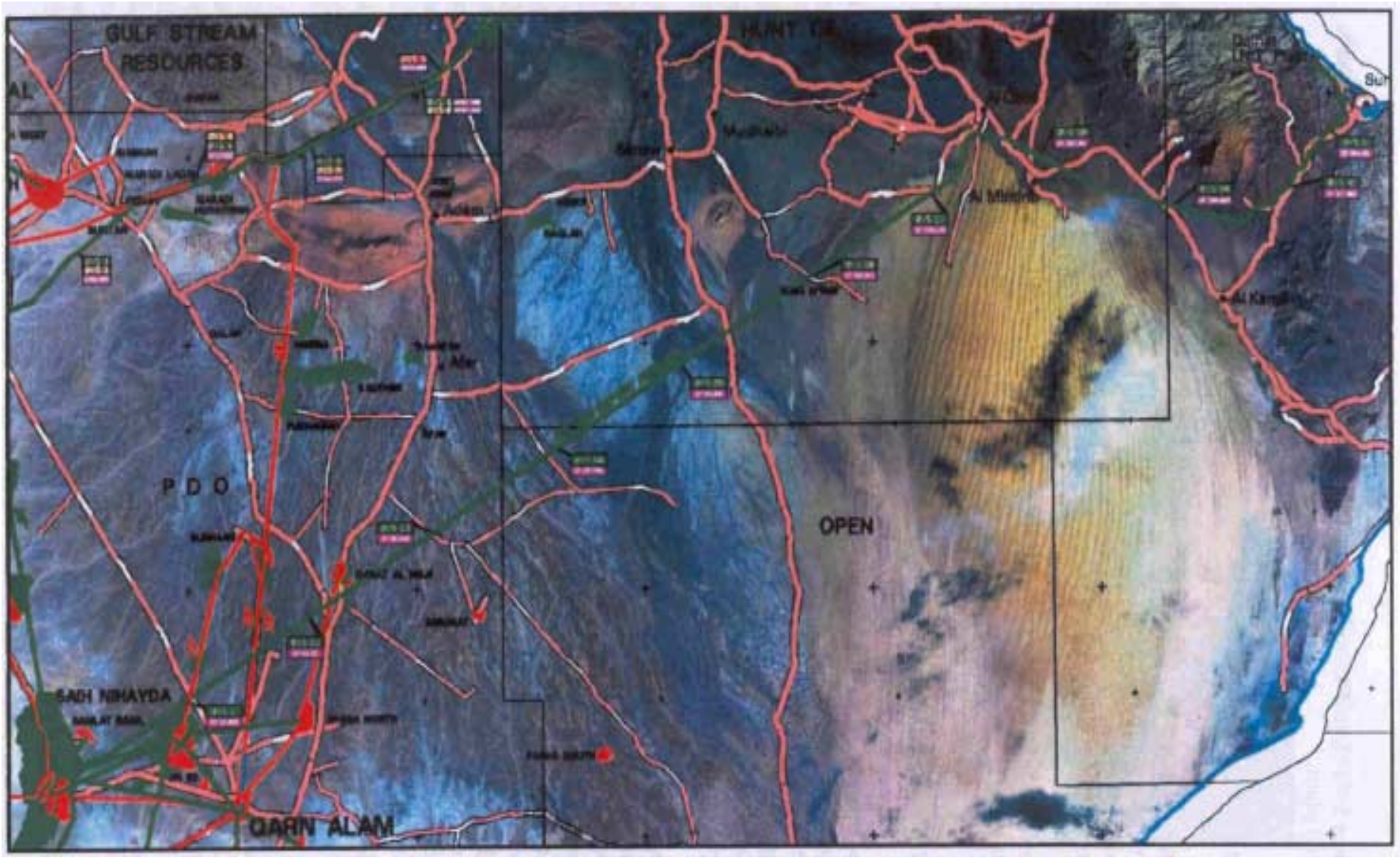


Figure 3.1: Existing 48” Pipeline Route

3.2.3 Full Loop

In May 2003 the Ministry of Oil and Gas (MOG) approved PDO to explore the "full loop" as an option. This option would entail constructing the new 40" pipeline alongside the full length, and essentially duplicating, the existing pipeline running from the Saih Rawl CPP to the OLNG plant, covering a distance of 358 km. In addition to the gas exported from Saih Rawl CPP, Kawther field would be connected to the pipeline at BVS 5, increasing gas delivery to a total of 82 million m^3/day.

3.3 Project Schedule and Approach

The project schedule can be split into five phases by PDO:

Phase 1 (ongoing): The project specification, which optimizes the development concepts and undertakes a number of specialist studies to identify the optimum route. These studies were designed to identify the engineering and environmental constraints applying to the route and the requirements for specialist construction techniques.

The project is now at the end-stages of this phase.

Phase 2 (June 2003 – Jan 2004): Tender and award of EPC contract

Phase 3 (Jan 2004 – Mar 2004): General mobilization, detail design, and site mobilization

Phase 4 (Apr 2004 – Oct 2005): Construction, final reinstatement and pre-commissioning

Phase 5 (Nov 2005): 1st gas delivery for commission of 3rd Train of OLNG plant.

The pipeline will have a life cycle of 25 years and will be decommissioned in 2030.

3.4 Route Description

The following route description has been divided into three sections: Saih Rawl – BVS 7, BVS 7 – Al Saleel Park, and Al Saleel Park – OLNG Plant. The UTM coordinates for all highways crossed by the pipeline are presented in Appendix 5.

3.4.1 Saih Rawl – BVS 7

The pipeline route originates from Saih Rawl and travels almost in a direct line in a northeastern direction passing Qarat Al Milh and Nibras to Block Valve Station 7, which is located to the northwest of the Wahiba Sands. The route crosses both the Qarn Alam – Adam Road and the Sanaw/Duqum – Salalah Road.

3.4.2 BVS 7 – end of Al Saleel Nature Reserve

The pipeline continues in a northeastern direction for 7.5 km when it turns directly north and travels for a distance of approximately 7 km. The route then turns southeast towards Al Wasil, crossing both the Ibra – Sur Highway twice and Al Zahib – Al Wasil road. The pipeline travels in a southeasterly direction for approximately 51km along the northern boundary of the Wahiba Sands. It then crosses the Ibra – Sur Highway again and passes through the Al Saleel Nature Reserve boundary for 1 km in a southeasterly direction up to BVS 9. ***This is where the new pipeline would end should the partial loop option be chosen***. Once the pipeline passes BVS 9 it continues on its southeasterly direction through Al Saleel Nature Reserve for another 15 km to the Reserve's eastern boundary.

3.4.3 Eastern Boundary of Al Saleel – Qalhat (OLNG plant)

Once out of Al Saleel Nature Reserve the pipeline route turns northeasterly for approximately 9 km through the Eastern Hajar Mountains via the Ma'ayah Pass to BVS 10. The route continues in a northeastern direction crossing the Ibra - Sur Highway twice heading towards Sur for approximately 11.5 km before turning north for 1 km. The pipeline changes to a northwestern direction for 2.5 km, then north for 2.5 km, then northwest again for a further 7.5 km before turning northeast again for the final 800 m ending at the OLNG plant in Qalhat.

3.5 Factors Influencing Route Alignment

The primary objective when selecting the route was to minimize the length of the pipeline in order to reduce construction and operational costs. This section describes additional factors influencing the route.

3.5.1 General Factors

The pipeline route was considered taking a number of factors into account, as listed below:

- the requirement for the pipeline;
- the technical feasibility of the pipeline;
- the economic justification of the pipeline;
- the sensitivity of the environment (a senior HMR environmental consultant was present during the reconnaissance and topographical survey and environmental concerns were taken into account when considering the route);
- the concerns of local authorities and residents.

3.5.2 Land Ownership

Land ownership was included in the initial studies in order to route the corridor through areas where landowners do not object to the project. Areas of population were avoided as far as possible in view of safety and land compensation issues. Safety was a prime consideration during the initial studies.

3.5.3 Supplementary Criteria

Supplementary criteria influencing the route corridor where practical, can be highlighted as follows:

- There should be a minimum of 25 m between the pipeline and buildings, except in special circumstance where this separation width is not practical;

- In mountainous terrain the maximum vertical slope for construction would be 45^0, routing across slopes and unstable slopes should be avoided;

- The minimum horizontal distance between the pipeline and other utilities running parallel shall be 30 m;

- At crossings the minimum vertical separation shall be not less than 0.7 m;

- Wherever practicable, routing near villages should be avoided, as should routing near to urban/suburban areas with future expansion plans and known sites of archaeological interest;

- The number of crossings of roads, wadis and aflaj, etc. should be kept to a minimum;

- The pipeline should preferentially be routed in a straight line between points of significant constraints, where changes of direction will be required to avoid them.

3.6 Pipeline Design Specification

3.6.1 Export Gas Composition

The typical composition of the gas is shown below in Table 3.1.

Table 3.1: Typical Gas Composition

Component	Mol % Export Gas
N_2	9.16
CO_2	0.33
C_1	83.36
C_2	3.8
C_3	1.71
iC_4	0.47
nC_4	0.59
iC_5	0.20
nC_5	0.16
nC_6	0.18
C_7	0.03
C_8	0.01
C_9	0.00
H_2S	0.00

3.6.2 Pipe System

The pipes will be manufactured in accordance with relevant international standards and codes.

The thickness of the pipe will vary according to engineering and safety requirements in standard wall thickness for normal situations and thicker wall pipe for road and wadi crossings, etc or where safety criteria dictate.

3.6.3 Land Take

The proposed pipeline will lie 30 - 50 m away from the existing pipeline. A strip of land 10 m wide on either side of any pipeline is designated as a "Restricted Reserve". An additional strip of land 15 metres wide on either side of the pipeline and outside the Restricted Reserve is designated an "Open Space Reserve". This makes the total width of the pipeline "Right of Way" (RoW) corridor 50 m, which overlaps with the existing adjacent pipeline RoW by 5m. The boundaries of this RoW corridor are marked by 1 m high, 0.08 m diameter black and yellow posts.

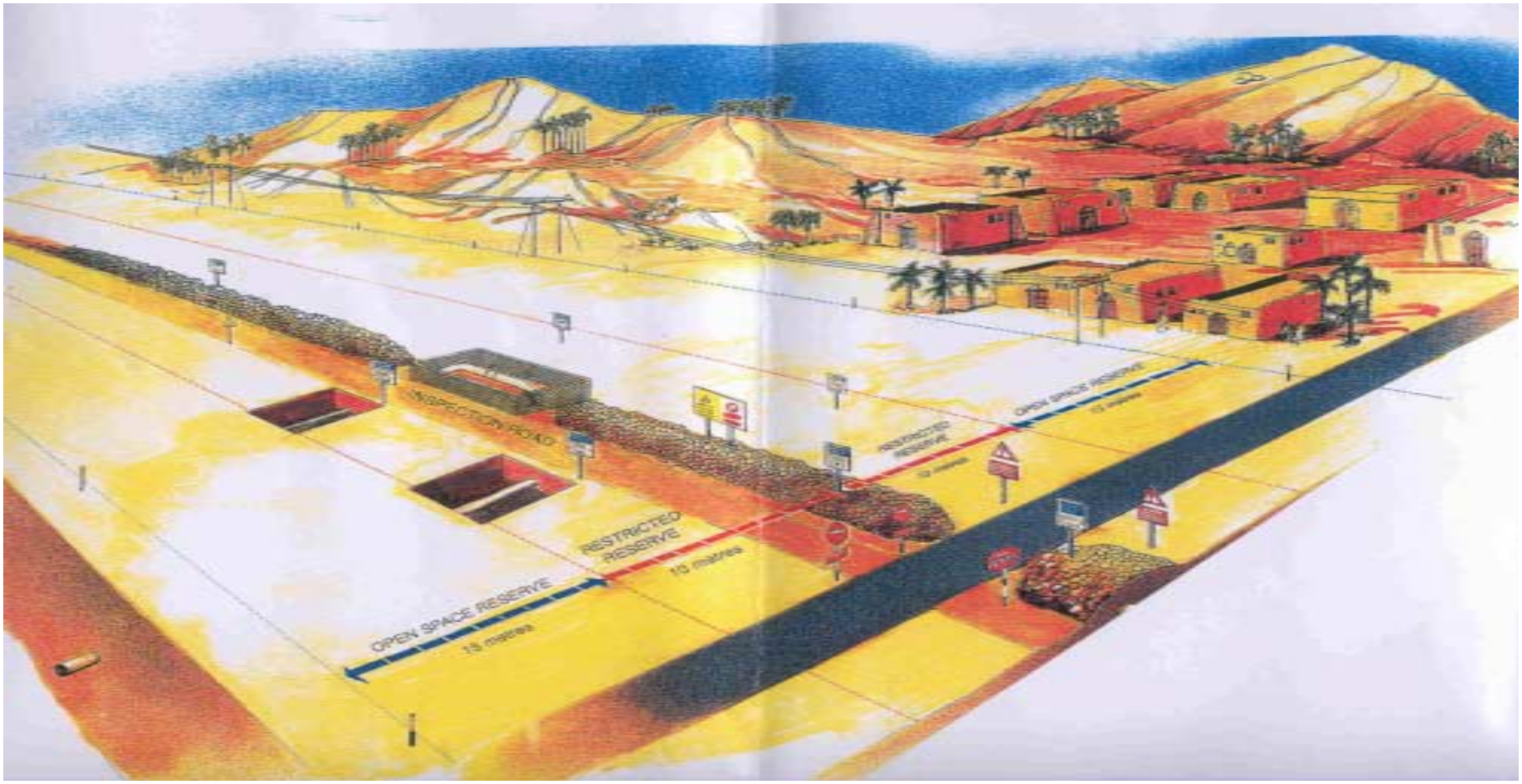
Additional pipeline signs are installed along the pipeline in areas of development and growth to protect the pipeline(s) from public encroachment. Critical areas, such as road crossings, are protected with barriers. See Figure 3.2 for an illustrative of the RoW and road crossings.

3.6.4 Depth of Cover

The minimum depth of cover will be 1.0 metre below ground (except in areas of rock) where it will be 0.7 m. At wadis, roads and built-up areas, the depth will increase to 1.5 m.

3.6.5 Corrosion Protection

The pipelines will be protected from external corrosion by 3 layer PE/FBE (Polyethylene/Fusion Bonded Epoxy) coating. In addition, an impressed current cathodic protection (CP) system will be provided to further protect the pipeline against external corrosion.



Source: Ministry of Petroleum & Minerals

Figure 3.2: Illustrative of Right of Way

3.6.6 Block Valve Stations (BVSs)

In order to commission, operate, maintain and control the gas export pipeline, it is necessary to subdivide it into a number of sections. This is carried out by incorporating a number of Block Valve Stations (BVS) at selected intervals along the route. At each BVS, and at each end of the Pipeline there will be a Cathodic Protection (CP) station. There will be 9 BVSs if the partial loop option is chosen and 11 BVSs should a full loop be decided upon. These BVSs will be equally spaced along the pipeline at a distance of 33 km.

There will be facilities for the launching and receiving of pig traps at Saih Nihayda Gas Treatment Plant and BVS 9 (partial loop), respectively. Should the full loop option be decided upon, the receiving of pig traps would occur at the OLNG Plant in Qalhat.

All such stations, outside facility stations, shall be in properly fenced compounds in accordance with international regulations. CP stations will derive their power supply from solar panels to be installed at each BVS.

3.6.7 Control Station

The locations of the main control stations for control and monitoring of the pipeline will be at Qarn Alam and Saih Rawl CPP.

3.6.8 Leak Detection

The existing leak detection system will be upgraded to include the integrated pipeline.

3.7 Typical Construction

The construction activities will be controlled by means of detailed contract specifications issued to the contractors by PDO. The contract specifications define requirements for undertaking the various construction tasks. These contract specifications, as well as detailing the engineering requirements, give specific requirements for environmental protection measures. PDO intend that there should be a clearly defined obligation on the construction contractors to ensure that their activities do not cause unacceptable environmental impacts.

Construction work will be conducted on a moving assembly-line basis with each sequential activity maintaining a consistent rate of progress. The work will be carried out by a pipeline contractor under the supervision of experienced pipeline management personnel supplied by PDO.

Pipeline construction is described and defined in PDO's Pipeline Construction Specification: PCS-01 (SP-1208) [Ref. 14]. This section contains a general description of pipeline construction procedures typical to arid deserts and mountain regions such as those of Oman and conforming to PDO's standard pipeline construction specifications. This will be supplemented by the EPC Contractor's Scope of Work which includes project specific requirements.

3.7.1 Working Strip

All construction activities are undertaken within a strip which is referred to as the "working strip" and which is delineated by marker poles or alternatively fenced, e.g. in developed areas. In most cases this width will be up to 50 m although it may be increased adjacent to crossings, e.g. roads and wadis. It may be decreased where there are physical limitations due to existing development, e.g. alongside existing services, or in areas of recognised conservation importance.

Before any of the principal construction activities are begun, temporary marker poles or fences are erected along the boundary of the working strip. The marker poles will be of steel, painted so as to be easily visible to the construction crew. Their prime purpose is to contain the area affected by construction and ensure plant, vehicles and personnel do not unnecessarily have access to or risk causing damage to land outside the working strip or other designated contractor areas, e.g. borrow. pits and pipe dumps. In settlement and village/urban areas fencing may be required to exclude the local population and/or their livestock from the working strip.

Generally, surface material which may impede construction such as loose surface rocks and local surface features will be cleared/graded and the material stored to one side of the working strip. Vegetation including grasses and shrubs, such as that occur in wadis and in plains areas will be removed but larger trees within the working strip will be avoided wherever practicable and where necessary protected.

3.7.2 Trench Excavation

A trench is excavated to a depth which will allow the pipeline to be buried with a minimum cover over the top of the pipe of 1 m. At road and wadi crossings the depth of the trench will be increased to 1.5 m.

The material from the pipe trench excavation is placed in a windrow on the side of the trench away from the vehicle running strip.

3.7.3 Blasting

Where the ground is rocky and blasting is considered necessary, this work will be undertaken in a manner approved by PDO and undertaken by specialists experienced in blasting. The EPC contractor will determine the amount of explosives required. It is estimated, however, that 75% of the area will need blasting. Controlled blasting will be used should the pipeline be 30 m away from the existing pipeline. Full blasting will be used should it be 50 m away. Proper authorised explosive storage areas will be used. Coordination and consultation will occur between the EPC Contractor and the Royal Oman Police (ROP).

3.7.4 Pipe Storage Area

It is likely that, for logistical reasons, a pipe storage area will be required following unloading from the port prior to transportation to the project site. The contractors will transport the pipe to temporary pipe storage areas on the project site. The location of these temporary pipe storage areas has yet to be determined although it is likely they will be located adjacent to the working strip, perhaps every 10 km. It will be a requirement for the contractors to obtain all necessary approvals and consents from PDO and the authorities and landowners prior to establishing storage areas. Typically a pipeyard requires between 1 and 2 hectares on level ground adjacent to the pipeline RoW.

3.7.5 Stringing

Pipes are transported to the working strip from the pipe storage area and lain on wooden sleepers or cradles along a line parallel to the proposed trench. Gaps are left where

temporary works or public access across the working width is required. Where the pipeline changes direction, bends are installed.

3.7.6 Welding

The pipes are welded together to make a continuous pipeline and the welds are subjected to 100% radiographic inspection. Any faults detected are then repaired or cut out and replaced, and then re-inspected until the specified standard is reached.

3.7.7 Field Joint Coating

The pipes arrive on site with a protective coating already applied except at their ends. After welding and x-raying, the bare metal at the joints is blast cleaned and coating applied to make it continuous along the outside of the pipeline. The pipeline coating is then carefully examined for damage. All defects or damages located are clearly marked, repaired and re-examined immediately prior to lowering in.

3.7.8 Pre-Padding, Lowering-in, Post Padding and Backfilling

In areas of rocky or potentially abrasive soil the bottom of the trench is lined with graded sand ("sand padding material") to create a smooth surface, and then after lowering the pipe onto the sand bed, the trench is backfilled with sand up to just above the crown of the pipe. The volume of sand required is not known at this stage and will be established by the EPC Contractor. Sand from within the working strip may not always be available or acceptable in which case the contractor is to obtain suitable padding material from elsewhere. PDO's guidelines (SP-1012) [Ref. 21] place restrictions on the winning of this material including a prohibition on the winning of material from wadis. The Contractor will need to establish suitable sources of material from locations and in a manner not deemed environmentally sensitive.

After the pipeline is lowered into the trench it is backfilled with subsoil, which is graded to avoid damage to the pipeline coating. The subsoil is carefully compacted around and over the pipe up to the top of the trench.

Finally, the trench excavation material remaining is backfilled over the pipe and the surplus material is replaced over the trench in the form of a windrow. In wadis and other sensitive environmental areas the windrow will be omitted or where specified,

alternatively profiled as a flattened mound. There will be gaps in the windrow at suitable distances to allow the crossing of livestock and wildlife.

At steep slopes in ground where erosion could occur, erosion barriers made up using flexible filled bags are placed around the pipe below ground level to prevent the backfilled material being washed down its trench. Stability calculations will be carried out during the detail design of the project.

3.7.9 Cleaning and Gauging

The pipeline is then cleaned internally using a swabbing "pig" driven through by compressed air. A gauging pig is then installed and the pipeline filled with water. The gauging pig measures and records the "internal" diameter of the pipeline and enables any deformity to be detected.

3.7.10 Hydrostatic Testing

The pipeline is then hydrostatically tested by increasing the pressure of the water after temporarily closing off the ends of the pipe. Water will be reused where possible. The residual water will be removed by vacuum drying.

The source of hydrotest water is not yet known and will be determined by the EPC contractor. The possibilities include:

- Awaifi Water Supply Well (approximately 86 km east of Fahud: E 497 250; N 2 460 488) – This is the current source of hydrotest water used by PDO;

- Reverse Osmosis (RO) plants – The Qarn Alam RO plant is currently being extended and may be used as a source of water for sections of the route close to the plant;

- Seawater – Should the full loop be constructed, seawater may be used for hydrostatic testing at sections close to Qalhat. EPC contractors would obtain necessary permits for this;

- Water wells – The drilling of water wells is unlikely. Should it become necessary, however, the EPC contractors will obtain the necessary permits.

The quantities of test water required is unknown at the present time and depend on the lengths of pipe section to be tested and will be determined by the EPC contractor. However, if it is assumed that this will be carried out between individual block valves rather than the complete length of pipe.

The disposal method of the hydrotest water is unknown at the present time. However, it is thought that lined and fenced evaporation ponds will be used.

3.7.11 Radiation Testing

In order to test the integrity and thickness of the pipeline, x-rays and gamma rays are used during the non-destructive testing of the pipeline. This is performed over a series of days.

3.7.12 Permanent Reinstatement

Reinstatement of the surface of the land within the working strip is carried out. Permanent pipeline markers and CP test posts are installed. In conservation areas, reinstatement may be modified to suit specific environmental conditions.

3.7.13 Transportation and Construction Vehicles

It will be necessary to establish approved routes for all construction traffic. Existing roads and tracks are generally expected to be used. Their location and the measures needed to minimise environmental damage cannot be accurately determined at this stage and will require consideration once their preferred locations are known. The EPC contractors will be required to make a pre-construction assessment of the existing road network in order to establish efficient, economical and safe transport routes, considering possible adverse impacts on existing users and those adjacent to them. Table 3.2 below gives an estimate of construction equipment needed. This information was supplied by a contractor bidding for the tender for the existing 48" pipeline construction. The new loop line is expected to require identical equipment.

Table 3.2: Estimated Construction Equipment to be Used

Equipment	Utilization	Number of Vehicles
Grader Cat 14 G	Levelling / Grading	2
D8 Dozer	Filler / Levelling	2
Excavator Cat 235	Excavation	4
Hydraulic Rock Breaker	Excavation for foundations	2
Roller Compactor	Compaction	1
Plate Compactor	Compaction	1
Hydraulic crane, 30T	Hauling, Lifting, Piping	2
Diesel Welding Machines, 250A	Welding	14
Loader Cat 966/950	Civil Works / Earth Works	4
Jack Hammer	Excavation	2
Air Compressor, 600 CFM/375 cfw	Hydrotesting / Cold cutting / Excavation	2
Concrete Mixer	Concrete Works	1
Concrete Vibrator	Concrete Works	2
Fill Pump	Hydrotesting	1
Pressure Pump	Hydrotesting	1
Mack Truck with winch	Pipe & material hauling, Hydrotesting	3
Float Trailer, 40/50 tons	Pipe & material hauling, Hydrotesting	3
Water Tanks, 30000 liters	Hydrotesting	1
Diesel Generator Set, 12 KVA	Hydrotesting	1
Testing Cabin	Hydrotesting	1
Dump Trucks, 18 cu. M.	Padding & Backfilling, Plot Grading	4
Hiab Trucks, 3 tons	General	1
Canter Trucks, 3 tons	General	8
Crew Cab/Pick-up	General, Transportation	8
Blasting/Painting Set	Painting	1lot
Cutting Set	Tie-Ins / Fabrication	4 Nos.
Bevelling Machine	Tie-Ins / Fabrication	3 Nos.
Electrical/Instrument Test Equipment	Electrical / Instrument	1 lot
Rock Saw/Ditch Machine	Trenching	1
Side Boom 561/571/572/583	Pipe Laying	7
Fuel Truck	Fuel Transportation	1
Bending Machine CV 6" – 20"/ 22-36"	Bending	2
Tack Rig Cat D5	Welding	2
40 S Bus / 26 S	Transportation	4
Blasting Equipment	Trenching	1 lot
Camp Items	Camp Facility	1 lot
Internal Clamp & Mandrel	Pipeline Welding/ bending	1 lot
Mobile Screening Plant	Sand Padding	2

3.7.14 Fuel

A minimal amount of petrol will be used for vehicles. There will be no storage of petrol on site and should it be needed, it will be obtained from local petrol stations in the area.

Diesel fuel will be mainly used for both vehicles and construction equipment. Diesel fuel will be stored in accordance with strict PDO regulations. Areas of storage facilities are unknown at the present time but will be equipped with bund walls and be outside of camps.

Quantities of both fuel types are unknown and will be determined by the EPC contractor.

3.7.15 Power and Electricity

Generators will be used for power and electricity supply required by construction activities. The quantities are unknown at the present time and will be determined by the EPC contractor.

3.7.16 Supervision of Construction Activities

As already noted, PDO has developed a series of contractual obligations which should ensure that the construction activities are carried out with minimum environmental impact. However, notwithstanding these contractual obligations, it is sound practice to ensure that the contractor is adequately supervised during the course of the work by experienced personnel, to ensure that all appropriate environmental conditions are adhered to in practice. Efficient management of the construction process by PDO will be fundamental to ensuring the engineering and environmental control works are carried out to a satisfactory standard.

3.8 Construction at Special Crossings

In addition to the above typical construction methods, the contractor will undertake work associated with road, wadi and services crossings or other sections of constricted working which require some variation in standard methods. In sections of particularly sensitive environments, modifications may be made to the standard technique so as to mitigate environmental impacts. Measures will also be taken to reduce the risk of third party damage to the pipeline, including increased depth of cover, thicker walled pipes or

protection by concrete. The construction techniques adopted vary with the type of crossing. The following subsections outline the general categories applicable:

3.8.1 Road Crossings

For most roads where the disturbance to traffic is small and fairly easily controlled, the principal method of crossing is expected to be by open-cut. At major roads and subject to agreement with the relevant authorities, temporary off-set diversion roads are constructed and maintained for the safe passage of vehicles until after such time as the reinstatement of the permanent road crossing has been completed.

3.8.2 Wadi Crossings

Wadis are dry riverbeds, which may be temporarily filled with water following rain. The manner of crossing them depends upon their categorisation and can include:

- Increase depth of pipeline to 1.5 m;
- providing a continuous concrete protection;
- protection with rock-filled gabions.

The choice is dependent on the expected velocity of flow and depth of scour after rain. The standard windrow is not installed over the trench except intermittently on wider wadis to mark the location of the pipeline, but avoiding the principal channels.

Where the pipeline corridor crosses wadis, the delineated working strip will be reduced to the minimum required by the contractor to construct the pipeline whilst being able to efficiently operate his plant in the manner specified by PDO. Under these conditions the standard construction approach may need to be modified.

3.8.3 Aflaj Crossings

Aflaj can be buried aqueducts or open channels, often of great age, usually running above the surface of wadis and carrying groundwater from distant upland sources to villages and gardens. The manner of crossing them will depend on their depth relative to the pipeline and their condition. Crossings will be individually designed to suit each site and subject to pre-construction survey and the agreement of the relevant authorities. Excavation and reinstatement are carried out in a controlled and regulated manner such

that disruption to flow and damage to the aqueduct structure is minimised. Whether in current use or not, aflaj are regarded as having archaeological and cultural significance and will be treated as ancient monuments.

3.8.4 Urban/Industrial Areas

Where a proposed pipeline corridor traverses areas of existing or planned residential, industrial or other development, construction may be adapted to meet the needs of local residents, etc. However, in principal, the pipeline route has been chosen so as to avoid such areas as much as possible.

3.8.5 Archaeological Sites

All graves and graveyards along the RoW shall be verified and demarcated by the Contractor in liaison with and in the presence of the appropriate local authorities. A letter of no objection must be obtained from the Ministry of Heritage and Culture before construction commences. The graveyards shall be demarcated and fenced off prior to commencement of site construction activities to avoid potential desecration. Where the graves are in direct line of the RoW, the pipeline may be re-routed.

3.9 Camps

It will be necessary to erect temporary construction camps to house the contractor's workforce and site offices for each spread or construction unit. The camps shall be built in strict accordance to PDO's standards and guidelines, the camps shall be securely fenced with access via main gates. The camps will be occupied for periods of several months, up to the full period of the construction. They will be fully equipped with air-conditioned accommodation and recreational/messing facilities.

3.9.1 Size

The contractor's camps size depends on the number of personnel housed and the requirements for office facilities, plant and materials storage and for workshops for plant repair and maintenance. The number of workers is dependant upon the EPC contractor but it is predicted that at peak construction there may be between 1000-1500 workers in the camps. Typically, they may require an area of land of 5 to 10 hectares.

3.9.2 Location

During the construction of the existing pipeline, worker camps were established at 3 points along the route. The first remained in place for 9 months, and was located at the Wadi Bani Khalid junction, 25km from the town of Bidiya. The second camp was the base camp for the project, and it was located about 10km off the pipeline route at BVS 5, where it remained in place for 13 months. The final camp was located between BVS 3 and BVS 4 for approximately the last 6 months of construction. Although the number, exact location and duration of the camps is at the discretion of the contractor, the pattern is likely to be similar for the construction of the new pipeline.

There are existing camps at Qarn Alam (Saih Rawl end of pipeline) which may be used by the contractors. At the Qalhat end of the pipeline there are no existing facilities and camps would have to be constructed.

3.9.3 Water

Throughout most of the camps along the route, local authorised suppliers will truck water to the camps for domestic use. Existing reverse osmosis (RO) plants will be used for the camps located near Qarn Alam. The quantities of water needed are not yet known and will be determined by the EPC contractor.

3.9.4 Power and Electricity

Generators will be used for power at most of the camps. Should the existing camps at Qarn Alam be used, a power supply is readily available. It is unknown how how much power will be needed. This will be determined by the EPC contractor.

3.9.5 Sewage Treatment

A sewerage collection and sewage treatment and disposal system is needed for the camps. EPC contractors will need to obtain the necessary permits for waste disposal. Sewage will be collected in septic tanks and disposed of by trucks and transported to the nearest sewage treatment plant (STP). Following consultation and agreement with the relevant Municipal authorities, domestic waste will be disposed of at the nearest municipal dumps. Disposal of sewage and waste will be strictly controlled and in accordance with both PDO guidelines (SP-1009) and local regulations.

3.9.6 Hours of Working

The contractor will be required to observe the hours of working prescribed under Omani law. He can be expected to work up to 7 days a week, but during daylight hours only; night-time work or driving being prohibited by PDO. The only operations expected to require working outside normal hours are the vacuum drying of the pipeline during the pre-commissioning and hydrostatic pressure testing. Work will be carried out in shifts.

3.10 Operation

To ensure that the pipeline operates in a safe, cost effective manner, the pressure and flow rates are continuously monitored. In the event of a drop in pressure, shutdown would be initiated. Inspection would be carried out by periodic inspection of the pipeline route. This will check for any third party surface disturbance or other risks to pipeline integrity.

The need for inspection and corrosion monitoring of the pipeline to establish and confirm its integrity throughout the pipeline's life has been identified. Various techniques have been examined as part of the front end design (FED) and the following programme will be initiated:

- intelligent pigging of the pipeline (baseline 18 months after commissioning and then after every 6 years);
- routine pigging every 6 months;
- yearly external ultrasonic testing;
- continuous monitoring using corrosion coupons.

3.11 Decommissioning

Decommissioning will occur if part of the proposed pipeline system needs to be diverted due to the requirements of a third party activity integrated during the lifetime of the system, or at the end of the pipeline's life (25 years).

Customers will consume the majority of the remaining gas. Only a small volume will then need to be disposed of by venting or flaring at the nearest BVS.

The detailed procedures for decommissioning the pipeline have not yet been finalised. However, based upon procedures used elsewhere they are likely to involve purging the

pipeline with inert gas, (to ensure a non-combustible atmosphere) and filling the redundant section with water or lean concrete mix. Having sealed and made safe the pipeline, periodic inspection would be terminated. All above ground buildings and equipment can then be dismantled, allowing the land to revert to its original use.

4 DESCRIPTION OF THE ENVIRONMENT

4.1 Introduction

The degree of environmental sensitivity along any given pipeline route is a crucial factor in planning the pipeline. It is important to identify in advance and to be aware of the environmental sensitivities and the constraints they may impose on construction activities. Some areas along the proposed pipeline corridors are particularly important in this regard due to archaeological, ecological and socio-economic sensitivity.

The proposed 48" pipeline travels from Saih Rawl CPP (E 452 065; N 2 351 249) to the OLNG plant in Qalhat (E 704 619; N 2 500 679) north of Sur. Figure 3.1 shows the route of the existing pipeline, along which the proposed one is to follow.

This chapter describes the existing environment along the proposed route. For purposes of presenting the information in a practical manner, the baseline has been divided in to three sections along the pipeline:

- Saih Rawl – BVS 7;
- BVS 7 – through Al Saleel Nature Reserve to its Eastern boundary;
- Eastern boundary of Al Saleel Nature Reserve – OLNG plant.

This division is also useful when looking at the two loop options being considered. Should the full loop be chosen, all three sections will be valid. Should the partial loop be chosen, the first 2 sections from Saih Rawl – BVS 9 (slightly into the reserve boundary) will be valid.

An analysis of alternative routes is presented at the end of this chapter in section 4.5. All Plates mentioned in this chapter can be found in Appendix 6.

4.2 Saih Rawl – BVS 7

The UTM coordinates for these two points are:
Saih Rawl CPP: E 452 065; N 2 351 249
BVS 7: E 651 413; N 2 452 826

Figure 4.1 shows the section of the pipeline route from Saih Rawl to BVS 7.

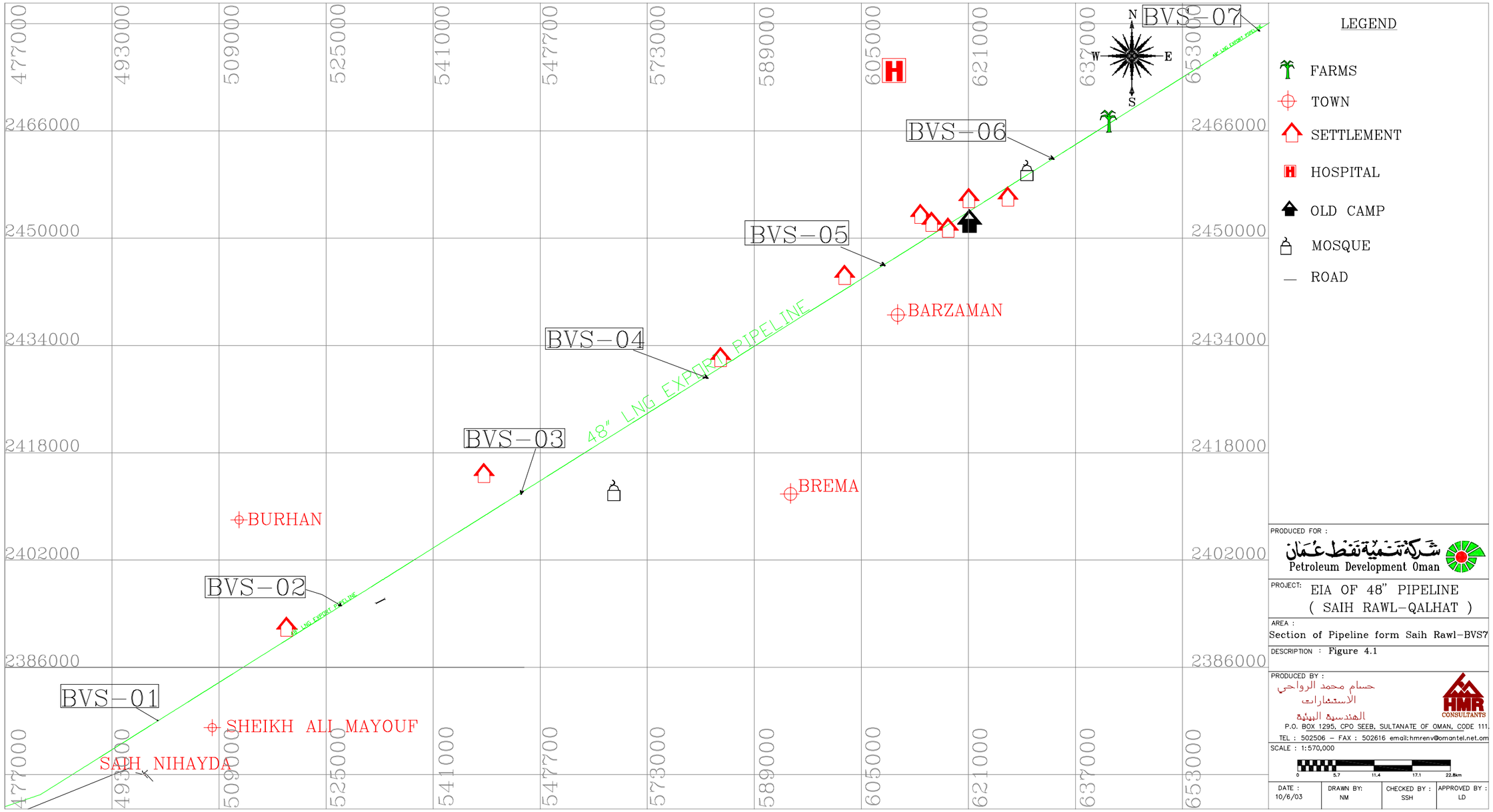


Figure 4.1: Pipeline Route: Saih Rawl to BVS 7

4.2.1 Topography and Landscape

The pipeline route commences at Saih Rawl and travels almost in a direct line in a northeasterly direction across the region to BVS 7. It traverses an essentially flat, sand lain expanse overlain with rocks and gravel. There is little soil cover and vegetation is sparse. Low limestone and gravel hills and a few rocky outcrops intersperse the otherwise featureless plains. Salt domes are visible at various points along the pipeline route but none are close to the pipeline. To the north of the route are The Hajar Mountains.

4.2.2 Climate

The climate is that of a hot arid desert with an annual mean temperature of 28.5^{o}C. Maximum temperatures can reach up to 49^{o}C in the summer and a minimum of 9^{o}C in the winter. These temperatures were recorded at the Qarn Alam meteorological station between the years 2000 and 2001. Appendix 2 shows complete air temperature data.

Rainfall in this area is scarce (less than 100mm per year and frequently less than 50 mm). At a rainfall station in the village of Adam, approximately 60 km north of the pipeline, rainfall data was collected from 1977 – 1992. The annual mean was recorded as 71mm. Appendix 3 shows complete rainfall data at this station.

4.2.3 Geology

In this section of the route the substrate is limestone, sandstone and shale covered with Aeolian sands. The central plains are made of almost horizontal mid-Tertiary limestones from the Oligocene and Miocene and are representative of ancient seabed levels.

4.2.4 Hydrology and Hydrogeology

Extensive groundwater resources exist in Oman, but most are too saline for potable or agricultural use. Fresh groundwater can occur near the surface as seepages and in shallow wells in the mountains and adjacent wadi areas. The main aquifer in the interior is the Umm er Rhadhuma (UeR), but other important local aquifers include the Fars formation which is used as the source of water for the RO plant producing potable water for the Qarn Alam camp and its adjacent area.

This section of the pipeline crosses a number of southward flowing wadis originating in the Northern Oman Mountains of which the major ones are the wadis Andam and Halfayn. Rainfall in the Hajar Mountains to the north occasionally flows in the wadi systems. Some of the wadis have low, steep sides showing signs of erosion, which indicates that the occasional flows are significant. Figure 4.2 illustrates the location of wadis present in the study area.

There are no sources of ground or surface water suitable for potable or irrigation supply in this pipeline section.

4.2.5 Air Quality

It can be assumed that the air quality conditions over the length of the route are generally good due to the lack of major sources of industrial emissions. The general absence of emission generators for most of the study area means that the ambient air quality is good with concentrations of air pollutants at or close to background/ambient levels that may be expected to be in an arid uninhabited desert environment. As this covers the entire length of the route, the existing air quality section will be omitted from the rest of the route baseline.

4.2.6 Flora and Fauna

As a result of hyper-aridity along this section of the pipeline route, some occasional vegetation tends to be restricted to depressions and wadi beds. Between the depressions, vegetation is scarce to non-existent. *Acacia* (Plate 1) dominates the plant community across the regions. Throughout the area, *Acacia tortilis* and *Acacia ehrenbergiana* are found along the wadis, their occurrence and density dependent upon soil conditions, favoring gravels and silts, and the depth to sub-surface water. The plant community includes *Prosopis cineraria*, which is the dominant tree species in dry sandy soils. *Washingtonia* species (Plate 2) are found quite frequently at depressions along the route.

Very few significant fauna species are encountered along this section of the route.

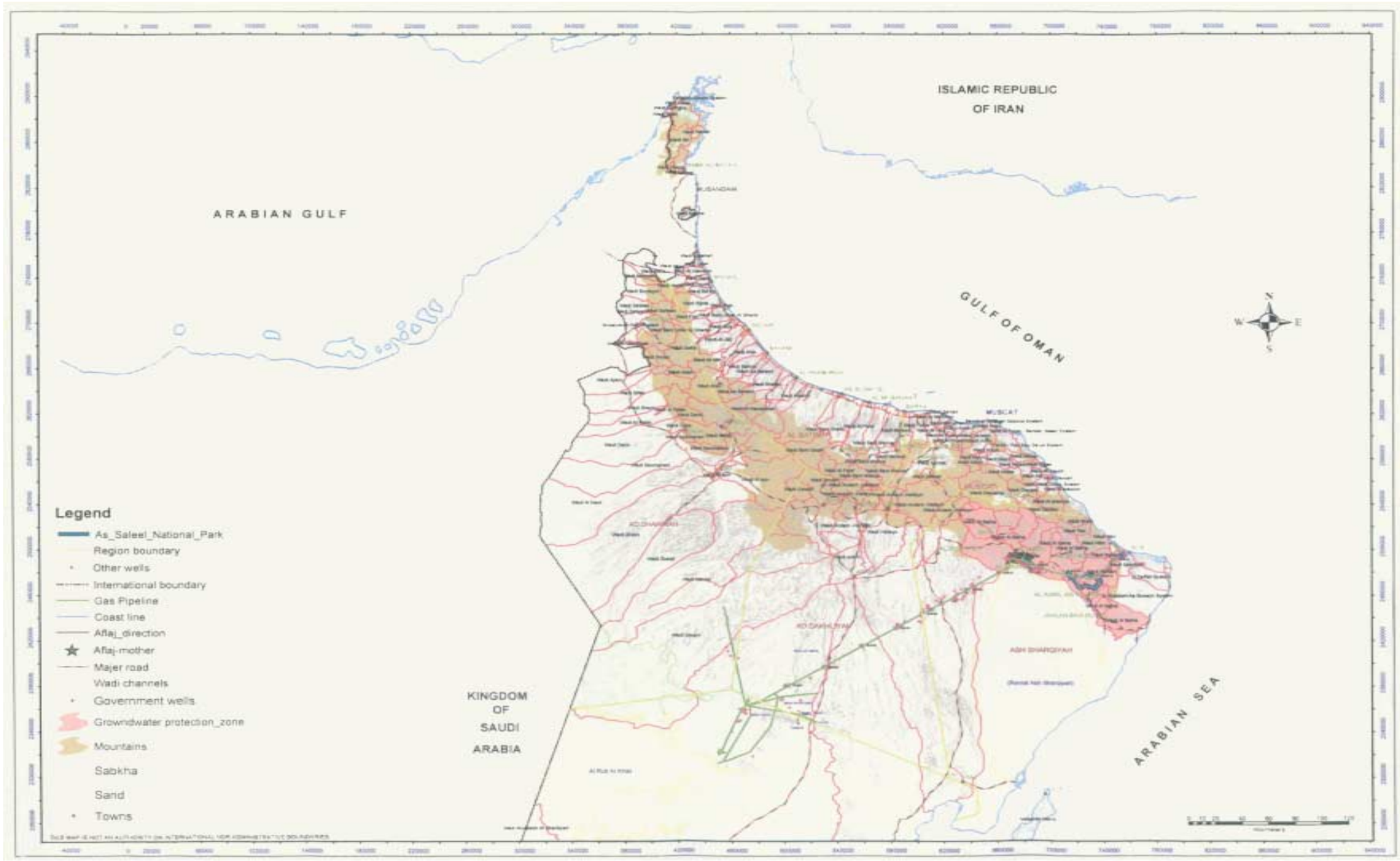


Figure 4.2: Wadis Present Along Pipeline Route

4.2.7 Socio-economic Aspects

This section of the pipeline passes through Al Wusta and Al Dakhilya Region, specifically, the wilayats of Haima and Adam. The region seasonally supports a significant population of migrating Bedouin. The southern end of this section of the route has sparse Bedouin populations adjacent to the pipeline route. Appendix 4 shows the summary of demographics of Regions.

The Durai tribe predominate the area around Qarn Alam. There are no major towns along the pipeline and access to services is limited. Levels of education are low and infrastructure is more basic than elsewhere along the pipeline. Once into the Wilayat of Adam, the population derives from a number of Bedouin tribes: Al Harasiis, Al Janaba, Al Junaibi, Al Wahiba and Al Jahafi. Their main economic activity of this area is livestock rearing.

The pipeline then enters Al Mudhaibi Wilayat, of which the population is relatively more dense, and includes the towns of Barzaman and Al Aflaj (approximately 1000 people combined). The main economic activities include date farming, livestock rearing and farming of citrus fruit and animal feed.

The nearest health facilities along this section of pipeline are in Adam and Nizwa, approximately 170 km and 200 km from Qarn Alam, respectively. In addition, there are PDO clinics at the Qarn Alam camp, which as a matter of policy do not turn away members of the surrounding community who seek their services.

PDO is currently supplying water to the 300 residents of Qarn Alam. PDO spends RO 330, 000 or USD 857, 588 annually within the northern part of PDO's concession area providing water to residents. This supply comes mainly from wells paid for and maintained by PDO. Residents drive approximately 5 km to a well and transport the water by car.

4.2.8 Landmarks of Interest

Between BVS 5 and 6 about 100 m away from the RoW, is a small mosque and a water well (see Plate 3). Appendix 5 shows the specific UTM coordinates of the mosque and settlements adjacent to the existing pipeline route (Figure 4.1).

4.3 BVS 7 – Eastern Boundary of Al Saleel Nature Reserve

The UTM coordinates for these two points are:

BVS 7: E 651 413; N 2 452 826

Eastern Boundary of Al Saleel: E 733 000; N 2 477 500

Figure 4.3 shows this section of pipeline route from BVS 7 through Al Saleel Park.

4.3.1 Topography and Landscape

This section of pipeline traverses along the northern border of the Wahiba Sands: an area of low dunes and sand and gravel plains. The route passes through Al Saleel Nature Reserve, whose northern border reaches the foothills of the Eastern Hajar Mountains approximately 30 km beyond BVS 9, close to Al Kamil power station. Following the dense acacia woodlands of the Reserve the pipeline route passes through the narrow Wadi Tahwah for a distance of approximately 5 km before reaching the Reserve's eastern boundary.

4.3.1.1 Al Saleel Nature Reserve/Park

Al Saleel Nature Reserve is currently under development and covers an area of 220 km^2, which the MRME&WR intends to fence. It is located near the Wilayat of Al Kamil and Al Wafi between the Eastern Hajar Mountains and the black top road to Sur. Figure 4.4 shows the Reserve boundaries and the existing pipeline route traversing through it in a straight line. The Park was designated under Royal Decree (RD) No. 50/97 for its importance in supporting a range of large mammals. The park consists of acacia woodland and provides a safe habitat for many of Oman's indigenous mammals. The park is featured in Plate 4.

There are three main areas to the park: the first is the alluvial plain covered in acacias; the second consists of the wadis in the mountains and the third is the sparsely vegetated hills and rocky outcrops which form the northern boundaries and higher elevations.

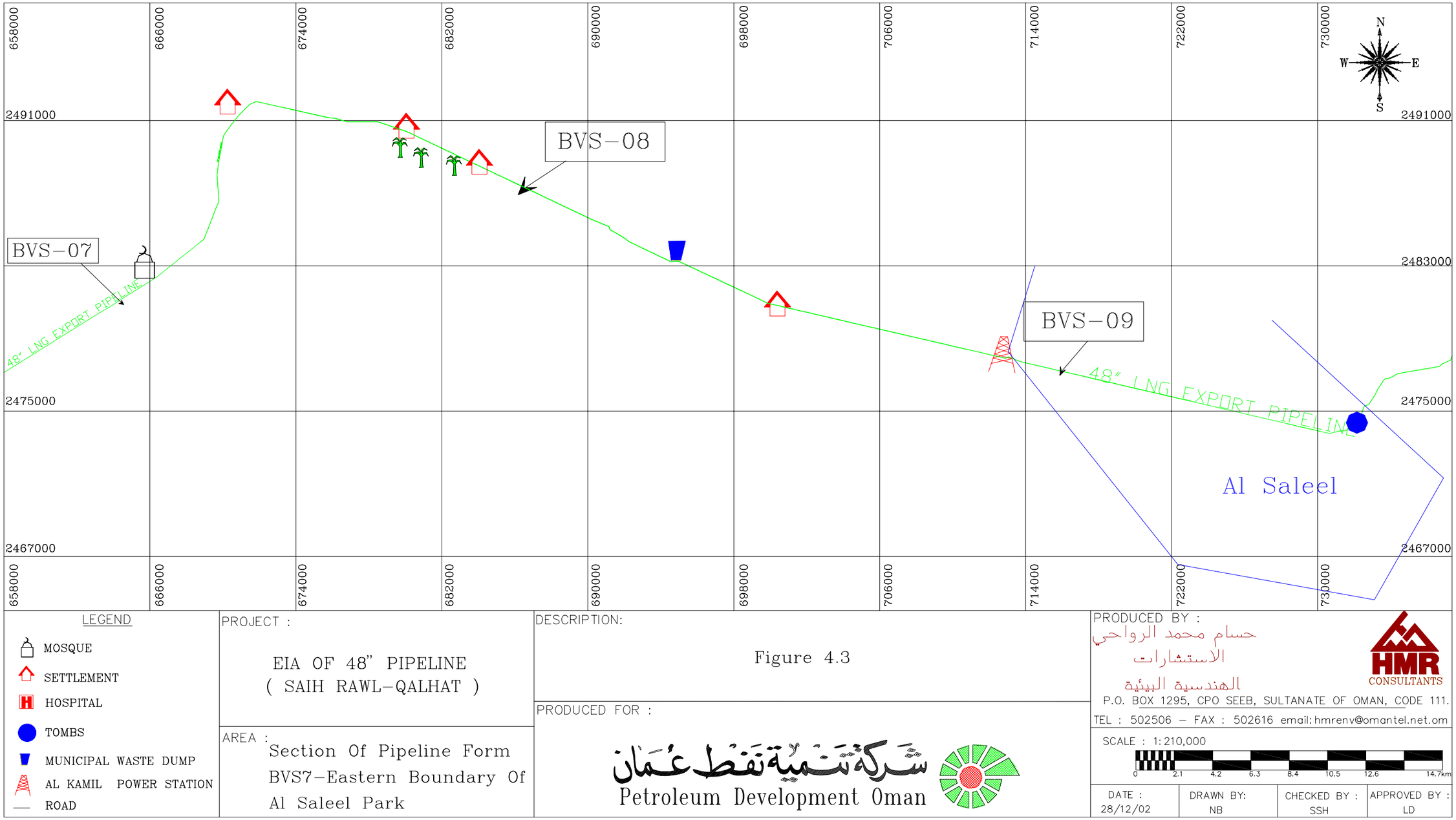


Figure 4.3: Pipeline Route - BVS 7 to Al Saleel Nature Reserve

4.3.2 Climate

The climate of this area is that of a hot semi-arid desert with low humidity during most of the year. The mean annual temperature on the alluvial plain is approximately 28^{o}C, with maximum temperatures of 47^{o}C being experienced between June and August and a minimum temperature of 8^{o}C in the winter. These temperatures were recorded at a meteorological station in Ibra from 1998 – 2001. Complete temperature data is shown in Appendix 2.

At a rainfall station in the village of Driz, approximately 6 km north of the pipeline, rainfall data was collected from 1974 – 1992. The annual mean was recorded as 83.2mm. Appendix 3 shows complete rainfall data at this station.

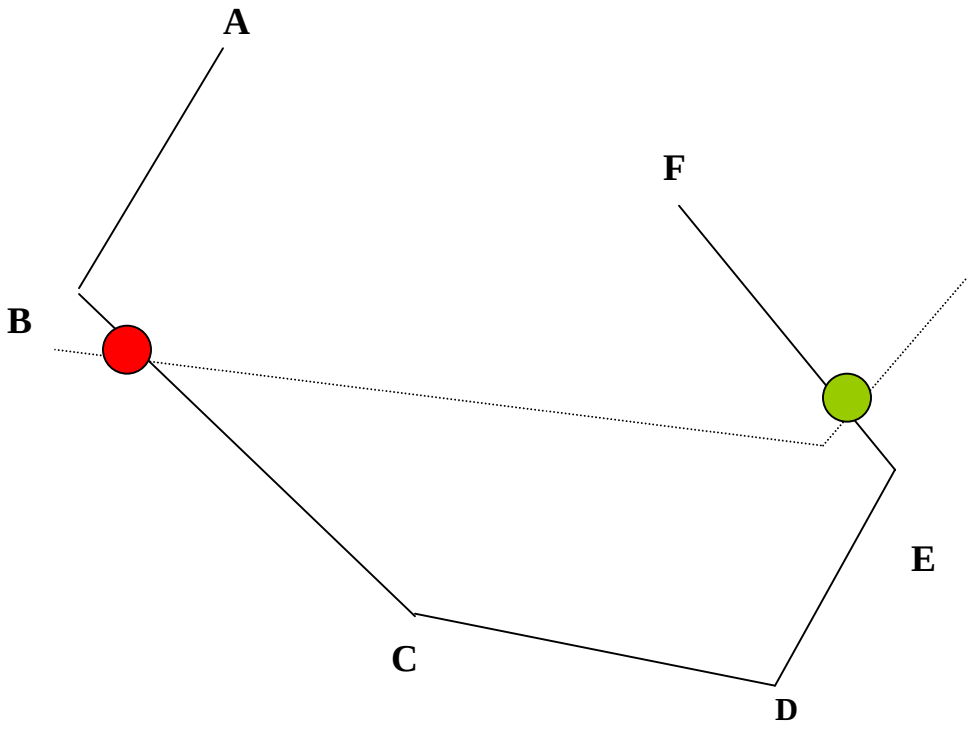
4.3.3 Geology

North of the Wahiba Sands, the geology is recorded as consisting of alluvial drift deposits comprising reworked material originating from the mountains to the north, overlying the Upper Fars formation. The Upper Fars may be encountered at depths between 15 and 50m below ground level.

4.3.4 Hydrology and Hydrogeology

The groundwater resources of this area occur in the alluvial deposits that form the wadi beds as well as the geology underlying the Wahiba Sands. The groundwater across the Region is extensively exploited by wells and aflaj. Recharge of the alluvium is secured from wadi floods and the hard rock aquifers. The permeability of the saturated alluvium is usually high and the quality of water is good.

Within the region, Ibra exploits the groundwater resources of Wadi Masrun that originates from the southern slopes of the Jabal Mukhtaran and which flows in a southeasterly direction to join Wadi Ibra. The depth to water level in the vicinity of Ibra ranges from between 7 and 8 mbgl. The average discharge of three production wells drilled in the Wadi Masrun aquifer, which serves Ibra, has been recorded in the past at approximately 1695 m^{3}d.



———	Al Saleel Nature Reserve Boundary
.....	Existing Pipeline Route
A	E 714 500; N 2 483 000
B	E 713 045; N 2 478 268
C	E 722340; N 2 465 541
D	E 733 108; N 2 464 619
E	E 736 901; N 2 471 322
F	E 727 500; N 2 480 000

Point where pipeline crosses through western boundary of Reserve (E 713 000; N 2 478 500)

Point where pipeline crosses through eastern boundary of Reserve (E 733 000; N 2 477 500)

Figure 4.4: Al Saleel Nature Reserve Boundary

Once the pipeline passes BVS 7 it enters a groundwater wellfield protection zone. The Ibra wellfield is most valid in this section. The Ibra groundwater wellfield consists of three production wells that supply Ibra Wilayat, which in 1996 had an estimated population of 26, 750 that required 0.77 mm^3/d.

Wadi Al Batha is the main wadi at this section of the pipeline. Figure 4.5 shows both the groundwater protection zone and Wadi Al Batha as the catchment area.

As is common across the arid and semi-arid climatic zones, villages and towns have developed close to water sources but with negligible free-flowing surface water-courses. In the Sharqiya Region, settlements tend to be close to groundwater resources and afalaj. Falaj systems arising from groundwater occur in the vicinities of Ibra, Bidiyah and Mintrib that cross the pipeline route (see Plate 14). Figure 4.6 shows the main aflaj systems at this section.

The pipeline route crosses eight aflaj along this section: Hatuh, Al Shariq, Al Wasil, Al Ghabbi, Al Aswad, Al Daher, Al Asham, and Al Akhdar. Table 4.1 below gives the UTM coordinates of where the existing pipeline crosses the aflaj systems.

Table 4.1: Aflaj Systems Crossing Existing 48" Pipeline

Falaj Name	UTM Coordinates (where falaj crosses existing pipeline)	Status of Falaj
Hatuh	E 682 305; N 2 489 334	Alive
Al Shariq	E 683 385; N 2 488 835	Alive
Al Wasil	E 677 632; N 2 490 943	Alive
Al Ghabbi	E 677 486; N 2 490 920	Alive
Al Aswad	E 676 259; N 2 491 109	Dead
Al Daher	E 675 837; N 2 491 166	Dead
Al Asham	E 674 311; N 2 491 503	Dead
Al Akhdar	E 676 012; N 2 491 154	Dead

Figure 4.5: Wadi Batha Catchment Area

Figure 4.6: Main Aflaj Systems at 2nd Section of Pipeline

4.3.5 Flora

The beginning of this section is sparsely vegetated with *Acacia* and *Washingtonia*. Once into Al Saleel Reserve the route is covered in *Acacia tortillas* woodland mixed *Acacia ehrenbergiana*. The Acacia community includes *Prospois cineraria* which is the dominant tress species in dry sandy soils. Shrub species often associated with the Acacia communities in wadis include *Rhzya stricta, Tephrosia apollinea, Haloxylon salicornicum and Salsola rubescens*. Vegetation has been removed along the immediate length of the pipeline RoW to allow the existing 48" pipeline to be laid (Plate 4).

4.3.6 Fauna

The mammal species of note and conservation importance throughout this section are the Arabian Gazelle (*Gazella gazella arabica),* Arabian Tahr and Ruppel's Sand Fox (*Vulpes ruppelli*). Many camels and goats are also seen throughout this section. Two species of hedgehogs are present in the area, Brandt's hedgehog (*Paraechinus hypomelas*) and the Ethiopian hedgehog (*Paraechinus aethiopicus*). Rodent species include the Lesser Jerboa (*Jaculus jaculus*), the Baluchistan Gerbil (*Gerbillus nanus*) and Jirds (*Meriones*).

Due to the broad spectrum of habitats to be found along the RoW, avifauna is diverse and includes the Egyptian vulture (*Nephron percnopterus*) of which many were sighted close to the municipal waste dump discussed in section 4.3.9. Thirteen species of reptiles, none endangered, are likely to be found. These include Thomas' dhabb (*Uromastyx thomasi*) as well as the small-scaled shabby (*Uromastyx microlepis*)

There are presently over forty Arabian Gazelles roaming through the park. Other mammals in the Reserve include the rare Gordon's Wild Cat (*Felis silvestris Gordoniensis),* wolves (*Lupus arabicus*) and a small number of Red Foxes (*Vulpes vulpes arabica*). Future plans for the park aim to achieve sustainable use of the vegetation for feeding Arabian Oryx and the Reem Gazelle. These animals will be introduced once the vegetation improves. More Arabian Gazelles may be introduced later in order to enhance the genetic base of the species within the park.

4.3.7 Archaeology

There are the remains of six tombs immediately adjacent to the pipeline route in the wadi that passes through the Eastern Hajar Mountains just before the eastern boundary of Al Saleel Nature Reserve. The UTM coordinates for the point on the RoW from where the tombs can be seen from are E 732 190; N 2 474 399. These tombs are featured in both Figure 4.3 and Plates 5 and 6.

4.3.8 Socio-economic Aspects

This section of the pipeline route is more urban than the previous section and passes through both Al Dakhiliya and Al Sharqiya Regions, specifically the wilayats of Adam, Al Mudhaibi, Al Qabil, Bidiya and Al Kamil and Al Wafi. Appendix 4 shows the basic demographics of these regions. Al Qabil and Bidiya Wilayats are areas of relatively high population density. There are a number of Bedouin settlements, houses and farms along the pipeline route, which can be seen in Figure 4.3 and also in Plates 11, 12 and 13. When the original pipeline was built it generally avoided housing and cattle sheds. However, within the last four years Bedouin settlements have moved close to the RoW for convenience sake and camels can be seen traversing the landscape throughout this section of the route (see Plate 7). The RoW provides easy access to main roads and is conveniently leveled for vehicles.

Ibra is an important service center and the Ibra Wilayat has been proposed for development as a Regional Center. Ibra and Al Qabil face problems of high unemployment, especially amongst the youth. The area has relatively higher levels of education and access to services.

Ibra Hospital is the closest major health care facility to the pipeline in this area and, in 2004, will be upgraded to a full regional hospital providing tertiary care.

4.3.9 Landmarks of Special Interest

UTM coordinates of all sites listed below can be found in Appendix 5. They are also featured in Figure 4.3.

- Archaeological sites adjacent to the pipeline in between BVS 9 and 10 are discussed in section 4.3.7 above;
- There is a small mosque 20 m away from the pipeline route just after BVS 7;
- Crossing the pipeline route in between BVS 7 and 8 is a camel racetrack (see Plate 8);
- There is a new farm that has been built by the Ministry of Agriculture and Fisheries adjacent to the route (about 30 m away) in between BVS 7 and 8. It is a new project designed to test new irrigation systems;
- Al Kamil Power Station can be seen from the RoW just before BVS 9;
- Approximately 10 m away from the current RoW at Hawiyah in between BVS 8 and 9 is a municipal waste dump, which during the IIA site visit had burning rubbish very close to the pipeline (see Plate 9). Ministry officials at the MRME&WR were notified of this at the time;

4.4 Eastern Boundary of Al Saleel Nature Reserve – OLNG Plant

The UTM coordinates for these two points are:

Eastern Boundary of Al Saleel: E 733 000; N 2 477 500
OLNG Plant: E 704 619; N 2 500 679

Figure 4.7 illustrates the location of this section of the pipeline.

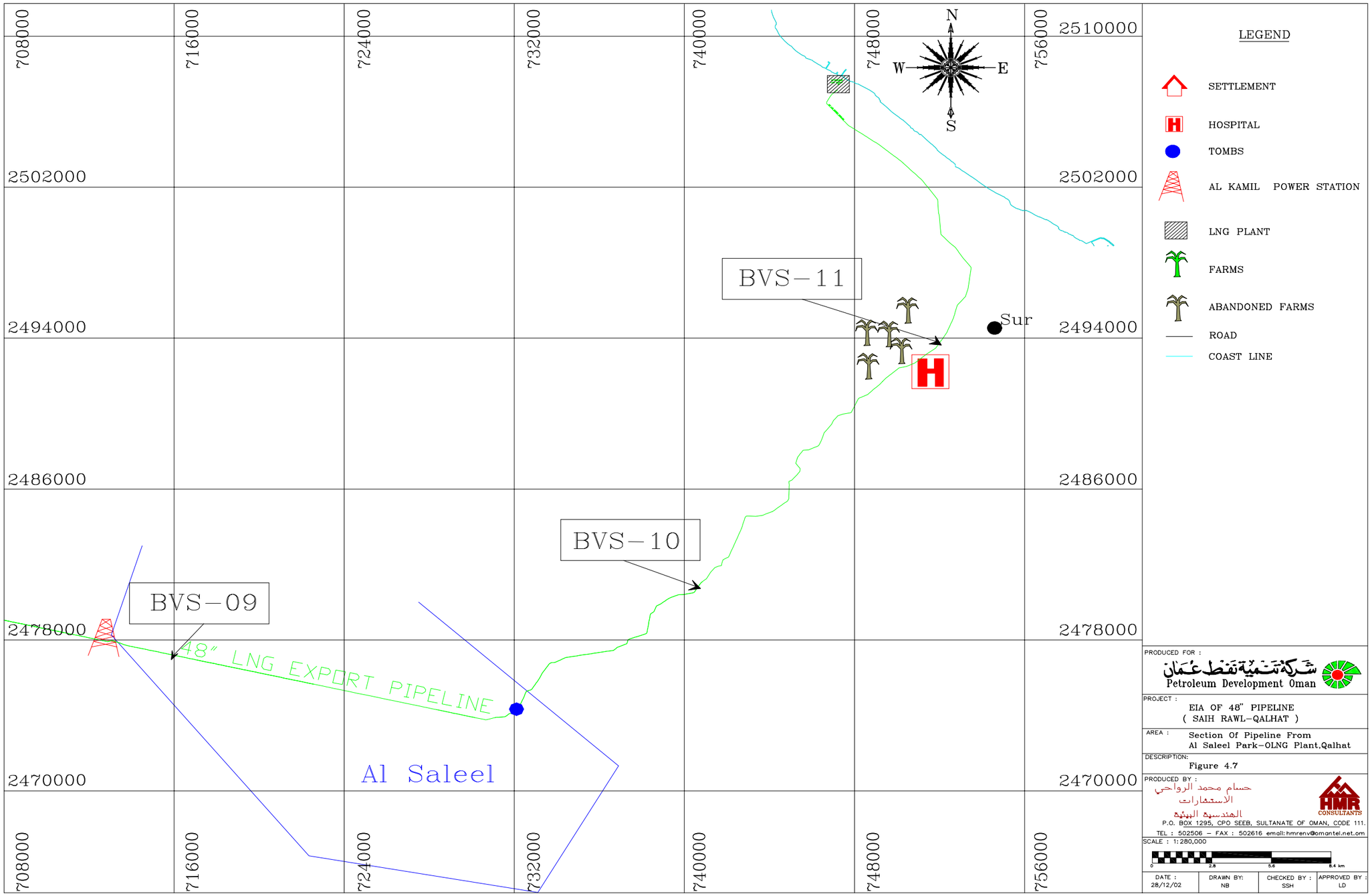


Figure 4.7: Pipeline Route Section - Al Saleel to OLNG Plant, Qalhat

4.4.1 Topography and Landscape

The pipeline enters a plateau area of sand and gravel cut by deep, wide wadis. Following which the pipeline traverses the mountainous landscape of the Eastern Hajars via a low col north of the Ma'ayah Pass and the Muscat-Sur road. The pipeline passes through many abandoned farms and a residential area on the outskirts of Sur, before crossing the narrow coastal plain to the OLNG plant at Qalhat.

4.4.2 Climate

This section of the pipeline traverses through an arid climate with an annual mean temperature of 28.7^{o}C with very low rainfall. Maximum temperatures vary from 7^{o}C in the winter to 45^{o}C in the summer. These temperatures were recorded at the Sur meteorological station between 1977 and 2001. Complete temperature data is shown in Appendix 2. Humidity ranges from 10 to 100% and average wind speeds range from 12 to 26 km/h.

At a rainfall station in the town of Sur, approximately 2.6 km east of the pipeline, rainfall data was collected from 1974 – 1992. The annual mean was recorded as 98mm. Appendix 3 shows complete rainfall data at this station.

4.4.3 Geology

The Eastern Hajar is comprised of two major units: the Permian basement and the Hajar Supergroup. The basement units in the Easter Hajar formed in the Middle to late Ordivician. The overlying Hajar Super group consists predominantly of carbonate deposits ranging in age from Late Permian to Late Cretaceous.

The southern areas of the mountains comprise the Samail Nappes, shouth of which the geology comprises piedmont and alluvial deposits overlying Tertiary limestone. The uncemented alluvial wadi sediments are found in recently formed wadi channels and consist of boulders, gravels and silty sands.

4.4.4 Hydrology and Hydrogeology

The groundwater protection zone that the pipeline entered into once passed BVS 7 continues into both Al Kamil wellfield still within Wadi Al Batha, and Sur wellfield to

the end of the pipeline route at Qalhat which ends within the catchment area Wadi Rafsah. This is shown in Figure 4.5.

At Al Kamil, on the outwash plain of Wadi Al Batha, the MRME&WR record that groundwater is encountered at depths between 52m and 92m below ground level within Tertiary and Quaternary unconsolidated gravel, clay and silts.

The groundwater is shallow to the west of Sur, the area being underlain by Marl, which forms an aquiclude. Overuse of the groundwater in recent years has resulted in saline intrusion and resulted in declining water quality. The production wells and desalination plant cannot provide sufficient water to serve Sur area. Currently 20% of the demand is being provided from the desalination plant at the OLNG plant and one million gallons per month is being transported by road from Al Kamil[1].

There are surface aflaj at Sur where the water sources occur as springs. The pipeline is not known to cross any alflaj systems in this section of the pipeline.

4.4.5 Flora

Vegetation is sparse through the mountains and across the plateau area where *Acacia tortilis* dominates the plant community in the wadis. The plains to either side of the wadis support some vegetation. Also present are *Prosopis cineraria* scrub, *A. ehrenbergiana*, *Heliotropium kotschyi*, *Fagonia ovalifolia*, and *Arnebia hispidissima*. Lycium *shawii* is not uncommon, associated with and often growing in the shade of the canopy of *A. tortilis*. Members of the Chenopodiancae and Zygophyllaceae families dominate ground cover. These include *Salsola rubescens, Cornulaca* spp., *Zygophylum quatarense* and *Fagonia* spp.

4.4.6 Fauna

Sightings of the Arabian Tahr, Arabian Gazelle, Arabian Wolf, Rueppel's Sand Fox, Arabian red fox, Striped Hyena and Gordon's Cat have all been recorded in the col area above Wadi Tahwah and are considered vulnerable.

[1] This information has been provided by the local Sur office of MRME&WR

Avifauna include the Egyptian vulture, chestnut-bellied sandgrouse (*Pterocles exustus*), stone curlew (*Burhinus oedicnemus*), black-crowned finch lark (*Eremopterix nigriceps*), hoopoe lark (*Alaemon alaudipes*), desert wheatear (*Oenanthe deserti*) and the brown-necked raven (*Corvus ruficollis*). Reptiles may include Thomas' dhabb and the small-scaled dhabb (*Uromastyx aegyptius microlepis*).

4.4.7 Socio-economic Aspects

This section of the pipeline crosses through the Sharqiya region of Oman, specifically the wilayats of Al Kamil and Al Wafi, and Sur. Sur is the largest town and most densely populated area along the route. Basic demographic data for these wilayats are shown in Appendix 4. There are currently no oil-related settlements within the region other than the OLNG residential camp at Sur. However, the region has a history of hydrocarbon exploration activities that resulted in the establishment of many permanent, semi-permanent, and mobile accommodation camps.

The decline in water supply and water quality in recent years, as mentioned in section 5.4.3, has resulted in the consequent decline in farming in the wadi areas. Palm trees and vegetation in the farms at the sides of the wadis generally appear to be in a poor state, and there are numerous abandoned farms and cultivated areas (see Plate 10).

To accommodate increased electricity consumption across the Region a gas powered electricity generating station has recently been built at Al Kamil immediately adjacent to the pipeline and close to BVS 9. (see Figure 5.6). The power station replaces diesel generator previously located at Sur, Al Kamil, Bani bu Hasan, Al Mudayrib and Al Mudaybi and has raised the total generating capacity in the Region to 285 MW. A new grid distribution line has also been constructed from Al Kamil Power Station to the Sur Industrial Area where the OLNG plant is located. These various power lines cross the pipeline RoW at numerous locations.

There is a school, training college and a residential area located near the pipeline after the route passes through the Eastern Hajars, between Sur and the OLNG plant. The exact coordinates of the residential area are not known. Their approximate location is shown in Figure 4.7.

4.5 Analysis of Alternative Routes

4.5.1 General

The fact that the pipeline route should follow adjacent to the existing pipeline is considered to be a positive aspect of the project. This means that there are fewer impacts associated with the project when it comes to land take. The only section of the route that is problematic in this respect is in proximity to Al Saleel Nature Reserve. The Reserve also includes the archaeological site of interest discussed in section 4.3.7. The following sections discuss alternative pipeline routes that would minimise impacts that occur in this area.

4.5.2 Do-Nothing Scenario

The Do-Nothing Scenario would require the abandonment, or non-start of the pipeline project. For this alternative option there would be no environmental impact, but proposed developments around Sur would require an alternative fuel source and the economic development of the area would not progress unless an alternative, cost effective fuel source was found.

4.5.3 Alternative Routes Bypassing Al Saleel Reserve

A meeting was held between the Director General of Nature Reserves at the MRME&WR and PDO on the 17th February, 2003, the subject being the environmental aspects of the tie-in location and pipeline route in Al Saleel Park. These impacts are discussed in section 5.5. At the time of the meeting, it was thought that the partial loop was the go ahead option and the discussion, therefore involved the pipeline crossing through 1 km of the Park, tying in at BVS 9. The following section briefly discusses alternative routes that would bypass the Park discussed at the meeting.

New Tie-in Location

Should the partial loop option be constructed, BVS 9 would be the terminal point of the pipeline. An alternative location for the tie-in could then be identified just outside the Park, approximately 1 km upstream from BVS 9. A tie-in at this location would require hot tapping in to the existing live gas line under pressure. This is considered a technically feasible operation, but involves unnecessary risks and relatively high costs.

As described in Section 3.2.2, should the tie-in at BVS 9 be constructed a minor extension to cater for the tie-in piping with valves and pig receiving facilities would be required. All other facilities, such as passive shelter for instrumentation and battery storage, aerial communication, access roads, fencing and gates are already existing and do not need a major upgrade. Should this new plot be required, 1 km away from the existing BVS 9 plot, all the above facilities would have to be rebuilt from scratch at the new plot.

Decrease in Pipeline Length

A decrease in the length of the loop line will have a proportional negative effect on the line pack, required for the capacity increase of the pipeline system, which is the main objective of this export project. As such this alternative is unfeasible.

Bypass BVS 9

Another alternative is to bypass BVS 9 and tie-in at BVS 10 or 11 outside the boundary of the Park. At the time that this alternative was presented to PDO, there was no financial cover in the project budget to extend the battery limit beyond BVS 9.

Full Loop Option

Should the decision be made to construct the full loop, which would route in a straight line through the entire length of the Park, it is quite possible that none of these alternatives will be valid. Further, should this option be chosen it is anticipated that it will not be economically feasible to bypass the entire Park (as mentioned in the above alternative).

Preferred Option – Tie- in at BVS 9

It was agreed in principle by all parties present at the meeting that a tie-in at BVS 9 should be the preferred option under the circumstances at the time and the scope of the project selection to the partial loop option. The MRME&WR had no major objections against the tie-in and the ensuing minor extension of BVS 9.

5 ENVIRONMENTAL IMPACT ASSESSMENT

5.1 Methodology

In this chapter, the potential impacts on the environment from the construction, operation and decommissioning of the full loop option be constructed are identified and assessed. Possible impacts occurring from alternative routes are presented in Section 5.8.

The identification of impacts is based on a matrix method. First, the environmental hazards (sources of potential environmental effects) associated with the construction and operational activities of the proposed project are identified based on the project description (presented in Chapter 3). Combining this information with the detailed environmental description of the project site (presented in Chapter 4), the environmental hazards and sensitivities are identified. These hazards and sensitivities are listed on a matrix to check whether an interaction exists between two elements. Wherever such interactions exist, they are further analysed for significance and thus the potential environmental impacts are identified.

Qualitative predictive techniques are mainly used for the evaluation of the potential impacts as the exact amounts of materials and resources to be used that may impact the environment are not yet decided upon. While assessing the impacts, the control measures given in Chapter 3 are taken into consideration.

The EIA study in general is carried out according to the "Ministry Guideline on Environmental Impact Assessment (2000)" issued by the DGEA in MRME&WR. The specific analytical and predictive procedures used in this study are based largely on the standard methods and guidelines given in the various manuals issued by the Environmental Protection Agency in the USA (USEPA). Guidance is also taken from the "Good Practice Manual for Environmental Analysis and Review of Projects (1993)" issued by the International Finance Corporation on behalf of the World Bank, as well as PDO's "Environmental Assessment Guideline" (GU-195) [Ref. 13].

5.2 Potential Impacts from Construction Activities

For the construction phase of the project, the significant sources of impacts, potentially significant environmental impacts and their risk rating without mitigation are identified as shown in Table 5.1 below:

Table 5.1: Potential Impacts for Construction Phase

Significant Sources of Impact	Potential Environmental Impacts / Risk
Land Take	
• Temporary land take (For installation of project facilities; construction of labour camps; storage of construction materials and storage and disposal of waste materials)	• Loss of fauna habitat / low • Displacement of local inhabitants / low • Landscape changes / low • Aesthetics / high
• Permanent land take (Camp abandonment and lack of remediation)	• Aesthetics / medium
Construction Works (Direct Actions and Effects)	
• Construction work (Site preparation, trenching, digging, excavation, foundation work and concrete work)	• Damage to topography and landscape / medium • Damage to vegetation / medium • Disruption of wildlife breeding and migration / medium • Loss of habitats for fauna / medium • Safety hazard to local population and fauna / low • Dust generation / high • Structural damage to buildings / low • Damage to aflaj / medium • Damage to archaeological sites / high • Temporary disruption of power supply to local communities / high • Health risks due to stagnant water leading to malaria transmission / medium
• Presence of windrow	• Hindrance or barrier to fauna / medium
Resources Use	
• Utilization of groundwater resources (For construction water and potable water in labour camps)	• Stress on groundwater resources / high

• Use of land resources (For sand winning)	• Destruction of wadis and sensitive areas / low
• Utilization of human resources (Employment of immigrant / expatriate workers for construction)	• Generation of employment for local workers (positive impact) • Public health risks from large scale use of immigrant workers / low
• Utilization of local infrastructure facilities (Accommodation, roads, local transport, power supply, water supply, sanitation, hospitals etc.)	• Stress on local infrastructure facilities / high • Traffic congestion / high • Public safety and health risks (RTAs) / high • Local life style and cultural conflicts / medium
Releases to Environment	
• Release of air pollutants (Dust from construction activities and road traffic; gaseous emissions from engines)	• Degradation of air quality / medium
• Generation of high level noise (From construction equipment and transport vehicles)	• Increase of ambient noise levels causing disturbance and nuisance to both communities and wildlife / high • Safety hazard for employees / high
• Discharges of liquid effluents (Discharge of equipment washings from construction site, disposal of sewage from labour camps; hydrostatic testing; accidental spillage of hazardous liquids etc.)	• Groundwater pollution / medium • Land contamination / medium • Direct exposure of chemicals to fauna watering at evaporation pond / medium
• Disposal of solid wastes (Transport and disposal of non-hazardous construction wastes and domestic wastes from labour camps)	• Land contamination / medium • Groundwater pollution / medium • Public health risk from non-hazardous waste transport and disposal / medium
Functional Aspects	
• Transport of materials and workers to site	• Traffic congestion / high • Public safety risk (RTAs) / high
• Handling, storage and transport of hazardous substances (Fuel oils, hazardous chemicals etc.)	• Land contamination / medium • Groundwater contamination / medium • Public health risk from hazardous waste transport and disposal / low
• Artificial lighting (night-time work)	• Disturbance to animals / high • Landscape changes / low • Nuisance to communities along route / high

5.3 Potential Impacts from Operational Activities

For the operational phase of the project, the significant sources of impacts, potentially significant environmental impacts, and their risk rating prior to mitigation are identified as shown in Table 5.2 below:

Table 5.2: Potential Impacts for Operational Phase

Significant Sources of Impact	Potential Environmental Impacts
Land Take	
• Permanent land take (For RoW and windrow)	• Loss of terrestrial habitat / low • Landscape changes / medium
Operation and Maintenance	
• Driving along RoW in Al Saleel Reserve	• Disturbance to fauna / high
• Possible gas leak	• Injuries and potential death of employees, community members / medium • Strain on local health facilities / medium
Releases to Environment	
• Sludge discharges (From pigging)	• Contamination of groundwater / medium • Contamination of soil / medium
Functional Aspects	
• Increase of traffic (from use of RoW)	• Damage to pipeline / medium • Injury to users of RoW / low • Disturbance to wildlife in sensitive areas / high

5.4 Potential Impacts from Decommissioning Activities

For the decommissioning phase for the project, the significant sources of impacts, potentially significant environmental impacts and their risk are identified as shown in Table 5.3 below:

Table 5.3: Potential Impacts for Decommissioning Phase

Significant Sources of Impact	Potential Environmental Impacts
Resources Use	
• Use of groundwater resources (for filling in pipe)	• Stress on groundwater supplies / high
Functional Aspects	
• Increase of traffic (from use of RoW to perform decommissioning)	• Disturbance to wildlife in sensitive areas / medium • Disturbance to settlers along the RoW / medium

5.5 Assessment of Impacts for Construction Phase

5.5.1 General

Experience has shown that most environmental impacts arising from pipeline projects occur during the construction period or as a result of it. Clearing the working strip, sand winning operations and trench excavation activities are the major areas where impacts can arise due to damage to the soil structure, to existing flora and fauna, to local residents and their livestock, to water supplies and to sites of archaeological and cultural sensitivity. The use of plant and machinery and blasting can cause problems through dust, noise and gaseous emissions.

In Table 5.1, the significant impact sources, their potential impacts on the environment and their risk during the construction phase are identified. In this section, these impacts are evaluated for their magnitude and significance. The evaluation is qualitative for these impacts for the reasons discussed in Section 5.1. It may be noted that for a potential impact, there is more than one source (cause). This section is divided into the most practical subsections in order to discuss these impacts in a practical manner: Landscape, Topography and Geology, Hydrology, Air Quality, Noise and Vibration, Waste and Land

Contamination, Flora and Fauna, Archaeology, Socio-economic Impacts, and Traffic and Transportation.

5.5.2 Landscape, Topography and Geology

The location of barriers and a windrow in accordance with PDO HSE requirements would cause a landscape impact and it is thought that some barriers may be required on around road crossings. In considering the landscape impact from barriers and a windrow it should be remembered that the existing RoW and windrow have already made an impact and this fact significantly reduces the impact from the proposed pipeline. Al Saleel Park, however, has been earmarked for wildlife tourism and education. The presence of a second windrow and the widening of the existing RoW will have an aesthetic impact on this acacia woodland.

The availability of a RoW for local usage (although discouraged by PDO) would heighten the landscape impact through its repeated use.

With the exception of areas between BVS 5 and BVS 8 the proposed pipeline does not cross any areas of agricultural significance. Between these two points farms can be seen from the route, but the route does not cross through these plots. On the basis that important soils only occur in agricultural plots, the impact of the pipeline on good quality soil land take is considered minimal.

Although the pipeline traverses through formations that are part of the Oman's geological and topographic heritage, no feature except for the Eastern Hajar Mountains was found along the route that could be classified as important in its own right. Cuttings from these mountains between Al Saleel and Qalhat will be necessary in order for the pipeline to cross this area. This will have an aesthetic impact due to their location relative to viewing points along the road from Al Kamil to Sur. Since construction of the existing pipeline, a number of power lines of different capacity have been constructed that cross the RoW. These power cables represent a hazard during construction and at some locations inhibit the construction of cuttings to widen the RoW.

Sand winning is necessary in order to obtain suitable padding material. The exact volume and source of this sand is not known, but a significant amount is required. Should the Contractor take the material from sensitive areas, such as wadis, there may be significant impacts.

Aesthetic impacts will occur should the construction site not be remediated, or the labour camps be abandoned without appropriate decommissioning. When a camp is constructed, certain structures may require temporary concrete foundations for structural support. Once the camp is abandoned, very often these concrete bases are left behind. The concrete takes a long time to break down and can be an aesthetic blight on the property.

5.5.3 Hydrology

The access to potable water for human and agricultural use is an extremely important requirement of life in Oman. The presence of the pipeline within the vicinity of wellfields is regarded to pose a potentially significant impact, where accidents that may occur during construction could cause the contamination of the underlying aquifer.

Potential causes for groundwater contamination include the discharge of liquid effluents and disposal of wastes to land, followed by the infiltration of leachates into the aquifer. Effluents discharged to land at the site shall include de-oiled machinery washings and hydrotest water, both of which will be free of any contaminants. All solid wastes will be disposed of at municipal landfills or at an approved MRME&WR facility.

Hydrostatic Testing

The sourcing of hydrotest water is unknown at this stage. Section 3.7.10 discusses the possibilities. Should water be obtained from Al Awaifi Water Supply Well, which is currently used as a water source for other PDO projects, over exploitation may result. Should water from the marine environment be used, there may be an impact upon the receiving environment. At this stage in the project-cycle it is not possible to be specific because the location of such actions are not known and remain subject to permitting and the Contractor's detailed design options. The drilling of water wells is unlikely as a means to source hydrotest water. Should groundwater become a requirement it shall be important to select a sustainable abstraction well and obtain approval from the MRME&WR. Competition for scarce water resources between existing users and the pipeline contractor could negatively influence local opinion to the project and cause disruption to local farmers, which could subsequently result in claims for compensation.

A principal source of waste associated with the pipeline shall be wastewater from hydrostatic testing. It is assumed that this will be carried out between individual block

valves rather than the complete length of pipe. The volumes will be dependent upon the Contractor. The hydrotest water shall require disposal after use.

The possibility of leakage during the procedure presenting potential significant impact, although this is dependent upon the location and the amount of water lost. Leakage within Al Saleel Nature Reserve and within the wellfields (see Chapter 4) could cause significant impacts.

The presence of added biocides, oxygen scavengers and corrosion inhibitors within the hydrotest water means that the disposal area and disposal method should be chosen with due regard to the receiving environment. Significant environmental impacts could arise due to the presence of biocides and corrosion inhibitors. Oxygen scavengers evaporate to the atmosphere whilst corrosion inhibitors and biocides are eco-toxic.

Disposal of hydrotest water on land could lead to contamination of the local water sources. In the event that these sources are sweet (potable), contamination by the hydrotest water could lead to the deterioration in quality and an impact to existing or potential users.

Disposal impacts common to all areas relate to the potential for ground and surface water contamination and its significance is dependent upon the proximity of the pollution to potable water supplies, ecologically sensitive areas and human habitation.

Sewage

Adverse impacts may also arise if sewage disposal arrangements are inadequate at the camp and construction sites. This could result in localised contamination of water sources, particularly along the section of the pipeline route where settlements occur. Whether or not this occurs in practice will depend upon the siting of construction camps, which are at the discretion of the Contractor in consultation with the local Wali and MRME&WR. It is noted that in camps of greater than 150 people a Sewage Treatment Plant (STP) is required (MD 5/86). If it is shown to be economically feasible in camps with less than 150 people a mobile STP can be used, otherwise the material should be tankered to the nearest disposal facility. A Permit to Discharge is required to dispose of solid wastes and wastewater (including sewage).

It is not known how sewage will be handled as this is dependant upon the EPC

Contractor. However, it is thought that the sewage generated on-site will be transported to an off-site STP for treatment and disposal. At the Contractor's camps, the sewage generated will be collected in septic tanks (following MRME&WR regulations) from where they will be transported to an MRME&WR approved STP for treatment and reuse. Similarly all the solid hazardous and non-hazardous wastes will be disposed of at municipal landfills. Therefore, there should be no risk of groundwater contamination associate with construction activities.

Aflaj

Aflaj systems are typically between 4 and 20 m below ground level and provide water to many villages and settlements in the section of pipeline between BVS 7 and the Eastern Hajar Mountains. These aflaj can be damaged during construction works through digging and blasting activities, causing collapse and blockages; disrupted water supply may consequently result.

The pipeline is generally buried at 1.5 m depth although in places it shall be buried deeper where required, i.e. special crossings (see Section 3.8). The depth at which the pipeline is buried should not have any impact upon the existing water resources of the area.

Section 4.3.4 lists the aflaj present along the route. The severity of the impact is dependent upon the location and the contaminant neither of which can be predicted at this time.

Wadis

There are major wadi systems to be traversed that flow southwards between Saih Rawl and the foothills of the East Hajar Mountains at Al Saleel. The current pipeline is protected by a windrow along most of the route except were the pipeline crosses a wadi. Where these crossings occur, it is normal engineering practice to bury the pipeline deeper and there is no windrow present (see section 3.8). There is thus no impediment to the flow of water, which originates from rainfall in the mountains. The water flow in the wadis recharges the groundwater in the plains to the west of the mountains, which has been the source of water for the aflaj in this area. The groundwater is the source of three major groundwater wellfields located within the pipeline route (see sections 4.3.4 and

4.4.4). Should a windrow be placed within wadis, a significant impact could occur by impeding the water flow and reducing this important source of water.

Although the wadis are dry for long periods it should be remembered that they can occasionally carry high volumes of water. Should periods of high flow catch the contracting team unawares, pollution may result from engulfed construction plant.

5.5.4 Land and Soil Contamination

The development of the Pipeline will give rise to a number of waste concerns. Waste expected from the development will include:

- General Construction waste;
- Domestic waste from contractors camps, including sewage arisings;
- Spillages/leakages of oils/solvents, etc.;
- Effluent from hydrostatic testing.

The scale of the construction work and the numbers of personnel involved mean that the impacts could be significant. There is a need to ensure that waste is properly controlled and disposed of in an environmentally acceptable manner.

Regulations pertaining to the management of wastes are documented in PDO's Waste Management Guideline (SP-1009 [Ref. 18]). The objectives of PDO's policy can be summarised as:

- To ensure the responsible and safe disposal of non-hazardous wastes from houses, camps, offices and industrial operations;

- To treat hazardous waste and render it non-hazardous before disposal, or where this is not possible;

- To ensure safe, ultimate disposal of hazardous waste or to ensure safe disposal while retaining control for possible future treatment;

- To reduce the volumes of (hazardous and non-hazardous) wastes generated.

PDO's policy on waste management also applies to contractors. A system of contract custodianship is in operation which is designed to ensure that contractors' obligations, with respect to the PDO Waste Management Guideline, are fully honoured.

The amount of general industrial waste is anticipated to be modest and its disposal should not present any difficulty if carried out in accordance with PDO's Waste Management Specification. No adverse environmental impacts are therefore anticipated from this source.

A significant number of personnel will be employed on the construction of the pipeline. It is estimated that the total construction workforce could be approximately 1500 accommodated at a number of camps. To avoid residual impacts through litter or non-combustible packaging, which may present hazards to scavenging wildlife in remote areas, waste segregation should be practiced.

Discharge of liquid effluents and disposal of hazardous wastes on land can have the potential for land contamination. Such potential may exist at the project site as well as off-site locations, where labour camps will be located. The proposed practices on the discharge of liquid effluents and disposal of hazardous wastes from both project site and labour camp sites are already discussed in Section 5.5.3. These practices will ensure that there will be no land contamination. Similar practices will be used for on-site sewage and solid waste.

Significant accidental leaks and spills of hazardous liquids such as oils, chemicals and paints can lead to soil contamination at construction site. The necessary measures for control and mitigation of such accidents are discussed in Chapter 6.

5.5.5 Air Quality

The PDO "Specification for Emissions to the Atmosphere" (SP-1005 [Ref. 15]) although primarily concerned with emissions from the petrochemical industry does mention that the PDO Asset Manager is responsible for vehicle emissions. An Asset Manager's responsibility includes contractors.

It is difficult at this stage, to estimate vehicle emissions and give quantitative predictions for their effect on the air quality. However, it should be remembered that the vehicles will be used along the entire length of the route and therefore emissions will be emitted

over 290 km should the partial loop be constructed, and 358 km should the full loop be constructed. Emissions will be transient and localised, will quickly disperse and are therefore not likely to be of significance. There should therefore be minimal impact to the environment from vehicle emissions. Based on past experience, it is reasonable to assume that any adverse impacts will be highly localised, and are unlikely to impact surrounding populations who are at a distance of 1 km from the route. Within the working strip, the impacts could be significant as there are a number of settlements along, and extremely close to the route (see Figures 4.1, 4.3 and 4.7). These impacts can be mitigated as discussed in Chapter 6.

The major cause for potential impact on air quality during construction phase is the significant dust generation from earthwork, movement of vehicles on unpaved surfaces, and the engine emissions. This dust will be a source of health risks and a nuisance to settlements close to the pipeline as well as to fauna in the surrounding area. This is discussed in more detail in section 5.5.10.

There will be no impact from the use of radioactive materials during the non-destructive phase (described in section 3.7.11) as MRME&WR regulations for handling materials and equipment will be followed. PDO specifications for Handling and Use of Radioactive Materials (SP-1170 [Ref. 22]) should also be followed. No waste will be generated during this process.

5.5.6 Noise and Vibration

Noise

There are two Ministerial Decisions that relate to Noise within the Sultanate of Oman. The MDs cover occupational and public environments:

- Ministerial Decision 79/94: Regulations for Noise Pollution Control in Public Environment

- Ministerial Decision 80/94: Regulations for the Noise Pollution Control in Working Environment

The levels of noise limits for the public environment specified in Ministerial Decree 79/94 are shown in Table 5.4 below. Article 2 of the MD classifies external noise

sources. The pipeline and its construction would fall into category a) Industrial Plants and Public works. Table 5.5 shows the noise levels associated with typical pipeline construction activities. The levels are based upon experience of pipeline construction activities and were used in the existing 48" pipeline EIA.

Table 5.4: Ambient Noise Standards

Type of District	Maximum Permissible Noise Level [as L_{eq} in dB (A)]		
	Day Time (7AM –6PM): Workdays	Evening Time (6AM –11PM): Workdays	Night Time (11PM- 7AM) on Workdays and All Times on Holidays
Rural, residential, recreational	45	40	35
Suburban residential	50	45	40
Urban residential	55	50	45
Urban residential with some workshops or business	60	55	50
Industrial and commercial	70	70	70

Table 5.5: Noise Levels Associated with Typical Construction Activities (dBa)

Activity	Composite Noise Level at distance of 10 m	Noise Level at distance of 50 m	Noise Level at distance of 100 m	Noise Level at distance of 200 m	Noise Level at distance of 500 m
Clearing/grading of working strip and R.O.W.	88	74	68	62	54
Ripping/blasting	86	82	66	60	52
Trenching	90	76	70	64	56
Reinstatement	88	74	68	62	54

Tables 5.4 and 5.5 show that there will be an excedance of stipulated noise levels during construction. However Article 16 of MD 79/84 does provide for such eventualities.

Where construction activity occurs within 500 m of settlements, MD 79/94-defined limits will be exceeded, i.e. it is considered an impact. Settlements within 500m of the pipeline are located between BVS 5 and Qalhat and both noise and vibrations will cause a nuisance to inhabitants of this area.

MD 80/94 specifies the regulations for noise pollution control in the working environment. These regulations state that no employee shall be exposed to noise levels exceeding 85 dB(A). It can be seen that noise from construction activities will exceed this level. The regulations specify that suitable noise protection devices shall be provided for workers. The attenuation of such noise protection devices shall reduce the noise level to 80 dB(A) or lower.

In addition to the machinery involved, the significant vehicle movements associated with pipe delivery will generate noise along the delivery route. The level of noise is not expected to be high or long in duration. However, the principal routes, which are at the Contractor's discretion subject to agreement with PDO (see Section 5.4.10), will experience an increase in traffic movements. It is not envisaged that this will be a major impact because property along these main routes is already exposed to high levels of traffic. Noise limits specified under MD 79/94, Article 2 for Road Traffic stipulate that for Rural Residential and Recreational Areas the decibel limit should not exceed 60 dBa. The amount of traffic generated in delivering the pipe to site is expected to increase the noise levels to over 60 dBa; dependent upon the numbers frequency of movements and type of vehicles used. Article 16 of MD 79/84 does provide for such eventualities.

Vibrations

Impacts associated with blasting are described separately to general construction noise levels within this report. The level of blasting required on the project is expected to be significant. Blasting is shown to exceed MD 79/84 designated levels at 500m (Table 5.4). However, it is highlighted that levels shown in Table 5.3 are for the stipulated time period (i.e. Period A covers 7am – 6pm). Blasting is not expected to be a continuous activity over an 11-hour period.

Vibration is associated with blasting, which is controlled under PDO's PCS-01 and gives clear guidance on where blasting can and cannot be used. Archaeological sites, however, may be impacted by the vibration (see section 5.5.8). There are also a few mosques located along the pipeline (see Appendix 5 for UTM coordinates). These may also be damaged due to blasting and vibrations.

Both noise and vibrations will cause disturbance to wildlife along the route, especially within Al Saleel Nature Reserve, which may cause a disruption of migration and breeding. Nighttime construction will not be permitted. Should this occur, however, the

level of perception to noise may be more acute at night and the impacts would be even greater to both human and animal populations.

5.5.7 Flora and Fauna

All wildlife is protected throughout the Sultanate and this is enforced by MRME&WR through MD 207/93. Applicable legislation is covered in greater detail in Chapter 2. The PDO Specification for Flora and Fauna Protection (SP 1011) requires the protection of flora and fauna in accordance with the laws of Oman.

Positive Impacts

The presence of a windrow can be considered as a benefit to small fauna by providing additional habitat for burrowing and basking. It is notable that when driving past existing windrows birds are in greater evidence on those windrows that contain a high number of rock particles than those that consist of sand and loose material.

A positive benefit to the presence of large numbers of people within remote areas is that they can report sightings of animals to the appropriate authorities (MRME&WR) for help in determining the status and behaviour of animals.

Negative Impacts

Saih Rawl – BVS 7

The plant and animal species seen along the route from Saih Rawl to BVS 7 are distributed more or less throughout the central desert region and none are exclusive to the route. Impacts caused by land-take will not have a significant affect on the habitats present.

The requirement of a 50 m RoW throughout the pipeline corridor can be seen as a significant loss of habitat when considering total area. The area requirement is also increased by the need for temporary construction camps and pipe storage yards during the construction phase. After construction, vegetation can re-colonise the area. The areas passed by the pipeline from Saih Rawl to BVS 7 are not isolated habitats, but are components of larger habitats and ecosystems to which the overall impact from land take

should be negligible. To prevent unnecessary damage to the desert environment, which recovers very slowly, the working strip should be strictly adhered to.

Fauna can be disturbed by the noise, dust and the general activity (vehicle movements, lights, vibration etc.) associated with the pipeline construction. Fauna are mobile and no areas of fauna sensitivity have been identified in this area. It is therefore considered that the impact from the project on habitats present within this area shall be minimal.

Al Saleel Nature Reserve and East Hajar Mountains

As discussed above, throughout most of the route impacts on animal habitats should be minimal. In Al Saleel Nature Reserve, however, there will be a significant impact. There are some animal species in the Reserve and the Eastern Hajar Mountains that are particularly sensitive to artificial light and noise, such as the sand gazelle. Many of the species are either nocturnal, or are generally more active at night than during the day. Artificial light from construction work could disturb normal activity patterns of these animals. Noise and vibrations could affect both migration and breeding of sensitive animals.

Should there be land-take in addition to the existing RoW through Al Saleel, there will be an increased disturbance to vegetation and animal habitats. It is thought, however, that the existing RoW will be sufficiently wide to allow construction of the new pipeline and thus no further disturbance shall be necessary.

Whole Route

The presence of a windrow creates a hindrance to the movement of fauna along the pipeline. Should the windrow be too high and/or have no gaps, it may act as a barrier to fauna. This may affect migration patterns and access to food and shelter for some fauna. Section 5.5.9 discusses the windrow as a hindrance for livestock.

Indirect impacts arising from construction include impacts from poor site practice. The presence of putrescible material can attract scavenging fauna. Fuel spillage could, in certain instances, poison fauna or contaminate the area, impacting upon the ecosystem as a whole.

5.5.8 Archaeology

The Royal Decree 6/80 requires that antiquities should be protected and can only be destroyed or damaged with written ministerial permission. The emphasis is placed upon preservation where possible, but accepts that it is reasonable to impact upon a site, should the development be essential and where no alternative site exists. Further allowances are made should the antiquity not be unique.

Archaeological features – specifically the remains of six tombs, were found adjacent to the proposed pipeline route immediately after Al Saleel Nature Reserve (See Section 4.3.7. These remains will be destroyed from vibrations and blasting which may be necessary in the area. It is not known how many of these tombs will be affected, but any interference with archaeological features is deemed an impact. A letter of no objection must be obtained from the Ministry of Heritage and Culture prior to construction work taking place. Should the partial loop be constructed then there would be no impact to these sites.

5.5.9 Socio-economic Environment

The construction of the proposed pipeline has the potential to cause both positive and negative impacts on employment, land use and public infrastructure. These impacts are considered in the following subsections.

Positive Impacts

Some direct socio-economic benefits accrue from the project construction by way of short-term employment generation. The project will provide direct employment to locals during peak construction periods. Additionally, a large number will be indirectly employed. Out of the total manpower, not less than 30% will be employed from the local (Omani) population.

Negative Impacts

The siting of the pipeline close to permanent settlements and mosques (mainly between BVS 5 and 8) may have a significant impact. The route of the pipeline is adjacent to these houses and mosques and will disrupt the local populations during construction in terms of noise, vibrations and obstructions. Appendix 5 gives the exact UTM coordinates of these settlements and mosques.

Land-take deprives the local population of a scarce resource in Oman – cultivable soil. The RoW has an operational requirement to prevent vegetation growing within the restricted zone and, although vegetation is tolerated within the open space reserve, it is for landscape and ecological purposes only, not for cultivation. Therefore the loss of any productive land is to be considered a significant impact. The land along most of the route, however, is used for livestock grazing and not farming and so this is not valid. The losses of fodder for livestock, on the other hand, may severely impact the livelihoods of the Bedouin settlers.

Labour camps will be located off site. Only those sites approved by the local town planning authority will be selected for labour camps. This will ensure that the land taken is not used for agriculture or any other occupational use.

The presence of a windrow may hinder the movement of livestock and traffic. PDO windrows currently maintain non-specific gaps at least every 2 kilometres. This is not expected to be enough within the section from BVS 5 to 8. The windrow will have the affect of concentrating traffic at specific areas rather than *ad hoc* tracks crossing the plain allowing undisciplined traffic movement. Although advantageous for the control of traffic movement the windrow may have an impact on the movement of camels (goats are assumed to be able to cross the windrow). The presence of a windrow without suitable crossing points *may* increase the concentration of camels upon one side of the windrow. If this eventuality occurs it will lead to an increase in overgrazing, and in turn, erosion. It is accepted that project economics dictate that a windrow is used to prevent vehicles driving across the pipelines otherwise the wall thickness of the pipe would have to be increased leading to a substantial increase in the project cost. The impact of such a barrier is reduced when considering that the presence of the existing windrow may already cause this impact.

Livestock may be prevented from accessing grazing areas by the trench during construction. The Contractor may dig the trench in long sections to maximise the efficiency of his plant. If the trench is of such a length that livestock are prevented from accessing areas this would constitute an impact.

The accommodation of a large number of construction staff throughout the construction period and increased road traffic for the transport of material and men to the site can potentially place a stress on the local infrastructure such as accommodation facilities, power supply, water supply, sanitation, hospitals, local transport, roads etc.

A new grid distribution line has been constructed from Al Kamil Power Station to the Sur Industrial Area where the OLNG plant is located. These various power lines cross the pipeline RoW in numerous locations and during construction power may be cut off for a period in order to construct the pipeline in these areas. This would lead to the loss of power in communities. There is a need for structured coordination with the other project proponents and the local authorities for mitigating these adverse impacts. This is discussed in Chapter 6.

Deployment of large scale immigrant workers with different lifestyle and cultural background can have an adverse impact on the local lifestyle if they are not properly inducted. Most of the expatriate workers, however, would be long-term residents in Oman and will be familiar with local customs and lifestyles. For new expatriate labour, it will be necessary to provide an induction course explaining the need to respect local customs and lifestyle.

5.5.10 Traffic, Transportation and Public Health and Safety

The potential causes for impacts on public health and safety include the storage and transport of hazardous substances, disposal of hazardous wastes, increased road traffic and large-scale employment of expatriate workers.

Traffic and Transportation

With the exception of fuel oils none of the substances used during construction pose any significant threat to public safety and health. Fuel oil will be transported in dedicated oil tankers driven by certified drivers. To minimise fire risk the fuel oil storage tanks will be provided with the necessary safety and leak containment facilities. No significant

hazardous wastes will be generated during construction and they will de disposed of to MRME&WR approved sites.

Large numbers of vehicle movements are to be expected during a construction project of this nature. The estimated numbers of vehicles to be used is shown in Table 3.2. Over the construction programme, a degree of adverse impact from traffic movements is unavoidable.

Dust from vehicle movements along unpaved roads may pose a public health risk to surrounding populations Dust can be irritating to skin, eyes and lungs, and would be especially irritating to those already suffering from respiratory problems. The traffic routing and access are the responsibility of the Contractor, in discussion with PDO. At this stage in the project lifecycle it cannot be defined exactly where the impacts would occur. It is not thought that an increase in dust and noise would be significant along public highways because of their current existing usage by HGVs.

The potential requirement of vehicle movements for sand could result in a significant impact. These vehicle movements will generally be on or near to the working strip. The severity of the impact is dependent upon the land use within the area. In the context of this project, these impacts are likely to be more concentrated between BVS 5 and Qalhat where the concentration of human habitation and land use is higher. There would be a large impact specifically within the Al Saleel Nature Reserve, where the ecology is fragile.

The indiscriminate use of 4WD vehicles by construction personnel in desert areas can potentially cause damage to the environment. Tracks can remain visible for years and can disrupt population patterns by trapping seed within the runnels.

Road traffic accidents are already a leading cause of death in Oman. The number of extra vehicles on the public road system could lead to an increase in safety risk. This is potentially significant in areas where there is already high usage of the road.

An indirect impact of the construction programme and the project development is the provision of new roadways into areas where access has previously been poor. The availability of a new access road within the RoW can present shortcuts to otherwise tortuous journeys for the general public. Over the general course of the route there is not the population density to regard this as a significant problem. However, along the section

between BVS 5 and BVS 10, the RoW could be used by the local population. Increasing traffic and people within the area will lead to increased erosion pressures on an already suffering landscape. This impact is reduced drastically when one takes into account the already existing RoW which, as mentioned in Chapter 4, is already used frequently by locals.

Public Health and Safety

Exposed trenches and borrow pits can be a hazard to local populations as there is a risk of people or their livestock falling into the trenches. Of greater potential impact is the possibility for these pits to fill with standing water and become breeding grounds for malaria carrying mosquitoes. During the IIA study it was found that The Department of Malaria Eradication reported increases in malaria cases associated with construction of the OLNG plant, and attributed the rise to the presence of workers who were carriers combined with the creation of mosquito breeding areas from construction activities.

Deployment of large-scale immigrant workers can pose public health risk from infectious diseases. Even though up to 70% of the construction work force constitutes expatriate workers, most of them will be long term (a few years) residents of Oman. Further, as per the Omani labour law, all immigrant workers will be medically screened for any infectious diseases. Therefore, the risk level should be very low.

Use of explosives may pose a public safety risk as there are quite a few settlements close to the pipeline.

On the field reconnaissance during the IIA, a burning waste dump was observed adjacent to the pipeline close to BVS 8. It should be noted that this is a source of ignition to both the existing and proposed pipeline.

Litter, food wastes and other solid wastes will be generated by the worker's camp. Improper disposal of such wastes can provide a breeding ground for rodents, flies and other disease vectors, as well as a visual and odor nuisance. Direct contact (of workers or local community members) with improperly managed wastes can lead to intestinal, skin and other infections.

5.6 Assessment of Impacts for Operational Phase

5.6.1 General

There are few environmental impacts that would arise from the operation of the gas pipeline. The following sections discuss these impacts.

5.6.2 Traffic

Operational maintenance will require inspection vehicles to drive along the RoW during pipeline inspection, but their journeys are not expected to contribute a significant number of vehicle movements over the course of the pipeline's life. However, there may be an increased use of the RoW by local populations, leading to the damage of the pipeline, possible injuries to users, and disturbance of wildlife in sensitive areas, such as Al Saleel Park.

5.6.3 Air Quality

There will be no impact on air quality associated with the operation of the pipeline except during minor venting at the pig launch and receiving stations. Such venting releases hydrocarbons and pyrophoric dust in small quantities that are unavoidable due to operational requirements.

5.6.4 Noise and Vibrations

Operational noise will be at a minimum because of a) the low operational noise of a pipeline; and b) it is buried under 1.5 m of backfill. Vibration effects from the operation of the pipeline are minimal and not regarded as an impact.

5.6.5 Ground Contamination

The nature of the pipeline project is such that once the pipe becomes operational almost all waste production will cease. The only impact may occur from pigging: the pipeline maintenance will involve infrequent pigging operations that result in production of sludge at the receiving station. The sludge is classed as hazardous waste and its handling and disposal could result in contamination of the ground and groundwater.

5.6.6 Fauna

The impact of the presence of the windrow as a hindrance or barrier to fauna continues throughout the commissioning of the pipeline. This impact is discussed in sections 5.5.7 and 5.5.9.

5.6.7 Gas Leaks

During normal operations, the pipeline should have no impact on community health or safety. Safety precautions and constant monitoring will help ensure that the pipeline operates normally. However, even with the best-engineered pipelines with routine safety checks, there remains a remote possibility of a gas leak, which could lead to explosion or fire. Such an even could result in injuries to workers and/or to individuals living in settlements close to the pipeline. Surveys and interviews with local health facilities during the IIA indicate that they have little capacity to deal with a large-scale emergency situation with relatively large number of casualties.

5.6.8 Socio-economic

The operation of the pipeline will provide cheap fuel to the developing industries around Sur and provide them with a competitive advantage in the merchandising of their products.

5.7 Assessment of Impacts for Decommissioning Phase

5.7.1 General

Few impacts are associated with this phase of the project, 25 years after the commissioning of the pipeline. The sections below describe these few impacts.

5.7.2 Air Quality

The decommissioning phase of this project will involve a small volume of gas being disposed of by venting or flaring at the nearest BVS. This is not considered to be a significant impact, as it will be short term and a small amount of gas will be used.

5.7.3 Water Quality

The pipeline will then be purged with inert gas, to ensure a non-combustible atmosphere before filling the redundant section with water or concrete mix. The source of this water may cause a negative impact on the groundwater environment should proper studies not be done at this stage. Permits should be obtained from the MRME&WR to ensure the water comes from a sustainable source.

5.7.4 Traffic

The above procedure will involve the use of vehicles along the RoW, the impacts of which are similar to sections 5.5.6 and 5.5.10 above, but will be significantly smaller as there will be much fewer vehicles associated with this phase.

5.8 Impacts of Alternative Routes

5.8.1 General

The following section presents the impacts of the alternative routes that would by pass Al Saleel Reserve (excluding the full loop option which has been discussed throughout the previous sections of this chapter). The details of these alternatives are presented in section 4.5.

5.8.2 Partial Loop with a Tie-in at BVS 9

This option would impact both flora and fauna within Al Saleel Park as BVS 9 lies 1 km into the Park. As discussed in section 4.5, however, the BVS facilities already exist at BVS 9 and little extension would have to be made. This would mean that little land take would be necessary given that the existing RoW is wide enough to accommodate an additional pipeline within the Park as mentioned in section 5.5.7.

5.8.3 New Tie-in Location

Instead of relieving the project of a significant negative impact arising from routing the pipeline through 1 km of the Park, when taking into account the increase in land take necessary for this new tie-in location, this action may in fact produce a higher risk

impact. Extension of the existing BVS 9 plot is recommended over and above establishment of a second plot in the same area at 1 km distance.

5.8.4 Bypass BVS 9 (Tie-in at BVS 10 or 11)

This alternative would also create the same impact as discussed in the above "new tie-in location" section which would include additional land take but to a larger extent bypassing the entire boundary of Al Saleel. There is already a RoW running through the Park along the existing 48" pipeline. This area was cleared of vegetation during the construction of the existing pipeline and so is already damaged (see Plate 4). It would be less of an impact to follow the existing route rather than re-route around the Park.

5.8.5 Preferred Option (Tie-in at BVS 9)

This EIA report considers that, in terms of overall impacts, the partial loop with a tie in at BVS 9 will cause the least impacts to the receiving environment, be economically feasible and fulfill the project objective. However, should the full loop option be chosen, and mitigations presented in Chapter 6 be implemented, given that a pipeline already exists within the sensitive area, the impacts are lessened considerably.

6 ENVIRONMENTAL MANAGEMENT PLAN: MITIGATION AND MONITORING

6.1 Introduction

PDO is committed to ensuring its operations have the minimum impact on the environment. Environmental protection measures can, however, only be successfully operated it they are set within a strong environmental management framework.

The potential impacts on the environment from the construction and operation of the proposed project are discussed in Chapter 5. In this chapter, the proposed environmental management plans for the mitigation and monitoring of all potential adverse impacts are presented. The proposed plans cover the construction, operational and decommissioning phases of the project.

6.2 Construction Phase

As already noted, PDO has developed a series of contractual obligations which should ensure that the construction activities are carried out with minimum environmental impact. However, notwithstanding these contractual obligations, it is sound practice to ensure that the contractor is adequately supervised during the course of the work by experienced personnel, to ensure that all appropriate environmental conditions are adhered to in practice. Efficient management of the construction process by PDO will be fundamental to ensuring the engineering and environmental control works are carried out to a satisfactory standard. The Contractor shall follow the Pipeline Construction Environmental Specification (PCES), HMR Consultants, June 2003 [Ref. 2]. This is discussed in section 6.2.13. The Contractor shall adhere to all Omani legislation applicable. Table 6.1 presented at the end of this chapter provides a summary of impacts, mitigations, and risks before and after mitigation is implemented during the construction phase.

6.2.1 Sourcing of Raw Materials

It is within the Contractor's remit to identify a suitable source of raw materials. Identified areas are noted below where the contractors should not be allowed to remove material from ecological, social or visual reasons. This should not hinder the contractor in undertaking his duties. There are suitable materials in sufficient quantities within the

general vicinity of the pipeline for the contractor to be able to satisfy his material requirements such as sand for padding.

Contractors should not be permitted to obtain material from the following sensitive areas:

- wadis
- within Al Saleel Nature Reserve
- within 500 m of any dwelling, settlement, farmland or archaeological feature

PDO's guidelines (SP-1012 [Ref. 21]) place restrictions on the winning of sand including a prohibition on the winning of material from wadis. The Contractor will need to establish suitable sources of material from locations and in a manner deemed not to be detrimental to the environment.

The Contractor should undertake consultation with the local walis to identify suitable resources of water for their (the contractors) use. Should such sources not be available locally, the contractors should source water from suitable areas outside. The Contractor should have an estimate of the demand for potable water during the construction period (including water demands for the temporary labour force), which will allow him to make arrangements for the provision of water in advance. Advance planning will reduce the likelihood of the contractor's demands exceeding the sustainable capacity of existing developed sources in remote areas.

6.2.2 Landscape Management

Borrow pits should be re-profiled at the end of the construction in accordance with PDO guidelines (SP-1012 [Ref. 21]). The Eastern Hajar Mountains after BVS 10 are both unique and scenic. There should be no steep cuttings taken from this area during construction. Cuttings should be of gradual gradients so as not to cause aesthetic damage to this area. The detailed design should also take into account the possibility of these cuttings being eroded during heavy rainfall.

It should be the policy of the contractor to remove all concrete foundations and other structures which do not disintegrate readily to prevent an aesthetic impact.

6.2.3 Flora and Fauna Management

Ecological impacts occur as a direct result of construction. The PDO Specification for Flora and Fauna Protection (SP-1011 [Ref. 20]) should be adhered to.

Flora

The working strip should be reduced to the minimum distance required to ensure cost effective and safe working conditions for the contractor in order to lessen the amount of vegetation removal. All vehicles should remain within the working strip. The working strip should be highlighted by a highly visible means to ensue that the construction workforce has no excuse for straying outside of the working strip. The working area demarcation should be removed at the end of construction works. After construction the disturbed land should be re-seeded with native species.

Fauna

Careful consideration to the siting and use of a windrow should be given. As mentioned in 5.5.7 and 5.5.9, the presence of barriers and windrows can have a detrimental impact to the movement of fauna. Although the windrow is useful in deterring local traffic movement across the wall of the pipeline, thought should be given during the detailed design to reducing the height of the windrow to make it acceptable to camel migration whilst deterring casual vehicle traffic. Another option that should be considered is increasing the number of gaps in the windrow from one every 2 km to at least one every 1 km within the sensitive area, which is from BVS 5 to BVS 10.

The Royal Oman Police (ROP) should be informed of any incidents where employees hunt animals. Personnel should be encouraged to report sightings of native animals to MRME&WR.

In the event that night working is approved by PDO, in order to reduce the potential impact of lighting it is suggested that cut-off lanterns are utilised. They reduce the amount of 'overspill' light and are less visible from a distance, whilst providing high intensity light for the working area.

6.2.4 Environmentally Sensitive Areas (ESAs)

The contractor should maintain a list of ESAs. Such sites shall be treated with special consideration as detailed in this section. The list shall include as a minimum the following areas:

a) Within 500 m of irrigated gardens and other cultivation;

b) Within 500 m of temporary and permanent settlements;

c) Within 500 m of sites of historical or cultural significance (e.g. Archaeological sites and mosques);

d) Within vegetated wadi areas and/or near open water, wells and aflaj;

e) Within 500 m of a water extraction Wellfield Protection Zone;

f) The route across Al Saleel Reserve.

Where wadis, roads or other areas identified as environmentally sensitive are disturbed, the contractor shall restore the ground to its original contour and condition. In settlement or landscape areas the remaining material excavated from the trench will be spread over the trench and RoW and graded to produce a smooth, low berm, not visually intrusive nor forming any significant barrier to wild animals and livestock movement.

The crossing of the aflaj discussed in section 4.3.4 should maintain the quality and quantity of the water at all times. The crossing of aflaj and any wells should be subject to consultation with the local walis and falaj wakil together with the Ministry of Agriculture and Fisheries and MRME&WR.

Route deviations by the EPC Contractor should be preceded by a survey to determine whether the deviation would impact upon ecological features. If this is the case the deviation should be accompanied by a further mitigation measure study to reduce the damage.

Archaeology

The archaeological site discussed in section 5.5.8 must be considered before construction begins. A letter of no objection must be obtained from the Ministry of Heritage and Culture before approval is given to begin construction work. The Ministry may consider these sites not to be significant and give permission to destroy them. These sites may also be moved elsewhere, although damage would still occur from the excavation. Should the Ministry refuse to grant permission for the removal or destruction of the tombs, these sites will need to be fenced to prevent damage. This should be undertaken in the presence of an official from the Ministry and the local Wali's office. This mitigation, however, should blasting be necessary in the area, may not be sufficient to prevent damage to the tombs and re-routing may be necessary. Should the partial loop option be chosen then this there would be no impact and the approval and mitigation would be deemed unnecessary.

Al Saleel Nature Reserve

Mitigation measures were discussed and agreements made at the meeting held between the DG of Nature Reserves and PDO on the matter of Al Saleel Park (see section 5.8.2). These are discussed below.

The pipeline will have to be installed with the utmost considerations for restoration of the existing habitat and all vegetation removed will have to be reinstated to MRME&WR's full satisfaction. This shall be incorporated in the scope of work for the EPC contractor and shall be supervised by both PDO and representatives of the Ministry. This would also be valid for the 1 km section of the route impacted should the partial loop option be decided upon.

It was also agreed that damage caused by the previous pipeline installation will be reinstated as appropriate after construction of the new proposed loop line inside the Al Saleel Park boundary. For any plantation in the Park that PDO shall carry out or reinstate, the Ministry will provide all the plants and irrigation water free of charge. PDO will carry out site preparation, plantation, and provide the irrigation system. This will be part of the specified scope of work for the EPC contractor.

In addition to the above requirements, no nighttime work should take place adjacent to or within Al Saleel Park. Care should be taken to minimize the soil disturbance and access

to the construction works should be defined to reduce the likelihood for wind erosion and damage to vegetation. Construction work in this area should not take place during the breeding or migration season for animals.

6.2.5 Air Quality Management

Measures should be undertaken to reduce the generation of dust during construction. The use of water to dampen down the dust along the whole route would be a waste of a scarce resource and the effects of damping down would be extremely limited when considering the climate. It is more advisable to limit the cause of the dust. PDO have guidelines that indirectly reduce the generation of dust such as the limiting of vehicle speeds on graded roads (SP-2000 [Ref. 24]). It is recommended that within 500 m of any settlement the contractor undertakes dust minimisation measures and that vehicle speeds are reduced to 50 km/hour. Within ESAs, however, such as Al Saleel Park and adjacent to settlement and towns, dampening the ground is deemed a necessary mitigation. This should be done using low-grade water and should not be from a source that will adversely affect local water supplies.

Ancillary activities such as the siting of construction camps, pipe storage yards and the location of borrow pits and quarries should be situated away from local settlements to minimise potential dust nuisance to local inhabitants.

All vehicles and plant should be maintained in a serviceable and efficient condition to reduce emissions.

6.2.6 Noise and Vibrations Management

Noise

A degree of noise disturbance is unavoidable on a construction project of this scale. It is important that the contractor is aware of his responsibilities to adhere to the MD 79/94 on noise limits and make every effort to reduce excessive noise generating activities during unsociable hours. Article 16 of MD 79/84 allows dispensation where noise levels are exceeded by stating that "if measurements prove that noise limits exceed the limits stipulated for the sources, place and time in the regulations, additional measures proposed by the Ministry shall be adhered to". The Contractor should undertake discussions with MRME&WR to determine the most appropriate mitigation measures. Construction

equipment should maintain efficient exhaust filters and silencers. PDO's specifications on "Environmental Noise and Vibration" (SP 1010 [Ref. 19]) should also be taken into account.

The Contractor should provide a Community Relations Officer (CRO) to liaise and inform local residents of the construction activities. This PRO should act as the focal point between local residents and the contractors, and between the contractors and MRME&WR. As mentioned in Article 16 of MD 79/94 (dispensation for excedance of noise levels) can be obtained through consultation with MRME&WR.

In areas where settlements are within 500 m of the construction activity the contractors should undertake to reduce the level of nuisance experienced by the local population. The principal mitigation measure should be to minimise the working hours to daylight hours only. PDO already maintain a no nighttime working policy. The local community should be informed by the contractors of the passage of the route in time to allow them to make alternative arrangements, if desirable. If the CRO identifies a problem through consultation with the local population it is suggested that the Contractors offer to screen the working corridor with boarding to reflect sound away from the settlement. Although this would be a visual intrusion such measures do reduce sound levels. Noise levels should be monitored throughout the construction phase to ensure that these mitigation measures are working.

The contractors should undertake a traffic management policy whereby construction traffic is prevented from accessing settlements. This could be part of the Contractors CEMP which should also specify measures to control and mitigate noise measures.

Vibrations

The terrain and the presence of hard rock means that blasting is the only alternative available to the contractors to excavate the trench for significant sections of the pipeline route. Stringent management procedures need to be in place during blasting to accentuate safety and to minimise risk. PDO's PCS-01 (SP-1208 [Ref. 14]) specifies the following conditions for vibration:

"a) All activities including but not limited to storage, transportation and blasting shall be carried out in accordance with the NFPA No 495, BS 5607,and the instructions

of the Authorities and/or the requirements in this section, whichever are the most stringent.

b) Areas to be blasted are to be categorised as follows:

- Where blasting is to be carried out at, or more than, 50 metres away from any existing pipelines or structures (either above or below ground) the Contractor shall submit his proposed blasting procedure and perform a trial blast for Company approval.

- Where blasting is to be carried out between 50 and 20 metres from any existing pipeline or structure (either above or below ground) the Contractor shall submit a procedure for controlled blasting, which shall also detail safety precautions to safeguard existing pipelines or structures (e.g. break holes, slit trenches, etc). This procedure is to be approved by Company prior to commencement and performing of a trial blast.

- No blasting is allowed within 20 metres of any existing pipeline or structure (either above or below ground).

c) Blasting shall be carried out prior to stringing the pipes.

d) Ground vibration due to blasting within 50m of existing structures shall be continuously monitored with certified instruments to be provided by the Contractor and approved by Company. Peak particle velocities near existing structures (e.g. pipelines running parallel) shall be kept to a minimum and must be approved by the Company as part of the Contractors proposed blast procedure. In no case shall the peak particle velocity exceed 10 mm/sec.

e) Blasting will not be permitted in any location where possible danger exists to the general public, property, existing utilities or other structures. In such locations other methods of extracting rock shall be proposed by the Contractor for approval by the Company. **"**

6.2.7 Wastewater Management

Water quality must be maintained during the construction period. The Contractor must adhere to the PDO guidelines on Waste Management (SP-1009 [Ref. 18]) and Chemical Management (SP-1194 [Ref. 23]).

There should be the prohibition of the use of aflaj by the Contractor for swimming and washing, especially using soap and detergents.

The siting of construction camps, pipe storage yards and other construction storage areas should not occur in areas liable to experience flooding. To prevent on-site contamination, fuel storage areas should be bunded (with an impermeable base). When the route is crossing wadis, contingency plans should be undertaken to reduce the likelihood of contamination should water levels rise. On-site storage of materials should be on high ground and out of the wadi channel.

The Contractor should undertake best practice procedures within 500 m of a wadi and within the wellfield protection zones. Best practice is taken to include but not be limited to the following:

- No re-fuelling within the area
- No storage of fuel or material used for construction within the area
- No ancillary development within the area including construction camps, pipe storage areas and mineral extraction
- Complete removal of all waste.

Hydrostatic Testing

The Permit to Discharge will have to be obtained from MRME&WR by the Contractor and the use of hydrostatic water should be minimised to the required amount only. It is further recommended that testing within Al Saleel Nature Reserve and the wellfields is undertaken in sections of minimal length of pipe but sufficient for engineering requirements. This will reduce the volume of water available to contaminate the surrounding area in the unlikely event of failure. Within these areas during the hydrotest there should be continuous inspection along the tested section. Should there be an accidental release of the hydrotest water to the surrounding environment, PDO's

"Accidental Releases to Land and Water" specifications (SP-1007 [Ref. 16]) should be followed.

The use of chemicals within the hydrotest water should be to the absolute minimum to reduce eventual potential impact associated with its disposal and possible contamination during operation. Where available, biodegradable chemicals should be used.

Disposal should be away from potable water sources. Consideration should be given to the location of the final section of the pipe to be tested and the final water disposal. Whichever option is used, MRME&WR must be consulted and, in turn, approve the eventual method.

The following options should be considered by the Contractor in addition to those identified within the Waste Management Specifications:

Evaporation in purpose built lagoons

Evaporation within a purpose built lagoon would require an impermeable liner. The hydrotest water used on the existing 48-inch line was evaporated from a purpose built lagoon which was lined with a 0.75 mm membrane. Remaining residue from the evaporation process should be disposed of at a landfill site appropriate to accommodate such material or left in-situ with the approval of MRME&WR. The activity along the route by the resident and temporary human population and their livestock would require that the evaporation pond is fenced to prevent livestock mortality. The lagoon should be fenced no matter where its location is. The evaporation pond should be sited away from any human or animal use, planned development, or ecological interest including Al Saleel. It is highlighted that such an evaporation pond would be designated as a waste site after its operation and would remain sterile for use afterwards.

Sale or disposal for use within other oil production facilities (e.g. production well water).

The production facilities near the route may be possible receptors for the water to use as (for example) production well water. It is not known whether scope exists within the current infrastructure to transfer the water from facility to facility but this requires further investigation.

Disposal at Wastewater Treatment Facilities

It is a possibility that PDO-run STPs may be used to dispose of the hydrotest water. This requires further investigation by the contractor.

Disposal to sea.

The MRME&WR would require the following before allowing disposal to sea.

ii) A permit to Discharge in accordance with Article 2 of "Regulations for the Discharge of Liquid Effluents to the Marine Environment" (MD 7/84);
iii) Prior treatment of the hydrotest water of re-oxygenation (to remove the oxygen scavenger);
iv) LC level one-tenth that of the original LC 50 values. LC 50 is the Lethal Concentration to 50% of organisms tested within laboratory experiments.

MRME&WR would also prefer the hydrotest water to be discharged at least 600 m from the coast on the surface of the sea to allow greater dilution of the effluent. This would increase construction costs because of the engineering difficulties associated with complying with this requirement.

The Contractor will also need to determine the depth of water and prevailing currents for marine disposal.

6.2.8 Solid Waste Management

The principal means of mitigating the impact of waste arisings and waste disposal is that of waste minimisation. The procedures in PDO's Waste Management Specifications (SP-1009 [Ref. 18]) should be strictly followed.

Sewage treatment facilities will need to be provided at the construction camps and spread working areas. Care should be undertaken in the siting of the camp and the location of the treatment facility that no watercourse is present in the vicinity. In camps of greater than 150 people a STP is required (MD 5/86). In camps with less than 150 people a mobile STP can be used if it is shown to be economically feasible, otherwise the material shall be tankered to the nearest disposal facility.

The nearest landfill sites to the construction camp should be identified. According to SP-1009, self-contained field operations domestic refuse is to be disposed of at a landfill site (if it is within 50 km) or to a waste pit (if no landfill site exists within 50 km). In the event of a waste pit being used it should be fenced to prevent hazards to animals.

Construction material, fuels and chemicals should be adequately stored in accordance with PDO' guidelines on Chemical Management (SP-1194 [Ref. 23]). As a minimum, material should be secured in bags, drums or other containers on an impervious base, surrounded by an impermeable bund.

6.2.9 Handling and Storage of Hazardous Substances

Chemicals and fuels should be stored according to the requirements of the Material Data Sheets (MSDS) and PDO Safe Handling of Chemicals (SHOC) cards to control the risk of contamination to the ground and groundwater. Details can be found in SP 1194.

An adequate bunded area (110%) for the diesel storage should be provided to control the risk of contamination to the ground and groundwater.

The contractor should prepare a Spill Contingency Plan which should cover emergency response to and clean up of spillages of hazardous or polluting materials including fuel, lubricants and chemicals. Site personnel should receive training in the operation of the plan. The contractor should include in the plan, specific procedures for minimizing water and chemical spillage should a leak occur during hydrotesting in ESAs.

6.2.10 Labour Camps

The location of the labour camps for the construction workers is not yet known. A peak labour requirement will be 1500 workers. The details of the labour camps are discussed in section 3.9. Living quarters will be constructed in accordance with industry norms and regulatory requirements, and will be maintained in good order throughout the period of construction. The heads of camp will be required to strictly comply with the Omani regulations, and handle the treatment and disposal of domestic wastes and sewage as per MRME&WR's regulations.

The heads of camps will be required to implement a good health and hygiene management program, consisting of the following:

- Proper sanitation and drainage facilities
- Routine pest control measures such as spraying of insecticides and pesticides
- Regular waste collection and proper storage
- Regular inspections for any health problems of workers
- Good house keeping practices

6.2.11 Traffic Management

Ensuring that vehicles remain within the working strip minimises the amount of desert driving. It is suggested that marker posts are installed, delineating the working strip. The contractor should maximise the amount of established road that he can utilise which, when combined with utilising the working strip, would further reduce the necessity for desert driving. It is important that vehicle movements are restricted to designated routes and that the contractor should be made aware that movement outside delineated fence posts is prohibited. The contractor should maintain all existing roads that he uses during the construction period.

PDO maintain as part of their overall HSE plan, a Transportation Standards Manual (SP 2000) that requires employees and contractors to undertake Journey Management Procedures. This encourages Best Practice (for transportation) to be followed and gives clear line responsibilities and an auditable trail.

To maintain safety and to reduce environmental impacts the Contractor's 'Traffic and Transport Management Plans' should indicate that it is mandatory for drivers to be accredited, establish maximum speed limits on different road surfaces, identify rest stops, and establish route plans that take environmental and safety points highlighted in this report, and in the PCES, into full account.

6.2.12 Socio-Economic Management

Public Health and Safety

As per Omani law, all employees should be medically screened for infectious diseases before brought to the construction site.

The Ministry of Health's (MOH) Department of Malaria Control and Eradication has a comprehensive program for controlling the spread of malaria in the Sultanate. The basic tenants of this program are vector control and prevention, early detection of the cases and treatment. PDO and its contractors have successfully collaborated with this department in the past in controlling the spread of malaria and PDO occupational health standards and general practice within work camps generally require vector control. Before construction of the pipeline begins, the contractor should be required to make contact with the Department of Malaria Control and Eradication.

Standing water at trenches and borrow pits should be kept covered. Random testing of employees for malaria, immediate treatment, reporting of malaria cases among camp employees and spraying vectors around the worksite should all be made mandatory. Both Omanis and non-Omanis receive free medical treatment for malaria by the MoH. By avoiding the spread of malaria within the camp and detecting malaria cases in their early stages, the contractor is also minimizing financial and (other) burden on the local health care system.

Compensation

Should the route pass through any permanent settlements adjacent to the existing route, compensation for impact to private property caused by the passage of the pipeline, its construction and its operation should be paid at an early stage within the project. The compensation should be fair and adequate and in accordance with government guidelines. In close proximity (close proximity is taken to be within 500 m) to settlements consideration should be given to reducing the working strip. This is not always feasible because of engineering constraints presented by the difficult terrain. To avoid negligence claims by the local population against the Contractor care should be taken to prevent livestock straying into the working area and endangering themselves and the workforce. It is suggested that this could be done either by fencing or by the employment of members of the local population to keep their stock away from the working area.

Nuisance

To reduce nuisance to the local population the hours of working should be confined to daylight hours (see section 3.9.5). There are a few mosques within close proximity to the pipeline route. Working within their proximity should not occur during prayer time.

Route deviations by the EPC Contractor should be preceded by a survey to determine whether the deviation would increase nuisance to the local population. If this is the case the deviation should be accompanied by a further mitigation measure to reduce the nuisance.

Mineral workings and ancillary developments (i.e. pipe storage yards, contractors camps) should not be sited within 500 m of settlements.

Care must be taken during construction to avoid power cables and to minimize hazard and power disruption when work must occur in the vicinity of the cables. Should power disruption be unavoidable, local populations should be aware of the inconvenience and CROs should ensure clear communication in order to manage the disruption as best as possible.

Livestock

Livestock gaps within the windrow should be frequent in number (as discussed in 6.2.3) across the route to allow movement of livestock.

Trenches should be fenced and should be left open for the shortest period possible to prevent livestock from injuries resulting from falling into exposed trenches.

A Community Relations Officer (CRO) should be employed either by the Government, PDO, or the Contractor to liaise with the local population in advance of, and during construction works. The CRO should be Arabic speaking and the position would allow the local communities to have someone they can address their grievances to. It is considered advantageous that the position is filled by someone with experience of the areas. Particular attention should be given to the movement of livestock during construction. If the local population is able to utilise grazing areas that do not require crossing the working strip, then this should be encouraged.

6.2.13 Pipeline Construction Environmental Specification (PCES)

It is important therefore that "best practice" is adhered to on site by all aspects of construction. To this end a Pipeline Construction Environmental Specification (PCES) has been written by HMR Consultants [Ref. 2]. The purpose of the PCES is to specify working methods and procedures in environmental terms in order to minimise the

environmental impact of the pipeline construction works. The PCES identifies key areas and the related impacts which may occur and specify working methods, measures and controls which the EPC contractor shall comply with. The contractor should prepare a Construction and Environmental Management Plan (CEMP) (see section 6.2.15) based on the EIA and PCES. An Environmental Site Manger (ESM) should be retained to manage, control audit and report to the Company the Contractor's environmental performance relating to areas identified within the PCES.

6.2.14 Environmental Screening

To minimise potential impacts to the environment and to ensure that the above recommended mitigation measures are implemented, specific studies should be undertaken by the detailed design engineers and the contractor prior to construction. These include:

- Detailed study of water supply during construction, identifying the available resources and quantifying these in terms of sustainable capacity, existing usage and expected future requirements for humans, flora and fauna. Programme to maintain water flow at aflaj;

- Detailed study of environmentally sustainable sources of water and sand padding material, considering the expected quantities required and transport requirements along the pipeline routes;

- Development of a detailed restoration and aftercare programme for vegetated and other environmentally sensitive areas outside wadis;

- Evaluation of the most appropriate locations for contractors' areas, including plant and materials yards and camps, in order to minimise noise and other disturbance to the local population. In addition, to select the most effective traffic routes for conveyance and construction vehicles; this will be carried out in conjunction with the appropriate local authorities;

- Traffic flow study of existing network along the pipeline route in order to determine the most efficient route for transporting contractor's equipment from site to site, and the most appropriate place to site access roads;

- Development of a community liaison programme including public consultation and information;

- Contact with central government and local authorities for all applicable consents/permits (see section 6.2.16 below);

- Development of procedures for environmental audit of the construction works to ensure compliance with both contractual obligations and relevant legislation.

6.2.15 Construction Environmental Management Plant (CEMP)

The purpose of the CEMP is to demonstrate how the Contractor will implement and manage each of the environmental requirements of the PCES and the other contract documents. The CEMP should define work methods and controls together with practical mitigation measures which the Contractor proposes to implement to minimize any adverse environmental impacts during construction, and the environmental monitoring and auditing requirements for the EPC element of the project. The CEMP should include, but not be limited to the following five main sections:

a) Water Management Plan

b) Waste Management Plan

c) Spill Contingency Plan

d) Noise and Vibration Management Plan

e) Spill Contingency Plan

f) Flora and Fauna Management Plan

g) Traffic Management Plan

The Contractor shall submit the CEMP to the Company for approval before commencement of construction mobilisation and transportation of the line pipe. The CEMP shall be continuously reviewed, and updated, as necessary, by the Contractor throughout the construction period to take account of on-site experience and experience

with the application of the CEMP requirements. At three monthly intervals, the Contractor shall carry out a formal review of the CEMP and revise it as necessary. Revisions in the updated CEMP shall be clearly identified together with any additions and the updated version submitted for approval by the Company.

6.2.16 Environmental Approvals and Permits

The contractor shall ensure that all necessary statutory approvals and permits are obtained from the responsible authorities. These shall include but not be limited to:

a) Approval of local Walis for construction compounds, laydown areas, borrow pits and access roads;

b) Permits from MRME&WR for water abstractions;

c) Permits from MRME&WR for wastewater discharges, sewage disposal, and sludge disposal;

d) Permits from MRME&WR for use of radioactive materials;

e) Permits from the ROP and MRME&WR for blasting and black top road crossings;

f) Permits from Ministry of Transport and Communication for highway crossings;

g) Permits from MRME&WR and Ministry of Agriculture and Fisheries for aflaj crossings;

h) Permits from Ministry of Transport and Communication for telecommunication crossings;

i) Permits from Ministry of Housing, Electricity and Water for power line crossings;

j) Letter of No Objection from the Ministry of Heritage and Culture for works affecting historical and/or cultural sites.

The Contractor shall identify in his CEMP all those approvals and permits which are required for his intended method of working for construction of the pipeline and shall include them in the Contract Scope of Work.

6.2.17 Environmental Monitoring Plan

The environmental monitoring programme shall include but shall not be limited to:

- Pre-construction surveys prior to the start of works to identify and record all sensitive features within the Working Strip and other areas of land to be used.

- The Environmental Site Manager (ESM) should make daily inspections of the Working Strip and weekly inspections of camps and yards ensuring the strict observance of the requirements of the CEMP by all personnel.

- The contractor should have in place a programme of environmental site audits of the construction activities to be conducted every two months. The audits shall cover all issues identified in the PCES. The contractor shall ensure that there are suitable procedures for the correction of non-conformances identified.

- A post-construction route survey should be carried out to ensure that all debris is removed from the working strip and the restoration is completed to a satisfactory standard.

- Complaints from surrounding populations should be recorded

- Noise levels should be monitored and the noise levels specified in MD 79/84 should not be exceeded within ESAs. These levels should be recorded and reported as stipulated in PDO's "Environmental Noise and Vibration" Specifications (SP-1010 [Ref. 19]).

- Malaria cases among employees should be monitored and reported to the MoH.

6.3 Operational Phase

Table 6.2 presented at the end of this chapter provides a summary of impacts, mitigations, and risks before and after mitigation is implemented during the operational phase.

6.3.1 Public Health and Safety

Right of Way

The RoW will be used for locals as access roads across the desert area. Clear signs need to be posted explaining the risk of this use to the users and the prohibition of its use to the public. The CRO can also explain the risks which may decrease the number of users, but is unlikely.

A study undertaken by Electrowatt for the existing pipeline (Electrowatt Engineering: LNG 48" Pipeline Right of Way Protection Study, 1998) suggested the removal of the entire RoW except for the windrow, and that the RoW is returned to its native pre-construction condition, i.e. all graded roads are removed. The "inspection corridor", rather than the "inspection road", would be maintained to allow safe passage of PDO 4WD vehicles for maintenance. It is doubtful whether this alone would reduce the demand for traffic movements because the windrow would still be used as a navigation aid.

Although the justification for abandoning the RoW as a traffic management consideration may not solve the problem of unregulated access, it has advantages from a landscape consideration. For this pipeline, however, abandonment of the RoW would not be worthwhile because the pipeline route is adjacent to existing RoW and so the impact has already taken place.

Gas Leak and Explosions

A quantitative risk assessment (QRA) should be conducted and the necessary mitigation measures implemented.

An emergency response plan with nearby health facilities should be undertaken and PDO should engage in regular emergency exercises with local hospitals in surrounding Wilayats.

The municipal waste dump discussed in section 3.3.8 needs to be moved away from the pipeline route. There is a high safety concern of the burning of waste adjacent to the pipeline as explosions may result. This concern was reported to the local MRME&WR office in Ibra and the matter should be followed up by PDO prior to the construction of the pipeline.

6.3.2 Al Saleel Nature Reserve

The section of RoW through Al Saleel Reserve should be deliberately made inconvenient in usability in order to reduce the number of locals driving through the area. Maintenance vehicles should maintain low speeds and take special care when conducting work and driving through Al Saleel Reserve.

6.3.3 Sludge Management

MRME&WR regulations and PDO specifications (SP-1009 [Ref. 18]) for sludge management should be adhered to.

6.4 Decommissioning Phase

The pipeline has a design life of 25 years and after this time would need to be decommissioned, although with inspection and maintenance it is possible that the pipeline could continue working for longer than 25 years. It is possible that the pipeline could be abandoned earlier because of excessive deterioration from corrosion or because a change in customer requirements could make it uneconomic. Prior to the time when gas transport is no longer possible, a complete abandonment (including decommissioning and restoration) plan should be developed and reviewed with relevant government authorities. An EIA of the decommissioning should be prepared which should include consideration of the Best Practicable Environmental Option (BPEO). From these studies and contacts will come an abandon-salvage plan for the entire pipeline.

Abandonment of the pipeline's Block Valve Stations will be undertaken in accordance with the international, national and company standards and guidelines in force at the time.

An estimated 12-month period is assumed for decommissioning the pipeline. The removal of the pipeline is likely to cause significant environmental damage associated with re-excavating the pipe trench and removal of the line pipe. In most areas it will therefore be more appropriate to remove only the above ground facilities and to restore ground profiles insofar as this is practicable and desirable.

The environmental objectives during this time will be to restore all project sites to as near pre-project condition as possible. Because of the slowness with which vegetation grows in some parts of the Sultanate, it may in fact be many years before recovery of some impacted areas is complete.

Table 6.1: Summary of Mitigations – Construction Phase

Impact Category	Impact	Phase during Construction when Impact might occur	Risk Prior to Mitigation	Mitigations	Risk after mitigation
Topography and landscape - Permanent	Steep cuttings (aesthetics)	• Excavation	High	• Use gentler slopes in sensitive locations	Medium
	Damage to ESAs	• Sand winning	Medium	• Ensure sand winning does not occur in sensitive areas	Near miss
	Obstruction to livestock movement	• Backfilling / construction of windrow	Medium	• Insert sufficient crossings at sufficient intervals in windrow	Near miss/ Low (depends on crossing intervals in windrow)
	Abandoned camp structures causing visual / aesthetic impact	• Abandonment of camp	Medium	• Landscaping to minimise visual impact • Ensure all concrete structures are removed from site • Ensure site is fully remediated after use	Near miss
Topography and landscape - temporary	Land take may cause displacement / adversely affect land use	• Camp construction / Storage facilities	Medium	• Clear communication between PDO, Walis and CROs • Compensation management	Low
	Power line disruption	• Route design	High	• Avoidance of power cables • CRO communication with local population	Low

Impact Category	Impact	Phase during Construction when Impact might occur	Risk Prior to Mitigation	Mitigations	Risk after mitigation
	Exposed trench / borrow pit causing human/animal injury	• Trenching • Sand winning	Low for human injury; Medium for animals	• No trench open for more than one week near highly populated area • Construction to be managed so that trenches are open for shortest period possible in populated areas • Fencing of all holes/trenches in populated areas however temporary	Near miss
	Exposed holes leading to spread of / breeding ground for malaria	• Trenching / borrow pits	Medium	• Cover all exposed trenches and borrow pits if water is present • Collaborate with MoH Department of Malaria Eradication on vector control • Monitor camp and community for increase in malaria cases	Near Miss
Archaeology	Damage to archaeological sites	• Excavation / blasting	High	• Fence sites • Ensure blasting is kept to a minimum in the sensitive area • Obtain letter of no objection from Ministry of Heritage and Culture • Ensure controlled blasting is used in sensitive area	Medium
Hydrology and hydrogeology	Obstruction or damage to wadi or falaj	• Excavation / trenching / camp construction	High for falaj; Low for wadi	• Ensure EPC contractor is aware of all aflaj and wadi crossings • Ensure pipeline is at minimum depth of 1.5 m at wadi crossings • Liaise with falaj wakils and MRME&WR to create an acceptable crossing, monitoring and restoration plan • Locate camps away from afalaj and wadis	Low for falaj Near miss for wadi

Impact Category	Impact	Phase during Construction when Impact might occur	Risk Prior to Mitigation	Mitigations	Risk after mitigation
	Depleted water resources	• Water extraction for use at camps, dust suppression and hydrostatic testing	High	• Do not take water from a community water supply • Plan water sourcing and usage with MRME&WR • Use RO plants where available • Minimise water usage through conservation measures • Use low grade water not from local community supply for dust suppression • CROs should inform communities that local water sources will not be used	Low
Ground contamination	Chemical spill/hazardous waste causing soil/ground-water contamination	• Chemical handling • Fuel storage	Medium	• Store chemicals according to MSDS/SHOC requirements • Place fuel storage tanks in bunded area • Follow PDO guidelines and MRME&WR regulations for storage and waste management • Monitor soil quality of storage area • Create and follow spill contingency plan	Low
	Wastewater causing groundwater contamination	• Hydrostatic testing	Medium	• Line and fence evaporation pond • Ensure disposal is not within ESA.	Low

Impact Category	Impact	Phase during Construction when Impact might occur	Risk Prior to Mitigation	Mitigations	Risk after mitigation
	Solid waste and sewage causing soil and groundwater contamination	• Camp operations	Medium	• Follow MRME&WR and PDO regulations for waste management • Collect sewage in septic tanks • Select safe disposal sites • Select disposal sites that avoid groundwater resources • Treat all sewage before disposal (use vacuum trucks to collect sewage and transport to licensed sewage treatment plant) • Locate camp away from afalaj and wadis • Ensure that litter is collected • Educate against littering to construction workers and community	Low
Air Quality	Dust and emissions causing health hazard and nuisance to local communities. Construction equipment/vehicle fumes	• Trenching • Excavation of sand for laying pipe • Backfilling / construction of windrow • Transportation	Medium	• Spray low grade water (not from drinking or community sources) to dampen dust potential • Inform residents of upcoming trenching two weeks in advance of work; describe potential for dust and ways to avoid exposure • Ensure vehicles maintain low speeds • Ensure vehicles and equipment are well-maintained and comply with emission standards • Locate camps and storage areas away from ESAs • Maintain efficient exhaust filters on equipment	Low

Impact Category	Impact	Phase during Construction when Impact might occur	Risk Prior to Mitigation	Mitigations	Risk after mitigation
	Radioactive materials may be hazardous to population and employees	• Non-destructive testing	Medium	• Ensure MRME&WR regulations and PDO specifications on control and management of radioactive materials are followed	Near miss
Noise	Disturbance to local communities and fauna	• Camp construction • Excavation (blasting, digging etc) • Backfilling / windrow construction	High for nuisance and wildlife	• Avoid nighttime construction work • Monitor decibel levels in nearby settlements • Time construction work not to take place during breeding/migration season for animals/birds, particularly in Al Saleel Nature Reserve • Site camps away from ESAs • Ensure equipment is well maintained • Avoid noise generation during prayer time	Medium
	Hazard to employees	• Throughout construction	High	• Use efficient silencers on equipment • Ensure all equipment is well maintained • Monitor noise levels periodically • Ensure MRME&WR noise regulations are adhered to • Ensure protective ear equipment is provided to and used by employees	Low
Vibration	Damage to archaeological sites, aflaj, wadis and buildings	• Excavation / Blasting	High for archaeology; Medium for afalaj; Low for	• Carry out structural survey of buildings/archaeological sites within 50m of pipeline prior to construction team arrival • Control vehicle movements by identifying access routes • Avoid unnecessary off-road driving	Medium for archaeology; Low for afalaj; Low for

Impact Category	Impact	Phase during Construction when Impact might occur	Risk Prior to Mitigation	Mitigations	Risk after mitigation
			buildings & houses	• Complete construction work to minimize disturbance to foundations and stability of ground near archaeological features • Offer fair compensation for damage • Ensure controlled blasting in sensitive areas	buildings & houses
Light	Disturbance to local communities and fauna	• Trenching	High	• No nighttime construction work • Should nighttime construction be allowed, it should not take place in ESAs, especially Al Saleel Nature Reserve	Medium
Flora	Vegetation cutting/clearing causing loss of habitat and fodder	• Widening of RoW • Creating access to construction activities • Camp/storage area construction	Low	• Locate camps away from ESAs. • Minimize widening of RoW within boundary of Al Saleel Nature Reserve • Minimize wind erosion and vegetation cutting when creating access to construction works	Near miss
Services/ Infrastructure	Traffic diversion	• Trenching • Camp Construction	High	• Use traffic management plan • Time construction traffic to avoid peak traffic hours • Clearly mark routes for both construction and public traffic • Keep diversion time to minimum	Medium

Impact Category	Impact	Phase during Construction when Impact might occur	Risk Prior to Mitigation	Mitigations	Risk after mitigation
	Reduced access (for communities) to existing RoW during construction	• Excavation • Trenching • Construction of windrow	Medium	• Post clear signs siting RoW is not to be used	Low
	Increase in HGVs and LGVs on road causing increase in traffic and possible RTAs	• Transportation of materials	High	• Use transportation management plan. • Avoid transporting materials during the most congested days and times of day • With consultation of local communities, use suitable alternate routes for project vehicles that avoid main roads where possible • No convoys • Maintain roads that HGVs/LGVs are using	Medium
Community relationships	Poor communication between PDO and community members	• Throughout construction phase	High	• Employ CROs from local populations along route • Clear lines of communication, awareness • Ensure community members are aware of possible noise and nuisance impacts and danger to livestock • Ensure complaints are investigated within 24 hours	Low

Impact Category	Impact	Phase during Construction when Impact might occur	Risk Prior to Mitigation	Mitigations	Risk after mitigation
	Impacts from interactions between workers and communities	• Camp operations	Low	• Educate workers on local culture and traditions • Screen workers for diseases	Near Miss
Impacts on Local Economy	Local employment	• Throughout	Medium	• Ensure that local people are employed wherever possible at all sections of the pipeline	Low

Table 6.2: Summary of Mitigations – Operational Phase

Impact Category	Impact	Phase during Operations when Impact might occur	Risk prior to Mitigation	Mitigations	Risk after mitigation
Traffic	Increased traffic along RoW causing damage to pipeline, safety hazard to users and disturbance to wildlife in Al Saleel	• Use of RoW as a Road • Maintenance of pipeline	Medium	• Clear signs to be posted explaining danger and disallowing driving along RoW • Ensure RoW is inconvenient in usability at Al Saleel Nature Reserve • Maintain low speeds when conducting maintenances within Al Saleel.	Low
Ground contamination	Sludge management	• Pigging	Medium	• Adhere to MRME&WR regulations for sludge management	Low
Community Safety	Gas leak	• Normal operations	Medium	• Conduct QRA and implement necessary mitigations • Use construction standards and maintenance procedures • Prepare emergency response plan with nearby health facilities • Engage in regular emergency exercises with local hospitals in surrounding Wilayats • Move municipal waste dump at Hawiyah away from pipeline. • Post clear signs to ensure RoW is not used for everyday traffic	Medium

7 CONCLUSION

7.1 Introduction

This short chapter provides the conclusion and a summary of the EIA report for the proposed 48" gas pipeline. Due to difference in their overall impact, the significant impacts for the two options (partial and full loop) are addressed separately.

7.2 Partial Loop

Should a partial loop be constructed from Saih Rawl to the existing BVS 9 there would be few impacts. These impacts are discussed in the following subsections.

7.2.1 Settlements

The major impacts involved with the partial loop option concern the settlements along the section of route passing from BVS 5 to BVS 9. There are both permanent and temporary settlements, although fewer permanent houses can be seen. The construction would mean temporary displacement of the Bedouin settlements. This is not seen as a significant impact as these populations tend to migrate and camps are easily moved away from the route. It should be plausible for the pipeline route to avoid permanent settlements, but it is economically unfeasible to move the route a suitable distance away in order that there be no impacts. Impacts will be of higher significance to these permanent settlements as the construction work would not only be a nuisance in terms of noise, but also a hazard in terms of vibrations and dust arising from the work. This may cause disruption to daily life.

There are public health and safety impacts that may arise from the construction of the pipeline, notably an increase in road traffic accidents and vectors for the spread of malaria.

Mitigations for these impacts are presented in Chapter 6. Should these be implemented, the risk of impact would be reduced significantly.

7.2.2 Livestock

The windrow from the existing pipeline may have already impacted the grazing locations of the livestock by presenting a barrier forcing them to graze on one side of the windrow. Evidence of this was not found during the site reconnaissance. Should the mitigations presented in Chapter 6 be implemented, the movement of livestock should not be affected by the windrow.

7.2.3 Infrastructure

Local infrastructure such as highways will be highly impacted should a transportation plan not be designed and put into practice. There is a possibility of an increased number of road traffic accidents and congestion due to the increase in vehicle numbers during the construction phase.

7.2.4 Water and Waste

Soil and groundwater contamination may occur from the disposal of hydrotest water should regulations not be followed by the EPC contractor. Water for hydrostatic testing, dust suppression and use in camps should be obtained from a sustainable source so as not to add to stress on local groundwater resources. Wadis and aflaj systems are extremely important between BVS 7 and the Eastern Hajar Mountains. Should the mitigations discussed in Chapter 6 not be implemented, significant impacts may occur. Regulations and PDO guidelines for sewage and waste disposal should be strictly followed.

7.2.5 Al Saleel Nature Reserve

BVS 9 lies within 1 km of the boundary of Al Saleel Nature Reserve. Alternatives avoiding the Reserve are presented in section 4.5 and their impacts discussed in section 5.8. Fewer impacts would arise from the route traveling through 1 km of the Reserve than from bypassing the Reserve. The partial loop is therefore, the preferred option.

7.3 Full Loop

Should the full loop be constructed from Saih Rawl to the OLNG Plant in Qalhat, there would be impacts in addition to those mentioned above in section 7.3.

7.3.1 Al Saleel Nature Reserve

If the full loop option were chosen it would result in the construction of the pipeline through the entire length of Al Saleel Nature Reserve. Should this occur the major impact would be to the fauna inhabiting the area in terms of disturbance through noise and vibrations. This impact can be mitigated as discussed in Chapter 6. However, even after these mitigations are implemented there is still a medium risk of the impacts occurring. Impacts to flora are not considered significant as vegetation clearing has already been carried out for the existing RoW, which passes along the same route through the Reserve. This RoW is considered wide enough to allow the construction of the proposed pipeline without any significant loss of vegetation. The EPC Contractor will, however, ensure full remediation of the area under the supervision of the MRME&WR.

7.3.2 Archaeology

Before the pipeline reaches the end of the Reserve, archaeological sites are present directly adjacent to the route. As an archaeologist was not present during the site reconnaissance of the IIA team it is unknown whether these sites are of high significance. It is assumed in this report, however, that any interference with archaeological features is deemed a high impact. Considering the topography of the area, these tombs, as discussed in section 5.5.8, will be damaged during the construction phase of the project due to blasting. Mitigations are presented in Chapter 6 but the risk remains medium. It is necessary to obtain a letter of no objection from the Ministry of Heritage and Culture allowing construction to go ahead in this area.

7.3.3 Settlements

Both temporary and permanent settlements can again be found once the Reserve has been passed through. Impacts on these populations are the same as those discussed in section 7.2.

7.4 Conclusion

Significant impacts arising from this project will mainly occur during the construction phase. The proposed route travels parallel and adjacent to the existing pipeline. Impacts, therefore, will be minimized significantly for both options. The partial loop option presents fewer impacts caused by the construction of the pipeline than does the full loop

option. Should the contractor operate with environmental consideration and best practice and follow the PCES designed as discussed in section 6.2.13 the impacts will be significantly reduced. The EIA study has not determined any impacts which are of such significance in either the partial or full loop option that would require re-routing the pipeline. The study has not revealed any insurmountable constraints to the project implementation.

The routing and operation of the pipeline, if carried out in accordance with the recommendations of this EIA report, is such that environmental degradation of the area will be minimized. Any adverse environmental impacts associated with the project should be considered against the substantial economic benefits the construction and operation of the pipeline will be bring the region and to the nation.

APPENDIX 1: ORGANIZATION RESPONSIBLE FOR PREPARATION OF REPORT

HMR Environmental Engineering Consultants, Oman are responsible for the environmental assessment of the 48" gas pipeline project by PDO and the preparation of this report. HMR is the leading environmental engineering consultancy in Oman. HMR specializes in the fields of environmental management, water resources management, environmental assessment, environmental auditing, environmental monitoring, pollution control and environmental training.

HMR has a large pool of environmental engineers and scientists, who have work experience throughout the world and the Arabian Gulf. HMR also has technical collaborations and associations with a number of international engineering consulting companies. HMR is registered with the World Bank as well as with the Ministry of Regional Municipalities and Environment, Sultanate of Oman.

The following are the members of the team responsible for the technical component of this report

Name of Project team Member	Work Component	Affiliation
Lamees Daar	Environmental analysis, environmental baseline, and assessment. Preparation of report.	HMR Consultants, Oman

On behalf of PDO, the following individuals are responsible for the review of the EIA report at all stages of the study.

1. Ahmed Sabahi, CSM/25
2. Shawqi Barwani, GGE/54

APPENDIX 2: TEMPERATURE DATA

The data below has been extracted from the Ministry of Transport and Communication, Department of Meteorology 'Annual Climate Summary' 2001.

Table A2.1: Air Temperature at Qarn Alam

Long-term Monthly Absolute Maximum Air Temperature (°C)													
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Extreme	Period
29.2	36.2	38.3	43.5	47.7	47.2	47.9	46.5	44.9	40.9	39.1	34.9	47.9	2000 - 2001
Long-term Monthly Absolute Minimum Temperature (°C)													
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Extreme	Period
7	7.1	11.1	15.7	20.5	23.8	23.8	22.4	21.1	17.5	14	10.3	9.4	2000 - 2001
Long-term Monthly Mean Air Temperature (°C)													
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Period
19.1	21.5	25.2	30.7	34.8	35.5	34	32.4	31.1	29.5	25.3	22.3	28.5	2000 - 2001

Table A2.2: Air Temperature at Ibra

Long-term Monthly Absolute Maximum Air Temperature (°C)													
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Extreme	Period
32	35.9	40.8	41.9	46.7	47.5	47.5	45.5	45.1	40.6	36.6	34.5	47.5	1998 - 2001
Long-term Monthly Absolute Minimum Temperature (°C)													
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Extreme	Period
8.3	8.5	12.3	17.1	22.4	23.5	23.5	21.5	20.9	16.7	11.9	9.6	9.4	1998 - 2001
Long-term Monthly Mean Air Temperature (°C)													
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Period
19.7	21.5	25.5	30.3	34.5	35.3	34.4	33	31.2	29.3	24.8	21.8	28.4	1998-2001

Table A2.3: Air Temperature at Sur

Long-term Monthly Absolute Maximum Air Temperature (°C)													
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Extreme	Period
35.1	37.6	42.1	44.3	48.3	49.8	48.2	47.5	46.5	43.4	39.0	34.7	49.8	1977-2001
Long-term Monthly Absolute Minimum Temperature (°C)													
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Extreme	Period
7.0	8.8	9.6	16.7	20.9	16.8	17.2	16.0	15.0	14.2	9.0	8.8	7.0	1977-2001
Long-term Monthly Mean Air Temperature (°C)													
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Period
21.9	22.9	25.6	30.1	33.9	34.8	33.7	31.9	31.3	29.5	25.6	23.1	28.7	1977-2001

APPENDIX 3: RAINFALL DATA

The following data has been extracted from the Ministry of Water Resources Surface Water Department 'Rainfall Data' December, 1994.

Table A3.1: Monthly Rainfall (mm) at Adam EK 573525 BF (UTM: 05532E; 24755N)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975-76										--	.0	38.0	**
1976-77	.0	.0	1.0	45.0	10.0	.0	4.0	15.0	4.5	.0	.0	.0	79.5
1977-78	.0	.0	.0	7.0	.0	.0	.0	8.0	3.5	30.5	**	--	**
1978-79	.0	.0	.0	.0	.0	.0	6.5	.0	5.5	14.0	5.0	.0	31.0
1979-80	.0	.0	10.0	2.0	.0	9.0	.0	.0	.0	12.0	.0	.0	33.0
1980-81	.0	.0	.0	.0	.0	3.0	2.0	.0	.0	.0	.0	.0	5.0
1981-82	.0	.0	.0	.0	82.5	3.0	7.0	25.0	.0	.0	.0	.0	117.5
1982-83	.0	.0	4.0	.0	30.0	23.0	122.0	.0	.0	.0	4.5	19.5	203.0
1983-84	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	40.0	.0	40.0
1984-85	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
1985-86	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	18.0	.0	40.0
1986-87	.0	.0	.0	.0	.0	117.0	.0	11.0	15.0	.0	.0	.0	143.0
1987-88	.0	.0	.0	.0	--	--	--	--	--	--	--	--	**
1988-89	--	--	--	--	--	--	--	--	--	--	--	--	--
1989-90	--	--	--	.0	65.5	.0	9.0	.4	.0	1.0	3.0	14.0	**
1990-91	.0	.0	.0	.0	1.0	.0	.0	.0	.0	1.0	.0	.0	2.0
1991-92	.0	3.0	.0	47.0	5.0	18.0	64.0	1.0	.0	8.0	12.0	.0	158.0

Table A3.2: Monthly Rainfall (mm) at Driz (FK 793843 AF) (UTM: 06734E; 24983N)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1973-74							**	.0	.0	.0	.0	.0	**
1974-75	.0	.0	.0	3.5	28.0	5.0	30.0	.0	.0	11.5	.0	--	**
1975-76		--	--	--	35.0	--	46.0	--	--	--	**	--	**
1976-77	.0	.0	12.0	49.0	**	--	17.0	2.5	8.0	2.0	.0	2.0	**
1977-78	.0	.0	.0	1.0	2.5	3.0	21.0	.0	12.0	32.0	17.0	.0	88.5
1978-79	.0	3.0	.0	4.0	.0	.0	15.0	.0	.0	17.0	1.0	20.0	60.0
1979-80	.0	.0	.0	1.0	.0	58.0	.0	1.5	3.0	20.5	.0	.0	84.0
1980-81	.0	.0	.0	4.0	.0	22.0	4.0	4.0	.0	.0	.0	.0	34.0
1981-82	.0	.0	.0	1.0	59.0	11.0	27.0	13.0	.0	.0	.0	.0	111.0
1982-83	14.0	.0	22.0	.0	14.5	5.0	46.0	5.0	.0	.0	26.0	2.0	134.5
1983-84	.0	.0	.0	.0	.0	9.0	.0	.0	.0	.0	2.0	3.5	14.5
1984-85	.0	.0	.0	.0	.0	9.5	.0	23.0	.0	1.5	4.5	.0	38.5
1985-86	.0	.0	.0	.0	36.0	12.0	6.0	.0	10.0	28.0	42.0	.0	134.0
1986-87	.0	.0	.0	.0	.0	79.0	23.5	1.0	.0	.0	10.0	.0	113.2
1987-88	.0	.0	3.0	.0	9.0	.0	10.0	.0	.0	35.5	7.0	1.0	65.5
1988-89	.0	--	.0	.0	15.8	22.0	.0	.0	.0	2.0	4.0	.0	43.8
1989-90	.0	--	17.0	4.5	78.0	.0	28.0	.0	5.0	8.0	7.0	.0	147.5
1990-91	.0	.0	.0	.0	.0	6.0	32.0	.0	.0	.0	1.5	2.5	42.0
1991-92	.0	.0	.0	36.0	13.0	44.0	36.0	.0	.0	8.0	.0	.0	137.0

--: Missing Data **: Incomplete Data

Table A3.2: Monthly Rainfall (mm) at Sur (GK 594466 AF)
(UTM: 07546E; 24946N)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1973-74				.0	--	8.5	5.5	10.0	1.0	3.0	.0	.0	**
1974-75	.5	.0	.0	20.0	57.0	25.0	25.8	.0	.0	.0	.0	.0	128.3
1975-76	.0	.0	.0	36.5	31.0	67.5	48.1	.0	.0	.0	.0	1.7	184.8
1976-77	.0	.0	9.0	17.1	33.0	.0	10.1	.0	30.1	.0	.7	.0	100.0
1977-78	.0	66.9	.0	34.6	.0	7.5	10.5	.0	12.0	19.3	.0	.0	150.8
1978-79	.0	35.6	.0	1.0	.0	.0	3.4	.0	6.8	.0	.0	.0	46.8
1979-80	.0	.0	5.3	.0	.0	2.4	.0	.0	.4	.0	.0	.0	8.1
1980-81	.0	.0	.2	45.9	.0	51.6	.0	2.0	.0	.0	.0	.0	99.7
1981-82	1.0	.0	.0	21.8	95.8	3.7	21.0	.0	.0	.0	.0	.0	143.3
1982-83	.0	3.2	29.9	.0	197.1	1.8	36.4	.0	.0	.0	19.1	.0	287.5
1983-84	.0	.0	.2	2.3	.0	1.4	.0	.0	.0	.0	.0	.0	3.9
1984-85	.0	.0	7.8	5.4	.0	2.2	.2	.0	.0	2.9	.0	.0	18.5
1985-86	.0	.0	.0	.0	35.7	1.9	5.0	.0	3.9	.0	37.6	.0	84.1
1986-87	.0	14.9	20.9	13.0	7.1	54.6	1.3	.0	22.1	.0	.0	.0	133.9
1987-88	10.7	.0	.9	.0	3.0	.0	1.3	.0	.0	18.9	.0	.0	34.8
1988-89	.0	2.0	4.9	.0	7.0	17.6	1.7	3.4	.0	.0	.0	.0	36.6
1989-90	.0	.0	36.9	18.3	104.6	.0	40.6	.0	.0	.0	.0	.0	200.4
1990-91	.0	.0	.0	.0	2.7	1.9	.0	.0	.0	.0	.0	.0	4.6

APPENDIX 4: DEMOGRAPHICS

The following data has been extracted from Ministry of Development 'Socio-economic Atlas', November 1996

Table A4.1: Demographics of Regions Through Which Pipeline Passes

Region	Wilayats	No. of Housing Units	Total Population			Wilayat through which pipeline passes	Tribal Groups of Wilayat which pass through pipeline	
			Male	Female	Total			
Al Wusta	Haima	399	1664	685	2349	Haima	Al Harasiis	Al Junaibi
	Muhut	1416	4068	3301	7369		Al Janaba	Al Jahafi
	Al Duqum	677	2021	1377	3398		Al Wahiba	
	Al Jazir	773	2579	928	3507			
Al Dakhiliya	Nizwa	9421	32836	25746	58582	Adam	Al Duru	Al Naabi
	Samail	6259	20271	18132	38403		Al Mahrooqi	
	Bahla	7869	24776	21343	46119		Al Shuaili	
	Al Hamra	2450	7517	6873	14390		Al Busaidi	
	Manah	1733	5593	5025	10618		Al Hinai	
	Izki	4741	16132	13704	29836		Al Abri	
	Bib bid	2635	9889	8137	18026		Al Rawahi	
Sharqiya	Sur	9250	29960	23421	53381	Al Mudhaibi	Al Harthy	Al Battashi
	Ibra	3998	11791	8195	19986	Al Qabil	Al Alawi	Al Hashar
	Bidiya	3932	8545	6591	15136	Bidiya	Al Mukhaini	Al Mujaini
	Al Qabil	3003	6596	5361	11957	Al Kamil and Al Wafi	Al Marjibi	Al Ghailani
	Al Mudhaibi	10134	27141	23999	51140	Sur	Al Habsi	Al Sinadi
	Dima wa at Taiyyin	2769	7569	6860	14429		Al Farsi	
	Al Kamil wa Al Wafi	3524	9394	7318	16712		Al Maskri	
	Jaalan Bani Bu Ali	9830	21710	18005	39715		Al Rasbi	
	Jaalan Bani Bu Hasan	4795	12026	9852	21878		Al Jahafi	
	Wadi Bani Khalid	1323	3219	2813	6032		Al Hashmi	
	Maseirah	1513	5158	3141	8299			

APPENDIX 5: UTM COORDINATES

The following table contains the UTM coordinates of sites of interest along the pipeline route.

Table A5.1: UTM Coordinates of Sites of Interest

UTM Coordinates	DESCRIPTION
E 452 065 N 2 351 249	Saih Rawl CPP
E 499 890 N 2 378 032	BVS 1
E 503 258 N 2 354 456	Crosses Qarm Alam – Adam Road
E 527 275 N 2 395 174	BVS 2
E 554 110 N 2 411 757	BVS 3
E 548 648 N 2 414 797	Settlement
E 580 471 N 2 428 323	BVS 4
E 568 292 N 2 411 578	Mosque
E 584 779 E 2 431 263	Houses 300m off route
E 601 902 N 2 450 271	Crosses Sanaw – Duqum/Salalah Road
E 603 616 N 2 443 000	Settlements 1km off route
E 607 960 N 2 445 880	BVS 5
E 607 998 N 2 474 200	Al Ayoun HC
E 615 000 N 2 452 000	Settlement 1km off route
E 616 284 N 2 451 000	Settlements
E 617 581 N 2 451 819	Settlements (both temporary and permanent)
E 618 314 N 2 452 269	Old camp
E 622 015 N 2 454 591	3 Settlements 300m off route
E 625 440	Many houses 2km off route

N 2 456 738	
E 628 507 N 2 458 651	Mosque and water well 100m off route (see Plate 3)
E 635 015 2 462 178	BVS 6
E 641 961 N 2 467 090	Small farm
E 651 413 N 2 452 826	BVS 7
E 652 771 N 2 454 130	Crosses Ibra – Sur Road
E 653 206 N 2 454 021	Crosses Al Zahib – Al Wasil Road
E 654 293 N 2 453 532	Crosses Ibra – Sur Road
E 665 246 N 2 481 687	Mosque 20m off route. Houses 200m away
E 670 860 N 2 491 261	Permanent houses 30m off route
E 672 249 N 2 492 097	Animal yards
E 673 634 N 2 491 660	Water filling station 30m off route
E 674 311 N 2 91 503	Falaj Al Asham
E 674 722 N 2 491 421	Farm 3km off route. Animal yard 20 m away
E 675 837 N 2 491 166	Falaj Al Daher
E 676 012 N 2 491 154	Falaj Al Akhdar
E 676 259 N 2 491 109	Falaj Al Aswad
E 677 418 N 2 490 946	Sandy and barren. Some dry shrubs. Farm 3km off route
E 677 486 N 2 490 920	Falaj Al Ghabbi
E 677632 N 2 490 943	Falaj Al Wasil
E 680 050 N 2 490 419	5 small houses 150m off route
E 680 445 N 2 490 233	Farms and 7-8 big houses. 300 m off route
E 681 619 N 2 489 672	New farm built by Ministry of Agriculture and Fisheries. Installation of new irrigation systems (new project). 30m off route

E 682 305 N 2 489 334	Falaj Hatuh
E 682 696 N 2 488 542	Very healthy farm. Palm trees, houses
E 683 385 N 2 488 835	Falaj Al Shariq
E 684 043 N 2 488 525	4 settlements. 200m off route
E 684 509 N 2 488 297	Camel race track crossing pipeline (see Plate 8)
E 686 362 N 2 487 423	BVS 8
E 688 691 N 2 486 305	Animal yard
E 694 990 N 2 483 258	Municipal Waste Dump (see Plate 9)
E 700 371 N 2 480 852	2-3 houses
E 701 413 N 2 452 826	Crosses Ibra - Sur Road
E 712 249 N 2 477 841	Al Kamil Power Station
E 713 000 N 2 478 500	Western Boundary of Al Saleel Nature Reserve
E 715 423 N 2 477 927	BVS 9
E 732 190 N 2 474 399	Archaeological Site: Tombs (See Plates 5 and 6)
E 733 000 N 2 477 500	Eastern Boundary of Al Saleel Nature Reserve
E 703 967 N 2 453 152	BVS 10
E 704 293 N 2 453 749	Crosses Ibra – Sur Road
E 704 782 N 2 454 021	Crosses Ibra – Sur Road
E 750 000 N 2 454 239	BVS 11
E 751 622 N 2 492 193	Sur Hospital
E 704 619 N 2 500 679	OLNG Plant

APPENDIX 6: PLATES (ALL PHOTOS TAKEN FROM EXISTING ROW)

Plate 1: *Acacia tortillas* observed along the pipeline route

Plate 2: *Washingtonia* observed adjacent to route

Plate 3: Small mosque and water well located 100m off the route between BVS 5 and 6

Plate 4: Facing Al Saleel Nature Reserve from the Eastern Boundary

Plate 5: Tombs located directly adjacent to the route just before the Eastern Boundary of Al Saleel Nature Reserve (the vehicle is parked on the existing RoW)

Plate 6: Tombs adjacent to RoW (same location as above). Photo taken from RoW

Plate 7: Camel pictured behind windrow between BVS 7 and 8

Plate 8: Camel racetrack crossing existing pipeline route between BVS 7 and 8. The vehicles are driving along RoW

Plate 9: Burning waste at the municipal waste dump in Hawiyah just between BVS 8 and 9

Plate 10: Abandoned farms in the wadis between the East Hajar Mountains

Plate 11: Bedouin settlements adjacent to the pipeline route north of the Wahiba Sands

Plate 12: Farm adjacent to RoW between BVS 7 and 8

Plate 13: Permanent Settlements adjacent to pipeline route

Plate 14: Falaj in the Wilayat of Bidiyah
(photo taken within town about 5 km from route)

APPENDIX 7: REFERENCES

1. Abt Associates Inc., TripleLine Consulting, HMR Consultants and PDO for PDO, *Integrated Impact Assessment of the Central Oman Gas Expansion Project*, March 2003

2. HMR Consultants, *48" Gas Pipeline Capacity Increase – Pipeline Construction Environmental Specification*, June 2003

3. HMR Consultants for Ministry of Water Resources, *Ibra Wellfield Protection Plan*, December 1998

4. HMR Consultants for Ministry of Water Resources, *Samail Wellfield Protection Plan*, March 1999

5. Ministry of Transport and Communication, Department of Meteorology, *Annual Climate Summary*, 2001

6. Ministry of Water Resources, Surface Water Department, *Rainfall Data*, December, 1994

7. Ministry of Development *Socio-economic Atlas*, November 1996

8. Ministry of Health, Directorate General of Planning, *Annual Health Report*, 2001

9. Ministry of Regional Municipalities, Environment and Water Resources, Directorate General of Environmental Affairs Pollution Control Department, *Wellfield Protection Zones*, 2001-2002

10. Mott MacDonald for MRME, *Master Plan for Groundwater Pollution Protection in the Sultanate of Oman Draft Final Report Vol.4b*, 1997

11. Mott MacDonald for MRME, *Master Plan for Groundwater Pollution Protection in the Sultanate of Oman Draft Final Report Vol.5,* 1997

12. Penspen International Ltd., *Upstream Facilities and Pipelines: EIA Study – Support to Form J*, March 1996

13. PDO, *Environmental Impact Assessment Guidelines* (GU-195), 1999

14. PDO, *Pipeline Construction Specification-01* (PCS-01/SP-1208), April 2001

15. PDO, *Environmental Specification: Emissions to Atmosphere* (SP-1005), July 2002

16. PDO, *Environmental Specification: Accidental Releases to Land and Water* (SP-1007), July 2002

17. PDO, *Environmental Specification: Use of Energy, Materials and Resources* (SP-1008), July 2002

18. PDO, *Environmental Specification: Waste Management* (SP-1009), July 2002

19. PDO, *Environmental Specification: Environmental Noise and Vibration* (SP-1010), July 2002

20. PDO, *Environmental Specification: Flora and Fauna* (SP-1011), July 2002

21. PDO, *Environmental Specification: Land Management* (SP-1012), July 2002

22. PDO, *Environmental Specification: Naturally Occurring Radioactive Materials* (SP-1170), July 2002

23. PDO, *Environmental Specification: Chemical Management* (SP-1194), July 2002

24. PDO, *Transportation Standards Manual* (SP-2000), December 2001

25. PDO, *Transport Operations Manual* (TOM/04/001), 1994/1996

26. WS Atkins, *LNG Upstream Studies: Preliminary Environmental Assessment Phase 11 (The Preferred Options)*, September 1993