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Special Economic Zone Authority Duqm

Design of Road Nos. 1 and 5 and Drainage Systems, Duqm

April 2017

EIA REPORT

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EIA REPORT

Project No: HMR #4077

Issue and Revision

Rev	Doc No.	Description	Issue	Date	HMR			PARSONS
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R0	4077 – EIA - 1	EIA Report	Draft	July 27, 2015	SR / GR	GR	RW	PARSONS
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EXECUTIVE SUMMARY

The Special Economic Zone Authority at Duqm (SEZAD) has commissioned Parsons International Limited (Parsons) for the "Design and Supervision of Road Nos. 1 and 5 and Drainage Systems (Contract C36/2015, the "Project")",as part of the road infrastructure works in the SEZAD area. The proposed Project intends to provide and improve access to the Duqm Port and the Liquid Jetty. Road No. 1 connects the National Road No. 32 (Duqm – Mahoot) with the Port Road No. 2 and enables easier access to the Duqm Port. Road No. 5 connects the Road No. 1 to the Liquid Jetty. The Liquid Jetty will serve the Duqm Refinery and several heavy/ petrochemical industries coming within the proposed heavy industrial zone in SEZAD. Also the Project involves development of service roads, ground improvement works, street lighting, drainage systems, associated culverts and other related structures.

As per the categorization of projects by the Ministry of Environment and Climate Affairs (MECA), the proposed Project would be categorised under 'Group 5: Service Projects'. Therefore, the Project will require an environmental impact assessment study (EIA) with detailed evaluation of the potential environmental impacts, identification of appropriate control measures to mitigate significant impacts, and preparation of a detailed management plan to obtain the Preliminary Environmental Permit (PEP) from SEZAD. In order to undertake this study as per the regulations, Parsons has commissioned HMR Environmental Engineering Consultants (HMR, the "sub-consultant") to carry out the environmental impact assessment study.

Environmental Laws and Regulations

The proposed road networks are falls under the SEZAD legislative jurisdiction. In accordance with RD 79/2013 - Article (16), SEZAD has been vested with powers to have the functions of the Ministry of Environment and Climate Affairs (MECA) in relation to issuing environmental permits for the projects in the SEZAD area and take necessary environmental measures. The current EIA study also refer to the "Guidelines on Environmental Impact Assessment" issued by Directorate General of Environmental Affairs (DGEA) at Ministry of Environment and Climate Affairs (MECA).

Project Overview

Road No. 1 is approximately 3.93 km in length and Road No. 5 is approximately 3.75 km in length. The right of way for both the roads is 200 m. They are being designed for a design speed of 80 kilometres per hour (kph) with a posted speed level of 60 kph. Road No. 1 is a 2x2 dual carriageway expandable to 6x6 lanes, while Road No. 5 is a 2x2 dual carriageway. Road No. 1 has been designed to accommodate extraordinary long vehicles called "Self Propelled Modular Transport" (SPMT) for transporting the refinery equipment from Duqm Port to Duqm Refinery. Provision is also being provided for future railway networks, bus service, and in this regard, approximately 40 m wide corridor adjacent to the outer shoulder is reserved for future road facilities including bus stops, taxi bays, and future pedestrian overpass as whenever this becomes a need. The utility corridor and drainage channel plan illustrate the infrastructure that will be developed as part of the Project which will comprise of the actual roads, utility corridor, and the drainage channel.

Environmental Baseline

The description of the environmental baseline based on the desktop assessment and review of the information available from previous studies has been carried out. The detailed baseline characterization of the ecology, hydrology, hydrogeology, geology, meteorology, air quality, and socio-economic data of the area is used to assess the significance of the Project environmental aspects and subsequently to reduce potentially significant environmental impacts such that this Project evolves into a more socially and environmentally sustainable project.

Environmental Releases

The releases during the construction phase will depend upon the type of construction activities, construction methods, construction equipment, materials used, source / amount of utilities and duration of site work, emissions from construction equipment and vehicle, movement of transport vehicles, dust generation from earthworks, sewage generated at site, waste chemicals generated at site, maintenance wastes, construction wastes, and metal, wooden and plastic scraps, etc. Accidental releases are possible from the spills / released of diesel, paints and spills or leaks of hydraulic fluid from construction equipment.

The releases during the operational phase will be limited to only vehicular movement, periodic maintenance of the roads and occasionally accidental oil / hazardous spills. Major noise during both phases will be from vehicular movement. The main noise sources during construction phase will be from construction equipment, diesel generators and during the operation phase will be from vehicular movement.

Climate Affairs

A detailed description of the impacts on climate affairs resulting from the project activities are discussed in Chapter 7 of this EIA. The section provides relevant details on the Ozone Depleting Substances (ODS), types of greenhouse gases resulting from project activities, Greenhouse Gas (GHG) Emissions, GHG emission estimations and control measures, climate change impact assessment, climate change adaptation and abatement, etc.

Environmental Impacts

The assessment of potential impacts was done using Impact Assessment Matrix method. The impacts are rated as 'low', 'medium' or 'high' depending on the severity of the impact and the likelihood of the impact. The impact ratings for the project construction and operation phases are presented in ***Table EI-1*** and ***Table EI-2***, respectively.

Table EI-1: Summary of the Construction Phase Environmental Impact Ratings

Receiving Environment	Severity	Likelihood	Impact
Natural resources	Major	Likely	Medium
Groundwater / Surface water resources	Major	Likely	Medium
Land	Major	Likely	Medium

Receiving Environment	Severity	Likelihood	Impact
Air quality	Major	Likely	Medium
Ambient noise	Minor	Certain	Low
Local infrastructure	Minor	Likely	Low
Public health and safety	Major	Likely	Medium
Cultural heritage	Major	Likely	Medium
Socio-economic	Minor	Likely	Low
Terrestrial/ marine ecology	Major	Likely	Medium

Table EI-2: Summary of Operation Phase Environmental Impact Ratings

Environmental Element	Severity	Likelihood	Impact
Air quality	Major	Certain	High
Ambient noise	Major	Certain	High
Ecology and wildlife	Localised	Very Likely	Medium
Climate	Localised	Very Likely	Medium
Water Resources	Major	Likely	Medium
Land	Major	Likely	Medium

Environmental Mitigation and Monitoring Plan

An Environmental Management Plan (EMP) is prepared for the construction phase and operational activities of the proposed project activities so as to reduce and maintain the environmental impacts below the As Low As Reasonably Practicable (ALARP) levels. A suitable environmental audit and monitoring program has been recommended, as a part of EMP, for the construction as well as operation phases of the project in order to mitigate impacts and to ensure compliance with Omani regulations. The proposed project activities are within the environmental regulatory compliance requirements and no significant negative environmental impact is anticipated. Details on control measures to be adopted for minimizing the above releases are provided in the Environmental Management Plan (EMP) as Chapter 9 of this EIA study.

Through this EIA submittal, Parsons seeks approval from the SEZAD on the overall project development.

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ABBREVIATIONS

AAQMS	Ambient Air Quality Monitoring Station
AASHTO	American Association of State Highway and Transportation Officials
ALARP	As Low As Reasonably Practicable
BAT	Best Available Technology
CAAQMS	Continuous Ambient Air Quality Monitoring Station
CEMP	Construction Environmental Management Plan
cm	centimetre
CO	Carbon Monoxide
COPS	Central Oman Paleolithic Survey
dB(A)	Decibels (A Rated)
DG	Diesel Generator
DGCA	Directorate General of Climate Affairs
DGEA	Directorate General of Environmental Affairs
DPTC	Duqm Petroleum Terminal Company
DRPIC	Duqm Refinery and Petroleum Industries Company
EHS	Environmental, Health, and Safety
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
EMS	Environmental Management System
EPC	Engineering, Procurement, and Construction
ESIA	Environmental and Social Impact Assessment
EU	European Union
FEP	Final Environmental Permit
GHG	Green House Gases
H_2S	Hydrogen sulphide
HC	hydrocarbons
HMR	HMR Environmental Engineering Consultants
IAM	Impact Assessment Matrix
IFC	International Finance Corporation
IPAS	Institute for Prehistory and Archaeological Science
IPCC	Intergovernmental Panel on Climate Change
ISLM	Integrated Sound Level Meter
ISO	International Standards Organization

IUCN	International Union for Conservation of Nature and Natural Resources
KPI	Kuwait Petroleum International
km	kilometre
km^2	Square Kilometres
kph	Kilometres per hour
m	Metre
m^2	Square metres
MD	Ministerial Decision
MECA	Ministry of Environment and Climate Affairs
mm	millimetres
MMD	Maximum dry density
MoCI	Ministry of Commerce and Industry
MPa	Megapascal
MRMEWR	Ministry of Rural Municipality, Environment, and Water Resources (this was split to MRMWR and MECA)
MRMWR	Ministry of Regional Municipalities and Water Resources
MSL	Mean Sea Level
MYA	Million years ago
NAAQS	US National Ambient Air Quality Standards
NO_X	Oxides of Nitrogen
O_3	Ozone
OAAQS	Oman Ambient Air Quality Standards
ODS	Ozone Depleting Substance
OESHCO	Oman Environmental Services Holding Company (be'ah)
OOC	Oman Oil Company
OS	Omani Standard
OSHA	Occupational Safety and Health Association
Parsons	Parsons International Company Limited
PEP	Preliminary Environmental Permit
PIA	Project Influence Area
PM	Particulate Matter
PM_{10}	Particles smaller than 10 mm in aerodynamic diameter
PPE	Personal Protective Equipment
ppm	Parts Per Million

RD	Royal Decree
ROP	Royal Oman Police
SCTP	Supreme Council of Town Planning
SEZAD	Special Economic Zone Authority Duqm
SO_2	Sulphur dioxide
SPMT	Self Propelled Modular Transport
SS	Suspended Solids
STP	Sewage Treatment Plant
SWIP	Duqm Sea Water Intake Project
UER	Umm Er Radhuma
UNFCCC	United Nations Framework Convention on Climate Change
USEPA	United States Environmental Protection Agency
VOC	Volatile Organic Compounds
WHO	World Health Organization
WWTP	Wastewater Treatment Plant

1 INTRODUCTION

1.1 Overview

The Special Economic Zone Authority at Duqm (SEZAD) has commissioned Parsons International Limited (Parsons) for the "Design and Supervision of Road Nos. 1 and 5 and Drainage Systems (Contract C36/2015, the "Project")". As part of the Prime Contract, Parsons has commissioned HMR Environmental Engineering Consultants (HMR, the "sub-consultant") to carry out the environmental impact assessment study (EIA).

The Project forms part of the road infrastructure works in the SEZAD area, and involves the design and construction of Road No. 1 and Road No. 5 and the associated drainage systems along these proposed roads.

Duqm is located approximately 600 km south of Muscat on the Arabian Sea coast, with the SEZAD area covering around 1,745 square kilometres with a 60 km long beach front. Various developmental works have been completed or are currently occurring including a sea port, fishing port, airport, logistics, industrial, tourism, commercial, and residential zones.

The Project involves development of:

- Road No. 1 (2x2 lane dual carriageway) from its intersection with National Road No. 32 (Duqm-Mahoot Road and goes towards Duqm Port upto Road 7, including common corridors for utilities, street lighting and drainage systems; The length of Road 1 within this scope is 3.93 km, with 1.5m inner and 3.0 m outer shoulder, 3.75 m lane width and 40.90 m wide median;
- Road No. 5 (2x2 lane dual carriageway) from its intersection with Road No. 1 and Road No. 6 to the proposed liquid berths at the seaside, including common corridors for utilities, street lighting and drainage systems; The length of Road No. 5 is 3.3 km, with 1.5m inner and 3.0 m outer shoulder, 3.75m lane width and 18.40 wide median;
- Road No.32 (existing National Duqm-Mahoot Road) is to be upgraded for 1.62 km to match with under construction road (by other contractors) on the south side and to match with existing road on north side. The current scope of works for Road No.32 includes LED decorative street lighting and drainage systems;
- Service Road (SR -01 and SR-02) starts from the project limit of construction near National Route Mahout – Duqm road and runs along Road No. 1 & Road No.5. This road will be utilized for transportation of solid product materials to liquid jetty. The length of the Service Road SR-01 is about 6.27 km and about 0.5 km for Service Road SR-02;
- Drainage systems along proposed Road Nos. 1, 5 and Service Road;
- Associated culverts and other related structures;
- Landscaping and Irrigation; and

- Ground improvement works for the construction of the roads and drainage structures.

The proposed Project road layout in Duqm is shown in ***Figure 1-1***. Road No. 5 ends in a liquid berth where a pipeline corridor also ends which is originating from the Duqm Refinery & Petrochemical Industries Company (Duqm Refinery), promoted by Oman Oil Company (OOC) and Kuwait Petroleum International (KPI). The liquid jetty will be operated by the Duqm Petroleum Terminal Company (DPTC) and will be utilised for importing crude oil and exporting refined products, with the material will be sent and received via a dedicated pipeline corridor from the refinery fence to the marine jetty battery limit.

As per the categorization of projects by the Ministry of Environment and Climate Affairs (MECA), the proposed Project would be categorised under '*Group 5: Service Projects*'. Therefore, the Project will require an EIA study with detailed evaluation of the potential environmental impacts, identification of appropriate control measures to mitigate significant impacts, and preparation of a detailed management plan to obtain the Preliminary Environmental Permit (PEP).

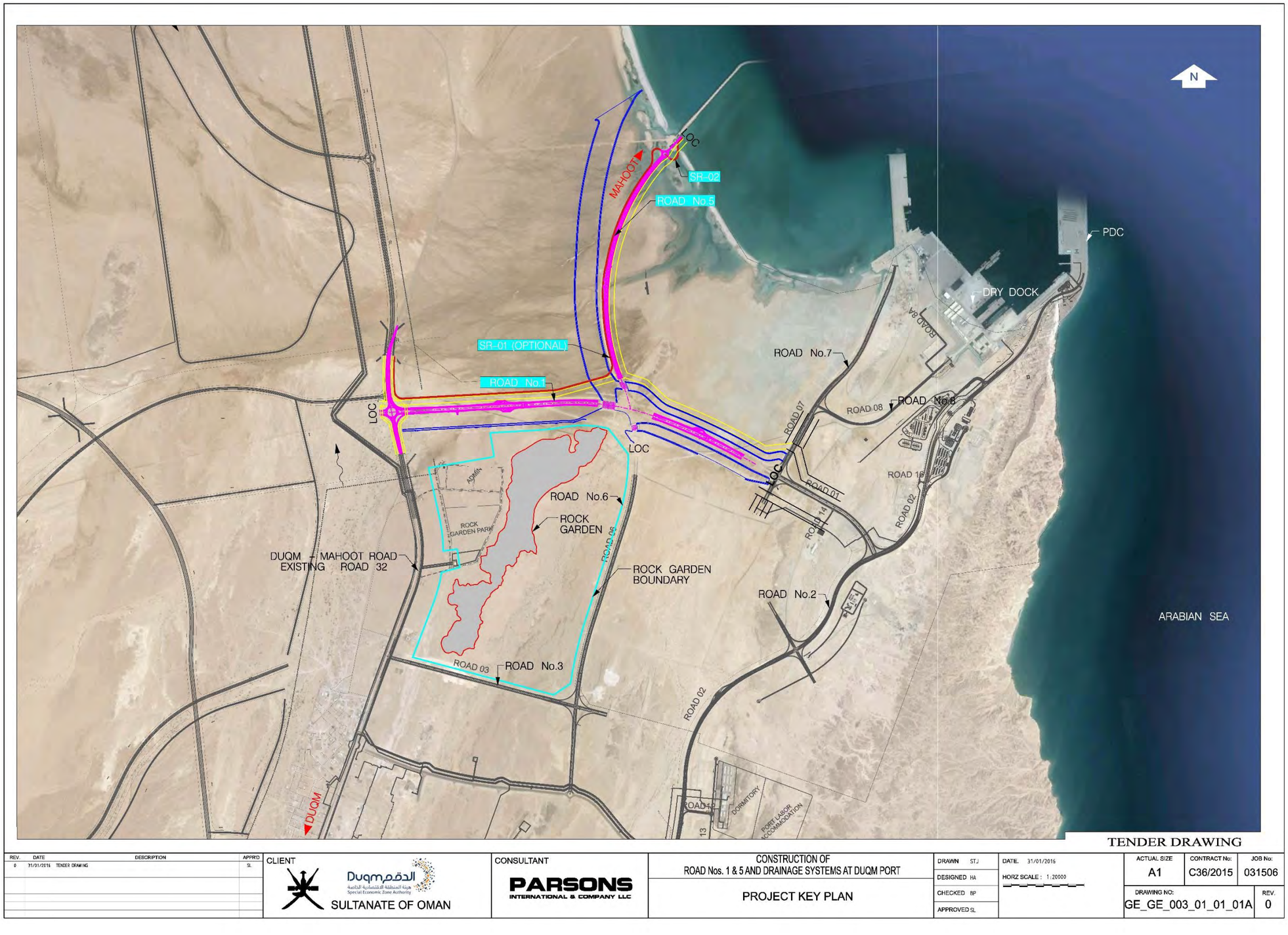


Figure 1-1: Location Map

1.2 Project Background

The Government of Oman is in the process of developing the Port of Duqm as a strategic dry dock, free trade zone, industrial area, and tourism destination.

The overall master plan for Duqm Town, which includes the town's own airport, was prepared by Oman's Supreme Council for Town Planning (SCTP) designating land / sites for various components of this ambitious project since 2007. As a result of the Royal Decree (RD) 119/2011 establishing SEZAD, the Port of Duqm becomes part of SEZAD and the planning vision of the Port will take into consideration the strategic development of Duqm as well. In accordance with RD 79/2013 - Article (16), SEZAD has been vested with powers to have the functions of the Ministry of Environment and Climate Affairs (MECA) in relation to issuing environmental permits for the projects in the SEZAD area and take necessary environmental measures.

As indicated above, to execute the Project, SEZAD has commissioned Parsons who will carry out the design, preparation of tender documents, and construction supervision of the construction work that will be executed by the construction contractor. Upon completion of the construction works, SEZAD will be responsible for the maintenance of the roads.

1.3 Need for the EIA Study

As per Omani regulations it is required to undertake an Environmental Impact Assessment (EIA) study to address the potential environmental impacts from the projects and to obtain Environmental Permits for the projects from the SEZAD. The EIA will identify and estimate the potential environmental impacts arising from the Project construction and operation. The Environment Management Plan (EMP), prepared as a part of the EIA, will propose appropriate measures to prevent and mitigate potential impacts and ensure compliance with applicable regulations.

Prior to embarking on the EIA study, traditionally a Scoping Report as per the requirement of the '*Guidelines for Obtaining Environmental Permits*' issued by MECA is prepared and submitted to the regulatory authority. In this case, the Scoping Report was submitted to the SEZAD environmental department on May 26, 2015 for which review comments were provided by the SEZAD environmental department on June 18, 2015. An updated Scoping Report addressing the comments was prepared and submitted on August 6, 2015 and the Project has received the EIA scoping approval from SEZAD on September 27, 2015. However, this project was on hold due to technical issues and Oman National Railway alignments that crossing the road corridor. According to Ministry of Transport and Communications this railway project has been delayed and targeting to start construction on its national rail network sometime in 2018. This rail network will connect the country's minerals, oil and gas sector with port cities Duqm and Salalah. Since the project has commenced HMR prepared the final EIA with addressing the comments in the EIA scoping approval.

The EIA has been carried out in accordance with the '*Guidelines on Environmental Impact Assessment*' issued by the Director General of Environment Affairs (DGEA) at MECA (Appendix B of the 'Guidelines for Obtaining Environmental Permits').

The Project information was provided by Parsons and was taken from the Concept Design Report (Parsons, 2015). This information was reviewed to conduct the detailed environmental analysis of the Project. Based on the review of the Project information, the applicable environmental regulatory requirements for the Project were identified.

Further, the secondary data on the environmental baseline of the Project area has been collated from published information and from relevant previous studies for the area. Parsons had also commissioned Swissboring to undertake geotechnical investigation in the Project area to assess general ground conditions at the Project site. The results and findings of the geotechnical investigations is incorporated in Chapter 4 – Environmental Baseline.

1.4 Objectives of this Report

The overall objective of this EIA is to identify and evaluate significant impacts on the environment due to the road construction activities in order appropriate control and management plans can be developed to mitigate potential adverse impacts. This process will ensure the Project complies with applicable Omani environmental regulations and provide the necessary information and documentation to obtain PEP from the SEZAD.

As indicated previously, this EIA has been prepared in accordance with Omani regulatory requirements, as specified in the '*Guideline on Environmental Impact Assessment*' issued by the DGEA in MECA. In addition, MECA's recently promulgated guidelines on the '*Information on Climate Affairs to be provided in the EIA study submitted to the Ministry*' has also been adopted and followed.

The scope of this EIA includes the following:

- Highlight the environmental legislation and standards pertinent to the Project activities;
- Desktop reviews for assessing the current status of the environment and socio-economic profile of the Project area to understand the baseline conditions;
- Appreciation of the baseline conditions thereby to evaluate the impacts of the proposed Project development;
- Identification and assessment of potential environmental and social impacts of the Project including the impacts on climate change, primarily during the construction stage, and determination of significant impacts of the Project;
- Environmental review of the Project for characterization and quantification of wastes generated, greenhouse gas (GHG) emissions, ozone depleting substances (ODS) used, and energy requirements;
- Environmental analysis of alternatives for the Project location, project design, and approaches associated with the Project development; Recommend suitable environmental and social management plans including mitigation measures and monitoring programs; and
- Preparation of the EIA report for review by the regulator to obtain the PEP.

1.5 EIA Approach and Methodology

The overall EIA methodology was based on the guidelines from MECA. The EIA study involved the following tasks and activities:

- Obtaining and reviewing the Project data;
- Coordinating with Parsons for discussions on environmental management requirements;
- Collating the environmental baseline data (secondary data) for the Project based on published information and other available data from HMR archives;
- Characterization and quantification of various environmental releases (waste streams) generated from the Project during construction and operation phases, including the review of proposed control measures for the management of such waste streams;
- Analysis of alternatives considered for the Project;
- Identification and assessment of potential environmental impacts from the proposed Project, primarily during the construction and operation phases;
- Determination of GHG emissions, use of ODS, if any, climate change adaptability of the project, energy conservation measures, etc.;
- Developing an Environmental Management Plan (EMP), including mitigation measures and monitoring plan; and
- Preparation of the EIA Report and submission to SEZAD environmental department for review.

The scope of work also involves addressing clarifications raised by the SEZAD environmental department on the EIA report.

1.6 Project Proponent and EIA Consultant

As indicated above, Parsons has been commissioned by SEZAD for the "Design and Supervision of Road Nos. 1 and 5 and Drainage Systems", and accordingly is the Project Proponent. HMR is the EIA Consultant.

The contact details are presented below:

PROJECT PROPONENT	EIA CONSULTANT
Parsons International Limited	HMR Environmental Engineering Consultants
P.O. Box 1151, P.C. 133, Al Khuwair Muscat, Sultanate of Oman Tel.: 24390707; Fax: 24482890 Contact: Mr Ravi Kumar Rajgariha Project Manager Email: ravi.rajgariha@parsons.com	P.O. Box 1295, Postal Code 111, CPO Seeb, Sultanate of Oman Tel: 2461 8800; Fax: 2461 8811 Contact: Mr. Madhupal Puliampillil Project Manager Email: madhupal@hmrenv.com

1.7 Structure of this Report

This EIA report is divided into ten chapters as following:

- **Chapter 1: Introduction** - Introduces the project overview and background of the proposed development. It states the objectives of the study, scope of work and the methodology of the EIA study.
- **Chapter 2: Regulatory Framework** - Addresses applicable environmental regulations and standards provided in various Royal Decrees (RD) and Ministerial Decisions (MD) of the Sultanate of Oman. It also discusses relevant international best practices and highlights relevant international and regional treaties as applicable to the Project.
- **Chapter 3: Project Description** - Describes the road alignment, various features entailed in the project and associated infrastructure, construction methods, utilities, manpower requirements and the tentative project schedule.
- **Chapter 4: Environmental Baseline** – Provides the description of existing environmental baseline conditions along the route alignment based on secondary data analysis.
- **Chapter 5: Environmental Releases** – Describes various releases to the environment (gaseous, liquid, solid, and noise), waste generation, collection, treatment and disposal methods during the Project.
- **Chapter 6: Analysis of Alternatives** – Reviews the need for the project and the available alternative options from environmental stand point.

- **Chapter 7: Climate Affairs** - Presents the estimate of emissions of greenhouse gases (GHG) and ozone-depleting substances (ODS) from the Project construction and operation.
- **Chapter 8: Assessment of Impacts** – Identifies and assesses the significance of environmental impacts in view of the existing environmental setting and the identified sensitivities for the Project.
- **Chapter 9: Environmental Management Plan** – Proposes mitigation measures and framework management plans along with the monitoring and reporting plans/schedules.
- **Chapter 10: Conclusions** - Presents the critical issues and summary of impact assessment study as a conclusion to this report.
- **Appendices:** Supporting information included in the report providing further details as applicable.

In addition, there is also an Executive Summary incorporated to provide a concise view of the Project, the impacts, and the Environmental Management Plan (EMP).

2 ENVIRONMENTAL REGULATORY FRAMEWORK

2.1 Overview

The Omani legislative framework has two main legal instruments -Royal Decrees (RDs) and Ministerial Decisions (MDs). Typically, a RD provides a general framework relating to a particular area in need of statutory control and is comparable to a law; while MDs provide specific guideline using the framework provided in the RD akin to a regulation.

To identify and assess the impacts resulting from a project, a number of environmental regulatory requirements and guidelines are required to be taken into consideration. The term "environmental" is therefore used in the broadest context and includes standard biophysical components of the environment and also encapsulates social issues related to the general population.

2.2 SEZAD Legislation

The Special Economic Zone Authority at Duqm (SEZAD) is the subject of the Royal Decrees and Decisions listed below:

- *RD 119/2011: Establishing Duqm Special Economic Zone Authority and issuing its regulations;*
- *RD 79/2013: Issuing the regulation of the Special Economic Zone at Duqm;*
- *RD 44/2014: lifting the capacity of a public utility from some of the schemes within the scheme of the Special Economic Zone Authority at Duqm*, as well as amending the location and boundaries of the Special Economic Zone in accordance with the diagram attached to the Decree;
- *Decision No. 322/2015: Issuing the Regulation organizing the urban planning and building permits at the Special Economic Zone at Duqm*; and
- *Decision No. 323/2015: Issuing the Regulation organizing the Investment Environment at the Special Economic Zone at Duqm*.

With the enactment of the Royal Decree (RD) 119/2011 establishing SEZAD legislative jurisdiction and legal responsibility for this area, SEZAD are charged with overseeing the planning vision and strategic development of Duqm.

2.3 Jurisdictional Authority

In Oman the responsibility for implementation of the environmental legislative framework and laws resides with MECA, which issue regulations, standards, and guidelines through MDs. Within MECA,

the authority responsible for environmental permitting, inspection and control in the Sultanate is the DGEA. MECA has also established the Directorate General of Climate Affairs (DGCA), which is the authority to assess the potential aspects relating to climate change.

As explained previously, SEZAD is the jurisdictional authority for this Project as the roads are all located within the Special Economic Zone at Duqm, and accordingly, the SEZAD environmental department handles the responsibilities that usually sit with MECA.

2.4 Oman Environmental Legislation

The Omani laws on environmental protection, control, and management are covered under two basic laws, viz., the "*Law for the Conservation of the Environment and the Prevention of Pollution*" promulgated in November 2001 as RD 114/2001 (superseding RD 10/82 and its amendments) and the "*Law on Protection of Potable Water Sources from Pollution*" promulgated as RD 115/2001. These laws provide the framework for all other laws and regulations concerning environmental conservation and water resources protection.

In addition to the above, the requirements contained in other applicable RDs and MDs were reviewed during the EIA, and potential environmental impacts from the Project were assessed taking into account the requirements of such regulations.

The Omani environmental laws and regulations applicable to the development, operation, and maintenance activities of the proposed Duqm Road Nos. 1 and 5 Project are listed below in ***Table 2-1.***

Table 2-1: Applicable Environmental Law and Regulations

Reference No:	Description	Applicability to Project Activity
Royal Decrees (Environmental Law)		
RD 114/2001	Law for Conservation of the Environment and Prevention of Pollution	Guiding law on pollution prevention and natural resource conservation
RD 115/2001	Law on Protection of Sources of Potable Water from Pollution	Guiding law on preventing pollution of ground water resources
RD 6/2003	Law on Nature Reserves and Wildlife Conservation	Guiding law on protecting wildlife and habitat in the vicinity of the Project site
RD 29/2000	Issuing the Law of Water Resources Conservation	Guiding law on sustainable use of water resource
RD 73/1998	Law approving the Ratification by Sultanate of Oman to Vienna Convention for the Protection of Ozone Layer; and Montreal Protocol concerning Ozone Depleting Substances	Guiding law for the protection of ozone layer and control and management of Ozone Depleting Substances
RD 46/95	Law on handling and use of chemicals	Use of hazardous chemicals during the construction phase
RD 6/80	Law of Protection of the National Heritage	Protection and conservation of cultural or heritage sites in the Project area
RD 46/95	Law of handling and use of chemicals	Raw materials, chemicals, and fuel storage, handling, and transport
Ministerial Decisions (Environmental Regulations)		
MD 20/90	Regulations on Coastal Setbacks	Regulations on protection of coastal zones and areas
MD 145/93	Regulations for wastewater reuse and discharge	Prohibits discharge of untreated wastewater to the environment and regulates wastewater treatment
MD 18/93	Regulations for the management of hazardous wastes	Handling, storage and disposal of hazardous wastes generated from Project activities
MD 17/93	Regulations for the management of the solid non-hazardous wastes	Handling, storage and disposal of non-hazardous wastes from Project activities
MD 79/94	Regulations for noise pollution in public environment	Public noise control during the construction activities
MD 80/94	Regulations for noise pollution in the working environment	Workplace noise control during the construction activities

Reference No:	Description	Applicability to Project Activity
MD 248/97	Issuing the regulation for registration of hazardous chemical substances and the relevant permits	Chemicals management during construction phase and registration of chemicals used
MD 421/98	Regulations for Septic Tanks, Soak away Pits and Holding Tanks	Regulates construction of holding tanks, septic tanks and soak away pits during the construction phase
MD 169/2000	Regulations on cutting of trees	Regulation on protection of trees within the Project influence area
MD 200/2000	Regulations for Crushers, Quarries and Transport of Sand from Coasts, Beaches and Wadis	Regulates the use of crushers and quarries at Wadis
MD 264/2000	Regulations for water abstraction from bore wells	Construction of bore well to abstract water for commercial project purposes
MD 317/2001	Regulations for packaging and binding conditions / stipulations and putting information and labels on the hazardous chemical substances	Hazardous chemicals management during construction phase of the Project
MD 187/2001	Regulations for organizing obtaining environmental approvals and final environmental permit	Obtaining PEP and final environmental permit
MD 101/2002	Prohibition of killing, hunting, or capturing of wild animals and birds	Regulation on protection of wildlife
MD 281/2003	Regulations for control and management of radioactive substances	Management of radioactive substances if nuclear densometers are used for assessing the compaction levels
MD 118/2004	Regulations on controlling air pollutants emanating from stationary sources	Regulates installation and operation of stationary combustion sources during Construction phase
MD 159/2005	Regulations for the discharge of liquid effluents into the marine environment	Any accidental discharge into the seawater
MD 243/2005	Regulations for the control and management of Ozone Depleting Substances (ODS)	Prohibits the use of Ozone Depleting Substances
MD 286/2008	Regulations for Occupational Health and Industrial Safety Precautions	Occupational health and safety of employees
OS 8/2012	Omani Standard for drinking water (Issued by the Directorate General of Specializations and Measures and MoCI)	Potable groundwater quality standards

Reference No:	Description	Applicability to Project Activity
Omani (Provisional) Ambient Air Quality Standards (OAAQS)	Provisional Omani standards for ambient air quality	Ambient air quality in the Project area
Climate Affairs Guidelines	Guidelines on estimation and reporting of greenhouse gases (GHG) and ODS from project construction and operation phases, outlines the information to be provided towards evaluation of the influence of project activities on climate change, discusses impacts of climate change on projects, and the climate change adaptation and mitigation measures implemented by projects.	Estimation, reporting and control of GHG, ODS, energy consumption, etc., during construction phase. Statement of mitigation measures for reducing influence of climate change and minimizing vulnerability of the Project area to consequences of climate change

As part of the environmental design philosophy, the Project will be designed to ensure compliance with all applicable laws, environmental standards and guidelines, as well as construction and operation requirements.

2.5 Regional and International Conventions and Protocols

Several RDs concerning conventions and protocols to which Oman has acceded have been issued so that these are considered during development of new projects in the country.

The conventions and protocols relevant to the proposed Project are presented in ***Table 2-2.***

Table 2-2: International Conventions and Protocols

#	Convention	Description
1	Basel Convention on the control of trans-boundary movements of hazardous wastes and their disposal (1989)	To reduce the movements of hazardous waste between nations and specifically to prevent transfer of hazardous waste from developed to less developed countries.
2	United Nations framework convention on climate change (1994)	Related to controlling and stabilizing greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.
3	Convention on Biological Diversity (1992)	Concerned with conservation of biological diversity, Sustainable use of its components and fair and

#	Convention	Description
		equitable sharing of benefits arising from genetic resources.
4	Vienna Convention on the protection of the ozone layer (1985)	Acts as a framework for the international efforts to protect the ozone layer.
5	Montreal Protocol on substances that deplete the ozone layer (1987)	Is a protocol to the Vienna Convention for the Protection of the Ozone Layer designed to protect the ozone layer by phasing out the production of numerous substances believed to be responsible for ozone depletion.
6	United Nations Framework Convention on Climate Change (UNFCCC) (1992) including Kyoto Protocol (2005)	An international agreement on the reduction of greenhouse gas emissions and on mechanisms aimed at providing monetary and technology benefits for reducing emissions, in order to address possible changes in the climate.
7	Rotterdam Convention on the prior informed consent procedure for certain hazardous chemicals and pesticides in international trade (2004)	It is a multilateral treaty to promote shared responsibilities in relation to importation of hazardous chemicals. The convention promotes open exchange of information and calls on exporters of hazardous chemicals to use proper labeling, including directions on safe handling, and inform purchasers of any known restrictions or bans.

2.6 International Guidelines and Best Practices

To minimize environmental impacts, the areas for which Omani environmental regulations / standards are not available, applicable international guidelines have been used.

Where relevant, this EIA study has taken into account 'Best Practice' environmental standards / guidelines as well as Best Available Techniques developed internationally by:

- World Health Organization (WHO);
- Integrated Pollution Prevention and Control (IPPC);
- European Union (EU); and
- US Environmental Protection Agency (USEPA).

2.7 Applicable Environmental Permits

Based on our knowledge and experience, the proposed Project will potentially require the following permits, as applicable for construction or operation phase:

- PEP from the SEZAD environmental department1;
- Final Environmental Permit (FEP) from the SEZAD environmental department;
- Permit for storage, handling, transportation, and disposal of hazardous wastes during construction from SEZAD and Royal Oman Police (ROP);
- Permit for storage, handling, and transportation of chemicals and fuel used at site during construction and operation from SEZAD and ROP;
- NOC for disposal of hazardous and non-hazardous waste during construction to the dumping facility from Be'ah;
- Permit for operating stationary combustion sources;
- Permit for installing onsite sewage treatment plant (STP) for the site office or Approval for discharging sewage to municipal STP, as applicable;
- If required, permit for groundwater extraction well from Ministry of Regional Municipalities and Water Resources (MRMWR) and SEZAD (during construction);
- Permit for use of industrial / laboratory gas cylinders from SEZAD;
- Temporary environmental approval for construction of site office from SEZAD; and
- Fire regulations and permit from ROP.

In addition to the above, the contractors transporting /recycling / handling chemicals, fuels, other hazardous materials, and non-hazardous wastes will require approvals / permits.

[1] As per RD 79/2013, the role of MECA can be carried out by SEZAD and for all the new projects coming up in the SEZAD area, SEZAD is acting as the regulator.

3 PROJECT DESCRIPTION

This section of the report summarizes the Project information that is presently available for the Road Nos. 1 and 5, and the description provided is based on information provided by Parsons to date.

3.1 Overview

The Government of Oman is in the process of developing the Port of Duqm as a strategic dry dock, free trade zone, and industrial and tourism destination. As a result of the RD 119/2011 establishing SEZAD, the Port of Duqm becomes part of SEZAD and the planning vision of the Port will take into consideration the strategic development of Duqm as well.

As stated above, SEZAD has commissioned Parsons to design and supervise the construction of the Road Nos. 1 and 5 and the associated drainage systems as part of the road infrastructure development works in the SEZAD area.

The proposed Project intends to provide and improve access to the Duqm Port and the Liquid Jetty. Road No. 1 connects the National Road No. 32 (Duqm – Mahoot) with the Port Road No. 2 and enables easier access to the Duqm Port. Road No. 5 connects the Road No. 1 to the Liquid Jetty. The Liquid Jetty will serve the Duqm Refinery and several heavy/ petrochemical industries coming within the proposed heavy industrial zone in SEZAD.

The construction of Road No. 1 from its junction with Road No. 7 to its junction with the Duqm-Mahoot Public Road (National Route 32) was suspended during construction due to weak subsoil conditions ("sabkha") that were encountered. The construction of Road No. 5 was also similarly suspended. The current design has been prepared taking in to account the presence of sabkha along with the ground treatment and/or ground improvement proposed to enable construction in that area.

3.2 Project Location

As shown in ***Figure 1-1***, the Project (Road Nos. 1 and 5) is located in Duqm, south of the Duqm Refinery, and bound on the west by the Duqm – Mahoot Road (National Highway No. 32) and on the east by the Duqm Port. The Project's battery limits are bounded by the co-ordinates listed in ***Table 3-1.***

Table 3-1: Coordinates of the Project Site (Road Alignment)

#	Easting (UTM)	Northing (UTM)
Road No. 1	567326	2173905
	569558	2173716
	570769	2173345
	571673	2172758
	571837	2172636

#	Easting (UTM)	Northing (UTM)
Road No. 5	570405	2173517
	570343	2173881
	571311	2176618
	571388	2176708
	571489	2176761
Service Road .01	567602	2174568
	569465	2173884
	570125	2173959
	571052	2176445
	571262	2176576
Service Road .02	571262	2176576
	571313	2176516
	571428	2176634
	571501	2176747

3.3 Conceptual Design

3.3.1 *Roadways*

The roadways have been designed in conformance with the following standards:

- *Sultanate of Oman Highway Design Standards* (Vol. 1 & 2 June 2010 Edition);
- *Sultanate of Oman Standard Specifications for Road & Bridge Construction* (Vol. 3 June 2010 Edition); and
- All relevant and applicable American Association of State Highway and Transportation Officials (AASHTO) Design Standards.

Road No. 1 is approximately 3.93 km in length and Road No. 5 is approximately 3.3 km in length. The right of way for both the roads is 200 m. They are being designed for a design speed of 80 kilometres per hour (kph) with a posted speed level of 60 kph. Road No. 1 is a 2x2 dual carriageway expandable to 6x6 lanes, while Road No. 5 is a 2x2 dual carriageway.

The cross-sectional elements of the road are provided in the below ***Table 3-2.***

Table 3-2: Roadway Cross-Sectional Widths

Roadway Type	ROW (m)	Median Width Curb to Curb* (m)	Median/ Inner Shoulder (m)	Lane Width (m)	Outer Shoulder (m)	No. of Lanes in each Directions	Verge (m)
Road 1- Urban Arterial-Dual Carriageway	200	40.90	1.5	3.75	3.0	2	2.0
Road 5 – Urban Arterial –Dual Carriageway	200	18.4	1.5	3.75	3.0	2	2.0

Road No. 1 has been designed to accommodate extraordinary long vehicles called "Self Propelled Modular Transport" (SPMT) for transporting the refinery equipment from Duqm Port to Duqm Refinery. Two long equipment (Vacuum Distillation Column and Crude Distillation Column) will be transported from Duqm Port to Duqm Refinery using Road No. 1. However, no hazardous material transported between Duqm Refinery and Duqm Port will be sent through this road, but through a service road that will come up later.

Provision is also being provided for future railway networks, bus service, and in this regard, approximately 40 m wide corridor adjacent to the outer shoulder is reserved for future road facilities including bus stops, taxi bays, and future pedestrian overpass as whenever this becomes a need.

3.3.2 *Peripheral Infrastructure*

Parsons has designed the drainage channels outside of the utility corridors in order to provide the services directly to the plots without crossing the drainage channels. Since the existing ground within the utility corridor is unstable with shallow groundwater table, the ground conditions make it impossible to construct the utilities directly on the existing unstable ground. Therefore, it is proposed to fill the proposed utility corridor with approved suitable borrow material up to 3 m minimum and compacted in 25 cm embankment layers. The embankment fill material will be reinforced with the two geo-grid layers approximately 40 to 60 cm below the bottom of utilities to avoid the differential settlement.

The utility corridor and drainage channel plan illustrate the infrastructure that will be developed as part of the Project which will comprise of the actual roads, utility corridor, and the drainage channel. Detailed layouts of utility corridor, drainage channel and its cross sections are presented in ***Figure 3-1*** through ***Figure 3-23.***

While ***Figure 3-19***, shows the Road No. 5 drainage channel draining to the Bay of Duqm on the northern side of the lee breakwater, discussions are currently in progress between Parsons and SEZAD for the flow of the drainage channel to be diverted into Wadi Saay, which is being designed by Renardet. This will avoid the need for the drainage channel to join the Bay of Duqm at an ecologically sensitive location.

3.3.3 *Ground Improvement*

Soil improvement techniques are typically implemented to enhance the soil-stiffness and/or consolidate the existing loose compressible subsoil in order to increase the soil bearing capacity, prevent excessive settlement under foundations and mitigate the liquefaction hazards.

The existing ground along Road No. 1 is generally covered with sabkha deposits comprised of very silty / clayed fine sand / gypseferous sand with some shell gypsum crystals and shell fragments. Sabkha is an Arabic term used locally to describe relatively fine-grained, hypersaline, silt and sand deposits, which are typically saturated with brine and are salt-encrusted, and possessing low shear strength, high compressibility and high salt content.

Based on the available geotechnical information, the soil at the ground surface is sabkha formation. The sabkha formation found extended from surface up to 5.0m deep. The proposed road finished level is approximately 3m above the existing ground level. Building an embankment over the existing soft clayey sabkha with low bearing capacity is not advisable due to the possible chances of ground settlement and expansion. The water table is also very close to the ground level along road no.1 and at ground along road no.5. Therefore, the existing ground needs to be stabilized by ground improvement or ground treatment before embankment construction.

Due to the presence of less stable soil layers, ground improvement has now become an integrated and essential component of infrastructure development. There are several ground improvement techniques adopted for road construction in the region, the selection of the proper technique is mainly governed by the nature of soil to be treated, time required for ground improvement or soil stabilization, the type of proposed structure and cost involved in the ground improvement method.

After reviewing the geotechnical report from Swissboring, Parsons is proposing the following ground improvement measures for the sabkha will be employed:

Types of Ground Improvements:

- Preloading with Sand Drains;
- Vibro-Replacement or Stone Columns;
- Stabilization with Geosynthetic Reinforcement; and
- Stabilized Rock (Boulder) Foundation Layers;

The other ground improvement techniques like Preloading with Pre-fabricated vertical drains, Vacuum Consolidation with Pre-fabricated vertical drains, Dynamic Compaction, Dynamic Replacement, Vibro-Compaction or Vibro-Floatation, Deep Soil Mixing and Stabilization using Admixtures are not suitable for this project. Comparison of different ground improvement techniques are presented in the ***Table 3-3.*** The following sections briefly provide the characteristics, suitability, limitations, and advantages of the techniques.

3.3.3.1 Foundation Preparation Using Boulder (Rock Fill) Layer

In order to overcome the constraints due to the presence of sabkha and high water level, a layer boulder can be placed and compacted at the surface. If the ground does not become stable another layer boulder shall be placed above and compact. Above this boulder layers a 300mm thick road base material shall be placed and compacted 98% Maximum dry density (MDD). A geotextile fabric shall be placed above the road base above that approved fill material shall be placed up to the pavement design section.

The rock fragments will angular edges will help to develop interlocking between rock fragments. The maximum size of the rock particles shall not be more than half of the layer thickness. No individual layer thickness shall exceed 400mm.

3.3.3.2 Methodology for the Construction of Boulder Layer

The rock fill layer shall be compacted using Bulldozer D10 or larger in size and weight. The material passing on 0.425mm shall not be more than 10% and material passing on 10mm shall not be more than 25%. The rock should hard enough not to be pulverized under the movement of bulldozer. After leveling the rock fill, the layer shall be compacted by at least 5 passes bull dozers. The level shall be checked by marking grades of not more than 5mx5m. The layer shall be again compacted by at least 5 passes. The level shall be checked again at the same points of previous measurement in the grid and the settlement shall be calculated. The settlement shall not be more than 5mm between each cycle of 5 passes. The compaction cycles shall be continued until the settlement between the cycles in not more than 5mm.

Once the settlement criteria are achieved, a second layer of rock fill shall be placed. All procedures specified for the first layer shall be applied for the second layer also. A capping layer of 300mm minimum shall be placed above the second layer of rock fill. The material of the capping layer shall meet the requirements of Granular Sub base material as specified in the Contract Specifications

3.3.3.3 Methodology for the Embankment Fill

To ensure the quality of fill, it is essential to carry out the compaction according to a set of project specifications related to the purpose of the fill, its characteristics at the time of use and equipment to be used for compaction. Some preliminary recommendations for the compaction of the material encountered at the site based on BS-6031; can be summarized as follows:

- The filling should be carried out in successive lifts, with maximum thickness of each lift ranges between 200mm to 300 mm, depending on the weight and type of equipment used for compaction
- The fill material should be compacted to at least 95% of the maximum dry density of the material as determined by laboratory compaction (BS 1377, Part 4, Test 3.6 or 3.7)
- Minimum number of runs for compaction (compaction effort) range between 4 and 16 depending on the weight of equipment used.

- One Field Density test shall be conducted for every 500m^2 of each compacted layer. The number of tests per location shall be at least two.
- Plate Load test every 1000 m^2 on every three consecutive compacted lifts shall be conducted. The diameter of the plate shall be 90cm at least.
- Cone Penetrometer Testing in a suitable grid pattern across the site as selected by the Engineer; and
- Empirical correlations are available to correlate the plate load test results with CBR values.

1.4 Geogrids and Geotextile Membranes

Two layers of geogrids as shown on the Contract Drawing shall be placed within the fill. The geogrids shall be extruded type. The tensile strength of the geogrids in machine direction and cross machine direction shall be 40 MPa (Megapascal) minimum. Geogrids shall be prepared virgin polymers. The storage, handling and installation of the geogrids shall be in accordance with the manufacturer's recommendations as well as the Contract requirements.

The geotextile shall be placed above the capping layer after second layer of boulder (rock fill) layer. The geotextile shall be at least 500g/m^2 weight. The geogrids shall meet the properties listed in the Contract documents. It is recommended to carry out construction trials on compaction procedures prior to commencement of actual works, due to the possible variability of fill material and specifications of the equipment and plants to be used.

Table 3-3: Comparison of different ground improvement techniques

Ground Improvement Method	Advantages	Disadvantages	Remarks
Preloading with Sand Drains	• Increase in compressive strength of soil • Long term stability for artesian pressures. Acts as relief wells. • Suitable for improving loose soils of shallow depth	• Availability of prescribed sand material • Material handling and Quality control problems	Suitable for sabkha treatment since compressibility characteristics of soil is improved. Provide drainage paths until the life of structure and increase in bearing capacity of soil
Preloading with Pre-fabricated vertical drains	• Locally available materials or materials identified for embankment may be used for preloading. • Minimum disturbance of soil layers during installation • Fast and easy installation • Suitable for soft ground/low permeable soils	• Does not provide short term improvement in soil compressive strength • Not suitable for long term artesian flows • High Equipment mobilization costs • Head room restrictions • Full saturation of target soil layer is required • Relatively flat working surface is required	Not suitable for current project since it does not improve permeability on long term basis and no improvement in strength of soil/
Vacuum Consolidation + Pre-fabricated vertical drains	• Reduction in the quantity of the surcharge fill • The risk of bearing capacity and slope failure resulting due to application of surcharge on the in-situ soil is reduced • The pressure applied in this process is isotropic in nature.	• Extreme caution is required while sealing the area of treatment zone • Very Expensive and time taking if the area to be treated is very large.	This technique is not suitable since the area to be treated is very large. Also, there are chances of continuous ground water flow making it difficult for successful ground improvement.
Dynamic Compaction	• Improves soil densification • Economical for large areas of ground improvement	• Effective for treating shallow depths (normally 5 to 10 m) • Not suitable for highly expansive and plastic clays with poor drainage	Not suitable for this project. Since the soil is clayey and silty in nature with intermediate to high plasticity and high GWT.

Ground Improvement Method	Advantages	Disadvantages	Remarks
	• Collapse of large voids if any present • Effective for compaction of loose sand and silty soils • Soils of heterogeneous nature can be densified (boulders, fills etc)	characteristics, where ground heaving is not under control • Ground Vibrations disturbs surrounding structures significantly • The GWT should be atleast 6.5 feet below the existing ground to prevent softening of the surface soils and to limit the potential of the tamper sticking in the soft ground.	
Dynamic Replacement	• Reinforces soil mass • Reduce post construction settlements • Provide drainage for pore pressure dissipation • Suitable for shallow depth soft to very soft ground treatment	• Dynamic replacement is very effective in granular non-cohesive soils, can be used in silty to clayey soil upto a limited depth. • Not suitable for the clayey deposits more than 3 meters in depth • Disturbance to local structures and occupants • Will require more time for deeper layers of non-cohesive soils • Suitable if relatively Dense or compacted layers are on the surface and Soft soils at depth need to be improved • There is a need to minimize heave in the surrounding soils	Not suitable for this project. Dynamic replacement for such large area requires more time. Huge quantities of backfill material are required.
Vibro-Compaction or Vibro-Floatation	• Increased soil bearing capacity • Reduced foundation settlements • Increased resistance to liquefaction • With vibro-compaction, the angle of internal friction is increased on	• Vibro-compaction is effective only in granular non-cohesive soils • Proper densification generally cannot be achieved when the granular soil	Not suitable for this project. Since the soil is clayey and silty in nature with intermediate to high plasticity

Ground Improvement Method	Advantages	Disadvantages	Remarks
	average 5 to 10 degrees, resulting in much higher shear resistance • Reduced permeability • Replacement for deep foundations and hence economical • No foreign materials like gravels or boulder is required	contains more than 12 to 15 %silt or more than 2 % clay • The increase in density of the granular soils causes a downward movement of the soil around the vibrator. This downward movement creates a conical depression at the ground surface and a small void around the probe. This depression requires constant filling with additional granular materials	
Vibro-Replacement or Stone Columns	• Increases soil bearing capacity and Reduce settlement by reinforcing soil mass • Reduces liquefaction potential • Long term benefits- Relief wells for dissipation of excess pore water pressure • Most effective technique for liquefiable soils that fall within the typical grain size range • Most effective for compressible silts and clays	• This method is generally economical but costlier compared to methods such as preloading, vibro-floatation, geosynthetic reinforcement. • Availability of foreign materials used in stone column • Suitable for treating minimum depth of 5-6m • Equipment mobilization costs	Suitable for sabkha treatment since compressibility characteristics of soil is improved. Provide drainage paths until the life of structure and increase in bearing capacity of soil is achieved.
Deep Soil Mixing	• Increases composite shear strength of treated zones • Prevents migration of excess pore between untreated and treated zones • Works well in soils with high fine content	• Requires overhead clearance • Stiff strata can impede augers • Inefficient for liquefiable soils with a limited thickness at a significant depth • Overlapping soil-cement columns are brittle - tendency to crack with earthquake shaking • Very high mobilization costs	Not suitable for this project. Very expensive for the depth of treatment under consideration. (5 to 8m)

Ground Improvement Method	Advantages	Disadvantages	Remarks
	• Problems associated with disposal and replacement of materials can be avoided	• No standardized method for quality control testing • Economical solution for treatment weak soils present at deeper depths. Rarely used for shallow depth treatment	
Stabilization using Admixtures	• Improves strength stiffness and durability of soil • Reduces swelling of soils	• Cost of cement/lime increases with the quantity of soil area to be treated • Not suitable if large areas are to be treated and if depth of treatment is more than 3m • Involves pulverization and mixing of admixtures. Handling and disposal costs is increased and not very neat construction area is maintained	Not Suitable option for this project as the estimated quantity is high and GWT is high.
Stabilization with Geosynthetic Reinforcement	• Increase Stability • Prevents differential settlement • Long term benefits with regards to settlement control, durbaility • Long life of the non-biodegradable material if properly selected	• Does not minimize immediate settlement • The use of Geosynthetic alone will not be sufficient to reduce the settlements of soft soils present at deeper layers	Suitable option for this project. But it has to be used in combination with other ground improvement since the depth of improvement is up to 8m.
Stabilized Rock (Boulder) Foundation Layers	• Very cost effective method • Locally available rocks can be used • The stabilization process is faster than other methods like preloading, dynamic replacement or vibro replacement • Rocks with angular edges will provide good interlocking	• Possibility of residual settlement • Settlement need to be monitored until the soft layer is stabilized. More time is required to cause consolidation settlement. • Geotextile will be required to prevent migration of particles from top layers	Suitable option for this project. Most economical and fast in construction. And long term benefits. Requires a trial run and the settlement to be estimated. The time required for stabilization need to be monitored.

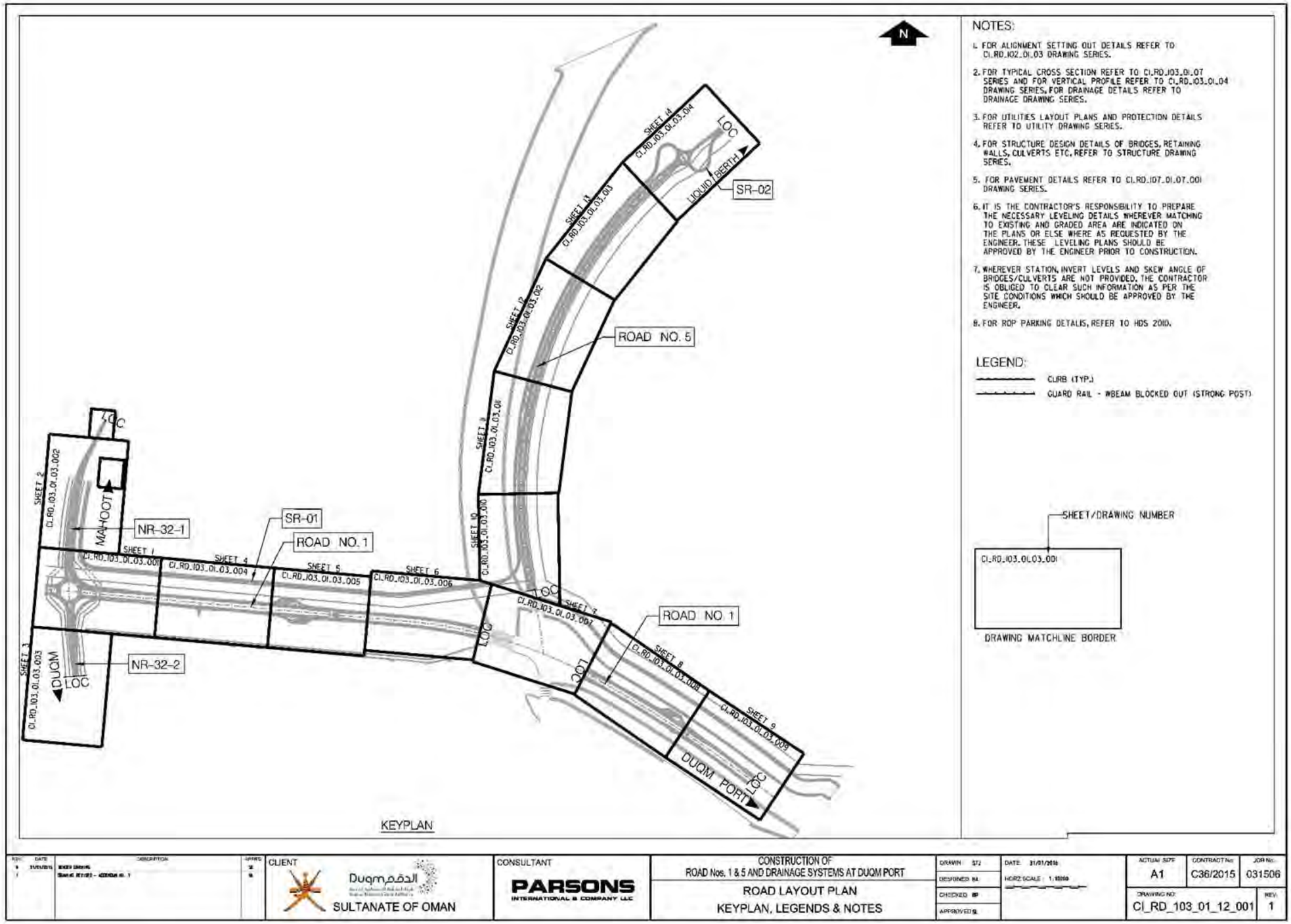
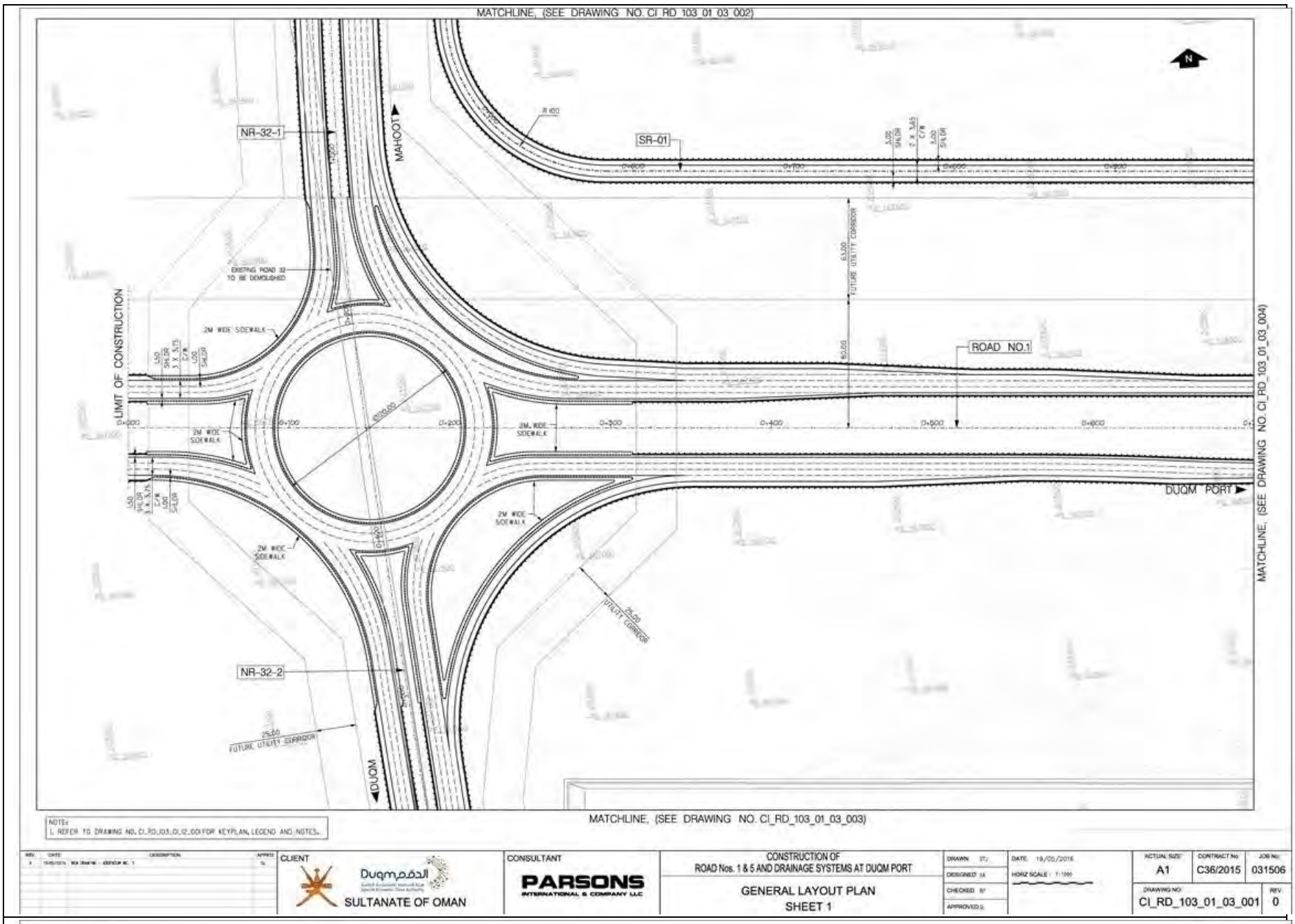


Figure 3-1: Road Layout Plan



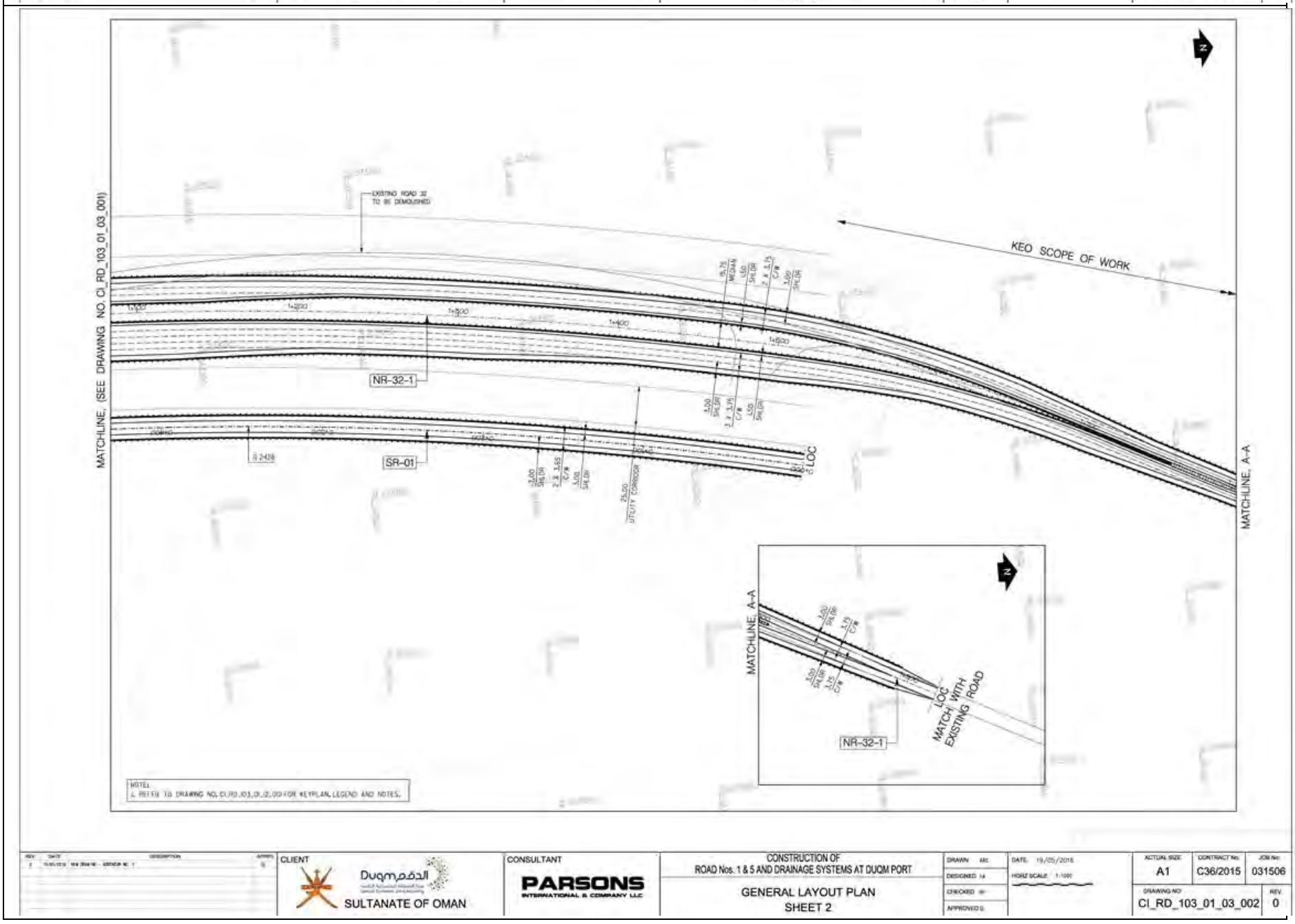
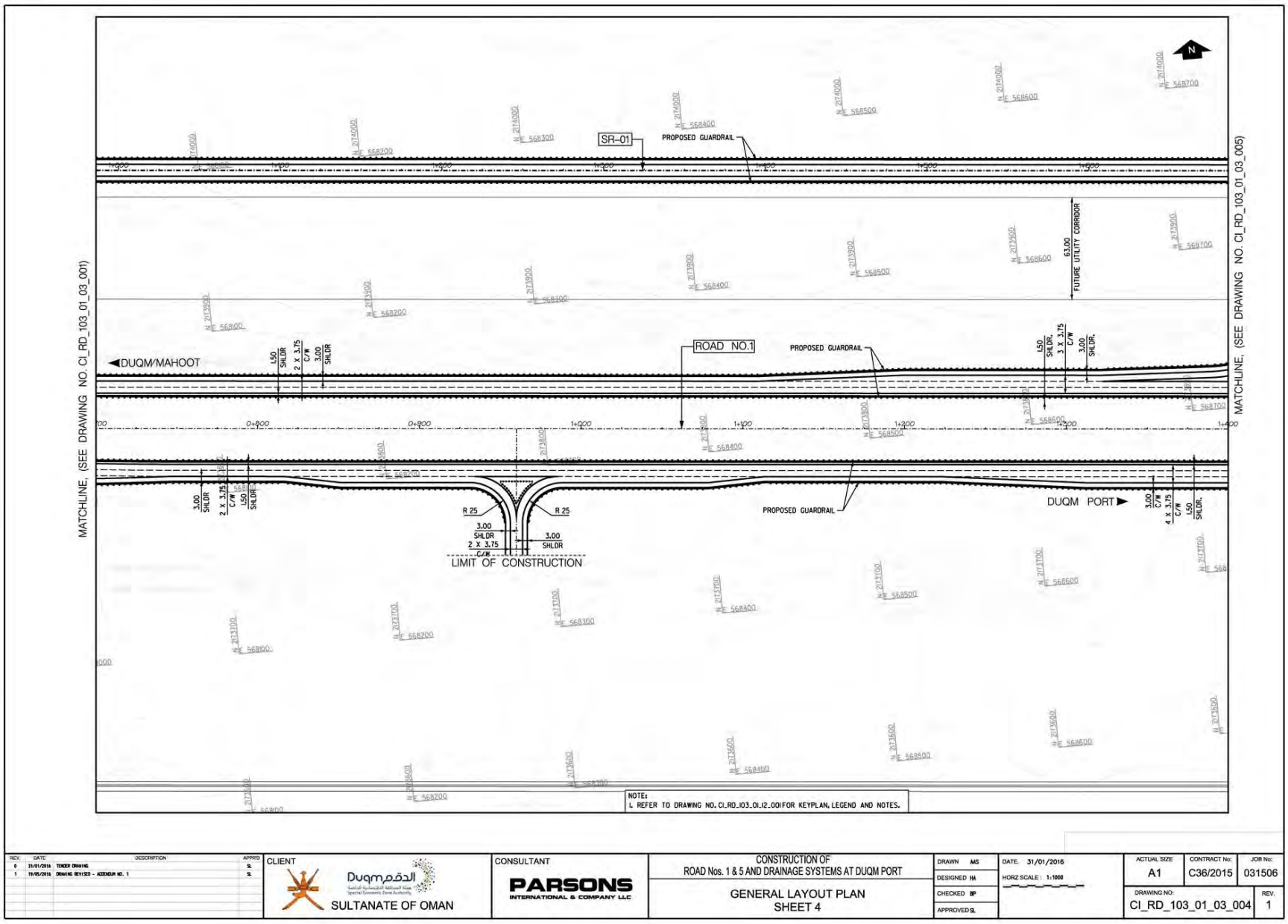


Figure 3-2: Detailed Layout plan of section 1 &2



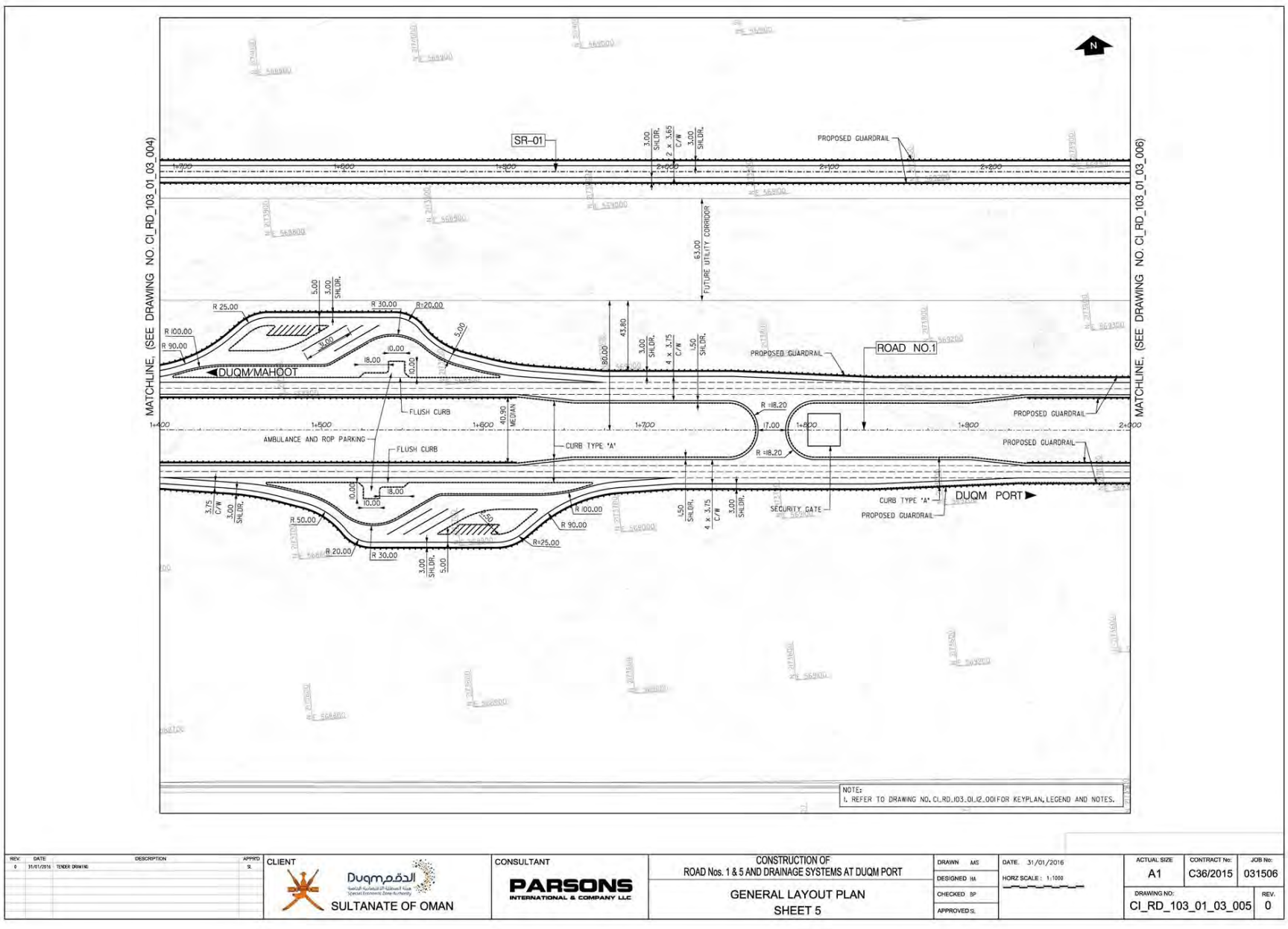
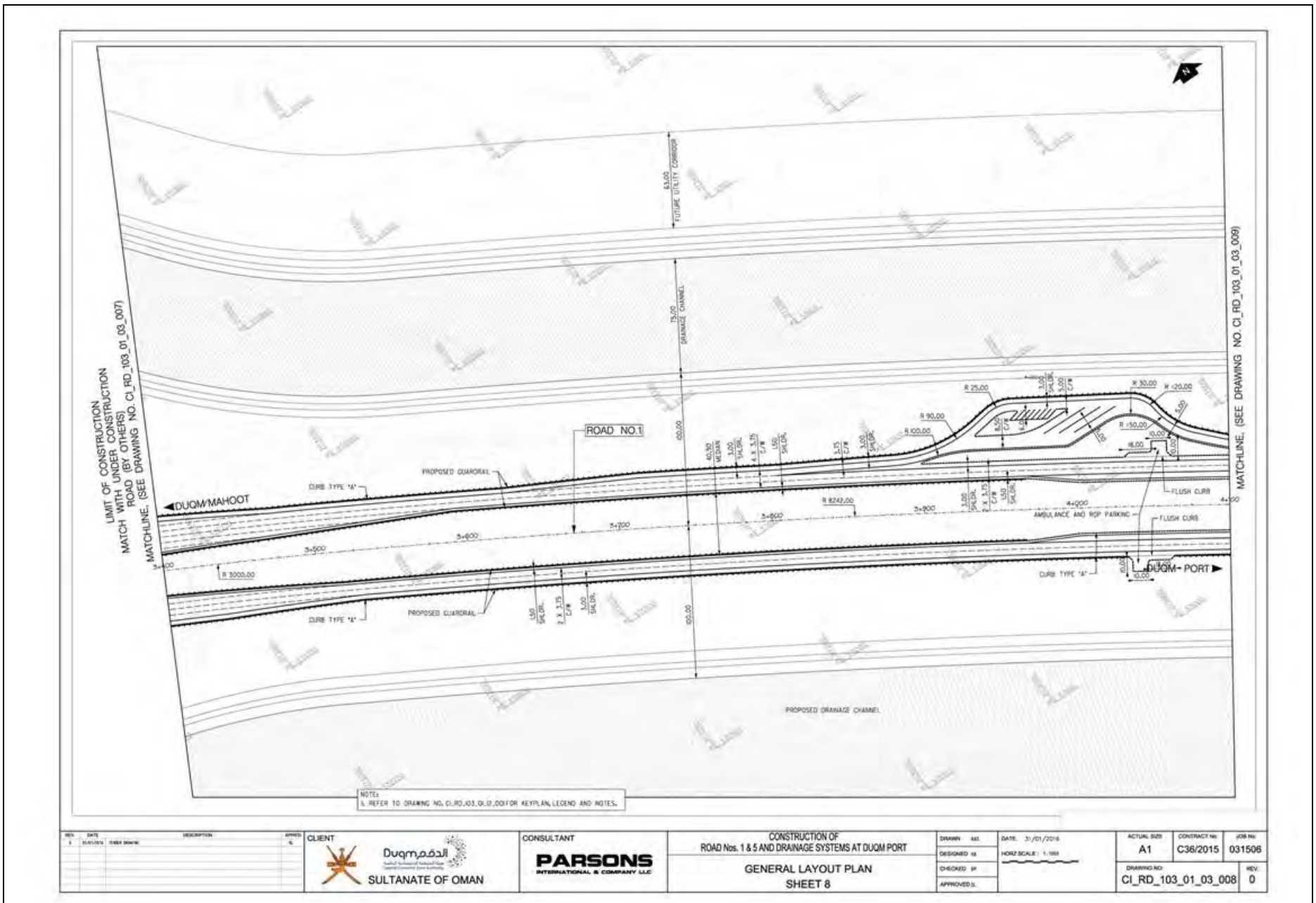


Figure 3-3: Detailed Layout plan of section 4&5

Figure 3-4: Detailed Layout plan of section 6&7



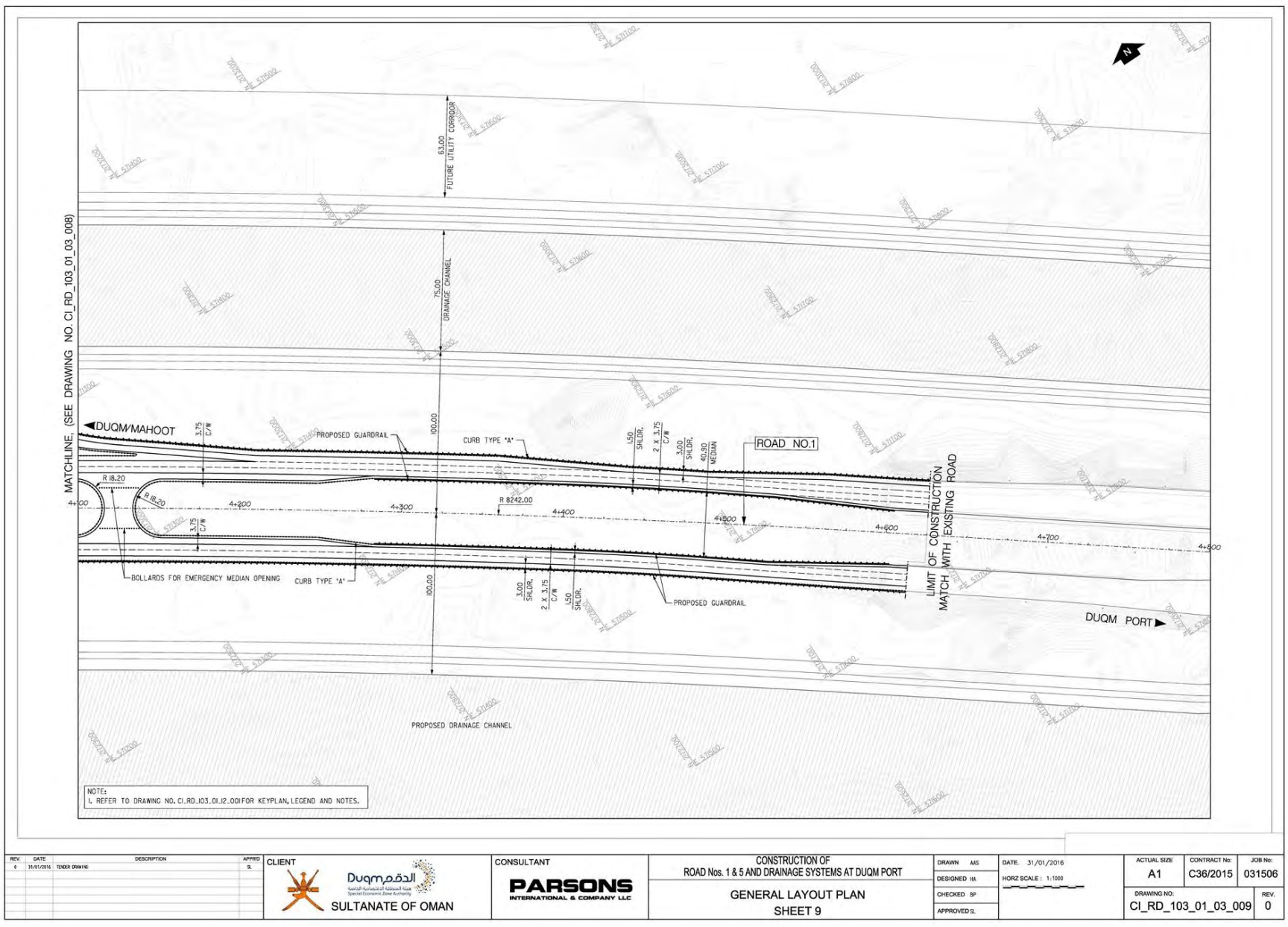
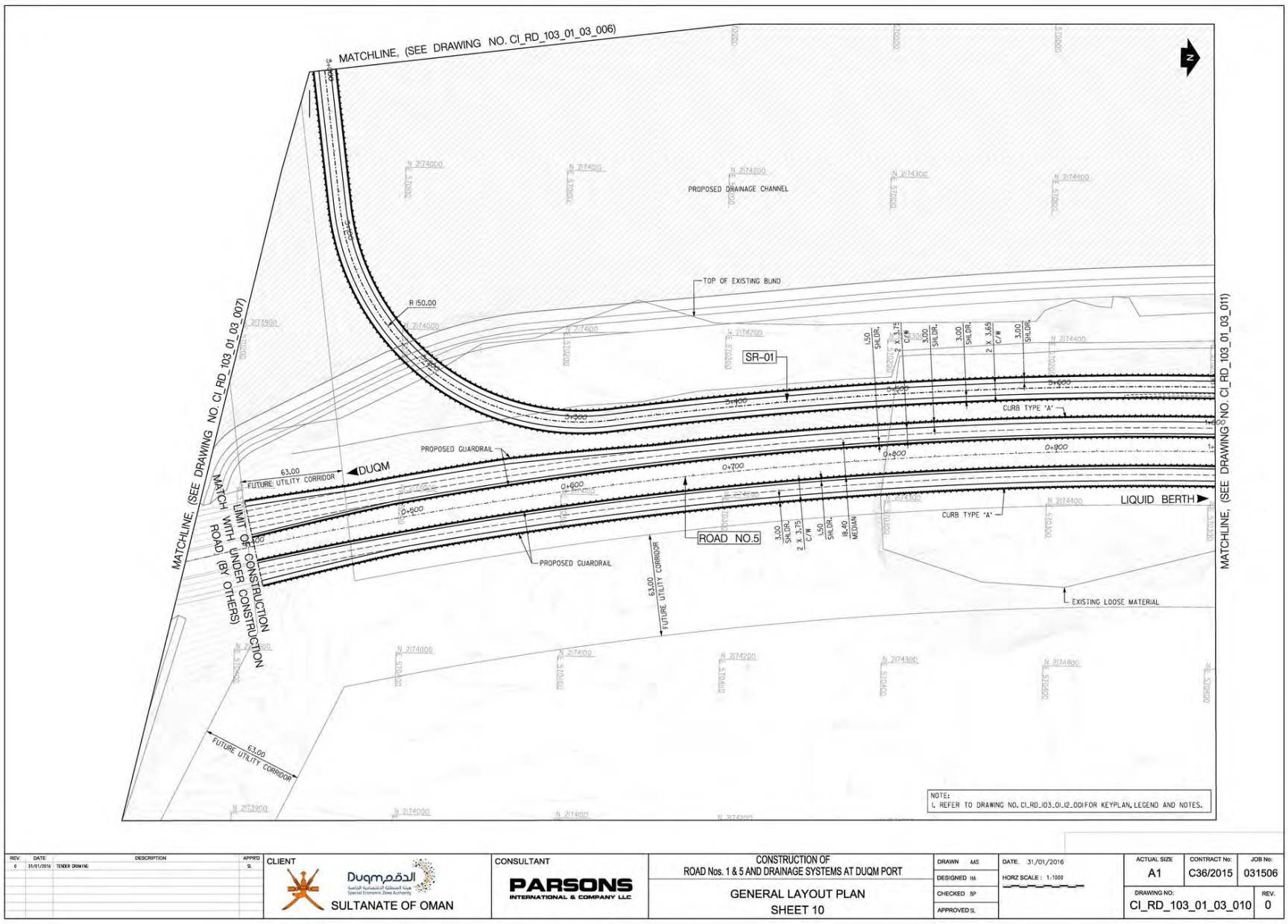


Figure 3-5: Detailed Layout plan of section 8&9



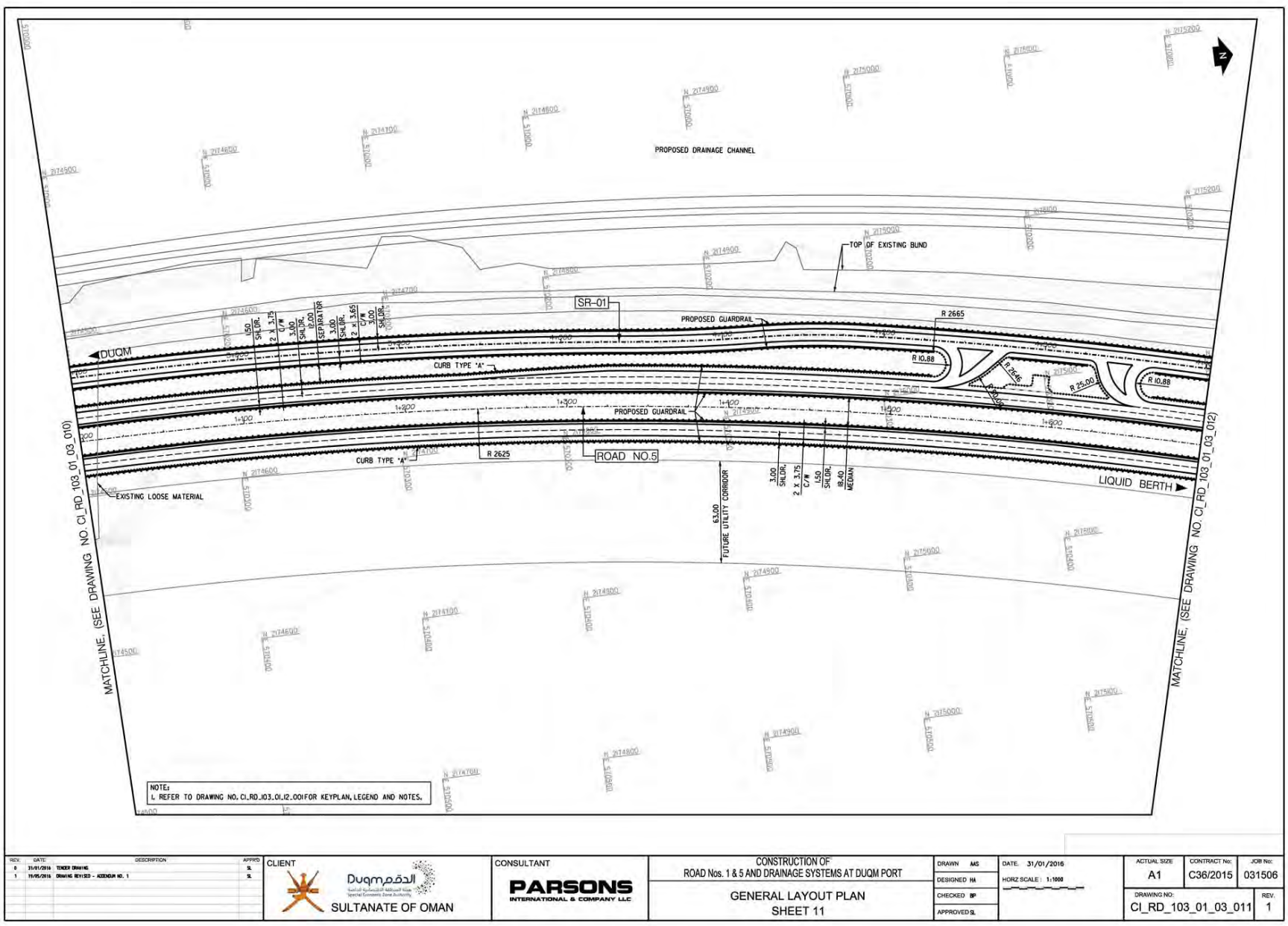
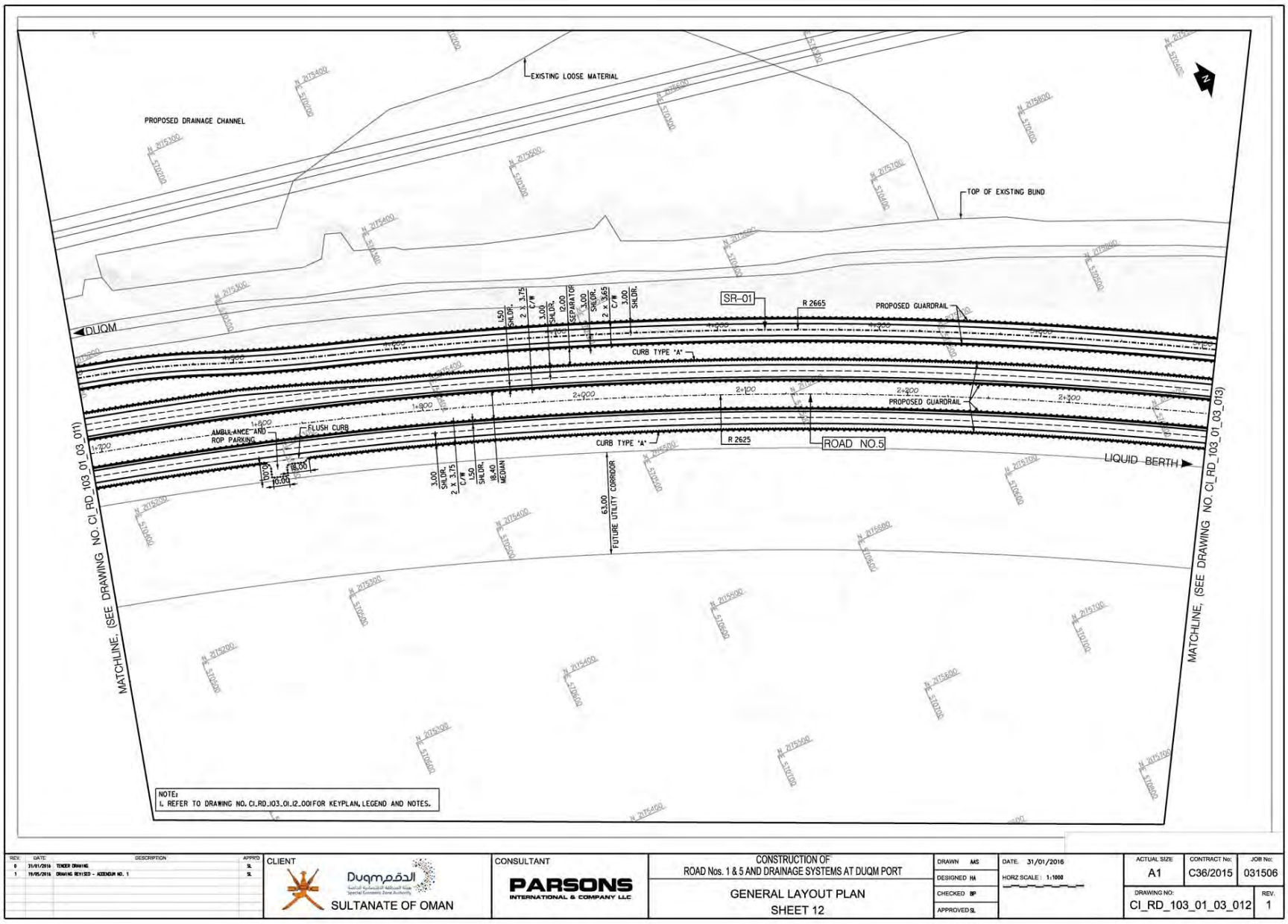


Figure 3-6: Detailed Layout plan of section 10&11



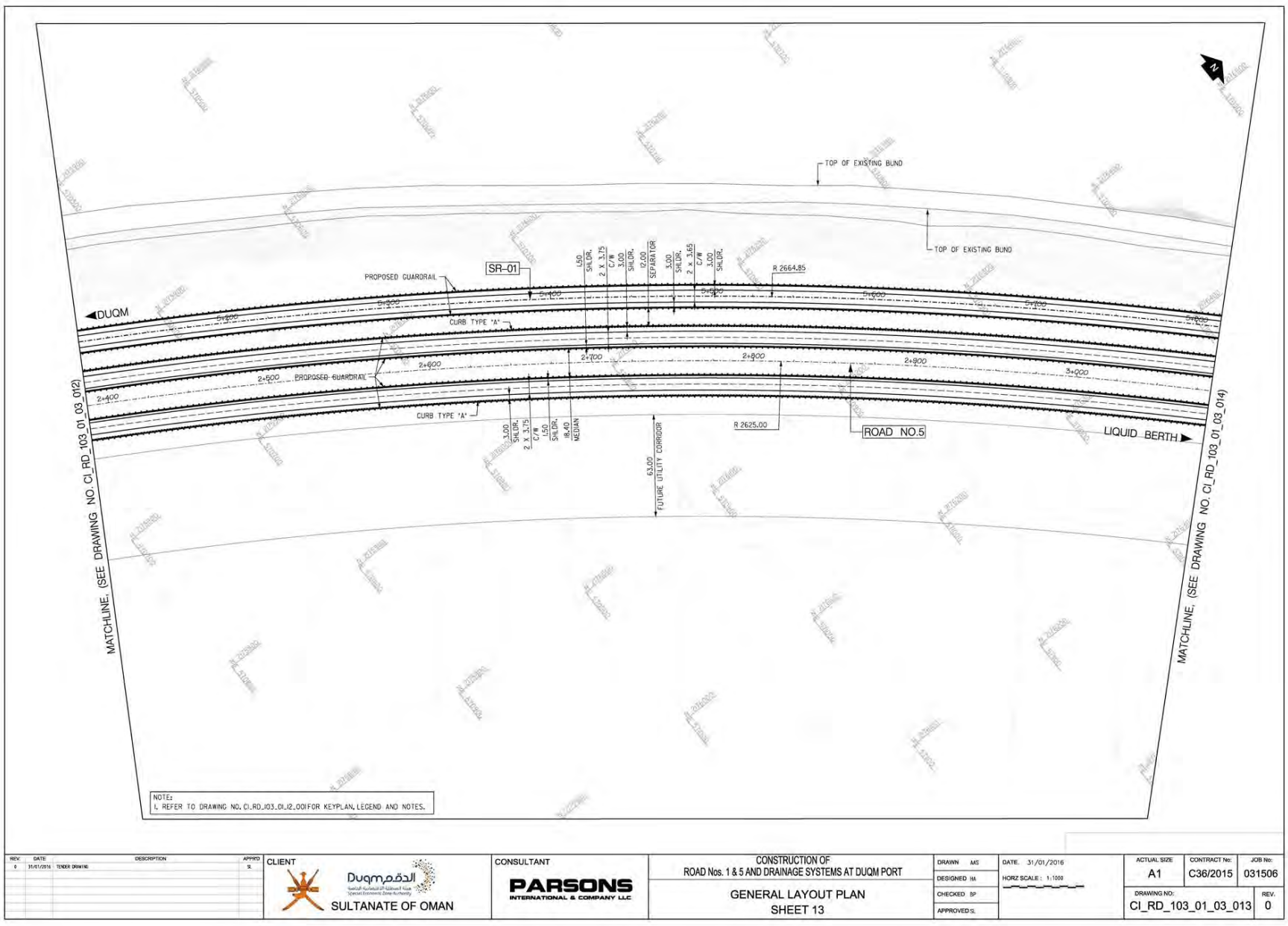


Figure 3-7: Detailed Layout plan of section 12&13

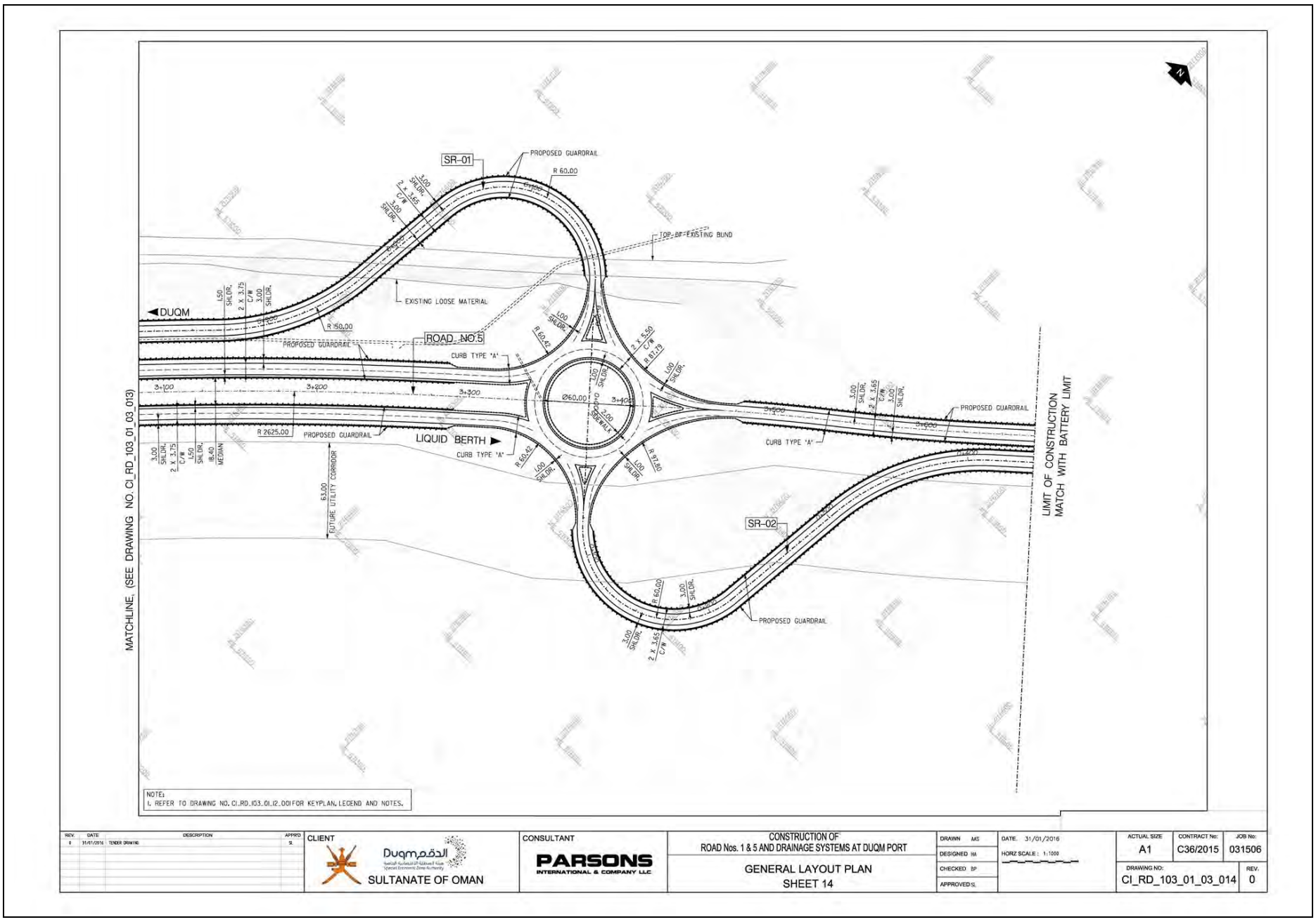


Figure 3-8: Detailed Layout plan of section 14

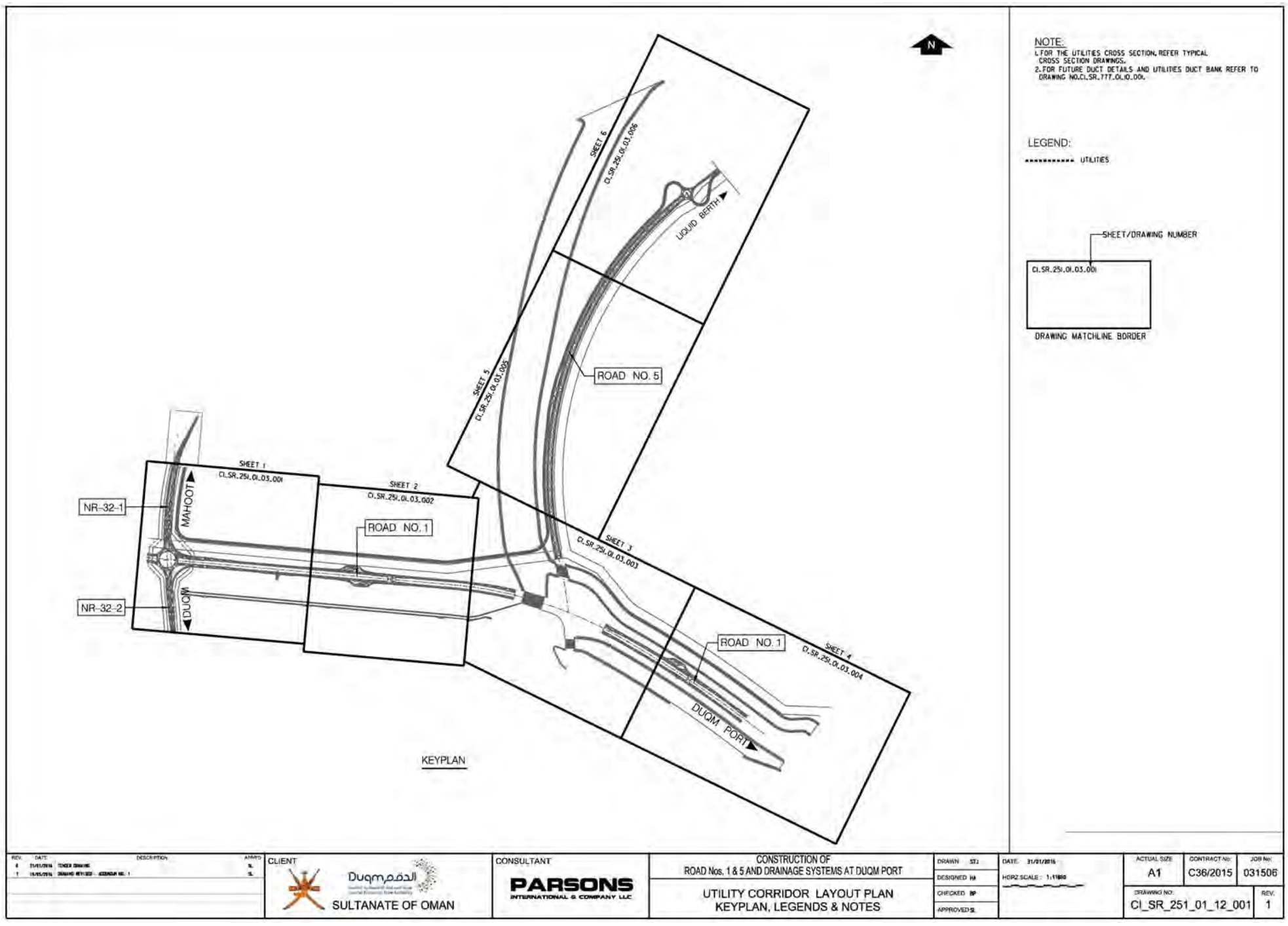
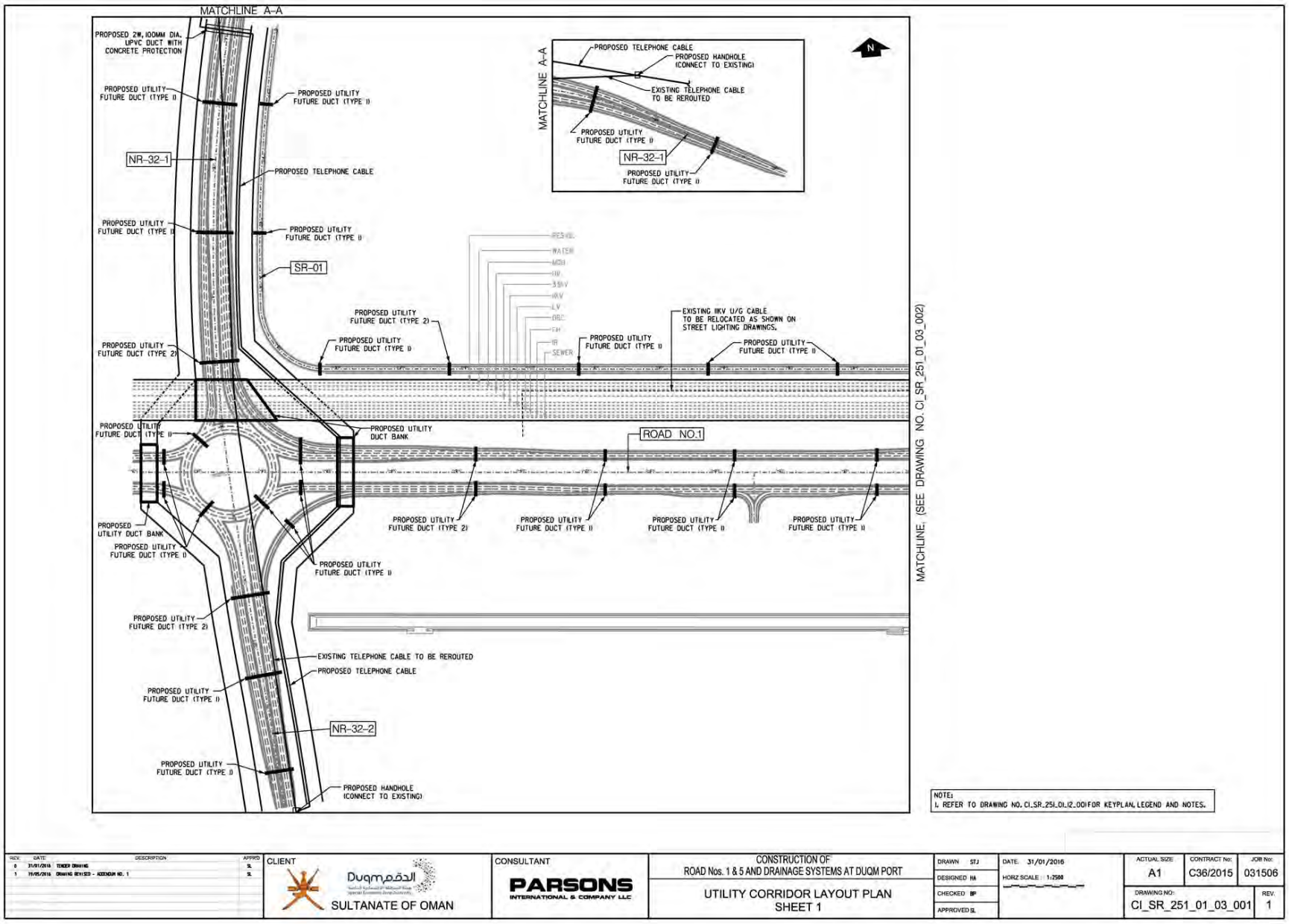


Figure 3-9: Utility corridor Layout Plan



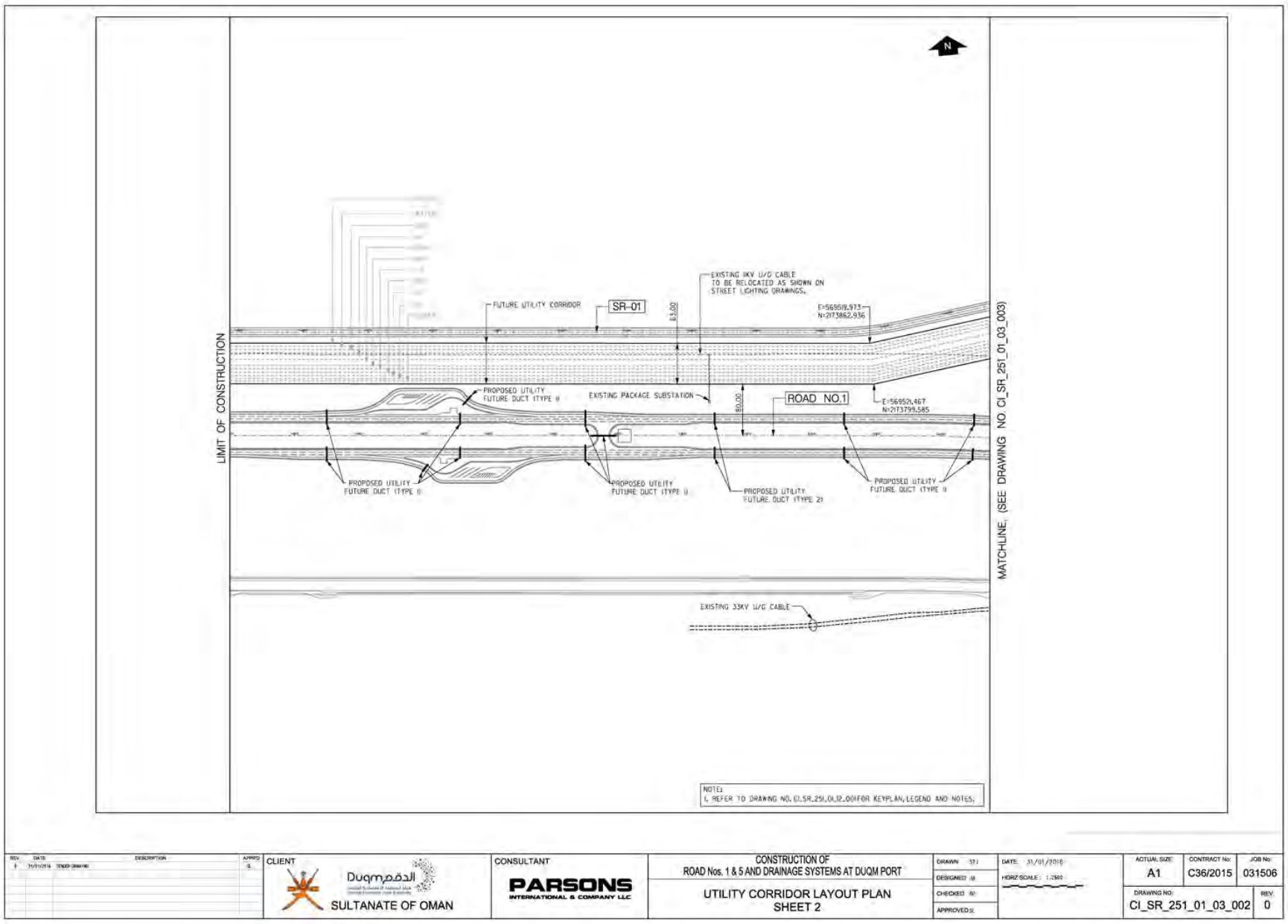
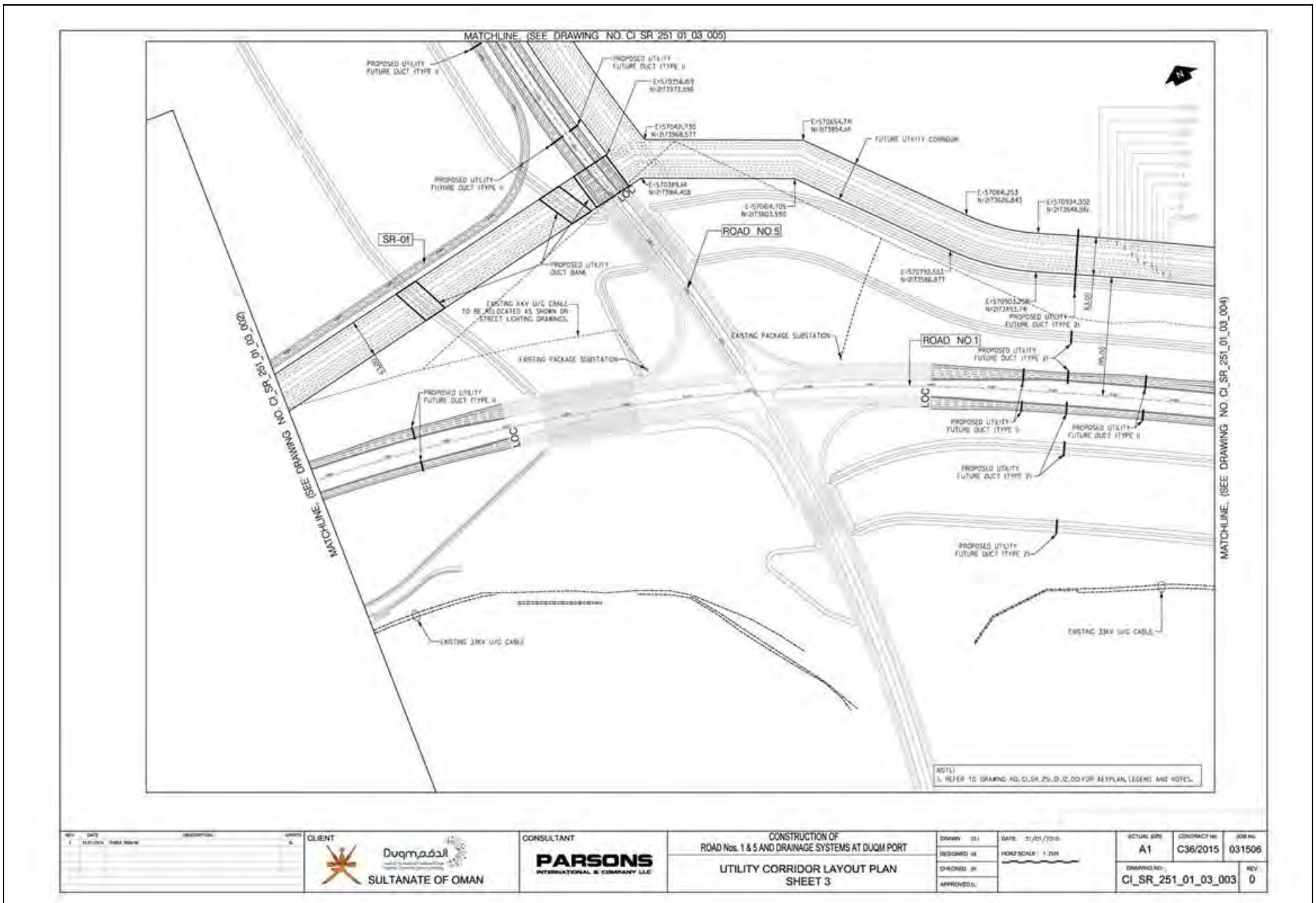


Figure 3-10: Detailed Utility corridor Layout Plan- section 1&2



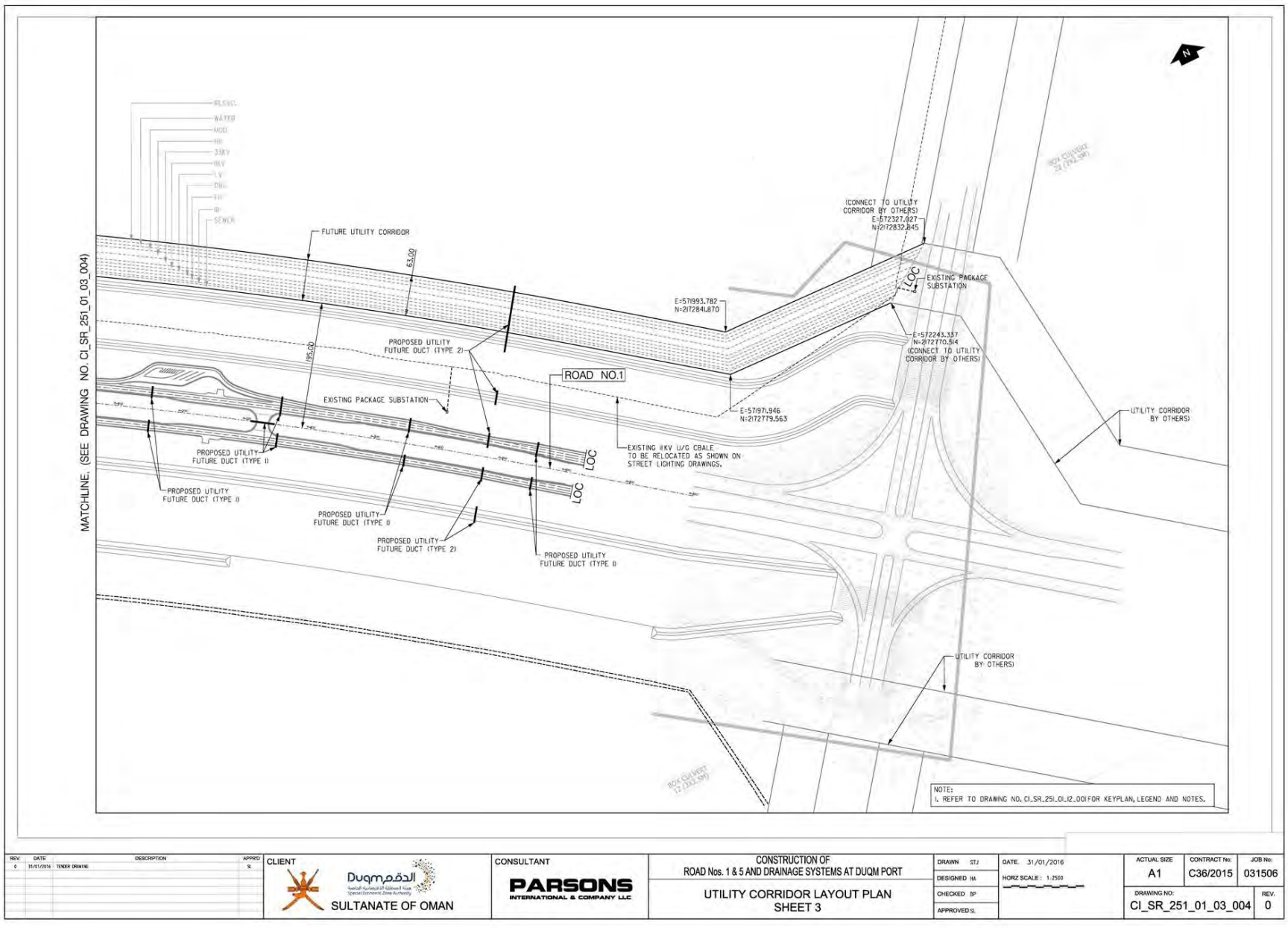


Figure 3-11: Detailed Utility corridor Layout Plan - section 3&4

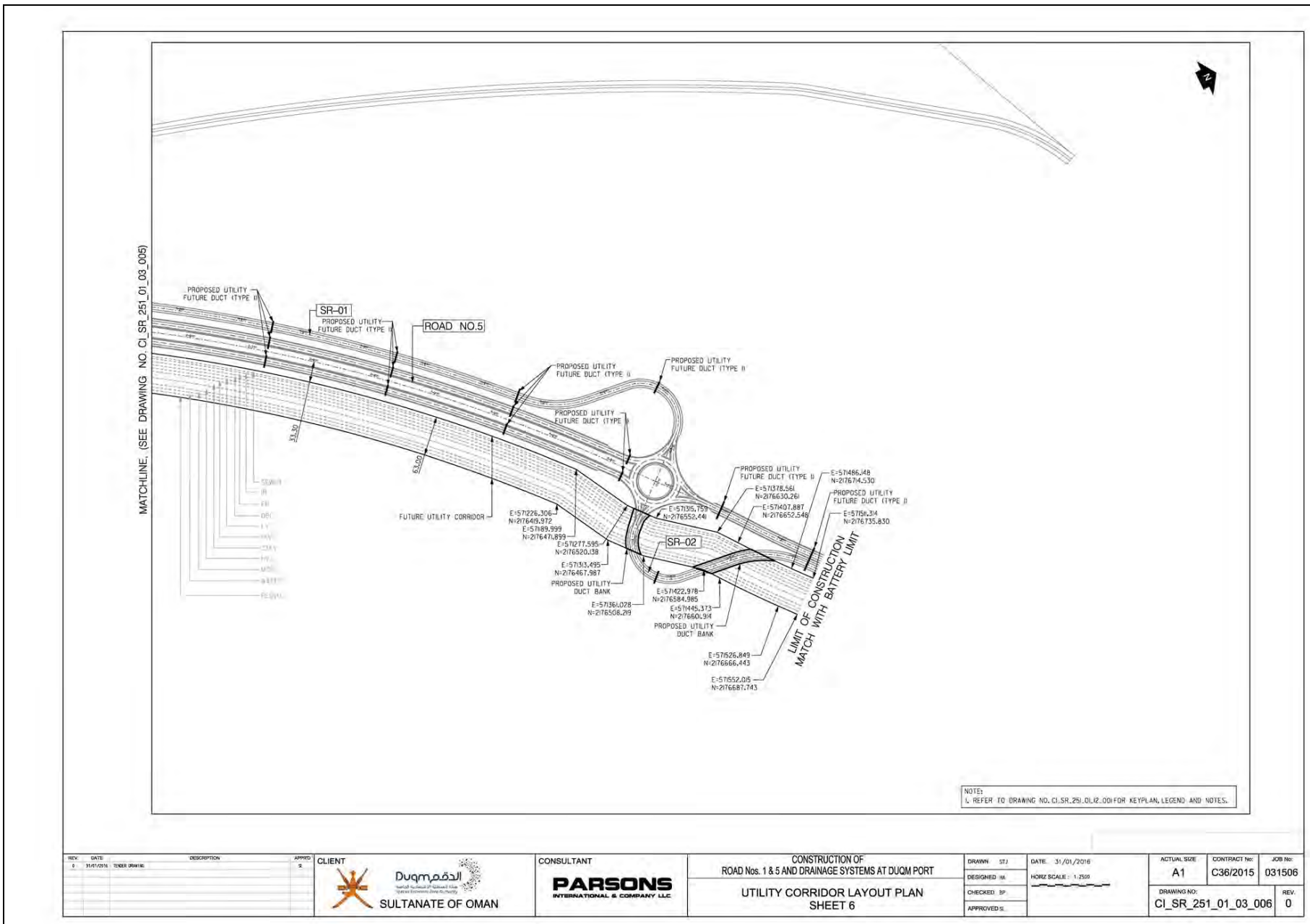


Figure 3-12: Detailed Utility corridor Layout Plan - section 5

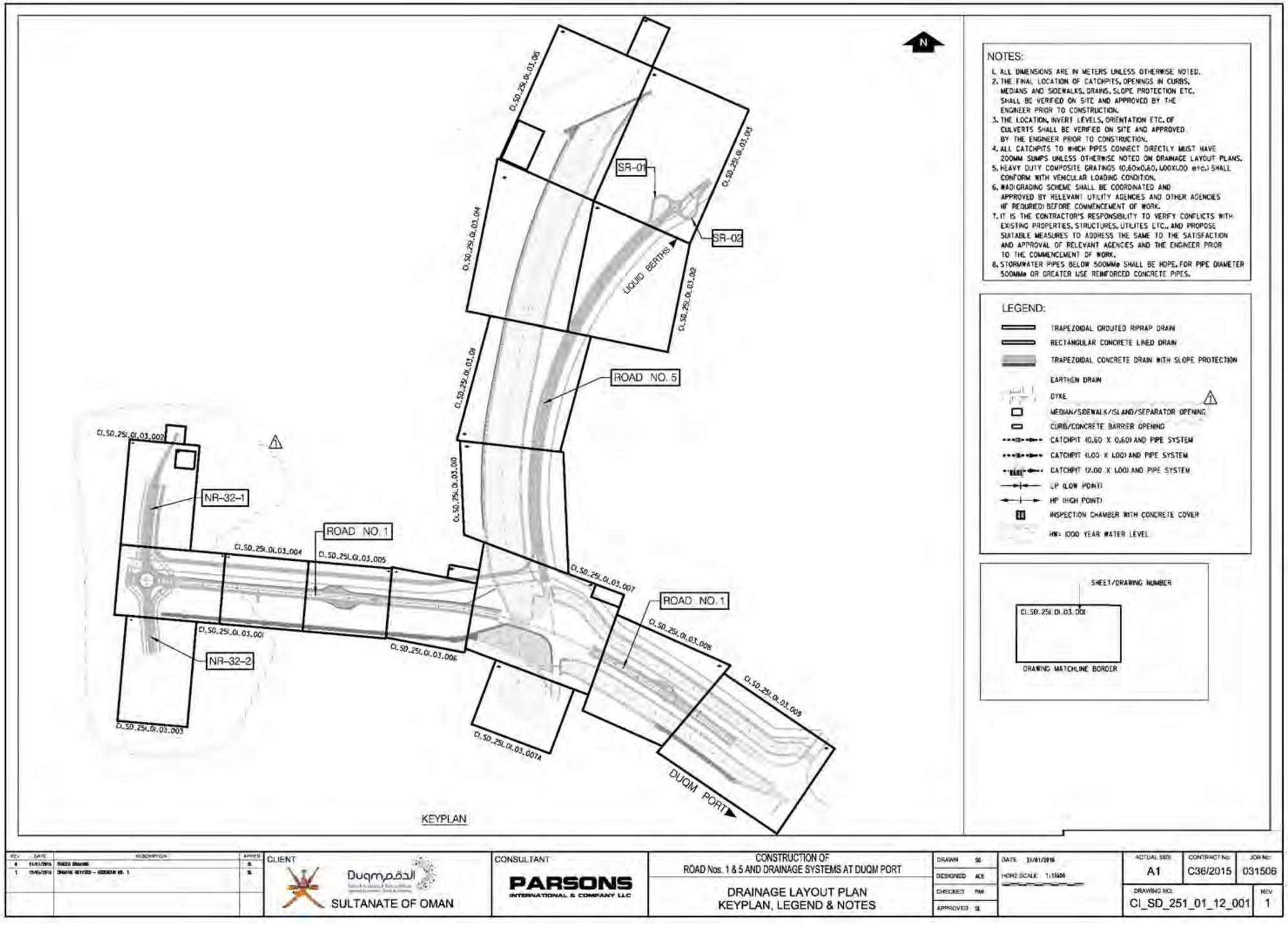


Figure 3-13 Drainage Layout Plan

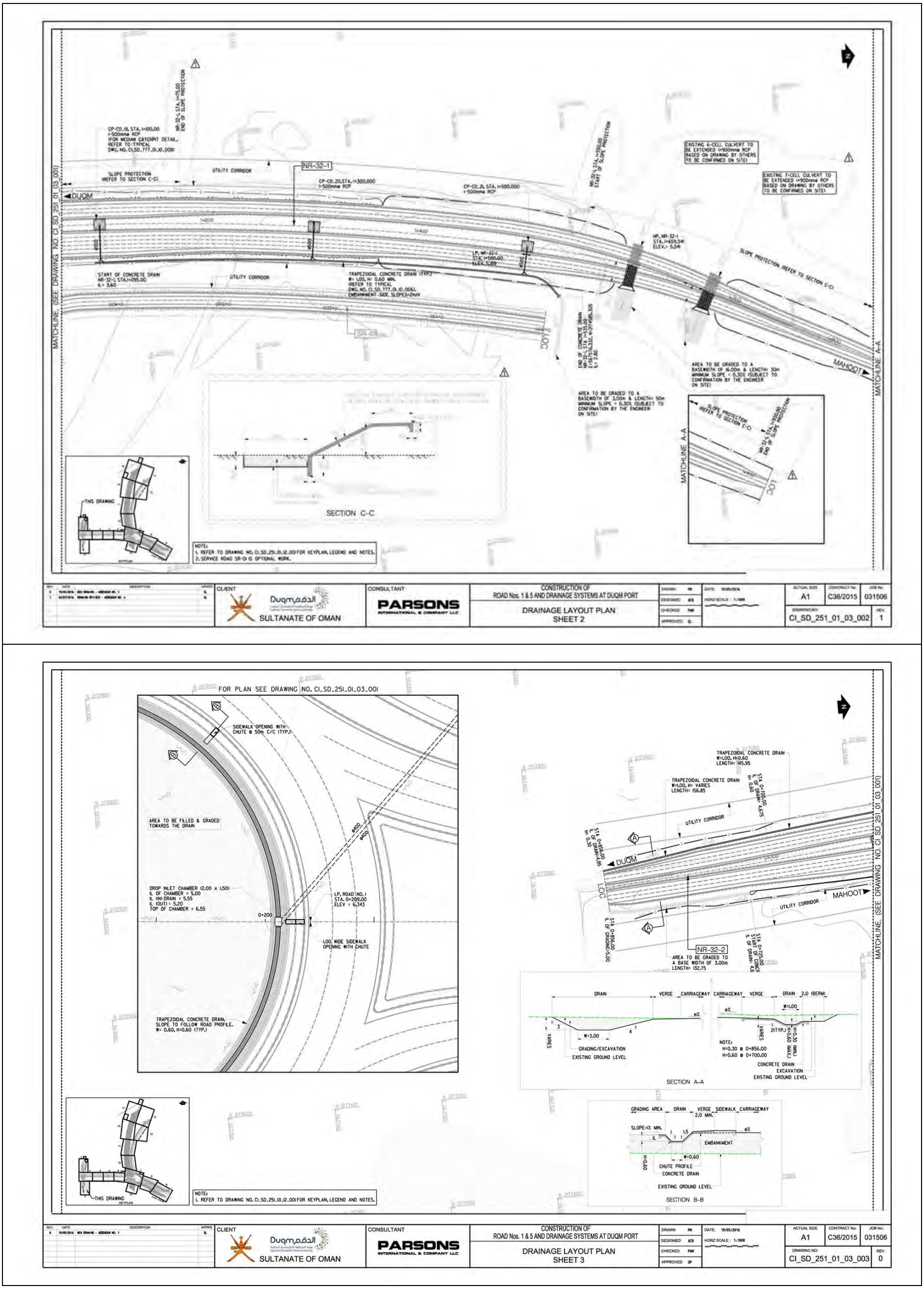
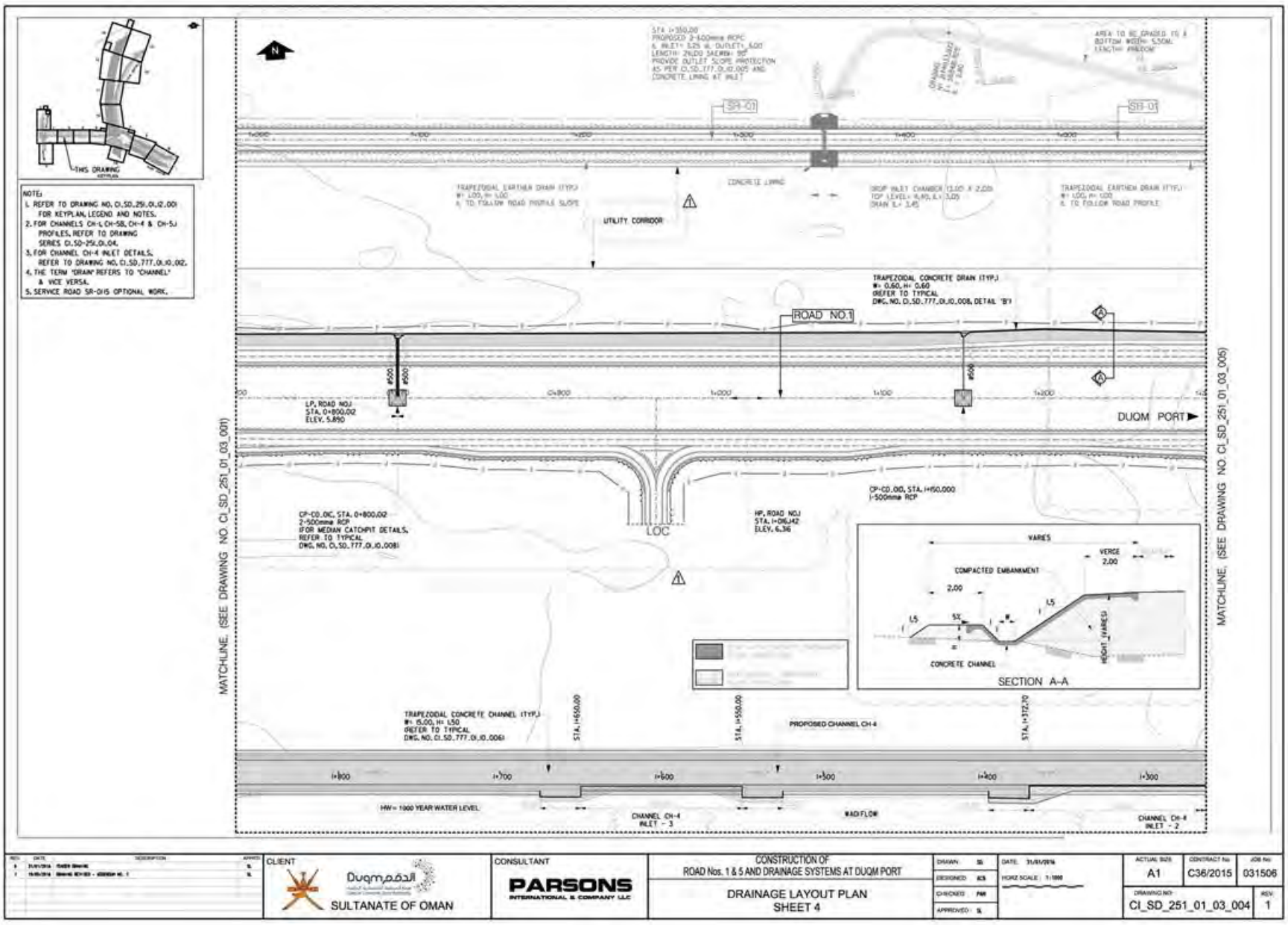


Figure 3-14: Detailed Drainage Layout Plan Section 2 & 3



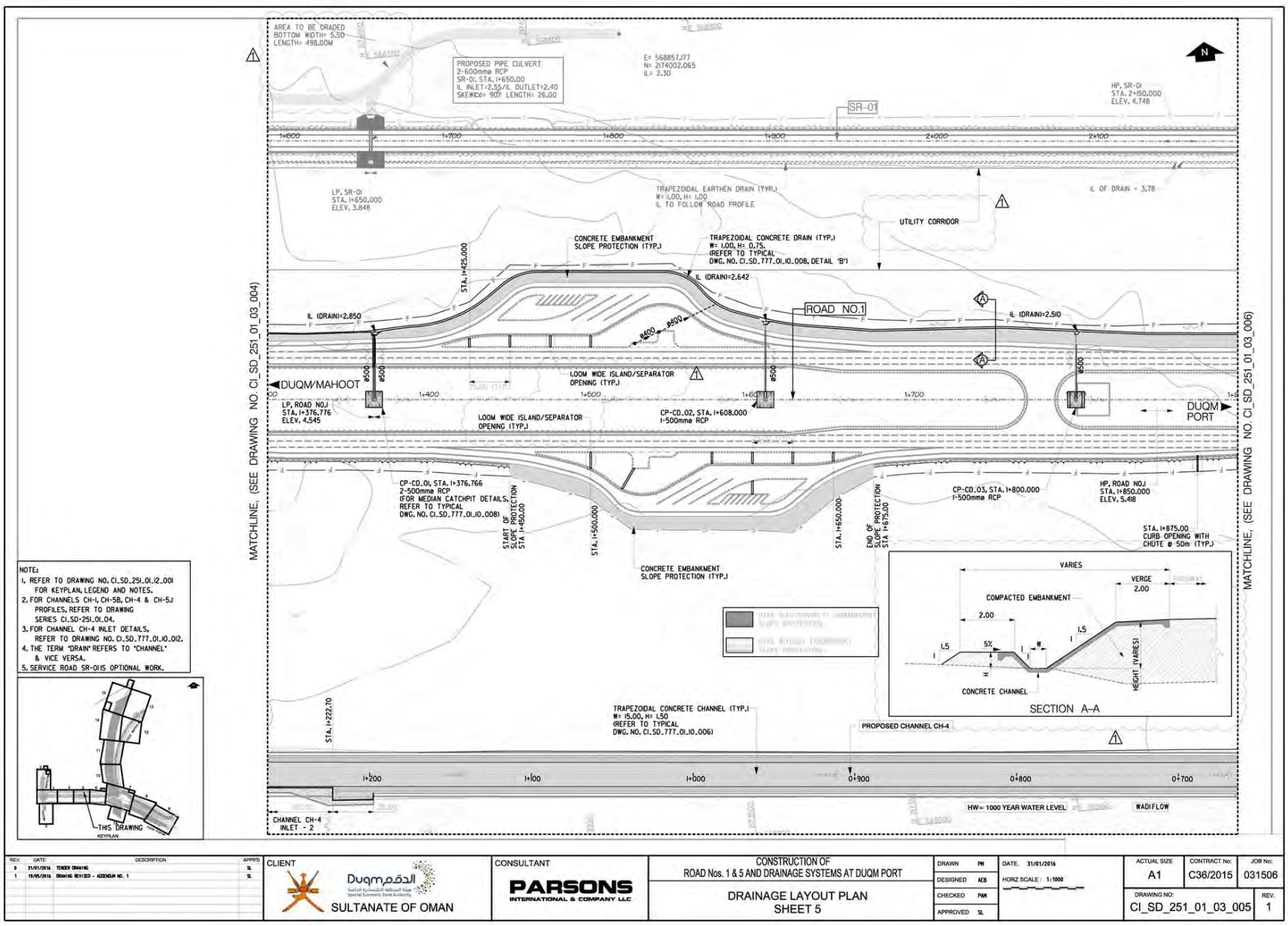
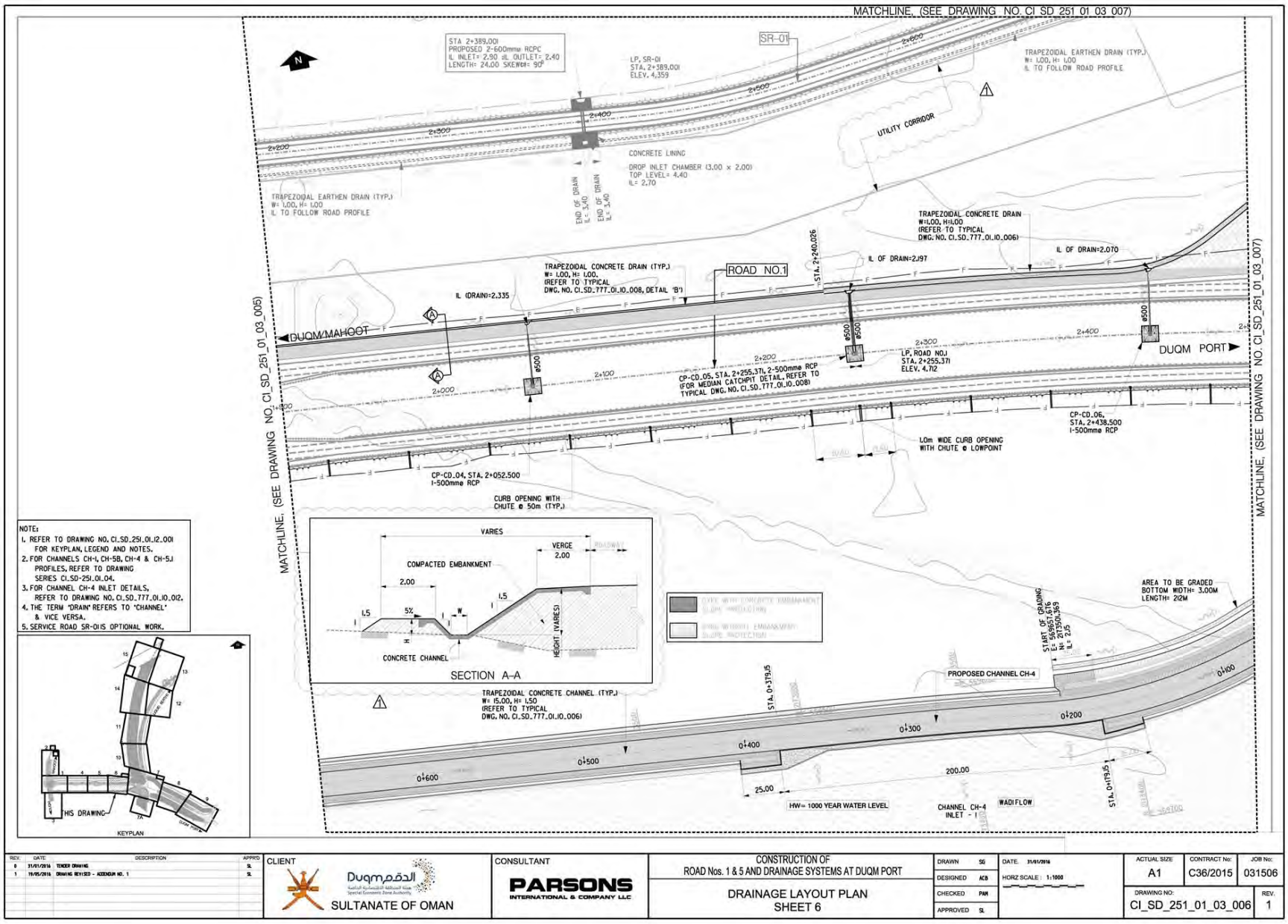


Figure 3-15: Detailed Drainage Layout Plan Section 4 &5



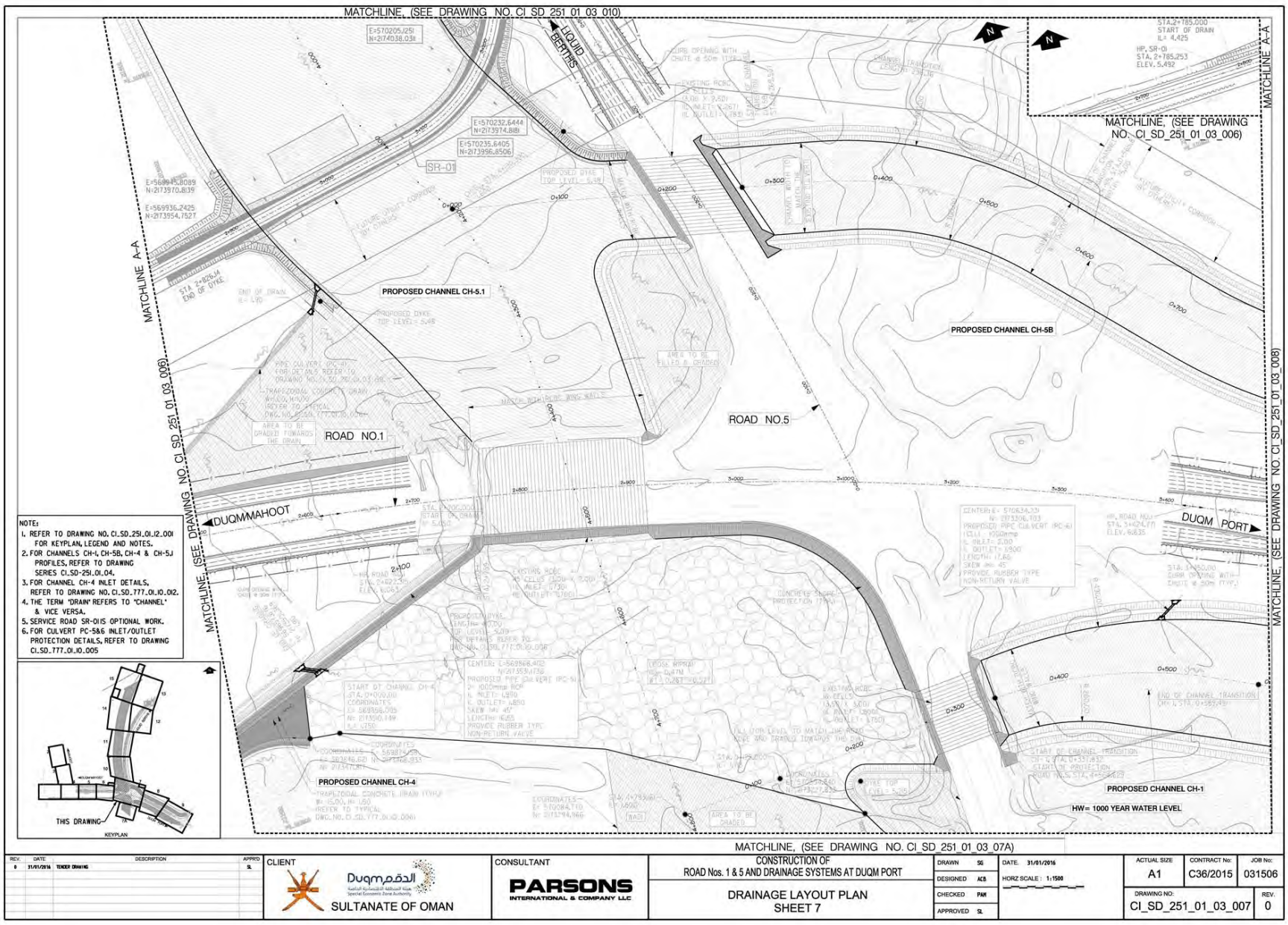
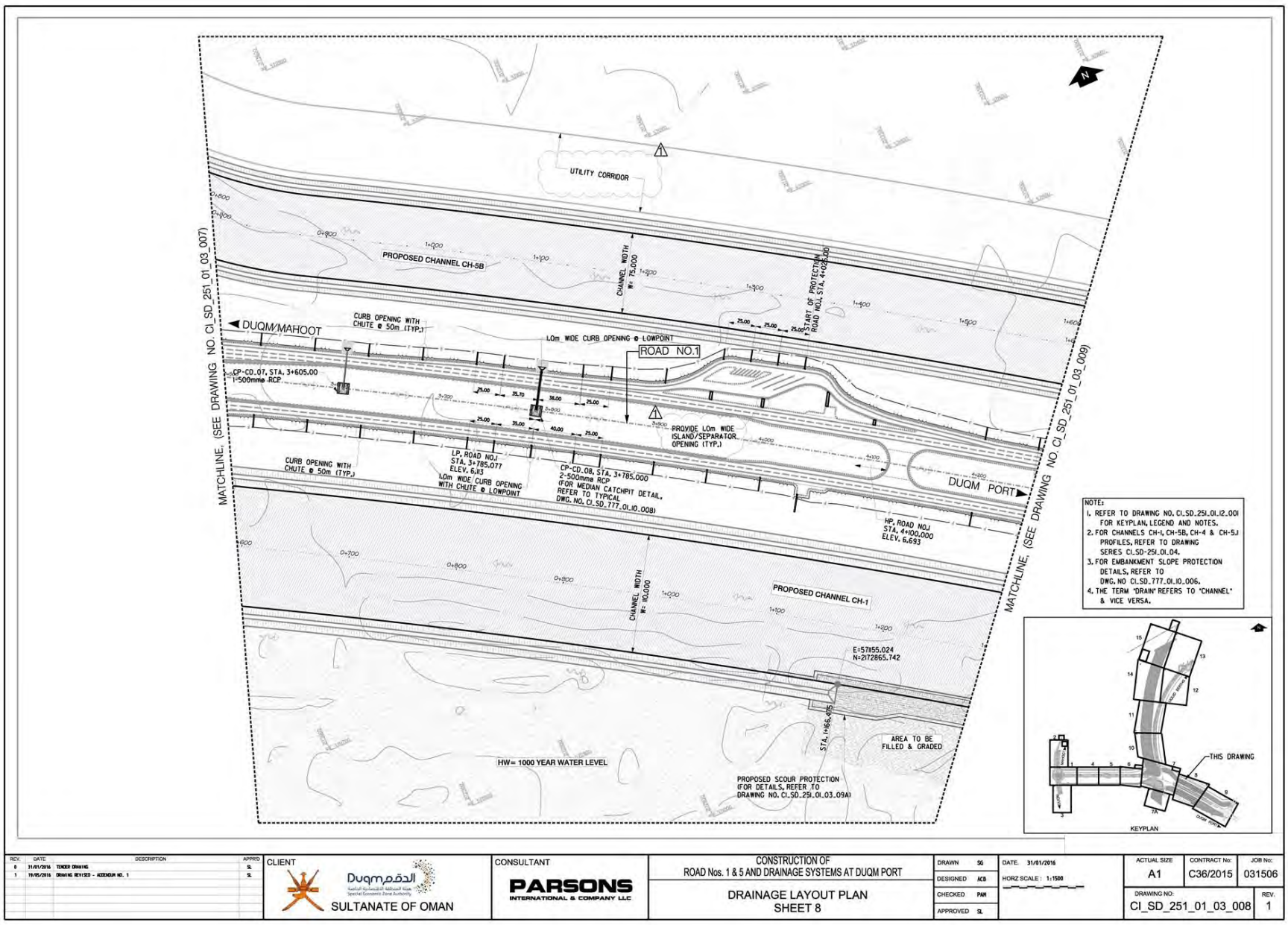


Figure 3-16: Detailed Drainage Layout Plan Section 6 &7



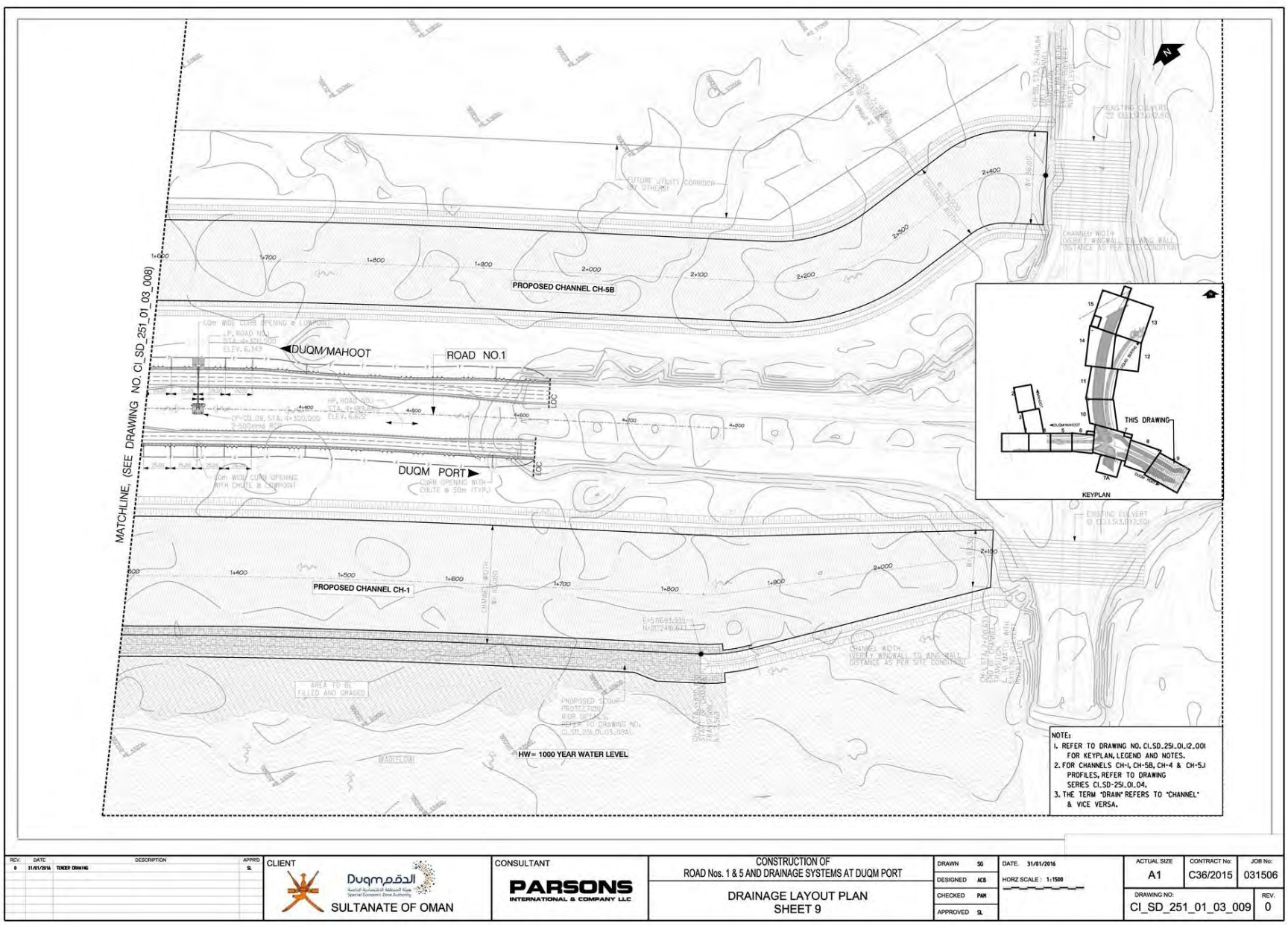
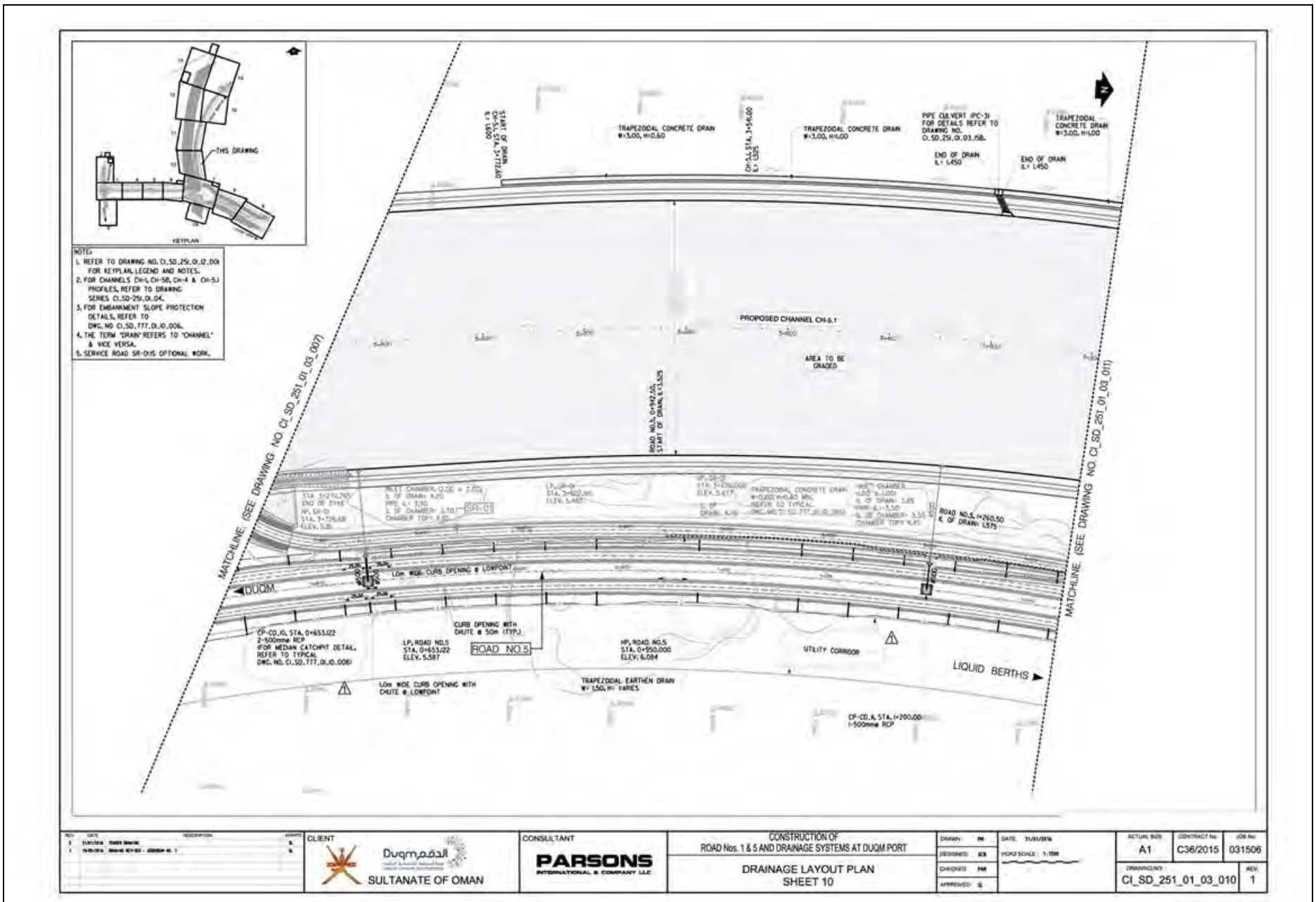


Figure 3-17: Detailed Drainage Layout Plan Section 8&9



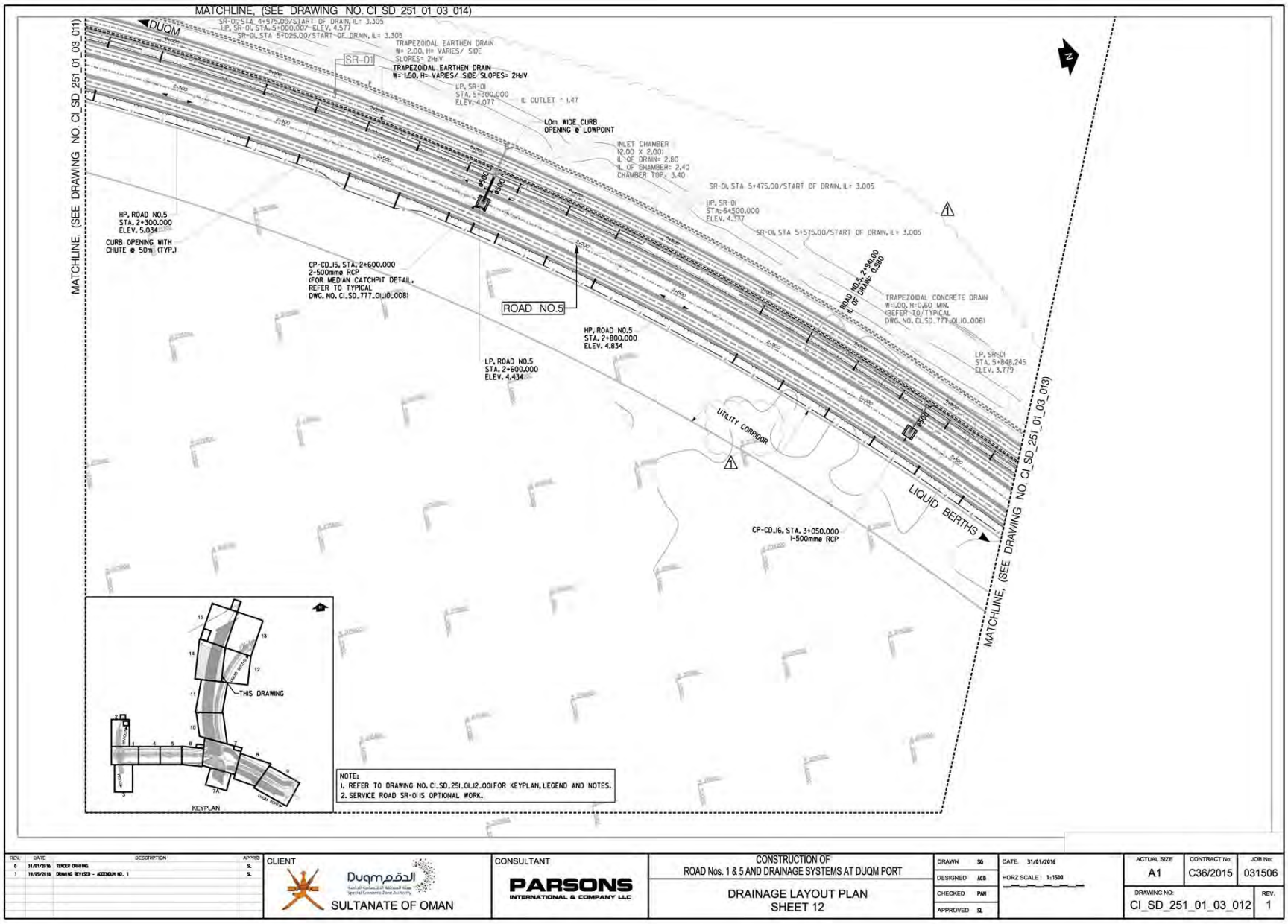
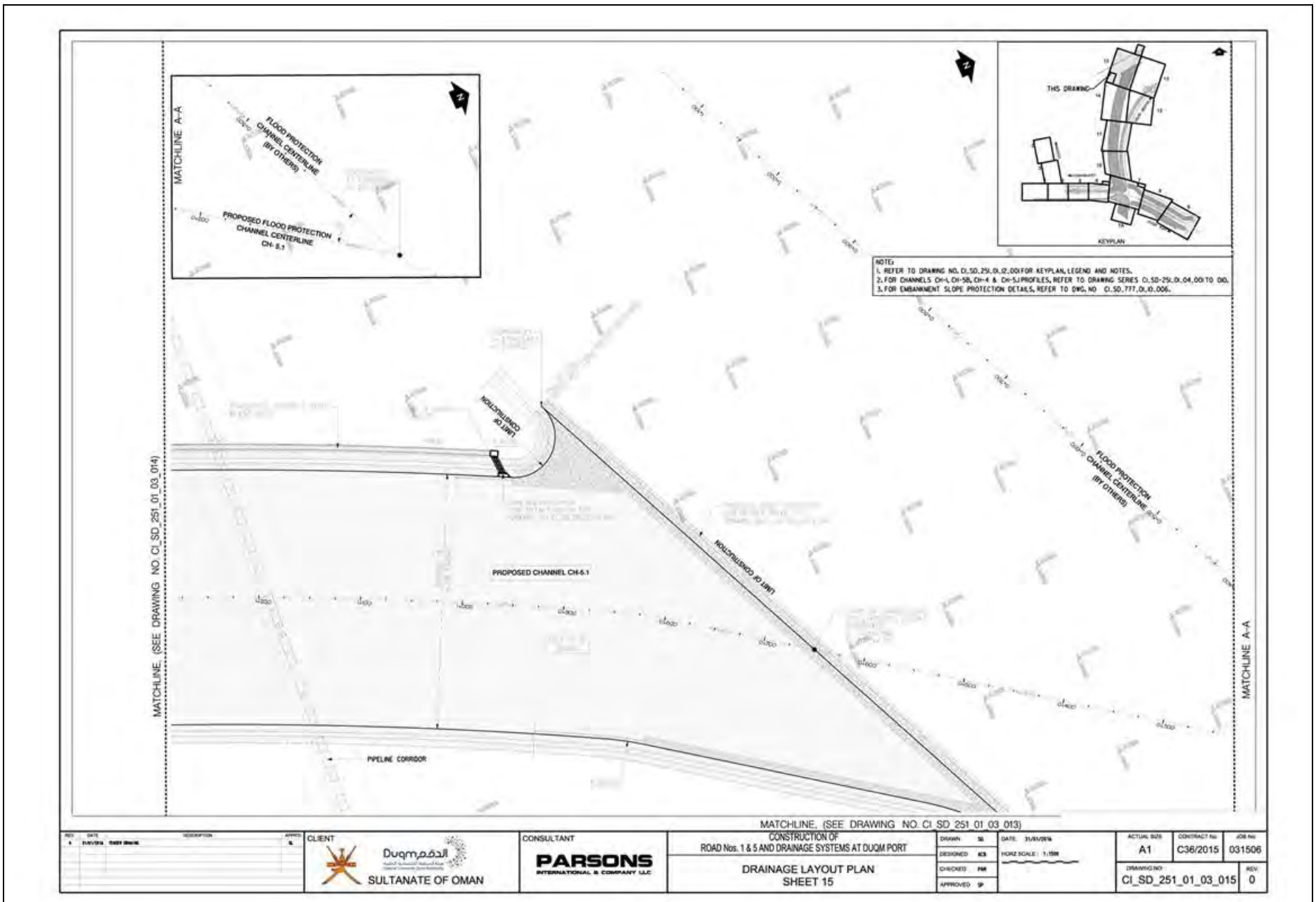


Figure 3-18: Detailed Drainage Layout Plan Section 10&12



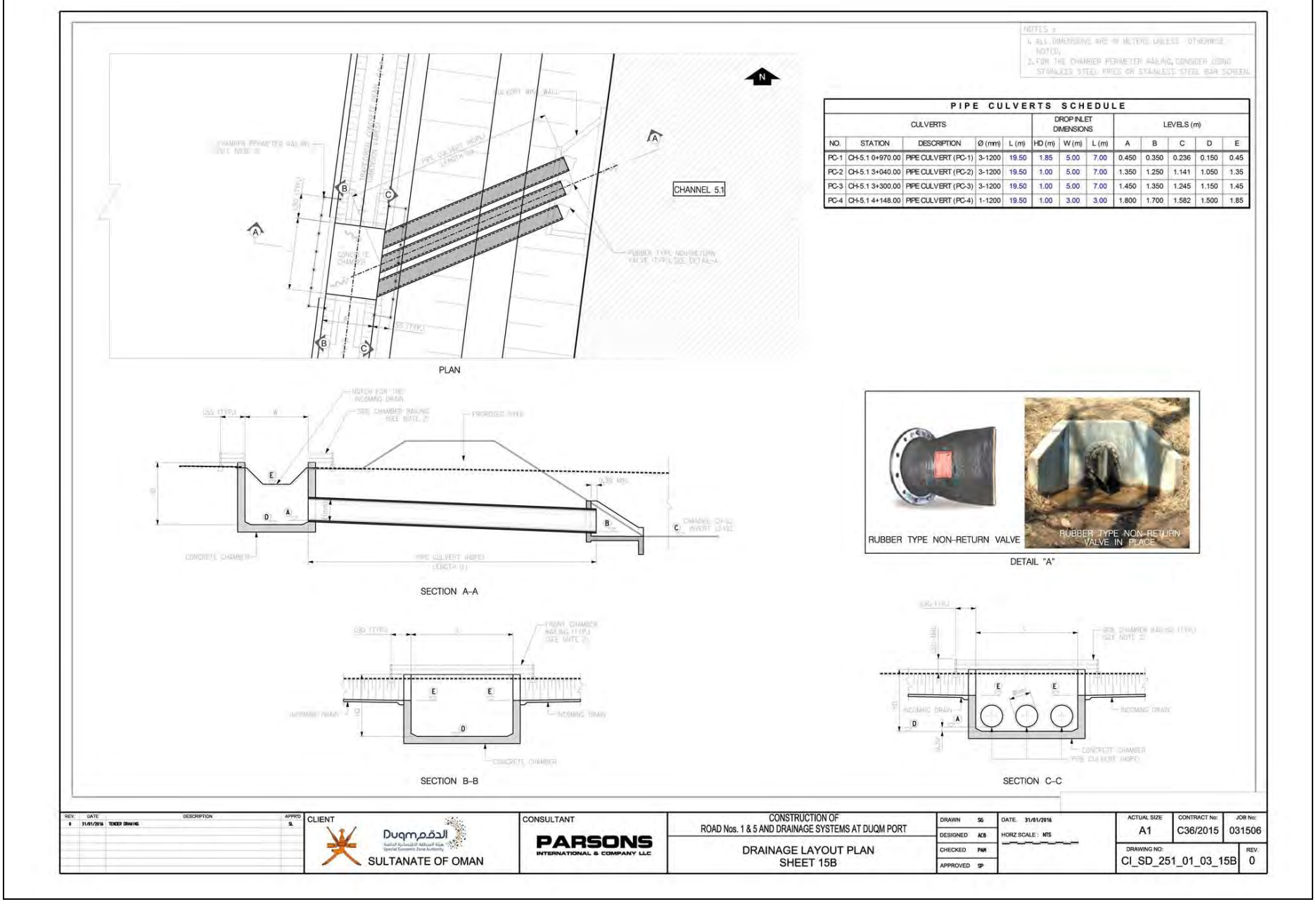


Figure 3-19: Detailed Drainage Layout Plan Section 15

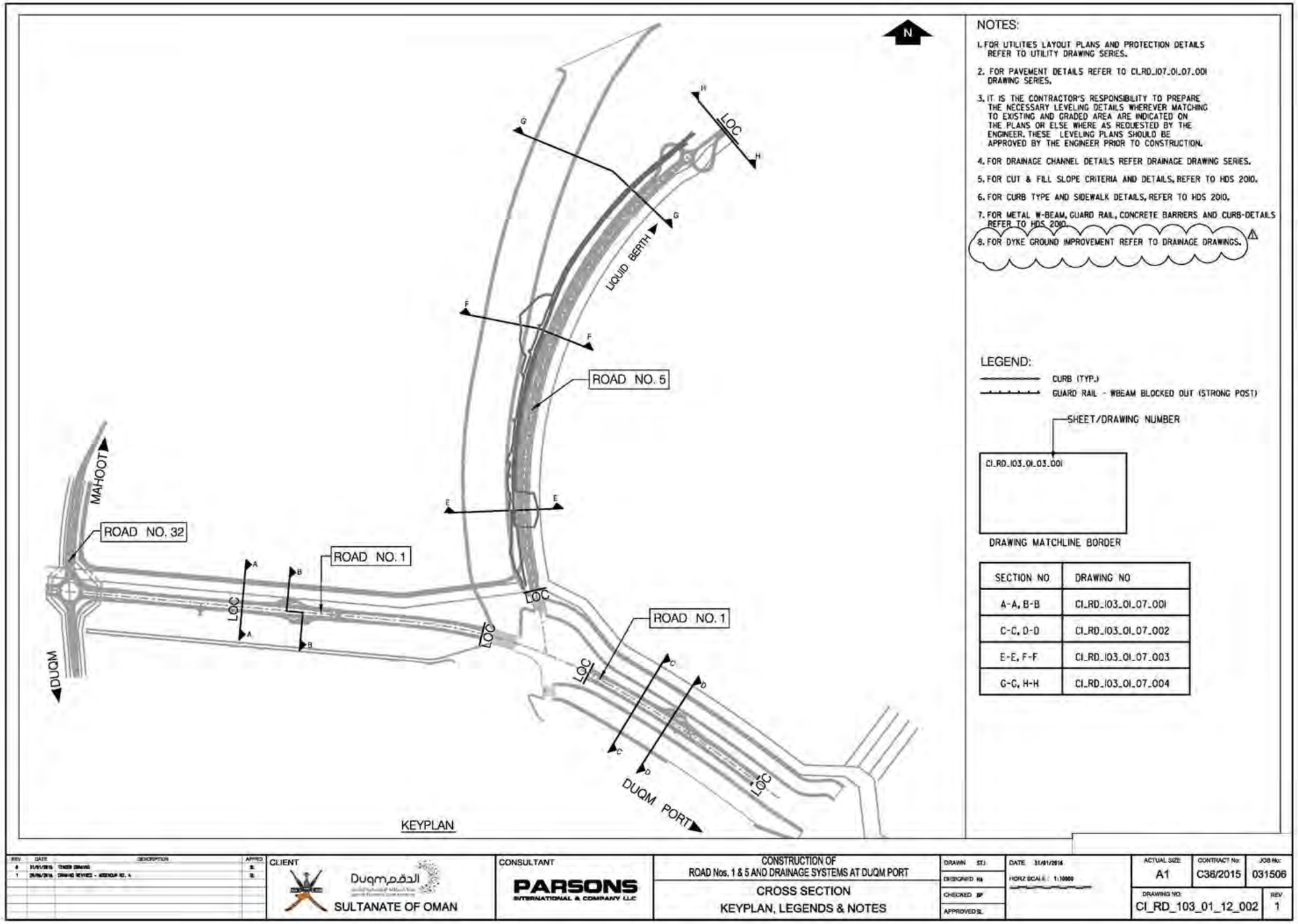
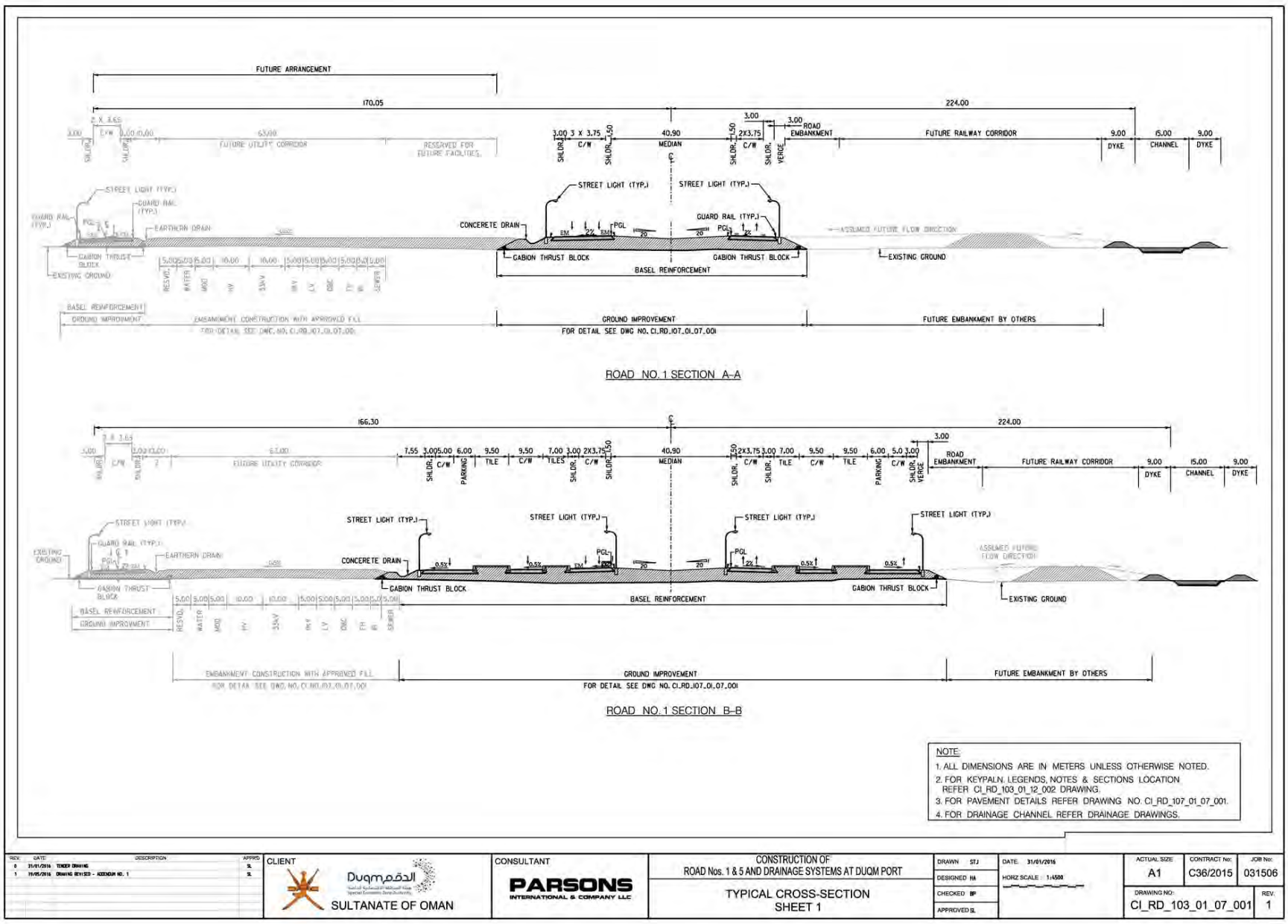


Figure 3-20: Cross-Section Details



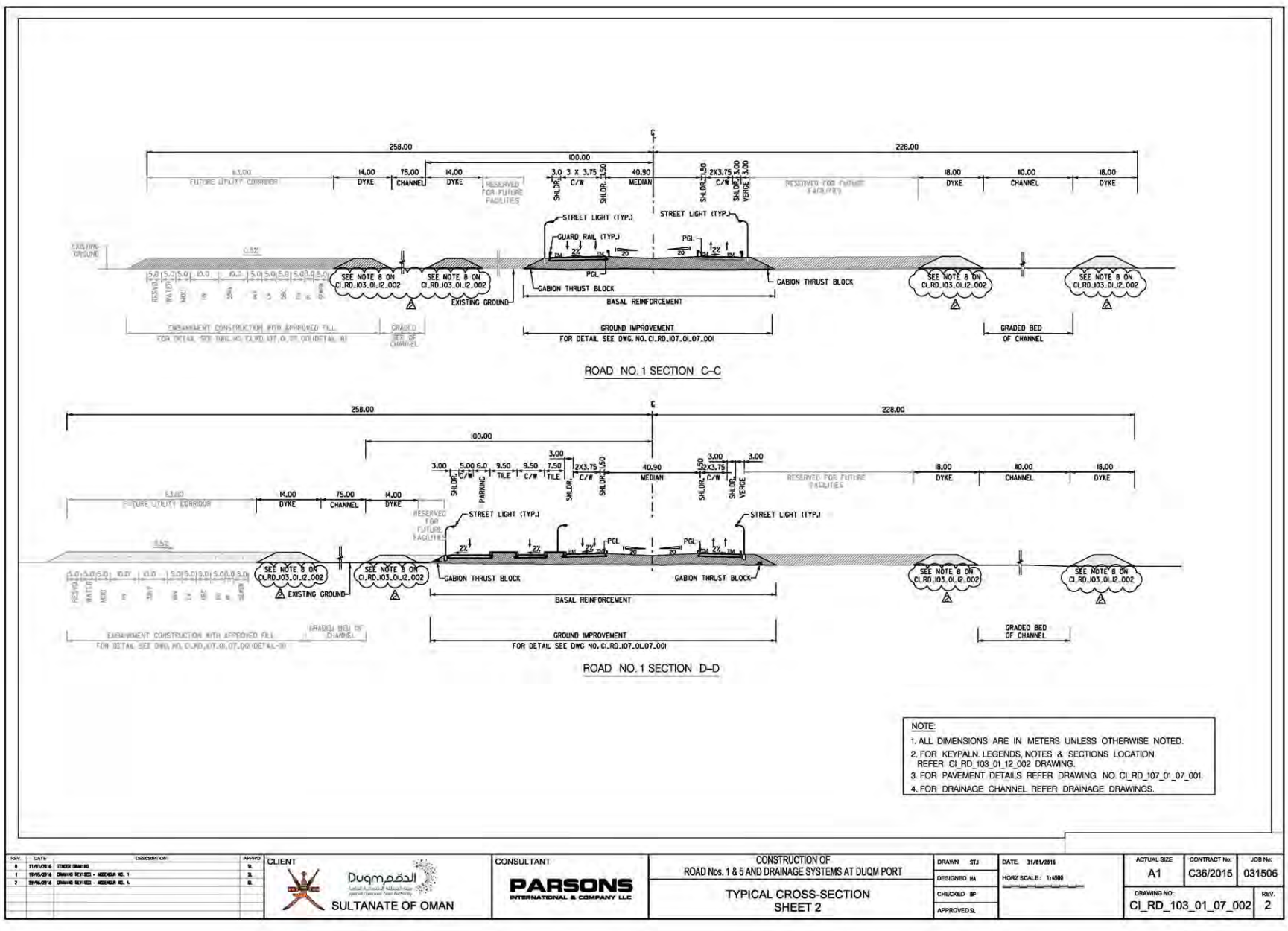
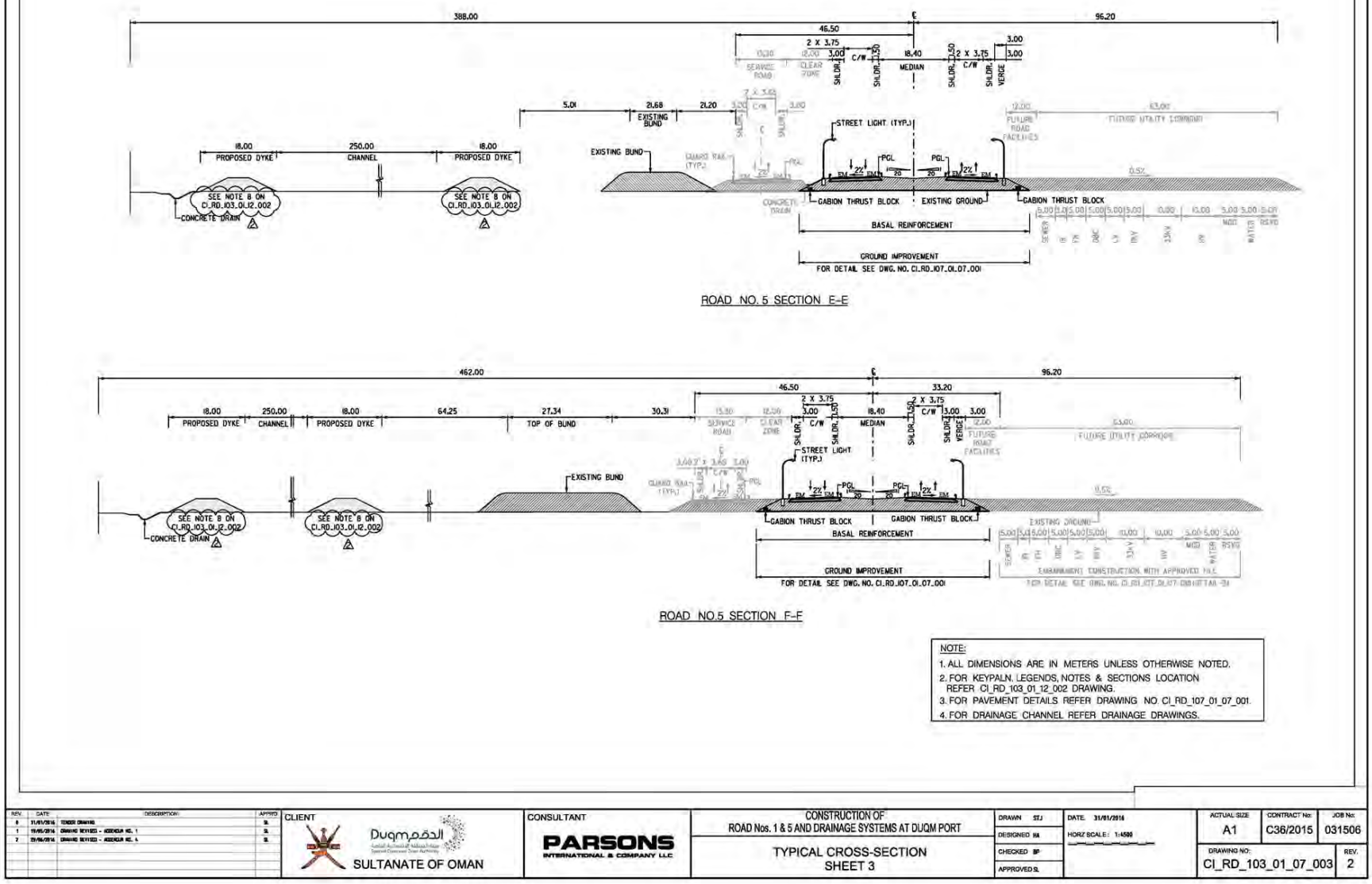


Figure 3-21: Cross-Section Details of Road-1



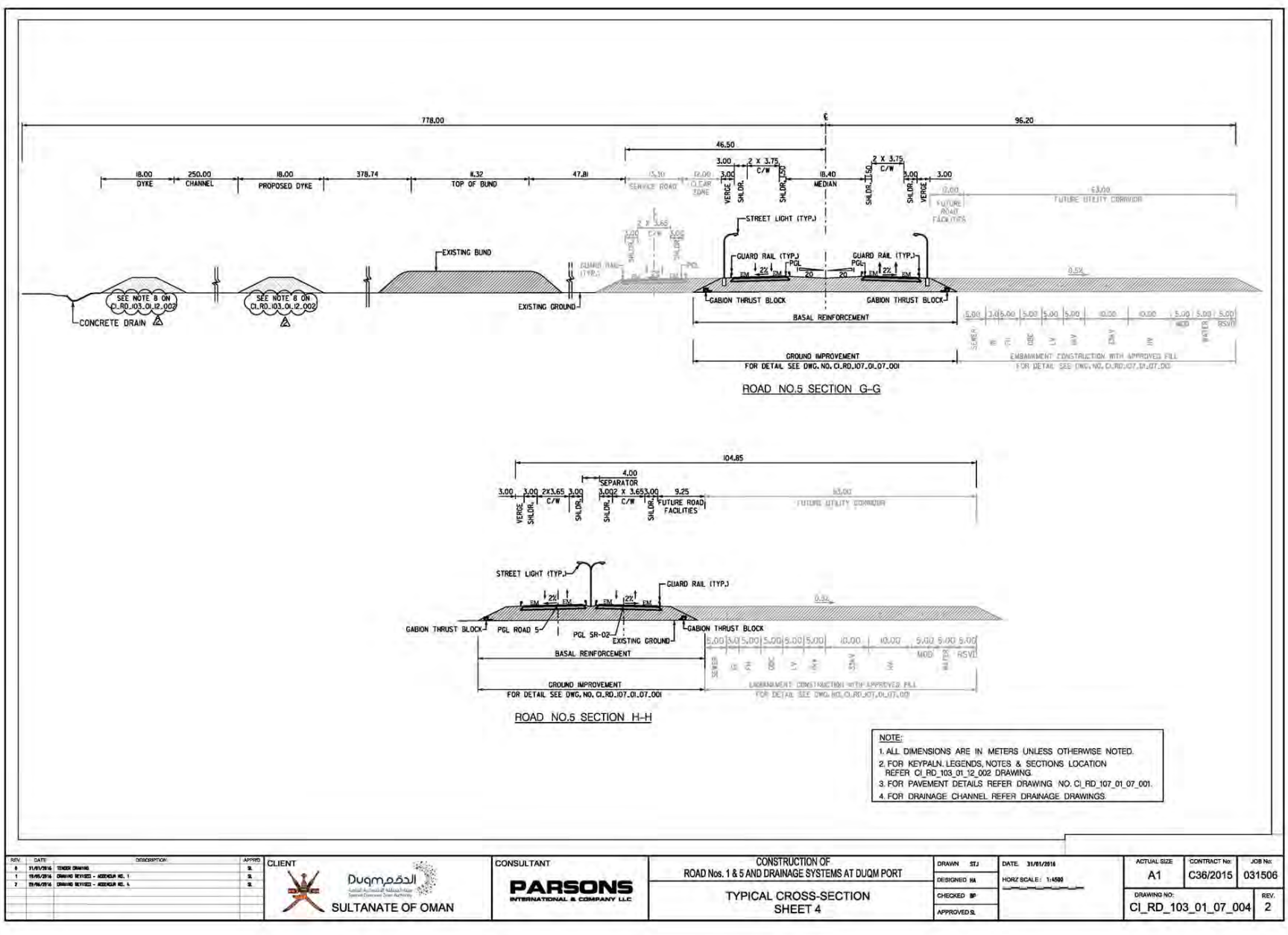


Figure 3-22: Cross-Section Details of Road 5.

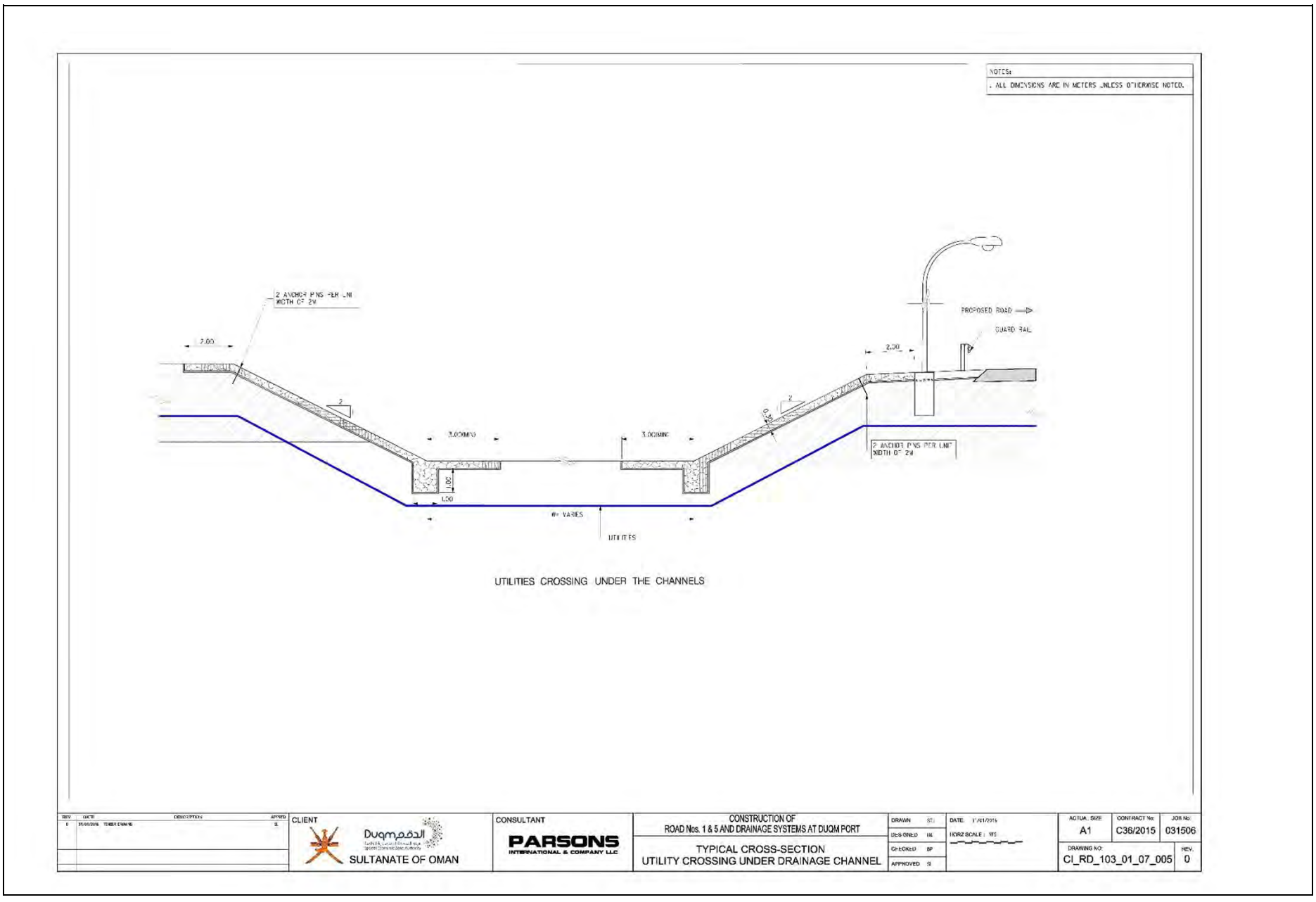


Figure 3-23: Cross-Section of Utilities crossing under the channels.

3.4 Construction Details

The Project construction will commence with site preparation efforts involving clearing and grading of site, allocating designated areas for properly cordoned construction yards with areas for storage, concrete and asphalt batching, water tanks, and steel storage. The various stages of construction will involve heavy machineries and equipment to carry out various construction activities such as excavation, cut and fill, metal works, concreting, and tarmac paving.

Road Construction thus involves the following major activities:

1. Route survey and setting up a working strip;
2. Site clearing and grading along the proposed route;
3. Cutting and filling;
4. Preparing a metal base along the proposed route; and
5. Providing a tarmac paving for the entire stretch of the proposed road.

It is anticipated that no construction labour camp, material laydown, or storage area will be established along the corridor of Road Nos. 1 and 5, since the existing ground is sabkha and relatively unstable.

3.4.1 *Working Strip*

All construction activities will be undertaken within a strip which is referred to as the "working strip" delineated by marker poles or alternatively barricaded with safety tapes especially in developed areas. In most cases the working strip will be less than 50 m although it may be increased adjacent to any road crossings. However, it will be decreased where there are physical limitations due to any existing development, such as alongside existing services or in areas of particular environmental sensitivity. The on-site temporary storage facilities for construction materials and construction wastes will all be located within the working strip.

3.4.2 *Site Clearing and Grading*

Generally, surface material which may impede construction such as loose surface rocks / soils and local surface features will be cleared and pushed to one side of the working strip. Vegetation such as grasses and shrubs within the working strip will be removed, but larger trees within the working strip will be avoided wherever practicable. In this Project, most parts of the site has very limited vegetation growth and large scale clearing is not required.

3.4.3 *Cutting and Filling*

Cutting and filling will be done by using heavy earthmoving equipment. Accurate estimates at this point of the Project will be difficult, but on the whole, it is anticipated that about 0.939 million m³ is expected to be cut of which about 2.473 million m³ will be used for earthen filling and 0.822 million m^3 rock filling. The remaining cut material, will be disposed at the local municipal waste disposal site in accordance with the Omani regulations. ***Table 3-4*** shows the expected estimates of the quantities will be required.

Table 3-4: Estimated Quantities

Item No.	Item Description	Unit	Quantities
1	Unclassified excavation	cu.m.	22,000
2	Excavation to waste (for removing the dumped material at site)	cu.m.	917,500
3	Borrow excavation to embankment, Dykes & utilities	cu.m.	2,473,800
4	Rock fill to embankment	cu.m.	822,150
5	Granular Sub-Base Course (Class B)	cu.m.	121,410
6	Crushed Aggregate Base Course (Class A)	cu.m.	111,300
7	Bituminous Base Course	cu.m.	51,230
8	Bituminous Wearing Course	cu.m.	17,690
9	Polymer Modified Bituminous Wearing Course	cu.m.	1,500
10	Double twisted hexagonal galvanized steel mesh	sq.m.	24,650
11	Unreinforced Concrete Class 16/20 for Culverts	cu.m.	601
12	Concrete Class 37.5/20 MS7 with migrating corrosion inhibitor in Reinforced Concrete Pipe Culverts	cu.m.	460
13	Reinforced Concrete Class 25/20 with migrating corrosion inhibitor for Floodways cut-off walls	cu.m.	1,100
14	High yield deformed steel bar reinforcement, Grade 500B, Type 2	t.	400
15	Reinforced Cement Concrete (Class 28/20) with corrosion inhibitor for Floodways Pavement	cu.m.	820
16	Loose Stone Riprap (Class B) of varying thickness for slope protection as shown on Dwg.	cu.m.	68,300
17	Geotextile Fabric Filter	sq.m.	119,700
18	Polyamide coated Gabion mattress lining of varying thickness	cu.m.	122,870
19	Polyamide coated gabion thrust blocks as shown on dwg.	cu.m.	9,020
20	Reinforced Concrete Slope Protection with migrating corrosion inhibitor 100mm thick (1.2m x 1.2m Panels) including reinforcement	sq.m.	21,600
21	Concrete Lining (150mm Thick with migrating corrosion Inhibitor) with wire mesh	sq.m.	138,700
22	W-Beam Guardrail (Strong Post) including W150 x 13.5 Steel post	lin.m.	43,000

3.4.4 *Construction Equipment & Plants*

The equipment used for construction work include batching plants, crushing machines, Asphalt batch mix plants, hot mix plant (HMP), excavators, shovels, dozers, rock breakers dumpers, tippers, vibrators, compactors, rollers, graders, mobile cranes, water tankers, trailers and diesel generators. Most of the equipment will be operated during the daylight hours only. Although it is difficult to make an exact estimate of the number of equipment that will be used so early in the Project, the actual quantity may vary based on approved tender clause 14 program during the execution stage, a projection is presented in ***Table 3-5*** below:

Table 3-5: Construction Equipment

No	Item Description	Estimated Plant
Plants		
1	Batching Plant (90 Cum/Hr) & its Associated Equipment's	1
2	ABC Plant (200 Tone/ hour)	1
3	HMP Plant (160 Tone/hour)	1
Equipment		
1	Grader	8
2	Vibratory Roller	11
3	Front End Loader	12
4	Excavator	12
5	Dozer	10
6	Water Tanker	15
7	Tipper 18 cum	79
8	Paver	2
9	Tandem Roller	3
10	PTR (Pneumatic Tyred Rollers)	3

3.4.5 *Resource Requirement*

The list of construction materials and utilities required for the project construction, their sources of supply, mode of transport and on-site storage facilities are presented in ***Table 3-6*** below. At this stage, precise estimates and material quantities have not been yet derived by the project planners.

Table 3-6: Materials and Utilities Required during Construction

Construction Material	Supply Source and Mode of Transport
Fill materials and aggregates	Use of excavated material from local approved quarries by road trucks
Metal	Approved suppliers - to site by road trucks
Cement	Approved suppliers - to site by road trucks
Mixed Asphalt	Approved suppliers - to site by road trucks

Construction Material	Supply Source and Mode of Transport
Paints and other surface coating materials	Approved suppliers - by road trucks and tankers
Lubricating oils and greases	Approved suppliers – by approved road trucks
Chemicals	Approved suppliers - by approved road trucks
Freshwater	Approved suppliers - to site by road tankers
Electrical power	Onsite diesel generators
Diesel oil	Approved suppliers - by approved road tankers

3.4.6 *Construction Workers*

During construction, the peak labour requirement for civil, mechanical, and electrical works is envisaged to be in the order of 200 workers. It is expected that wherever possible local contracting companies will be engaged as sub-contractors.

3.4.7 *Utilities*

The supply source and mode of transport for freshwater, power, and fuel are described in ***Table 3-7***. The preliminary estimates for the requirement of utilities were not available during the time of preparation of this report.

Table 3-7: Utilities Required During Construction Phase

Utility	Supply Source and Mode of Transport
Freshwater	From the existing local desalination plant in Duqm
Construction water	From the existing local desalination plant in Duqm. It will be supplemented with treated sewage if any onsite STP is set up as part of the roadway construction.
Electrical power demand	From diesel generators or from the local grid if available.
Fuel	From approved retailers and transported in dedicated road tankers

3.5 Project Timelines

The Project timelines are provided below:

- Receive SEZAD Instruction to Proceed - March 04, 2015;
- Mobilization – March 04, 2015 to April 05, 2015;
- Data Collection - March 04, 2015 to May 14, 2015;
- Traffic Study and Analysis – March 23, 2015 to October 18, 2015;
- Geotechnical Investigations – March 16, 2015 to July 30, 2015;
- Concept Design –March 04, 2015 to September 09, 2015;
- Topographical Surveying - May 17, 2015 to October 04, 2015;

- Preliminary Design – May 25, 2015 to October 05, 2015;
- Detailed (Final) Design – August 03, 2015 to December 03, 2015
- Tender Documents – Submission – January 05, 2016
- Tender for construction announcement – April 25, 2016;
- Tender Period - 25 April 25, 2016 to July 19, 2016;
- Award of Construction Contract - March 23, 2017; and
- Construction Period - July 03, 2017 to July 02 2019.

4 ENVIRONMENTAL BASELINE

In this chapter, a description of the environmental baseline based on the desktop assessment and review of the information available from previous studies has been carried out.

4.1 Overview

This existing environmental baseline summary has utilised information extracted from HMR's archives, existing HMR reports, and other documents primarily related to the:

- *Environmental Baseline Studies for the proposed Duqm Refinery & Petrochemical Industries Company (Duqm Refinery) site* (HMR, 2014b);
- *Environmental Baseline Studies for Duqm Development and Surroundings for SEZAD* (HMR, 2014a; HMR, 2013b; HMR, 2013c; and HMR, 2013d);
- *Environmental Baseline Studies for Duqm Seawater Intake Project (SWIP) for Parsons / CUC / SEZAD* (HMR, 2015a); and
- *Environmental Baseline Report for Service Corridor - EIA for Service Corridor, Duqm for SEZAD*, July 2015 (HMR, 2015b)

The environmental baseline studies includes review of secondary data available from the above studies carried out by HMR in Duqm, apart from the primary data of geotechnical investigations study commissioned by Parsons and carried out by Swissboring.

The detailed baseline characterization of the ecology, hydrology, hydrogeology, geology, meteorology, air quality, and socio-economic data of the area is used to assess the significance of the Project environmental aspects and subsequently to reduce potentially significant environmental impacts such that this Project evolves into a more socially and environmentally sustainable project.

4.2 Topography and Landscape

The general topography of the Project site is similar to the other undeveloped areas along the Duqm coastal area. The surface features of undeveloped areas along the coast near the Project site consist of coastal dunes and belts of scrub starting approximately 500 m inland. Further inland from the shoreline, featureless sabkha with sparse vegetation is observed in the northern area of the proposed site.

It is found that the Project site is uneven, and for some parts filling and construction work is in progress. The ground levels along Road Nos. 1 and 5 vary according to the topography. The existing ground along Road No. 1 is generally covered with sabkha deposits comprised of very silty / clayed fine sand / gypseferous sand with some shell gypsum crystals and shell fragments. At some locations the soil is moist and water bodies were found in the site which indicates the ground water level is high in this area.

Existing ground surface along Road No. 5 is found to be covered with brown to reddish brown clay and clayey sand with gypsum. From the Swissboring boreholes, it is seen that the sabkha soft soil layer extends to the depth ranging from 3.5 m to 8.0 m below the existing ground level (Swissboring, 2015). From previous drillings, it was observed that the sabkha deposits depth extended up to 5.0 m below the existing ground; and beyond that, marl or grey mudstone was observed.

As indicated previously, Sabkha is an Arabic term used locally to describe relatively fine-grained, hypersaline, silt and sand deposits, which are typically saturated with brine and are salt-encrusted. These deposits form in natural evaporation pans or basins where saline water, introduced by sea encroachment or elevated saline ground water level, is able to accumulate at a new ground surface level. Sabkha has a characteristic of possessing low shear strength, high compressibility, and high salt content, and accordingly, this is not a suitable material to use as embankment.

The topography of the Project area is more or less flat terrain, ranging from low-lying coastal and alluvium plains. The low-lying coastal and coastal alluvium plains are confined to the Eastern side of the study area and the North West – Western side comprises with alluvium plain. The ground surface features of undeveloped area along the coast, near to the project site consist of limited coastal dunes extend up to 10 to 20 m from the shoreline.

4.3 Geology

This section draws on information HMR has in its archives from the Ministry of Petroleum and Minerals for Geology, and sourced from the former Ministry of Regional Municipalities, Environment, and Water Resources (MRMEWR, 1997).

4.3.1 *Regional Geology*

The geology mapping for Duqm (Clarke, 1990) shows formations from four different ages intersect in this region with evidence of surface geology from:

- Palaeozoic and Pre-Cambrian era [289 – 650 million years ago (MYA)];
- Lower Cretaceous, Jurassic, Triassic and Permian periods (96 – 289 MYA);
- Upper Cretaceous epoch (65 – 96 MYA); and
- Tertiary age (1-65 MYA).

The regional geological settings of the Duqm consists of the Permian basement Huqf Group which further consists of the Buah Formation (interbedded dolomite / stromatolites), the Shuram Formation (thin-bedded silty shales with oolitic limestone) which is exposed on the coast; and the massive dolomite with chert limestone Khufai Formation exposed northwest of Duqm.

West of the Sanah to Duqm road, north of Ghubbat Hashish and Mahoot (Hay) the geology consists broadly of Quaternary drift deposits (sabkah and sand deposits) overlying the Simsima Formation, whilst immediately east of the road very ancient to Ancient alluvial fans are interspersed with sub-recent to recent fans. The Sabkha group comprised of clay-silt deposits and fine-grained brown yellow sand with small gypsum crystals. The beach sand consists of recent coastal dunes and Aeolian sand veneer, with the small area of Sub-Recent to Recent marine silty clay.

The stratigraphy underlying the western side towards the Bahja Asset is general dominated by Quaternary drift deposits underlain by the Tertiary Fars Formation, which is in turn underlain by the Hadhramaut of which the Umm Er Radhuma (UER) in a component. The drift deposits are typically 0 to 1 m thick, and the underlying Fars ranges in thickness between 80 to 120 m. The Fars is comprised of compact limestones, mudstones with intercalated gypsum and shale layers. The Hadhramut group of formations consists of the UER, which may be encountered at approximately 200 m below ground surface; and the Rus formation, which is absent from some areas, but typically, has a thickness of between 80 to 100 m and consists of evaporites with intercalated shales and marls overlying the Fars.

4.3.2 *Local Geology*

The local geology information for the Project area (MRMEWR, 1997) intersects several different geological formations. The central portion of the Project area consists of coastal (Qm), sabkah (Qb), and alluvium (Qf) deposits as shown on ***Figure 4-2***. These deposits are of Quaternary age and the sediment grains consist of fragments of fossils, limestones, and dolomites, and other carbonate grains,

or some combination of these. The limestone formation is predominantly composed of detrital (transported) sand, corals, shells, pellets, and other carbonate grains.

As indicated previously in Section 4.3, Sabkah is a flat, often broad, salt-encrusted depression which has formed when floods intermittently leave a salt crust when the water evaporates. The cemented broken limestone fragments cover alluvium fans at the outlets of major wadis where there is an abrupt break of slope. Fine grained to gravelly alluvial deposits in small closed basins are widely developed. Channeled alluvial deposits occur not only on old terraces but also in the recent beds of present day wadis in the study area.

The surface geology of the site is made up of recent to ancient piedmont deposits and sabkha with the Lower Ecocene Sirab Formation exposed in places. This is composed largely of marl and chalky limestone.

As part of the design process, Parsons commissioned Swissboring to carry out geotechnical investigation with the objective to obtain technical advice for the treatment of sabkha material and high water table, and propose remedial measures to overcome the constraints. This also includes verifying the previous geotechnical investigation work done by others along Road Nos. 1 and 5.

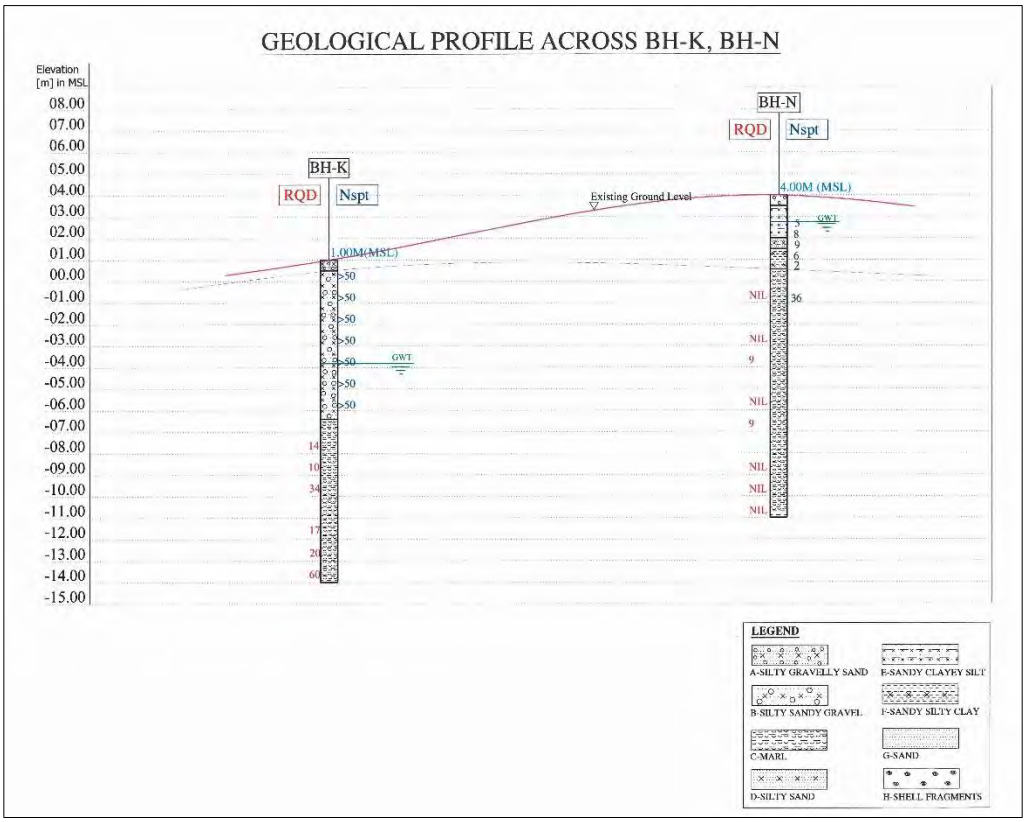
The Swissboring geotechnical investigation consultancy services for the Project Road No.1 and 2 and Drainage Systems at Duqm commissioned by Parsons is reported in the "*Factual Geotechnical Investigation Report, Road 1 & 2 and Drainage Systems at Duqm, June 2015*" referenced as Swissboring, 2015. To avoid confusion it must be noted that these geotechnical investigations were conducted along the length of the road alignments referred to by all others (HMR, Parsons, and SEZAD) as Road No.1 (east-west orientation) and Road. No.5 (north-south orientation).

Swissboring drilled 5 boreholes with depth up to 15 m below existing ground level and 16 trial pits with depth up to 1-3 m below existing ground level (Swissboring, 2015). Location are presented in the ***Figure 4-3.***

The geotechnical investigation was to assist in determining the properties of the existing soil under the proposed Road Nos. 1 and 5, preparing soil profile drawings showing the terrain, location of test pits and boreholes, types of soil / rock strata encountered, and summaries of test results, obtaining subsurface data for stabilization in potentially unstable areas, locating the sabkha layer under the proposed carriageway, and designing existing ground improvement measures along the Road Nos. 1.

Although the intention was to have trial pits to a depth of 3.0 m, at some locations, cemented soil or rock layer was encountered leading to excavating only to a shallow depth and at other places, groundwater was encountered above 3.0 m depth and excavation had to be terminated.

3 out of the 5 boreholes were in the sabkha area and the soft soil layer extended down to a depth ranging from 3.5 m to8.0 m below the existing ground level. The layer was underlain by very weak to moderately strong marl down to the investigated depth of 15.0 m. Geological profiles across the boreholes is presented in the Figure below.



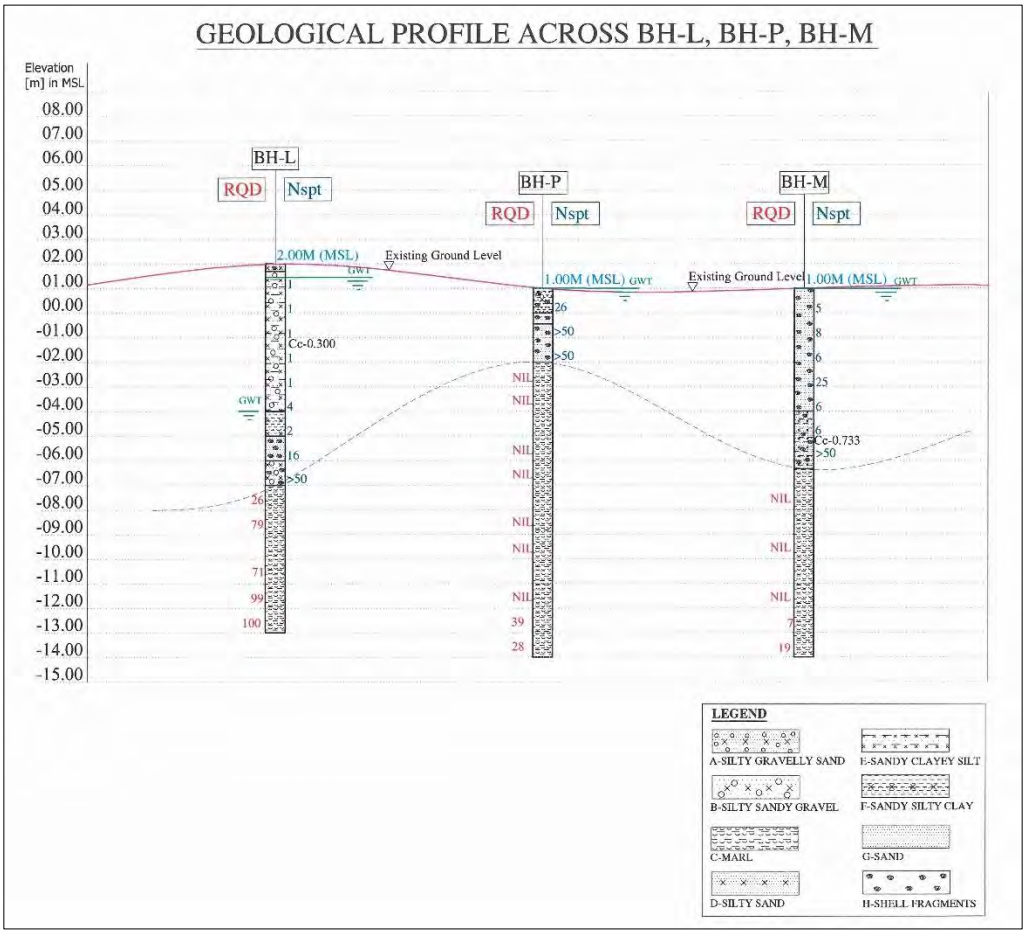


Figure 4-1: Geological profiles across the boreholes

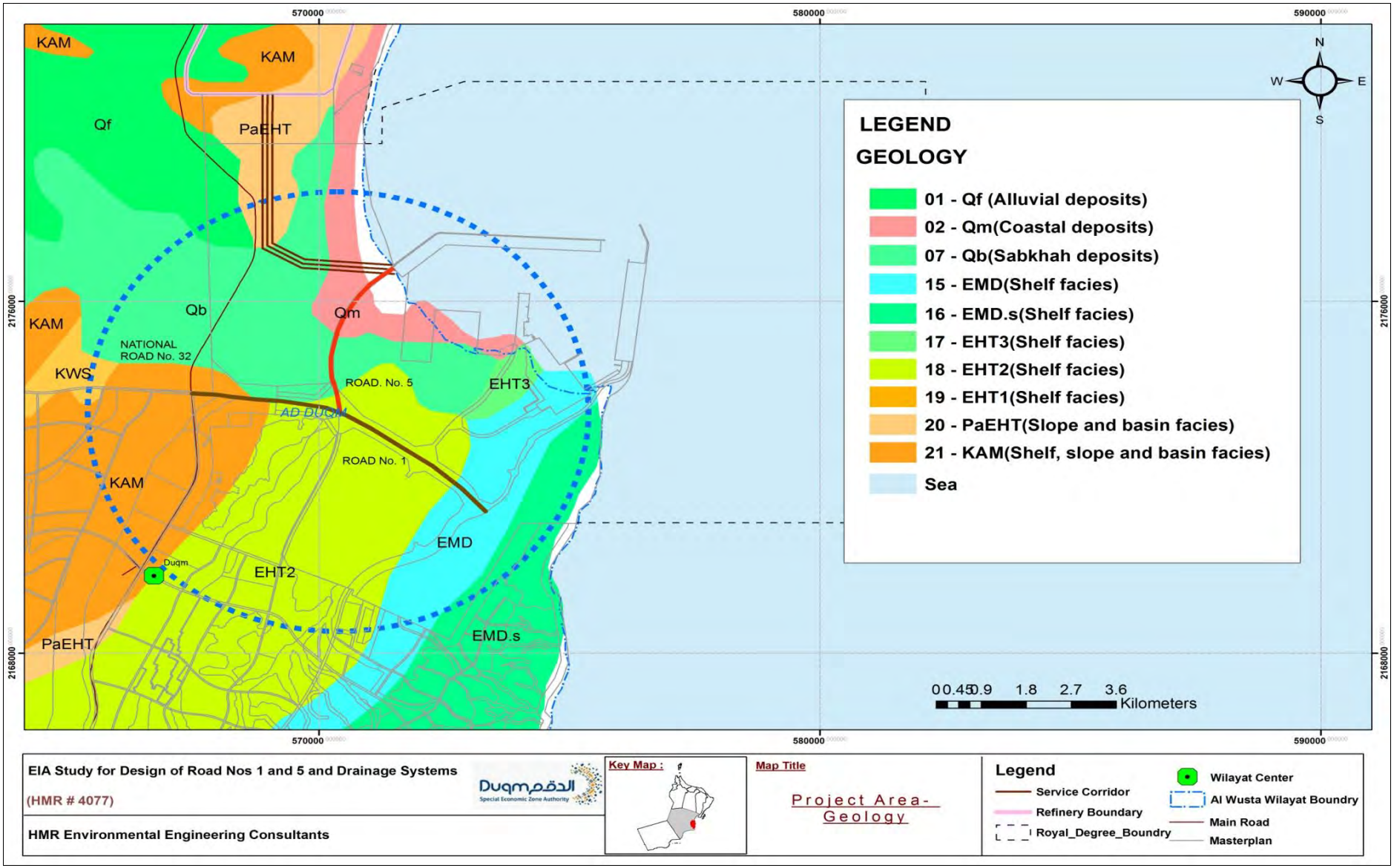


Figure 4-2: Project Area - Geology Map

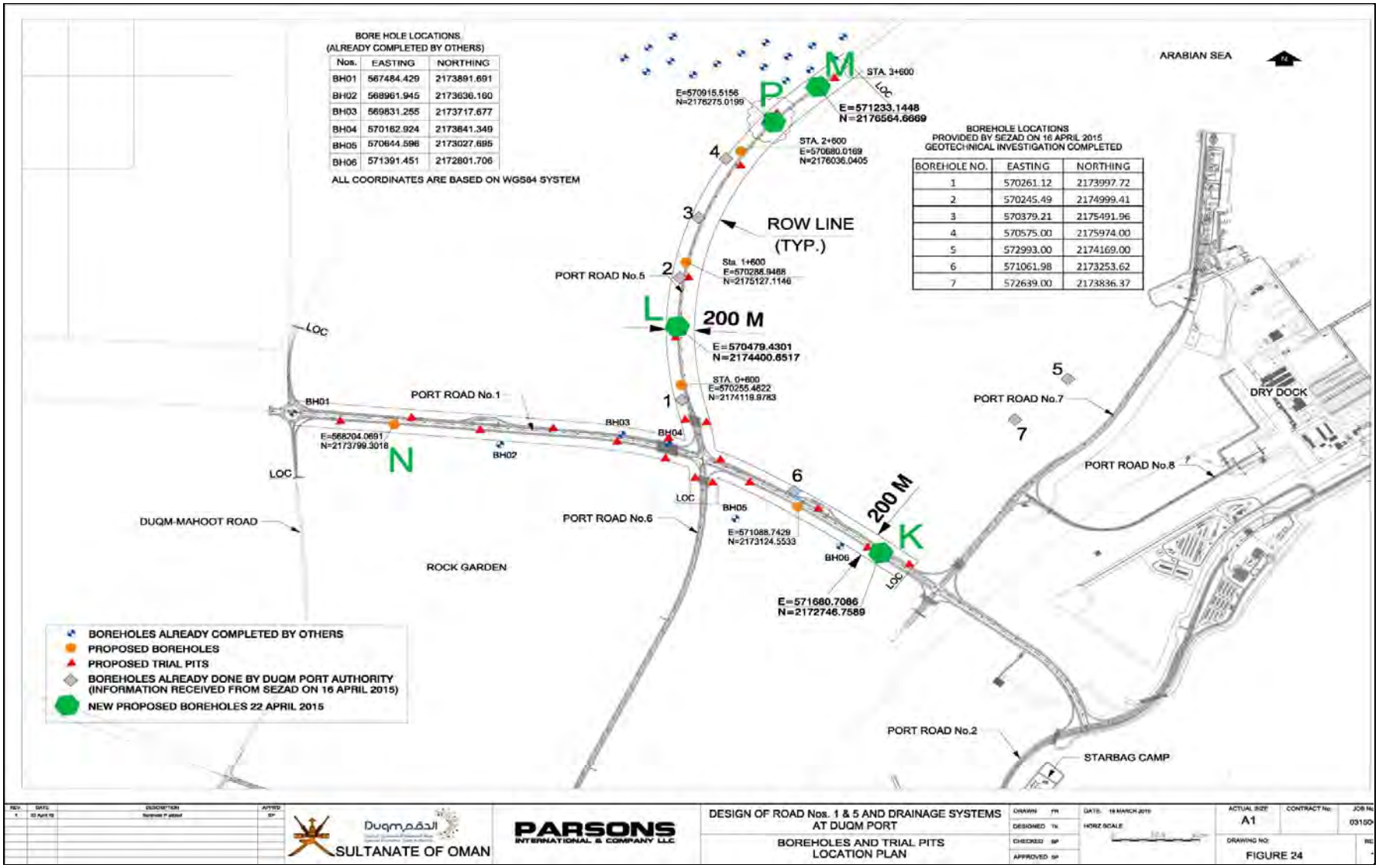


Figure 4-3: Boreholes and Trial Pits Locations

4.3.3 *Soil Sampling*

As part of the Duqm Refinery environmental baseline study (HMR, 2014b), and the Duqm Service Corridor environmental baseline study (HMR, 2015b) composite soil samples were collected and analyzed to capture primary information on subsurface conditions within the geotechnical investigations that were carried out. In lieu of applicable Omani standards for soil quality, the soil analysis results were compared with the USEPA Site Notification Standard 2008 for Residential and Industrial Soil, and the Dutch Intervention Values for Soil Remediation (DIVSR, 2000).

These previous soil investigations have reported that the soils were found to be alkaline with pH values ranging from 7.7 to 9.1 for all samples, which is common for soils in low rainfall areas. Analytical results for the soils showed no indication of contamination and in particular no evidence of hydrocarbons. The remaining parameters in the samples are well within the specified limits of the applicable guideline values with the exception of Arsenic, which was reported higher than the USEPA standard (2008) but was less than the Dutch value (2000).

The high arsenic levels are attributed to naturally occurring arsenic in the environment due to the age of the geologic formation of the area. Literature review explains that geologically composed marine deposits, like bioclastic limestone with molluscs and scarce corals, along with white chalky limestone and biocalcarenite are contributing to the higher arsenic concentrations (Madany, 1996). Higher arsenic values were also observed during the soil sampling undertaken for the Environmental Baseline Study for Duqm Development and Surroundings (HMR, 2013b).

4.4 Hydrology

This section draws on information HMR has in its archives from Ministry of Regional Municipalities and Water Resources (MRMWR) for Hydrogeology and Hydrology.

4.4.1 *Groundwater Hydrology*

The Project area is underlain mainly by Tertiary sediments of the Hadramout group. The main aquifer is the UER formation. Recharge occurs through the regional aquifer system and it is approximately 200 m below ground level. It constitutes the main regional aquifer in the Najd (Southern Oman), with groundwater salinity increasing from fresh in the area of Dhofar Mountains to saline with proximity to the ocean in the Al Wusta region.

Alluvial aquifers in the Project area are generally negligible. Recharge to this area is presumed to be from the fresh water is provided by wadi flood recharges during occasional periods of intense rainfall, such as cyclonic storms which develop over the Arabian Sea. A portion of this fresh water is most likely gradually released into the underlying limestone aquifer to form freshwater lenses along with the shale / clay patches. Localised areas of near potable quality water occur as a perched water table in wadi alluvium land in the Tertiary sediments due to presence of clay lenses. Potable supplies in this area largely depend upon these freshwater lenses which overlay the saline regional groundwater flow system of Fars then UER at depth.

In this area of the Interior Plains the Fars aquifer is mainly represented by the limestone Ghubbarah Formation with groundwater in the Project area saline in nature and not suitable for drinking. The groundwater salinity reported from MRMWR and previous reports indicate salinity between 20,000 – 40,000 ppm from deep aquifers, which is indicative of the coastal influence. Based on literature review there is no evidence of any contaminant in the groundwater system.

Combined effects of strong winds, high temperatures, and low rainfall result in significant evaporation, and high salinities in the Duqm region. These conditions lead to the precipitation of the evaporate minerals gypsum and anhydrite beneath the sediment surface of the sabkha settings, resulting in groundwater salinity levels higher than those found in the sea. Therefore it is unlikely that the groundwater resource would have significant scope for sustainable groundwater development, but this needs to be confirmed with further investigation.

4.4.2 *Fluvial Hydrology*

The project area lies in two main natural wadi systems namely, Duqm-Al Khauf and Ras ad Duqm-Shuwayr. There are currently no flood protection dams. However, there is a separate ongoing design for the Duqm Development Drainage Network and Flood Protection Schemes-Phase 1. The above scheme will include Wadi Jurf and Wadi Saay Dams, and main flood protection channels – Wadi Dangert, Wadi Jurf, and Wadi Saay. Wadi Saay will divert natural flows away from a section of Route No. 32 up to a point just downstream of the confluence of Wadi Jurf and Wadi Saay.

Based on the Duqm drainage modelling study conducted by Sering International for the Supreme Committee of Town Planning, the upper central portion of the channel is characterised by lower slopes and consequently sedimentation is to be expected due to the higher rates from the upper portion (Sering, 2012).

4.5 Hydrogeology

The Project area is underlain mainly by Tertiary sediments of the Hadramout group. The main aquifer is the UER formation (Clarke, 1900). Recharge occurs through regional aquifer system and it is at a depth of approximately 200 m below ground level.

Localised areas of near potable quality water occur as perched water table in wadi alluvium land in the Tertiary sediments due to presence of clay lenses. Recharge to these areas is presumed to be from local rainfall, probably mainly from occasional cyclonic storms which develop over the Arabian Sea.

As part of the geotechnical investigations for this project, Swissboring also collected water samples from boreholes for laboratory analysis. Results are presented in the Table below.

Table 4-1: Results of chemical analysis of water

Location	Sample	Sulphate content as SO_3 mg/L	Chloride content as Cl mg/L	pH Value	Total Dissolved Solids (mg/L)
BH-K	Water	2994	67932	6.9	143604
BH-L	Water	1000	119355	6.7	242596
BH-M	Water	2551	20122	7.5	43460
BH-N	Water	1658	28721	6.3	61700
BH-P	Water	2968	23045	8.3	56456

Chloride and sulphate are normally occurs in natural waters and their concentrations vary considerably according to the mineral content of the Sabkha area. Higher concentration of chlorides and sulphate will be accelerated the deterioration of reinforced concrete foundation of different structures may occur as a result of different chemical and physical processes caused or accelerated by the presence in the ground environment of chlorides and sulphates.

4.6 Climate and Meteorology

There are three meteorological stations located in and around the Duqm area, with the nearest weather monitoring station located at the Duqm Port.

Oman has two distinct seasons, winter (between November and April) and summer (between May and October). The daily sunshine hours typically average about 10 hours annually with the exception of mountainous areas and the Khareef-affected south, which experiences very little sunshine between mid-June to mid-September.

The climate of Duqm is mainly influenced by the summer and winter monsoons. While the winter winds are relatively gentle, the summer winds are quite vigorous. The historical records for ambient air temperatures at Duqm Port show that the lowest temperatures occur in January and steadily increase to a peak in May. From June with the arrival of the summer monsoon, the temperatures begin a steady decline until December. The mean relative humidity is approximately 64% in most months.

Rainfall in Duqm area is low, with the region classified as between arid and hyper arid. However, high intensity storms, capable of producing significant run-off and recharge, occur infrequently at irregular times of the year. Historical rainfall records, for 1983 to 2010, at Duqm Port show that the month of August has the maximum amount of rainfall and September has the lowest mean rainfall (HMR, 2013a).

4.7 Ambient Air Quality

Ambient air quality monitoring is conducted utilizing a mobile Continuous Ambient Air Quality Monitoring Station (CAAQMS) to measure the concentrations of these air pollutants: SO_2, NO_X, CO_2, O_3, H_2S, PM10, and Hydrocarbons (in the forms of methane and total non-methane hydrocarbons). Ambient air quality measurements (for wind speed, direction, relative humidity, and temperature) are recorded via meteorological sensors installed at the same time. This methodology intends to determine the current levels of ambient air pollutants to enable assessment of air quality impacts from the Project activities (especially the construction and operational phases of the new development) as well as to facilitate future comparisons.

A number of ambient air quality monitoring surveys (AAQMS) for environmental studies have been conducted by across the SEZAD area, with HMR completing these three studies involving:

- 3 monitoring locations for a period of over 12 months for the Duqm SEZAD Environmental Baseline Study (HMR, 2013b; and HMR, 2013d);
- 3 monitoring locations for a period of over 3 months (June-July 2014, and October-November 2013) for the Duqm Refinery Environmental Baseline Study (HMR, 2013a); and
- 3 monitoring locations for a period of minimum 10 days at each location for the Duqm Sea Water Intake Project between October and December of 2014 (HMR, 2015a).

Typically air quality sampling locations are chosen considering predominant wind direction, which is from SW to NE at the Duqm site.

The ambient air quality monitoring for the Duqm SEZAD Environmental Baseline Study was undertaken at three different locations between 2012 and 2013 to capture the data during each of the distinct seasons of winter and summer (HMR, 2013b; and HMR, 2013d). The AAQMS were located at:

- CAAQMS-1 in the north to represent the heavy industrial area in the vicinity of Sidrah in November 2012;
- CAAQMS-2 in the current Duqm township during February 2013; and
- CAAQMS-3 to the south near the Duqm Airport during March-April 2013 and November 2013.

For this air quality monitoring round, the measured average levels of all pollutants (except PM10 at CAAQMS-2) for the respective averaging periods were observed to be within the Provisional Omani Standards. The higher PM10 levels at CAAQMS-2 during February 2013 could be attributed to the characteristic shamal winds.

Based on this wind direction, for the Duqm Refinery Environmental Baseline Study (HMR, 2013a) the AAQMS were located at:

- AAQMS 1 located at the site boundary for obtaining site specific baseline information for two periods in October 2013 for 18 days and in June-July 2013 for 14 days;
- AAQMS 2 placed for 16 days in October 2013 at a crosswind direction at settlement Wadi Dhanjart, which is a sensitive receptor; and
- AAQMS 3 was located for 14 days from October-November 2013 in a downwind direction from the proposed Refinery site in the permanent settlement of Nafun, which is a sensitive receptor.

For the majority of parameters, the measured concentrations were observed to be well within the Oman Ambient Air Quality Standards (OAAQS) and United States National Ambient Air Quality Standards (NAAQS).

Even though PM10 monitoring was carried out using the CAAQM station, further monitoring of ambient dust levels was conducted at 12 locations in September 2013 based on sensitive receptors in the buffer zone area considering predominant wind direction. Dust is expected to be one of the major pollutants generated during the Project construction phase.

During the Sea Water Intake Project environmental baseline studies (HMR, 2015a), based on the prevailing wind direction (i.e. which for Duqm is from the south west to the north east), the permanent settlement at Nafun was considered a sensitive receptor (AQM1) in the downwind direction from the proposed site and monitored. Further, AQM2 was placed in the centre of the Project area in the vicinity of the coastal landing site where infrastructure is proposed to be located in the future. The AQM3 site

was near to Duqm town where sensitive receptors reside, and this location was also chosen to obtain site specific baseline wind information.

The results at AQM1 were less than the air quality limits in the Omani Provisional Standard. At AQM2, the concentrations of pollutant parameters measured were reported to be within the Omani Provisional Standards limit except for the 24-hr sulfur dioxide (SO_2). Finally, at AQM3, the results recorded exceeded the Omani Provisional Standard limit for the 8 hour ozone, and all other parameters were less than the air quality limits. To summarize, it can be noted that concentrations of all pollutant parameters measured by the CAAQMS for the Duqm SWIP baseline study are reported to be within the Omani Provisional Standards limits, with the exception of the 24 hour sulfur dioxide (SO_2) at AQM2, and the 8 hour ozone (O_3) at AQM3.

For the Duqm Refinery baseline study Odour sampling was carried out using sorbent tubes at 2 locations for one day at each location in September 2013 (HMR, 2013a). Parameters selected for odour monitoring represent the typical emissions from refineries and petrochemical complexes. The odour results indicated that all selected parameters, mainly S and N compounds, are less than detection limits. Likewise, odour sampling was carried out at 1 location in November 2014 (HMR, 2015a). It was analyzed for oil compounds, chlorine, and ammonia, and the results were all less than detection limits.

The major sources of air emissions generated during construction will occur from construction plant and equipment such as machinery, diesel generators, transport vehicles, fuel oil storage tanks, and traffic on graded roads. The major pollutants released from these sources include particulate matter (PM10), oxides of nitrogen (NOx), sulphur dioxide (SO_2), carbon monoxide (CO), and un-burnt hydrocarbons (UHC).

The air emissions sources and the nature of emissions due to the various construction activities are presented in ***Table 4-2.***

Table 4-2: Air Emissions – Construction Phase

#	Source Name	Source Type	Nature of Emissions and Quantity	Significant Air Pollutants
1	Construction machinery	Stationary point sources[2]	Products of combustion of fuel oils	NO_x; SO_2; CO; HC
2	Diesel generators	Stationary point source	Products of combustion of fuel oils	NO_x; SO_2; CO; HC
3	Transport vehicles	Mobile sources	Products of combustion of fuel oils	NO_x; SO_2; CO; HC
4	Fuel storage tanks	Area sources – fugitive emissions	Vapors generated due to evaporation under storage	NO_x; SO_2; CO; HC
5	Traffic on graded roads and earth work	Area sources – fugitive emissions	Dust generation	PM_{10}
6	Construction materials and aggregate storage yard	Area sources – fugitive emissions	Dust generation	PM_{10}

Based on ***Table 4-2,*** emissions to air will be primarily due to combustion of fuel oil for various construction activities. The construction plant, equipment, machinery and vehicles will be designed to the latest standards and will be well maintained, which will minimize emissions to the atmosphere. PM10 in the form of dust will be released during movement of vehicles on graded/un-graded roads and from material handling during construction.

The civil works will mainly include site clearing, levelling and excavation, and these activities will generate dust emissions. The dust generating activities include handling and use of fine material such as aggregates, sand, and construction materials. Dust emissions from these operations are primarily dependent on the quantity and fineness of material, wind speed, and moisture content of the material. Construction materials such as aggregate and sand will be stockpiled in open lay down areas, while the cement will be stored in sheds nearby to work area, as work progress along the road. Stockpiling of these materials is expected to be for short durations anywhere from a few days to a maximum of a few weeks. Apart from continuous particulate emissions from the storage stockpiles due to wind erosion, the movement of material at stockpiles may generate considerable dust. Stockpile dust emissions due to wind erosion will depend on the stockpile material, area, height of stockpile, and number of loading and unloading operations.

Figure 4-4 shows the locations where monitoring has previously occurred in proximity to the Project area for Road Nos. 1 and 5, with AAQMS locations marked in yellow and odour locations marked as a circle.

[2] Machinery considered as stationary point source when operating at any single location within the construction site.

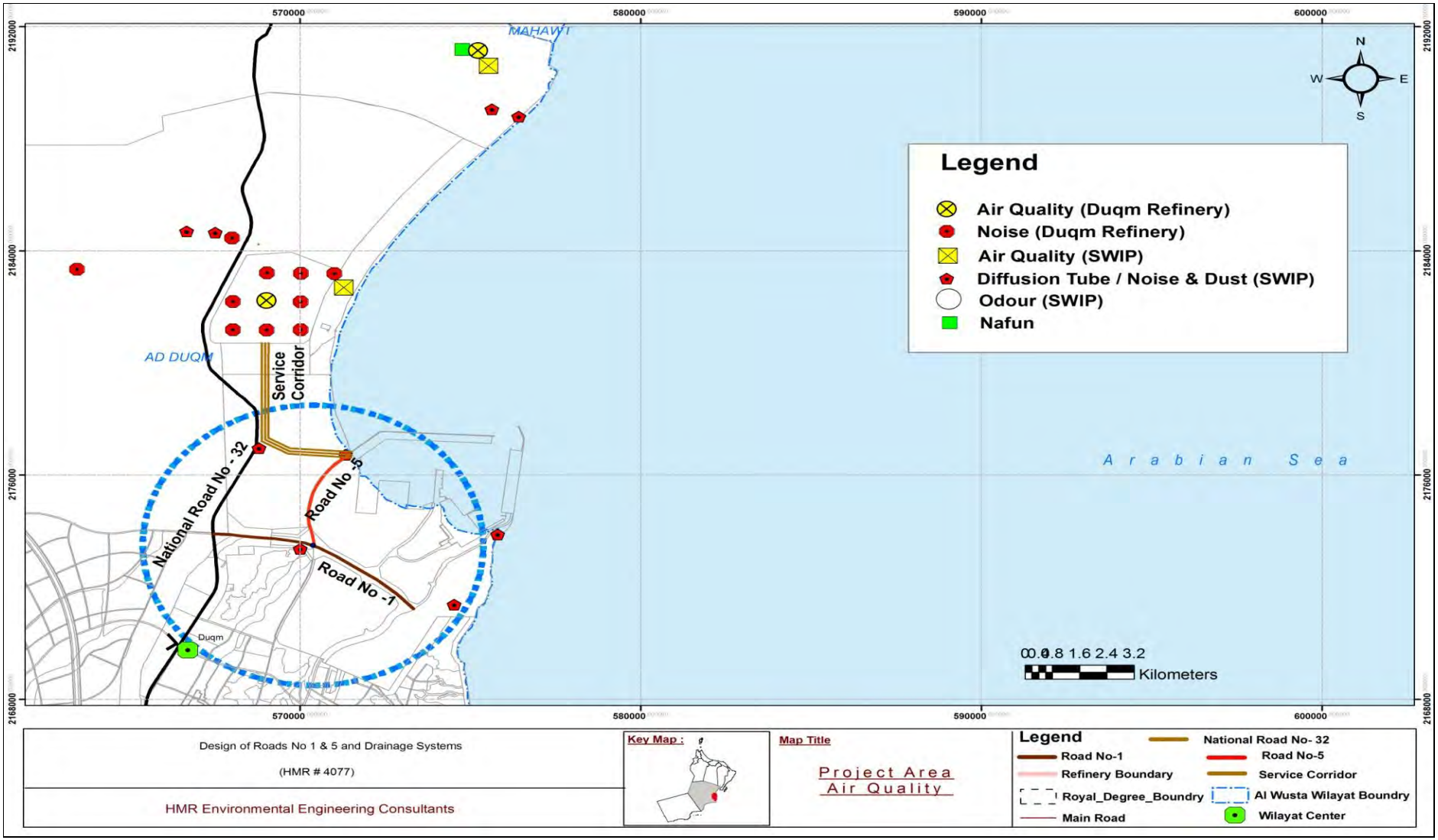


Figure 4-4: Ambient Air Quality Monitoring in vicinity to Project Area

4.8 Ambient Noise

The proposed Project area can be characterised by its open nature and relative absence of high noise sources typically associated with industrial activities, with most potential noise derived from sources such as roads and settlements concentrated in relatively small areas.

Typically, various locations within the site and outside the site boundary are chosen based on the rationale that maximum noise is expected to be generated from the site and there will be both a crosswind and downwind. Noise level measurements are conducted using Integrating and logging Sound Level Meter (ISLM) and Quest SoundPro. The instrument is capable of measuring equivalent continuous noise levels (Leq) with standard measurement settings conforming to regulatory requirements. Noise data is captured for at least 15 minutes at each location during daytime, evenings and nights for the time periods defined in Article (6) of MD 70/1994.

As part of the SEZAD Environmental Baseline Study (HMR, 2013b; and HMR, 2013d) ambient noise monitoring was conducted on a regional scale, the ambient noise levels recorded at these three locations were within applicable limits.

For the Duqm Refinery Environmental Baseline Study (HMR, 2014b) noise levels were measured at 12 monitoring locations in the first week of September 2013. The Duqm Refinery Environmental Baseline results indicate that the noise levels at several locations are higher than the threshold values and exceed limits specified in MD 79/94. Inherently higher noise levels can be attributed to strong winds, which are a common feature in the Duqm region, and also from the noise of wave breaks considering the proximity to the ocean. High noise levels were measured at a number of locations and can also be attributed to vehicular traffic, and other environmental disturbances including avifaunal squawk and dog barking.

The higher noise level was also confirmed through the results from the Duqm SWIP EIA study (HMR, 2015a) wherein noise level measurements were conducted using Brüel & Kjær Type 2250 Light Sound Level Meter at 10 locations in October 2014. The results confirmed that the background noise concentration in the Duqm area was high. It was seen that the average noise level in this region is around 46.4 dB(A) which is in exceedance of the noise standard for rural, residential, and recreational type of area.

The construction machinery, mechanical equipment, and vehicles engaged during construction will generate noise during their operation. Construction activities such as bulldozing and site preparation may generate significantly high-level noise. Various equipment like excavators, mixer machines, vibrators, bar cutting and bending machines, air compressors and pumps will all generate noise on this Project. In addition, diesel generators (DG) used for emergency power supply and for powering the site will produce noise.

Vehicles used for the transport of materials and personnel to site will generate traffic and noise along the route. Typical noise levels expected from construction equipment are presented in ***Table 4-3.***

Table 4-3: Noise Levels – Construction Equipment

Source of Noise	Duration of Operation	Noise Level at 1m from Source
Excavators, shovels, dumpers etc.	Day and night time	70-80 dB(A)
Vibro-hammers	Day and night time	80 dB(A)
Vibrators and compactors	Day and night time	78 dB(A)
Dredgers	Day and night time	67 dB(A)
Concrete mixers	Day and night time	70-80 dB(A)
Motors and compressors	Day and night time	65-70 dB(A)
Diesel generators	Day and night time	80-85 dB(A)
Trucks	Day and night time	75-80 dB(A)

Construction equipment will be regularly maintained as per manufacturers' specifications to ensure their optimum operations and noise levels are within specified limits. All plant and equipment will be fitted with mufflers to reduce noise levels and comply with the noise standards specified under MD 79/94 and MD 80/94.

Figure 4-4 shows the locations where ambient noise monitoring, marked by red symbols, has previously occurred in proximity to the Project area for Road Nos. 1 and 5.

4.9 Terrestrial Ecology

The terrestrial ecology methods completed across the SEZAD area have comprised of flora and fauna surveys aiming to identify all plants via transects and quadrat sampling, and record their abundance. The taxonomy of most of these species has not yet been assessed for the International Union for the Conservation of Nature and Natural Resources (IUCN) Red List with the exception of a few species which are in the "Least Concern" category.

In Duqm region , the most dominant species in the gravel plains / sandy area were *Crotalaria aegyptiaca*, *Tetreana quatarensis*, *Cyperus conglomerates*, *Limonium sacrophyllum*, Echiochilon kotschyi and *Pulicaria glutinosa*. The dominant species in the Sabkah habitats mainly comprise of *Halopeplis perfoliata*, *Arthrocnemum macrostachyum*, *Suaeda moschata*, *Halopyrum mucronatum* and *Cistanche tubulosa*. Collectively the plant community of the Duqm coastal area, is mainly comprised common and highly adaptable species including the regional endemic (REN) and endemic (END) species, which are usually found in the coastal environment of gravel plains and sabkah.

Based on HMR's previous projects in the Duqm area, the key observation on species in the SEZAD area are:

- The region has very low rainfall and mostly arid and has elevated topography with rocky surfaces forming mosaics with desert sand. The low lying areas are denuded and comprised of gravelly to pebble type of surface.
- Overall the vegetation is sparse and is mainly fed by the fog moisture and comprised of many different micro habitats with varying vegetation and associated fauna depending on the type of local topography and geology (WWF, 2014).
- On the eastern coast the sabkah is a feature, which serves as refuge for many organisms especially avifauna. Reportedly, the sabkah near the northern breakwater of Duqm Port is listed as an Important Bird and Biodiversity Area (IBA) by BirdLife International[3]; however the area has not been offered official conservation status. Nevertheless, the Royal Decree 64/2012 ratifies the Sultanate of Oman's joining the Convention on Wetlands of International Importance and the above stated sabkah area is a wetland and a known site for visiting migratory birds including some rare species.
- Sabkah habitats mainly comprise of *Halopeplis perfoliata* (string of beads), *Arthrocnemum macrostachyum* (glaucous glasswort), *Tamarix aucheriana*, *Tetraena qatarensis* (Bean caper), *Cressa cretica* and *Limonium sarcophyllum*.
- Coastal areas close to sandy beaches have a silty and saline surface that supports halo-phillic vegetation. The strong wind regimes in this region induce a wide spray zone, which brings moisture and salinity on the coastal dunes and adjoining habitats. The plant community in this

[3] http://www.birdlife.org/datazone/sitefactsheet.php?id=8234

habitat is segregated due to hyper-saline conditions and dune vegetation is restricted by plants with very specialised adaptations.

- Total of 39 species (Gardner, 1990) of herpetofauna are available in the industrial development zone, including 8 species with doubtful occurrence. The most abundant species recorded were *Mesalina adramitana* (Hadramaut Sand Lizard), *Acanthodactylus boskianus* (Bosk's Fringe-fingered Lizard), and *Acanthodactylus opheodurus* (Snake-tailed Fringe-toed Lizard).
- The maximum avifaunal diversity was observed in the coastal region where over-wintering shore birds dominate the beaches. The most prevalent avifauna in the region is the Siberian Gull and the Caspian Gull, comprising about 95% of the total avifauna on the coast.

The Project is unlikely to have a major impact on the floral conservation and distribution of the region. However, the Ministry through the enactment of Royal Decree on environmental conservation and pollution prevention (RD 114/2001) emphasizes the need to conserve soil and combat desertification (Article 21) and does not allow cutting down or uprooting trees, shrubs or grass until a valid permit is obtained. Considering the overall SEZAD region, the Project area is a small fraction of the overall area and does not pose a risk to any of the plant species as part of the development of the roads Project.

The Project is to have a minimum impact on the terrestrial fauna. However, the avifauna will be impacted, as the current alignment of the drainage channel for Road No. 5 is proposed to drain to the northern side of the lee breakwater into the Bay of Duqm which is an important migratory bird habitat. However, as indicated in Section 3.3, this alignment is being altered to discharge the drainage channel in to Wadi Saay which will avoid this impact.

Lagoon area with sensitive avifauna northern side

Lagoon area with sensitive avifauna southern side

Halophytic plants at lee breakwater area

Lizard *Acanthodactylus sp.*

Terns

4.10 Marine Environment

The proposed Project site is located near to the long crenulated bay (Ghubbat Quwayrat bay) in the northern area of the Duqm port (lee breakwater). Intertidal lagoon at the liquid jetty end of the Road No. 5 in project site is the most important area to protect existing environment. The proposed Road 5 alignment will block the tidal flux in the lagoon area and will affect the faunal distribution in this tidal flat area.

The beach and shoreline at the lee breakwater areas are constantly being changed by tides, currents and waves. Beach profiling, width and slope measurement was conducted by HMR for the comprehensive Environmental Baseline study for SEZAD, with a total of 4 profiles conducted along the Project beachfront (HMR, 2013b). The width of the Project beachfront profile (foreshore and backshore) was noted to be around 94 m at the lee breakwater area. Particle size distribution testing was conducted for the beach samples, and results show all samples are significantly dominated by sand with a composition of 98% sand, and very low percentage of silt and of 2% silt / clay. Three prominent Wadis are present in this area which supplies sedimentary materials to the near shore waters (HMR, 2013b).

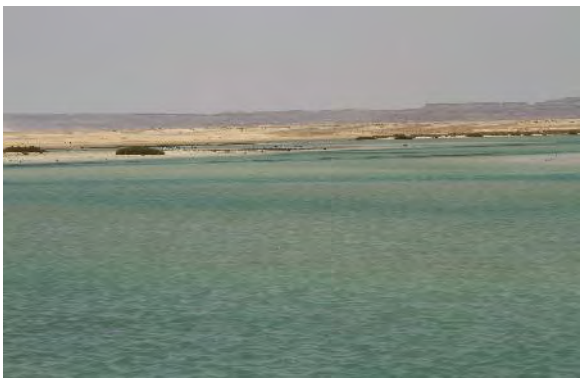
The lagoons are important nursery areas for various fish species, are feeding grounds of large variety of migratory wading birds, and are rearing areas for cephalopods, crustaceans and invertebrates. This lagoon in the Project area supports a large number of fishes (especially juvenile, fry and fingerlings), shrimps, crabs and molluscs (HMR, 2015b). The tidal mud flat in the lagoon hosts many fiddler crabs, sand bubbler crabs (*Dotilla sp.*), Ghost crabs (*Ocyopode sp.*) and clams.

Northern alignment of Road 5 in lagoon area

Southern alignment of Road 5 croosing tidal flat area

Fiddler crabs are one of the most important taxa among the macro fauna commonly found in muddy tidal lagoons. There are two species of fiddler crabs found in Oman (*Uca lactea annulipes* and *Uca tetragonon*). In the recent ecological survey for the Duqm Service Corridor project, *Uce lactea annulipes* is the predominant crab species found across the Project site (HMR, 2015b). The average density was 21 crab burrows/m^2 in the intertidal area indicates the healthy population this species in the lagoon. They are also important to the food web, as they are food for coastal birds and large crustaceans. The common Rock crabs (*Grapsus sp.*) were noticed in the existing tidal inlets. Smaller patches of sabka vegetation are also found on the northern side on a sandy / muddy bottom.

Fiddler crab *Uca lactea annulipes*



Lagoon area during high tide

As part of the rapid aquatic ecological survey for the Duqm Service Corridor Environmental Baseline Study, cast net sampling was conducted at the tidal inlets of the lagoon area to assess the aquatic species (HMR, 2015b). Fish survey was conducted at three locations along the length of the estuarine intersection (tidal inlets) during high tide. Many Juveniles, fry and fingerlings of different fish species were observed, predominantly in lagoon survey areas and intertidal area. Nine fish species, Stingray *Himantura sp.*, Halfbeak *Rhynchorhamphus georgii* with an average size of 15cm, *Terapon jarbua* (average size of 12.5cm), Arabian Sillago *Sillago arabica* (average size of 10.5cm), Mojarra *Gerres acinaces* (average size of 21cm), Mojarra *Gerres filamentosus* (average size of 5.5cm), Mullet *Chelon persicus* (average size of 12cm), Flathead *Papilloculiceps sp.* (size of 10.5cm), Juvenile sardines *Sardinella sp* (averge size of 9.8cm), two cephalopods Juvenile Squid *Sepioteuthis sp.*, Juvenile

Cuttlefish *Sepia sp*. and one Flower crab *Portunus segnis* were identified during previous survey (HMR, 2015b).

4.11 Social Baseline

Secondary information on socio-economic profile and existing infrastructure of the Duqm area and its surroundings has been primarily obtained through desktop review of data available from HMR archive, census reports, and published information from various government agencies. In addition, the perceived issues on the community were gathered through community and stakeholder consultations as part of the Sea Water Intake Project EIA study (HMR, 2015a).

Typically a radius of 5 km around the proposed Project site is established as the Project Influence Area (PIA) to assess likely impacts on the local social, cultural factors, and public health. The baseline study encompasses an appreciation of demographic characteristics, economic characteristics, social and physical infrastructure, and archaeology and heritage.

The PIA for the Duqm Refinery site Environmental Baseline covered 11 settlements that are part of Ad Duqm wilayat, with the majority of the settlements located along or near the shoreline, of which six are unpopulated as per 2010 as presented in ***Table 4-4.***

Table 4-4: Settlements within study area[4]

S.No.	Name of the Settlement	Total Population
1	Ghafat Mahjan	115
2	Nafun	185
3	Wadi Ad Dishayshah	0
4	Wadi Al Khaban	0
5	Wadi Dhanjart	68
6	Wadi Qadih	0
7	Wadi Say	6,183
8	Al Hawiyah (1)	0
9	Al Hawiyah (2)	500
10	Wadi Mudrab	0
11	Wadi Qutnah	0
12	Total	7,051

The stakeholder engagement consultations conducted during the baseline study for the Sea Water Intake Project EIA study found that the reason why these 6 settlements were unpopulated was because the Government of Oman had relocated the population from these areas to establish the Special Economic Zone at Duqm (HMR, 2015a).

[4] Source: (Census 2010)

4.11.1 *Regional Demographics*

The Al Wusta Governorate is situated to the south of both A'Dakhliah and A'Dhahirah Governorates, at the east side it is linked to the Arabian Sea, at the west to the Empty Quarter and at the south to Governorate of Dhofar. The Al Wusta Governorate had a population of 22,983 as of 2003 Census. As per 2010 Census the total population almost doubled to 42,111 and accounted for 1.5% of the Sultanate's population. This is largely due to proliferation of the governorate's expatriate population, which almost quadrupled from 2003 to 2010.

Population density for the wilayats of the Al Wusta Governorate has been analyzed for 1993, 2003 and 2010. Maximum density is only evident in Mahout wilayat which is around 1.55 persons / km^2. This has increased at the rate of 3% per annum over a span of 17 years between the first and the most recent census of 2010. However, population density of Hayma and Ad Duqm has proliferated by a much greater rate of almost 10% and 8% respectively for the same time span.

Population structure for the wilayats of the Al Wusta Governorate has been analyzed separately for Omani and non-Omani population. During the year 2010, the Governorate had a total of 23,068 non-Omani people, which contributed to nearly 3% of the Sultanate's expatriate population.

Sex ratio is the proportion of males to females in a given population, and typically the natural sex ratio is usually within the range of 100 – 105. The sex ratio for the Al Wusta Governorate has been compared for both Omanis and non-Omanis for 1993, 2003 and 2010 (***Table 4-5***). The content of ***Table 4-5*** depicts number of males present for each 100 females in a given population. For example, as per Census 2010, there were 316 males per 100 females for the total population of Al Wusta Governorate. The sex ratio within the wilayats of Al Wusta Governorate is dominated by male population and has increased considerably for the non-Omani population from 1993 to 2010. This is attributed to the migration of non-Omani male population to the region for employment opportunities.

Within the Omani population a much lower composition of males and females has been observed. For each 100 females, there were 114 males during 1993, which has further decreased to 105 in 2010. As per 2010 Census, sex ratio for Omani population for all the wilayats of Al Wusta Governorate is observed to be stable. For non-Omani population, during 1993 the composition of male non-Omani was as high as 2,695 males per 100 females at the Governorate level, which decreased to 1,107 males during 2003 followed by an increase to 2,689 in 2010.

Table 4-5: Omani to Non-Omani Ratio 1993, 2003 and 2010 for Al Wusta Governorate

	Wilayat	1993			2003			2010		
		Omani	Non Omani	Total	Omani	Non Omani	Total	Omani	Non Omani	Total
1	Hayma	130	2,550	243	137	921	254	105	3,420	789
2	Mahout	108	3,306	123	108	970	129	106	758	136
3	Ad Duqm	109	1,964	147	104	504	135	105	4,864	457
4	Al Jazer	135	3,017	278	143	2,064	323	103	2,522	389
Al Wusta Governorate		114	2,695	164	115	1,107	176	105	2,689	316

4.11.2 *Social Consultations*

In November 2014 HMR had conducted social consultations for the EIA study for the Duqm Sea Water for Industrial Zone Project (HMR, 2015a); the excerpts of those consultations are given below:

Study was conducted to understand the socio-economic perspective of people and local communities residing in 10 numbers of settlements falling within the Project Influence Area of SEZAD.

Consultations were carried with Wali of Duqm, Sheikhs, and local people to gauge the socio-economic status and understand the local population's demands and needs.

Oman is a hierarchical system where the local population reports its demands and complaints to the local Sheikhs. These issues are then passed on to the Wali who in turn express them to the Governor / government. During consultation with Wali of Duqm, Sheikhs, and local people some of the important and interesting information on the targeted issues was received.

Fishing and livestock rearing were found to be the traditional occupations that exist in Wilayat to a certain extent. People residing in PIA traditionally practice the raising of Camel, Goats and Sheep's and keep them in temporary shelter.

It was observed that due to development planned in and around Duqm, most of settlements, except Nafun, have been shifted and relocated by the Government of Oman to Wadi Say. In future, the Government is planning to shift these settlements from Wadi Say to an upcoming township (150 houses) near to the Duqm Airport in South.

For some groups of people, traditional household industries of handicrafts, spinning and weaving are traditional occupations. The majority of people in Ad Duqm Wilayat were mostly dependent on fishing and livestock rearing. Women were mainly involved in animal rearing and household works.

During consultations, educational opportunity is confined to only Wilayat Centre. Schools giving basic education are present in Wadi Say. Lack of transportation, financial stress, are leading to drop out from higher education. Very few people are able to get their higher education in Sinaw and Nizwa.

4.12 Archaeological and Protected Sites

Archaeological studies since 1970 have shown Oman's coastline to be rich in human occupation sites that date from early pre-Islamic times. A number of archaeological studies have been carried out in the proximity of Duqm area:

- The first study was conducted by Biagi in 1994 where a survey of coastal sites, as well as in the Huqf escarpment was carried out. Flint sites containing hand axes from the Acheulian period were found. Biagi singled out the Bay of Duqm as providing the best evidence of prehistoric occupation between Ras Halat and Ras as Aqit;
- Macumber conducted a field survey in 1997, which resulted in northward expansion of the boundaries of the Arabian Oryx Sanctuary;
- In 2002, Whelan studied lower Palaeolithic sites in the Huqf area; and
- Recently, Dr. Reto Jagher lead a study titled 'Central Oman Palaeolithic Survey (COPS)' organised by the Institute for Prehistory and Archaeological Science (IPAS) of the University of Basel (Switzerland) under the patronage of the Ministry of Heritage and Culture was carried out during 2007 and 2008 in the Huqf-Al Haushi area of Oman recording over 1,400 archaeological sites.

Amongst these findings, Duqm was observed to be extremely rich in archaeology sites and a number of discoveries were made in the area adjacent to the location of the proposed master plan for Duqm. Moreover, despite extensive exposure to weathering and erosion, these sites have been well preserved on their own accord as erosion at many sites was observed to be extremely slow. The sites discovered in the Huqf region were in almost pristine conditions and without any protection or fencing around them owing the remoteness of the area.

Figure 4-5 illustrates archaeological and heritage sites present within and around the Project Influence Area. Of significance, the Rock Garden is located to the south of the intersection of Road Nos. 1 and 5. The other archaeological finds are reported to include Stone Structures, Stone Circles, Heavy Bifacials, Flint Artefacts, Ceramics, Tumuli, and items recorded as "*without archaeological discoveries*".

With progressive development in the SEZAD area, accessibility to these sites would increase in the future, thereby threatening their protection. The construction activities carried out in the proximity of such sites could have long lasting and adverse impacts on these sites. Another threat is the impact of local fishery landing and harbours, which can potentially harm these sites. Consequently, conservation and protection of such sites becomes a major consideration.

As per Ministry of Heritage and Culture, there is no specific buffer zone described for each archaeological site for their protection. However, it has been suggested that buffer of 150 m should be reserved around archaeologically important sites. Some leniency is allowed in certain cases where it becomes necessary to occupy the area adjacent to the site. In such cases, a buffer zone of no less than 50 m is to be reserved to ensure protection of the site. The ongoing project development in Duqm has

started to threaten the archaeological legacy of this area as these sites are extremely vulnerable. Taking precautionary measures to protect these sites and preserve the archaeological legacy is recommended.

If any object of cultural / archaeological significance is encountered during excavation, such area will be immediately cordoned off and the construction contractors will inform the Ministry of Heritage and Culture accordingly to obtain further advice from the Ministry.

Further the expatriate construction workers in the area can have potential impacts on local lifestyle and culture, although with proper implementation of cultural awareness plan for the expatriate labourers the impact can be considerably minimised to a low level.

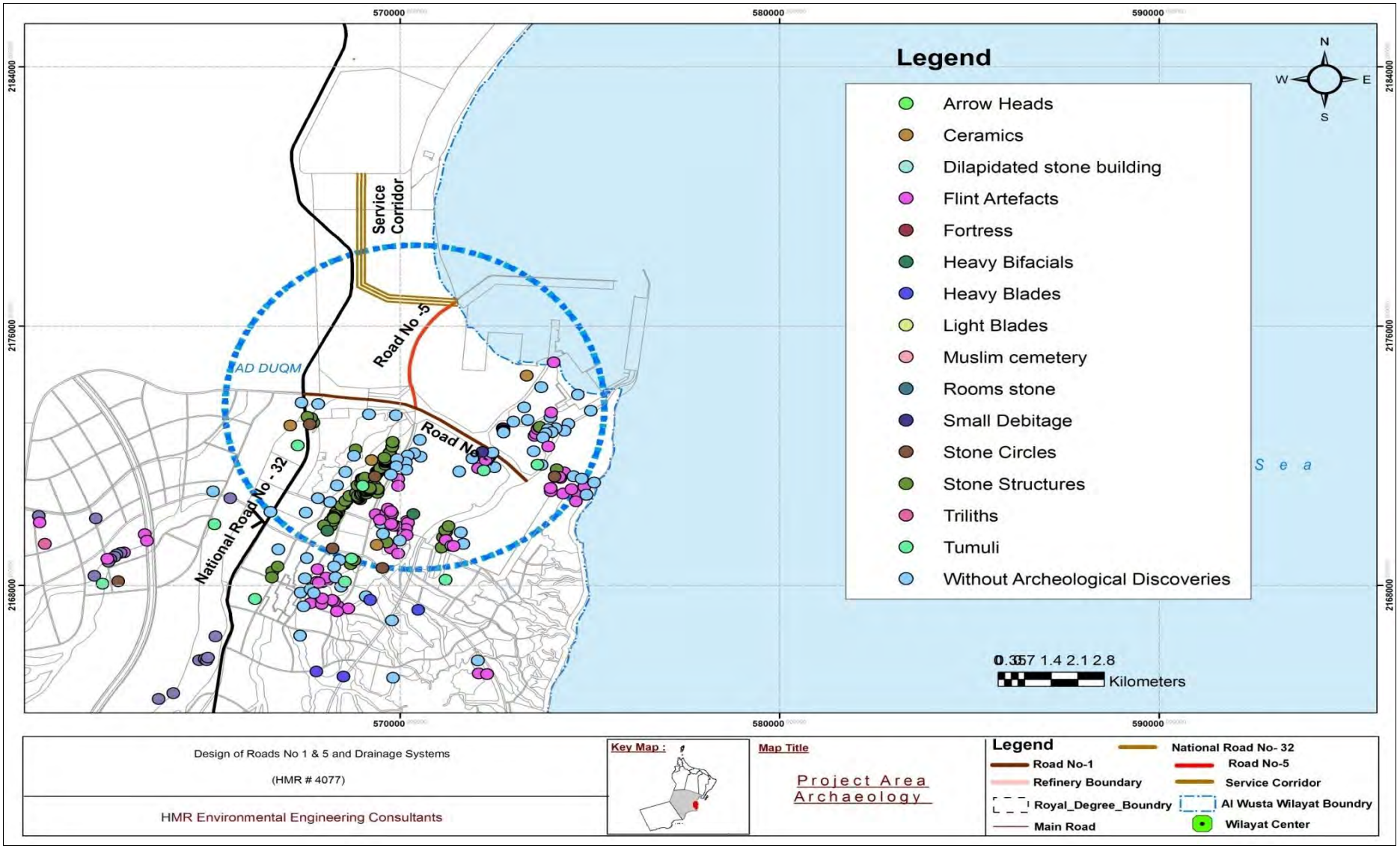


Figure 4-5: Archaeological Sites in the Project area

5 ENVIRONMENTAL RELEASES

This chapter identifies and describes the potential environmental issues that may arise from the Project.

5.1 Overview

The identification of environmental issues is primarily based on the review of Project information and environmental baseline conditions. The environmental issues as identified in this chapter cover those that may potentially arise from the construction phase of the proposed Project since environmental issues generated during the operation phase of the Project will be minimal. During the operational phase, it will be limited to only vehicular movement, periodic maintenance of the roads and occasionally accidental oil / hazardous spills.

These waste streams include air emissions, liquid effluents and solid wastes. In addition, noise generated from various equipment and machines used in construction is also discussed, since noise generation will be transient and cannot be quantified for the operation phase.

Note that most of the data presented in this chapter are based on the Project details made available at this stage for conducting the current EIA study. Wherever sufficient information is not available, an attempt has been made to estimate the characteristics using empirical predictions. Volume estimates are difficult to predict at this point of time; these estimates will become available and be updated during the EPC phase. The roads will continue to be in existence even after the project life period and would be maintained and engineered for future use at that time. Accordingly, it is not possible to conceive the environmental impacts during the decommissioning phase and therefore, is separately discussed.

The wastes released to the environment are classified into the following groups, based on their physical state as well as nature:

- Accidental Releases (Gaseous releases into atmosphere and Liquid spills and leaks on land);
- Air Emissions (Stationary source, Mobile source, and Fugitive emissions);
- Hazardous Wastes (Hazardous non-recyclable wastes and Hazardous recyclable wastes)
- Noise;
- Non-Hazardous Solid Wastes (Non-hazardous non-recyclable wastes and Non-hazardous recyclable wastes);
- Traffic Impacts
- Wastewater (Effluent from construction site, Sewage, and Stormwater); and
- Water.

5.2 Releases during Construction Phase

The releases during the construction phase will depend upon the type of construction activities, construction methods, construction equipment, materials used, source / amount of utilities and duration of site work, emissions from construction equipment and vehicle, movement of transport vehicles, dust generation from earthworks, sewage generated at site, waste chemicals generated at site, maintenance wastes, construction wastes, and metal, wooden and plastic scraps, etc. The source and the nature of releases are presented in ***Table 5-1.***

5.3 Releases during Operation Phase

As indicated previously, the releases during the operational phase will be limited to only vehicular movement, periodic maintenance of the roads and occasionally accidental oil / hazardous spills. The source and the nature of the releases are presented in ***Table 5-2.***

Table 5-1: Environmental Releases during Construction Phase

#	Source	Nature of Release	Proposed Treatment and Disposal Methods
Water / Wastewater			
1	Sanitary wastewater from construction site and project site offices	Continuous - Biodegradable organics and suspended solids. Contains SS, O&G, BOD, and COD	• Collected in adequate holding tanks and will be treated in a temporary sewage treatment plant (STP) and the treated effluent will be used for dust suppression in the construction area
2	Surface runoffs - Drainage of rain water from within the project site	Rare occurrence – No pollutants expected unless drained from accidentally contaminated areas	• Runoffs from uncontaminated areas to be directed to appropriate drainage collection points. • Runoffs from potentially contaminated areas to be collected in holding basin and will be treated before discharge.
3	Wastewater from construction site	Continuous during construction. Contains suspended solids	• Segregated, collected, and preliminary treated at site and sent to the SEZAD STP in Duqm.
4	Water from dewatering	Intermittent - Dewatered during excavations for foundation construction	• If required, water arising from dewatering will be collected and discharged to the sea or wadi channel, whichever is more feasible5. • SEZAD may also consider allowing short-term re-use of the dewatered groundwater for dust suppression - provided that the volumes are small and the irrigation is in short durations only. • SEZAD may also require the dewatered groundwater to be treated (due to presence of salts) prior to reuse or discharge into the environment.
5	Machine washings – periodic washing of the construction machinery	Intermittent – hydrocarbon wastes	• Segregated, collected, and preliminary treated at site (neutralised) and sent to the approved offsite STP. • Construction vehicles and equipment will be serviced offsite and therefore waste oil will not be generated onsite. • Silt collected and stored with contaminated soil.

[5] Abstraction and disposal permits are required

#	Source	Nature of Release	Proposed Treatment and Disposal Methods
Non-Hazardous Solid Waste			
6	Cleared and excavated soil	Continuous during site clearing, leveling, and excavation activities – Normally uncontaminated	• Excavated soil to be stockpiled in dedicated storage areas at site. • To be reused for backfilling wherever possible and the rest to be disposed at the nearest approved landfill site. Depending on the nature of this material it may be able to be used as landfill day cover. • If contaminated, to be collected and stored in dedicated, bunded storage area as hazardous waste; a waste handling facility will be developed / identified for the purpose.
7	Domestic wastes, office wastes from project office, kitchen wastes, etc.	Intermittent – Non-recyclable, biodegradable waste	• To be collected in waste skips and disposed at the nearby approved waste disposal site.
8	Miscellaneous wastes such as waste tyres, waste cables, light fittings, etc., from the site, and other construction debris	Intermittent – Non-recyclable, non-biodegradable	• Stored in dedicated areas / skips and disposed to the nearby approved waste disposal site. • EPC contractor will be encouraged to go for bulk supply deliveries to reduce packing wastes.
9	Metal scrap and empty metal drums of non-hazardous materials from any fabrication activities and material storage	Intermittent – Recyclable, non-biodegradable	• Stored in segregated and dedicated storage area at site and sold to scrap metal dealers to the extent possible, and rest disposed to approved waste disposal site.
10	Paper and wood scrap from packaging materials	Intermittent – Recyclable, biodegradable	• Stored in segregated and dedicated storage area at site and sold to scrap buyers to the extent possible, and rest disposed to approved waste disposal site.

#	Source	Nature of Release	Proposed Treatment and Disposal Methods
11	Empty plastic containers of non-hazardous materials from packaging materials	Intermittent – Non-recyclable, non-biodegradable.	• Stored in segregated and dedicated storage area at site and sold to recyclers to the extent possible, and rest disposed to approved waste disposal site.
Hazardous Wastes			
12	Oil sludge from diesel storage and lube oil from vehicle maintenance	Intermittent - Hydrocarbon wastes	• As part of the Waste Management Plan developed for the Project a specific procedure for hydrocarbon wastes must be developed and implemented. • Hydrocarbon wastes shall be segregated and consolidated at protected storage area at site. • Waste oil recycled to authorized waste oil treatment facilities Oily sludge, if any, will have to be treated and disposed by the EPC contractor in consultation with be'ah
13	Waste cleaning solutions, waste paints, chemicals, etc.	Intermittent - Acids, caustic, detergents, organics solvents, etc.	• Segregated and stored at on-site at dedicated hazardous waste storage yard. • Waste chemicals / solvents recycled to the supplier if feasible and / or disposed accordingly.
14	Containers of hazardous materials (oil drums, paint drums, chemical drums, etc.)	Intermittent - Empty containers contaminated with hydrocarbons and chemicals	• Stored on site in segregated and enclosed area. • Decontaminated for disposal as non-hazardous waste or sent to the approved disposal site.
15	Contaminated soils due to accidental spills and leaks of oils and liquid chemicals	Intermittent - Contaminated soil / sand	• Stored on site in a bunded area with impervious flooring or in drums. • The EPC contractor will develop and implement a project specific Waste Management Plan in consultation with be'ah • The EPC Contractor will liaise with be'ah to ensure the management of all construction, hazardous, and non-hazardous wastes meets be'ah requirements Should a be'ah approved waste disposal location not be available, the EPC Contractor will design and construct a dedicated on-site storage facility for hazardous wastes
16	Unused and off-spec chemicals	Intermittent – Waste chemicals	• Stored on site in segregated and protected area, sent back to the supplier if feasible. • Non-reusable/recyclable material will be sent to approved disposal site

#	Source	Nature of Release	Proposed Treatment and Disposal Methods
17	Waste oil and oil sludge from fuel oil storage and vehicle maintenance area	Intermittent – hydrocarbons based waste	• Stored on site in segregated and protected area and sold to approved waste oil recyclers.
18	Miscellaneous wastes such as spent batteries, used cotton wastes, oily rags, etc.	Intermittent – hazardous waste	• Stored on site in segregated and protected area and recycled as feasible, and rest sent to approved vendor.
19	Medical Waste from the site office	Periodic – medical waste	• Medical waste volumes generated from this Project are estimated to be very small • However medical waste will be stored on site in accordance with the medical waste storage requirements and segregated in protected storage containment / area • Medical waste will likely be sent to bio-medical incineration facility located in Muscat after consultation with be'ah • For any medical waste generated, the EPC Contractor will have an agreement letter with be'ah and an acceptance letter from the bio-medical waste incineration facility for treatment
		Air Emissions	
21	Engine emissions from construction machinery/ equipment	Continuous release during construction activities: Combustion products - NOx, SO_2, CO, and Particulates), and Greenhouse Gases - CO_2, CH_4, and unburnt Hydrocarbons (HC)	• Use of standard construction equipment and vehicles. • Proper maintenance of equipment and vehicles. • Emission test certificates to maintained. • Periodic monitoring of pollutants such as SO_2, NOx and CO at the exhaust gases.
22	Diesel Generator emissions	Continuous release during construction activities: Combustion products (NOx, SO_2, CO, and Particulates); and	• Proper maintenance of the Diesel Generators (DGs). • Providing standard exhaust pipes. • Periodic monitoring of pollutants such as SO_2, NOx and CO in the exhaust gases.

#	Source	Nature of Release	Proposed Treatment and Disposal Methods
		Greenhouse Gases (CO_2 and unburnt HC)	
23	VOC emission from fuel storage tanks required during construction	Fugitive emission of vapours generated during storage and tank utilization	• Periodic maintenance of tanks and fittings to reduce leaks
24	Dust emissions from earth work and vehicle movements on unpaved roads	Intermittent release during construction activities and vehicle movements: Fugitive airborne dust (PM_{10})	• Water spraying to reduce dust emissions
Noise			
25	Noise from construction activities	Continuous during construction activities – engine noise, noise from excavation, vehicle movement, grading, etc.	• Proper maintenance of equipment and vehicles. • High noise activities to be restricted to day time only. • High noise areas to be indicated. • Provide PPE to workers in high noise areas. • Install noise control measures. • Ensure the equipment used is provided with suitable noise control systems and source noise levels confirm to Omani standards.
26	Noise from Diesel Generator (DG) sets	Continuous during construction activities	• DGs shall be housed in fully enclosed areas. • Install noise control measures. • Provide PPE to workers in high noise areas. • Ensure the equipment used is provided with suitable noise control systems and source noise levels confirm to Omani standards.
Accidental Releases			

#	Source	Nature of Release	Proposed Treatment and Disposal Methods
27	Accidental releases of fuel, fuel oil, lube oil, paints, chemicals, welding gases, etc.	Rare occurrence – liquid, solid, or gaseous hazardous materials	• Hazardous materials to be stored in dedicated and enclosed areas with controlled access. • Spill containment systems for storage of fuel, lube oil, chemicals, paints, etc. • Protected and appropriate storage for gas cylinders, emergency response plans, etc. • Spill containment during tank filling by trucks. • Contaminated soil (resulting from the accidental releases) segregated and stored at dedicated hazardous waste storage yard and to be remediated before discharge.
Traffic Impacts			
28	Traffic during construction from passenger vehicle trips, construction equipment, and machinery	Possible during construction activities	• Proper sign boards to be installed onsite and on joining roads. • Locate access points to optimize visibility. • Widening of intersection approaches to provide additional capacity. • Prohibiting left turns (if possible) to and from the proposed development. • Restrict truck deliveries to major highways and encourage deliveries during the off-peak hours. • Establish a monitoring program to ensure that project traffic volumes do not exceed projected traffic demand.

Table 5-2: Environmental Releases during Operation Phase

#	Source	Nature of Release	Proposed Treatment and Disposal Methods
Wastewater			
1	Oily and chemical contaminated water generated during maintenance or cleaning activities	Intermittent – wastewater containing hydrocarbon materials	• If the EPC Contractor proposes to discharge wastewater to the environment, it will be treated to meet the requirements of MD145/1993 for wastewater reuse and / or MD159/2005 if marine discharge is proposed. • Alternatively if the construction workforce is less than 150 people the wastewater will be treated prior to routing to the Duqm STP for treatment and disposal
2	Water from spills, clean-up, fire events, rainwater run-off, etc., from storage tank area (tank bunds), roof tops, etc.	Unique occurrence, wastewater contaminated with hydrocarbons and chemicals	• The generation of this wastewater will be a rare occurrence and is not regular, and hence, it will not be possible to have specialized treatment plant for spills and accidental releases. Rather it is both practical and cost-effective to use the existing STP for treatment. • Onsite treatment of wastewater prior to routing to Duqm STP for treatment and disposal may be required depending on the nature of the wasterwater. • If the EPC Contractor proposes to discharge wastewater to the environment, it will be treated to meet the requirements of MD145/1993 for wastewater reuse and / or MD159/2005 if marine discharge is proposed
Non Hazardous Solid Waste			
3	Metal, wooden, and plastic packing materials, empty containers, drums, etc. generated during road maintenance activities	Intermittent - recyclable – metal, wood, and plastic scrap (generated during maintenance)	• To be stored in segregated area, recycled to scrap buyers / recyclers or disposed at an approved waste disposal site.
Hazardous Solid Waste			
4	Containers of hazardous materials (oil drums, paint drums, chemical drums, etc.) generated during road maintenance activities	Unique occurrence - Empty containers contaminated with hydrocarbons and chemicals (generated during maintenance)	• Stored on site in segregated and enclosed area. • Decontaminated for disposal as non-hazardous waste or sent to the approved disposal site.

#	Source	Nature of Release	Proposed Treatment and Disposal Methods
Air Emissions			
5	Vehicle movement on the roads	Continuous – Gaseous emissions, fuel combustion products (CO, CO_2, NO_X, SO_2, unburnt HC, and PM)	• Sign and enforce appropriate road speed limits.

6 ANALYSIS OF ALTERNATIVES

All available alternatives for the major project design decisions are to be discussed with a particular emphasis on environmental considerations. The rationale and the need for the project are discussed in this section:

- Need for the Project;
- No-Project Alternative; and
- Sourcing for utilities for construction phase.

6.1 Need for the Project

When Road Nos. 1 and 5 comes in to operation, it will provide and improve access to the Duqm Port and the Liquid Jetty with the rest of Oman. It will lead to faster transit time, safer driving conditions, and improve accessibility between the Duqm Refinery and the Jetty, which is intended to serve the Duqm Refinery and several heavy / petrochemical industries coming within the proposed heavy industrial zone in SEZAD. The development of roads in SEZAD is expected to attract more industrial / commercial establishments to the SEZAD area.

6.2 No Project Alternative

In the no project alternative, the road will not be constructed and future traffic will continue to flow through the existing border roads; in such a situation adverse impacts associated with the project construction phase can be avoided. However, this option does not allow for exploring potential economic prospects that reflect on socio-economic growth of the region. Among various options for the development, Oman government has identified petrochemical industry and tourism as one of the promising prospects. The Government of Oman is in the process of developing the Port of Duqm as a strategic dry dock, free trade zone, and Duqm as an industrial and tourism destination. This requires good connectivity with the rest of Oman and hassle free travel. If these roads are not there, the traffic to the Port and Jetty has to take a circuitous path leading to increased travel time, additional use of energy and generation of GHGs, unsafe conditions, and congestion, and all these may impact the future development of the Duqm Port and the industries there. In addition, the recreational enhancements envisaged in Duqm as a tourism centre will also be impacted by the development if there are lot of traffic jams. The Project will also initiate both employment and trade along with infrastructure development in the area.

6.3 Sourcing of Utilities

The major utilities required during the construction phase of the Project are DG sets, potable and non-potable water, and fuel.

- **Power:** The power demand during construction phase is not expected to be significant. It is proposed that on-site diesel generators (DGs) will be used. The power requirements during operations phase will be very limited as this is only a road and only lights will be there.

Therefore, the power requirement is only for the construction phase and will be met from the onsite diesel generators.

- **Non-potable and Potable water:** Water will be sourced from the existing desalination plant particularly for potable purposes and this will be supplemented by bottled water as and when required. For non-potable purposes, water can be again sourced from the existing desalination plant or from local shallow groundwater wells.
- **Fuel:** Fuel to operate equipment's will be sourced from local fuel vendors. There is a petrol station in Duqm and the EPC contractor can discuss transportation of the fuel on requirement basis through vehicles as opposed to storage tanks.

7 CLIMATE AFFAIRS

This chapter presents the Green House Gas (GHG) releases from the construction of the Road Nos. 1 and 5 and the associated drainage systems and discusses the impact on the climate due to the Project.

An estimate of greenhouse gases (GHG) emissions using the emission factors from the Intergovernmental Panel on Climate Change (IPCC) Guideline, and data from the design documents is presented in this chapter.

This chapter has been prepared and structured as per the guidelines from the Directorate General of Climate Affairs (DGCA) at the Ministry for Environment and Climate Affairs (MECA), and its subsequent updates.

7.1 Contact Details

The organization and contact details for issues related to climate affairs issues are provided below:

Organization	-	SEZAD
Address	-	P.O. Box 25, P.C. 103 Bareeq Al Shatti, Muscat, Sultnate of Oman
Name of the Contact Person	-	Head of Environmental Affairs
Telephone Number	-	+968 24507500
Name of Climate Affairs Consultant	-	HMR Environmental Engineering Consultants (Mr. Madhupal, Project Manager)
Telephone Number	-	(+968) 24618800
Fax Number	-	(+968) 24618811
Email	-	madhupal@hmrenv.com

7.2 Integration of Climate Affairs Issues to the EIA

7.2.1 *Type of Ozone Depleting Substances*

The only device likely to contain Ozone Depleting Substances (ODS) during the project activities are the air conditioners used in the site offices. As indicated in Chapter 3, no construction labour camp, material laydown, or storage area is going to be established along the corridor of Road Nos. 1 and 5.

During construction, the peak labour requirement to service the civil, mechanical, and electrical works is envisaged to be in the order of 200 workers. Accordingly, a maximum of 20 units of window air conditioners might be installed in the site office during construction activities. During the operation time, there will be no site office for the constructed roads.

It is possible that sulphur hexafluoride (SF_6) might be used as insulating material in the high voltage electrical equipment during the construction phase. The Hydrochlorofluorocarbons (HCFCs) will be phased out completely by 2015 in line with Montreal Protocol and since the construction is anticipated in the second half of 2016, all the air conditioners will comply with this requirement. It is also anticipated that no Halons and Chlorofluorocarbons will be used in this Project. However, trace amounts of refrigerants might be used in chiller packages for potable water, and the construction contractor will import chillers that use hydrofluorocarbons (HFCs) rather than HCFCs. The EPC contractor will take into consideration the requirements of Montreal Protocol and ensure compliance to it as well as requirements of MD 243/2005 (Regulation for the control and management of ozone depleting substances).

As this is a new road development, the actual quantity of the global warming potential inducing substances shall be quantified in the forthcoming Climate Affairs Application.

7.2.2 *Equipment Containing ODS*

The existing site offices will not use any ODS and will also not use polychlorinated biphenyl (PCBs), polychlorinated terphenyls (PCTs), and asbestos. No carbon tetrachloride (CCl_4) will be used in refrigerants. No new equipment purchased will be allowed to contain any asbestos.

Standard air conditioners that are commercially available in the local market through authorised distributors will be procured. The exact number and make of these air conditioners will be finalised during the detailed design stage of the project. The air conditioners will be sourced, serviced and maintained by authorised suppliers and service centres in Oman, which are expected to comply with the requirements of MD 243/2005. Controlled substances listed in MD 243/2005 or equipment, appliances, and products containing such substances will not be used during any stage of the project.

7.2.3 *ODS Alternative*

The project does not envisage use of any ODS, except for potential trace amounts of SF_6 but this will be known only during the detailed design stage. As noted earlier, the EPC contractor will identify and implement processes and procedures to ensure that only non-ozone depleting refrigerants get used during the project. Accordingly, the project will consider all options to use alternatives with less ODS potential.

7.2.4 *Plan for Use of ODS Alternative*

Regular maintenance of equipment that use ozone-depleting refrigerant is the best way to ensure optimum performance of equipment and minimize any possible leaks. Recapture and re-use of refrigerants will be employed for all equipment undergoing maintenance or being disposed. No equipment will be disposed from the project site if the refrigerant had not been captured or assigned to a location where it can be assured that recovery will occur.

7.2.5 *Adherence with MD 243/2005*

Controlled substances listed in MD 243/2005 or equipment, appliances, and products containing such substances will not be used during any stage of project.

7.2.6 *Identifying Climate Affairs Issues in the EIA Study*

The GHG emissions from various sources such as combustion sources, solid waste, solvent use, gas systems, wastewater treatment, etc. are presented in the following sections.

7.3 Greenhouse Gas (GHG) Emissions during Construction

7.3.1 *Stationary Combustion Sources*

One diesel generator of 1 MW rating each will be used to meet power requirements for the site office and the construction activities (such as concrete batching, pipe cutting, welding, etc.).

The type and quantities of the GHG emissions generated from stationary combustion sources is presented in ***Table 7-1.***

The detailed GHG emission calculations for stationary combustion sources are given in ***Table 7-2.***

The calculations are based on the IPCC[6] emission factors.

For the purposes of calculation, it has been assumed that the actual construction activity will be over a 6-month window.

Table 7-1: GHG Emissions from DG sets during Construction

Year	DG capacity	GHG (tonnes)		
		CO_2	CH_4	N_2O
2016 (6 months)	1 MW	2,312.49	0.0936	0.01872

Assumptions made in the calculations for ***Table 7-1:***

- 1 MW DG running at 75% load for the entire period will require 200 litres of diesel per hour.
- 144 m^3 per month of diesel consumption results in approximately 385 tonnes / month of GHG emissions for the 1 MW DG set (refer ***Table 7-1***) which will be used in the construction period.

For the construction period of 6 months, the total GHG emissions for the stationary construction activities would be approximately 2,313 tonnes of CO_2 (carbon dioxide). Emissions of CH_4 (methane) and N_2O (nitrous oxide) are very negligible.

[6] http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_2_Ch2_Stationary_Combustion.pdf

Table 7-2: Detailed GHG Emission Calculations for Stationary Combustion Sources

DG Capacity	1 MW	Units
Diesel requirement	144	m^3/month
Density of Diesel	0.86	kg/L
LHV of Diesel	42000	KJ/kg
CO_2 emission factor	74100	kg/TJ
CO_2 emitted from DG sets	385.415	tpm
	4,625	tpa
CH_4 emission factor	3	kg/TJ
CH_4 emitted from DG sets	0.0156	tpm
	0.1872	tpa
N_2O emission factor	1	kg/TJ
N_2O emitted from DG sets	0.00312	tpm
	0.03744	tpa

7.3.2 *Mobile Combustion Sources*

The GHG emissions summary from mobile combustion sources are presented in ***Table 7-3.*** It is to be noted that the mobile sources referred in the IPCC guidelines cover off road transportation sources including vehicles and mobile machinery used for construction and maintenance.

The detailed GHG emission calculations are given in ***Table 7-4***.

It is anticipated that certain construction activities will require diesel fuel for power including construction vehicles and equipment, such as excavators, loaders, hauler cranes, compactors, trucks, water tankers, and crew transport vehicles.

It is assumed that the diesel consumption for construction vehicles and equipment will be 6,000 L/month (i.e. 6 m^3/ month).

Table 7-3: GHG Emissions from Mobile Combustion during Construction

Year	GHGs (tonnes)		
	CO_2	CH_4	N_2O
2016 (6 months)	96.354	0.0054	0.0372

Assumptions made in the calculations for ***Table 7-4:***

- 6 m^3 per month of diesel consumption per month results in approximately 97 tonnes per month of GHG emissions in CO_2. Emissions of CH_4 (methane) and N_2O (nitrous oxide) are very negligible.

Table 7-4: Detailed GHG Emissions Calculations for Mobile Combustion Sources

Equipment	Value	Unit
Diesel requirement	6	m^3/month
Density of Diesel	0.86	kg/L
LHV of Diesel	42000	KJ/kg
Energy input	0.036	TJ/day
Mobile Combustion (IPCC Table - 3.3.1)		
CO_2 emission factor	74100	kg/TJ
CO_2 emitted from vehicle movement	16.0590	tpm
	192.708	tpa
CH_4 emission factor	3.9	kg/TJ
CH_4 emitted from vehicle movement	0.0009	tpm
	0.0108	tpa
N_2O emission factor	3.9	kg/TJ
N_2O emitted from vehicle movement	0.0062	tpm
	0.0744	tpa

7.3.3 *Fugitive Emissions*

Fugitive emissions from the project will be limited to only fugitive dust emissions.

It is to be noted that heavy construction, including activities such as land clearing, drilling and blasting, ground excavation, cut and fill, etc., is a source of dust emissions potentially having temporary impacts on the local air quality. The dust emissions often vary substantially from day to day, depending on the level of activity, the specific operations, and the prevailing meteorological conditions.

In addition, a large portion of the emissions results from equipment traffic over temporary roads at the construction site. The temporary nature of construction differentiates it from other fugitive dust sources as to estimation and control of emissions since it may vary substantially over different phases of the construction process in contrast to most other fugitive dust sources, where emissions are either relatively steady or follow a discernible annual cycle. By using the mitigation measures suggested in the EMP, no significant quantities of emissions are expected during construction or the operational phases.

7.3.4 *Land Use and Land Use Change or Others*

Not Applicable.

7.3.5 *GHG Emissions from Industrial Process of the Proposed Plant / Industry*

This is not applicable since it is simply a roadway construction.

7.3.6 *GHG Emissions from Solid Wastes*

The recyclable, hazardous, and non-hazardous wastes generated during the construction activities, will be collected, stored and disposed in accordance with MD 18/93 and MD 17/93 regulations.

There will not be any biological treatment, incineration, or open burning of waste at the project site during the construction and operational phases.

Accordingly, no GHG emissions are expected from the solid waste management.

7.3.7 *GHG Emission from Wastewater Treatment*

The sewage generated from the site, during the construction phase, will be collected in holding tanks and will be treated either through captive portable Sewage Treatment Plant (STP) units or at the STPs managed by the local municipality for treatment and disposal. There is already a STP in Duqm and this can be used, if required.

At the peak, the construction activity will have nearly 200 personnel, and estimating that the wastewater generation will be 100 litres per day of wastewater, the maximum wastewater generation will be around 50 m^3/day. Since the wastewater will be treated through STP, there will be no GHG emissions from wastewater treatment during construction phase.

7.3.8 *Reporting Total Amount of GHG Emission during Construction*

The details of the GHG emissions calculations from the above tables are presented in ***Table 7-5***.

Table 7-5: Total GHG Emissions during Construction

Type of Activity	Methodology according to IPCC	Emission Factor	Quantity of fuel for Combustion	Total Emissions for 6 months
Stationary Combustion	Emission factors provided in the 2006 guidelines for National Greenhouse Gas Inventories, Volume 2 by IPCC.	CO_2 – 74,100 kg/TJ CH_4 – 3 kg/TJ N_2O –0.6 kg/TJ	144 m^3/ month	CO_2 – 2,312.49 tonnes CH_4 – 0.0936 tonnes N_2O – 0.01872 tonnes
Mobile Combustion		CO_2 – 74,100 kg/TJ CH_4 – 4.15 kg/TJ N_2O –28.6 kg/TJ	6 m^3/ month	CO_2 – 96.354 tonnes CH_4 – 0.0054 tonnes N_2O – 0.0372 tonnes

Type of Activity	Methodology according to IPCC	Emission Factor	Quantity of fuel for Combustion	Total Emissions for 6 months
Fugitive Emissions from Oil & Natural Gas System		Not Applicable	-	-
Others		Not Applicable	-	-
Type of Activity		**Methodology according to IPCC**		

The total CO_2 emissions are estimated to be 2,410 tpa. Currently, there is no ceiling limit set for CO_2 emissions (mass) rates in Oman. According to the UN Statistic Division and the Carbon Dioxide Information Analysis Centre estimate, Oman generated approximately 57,202,000 tpa during 2010.

7.4 GHG Emissions during Operational Phase

7.4.1 *GHG Emissions during Operations Phase – Stationary Source*

Since it is a roadway project, there will be no need to have diesel generator during the operation stage. Accordingly, there will be no GHG emission from the operation phase stationary source.

7.4.2 *GHG Emissions during Operation Phase – Mobile Source*

During the operation phase, there will be vehicles using the roads that will generate GHG emission. However, it is not feasible to estimate the GHG emission at that time.

7.4.3 *Details of GHG Emissions from Operation Phase*

There will be no GHG emission in the operation phase.

7.4.4 *GHG Emissions from Solvent Use*

This will not be applicable.

7.4.5 *GHG Emissions from Solid Waste Generation*

Since it is a road project, there will be no solid waste generation during the operation stage. Accordingly, no GHG emissions are expected from the solid waste management.

7.4.6 *GHG Emission from Wastewater Treatment*

Because of the nature of this project, there will be no wastewater generation during the operation stage. Accordingly, no GHG emissions from wastewater treatment is expected during the operation phase.

7.5 Reporting Total Amount of GHG Emissions

The total GHG emission from the construction and operation is presented below in Table 7-6:

Table 7-6: Total GHG Emissions – Construction and Operation

	Type of Activity	Methodology according to IPCC	Emission Factor	Quantity of fuel for Combustion	Total Emissions for 18 months
Construction	Stationary Combustion	Emission factors provided in the 2006 guidelines for National Greenhouse Gas Inventories, Volume 2 by IPCC.	CO_2 – 74,100 kg/TJ CH_4 – 3 kg/TJ N_2O –0.6 kg/TJ	144 m^3/ month	CO_2 – 2,312.49 tonnes CH_4 – 0.0936 tonnes N_2O – 0.01872 tonnes
	Mobile Combustion		CO_2 – 74,100 kg/TJ CH_4 – 4.15 kg/TJ N_2O –28.6 kg/TJ	6 m^3/ month	CO_2 – 96.354 tonnes CH_4 – 0.0054 tonnes N_2O – 0.0372 tonnes
	Fugitive Emissions from Oil & Natural Gas System		Not Applicable	-	-
	Others		Not Applicable	-	-
Operation	Stationary Combustion, Mobile Combustion, Fugitive Emissions, and Others				0

7.6 Assessment of Climate Change Impacts and Vulnerability

The overall vulnerability of the project to climate change is low to medium. Any disruptions in operations that could occur as a result of weather events such as cyclones will be short term in nature. An overall change in climate will not affect the operation of the facilities.

A Climate Affairs Risks Matrix is provided in ***Table 7-7***

Table 7-7: Climate Change Risk Matrix

Type of Risks	Frequency/ degree of Vulnerability[7]	Climate Impacts due to identified Vulnerability[8]	Risk Magnitude
Natural Disasters such as cyclone, earthquake, high waves, landslides, and dust storms	2[9]	2	2
Sea Level Rise	2	2	2
Temperature Increase	1	1	1
Heavy Rains	1	1	1
Flash Flooding	1	1	1

7.7 Climate Change Mitigation and Adaptation

The mitigation options and adaptation measures for climate change is discussed in ***Table 7-8.***

[7] 1,2,3 indicate low, medium and high frequencies respectively of vulnerability
[8] 1,2,3 indicate low, medium and high impacts respectively due to identified vulnerabilities
[9] The frequency is taken as 2 since Oman had been impacted by cyclones such as Gonu and by dust storms. Likewise, since the roads are adjacent to the sea and possibility of them getting impacted by sea level rise is there, we have rated them as medium vulnerability. However, the other risks in this category such as heavy rains, flooding, etc. are rated only as 1.

Table 7-8: Mitigation measures

#	Mitigation options	Mitigation Measures
1	Identify the new technologies and measures to minimize the energy consumption and improve the energy efficiency for all stages of the Project.	The stationary DG will be used only for supplying power to the construction site office. However, it is anticipated that the EPC contractor will be required to include energy efficient designs and equipment during all stages of the construction, wherever it is applicable. The EPC contractor will be required to use certified energy efficient equipment (where possible) to minimize emissions to the maximum extent possible. The EPC contractor could be asked to adapt and install solar power units at the site office as it will then minimize the use of DG set and reduce the diesel consumption. The main sources of GHG emissions are construction vehicles, equipment, and diesel generator, etc. They will be used only during the 6 months construction period. They will be maintained properly so that the efficiency of the equipment and vehicles are not compromised.
2	Identify the potential usage of renewable energy for all the stages of the Project and explain the future visions of how to incorporate them into the project activities and how to eliminate the barriers, if exits, which prevents such action.	Already covered above.
3	Explore the benefits of CDM under Kyoto Protocol.	The proposed project currently does not involve opportunities for carbon capture, reduction, or sequestration.
4	Consider planting carbon sinks, which suits to local environment and conditions to reduce GHG.	This project area footprint in the construction phase will be quite small. So, carbon sink will not be possible.
5	Attach the landscaping plan/design of proposed plantation/ green cover.	It is only development of roads and the drainage system, and there is no plan to have any plantation or green cover.

7.7.1 *Mitigation*

The use of water and energy conservation fixtures at the construction site office will reduce the resource consumption. It is to be noted that the EPC contractor will utilize energy optimization methods, such as use of efficient and well-tuned equipment and energy efficient generator, for the office and construction activities which will minimize losses and in turn maximize energy efficiency.

The renewable energies available for use in the project area are wind and solar power. Although the region has high wind speeds, the installation and energy generation from wind power is presently not considered by the Government. Since the construction phase will be over in just 6 months, the wind power is not being considered.

The energy from the sun varies from place to place and is entirely dependent on weather conditions. Normally, the available energy from the sun is 1 KW/m^2 per hour in the absence of clouds. Some of the considerations for a solar energy system include the lifespan of the system and the hours of available sunlight. The hours of available sunlight further depends on latitude, climate, and unblocked exposure to the sun, ability to tilt panels towards the sun, seasonality, and temperature, etc. It is to also be noted that solar energy installation requires a large area for the system to be efficient in providing a source of electricity.

The use of water and energy conservation fixtures at the site facilities will reduce the resource consumption. It is anticipated that the EPC contractor will be asked to explore the feasibility of installing solar panels for the construction site office.

7.7.2 *Adaptation*

The main climate change impacts on the development would be from dust storms and cyclones during extreme weather events.

A description of the procedures and tools to adapt and mitigate the impacts of climate change for the project in case of floods, sea level rise, dust storms, Tsunami and increase in temperature are described below:

High Waves, Floods, Tsunamis, and Sea Level Rise

The greatest Tsunami threat facing the Omani coastline is expected to be from the Makran subduction zone in the Gulf of Oman and the Northern Arabian Sea. However, within the Arabian Gulf, it is rather unlikely for large tsunamis to form. Given that the coast is shallow, not prone to landslides, and is without volcanoes, the likelihood for tsunamis is relatively low.

SEZAD has conducted detailed studies on both the onshore and offshore areas to assess the risks and are also currently doing a study on "coastal erosion assessment and preparation of designs to minimize impacts". Therefore, extreme events such as floods, cyclones, Tsunamis, and storms will be considered and protective measures implemented. This will cover the project area as well.

Although the release of GHGs into the atmosphere contributes to global warming and consequently increasing the sea level, it is an on-going phenomenon globally, and historic rates are generally estimated to be in the range of 3.2 mm / year (or 0.16 m over 50 years). According to the study by the Arab Forum for Environment and Development, it is expected that only a fraction of the overall land area of the Sultanate of Oman will be impacted due to a 1 m rise in sea levels. It is anticipated, that the project will not be substantially impacted by these threats.

Drought and Change in Groundwater Level

The groundwater in the area is highly saline and it is expected that the EPC contractor will prefer using the existing desalination plant supplied potable water to meet the requirements of the site office. Therefore, the project will not directly contribute to change in groundwater levels in the area.

Dust Storms

The construction site office and other construction structures will be designed to withstand high winds and have the structural integrity to withstand events such as storms, floods, sea level rise, high dust loading conditions, sandstorms, etc.

Increase in Temperature

The region where the project is located is prone to high summer temperature for an extended period and therefore the site office will be adequately provisioned with heating, ventilation, and air conditioning (HVAC) systems.

Landslides

According to World Health Organisation atlas (http://www.who-eatlas.org/eastern-mediterranean/images/map/oman/omn-landslides.pdf), the landslide hazard index for complete Oman is between low and very low. Hence the likelihood of the project being affected by landslides is very unlikely, as presented in ***Figure 7-1.***

Figure 7-1: Risk of Landslides from Precipitation in Oman

8 ASSESSMENT OF ENVIRONMENTAL IMPACTS

8.1 General

In this chapter, the potential impacts on the receiving environment from the construction and operation of the Project have been identified and assessed. The assessment covers the construction and operational phases of the project based on similar considerations in the discussions on environmental releases in Chapter 5.

8.2 Methodology

The assessment of environmental impacts includes the following steps:

1. Identification of major activities during the project phase based on the discussions on project details provided in Chapter 3;
2. Identification of potential environmental aspects from the project activities (identified in the above step) based on discussions in Chapters 3 and 5;
3. Identification of potential impacts from the project considering the environmental aspects identified above on various environmental elements / sensitivities (receptors) based on discussions of environmental and social settings of the proposed route as presented in Chapter 4; and
4. Assessment of environmental impacts considering the severity of impact and the likelihood of its occurrence.

Potential impacts have been evaluated using qualitative assessment techniques. The impacts have been rated as ‘low’, ‘medium’ or ‘high’. This rating is based on two parameters, i.e., severity of impact and likelihood of occurrence of the aspect.

The severity of an impact depends on:

i. Magnitude of the impact,
ii. Duration of impact (reversibility of impacts)
iii. Cost of mitigation measures and
iv. Residual impact.

The likelihood depends upon the nature of the aspect/impact and the control measures in place. Rating of impact severity and likelihood of impacts are discussed in ***Table 8-2*** and ***Table 8-3*** respectively.

An impact assessment matrix as presented in ***Table 8-1*** below has been used for combining the two assessment criteria, i.e., severity of impact and likelihood of aspect occurrence. The matrix is a variant to internationally accepted Leopold’s matrix and Battelle's Environmental Evaluation System (BEES), and is developed taking into consideration components mentioned in the World Bank’s EIA methodology.

Table 8-1: Impact Assessment Matrix

Severity \ Likelihood	Very Unlikely	Unlikely	Likely	Very Likely	Certain
Insignificant					
Minor	**LOW IMPACT**				
Localised			**MEDIUM IMPACT**		
Major				**HIGH IMPACT**	
Catastrophic					

Table 8-2: Rating of Impact Severity

Severity	Definition
Catastrophic Effect	Persistent severe environmental damage or severe nuisance extending over a large area; Constantly high exceedance of statutory or prescribed limits (representing both a short and long term threat to ecosystem); Continuous severe impacts in terms of access and or damage on community activities, health and safety and assets; Complete behavioural and cultural change of local community; Complete damage to archaeological or cultural site.
Major Effect	Severe environmental damage; Extended exceedance of statutory or prescribed limits; Severe impacts in terms of access and or damage on community activities, health and safety and assets; Behavioural and cultural change of local community Damage to archaeological and cultural site; The company is required to take extensive measures to restore the contaminated environment to its original state.
Localised Effect	Instances of exceedance of statutory or prescribed limit; Disruption to access to community assets or resources; Causing localised nuisance both on and off site;
Minor Effect	Damage sufficiently large to attack the environment; No permanent effects to the environment; No permanent disruption to access to community assets or resources; Single exceedance of statutory or prescribed criterion; Single complaint.
Insignificant Effect	Local environmental damage and social impact; within the RoW and within systems; Negligible financial consequences.

Table 8-3: Rating for Likelihood of Impacts

Likelihood	Definition
Certain	Will occur under normal operating conditions.
Very likely	Very likely to occur under normal operational conditions.
Likely	Likely to occur at some time under normal operating conditions.
Unlikely	Unlikely to but may occur at some time under normal operating conditions.
Very unlikely	Very unlikely to occur under normal operating conditions but may occur in exceptional circumstances.

The resultant impact (consequence) is defined as the multiplication of severity and likelihood. Accordingly from the assessment matrix the resultant impacts are classified as i) low ii) medium and iii) high.

Low impacts are considered to be acceptable or within regulatory limits. Further control measures are not required to mitigate these impacts.

Medium impacts are those requiring control measures, an environmental and social management system to be implemented so as to mitigate the impacts to acceptable levels.

High Impacts are those that require additional studies (either detailed surveys or predictive modeling) to ascertain such impacts to determine if alternative activities with lower impacts or alternative locations with lower environmental/social sensitivities need to be considered during the detailed design stage of the project.

Qualitative techniques have been used for evaluating the potential impacts. While assessing the impacts, the environmental protection measures integrated in the project design (Chapter 3) and the pollution control measures proposed in Chapter 5 have been taken into consideration.

The impacts, which are rated as low are considered to be acceptable or within "As Low as Reasonably Practicable (ALARP)" levels. Control measures for further mitigation of these impacts may not be viable. Impacts that are rated as medium and high (significant impacts) will be managed through mitigation measures and implementation of the environmental and social management plan to reduce the residual risks / impacts to ALARP levels.

8.3 Impact Identification

Based on the available information and the nature of the proposed project, the activities leading to potential impacts (environmental and social hazards that have potential to cause prominent environmental consequences) and their consequences (ppotential environmental and social consequences associated with the above hazards) have been tabulated and presented in ***Table 8-4.***

Table 8-4: Hazards and Consequences

Activities leading to Potential Impacts	*Consequences*
Site mobilization includes route survey and marking. Earthworks associated with road and track preparation. Laying of bitumen along proposed route. Vehicular Movement. Workers Influx.	Visual Impact; Contamination of the surrounding air; Contamination of soil, ground water and water courses; Change in topography; Loss of native vegetation and habitat; Soil disruption, airborne dust;

Spills or leaks associated with storage of oil and fuels, refueling operations etc.; and Disposal of waste.	Soil erosion and disturbance to natural drainage patterns; Noise Generation; Damage to archaeological sites; Disruption of access to cultural sites; Health and safety of community and livestock; Impact on Land use specially grazing areas; Cultural impacts from population influx and increased movement of people; Impact on existing infrastructure such as medical, water wells etc; and Employment Generation for local community.

The potential environmental impacts along with mitigation measures during the construction and operation phase are presented in ***Table 8-5*** and ***Table 8-6*** respectively. Although the environmental issues arising from the Project activities during the operation phase will be less substantive and can be quite minimal.

Table 8-5: Potential Environmental Impacts and Mitigation during Construction Phase

#	Environmental Element	Environmental Aspects	Potential Environmental Impacts	Severity	Likelihood	Impact	Mitigation Measures
1	Natural resources	Consumption of large quantities of construction materials and fuel.	Depletion of natural resources	Major	Likely	Medium	• Optimizing use of resources through reduction, reuse and or recycle of materials
2	Groundwater / Surface water resources	Spillage / leakages of hazardous material and wastes. Abstraction of groundwater for construction purposes.	Ground and surface water contamination from accidental spills. Depletion of water resources.	Major	Likely	Medium	• for hazardous materials and wastes, with spill containment • Avoid storing and disposal in the wadis.Appropriate storage facilities
3	Land	Improper handling and disposal of hazardous materials and wastes. Ground stabilising works for route passing through sabkha land.	Land and Sabkha land will get disturbed. Land contamination from accidental spills.	Major	Likely	Medium	• Spill prevention plan and routine inspection of storage facilities. • If sourcing of water is required for construction, water must be sourced from legal sources with relevant permits. • Minimizing water consumption, and implementing water conservation measures where possible. • Necessary precautions will be taken to protect sabkha lands falling in the routes of road 1 & 5.

#	Environmental Element	Environmental Aspects	Potential Environmental Impacts	Severity	Likelihood	Impact	Mitigation Measures
4	Air quality	Dust emissions from earthworks. Emissions (of NOx, SO2, CO, VOCs, and PM) from construction vehicles and equipment, and DG sets. Fugitive VOC emissions from fuel storage tanks	Deterioration of visibility. Additional increase to background ambient air quality. Adverse health effects	Major	Likely	Medium	• Equipment and vehicles required to be properly maintained to control the emissions. • Water spraying for dust suppression during dry weather conditions. • Controlling vehicle speeds within the construction sites and graded roads.
5	Ambient noise	Generation of noise construction vehicles and equipment, and DG sets.	Increase of ambient noise levels may cause annoyance to local habitats, fauna, and sensitive species	Minor	Certain	Low	• Equipment and vehicles to be properly maintained. • No night time operation of high noise generating construction machinery. • Controlling vehicle speeds. • High noise equipment to be oriented away from receptors. • Ear muffs or ear plugs to be used by all personnel working in the vicinity of noise generating sources.
6	Local infrastructure	Utilization of existing roads, water suppliers, etc.	Minor stress on current infrastructure	Minor	Likely	Low	• Optimize use of the available infrastructure

#	Environmental Element	Environmental Aspects	Potential Environmental Impacts	Severity	Likelihood	Impact	Mitigation Measures
7	Public health and safety	Movement of heavy vehicles carrying heavy cargo by road to and from the project site. Improper handling and disposal of hazardous chemicals, wastes and operation of hazardous processes.	Adverse impacts in case of accidental failures	Major	Likely	Medium	• Prepare and implement a transport / traffic management plan. • Emergency response procedures to be established, response team to be identified and trained. • Appropriate training for the staff on safe handling of hazardous materials and wastes. • Defensive driving methods to be adopted and staff trained on the same.
8	Cultural heritage	Presence and movement of equipment, heavy vehicles, work crew	Damage to the archaeological artifacts	Major	Likely	Medium	• Work crew to be informed of the cultural heritage areas and the need to avoid any damage. • Response procedure in case of accidental damage.
9	Socio-economic	Requirement for construction staff by the EPC contractor and subcontractors. Requirement for local contractors and service providers. Influx of expatriate construction workers.	Employment opportunities for local people and business opportunities for local contractors and service providers – positive impact. Impact on the local culture and lifestyles – negative impact.	Minor	Likely	Low	• Engage/ consult with local community/ village heads and conduct project appraisal. • The expatriate construction staff are to be managed appropriately to prevent impact on local culture and lifestyles.

#	Environmental Element	Environmental Aspects	Potential Environmental Impacts	Severity	Likelihood	Impact	Mitigation Measures
10	Terrestrial/ marine ecology	Site preparation and grading	Disturbance to terrestrial/marine ecology, or habitat loss to terrestrial/marine ecology. Mainly in sabkha land and lagoon area. Impact on flora fauna, especially on avifauna in sabkha Disturbance to marine fauna in tidal flat/lagoon area	Major	Likely	Medium	• Minimise the impact by clearing vegetation only wherever required along working strip (especially Road 1area) . • Minimise extraneous noise sources and use adequate noise attenuation on engines. • Night time driving and off road driving will be restricted to emergencies only.

Table 8-6: Potential Environmental Impacts and Mitigation during Operation Phase

#	Environmental Element	Environmental Aspects	Potential Environmental Impacts	Severity	Likelihood	Impact	Mitigation measures
1	Air quality	Vehicle and equipment exhausts	Emissions of CO, CO_2, NOx, unburnt HC, and PM	Major	Certain	High	• Sign, and enforce road speed limits where possible. • Regular maintenance of the road.
2	Ambient noise	Generation from vehicular movement	Potential impacts on neighboring residents and sensitive receptors	Major	Certain	High	• Sign, and enforce road speed limits where ever possible. • Regular maintenance of the roads
3	Ecology and wildlife	Air, lighting, and noise pollution	Impact to local flora and fauna	Localised	Very Likely	Medium	• Disturbance to the domestic animals (camels in particular) moving around or grazing will be kept to a minimum. • Accidental injuries or fatalities to these animals will be reported to SEZAD / MECA / ROP / or relevant authorities. • Incoming of animals on to the road will be protected by providing vegetative fencing to divert the animals.
4	Climate	Release of greenhouse gases (GHG) from increased vehicle use	Climate change impacts such as global warming and depletion of ozone layer and consequent changes in wind	Localised	Very Likely	Medium	• Identifying opportunities for enhancing energy efficiency. • Regular maintenance of the roads to prevent idling of

#	Environmental Element	Environmental Aspects	Potential Environmental Impacts	Severity	Likelihood	Impact	Mitigation measures
			patterns, sea level changes, changes to rainfall, floods, etc.				vehicles which results in increased generation of GHG.
5	Water Resources	Surface run-off during monsoons. Accidental spills of hazardous chemicals /wastes etc.,	Contamination of water resources	Major	Likely	Medium	• Silt traps shall reduce entering of silt into natural drainage. • Mobile vehicles, shall be provided, equipped with tools to handle hazardous materials whenever accidental pills are happened.
6	Land	Accidental spills of hazardous chemicals /wastes etc.,	Contamination of land(including sabkha land)	Major	Likely	Medium	• Contaminated soil will be collected and sent to hazardous landfill sites.

9 ENVIRONMENTAL MANAGEMENT AND MONITORING PLAN

This chapter describes various measures that are to be implemented so as to mitigate the environmental impacts rated as medium/high from the construction and operation phases of the project to ALARP levels. The potential mitigation measures included briefly in Chapters 8 of this EIA Report have been discussed in detail in the following sections along with monitoring plans and management systems to implement the mitigation measures.

9.1 Overview

Road projects are generally intended to improve the economic and social welfare of people. Increased road capacity and improved pavements can reduce travel times and lower the costs of vehicle use, while increasing access to markets, jobs, education, and health services and reducing transport costs for both freight and passengers.

For all the positive aspects of road projects, they may also have significant negative impacts on nearby communities and the natural environment. The EMP is developed as a part of the EIA study in order to provide guidelines for the Construction contractors to ensure environmental compliance as per the Omani regulatory standards. It also includes a suitable management framework to mitigate social concern pertaining to the community, increased traffic, workforce influx i.e. construction workers, health and safety, etc.

The proposed EMP for the construction and the operation of the project includes specific mitigation actions for each adverse impact identified, monitoring program and resource allocation. Efforts have been made to provide mitigation measures commensurate with assessed level of risk e.g. low, medium and high. This EMP aims to feed directly into an HSE management system to be implemented by the construction contractor as well as Parsons.

A defined Environmental Management System (EMS) is important for effective implementation of environmental plans and mitigation measures during project execution phase. Effective EMS ensures timely incorporation of suitable measures and identifies review of site specific management plans to minimize potential adverse impacts. An EMS can assist in addressing environmental issues comprehensively, while achieving increased credibility, regulatory agencies and citizens. It sets out policies, objectives, targets and provides measurable goals and performance levels.

9.2 Organisation and Responsibilities

The construction contractor and its subcontractors will be required to establish an organizational structure for environmental management including health and safety issues to ensure effective implementation of mitigation measures and to review environmental management process. An indicative organization structure is presented in ***Figure 9-1.***

Construction contractors should ensure that the sub-contractors develop and implement an effective Environmental Management System (HSEMS) for the project construction phase. The HSEMS will comply with the control measures and environmental management requirements outlined in this EMP and any additional conditions provided by the regulators by way of initial environmental permit, construction permits, etc.

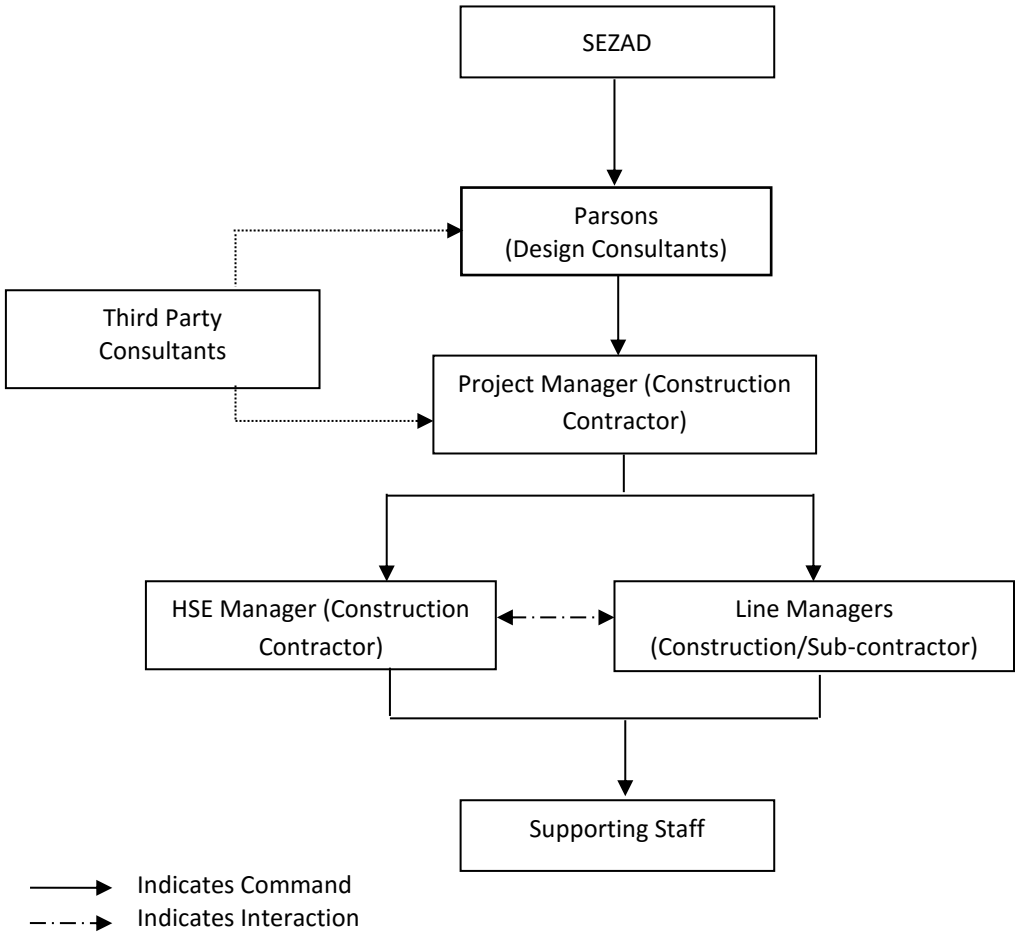


Figure 9-1: Proposed HSE Organisation Structure

9.3 Environmental Management Measures

The EMP along with environmental mitigations as suggested in this chapter ensures the compliance with stipulated Omani regulations for applicable environmental attributes. The environmental management required for the receptors at various stages were considered, analyzed and presented in separate sections below.

9.3.1 *Land Management*

- Clearing of land and vegetation will be avoided as much as possible;
- Stakeholders in the vicinity of activity site will be consulted for disclosure of project activities prior to, during and after the construction to avoid possible community issues;
- Use of community resource or infrastructure with prior disclosure through Wali / Sheikh;
- Off-road driving shall be strictly controlled. Defined speed limits shall be imposed and proper signage provided for all project related traffic;
- Disturbance to natural topography and soil will be minimised to the extent possible;
- Proper marking / pegging and signage shall be installed demarcating the project activities such as earth works, cutting, blasting etc., and socio-environmental sensitiveness such as endangered ecology and habitats, settlements, grazing area, wadi, etc; and
- Adequate culverts to be provided wherever the proposed alignment crosses wadi.

9.3.2 *Hazardous Waste Management*

- Any oil contaminated waste or soil shall be treated as hazardous waste, and handling and disposal will be made according to MD 18/93;
- No hazardous waste will be mixed with any other type of waste;
- All hazardous waste will be appropriately packed, labeled and will be accompanied by a waste consignment note when transported out of the proposed route;
- Hazardous waste will be transported through MECA licensed transporters;
- Hazardous waste will be disposed at MECA licensed treatment or disposal sites;
- In case of any accidental spillage, the community will be informed as per the emergency response plan;
- Handling of all hazardous wastes and non-hazardous wastes by interacting with be'ah;

- Hazardous waste storage area shall be established by the EPC Contractor to provide sufficient facility for storage of hazardous wastes until be'ah Integrated Waste Treatment Storage and Disposal Facility in Duqm IWML becomes operational;
- Hazardous waste will be transported through be'ah licensed transporters and disposed at licensed treatment or disposal sites in accordance with MD 18/93;
- The EPC Contractor must obtain an Agreement from be'ah to accept all wastes from the construction activity. A copy of this Agreement shall be submitted to SEZAD; and
- All non-hazardous and hazardous waste shall be handled by be'ah or be'ah approved contractor.

9.3.3 *Solid Waste and Wastewater Management*

- Sewage and waste water will be collected in holding tanks and subsequently sent to nearest STP;
- Recyclable waste shall be stored separately onsite and handed over to waste recycling contractors;
- Holding tanks designated for waste streams shall conform to MD 421/98;
- Solid non-hazardous waste will likely be disposed-off to the existing landfill site, following approval from be'ah;
- Within site offices, all solid wastes will be kept in waste bins. Recyclable waste will be stored separately onsite and will be handed over to waste recycling contractors. Non-recyclable waste will be stored separately onsite and sent to the nearest landfill; and
- Waste consignment records will be maintained by the contractors. The solid waste handling, storage and disposal methods shall ensure compliance with MD 17/93.

9.3.4 *Air Quality*

- During excavations water sprinkling will be carried out to control air / dust emissions;
- Vehicle speeds will be controlled to minimize dust emissions; regular water sprinkling will be carried out; and
- Generators, vehicles and other equipment/machinery will be kept in good condition to ensure exhaust emissions are minimized.

9.3.5 *Noise*

- Generators, vehicles and other equipment / machinery will be kept in good condition to ensure noise are minimised

- Generators will be kept within enclosures to minimize dispersion of noise;
- All applicable mitigations and monitoring programs shall be implemented to comply with MD 118/2004 for air environment;
- Restrict working hours for vehicle movement especially near villages;
- Noise and vibration monitoring should be considered during construction and operation phases; and
- Compliance with MD 79/94 for noise pollution in the public environment during the construction phase, and MD 80/94 for noise control in the working environment during the construction activities.

9.3.6 *Wildlife Protection*

- Hunting of avifauna will be strictly prohibited;
- Night time work / traveling will not be allowed;
- Vehicle speeds on access road shall be minimised to avoid incidental mortality of small mammals and reptiles;
- Vegetation clearing and land uptake shall be minimised as much as possible; and
- Entering of animals on to the road will be protected by providing vegetative fencing to divert the animals.

9.3.7 *Use of water*

- Use surface and groundwater sources only after consultation with and consent of local communities and other users;
- Water will be sourced from nearby suppliers through approved tankers;
- Wherever possible use non-potable water for dust suppression after ensuring the quality (MD 145/93) to avoid impacts on ecology and contamination to groundwater resources;
- Onsite water conservation measures will be implemented; and
- Complete record of water consumption during all operations will be maintained by the construction contractor.

9.3.8 *Community Involvement*

- Use of community resource / infrastructure with prior disclosure through Wali / Sheikh;

- Workers will be sensitised about local culture and traditions to avoid social issues;
- Disclosure of mitigation measures and management plans to the community;
- No hazardous material or equipment is left at the areas of community movement; and
- Project related community grievances will be documented and appropriate measures will be taken.

9.3.9 *Employment*

- Unskilled labour will be hired from local communities if required; and
- Preference will be given to locals for semi-skilled jobs; in both the cases, local residents living closest to the project location will be given priority.

9.3.10 *Emergency Response*

- Emergency response plans will be prepared covering traffic accidents, medical emergency, oil spills etc will be prepared, implemented, and followed;
- First aid kit will be made available at the work site, and in all construction vehicles; and
- Fire extinguishers and safety measures will be made available at all important areas.

9.3.11 *Safety and Health*

- Site Health, Safety and Environment (HSE) plans shall be prepared and followed;
- Importance shall be given on the usage of Personnel Protective Equipment's (PPEs);
- Proper signage or marking shall be installed to avoid accidents;
- First aid kit shall be made available at the work site, and in all construction vehicles;
- Emergency medical plan shall be in place at work site; and
- Training and awareness programs for staff shall be undertaken.

9.3.12 *Culture & Heritage*

- Workers shall be made aware about local culture and traditions to avoid socio-cultural issues;
- Employees and contractors shall minimize their interaction with local residents and make efforts to minimize their disturbance in the community by timing the operations and transits through local communities to avoid disturbing worship, school, and other community gatherings;

- Workers shall receive a briefing on recognizing archaeological artefacts and how to respond when found;
- All archaeological sites or finds shall be reported to the Ministry of Heritage and Culture; and
- A chance finds procedure shall be developed and implemented in areas where there is potential for previously unknown cultural property to be found during construction.

9.3.13 *Terrestrial /marine Ecology*

Construction period:

- Minimise the impact by clearing vegetation only wherever required along working strip;
- Minimise extraneous noise sources and use adequate noise attenuation on engines;
- Minimise disturbance to the coastal avifauna; minimise the impact on surrounding tidal flat.
- Vehicles and machinery used outside of project area shall be cleaned prior to commencement of work so as to avoid introduction of non-native species into the project area; and
- Night time driving and off road driving will be restricted to emergencies only.

Operation period:

- Disturbance to the domestic animals (camels particular in Road -1area) moving around or grazing will be kept to a minimum;
- Minimise disturbance to the coastal avifauna;
- Accidental injuries or fatalities to these animals will be reported to SEZAD / MECA / ROP / or the appropriate authority; and
- Incoming of animals on to the road will be protected by providing vegetative fencing to divert the animals.

9.4 Environmental Monitoring and Data Management

In order to ensure that the quality of the environment within the work sites complies with the Omani regulations, periodic environmental monitoring will be carried out through a third party.

All the monitoring data will be documented by the HSE Manager to demonstrate compliance.

Further, periodic environmental auditing will be carried out by a third party to check and review the effectiveness of the management system.

The proposed monitoring and auditing plan for the construction phase is presented in ***Table 9-1*** below.

Table 9-1: Environmental Monitoring and Auditing Plan

Environmental Aspect	Scope of Monitoring / Auditing	Method / Requirement	Frequency of Monitoring / Auditing
Construction Phase			
Air quality	Ambient PM_{10} concentrations at several locations within work sites	Using on-site analysers	Monthly
Noise levels	Sound pressure levels at several locations within work sites	Using sound pressure level meter	Monthly
Sewage	Quantity of raw sewage disposed from work sites	Volume calculated based on tanker capacity Waste consignment note issued for each transfer	Monthly records to be maintained
Wastes	Quantity of each category of waste disposed from work sites	Volume / weight calculated based on tanker capacity	Monthly records to be maintained
Water	Quantity of potable and non-potable water received at the work site	Volume calculated based on tanker capacity	Monthly
Operation Phase			
Air Quality	Toxic gasses and aerosols in selected points along the road.	Using on-site analysers	Quarterly
Noise Level	Sound pressure levels at several locations along the road.	Using sound pressure level meter	Quarterly

Environmental Aspect	Scope of Monitoring / Auditing	Method / Requirement	Frequency of Monitoring / Auditing
Safety System	Road safety system shall be executed within the road 1 and 5.	Safety procedures	Bi-annual

9.5 Environmental Permits, Compliance and Sampling

The applicable environmental permits required to be obtained for this Project is listed in Chapter 2.7.

In addition, the monitoring program to be followed during the construction and operation is presented in ***Table 9-1.***

9.6 Traffic Management Plan

9.6.1 *Overview*

The main aim of the traffic management plan (TMP) is to define a framework for movement of equipment, workers and local community to / from proposed route.

To enable formulation of the required plan for managing vehicular traffic and safety, an outline or framework for traffic management plan is prepared.

However, the following aspects need to be considered prior to formulating a TMP:

- Finalize movement track or route for machinery and workers transportation;
- Identification of main route/s for community movement or road users;
- Identify locations for intervention to mitigate interface; and
- Finalize and implement mitigation measures.

9.6.2 *Objectives of TMP*

To formulate an effective TMP, the main objectives can include:

- Facilitate safe travel to / from the proposed route for residents and workers;
- Maximize efficiency of existing road;
- Safeguard movement of livestock;
- Disseminate details of TMP to community, drivers and workers;
- Maximize safety; and
- Minimize impact on local community.

There will be different levels of traffic flow during different stages of project. Apart from the local traffic on the road, there will be additional traffic of movement of construction vehicles and machinery. Since the TMP is a working document, it will reflect the responses of the concerned agencies to variety of traffic issues on proposed route.

The proposed framework for the TMP is based on an initial traffic volume count, community meetings, appraisal of construction schedule and potential implementation of traffic management measures as presented in ***Table 9-2.***

Table 9-2: Traffic Management Plan Components

#	Component	Consideration	Scheduling of TMP
1	Site Access and Access Way Plan	Parking sites assignment for machinery & vehicles. Parking area onsite. Pick-ups and drop-offs for workers. Parking regulations such as main approach road.	Finalize & implement prior to initiating early works. During construction works for heavy machinery & trucks. During operation for routine monitoring.
2	Traffic Flow Plan	Route planning. Local traffic flow route. Alternate routes or access ways. Disclosure of access way/s as per construction schedule. Fencing or barricades as per safety standards around trenches, road intersection etc. Emergency access routes as per emergency response plan. Involvement of ROP.	Finalize & implement prior to initiating early works. For alternate route for early works activities. Accommodate excess of traffic volume during construction & operation.
3	Safety Plan	Accident prevention Signing of access way, speed limits, directions, grazing area signboards etc Public information safety campaign Service patrols during construction Traffic incident quick clearance initiatives	To be formulated prior to construction to address any emergency requirement

The preparation of the detailed TMP and its finalization will be responsibility of project proponent, Contractor and the Royal Oman Police for efficient implementation. The local community can be involved to formulate the TMP with due considerations of the local traffic concerns and safety of livestock as it is foreseen as social concern during community consultations. The final TMP will be prepared prior to initiating the construction works with proper access ways and signboards.

10 CONCLUSION AND RECOMMENDATIONS

The Project involves the design and construction of Road No. 1 and Road No. 5 and the associated drainage systems along these proposed roads, which is a part of developing the road infrastructure works in the SEZAD area. In this EIA report discussion of the environmental releases, assessment of impacts, and management plans are presented.

It is evident, road construction project usually change existing drainage pattern, however Parsons, as design and Project Management Contractor, will ensure that existing drainage will be maintained in their designing and be checked during PMC.

Environmental impacts can be minimised by implementing the suggested environmental management plan. It is recommended that, the sabkha land, drainage pattern, especially near to sea, should be maintained undisturbed both construction and operation periods, to protect conjunction of the lagoon into the sea.

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