TIMOR GAP, E.P.
TIMOR GÁS & PETRÓLEO

REPUBLICA DEMOCRATICA DE TIMOR-LESTE
SECRETARIA DE ESTADO DOS RECURSOS NATURAIS

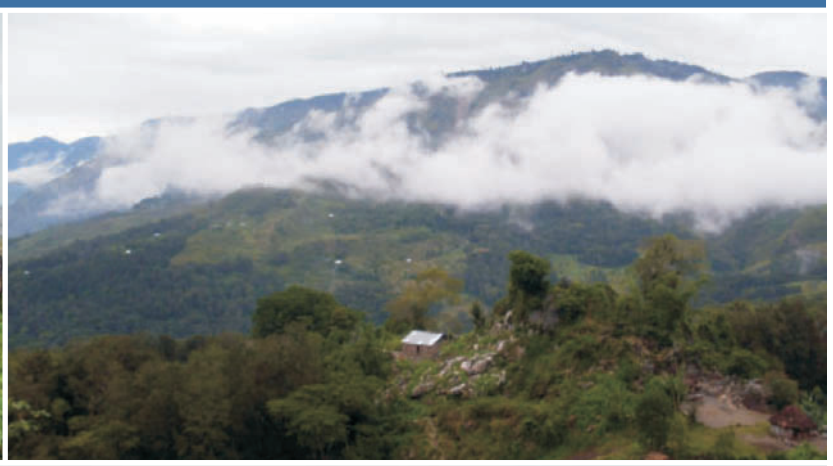
Tasi Mane Project - Betano Petroleum Refinery and Beaco LNG Plant

Strategic Environmental Impact Statement

Final Report

June 2012

Volume 2 - Main Report Part B



301012-01504-EN-REP-0005

WorleyParsons
resources & energy

WorleyParsons
resources & energy

TIMOR GAP, E.P.
TIMOR GÁS & PETRÓLEO

REPUBLICA DEMOCRATICA DE TIMOR-LESTE
SECRETARIA DE ESTADO DOS RECURSOS NATURAIS

This report has been prepared on behalf of and for exclusive use of the Democratic Republic of Timor-Leste and is subject and issued in accordance with the agreement between Democratic Republic of Timor-Leste and WorleyParsons Services Pty Ltd. WorleyParsons Services Pty Ltd accepts no liability responsibility whatsoever for it in respect of any use of or reliance upon this report by any third party.

Copying this report without the permission of the Democratic Republic of Timor-Leste or WorleyParsons Services Pty Ltd is not permitted.

The Tasi Mane Project – Betano Petroleum Refinery and Beaco LNG Plant Strategic Environmental Impact Assessment (Final Report) is made up of four separate volumes:

VOLUME 1 of 4: Betano Petroleum Refinery and Beaco LNG Plant Strategic Environmental Impact Assessment Main Report Part A (Chapters 1 to 6)

VOLUME 2 of 4: Betano Petroleum Refinery and Beaco LNG Plant Strategic Environmental Impact Assessment Main Report Part B (Chapters 7 to 10)

VOLUME 3 of 4: Betano Petroleum Refinery and Beaco LNG Plant Strategic Environmental Impact Assessment Main Report Part C (Appendices)

VOLUME 4 of 4: Betano Petroleum Refinery and Beaco LNG Plant Strategic Environmental Impact Assessment (Attachments)

Terrestrial Flora and Fauna Final Technical Report
Marine Environment Final Technical Report

This page has been left blank intentionally

STRATEGIC ENVIRONMENTAL IMPACT ASSESSMENT

Tasi Mane Project – Betano Petroleum Refinery and Beaco LNG Plant

VOLUME 1 of 4 Main Report Part A

DESCRIPTION	CHAPTER-PAGE
TABLE OF CONTENTS	**I**
FIGURES	VIII
TABLES	XVI
PLATES	XX
ATTACHMENTS	XXIV
GLOSSARY	XXV
EXECUTIVE SUMMARY	**ES-1**
1 INTRODUCTION	**1-1**
1.1 Context	1-1
1.2 Project Outline	1-1
1.3 This Document	1-5
1.4 Scope	1-5
1.5 Document Structure	1-6
1.6 Study Limitations	1-7
1.7 Alternatives	1-8
1.8 Page Numbering	1-8
2 REGULATORY CONTEXT	**2-11**
2.1 Constitution of the Republic of Timor-Leste	2-11
2.2 National Legislation	2-11
2.2.1 Environmental Law	2-12
2.2.2 Downstream Sector Law	2-14
2.2.3 Port Law	2-15
2.2.4 Civil Aviation Law	2-15
2.2.5 Road Transport Law	2-15
2.2.6 Water Supply Law	2-15
2.2.7 Telecommunications Law	2-16
2.2.8 National Electricity Law	2-16
2.3 Other Legislation and Regulations	2-16
2.3.1 Protected Ares Regulations	2-16
2.3.2 Logging Regulation	2-17
2.3.3 Quarantine Decree	2-17
2.4 Traditional Practices	2-18
2.5 Summary of Project Approvals	2-18
2.6 International Conventions	2-19
3 ENVIRONMENTAL CONTEXT	**3-23**
3.1 Betano	3-23
3.1.1 Climate	3-23
3.1.2 Biogeography	3-23
3.1.3 Biological Environment	3-24
3.1.4 Land and Water Resources	3-25
3.1.5 Socio-economic Environment	3-25
3.1.6 Cultural Heritage	3-26
3.2 Beaco	2-26
3.2.1 Climate	3-26
3.2.2 Biogeography	3-27
3.2.3 Biological Environment	3-28
3.2.4 Land and Water Resources	3-29
3.2.5 Socio-economic Environment	3-29
3.2.6 Cultural Heritage	3-30

DESCRIPTION CHAPTER-PAGE

4 PROJECT DESCRIPTIONS 4-33
4.1 Overview 4-33
4.2 Location 4-33
4.2.1 Betano 4-33
4.2.1 Beaco 4-34
4.3 Project-related Infrastructure – Betano Refinery 4-34
4.3.1 Refinery and Petrochemical Complex 4-34
4.3.2 Nova Betano 4-40
4.4 Project-related Infrastructure - Beaco 4-45
4.4.1 LNG Plant 4-45
4.4.2 Nova Viqueque 4-53
4.4.3 Nova Beaco 4-57
4.4.4 Viqueque Airstrip Upgrade 4-60

5 STAKEHOLDER CONSULTATION 5-63
5.1 Objectives 5-63
5.2 Stakeholders 5-63
5.3 Consultation Activities 5-65
5.3.1 Socio-economic Consultation Activities 5-65
5.4 Further Consultation 5-66
5.4.1 Communications Mechanisms 5-67
5.4.2 Grievance Mechanism 5-68

6 ENVIRONMENTAL IMPACT ASSESSMENT AND MANAGEMENT – BETANO REFINERY AND PETROCHEMICAL CLUSTER 6-73
6.1 Climate and Meteorology 6-73
6.1.1 Study Scope 6-73
6.1.2 Literature Review 6-73
6.1.3 Baseline Measurement Method 6-74
6.1.4 Data Assumptions and Limitations 6-75
6.1.5 Existing Environment 6-75
6.1.6 Impacts of Weather Patterns and Extremes of Climate on the Project 6-89
6.1.7 Avoidance, Management and Mitigation Measures 6-90
6.1.8 Further Work 6-90

6.2 Land Use and Visual Amenity 6-92
6.2.1 Study Method 6-92
6.2.2 Existing Environment 6-95
6.2.3 Environmental Impacts 6-103
6.2.4 Avoidance, Management and Mitigation Measures 6-107
6.2.5 Residual Impacts 6-108
6.2.6 Further Work 6-108
6.2.7 Summary 6-109

6.3 Topography, Geology and Soils 6-110
6.3.1 Study Method 6-110
6.3.2 Existing Environment 6-112
6.3.3 Environmental Impacts 6-137
6.3.4 Avoidance, Management and Mitigation Measures 6-137
6.3.5 Residual Impacts 6-138
6.3.6 Further Work 6-138

6.4 Air Quality 6-141
6.4.1 Study Method 6-141
6.4.2 Existing Environment 6-148
6.4.3 Environmental Impacts 6-152
6.4.4 Avoidance, Management and Mitigation Measures 6-153
6.4.5 Residual Impacts 6-154
6.4.6 Monitoring and Reporting 6-155
6.4.7 Further Work 6-155

DESCRIPTION	CHAPTER-PAGE

6.5 Noise 6-157
- 6.5.1 Study Method 6-157
- 6.5.2 Existing Environment 6-164
- 6.5.3 Environmental Impacts 6-166
- 6.5.4 Avoidance, Management and Mitigation Measures 6-171
- 6.5.5 Residual Impacts 6-174
- 6.5.6 Monitoring and Reporting 6-175
- 6.5.7 Further Work 6-175

6.6 Hydrology, Drainage and River Water Quality 6-177
- 6.6.1 Study Method 6-177
- 6.6.2 Existing Environment 6-180
- 6.6.3 Potential Environmental Impacts 6-182
- 6.6.4 Avoidance, Management and Mitigation Measures 6-185
- 6.6.5 Residual Impacts 6-185
- 6.6.6 Monitoring and Reporting 6-186
- 6.6.7 Further Work 6-186

6.7 Hydrogeology 6-187
- 6.7.1 Study Method 6-187
- 6.7.2 Existing Hydrogeological Concept 6-188
- 6.6.3 Environmental Impacts 6-190
- 6.7.4 Avoidance, Management and Mitigation Measures 6-193
- 6.7.5 Residual Impacts 6-193
- 6.7.6 Monitoring and Reporting 6-194
- 6.7.7 Further Work 6-194

6.8 Terrestrial Biodiversity 6-195
- 6.8.1 Study Method 6-195
- 6.8.2 Existing Environment 6-199
- 6.8.3 Environmental Impacts 6-207
- 6.8.4 Avoidance, Management and Mitigation Measures 6-208
- 6.8.5 Monitoring and Reporting 6-209
- 6.8.6 Further Work 6-209

6.9 Marine Ecology 6-210
- 6.9.1 Study Method 6-210
- 6.9.2 Existing Environment 6-214
- 6.9.3 Environmental Impacts 6-217
- 6.9.4 Avoidance, Management and Mitigation Measures 6-225
- 6.9.5 Residual Impacts 6-227
- 6.9.5 Monitoring and Reporting 6-227
- 6.9.6 Further Work 6-227

6.10 Social and Economic Values 6-229
- 6.10.1 Socio-economic Objectives 6-229
- 6.10.2 Study Method 6-229
- 6.10.3 Existing Social Environment 6-234
- 6.10.4 Socio-economic Impacts 6-239
- 6.10.5 Avoidance, Management and Mitigation Measures 6-251
- 6.10.6 Residual Impacts 6-260
- 6.10.7 Monitoring and Reporting 6-262
- 6.10.8 Further Work 6-263

DESCRIPTION	CHAPTER-PAGE

6.11 Land Transport 6-265
6.11.1 Study Method 6-265
6.11.2 Existing Environment 6-269
6.11.3 Environment Impacts 6-273
6.11.4 Avoidance, Management and Mitigation Measures 6-276
6.11.5 Residual Impacts 6-279
6.11.6 Monitoring and Reporting 6-279
6.11.7 Further Work 6-280

6.12 Waste Management 6-281
6.12.1 Existing Waste Environment 6-281
6.12.2 Waste Types 6-284
6.12.3 Waste Quantities 6-285
6.12.4 Waste Management Hierarchy 6-286
6.12.5 Waste Management Strategies 6-287
6.12.6 Waste Management Area 6-291
6.12.7 Further Work 6-292

STRATEGIC ENVIRONMENTAL IMPACT ASSESSMENT
Tasi Mane Project – Betano Petroleum Refinery and Beaco LNG Plant
VOLUME 2 of 4: Main Report Part B

DESCRIPTION **CHAPTER-PAGE**

7 ENVIRONMENTAL IMPACT ASSESSMENT AND MANAGEMENT – BEACO LNG PLANT CLUSTER 7-295

7.1 Climate and Meteorology 7-295
7.1.1 Study Method 7-295
7.1.2 Study Scope 7-295
7.1.3 Literature Review 7-295
7.1.4 Baseline Measurement Method 7-296
7.1.5 Data Assumptions and Limitations 7-297
7.1.6 Existing Environment 7-298
7.1.7 Impacts of Weather Patterns and Extremes of Climate on the Project 7-312
7.1.8 Avoidance, Management and Mitigation Measures 7-312
7.1.9 Further Work 7-312

7.2 Land Use and Visual Amenity 7-314
7.2.1 Study Method 7-314
7.2.2 Existing Environment 7-318
7.2.3 Environmental Impacts 7-325
7.2.4 Avoidance, Management and Mitigation Measures 7-330
7.2.5 Residual Impacts 7-331
7.2.6 Further Work 7-331
7.2.7 Summary 7-331

7.3 Topography, Geology and Soils 7-332
7.3.1 Study Method 7-332
7.3.2 Existing Environment 7-335
7.3.3 Environmental Impacts 7-363
7.3.4 Avoidance, Management and Mitigation Measures 7-363
7.3.5 Residual Impacts 7-364
7.3.6 Further Work 7-364

7.4 Air Quality 7-367
7.4.1 Study Method 7-367
7.4.2 Existing Environment 7-375
7.4.3 Environmental Impacts 7-378
7.4.4 Avoidance, Management and Mitigation Measures 7-380
7.4.5 Residual Impacts 7-381
7.4.6 Monitoring and Reporting 7-382
7.4.7 Further work 7-382

7.5 Noise 7-384
7.5.1 Study Method 7-384
7.5.2 Existing Environment 7-391
7.5.3 Environmental Impacts 7-394
7.5.4 Avoidance, Management and Mitigation Measures 7-398
7.5.5 Residual Impacts 7-401
7.5.6 Monitoring and Reporting 7-402
7.5.7 Further Work 7-403

DESCRIPTION	CHAPTER-PAGE

7.6 Surface Water 7-404
7.6.1 Study Method 7-404
7.6.2 Existing Environment 7-407
7.6.3 Potential Environmental Impacts 7-410
7.6.4 Avoidance, Management and Mitigation Measures 7-410
7.6.5 Residual Impacts 7-411
7.6.6 Monitoring and Reporting 7-411
7.6.7 Further Work 7-412

7.7 Hydrogeology 7-413
7.7.1 Background 7-413
7.7.2 Study Method 7-413
7.7.3 Existing Hydrogeological Concept 7-414
7.7.4 Environmental Impacts 7-416
7.7.5 Avoidance, Management and Mitigation Measures 7-419
7.7.6 Residual Impacts 7-419
7.7.7 Monitoring and Reporting 7-419
7.7.8 Further Work 7-420

7.8 Terrestrial Biodiversity 7-421
7.8.1 Study Method 7-421
7.8.2 Existing Environment 7-425
7.8.3 Environmental Impacts 7-434
7.8.4 Avoidance, Management and Mitigation Measures 7-436
7.8.5 Monitoring and Reporting 7-436
7.8.6 Further Work 7-437

7.9 Marine Ecology 7-438
7.9.1 Study Method 7-438
7.9.2 Existing Environment 7-443
7.9.3 Environmental Impacts 7-445
7.9.4 Avoidance, Management and Mitigation Measures 7-452
7.9.5 Residual Impacts 7-454
7.9.6 Monitoring and Reporting 7-454
7.9.7 Further Work 7-455

7.10 Social and Economic Values 7-456
7.10.1 Socio-Economic Objectives 7-456
7.10.2 Study Method 7-456
7.10.3 Existing Environment 7-461
7.10.4 Socio-economic Impact 7-469
7.10.5 Avoidance, Management and Mitigation Measures 7-481
7.10.6 Residual Impacts 7-482
7.10.7 Monitoring and Reporting 7-482
7.10.8 Further Work 7-483

7.11 Land Transport 7-485
7.11.1 Study Method 7-485
7.11.2 Existing Environment 7-490
7.11.3 Avoidance, Management and Mitigation Measures 7-497
7.11.4 Residual Impacts 7-500
7.11.5 Further Work 7-501

7.12 Waste Management 7-503
7.12.1 Waste Types 7-503
7.12.2 Waste Quantities 7-504
7.12.3 Waste Management Hierarchy 7-504
7.12.4 Waste Management Strategies 7-507
7.12.5 Waste Management Area 7-510
7.12.6 Further Work 7-512

DESCRIPTION	CHAPTER-PAGE

8 ENVIRONMENTAL MANAGEMENT FRAMEWORK **8-515**
8.1 Commitment to Environmental Management 8-515
8.2 Environmental Impact Assessment 8-515
8.3 Environmental Management Plans 8-516
8.4 Work Instructions 8-518
8.5 Environmental Monitoring Programs 8-518
8.6 Review and Reporting 8-519

9 CONCLUSIONS AND RECOMMENDATIONS **9-523**
9.1 Conclusions 9-523
9.2 Recommendations 9-524

10 REFERENCES **10-527**

STRATEGIC ENVIRONMENTAL IMPACT ASSESSMENT

Tasi Mane Project – Betano Petroleum Refinery and Beaco LNG Plant

VOLUME 3 of 4: Main Report Part C (Appendices)

DESCRIPTION

APPENDICES

APPENDIX A	SERN'S TERMS OF REFERENCE
APPENDIX B	SITE FEATURES AT THE PROPOSED DEVELOPMENT LOCATIONS
APPENDIX C	BETANO METEOROLOGICAL STATION DATA RESULTS
APPENDIX D	SOIL SAMPLES – LABORATORY RESULTS AND QUALITY REPORTS
APPENDIX E	AIR QUALITY CHEMICAL ANALYSIS – ALS
APPENDIX F	DUST SAMPLES – CERTIFICATES OF ANALYSIS – BETANO AND BEACO
APPENDIX G	INDONESIAN AND UNTAET LEGISLATION – MARINE ENVIRONMENT
APPENDIX H	ANZECC GUIDELINES (2000) - TRIGGER VALUES FOR TROPICAL WATERS AND SEDIMENTS
APPENDIX I	STAKEHOLDER CONSULTATION –INTERVIEW QUESTIONNAIRE
APPENDIX J	FOCUS GROUP QUESTIONNAIRE
APPENDIX K	UK INSTITUTE OF HIGHWAY ENGINEERS (IHT) GUIDELINES (EXTRACT)
APPENDIX L	VIQUEQUE METEOROLOGICAL STATION DATA RESULTS

WorleyParsons
resources & energy

TIMOR GAP, E.P.
TIMOR GÁS & PETRÓLEO

REPUBLICA DEMOCRATICA DE TIMOR-LESTE
SECRETARIA DE ESTADO DOS RECURSOS NATURAIS

STRATEGIC ENVIRONMENTAL IMPACT ASSESSMENT

Tasi Mane Project – Betano Petroleum Refinery and Beaco LNG Plant

VOLUME 4 of 4: Attachments

Attachment 1:
Terrestrial Flora and Fauna Technical Report

DESCRIPTION	PAGE
1 INTRODUCTION	**1**
1.1 Location	1
1.2 Project Brief/Scope	1
1.3 Regulatory Context	2
2 EXISTING ENVIRONMENT	**5**
2.1 Climate	5
2.2 Biogeography	5
2.3 Flora and Vegetation	7
2.3.1 Previous Surveys	7
2.4 Fauna	8
2.4.1 Previous Surveys	8
3 METHOD	**11**
3.1 Survey Areas	11
3.2 Timing of Surveys	11
3.3 Flora and Vegetation	11
3.3.1 Desktop Review – IUCN	11
3.3.2 Vegetation Survey	12
3.3.3 Flora Survey	12
3.4 Fauna	13
3.4.1 Desktop Review	13
3.4.2 Field Survey	14
3.4.3 Nomenclature	15
3.5 Limitations	15
3.5.1 Flora and Vegetation	15
3.5.2 Fauna	16
4 RESULTS	**19**
4.1 Flora and Vegetation	19
4.1.1 Vegetation Communities	19
4.1.2 Betano Development Area	19
4.1.3 Beaço Development Area	24
4.1.4 Agriculture	33
4.1.5 Vegetation of Conservation Interest	33
4.1.6 Flora	34
4.1.8 Species of Conservation Interest	36
4.1.9 Species of Economic Importance	37
4.1.10 Weeds/Invasive Species	37
4.2 Fauna	39
4.2.1 Fauna Habitat	39
4.2.2 Fauna Assemblages	41
4.2.3 Conservation Significant Fauna	43
4.2.4 Endemic Fauna	48

DESCRIPTION	PAGE
5 DISCUSSION	**51**
5.1 Summary	51
5.2 Environmental Impacts/Issues	52
5.3 Avoidance, Management and Mitigation Measures	52
5.4 Monitoring and Reporting	54
5.5 Further Work	54
6 REFERENCES	**57**

APPENDICES

APPENDIX 1 IUCN RED LIST

APPENDIX 2 FLORA SPECIES LIST

APPENDIX 3 IUCN LISTED FLORA

APPENDIX 4 FAUNA HABITAT ASSESSMENTS

APPENDIX 5 TIMOR-LESTE VERTEBRATE FAUNA LIST

APPENDIX 6 BAT CALL ANALYSIS

APPENDIX 7 POTENTIAL LIKELIHOOD OF OCCURRENCE OF CONSERVATION SIGNIFICANT SPECIES

STRATEGIC ENVIRONMENTAL IMPACT ASSESSMENT

Tasi Mane Project – Betano Petroleum Refinery and Beaco LNG Plant

VOLUME 4 of 4: Attachments

Attachment 2:
Marine Environment Technical Report

DESCRIPTION	PAGE
1 INTRODUCTION	**1**
1.1 Project Setting	1
1.2 Study Objectives	1
1.3 Regulatory Context	3
2 REGIONAL PERSPECTIVE	**6**
2.1 Climate	6
2.2 Biogeography	6
2.3 Bathymetry	7
2.4 Tides	7
2.5 Water Temperature	7
2.6 Coastal Processes	7
2.7 Biological Environment	7
2.7.1 Mangroves	8
2.7.2 Intertidal	8
2.7.3 Coral Reefs	8
2.7.4 Marine Fauna	9
2.7.5 Marine Protected Areas	10
3 FIELD METHODS	**12**
3.1 Sampling Locations	12
3.1.1 Betano	12
3.1.2 Beaço	13
3.2 Water Quality	17
3.2.1 Physicochemical Profiling	17
3.2.2 Chemical Sampling	17
3.2.3 Water Quality Criteria	17
3.2.4 Data Analysis	17
3.3 Sediment Quality	18
3.3.1 Sample Collection	18
3.3.2 Chemical Testing	18
3.3.3 Sediment Quality Criteria	18
3.3.4 Data Analysis	18
3.4 Benthic Habitat	18
3.4.1 Data Collection and Mapping	18
3.4.2 Data Analysis	19
3.5 Plankton	22
3.5.1 Sample Collection	22
3.5.2 Laboratory Analysis	22
3.5.3 Statistical Analysis	22
3.6 Infauna	23
3.6.1 Sample Collection	23
3.6.2 Laboratory Method	23
3.6.3 Statistical Analysis	23
3.7 Quality Control and Assurance	24

DESCRIPTION	PAGE

4 BETANO **26**
4.1 Water Quality 26
4.1.1 Physicochemical Water Quality 26
4.1.2 Chemical Water Quality 32
4.2 Sediment Quality 35
4.2.1 Chemical Sediment Quality 35
4.2.2 Particle Size Distribution 37
4.3 Benthic Habitat 37
4.3.1 Substrate 37
4.3.2 Biota 39
4.4 Plankton 39
4.5 Infauna 44

5 BEAÇO **48**
5.1 Water Quality 48
5.1.1 Physicochemical Water Quality 48
5.1.2 Chemical Water Quality 54
5.2 Sediment Quality 57
5.2.1 Chemical Sediment Quality 57
5.2.2 Particle Size Distribution 60
5.3 Benthic Habitat 60
5.3.1 Substrate 60
5.3.2 Biota 62
5.3.3 Plankton 62
5.3.4 Infauna 68

6 DISCUSSION **72**
6.1 Betano 72
6.1.1 Water Quality 72
6.1.2 Sediment Quality 73
6.1.3 Benthic Habitat 74
6.1.4 Plankton 75
6.1.5 Infauna 75
6.2 Beaço 75
6.2.1 Water Quality 75
6.2.2 Sediment Quality 76
6.2.3 Benthic Habitat 77
6.2.4 Plankton 77
6.2.5 Infauna 77

7 CONCLUSION **80**

8 REFERENCES **82**

WorleyParsons
resources & energy

TIMOR GAP, E.P.
TIMOR GÁS & PETRÓLEO

REPUBLICA DEMOCRATICA DE TIMOR-LESTE
SECRETARIA DE ESTADO DOS RECURSOS NATURAIS

Tasi Mane Project – Betano Petroleum Refinery and Beaco LNG Plant

Strategic Environmental Impact Assessment

CHAPTER 7

ENVIRONMENTAL IMPACT ASSESSMENT AND MANAGEMENT – BEACO LNG PLANT CLUSTER

301012-01504-EN-REP-0005
June 2012

7. ENVIRONMENTAL IMPACT ASSESSMENT AND MANAGEMENT – BEACO LNG PLANT CLUSTER

7.1 Climate and Meteorology

7.1.1 Study Method

Baseline climate and meteorological studies were conducted for the Beaco and Viqueque regions adopting the same method as the Betano study. The study method is summarised as follows:

- A literature review to identify:
  - Relevant documentation describing climatic trends;
  - Relevant sources of regional meteorological data;
- Establish of a temporary meteorological station in close proximity to the Beaco LNG plant area in general accordance with Australian Standard AS 3580.14-2011 *Methods for sampling and analysis of ambient air Part 14: Meteorological monitoring for ambient air quality monitoring applications* (AS 3580.14-2011);
- Determination of general climate and meteorological trends; and
- Development of recommendations for any future or ongoing meteorological monitoring for the Beaco and Viqueque study areas.

7.1.2 Study Scope

The study scope includes the Beaco LNG plant, Nova Beaco, Viqueque Aiport upgrade and Nova Viqueque areas plus the wider coastal lowland region extending approximately 10 km along the coast in either direction and approximately 15 km inland to the foothills.

7.1.3 Literature Review

Several sources of information are available describing the general climate for Timor-Leste on a country-wide scale. The following documents were reviewed as part of this assessment:

- Report on restoration of meteorological network – Timor Loro'Sae (Keefer, 2000);
- Vulnerability to climate variability and change in East Timor (Barnett et.al, 2007);
- Climate change in Timor-Leste – a brief overview on future climate projections (CSIRO, 2010); and
- Climate Risk and Agriculture in Timor Loro'Sae (Dolcemascolo, 2003).

Meteorological information was provided for an automated weather station (AWS) owned by the Ministry of Agriculture (MoA, 2012b) within the Viqueque study area. The reported information is provided in Appendix L. Location coordinates of the AWS are provided in Table 7-1. The information

spans the 2008 to 2011 calendar years and reports daily averaged information for the following parameters:

- Maximum, minimum and mean temperature (degrees Celsius);
- Maximum, minimum and mean relative humidity (%);
- Rainfall (mm);
- Mean wind speed (m/s);
- Solar radiation (MJ/m^2); and
- Evapotranspiration (mm).

Similar to the Betano information (MoA, 2012a), the supplied data are daily averages and do not report wind directions. This information does not provide sufficient time-dependant resolution to adequately determine prevailing climate trends.

In addition, AWS data was provided for the Beaco region spanning June to December 2011 (Pers.Comm., 2012). The information includes 10-minute averaged data for the following parameters:

- Wind and gust speed (m/s);
- Wind direction (degrees North);
- Air temperature (degrees Celsius);
- Humidity (%);
- Visibility (m);
- Atmospheric pressure (hPa);
- Solar radiation (W/m^2); and
- Rainfall (mm).

This information provides sufficient temporal resolution to adequately describe meteorological trends during the monitored period. Location coordinates for this AWS were not provided.

7.1.4 Baseline Measurement Method

A temporary, semi-automated meteorological station was established in Beaco from 15 December 2011 to 14 February 2012, on the beachfront of the Beaco village. Location coordinates of the meteorological station are provided in Table 7-1. The meteorological station was sited in general accordance with AS 3580-14-2011. The meteorological station was the same model and specification as the station deployed in Betano. Meteorological parameters were recorded automatically and downloaded periodically over the monitoring period to a computer for statistical analysis.

Table 7-1 AWS and temporary meteorological station coordinates

Label	Location Coordinates		Elevation Above Ground Level	Total Elevation Above Sea Level
	Latitude	Longitude		
AWS (Ministry of Agriculture)	8° 56' 35.1" S	126° 38' 38.9" E	2 m	73 m
Beaco Weather Station (WorleyParsons)	8° 56' 49.3" S	126° 26' 58.3" E	3 m	5 m

Parameters measured by the meteorological station are the same as the Betano station and are listed below:

- Date and time.
- Measurement interval (minutes).
- Indoor and outdoor humidity (relative %).
- Indoor and outdoor temperature (degrees Celsius).
- Absolute and relative pressure (hPa).
- Wind speed and gust speed (m/s).
- Wind direction (16 directions).
- Dewpoint temperature and wind-chill (degrees Celsius).
- Hourly, 24 hourly, weekly, monthly and total rainfall (mm).
- Wind and gust speed (Beaufort wind force scale 0 to 12). Whilst this data was recorded, data relating to wind speeds has been presented in m/s for this assessment.

Measurements were made automatically at 30 minute intervals from the time the device was reset. Measurements that are analysed on an hourly average (wind speed/direction and rainfall) were averaged or totalled over each hour period.

7.1.5 Data Assumptions and Limitations

There have been several limitations to this study as outlined below:

- The monitoring period for the baseline measurements spanned 65 days and is not representative of seasonal or long-term trends.
- A power outage causing equipment failure occurred during the monitoring period causing data spanning 5 January 2012 to 18 January 2012 to be lost.
- The meteorological station installed on site was oriented as close as reasonably practicable to true north; however, it cannot be guaranteed that the orientation angle was exact.
- Site personnel were not present for the entire duration of the monitoring period, therefore it is possible that the meteorological station may have been interfered with, altering the results.

- It was indicated in the proposal that more than 50 years of data should be available for up to 15 to 20 locations across the country. This data was not made available for analysis.

7.1.6 Existing Environment

General Description

The Beaco study areas display a typical tropical monsoonal climate with distinct wet and dry seasons. Seasonal variation in temperature is minimal, with the diurnal temperature variation often greater than the seasonal variation. Daytime temperatures are typically in the mid 20's to low 30's and night-time temperatures are in the mid to high 20's. Humidity is consistently high, frequently greater than 90%. Long-term multi-year rainfall trends are generally dictated by El Niño/La Niña effects; however, shorter-term annual rainfall patterns are monsoonal in nature experiencing a 7 to 9 month wet season with two peak months, December and May (CSIRO, 2010). The Beaco/Viqueque region often receives more rainfall than other lower-lying regions on the southern coast with events being torrential in nature. On average, six months of the year receive more than 1,000 mm of rain per month.

In general, higher wind speeds emanate from offshore directions (southern arc) and the lower wind speeds primarily emanate from the landmass (northern arc). A prevailing wind at low speeds has been observed to blow from the north and east. These winds are likely slowed due to increased turbulence at ground level due to the taller vegetation canopy.

Eleven cyclone events have been reported to be within 200 km of the study areas, with three of these cyclone events occurring within 100 km of the study area since 1920.

Major Influencing Climate Processes

The ENSO, as described in Section 6.2.2, is the primary process influencing climatic behaviour across all of Timor-Leste.

Solar radiation is a driving force for climatic processes. In the case of the Beaco study area, cloud cover is often minimal during daylight hours. Large cloud banks covering the sky later in the afternoon were frequently observed. These cloud banks were directly related to frequent rainfall events. In addition, these cloud banks are an indirect result of the evaporation of the ocean due to solar radiation. The Viqueque study area showed similar trends with cloud patterns; however, they typically occurred earlier in the day, often in the mid to late morning. Rainfall events were frequent and heavy.

The mountainous region spanning the length of the Timor island acts as a barrier to trade winds emanating from the northwest. Moisture-laden air from the surrounding oceans encounter the mountains and are pushed higher into the atmosphere. The moisture then precipitates out of the atmosphere due to the cooler conditions and results in torrential downpours throughout the highlands. These downpours affect the lowlands on the southern coast of the island by the frequent flushing of the river systems in the area, as well as deposition of sediment eroded from the highlands. The rainfall events observed in Viqueque in particular, are considered representative of this phenomenon.

Temperature

Timor-Leste has a tropical climate in which the temperature varies little throughout the year (CSIRO, 2010). This is substantiated by the recorded temperatures over the monitoring period. The Beaco study area is in the coastal low-lying region with an approximate elevation of less than 25 m above

sea level, and the monitoring period was during the southern hemisphere summer. It is therefore expected that the measured temperatures are representative of the hottest period of the calendar year for the region.

The time series for outdoor temperatures, as collected by WorleyParsons, daily temperature profiles for the monitoring period and the AWS data (Pers.Comm., 2012) are presented in Figure 7-1 to Figure 7-4. The time series data appears consistent with (CSIRO, 2010) during the monitoring period as there was very little temperature variation day to day. For the measured dataset, the maximum daily temperature varied between 26.4°C and 35.9°C and the minimum daily temperature varied between 23.1°C and 27.7°C. The average daily temperature difference between maximum and minimum over the monitoring period is 7.7°C.

In comparison, the AWS data (Pers.Comm., 2012) covers the second half of the 2011 calendar year including the southern hemisphere winter. In this dataset, the maximum daily temperature varied between 25.01°C and 31.91°C and the minimum daily temperature varied between 17.74°C and 25.76°C. The average daily temperature difference was 5.78°C for the monitoring period.

The daily profile plots show the average minimum temperature occurs at approximately 6:00 a.m. The maximum temperature is reasonably consistent between 9:00 a.m. and 2:00 p.m. and there is a consistent gradual decline in temperature between 4:00 p.m. and the following 6:00 a.m.

Table 7-2 presents the maximum and minimum daily temperatures recorded for Beaco throughout the monitoring period, as collected by WorleyParsons.

Relative Humidity

The time series plots for relative humidity and daily humidity profiles for the monitoring periods are presented in Figure 7-5 to Figure 7-8. The time series data shows that for all monitored data from both the AWS and WorleyParsons established meteorological stations, the maximum daily humidity is frequently above 90% and the minimum humidity does not drop below 45%. The daily profiles show that the measured relative humidity reaches a maximum of approximately 86% on average at 6:00 a.m. and falls to a minimum of approximately 70% on average during the daylight hours. The humidity then steadily climbs above 80% on average until midnight.

Rainfall and Evaporation

Typically the lower-lying areas of Timor-Leste experience lower total rainfall compared to the high altitude regions (CSIRO, 2010). The Viqueque region; however, is considered an exception to this. Viqueque has consistently recorded higher than average rainfall compared to other regions at similar altitudes. The AWS data spanning 2008 to 2011 shows that for 6 months of the year, Viqueque has an average rainfall greater than 1,000 mm per month.

The rainfall plots for the Viqueque AWS data, the Beaco AWS data and the data collected during the monitoring period in Beaco are presented in Figure 7-9 to Figure 7-11. It is apparent from the Beaco data that moderate to heavy rainfall events are frequent in the region and that measureable levels of rainfall occur most days. On 20 December 2011, the peak rainfall occurred with 154.5 mm over the day. The second highest rainfall event occurred the day after. It is likely that these values are associated with a singular rainfall event that spanned the two days. Table 7-3 presents the rainfall measured over the monitoring period.

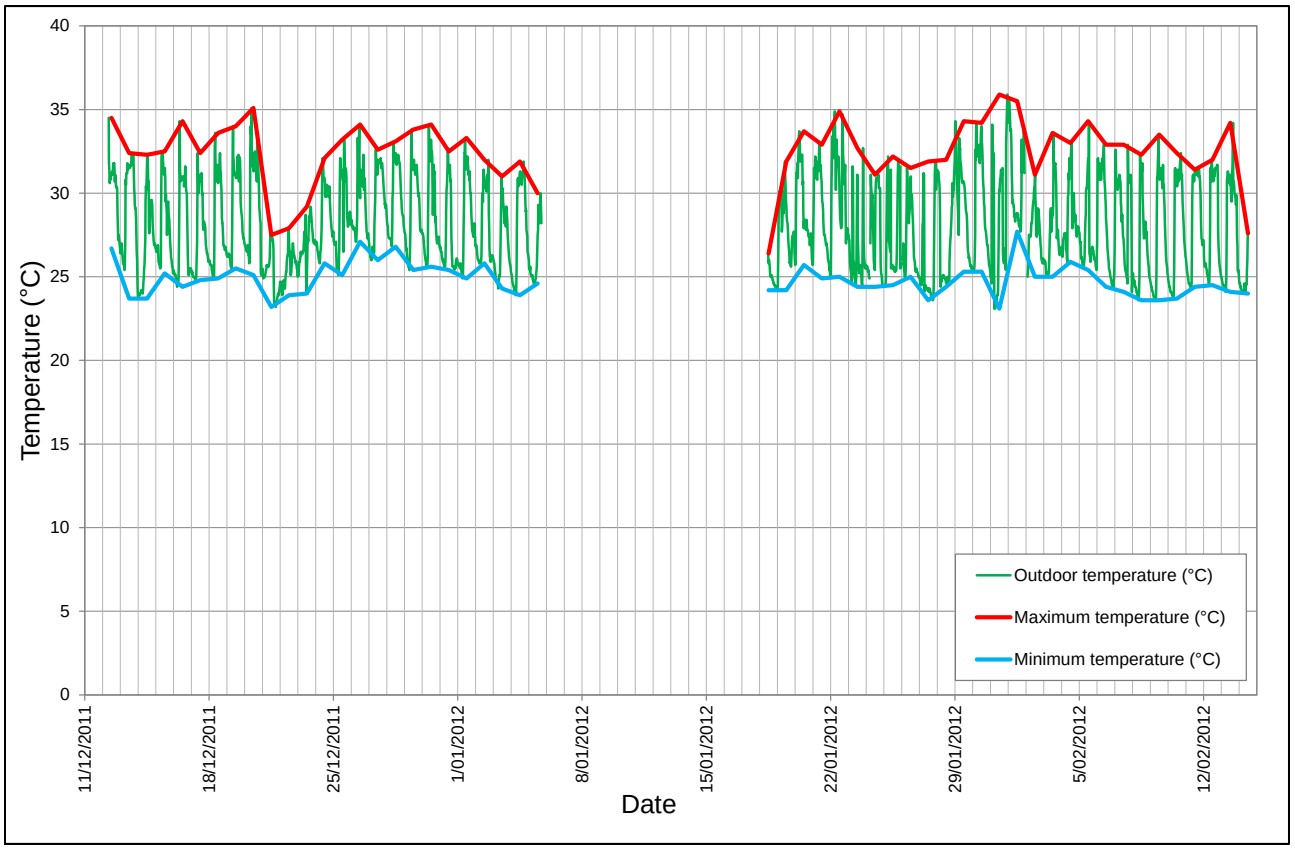


Figure 7-1 Beaco Temperature Plot 1: Beaco temperature time series at the established weather station

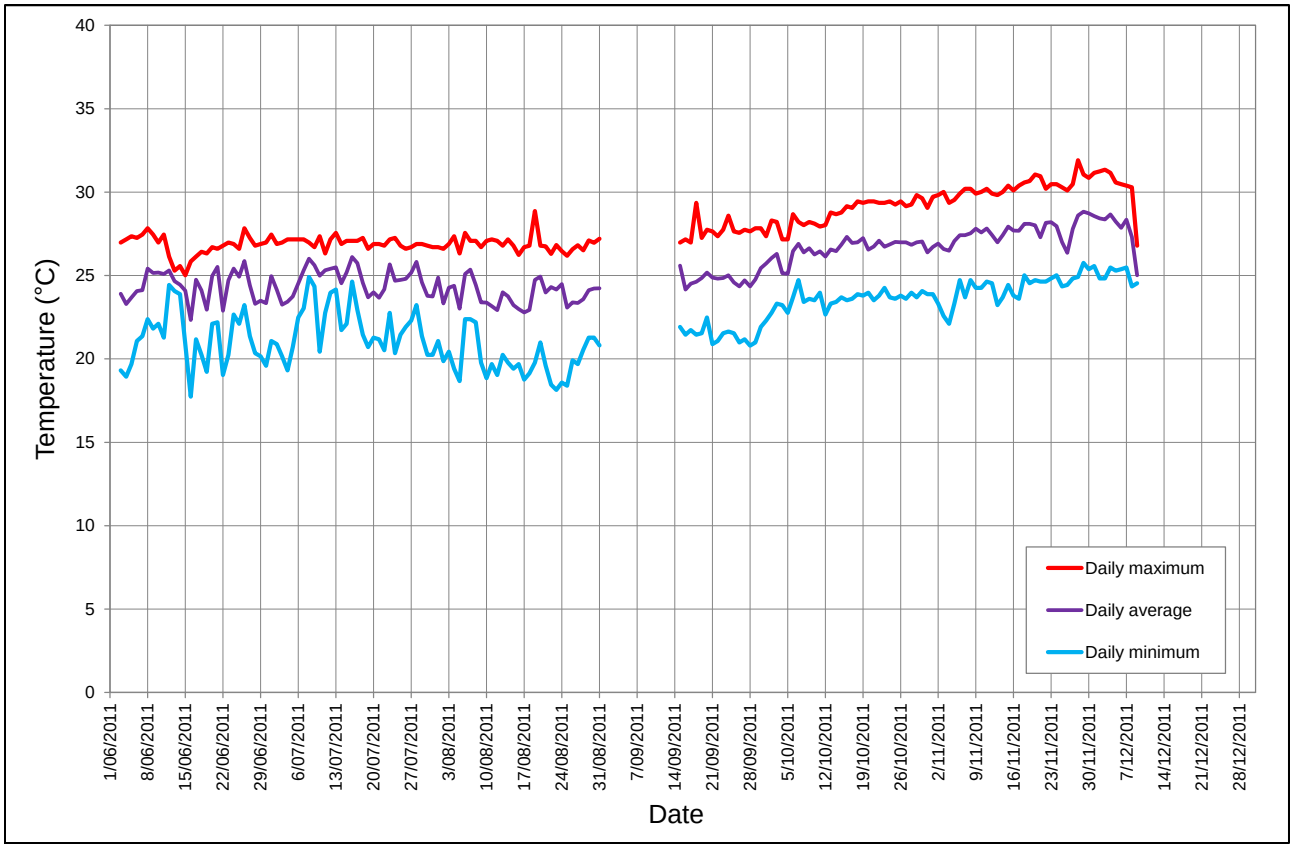


Figure 7-2 Beaco Temperature Plot 2: Temperature time series at Beaco AWS

NOTES:	REV	DATE	REVISION DESCRIPTION	DRN	CHK	DES	ENG	APPD	CUST	PROJECT: 301012-001504	TASI MANE PROJECT – BETANO AND BEACO STRATEGIC ENVIRONMENTAL IMPACT ASSESSMENT
	0	29/05/2012	FINAL FOR ISSUE	CS	GHi	CW	-	GH		A4 SHEET	Figure 7-1 Figure 7-2

WorleyParsons resources & energy

TIMOR GAP, E.P. TIMOR GAS & PETRÓLEO

REPUBLICA DEMOCRATICA DE TIMOR-LESTE
SECRETARIA DE ESTADO DOS RECURSOS NATURAIS

OneWay to zero harm

Copyright © WorleyParsons Services Pty Ltd

LOCATION: \\perworfil1\infstructlib\Projects\301012-01504 Enviro Imp Assessment Timor-Leste\2.0 Reports\2.9 SEIA - Betano and Beaco\Figures\03_Working\BF075_BF076\
PLOT DATE AND TIME: 29 May 2012, 4:29 PM
Creator: Courtenay Wheeler

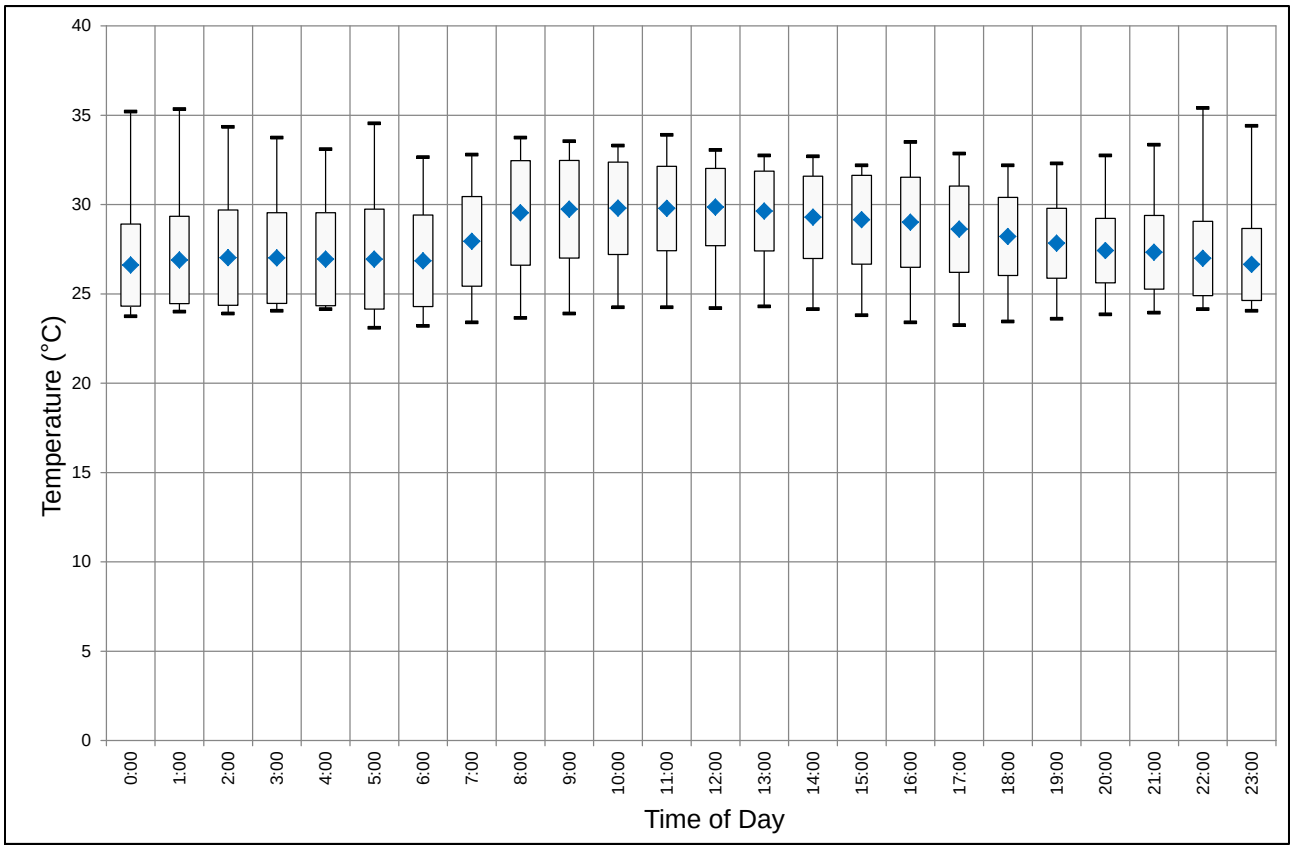


Figure 7-3 Beaco Temperature Plot 3: Daily temperature profile at the established weather station

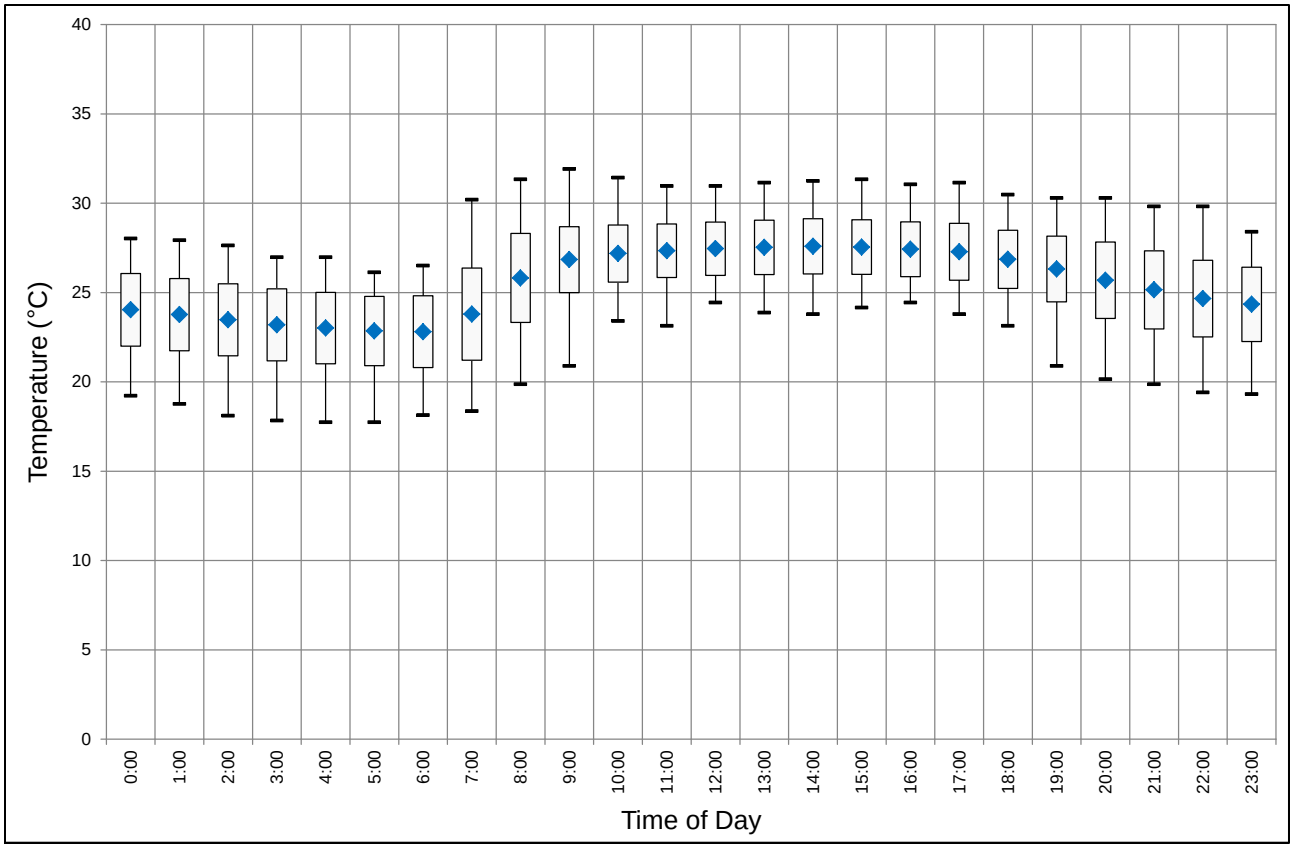


Figure 7-4 Beaco Temperature Plot 4: Daily temperature profile at Beaco AWS

REV	DATE	REVISION DESCRIPTION	DRN	CHK	DES	ENG	APPD	CUST	PROJECT: 301012-001504
0	29/05/2012	FINAL FOR ISSUE	CS	GHi	CW	-	GH		A4 SHEET

TASI MANE PROJECT – BETANO AND BEACO STRATEGIC ENVIRONMENTAL IMPACT ASSESSMENT

Figure 7-3
Figure 7-4

WorleyParsons resources & energy

TIMOR GAP, E.P. TIMOR GAS & PETRÓLEO

REPUBLICA DEMOCRATICA DE TIMOR-LESTE
SECRETARIA DE ESTADO DOS RECURSOS NATURAIS

OneWay to zero harm

Copyright © WorleyParsons Services Pty Ltd

LOCATION: \\perworfil1\infstructb\Projects\301012-01504 Enviro Imp Assessment Timor-Leste\2.0 Reports\2.9 SEIA - Betano and Beaco\Figures\03_Working\BF077_BF078\

PLOT DATE AND TIME: 29 May 2012, 6:11 PM Creator: Courtenay Wheeler

Table 7-2 Maximum and minimum recorded daily temperatures

Date	Temperature (°C)		Date	Temperature (°C)		Date	Temperature (°C)	
	Maximum	Minimum		Maximum	Maximum		Maximum	Maximum
12/12/2011	34.5	26.7	03/01/2012	31	24.3	25/01/2012	32.2	24.5
13/12/2011	32.4	23.7	04/01/2012	31.9	23.9	26/01/2012	31.5	25
14/12/2011	32.3	23.7	05/01/2012	30	24.6	27/01/2012	31.9	23.6
15/12/2011	32.5	25.2	06/01/2012	-	-	28/01/2012	32	24.4
16/12/2011	34.3	24.4	07/01/2012	-	-	29/01/2012	34.3	25.3
17/12/2011	32.4	24.8	08/01/2012	-	-	30/01/2012	34.2	25.3
18/12/2011	33.6	24.9	09/01/2012	-	-	31/01/2012	35.9	23.1
19/12/2011	34	25.5	10/01/2012	-	-	01/02/2012	35.5	27.7
20/12/2011	35.1	25.1	11/01/2012	-	-	02/02/2012	31.1	25
21/12/2011	27.5	23.2	12/01/2012	-	-	03/02/2012	33.6	25
22/12/2011	27.9	23.9	13/01/2012	-	-	04/02/2012	33	25.9
23/12/2011	29.2	24	14/01/2012	-	-	05/02/2012	34.3	25.4
24/12/2011	32.1	25.8	15/01/2012	-	-	06/02/2012	32.9	24.4
25/12/2011	33.2	25.1	16/01/2012	-	-	07/02/2012	32.9	24.1
26/12/2011	34.1	27.1	17/01/2012	-	-	08/02/2012	32.3	23.6
27/12/2011	32.6	26	18/01/2012	26.4	24.2	09/02/2012	33.5	23.6
28/12/2011	33.1	26.8	19/01/2012	31.9	24.2	10/02/2012	32.4	23.7
29/12/2011	33.8	25.4	20/01/2012	33.7	25.7	11/02/2012	31.4	24.4
30/12/2011	34.1	25.6	21/01/2012	32.9	24.9	12/02/2012	32	24.5
31/12/2011	32.5	25.4	22/01/2012	34.9	25	13/02/2012	34.2	24.1
01/01/2012	33.3	24.9	23/01/2012	32.7	24.4	14/02/2012	27.6	24
02/01/2012	32	25.8	24/01/2012	31.1	24.4			

Table 7-3 Daily rainfall measurements

Date	Rainfall (mm)	Date	Rainfall (mm)	Date	Rainfall (mm)
12/12/2011	13.8	03/01/2012	0.3	25/01/2012	11.3
13/12/2011	25.2	04/01/2012	0	26/01/2012	8.5
14/12/2011	13.5	05/01/2012	0	27/01/2012	16.6
15/12/2011	0	06/01/2012	-	28/01/2012	9.1
16/12/2011	7.5	07/01/2012	-	29/01/2012	7.3
17/12/2011	0.3	08/01/2012	-	30/01/2012	11.8
18/12/2011	0	09/01/2012	-	31/01/2012	27
19/12/2011	0	10/01/2012	-	01/02/2012	6.7
20/12/2011	154.5	11/01/2012	-	02/02/2012	31.7
21/12/2011	48.9	12/01/2012	-	03/02/2012	8.5
22/12/2011	2.7	13/01/2012	-	04/02/2012	10.5
23/12/2011	18	14/01/2012	-	05/02/2012	8
24/12/2011	0	15/01/2012	-	06/02/2012	10.6
25/12/2011	0	16/01/2012	-	07/02/2012	14.4
26/12/2011	0	17/01/2012	-	08/02/2012	9.1
27/12/2011	0	18/01/2012	0	09/02/2012	9.4
28/12/2011	0	19/01/2012	0	10/02/2012	9.2
29/12/2011	0	20/01/2012	0	11/02/2012	7.9
30/12/2011	0	21/01/2012	0	12/02/2012	8.1
31/12/2011	0	22/01/2012	0.6	13/02/2012	12.3
01/01/2012	0	23/01/2012	0	14/02/2012	3.9
02/01/2012	0	24/01/2012	14.1		

Evaporation rates were not measured over the monitoring period as this was beyond the capability of the installed meteorological stations. However, the following results are reported in CSIRO (2010):

- *In the lowlands, the monthly evaporation ranges from 60 to 230 mm while in the highlands it is 100 to 190 mm per month.*
- *The average daily potential evaporation was in the range of 5.2 to 6.5 mm in the lowlands and 2.6 to 4.9 mm in the midlands.*

Relative Pressure

Similar to the Betano dataset, the measured relative pressure in Figure 7-12 and Figure 7-13 shows two separate trends: the synoptic behaviour related to the migration of high- and low-pressure cells across the wider Australasian region; and the diurnal (daily) variation about the mean.

The synoptic-level trends are presented by examining the daily average relative pressures presented in Table 7-4. The measured pressure trends are very similar to the Betano dataset; however, they are shifted proportionally lower on the scale by approximately 3 hPa.

The diurnal pressure oscillates in a sinusoidal pattern between local maxima and minima on a 12 hour cycle. Daily minima occur at approximately 3:00 a.m. and 3:00 p.m. and daily maxima occur at approximately 10:00 a.m. and 10:00 p.m. The daily variation in pressure is on average 3.8 hPa, this

oscillation is representative of 'atmospheric thermal tidal patterns' based on the 24 hour solar heating/cooling cycle.

The longer-term daily maximum, minimum and average atmospheric pressure measured at the AWS between June and December 2011 (Pers.Comm., 2012) is also presented in Figure 7-12 and Figure 7-13.The general trends for the monitoring period are:

- June to August 2011 – The pressure oscillated about the mean value but the daily average remained consistently lower than the mean sea-level pressure of 1013 hPa.
- September to December 2011 – The pressure gradually decreased by approximately 6 hPa from 1011 hPa to 1006 hPa. The oscillation about the mean value remained consistent.

Table 7-4 Daily average relative pressure measurements

Date	Average Relative Pressure (hPa)	Date	Average Relative Pressure (hPa)	Date	Average Relative Pressure (hPa)
12/12/2011	1012.1	03/01/2012	1013.3	25/01/2012	1013.2
13/12/2011	1011.3	04/01/2012	1013.1	26/01/2012	1011.6
14/12/2011	1011.7	05/01/2012	1013.0	27/01/2012	1009.9
15/12/2011	1010.6	06/01/2012	-	28/01/2012	1010.0
16/12/2011	1010.5	07/01/2012	-	29/01/2012	1008.8
17/12/2011	1010.6	08/01/2012	-	30/01/2012	1010.6
18/12/2011	1010.8	09/01/2012	-	31/01/2012	1011.2
19/12/2011	1010.5	10/01/2012	-	01/02/2012	1011.5
20/12/2011	1010.0	11/01/2012	-	02/02/2012	1013.6
21/12/2011	1010.0	12/01/2012	-	03/02/2012	1012.5
22/12/2011	1007.8	13/01/2012	-	04/02/2012	1012.1
23/12/2011	1007.3	14/01/2012	-	05/02/2012	1013.7
24/12/2011	1008.2	15/01/2012	-	06/02/2012	1013.0
25/12/2011	1009.1	16/01/2012	-	07/02/2012	1011.7
26/12/2011	1010.2	17/01/2012	-	08/02/2012	1012.7
27/12/2011	1010.6	18/01/2012	1012.3	09/02/2012	1013.1
28/12/2011	1011.3	19/01/2012	1012.8	10/02/2012	1013.4
29/12/2011	1012.1	20/01/2012	1012.8	11/02/2012	1013.8
30/12/2011	1013.1	21/01/2012	1012.1	12/02/2012	1014.8
31/12/2011	1013.7	22/01/2012	1011.5	13/02/2012	1015.3
01/01/2012	1013.4	23/01/2012	1013.3	14/02/2012	1015.1
02/01/2012	1013.8	24/01/2012	1012.6		

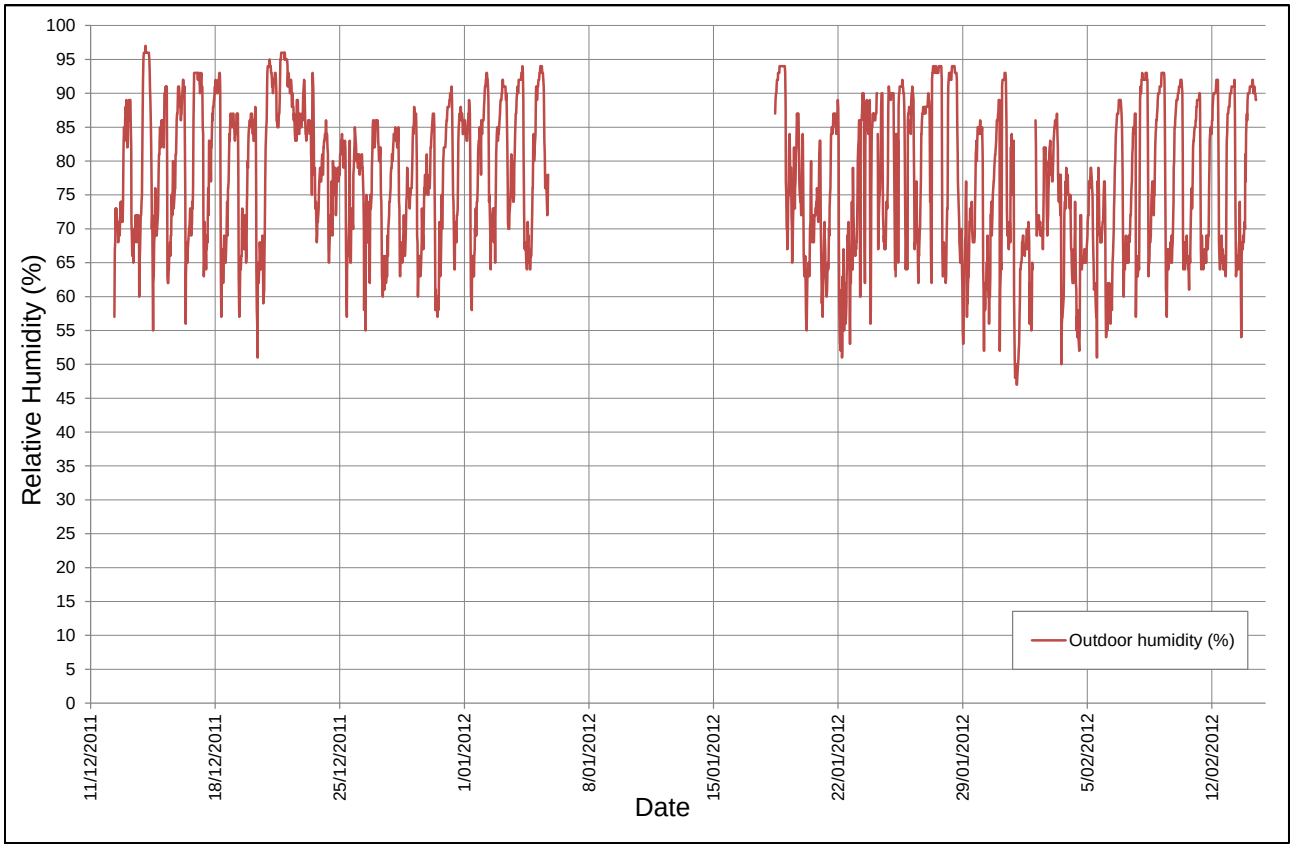


Figure 7-5 Beaco Humidity Plot 1: Humidity time series at the established weather station

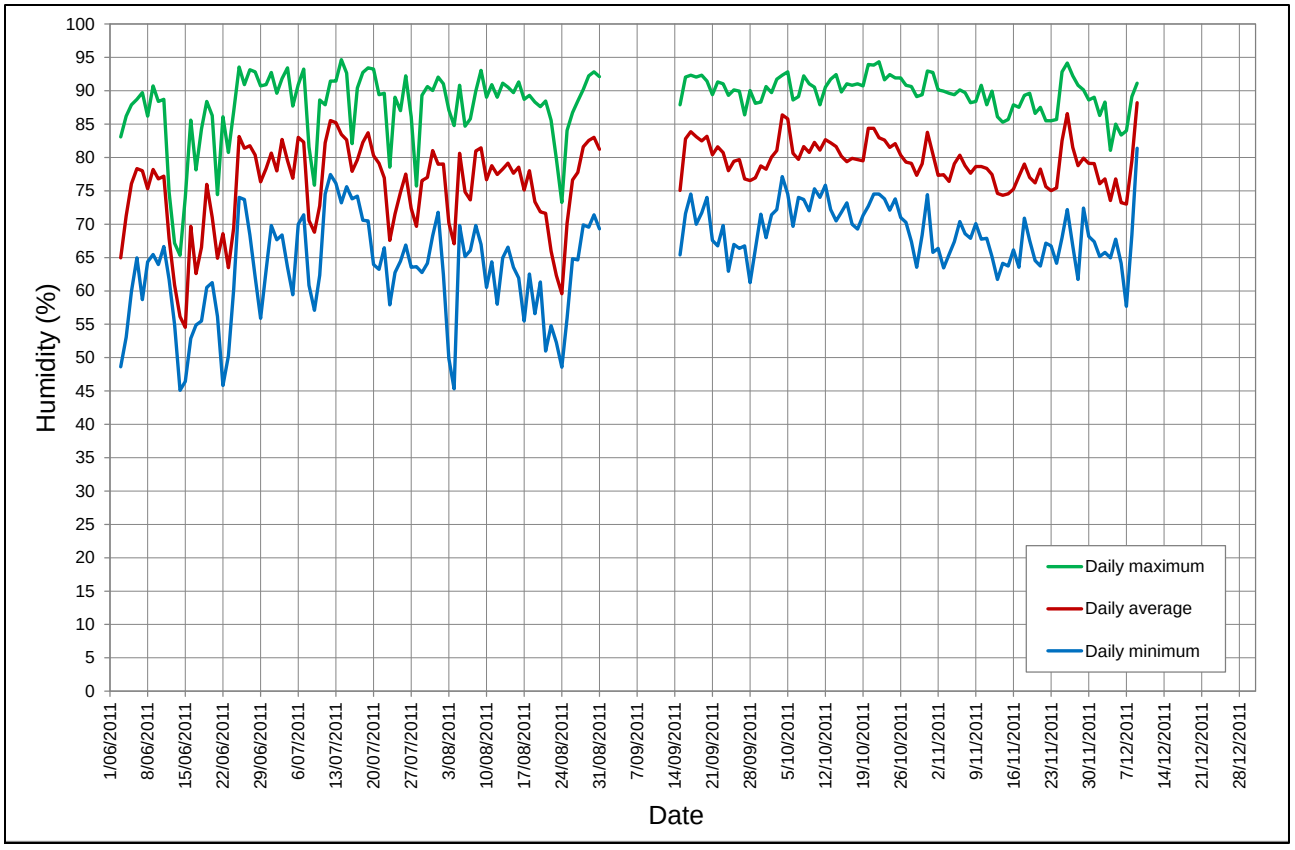


Figure 7-6 Beaco Humidity Plot 2: Humidity time series at Beaco AWS

REV	DATE	REVISION DESCRIPTION	DRN	CHK	DES	ENG	APPD	CUST	PROJECT: 301012-001504
0	29/05/2012	FOR FINAL ISSUE	CS	GHi	CW	-	GH		A4 SHEET

TASI MANE PROJECT – BETANO AND BEACO STRATEGIC ENVIRONMENTAL IMPACT ASSESSMENT

Figure 7-5
Figure 7-6

WorleyParsons resources & energy

TIMOR GAP, E.P. TIMOR GAS & PETRÓLEO

REPUBLICA DEMOCRATICA DE TIMOR-LESTE
SECRETARIA DE ESTADO DOS RECURSOS NATURAIS

OneWay to zero harm

Copyright © WorleyParsons Services Pty Ltd

LOCATION: \\perworfil1\infstructlib\Projects\301012-01504 Enviro Imp Assessment Timor-Leste\2.0 Reports\2.9 SEIA - Betano and Beaco\Figures\03_Working\BF079_BF080\

PLOT DATE AND TIME: 29 May 2012, 6:13 PM Creator: Courtenay Wheeler

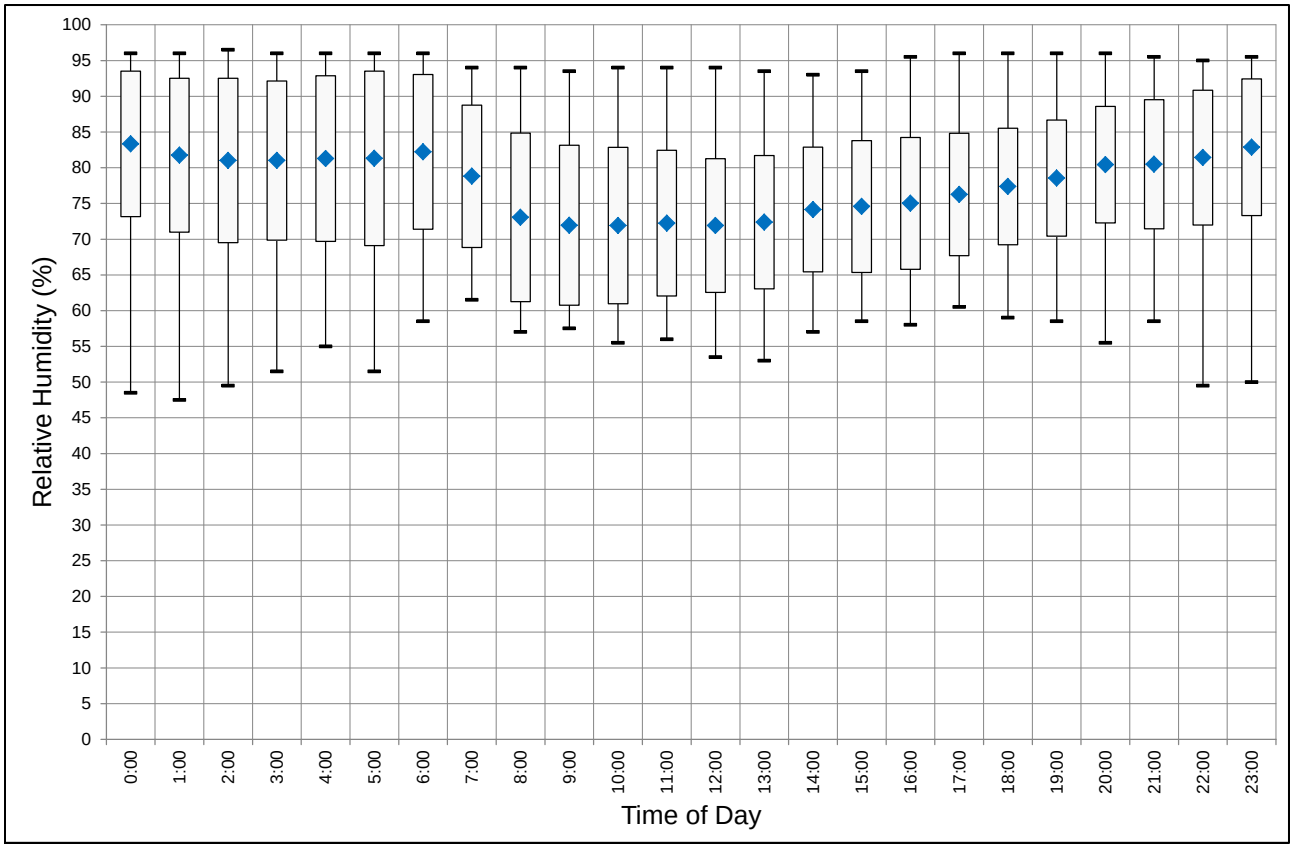


Figure 7-7 Beaco Humidity Plot 3: Humidity daily profile at the established weather station

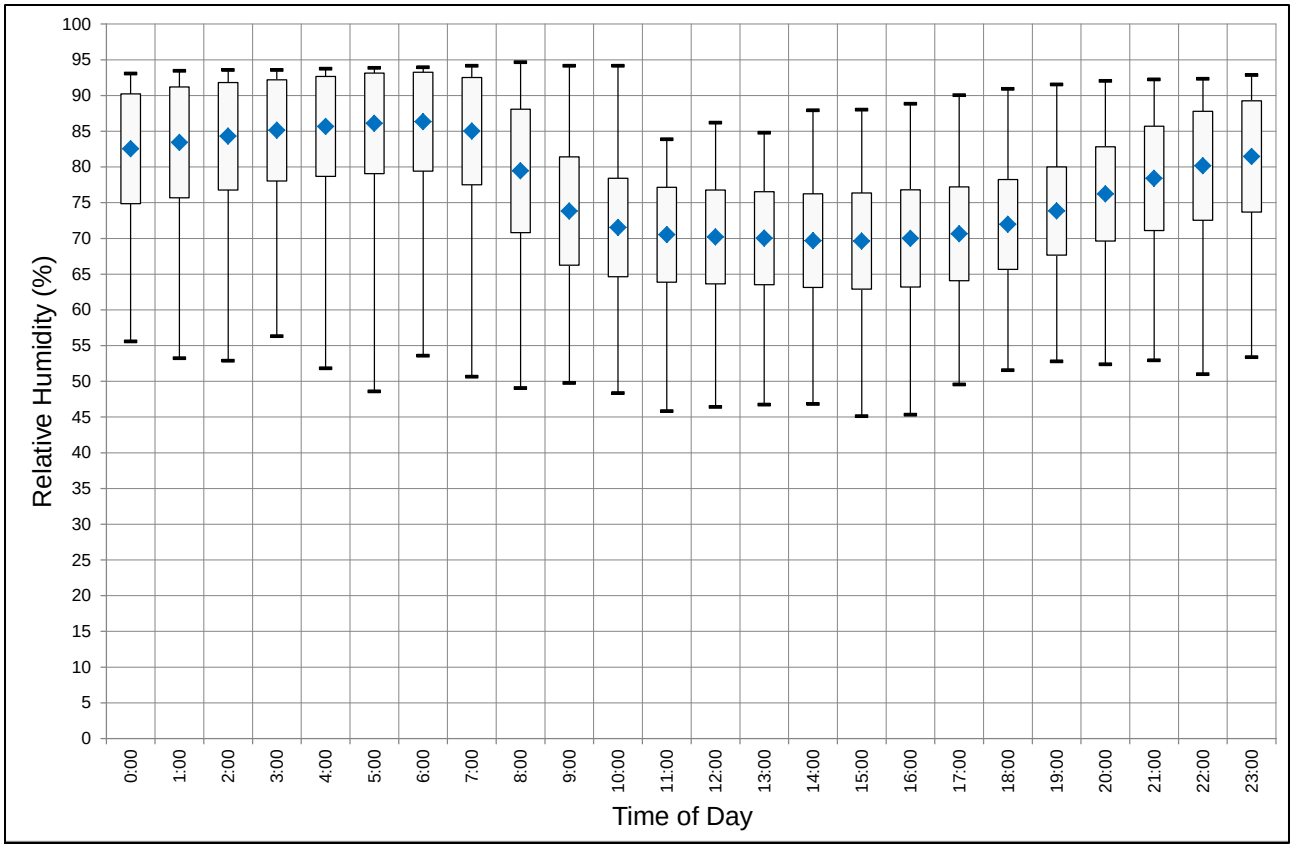


Figure 7-8 Beaco Humidity Plot 4: Humidity daily profile at Beaco AWS

REV	DATE	REVISION DESCRIPTION	DRN	CHK	DES	ENG	APPD	CUST	PROJECT: 301012-001504
0	29/05/2012	FINAL FOR ISSUE	CS	GHi	CW	-	GH		A4 SHEET

TASI MANE PROJECT – BETANO AND BEACO STRATEGIC ENVIRONMENTAL IMPACT ASSESSMENT

Figure 7-7
Figure 7-8

WorleyParsons resources & energy

TIMOR GAP, E.P. TIMOR GAS & PETRÓLEO

REPUBLICA DEMOCRATICA DE TIMOR-LESTE
SECRETARIA DE ESTADO DOS RECURSOS NATURAIS

OneWay to zero harm

Copyright © WorleyParsons Services Pty Ltd

LOCATION: \\perworfil1\infstructlib\Projects\301012-01504 Enviro Imp Assessment Timor-Leste\2.0 Reports\2.9 SEIA - Betano and Beaco\Figures\03_Working\BF081_BF082\

PLOT DATE AND TIME: 29 May 2012, 6:15 PM Creator: Courtenay Wheeler

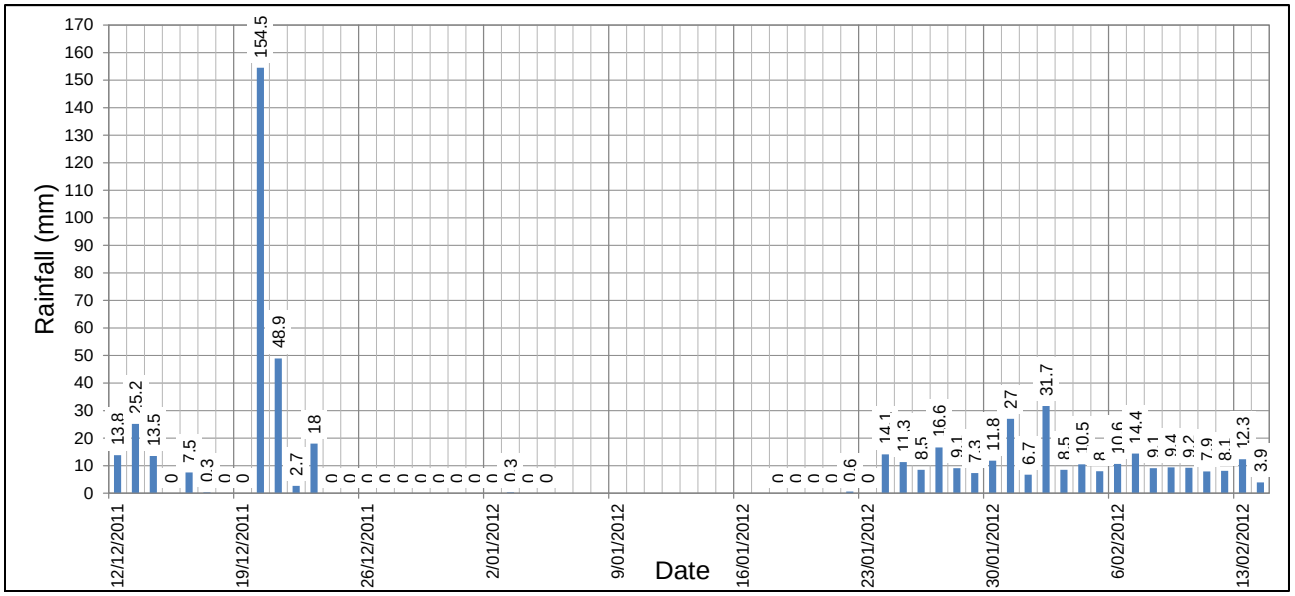


Figure 7-9 Beaco Rainfall Plot 1: Total daily rainfall recorded at the established weather station

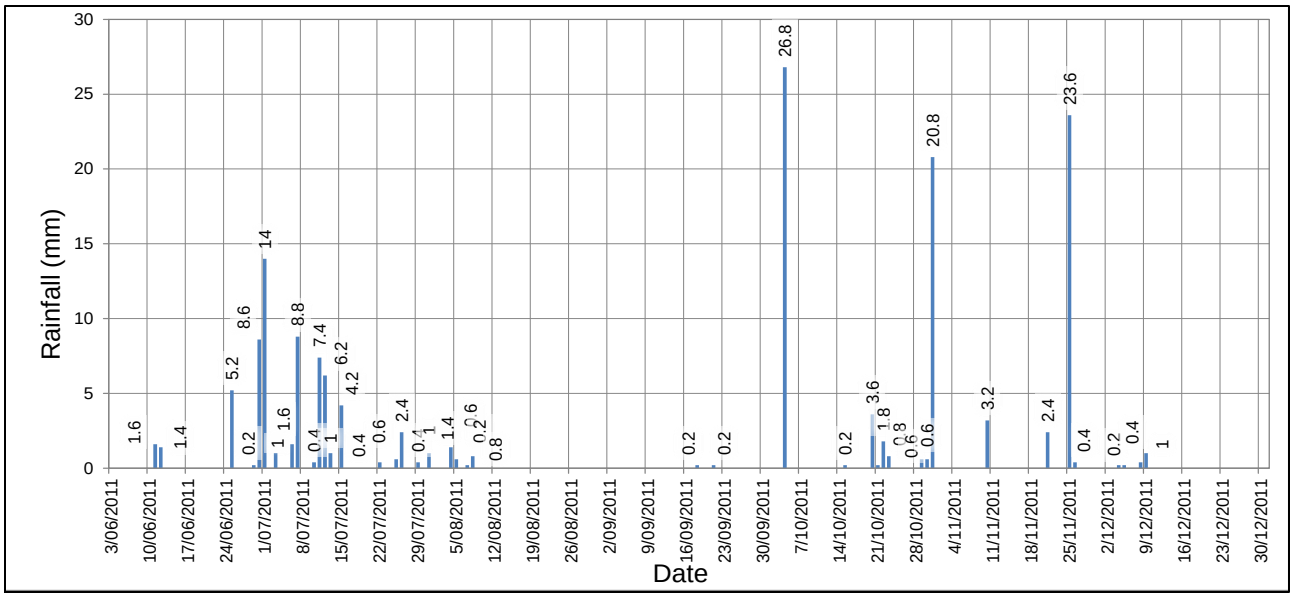


Figure 7-10 Beaco Rainfall Plot 2: Total daily rainfall recorded at Beaco AWS

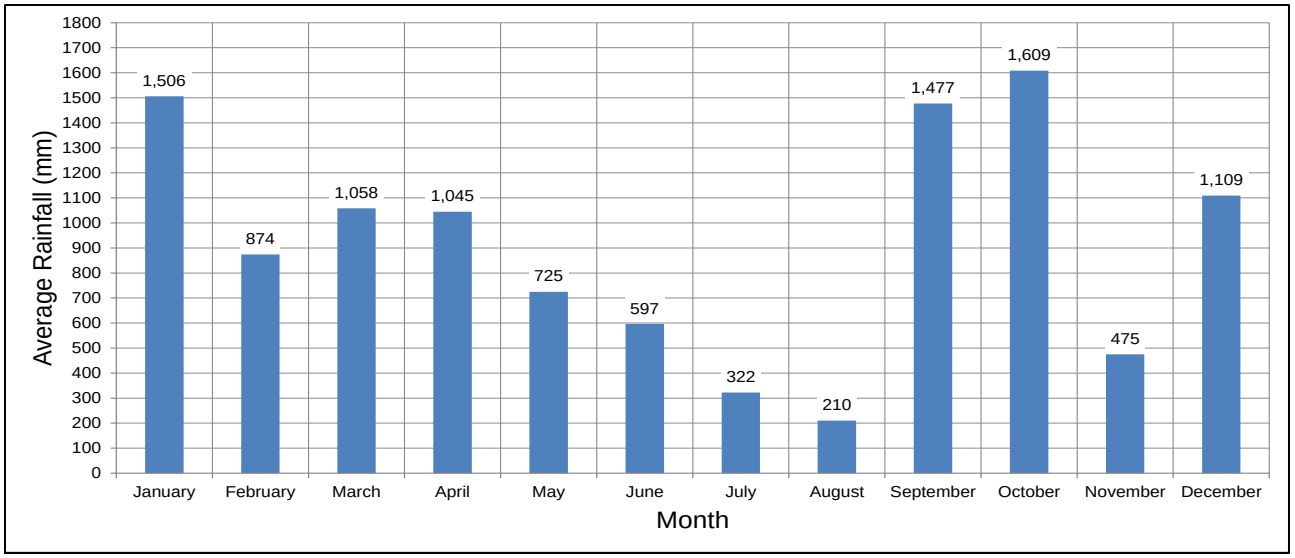


Figure 7-11 Beaco Rainfall Plot 3: Long term average rainfall recorded at Viqueque

REV	DATE	REVISION DESCRIPTION	DRN	CHK	DES	ENG	APPD	CUST	PROJECT: 301012-001504
0	29/05/2012	FINAL FOR ISSUE	CS	GHi	CW	-	GH		A4 SHEET

TASI MANE PROJECT – BETANO AND BEACO STRATEGIC ENVIRONMENTAL IMPACT ASSESSMENT

WorleyParsons resources & energy

TIMOR GAP, E.P. TIMOR GAS & PETRÓLEO

REPUBLICA DEMOCRATICA DE TIMOR-LESTE
SECRETARIA DE ESTADO DOS RECURSOS NATURAIS

OneWay to zero harm

Copyright © WorleyParsons Services Pty Ltd

Figure 7-9
Figure 7-10
Figure 7-11

LOCATION: \\perworfil1\infstructlib\Projects\301012-01504 Enviro Imp Assessment Timor-Leste\2.0 Reports\2.9 SEIA - Betano and Beaco\Figures\03_Working\BF083_BF084_BF085\

PLOT DATE AND TIME: 29 May 2012, 6:15 PM

Creator: Courtenay Wheeler

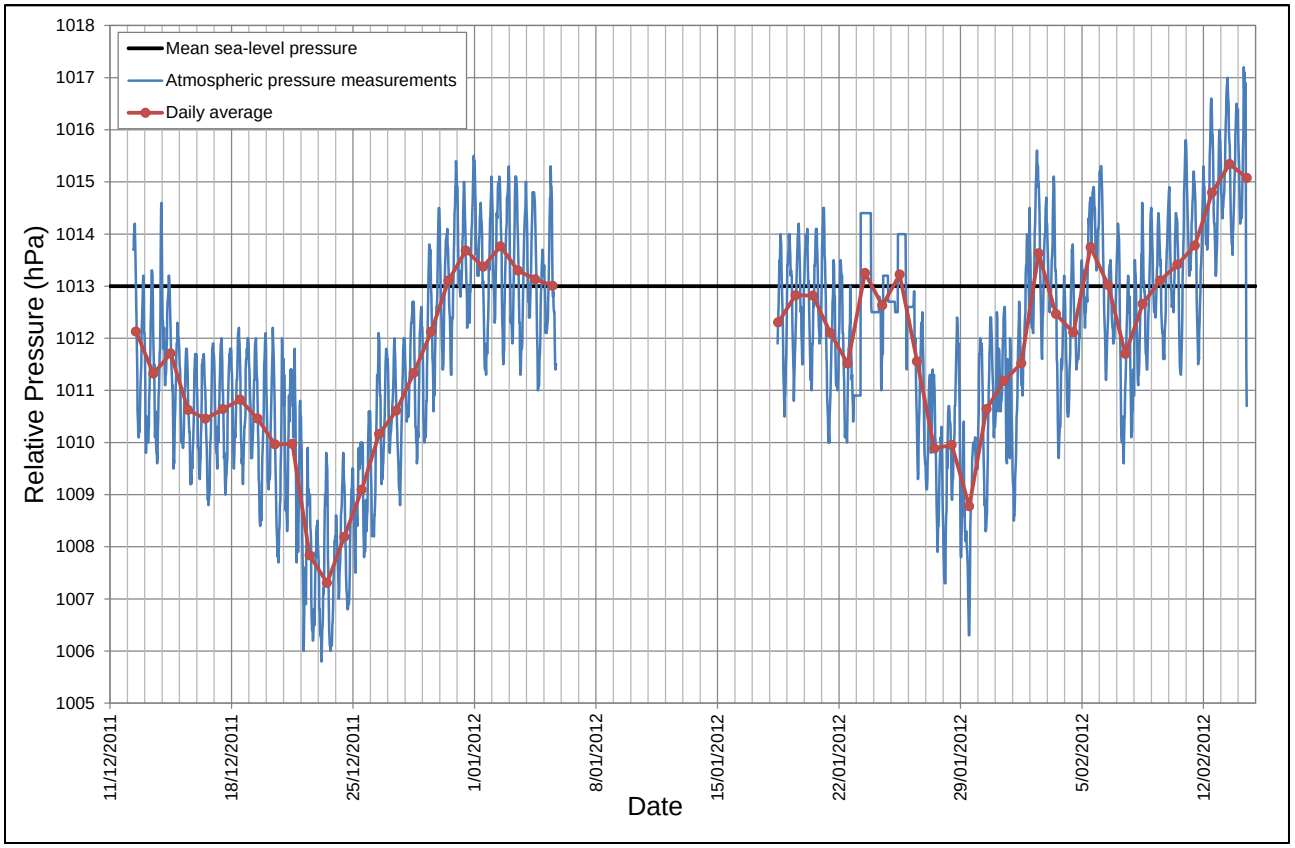


Figure 7-12 Beaco Pressure Plot 1: Pressure time series at the established weather station

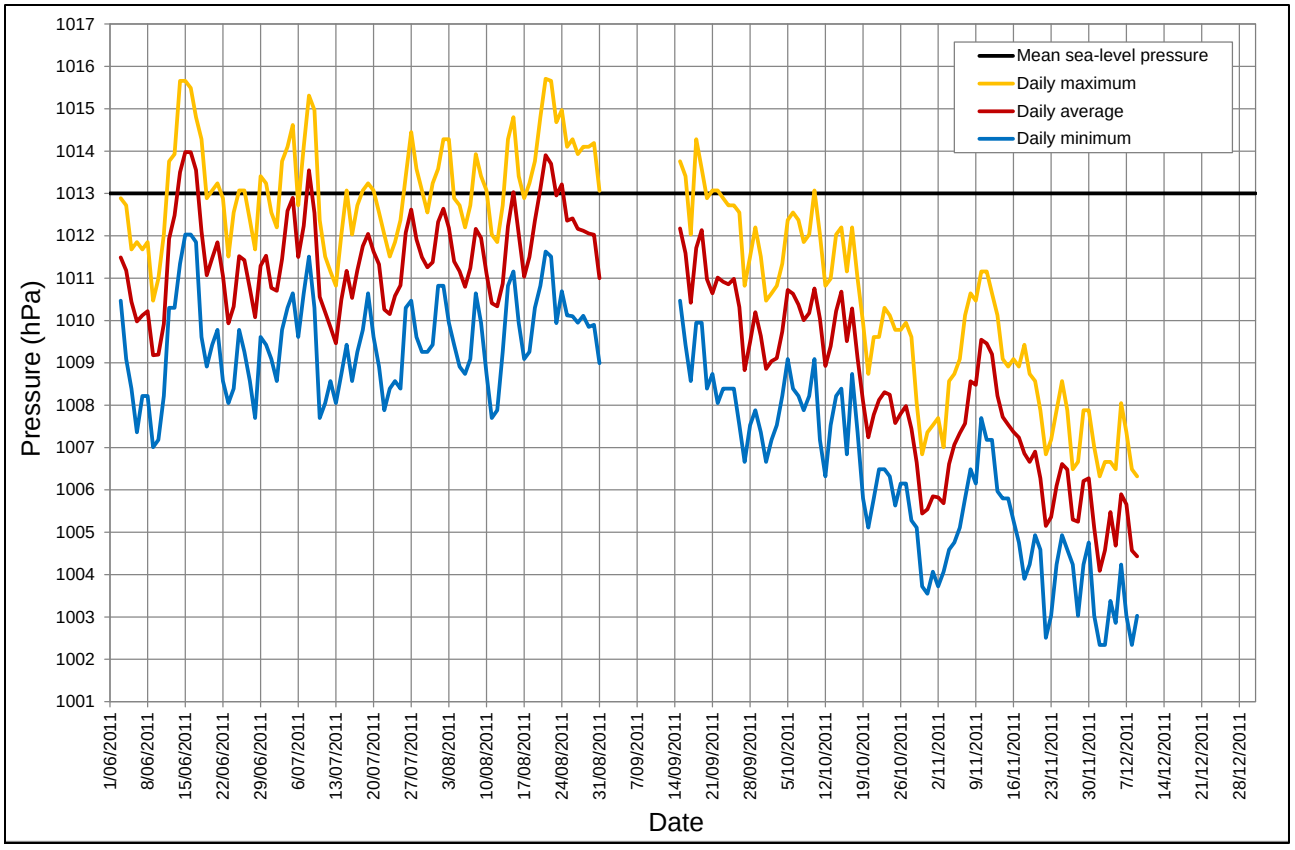


Figure 7-13 Beaco Pressure Plot 2: Pressure time series at Beaco AWS

REV	DATE	REVISION DESCRIPTION	DRN	CHK	DES	ENG	APPD	CUST	PROJECT: 301012-001504
0	29/05/2012	FOR FINAL ISSUE	CS	GHi	CW	GHi	GH		A4 SHEET

TASI MANE PROJECT – BETANO AND BEACO STRATEGIC ENVIRONMENTAL IMPACT ASSESSMENT

Figure 7-12
Figure 7-13

WorleyParsons resources & energy

TIMOR GAP, E.P. TIMOR GAS & PETRÓLEO

REPUBLICA DEMOCRATICA DE TIMOR-LESTE
SECRETARIA DE ESTADO DOS RECURSOS NATURAIS

OneWay to zero harm

Copyright © WorleyParsons Services Pty Ltd

LOCATION: \\perworfil1\infstructlib\Projects\301012-01504 Enviro Imp Assessment Timor-Leste\2.0 Reports\2.9 SEIA - Betano and Beaco\Figures\03_Working\BF086_BF087\

PLOT DATE AND TIME: 29 May 2012, 6:17 PM Creator: Courtenay Wheeler

Wind Speed and Direction

A major factor that influences local wind speed and direction trends is the topography and land use of the region. The Beaco to Viqueque region is particularly flat with elevations reaching 200 m above sea level approximately 15 km inland, and 5 km north of Nova Viqueque. In this case, the vegetation height is the primary factor in increasing ground-level turbulence of wind patterns and reducing wind speed. As the vegetation canopy is moderately tall, the higher wind speeds are from offshore whereas northerly winds (from the landmass) are typically slower.

Figure 7-14 and Figure 7-15 shows that the high speed winds (greater than 10 m/s) recorded at the established weather station primarily blew from the western arc, however a high proportion of slow winds (less than 3 m/s) blew from the north and east. In addition, Figure 7-14 and Figure 7-15 show that a very high proportion of slow winds blew from the north over the monitoring period with a moderate proportion of medium speed winds blew from the east-southeast.

Figure 6-8 (Chapter 6.1) presents wind roses for the Dili airport, Baucau and the three study areas: Suai, Betano and Beaco. For Dili, available data spans the period for July 2008 to October 2011. For Baucau, available data spans the period for January to October 2011. For the three study areas the data spans each monitoring period:

- Suai study area: 15 December 2011 to 7 February 2012.
- Betano study area: 10 December 2011 to 13 February 2012.
- Beaco study area: 12 December 2011 to 14 February 2012.

For the Dili region, the annual wind rose shows that for all winds measured, approximately 20% are blowing from the southeast and another 20% are blowing from the south-southeast. The predominant south-easterly winds have typically lower speeds ranging up to 5 m/s whereas; winds from the northern arc have been recorded to range up to 10 m/s.

Recorded winds for the Baucau region were only measured on an 8 point compass scale and averaged over an entire day. As such the data is only indicative of generalised wind proportions recorded during 2011. Similar to the Dili region, a high proportion of winds ranging up to 5 m/s were recorded to blow from the southeast.

For both the Suai and Betano semi-automated meteorological stations, a high proportion of low winds were measured. Suai shows an even distribution of winds blowing primarily from the southern arc and there is not enough data from the Betano meteorological station to accurately determine wind trends.

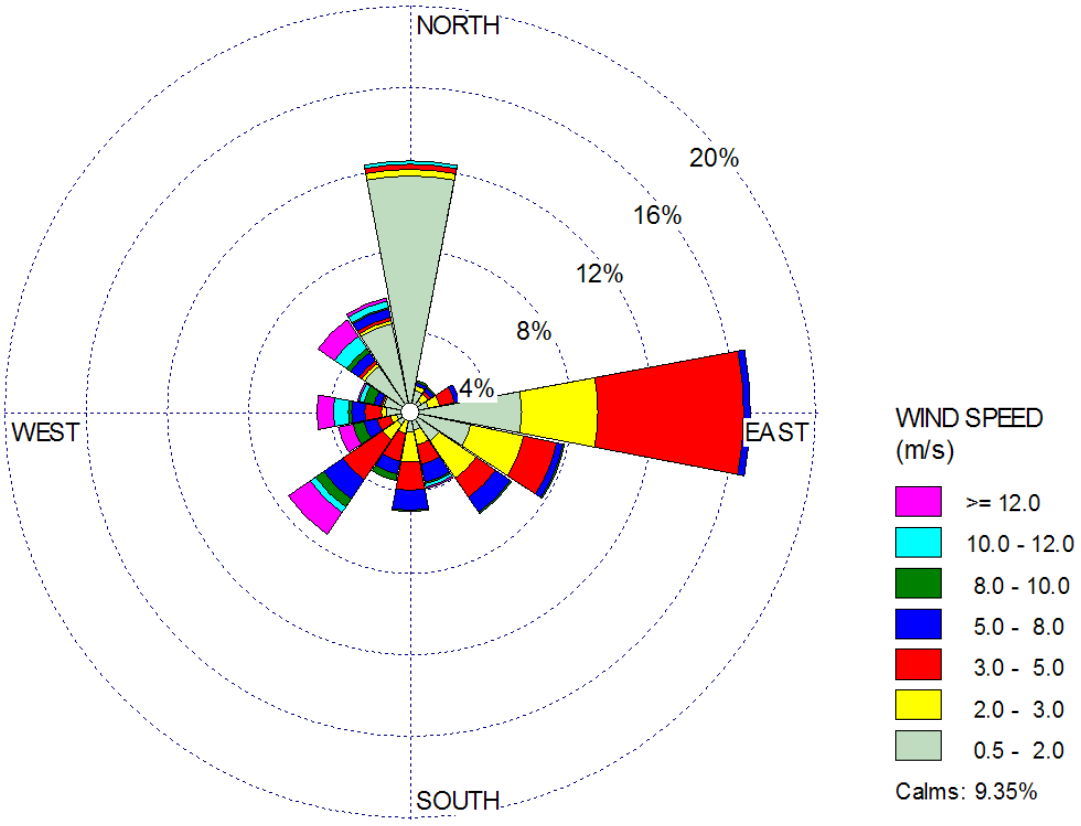


Figure 7-14 Beaco Wind Rose Plot 1: Wind Rose for recorded data at the established weather station

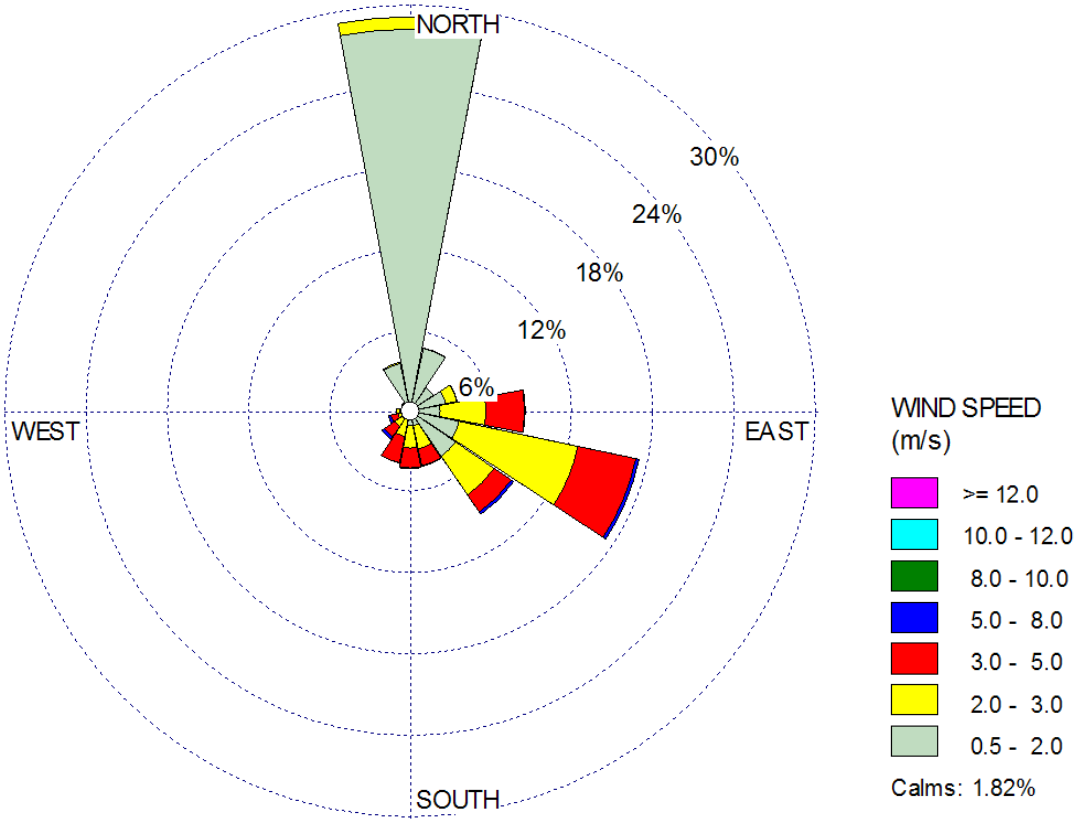


Figure 7-15 Beaco Wind Rose Plot 2: Wind rose for recorded data at Beaco AWS

NOTES:

Data sources:
- Established weather station: Ministry of Agriculture (2011)
- Beaco AWS: WorleyParsons (2012)

REV	DATE	REVISION DESCRIPTION	DRN	CHK	DES	ENG	APPD	CUST
0	6/06/2012	FINAL FOR ISSUE	CS	GHi	CW	GHi	GH	

A4 SHEET

PROJECT: 301012-001504

TASI MANE PROJECT – BETANO AND BEACO STRATEGIC ENVIRONMENTAL IMPACT ASSESSMENT

WorleyParsons resources & energy

TIMOR GAP, E.P. TIMOR GAS & PETRÓLEO

REPUBLICA DEMOCRATICA DE TIMOR-LESTE
SECRETARIA DE ESTADO DOS RECURSOS NATURAIS

OneWay to zero harm

Copyright © WorleyParsons Services Pty Ltd

Figure 7-14
Figure 7-15

LOCATION: \\perworfil1\infstructib\Projects\301012-01504 Enviro Imp Assessment Timor-Leste\2.0 Reports\2.9 SEIA - Betano and Beaco\Figures\03_Working\BF088_BF089\

PLOT DATE AND TIME: 6 Jun 2012, 2:56 PM

Creator: Courtenay Wheeler

Extreme Weather Events

The primary source of extreme weather events in the general vicinity of Timor-Leste is tropical cyclones.

A search of the Australian Bureau of Meteorology Australian Tropical Cyclone database (http://www.bom.gov.au/clim_data/IDCKMSTM0S.csv) revealed that 11 tropical cyclones travelled within a 200 km radius of Beaco, with three of these tropical cyclones travelling within a 100 km radius of the Beaco study area between 1906 and 2012. These cyclones are listed in Table 7-5 below. The paths for the cyclones within a 100 km radius of the Beaco study area are presented in Figure 6-9 (Chapter 6.1). CSIRO (2010) also reports that in April of both 1918 and 1919, cyclones passed in close proximity to the southern coast of Timor-Leste; however, their exact locations could not be determined. Cyclonic weather patterns were not observed in the Beaco study area during the monitoring period. However, tropical cyclonic activity (Tropical Cyclone Grant) occurred off the coast of the Australian Northern Territory between 21 and 31 December 2011.

Cyclonic activity in the vicinity of Timor-Leste primarily occurs during the monsoonal wet season focussing around the two maximum rainfall peak periods, December and late April/May.

Table 7-5 Historic tropical cyclones near Beaco study area

200 km Radius of Beaco		**100 km Radius of Beaco**	
Date Range	Cyclone Name	Date Range	Cyclone Name
6 – 13 April 1920	Unnamed #4	3 – 8 April 1995	Chloe
28 April – 3 May 1977	Verna	14 – 20 April 2000	Rosita
10 – 16 January 1978	Trudy	7 – 15 April 2002	Bonnie
22 – 31 December 1980	Felix		
18 – 20 December 1983	Esther		
15 – 28 February 1985	Jacob		
9 – 19 April 1991	Marian		
6 – 12 April 1994	Vivienne		
3 – 8 April 1995	Chloe		
14 – 20 April 2000	Rosita		
7 – 15 April 2002	Bonnie		

Thunderstorm activity was observed in Viqueque primarily during night hours and is frequently associated with the heavy rainfall events recorded. Lightning was observed to occur regularly; however, lightning strikes to ground-level were rare during the site investigation.

Due to the torrential nature of the rainfall in the monsoonal wet season, there is a risk of flooding of river beds in the development area. Due to the low-lying nature of the terrain, the Beaco study area is defined to be in a high flood risk region. No information was available regarding specific flooding events in the Beaco study area.

7.1.7 Impacts of Weather Patterns and Extremes of Climate on the Project

As the risks associated with climate extremes and climate change are very similar to the Betano development areas due to the similar topographical profile of the regions, the recommendations are the same. A summary of these recommendations is listed below:

- Climate extremes and projected climate change over the development life span (20 to 30 years) must be taken into account during the design phase of the development.
- A cyclone management plan should be developed covering both the construction and operational phases of the Beaco development.
- The cyclone management plan should also incorporate a policy regarding lightning strikes as well as high energy waves due to the coastal location.
- Soil erosion from flooding events should also be taken into account during the design phase of the development.

7.1.8 Avoidance, Management and Mitigation Measures

The recommended cyclone management plan should be consistent with the equivalent plan for Betano and would typically include, but not be limited to, the following:

- Potential cyclone identification methods and warning systems;
- 'Warning', 'Alert' and 'All Clear' communication methods for workers and the local populace;
- Cyclone-proofing for temporary structures/objects that are at risk of damage;
- Construction and operational policies for lightning strikes and high energy waves;
- Lockdown procedures, describing methods to secure all structures, vehicles and maritime vessels;
- Emergency action plans and evacuation procedures;
- Distress notification methods if additional aid is required; and
- Allowance for increased precipitation intensity in the design of water affected infrastructure.

Recommendations for the avoidance, management or mitigation of soil erosion effects, sedimentation, stormwater flow and waste containment are provided in the Topography, Geology and Soils (Section 7.3), Hydrology, Drainage and River Water Quality (Section 7.6), and Waste Management (Section 7.12) sections of the SEIA.

7.1.9 Further Work

A more complete meteorological dataset was available for the Beaco region compared to the Betano region. However, the upgrade of the Viqueque airport will require the installation of additional weather stations for aviation purposes.

It is therefore recommended that the automated weather station (AWS) in the Beaco/Viqueque study areas be upgraded to provide more complete datasets than what is currently recorded and that the

location and elevation coordinates are remeasured. The upgrade should be conducted in accordance with (AS 3580.14-2011) *Methods for sampling and analysis of ambient air Part 14: Meteorological monitoring for ambient air quality monitoring applications*, or an equivalent guideline. It is also recommended that the following parameters be continuously monitored and averaged on an hourly basis by the AWS:

- Station identification number;
- Date and time of record/observation;
- Air, wet bulb and dew point temperatures;
- Precipitation and evaporation;
- Relative humidity;
- Wind speed and direction;
- Solar radiation;
- Barometric pressure (relative, absolute and QNH {Barometric pressure adjusted to sea level for aviation purposes});
- Visibility;
- Cloud cover; and
- Cloud ceiling height (if practicable).

Some requirements of the above parameters listed in (AS 3580.14-2011) are provided in Table 7-6 below:

Table 7-6 Minimum requirements for meteorological monitoring instrumentation

Parameter	Units	Minimum Requirements		
		Range	Resolution	Accuracy
Wind speed	m/s	0.5 to 30 m/s	≤0.25 m/s	1% or 0.2 m/s*
Wind direction	Degrees to True North	0 to 360°	1°	±3°
Temperature	°C	-10 to 50°C	0.1°C	±0.3°C
Relative humidity	% Ratio	5 to 100%	1%	±2% (10 to 90%) ±4% (90 to 100%)
Solar radiation	W/m2	-	-	±30 to 50 W/m2
Atmospheric pressure	hPa	750 to 1050 hPa	1 hPa	±3 hPa
Precipitation	mm (or mm/hour)	0 to 400 mm/hour	0.5 mm	±5% (0 to 120 mm/hour)

Note: * Whichever is the greater value.

7.2 Land Use and Visual Amenity

Land use compatibility and changes to visual amenity associated with the Beaco development have been identified as issues with the potential to adversely affect the surrounding communities.

Currently there are no specific assessment standards or legislation relating to landscape and visual impact in Timor-Leste. In the absence of specific legislation, this strategic assessment has been carried out using a study method generally in accordance with *'The Guidelines for Landscape and Visual Impact Assessment' (2002) Second Edition*, published by the Landscape Institute (LI) and the Institute of Environmental Management and Assessment (IEMA) (United Kingdom), with some minor modifications to reflect the site's Timor-Leste context.

7.2.1 Study Method

This study was designed to undertake a preliminary land use and visual amenity impact assessment of the project, at a strategic level. The scope of this study is to:

- Consider how the changes in land use may affect the broader geographical area of Beaco, with a more detailed approach to the proposed LNG plant at Beaco. This includes a discussion of the local landscape, a description of the land use compatibility of the area with the proposed infrastructure, and consideration of future impacts on land uses; and
- Conduct a high-level visual amenity assessment of the Beaco development area, based on the information available, to consider changes in views that may be experienced by people observing the landscape.

This study method proposed for this assessment is summarised as follows:

- Desktop study: Undertake a literature review to identify GoTL or other relevant assessment standards and prevailing land uses in the Beaco development area;
- Site reconnaissance: The LNG plant development area and Nova Beaco were visited between 19 and 21 December 2011 with the aim of gathering site specific data for land use and visual amenity assessment purposes, including the topographical context to inform the assessment. Topographical considerations are more formally assessed in Section 7.3 (Topography, Geology and Soils).

Literature Review

As mentioned, the IEMA guidelines have been adopted in order to define the study method. The IEMA guidelines are internationally recognised guidelines which provide advice on assessing the landscape and the visual impacts of development projects.

The following guidance documents have also been referenced within this study:

- *Guidance on the New Approach to Appraisal.* Department of the Environment, Transport and the Regions, 1998. A New Deal for Trunk Roads in England; and

- *Guideline for Involving Visual & Aesthetic Specialists in EIA processes*. Oberholzer, 2005. Cape Town: CSIR, Provincial Government of the Western Cape, Department of Environmental Affairs and Development.

Site Visit

The site visit was undertaken between 19 and 21 December 2011 to gather site specific data for the project from a land use and visual amenity perspective. The objectives of the site visit were to:

- Identify the location and sensitivity of visual impact receptor sites for the project; and
- Gather baseline photographs from the visual receptor locations.

The site visit also included an account of aesthetic values (such as viewsheds, coastal vistas) and cultural values; these included:

- Religious and ceremonial significances (e.g., churches, graveyards); as shown in Plate 7-1.
- Traditional and indigenous significance sites (e.g., shrines); and
- Architectural significance (e.g., traditional and Portuguese forts, offices and houses).

Land Use

The land use aspect of this strategic assessment has been informed by a desktop review of relevant literature and aerial photography, GIS data obtained from the Timor-Leste GIS portal, websites and recent land use maps to provide an overview of the current land use. The existing land uses within and around the Beaco development area were noted (access permitting) during the site visits undertaken between 19 and 21 December 2011.

In the absence of a national planning scheme that would define preferred land uses in discrete zones, current and future land use compatibility could not be compared at this stage.

Source: Andrew Larsen, 2011

Plate 7-1 Graveyard in the Beaco development area

Source: Andrew Larsen, 2011

Plate 7-2 The Beaco development site is characterised by flat coastal plain topography

LOCATION: \\perworfil1\infstructlb\Projects\301012-01504 Enviro Imp Assessment Timor-Leste\2.0 Reports\2.9 SEIA - Betano and Beaco\Plates\03_Working\BP047_BP048\301012_01504_SEIA_Plate_7-1_7-2.vsd
PLOT DATE AND TIME: 31 May 2012, 12:24 PM Creator: Courtenay Wheeler

Visual Amenity

The visual amenity aspect of this strategic assessment considers a high level review of the likely visual sensitivity, significance of impact, and visual exposure of the Beaco development. Initial information was obtained from existing GIS data during the desktop review of topography and landmarks, and supplemented by field study findings, photographs and subsequent analysis.

Visual amenity impacts relate to how changes in the views resulting from a development are experienced by people who observe that landscape. The magnitude and sensitivity of a receptor would depend on the location and duration of the view of the development. Visual impacts relate to the appearance of the changes that arise in the composition of the view which results from a change to the landscape, to the viewer's response to the changes, and to the overall effects with respect to visual amenity (LI and IEMA, 2002).

Visual sensitivity

Visual sensitivity is typically defined by the duration and the nature of a view. For example, the longer the duration of the view and the more potential viewers who value the view, the higher the level of perceived visual sensitivity. It also relates to the degree of discord of the new view compared to that existing. The degree of discord of the refinery and petrochemical complex with the tropical agrarian setting would be very high, compared to an existing industrialised setting.

The degree of sensitivity is subjective and also reflects the attitude of the viewer to a view. Residential land users and medical institutions are often regarded as having a higher visual sensitivity, compared to agricultural and commercial areas whose day-to-day operations are less focussed on the fulfilment of visual amenity. High sensitivity to a view can also result from a short duration of exposure to the view but for a large numbers of potential viewers, for example from a public road or recreational space.The extent of the potential impact Beaco development has been assessed objectively according to the sensitivity of the receptor, taking into account potential mitigation measures to consider any residual impact. The identified viewpoints were assessed in the following order of sensitivity (adapted from LI and IEMA, 2002).

- High Sensitivity;
- Medium to High Sensitivity;
- Medium to Low Sensitivity; and
- Low Sensitivity.

Visual impact significance

In the absence of Timor-Leste standard or any other more comparative guideline, the significance of the visual impact of the refinery and petrochemical complex is likely to be 'substantially adverse', according to the following scale (adapted from DETR, 1988):

- Substantial adverse or beneficial impact;
- Moderate adverse or beneficial;

- Slight adverse or beneficial; and
- Neutral.

Although there are no recognised Timor-Leste standards and guidelines for determining the significance of visual impact, there is a need to assign significance to this assessment, where possible, for a more consistent method of evaluating visual impact. This is particularly so given that a detailed viewshed analysis could not be undertaken at this stage due to the lack of detailed contour baseline data available and three-dimensional design model of the proposed plant.

Visual exposure

Visual exposure refers to the relative visibility of a project or feature in the landscape. Exposure and visual impact tend to diminish exponentially with distance. The exposure is classified as follows (adapted from Oberholzer 2005):

- **High exposure** – dominant or clearly noticeable;
- **Moderate exposure** – recognisable to the viewer; and
- **Low exposure** – not particularly noticeable to the viewer.

7.2.2 Existing Environment

The location of the proposed areas for the Beaco LNG plant, Nova Beaco and Nova Viqueque and surroundings are largely undeveloped.

Landscape Setting

The topography of Timor-Leste is dominated by the Ramelau mountain range located along the central axis of the island with heights up to 3,000 m above sea level. The mountain range is dissected by deep valleys prone to flash floods. Towards the northern side, the mountains almost extend to the sea without extensive coastal plains. However, on the south coast, the mountains gently slope towards the sea, leaving a wide littoral plain that is more suitable for agriculture. The plain is generally between 20 and 30 km wide running almost the length of Timor-Leste, widening in the east.

The proposed site for the LNG plant will extend from the high water mark above the beach, inland (northwards) along the coastal plain, before intersecting a few low hills which occupy the central and northern parts of the site. The land rises gradually northwards to the central and upper parts of the coastal plain on which the area for Nova Beaco is located. Plate 7-2 shows the typical flat coastal plain topography within the area of the LNG plant site.

Nova Beaco, which will be located approximately 1 km east of the LNG plant site, will occupy a similar position in the landscape (coastal plain and adjacent low hills).

In contrast, Nova Viqueque, which will be located approximately 6 km north-west of the LNG plant site, will be established on a hilly location over a prominent set of ridges dissected by incised valleys. Gradients in this area range from moderate to steep, with many recent and palaeo-landslips in evidence.

Prominent valleys run through the hilly area north of the coastal plain before flowing out over the coastal plain as a network of shallow rivers and streams, with a few swampy or marshy depressions.

The central south coast of Timor-Leste around the existing town of Beaco is currently relatively sparsely populated with little infrastructure. The Beaco development area is primarily forested with a long, sandy coastal strip on its seaward side.

Land Use

Agriculture is the single largest land use in Timor-Leste, accounting for approximately 24% of the total land area. Subsistence farming (Plate 7-4) and rotational cropping supports the majority of rural communities in Timor-Leste (Bouma and Kobryn 2002).

Farmers depend on rainfed agriculture and grow corn, cassava and other tuberous crops. Corn was probably introduced into Timor by Europeans in the seventeenth century and, being well suited to the ecology of the island, it constitutes a staple of the Timorese diet. Rice is grown in irrigated fields and, where possible, has been introduced to the river valleys (Ormeling 1957).

During the site visit it was noted that the majority of the Beaco development area comprised agricultural land used for subsistence farming, natural landscape and scattered dwellings along the coastline. The land around the area allocated for Nova Beaco had mostly natural vegetation and plantations along the existing roads cutting through the site with few scattered dwellings on the southern boundary.

During the site visit, it was noted that the Maluru village and scattered dwellings (associated with farming) were in the vicinity of the proposed LNG plant site. The land around the area allocated for Nova Beaco comprised mostly fields, plantations and scattered field dwellings.

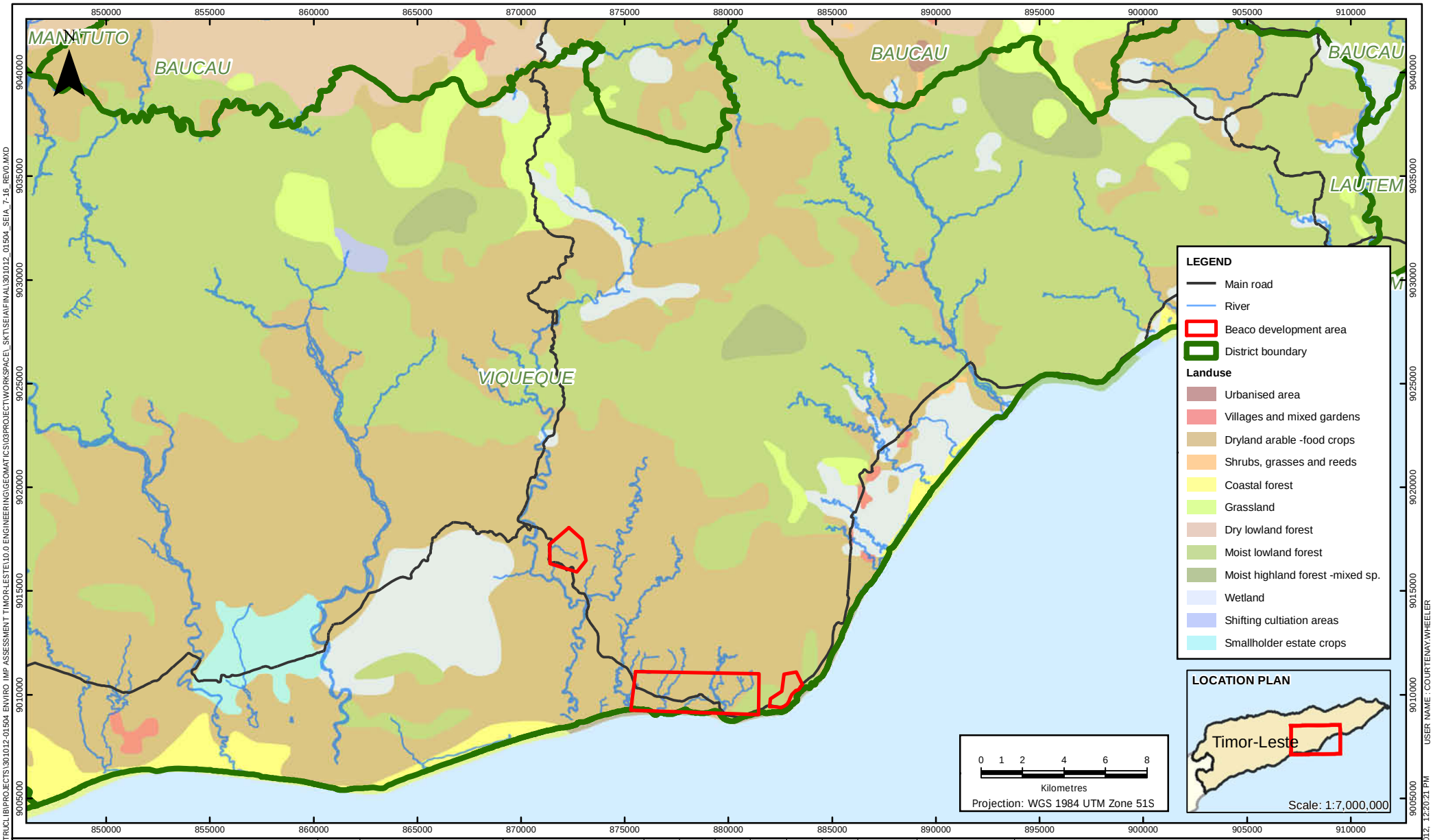
The identified land uses in and around the Beaco development area are shown in Figure 7-16.

Visual Amenity

Timor-Leste can be broadly divided into six ecological regions; namely, the mountainous areas, highland plains, moist lowland areas, arid lowland areas, coastal areas and urban areas (Metzner 1977).

The coastal landscape of the south coast of Timor-Leste is highly diverse with high aesthetic values. This is primarily due to the mountainous nature of the area inland, the steep coastal gradients, long isolated beaches and interspersed rocky headlands. The coastline is characterised with intact coastal vistas and mountain-sea landscapes.

A series of photographs were taken from many vantage points along existing roads and vehicle tracks during the December 2011 site visit. These photographs (Plate 7-5 to Plate 7-20) provide a record of the existing environment from a visual amenity perspective and their locations are shown in Figure 7-17.



LOCATION: \\PERWORFIL1\INFSTRUCL\IB\PROJECTS\301012-01504 ENVIRO IMP ASSESSMENT TIMOR-LESTE\10.0 ENGINEERING\GEOMATICS\03\PROJECTWORKSPACE_SKT\SEIA\FINAL\301012_01504_SEIA_7-16_REV0.MXD

USER NAME: COURTENAY.WHEELER

PLOT DATE & TIME: 29 MAY 2012, 12:20:21 PM

NOTES:
This map contains:
1. Rivers: Geographic Information Group TimorLeste (2010)
2. Roads: DivaGIS (2010)
3. District boundaries: Geographic Information Group (2008-2011)
4. Landuse: Pacific Disaster Center, (http://www.pdc.org/ghin/.) (2010)

REV	DATE	REVISION DESCRIPTION	DRN	CHK	DES	ENG	APPD	CUST
0	29/05/2012	FINAL FOR ISSUE	MW	CS	-	-	GH	

A4 SHEET | SCALE 1:250,000
PROJECT No: 301012-001504

WorleyParsons resources & energy

TIMOR GAP, E.P. TIMOR GÁS & PETRÓLEO

REPUBLICA DEMOCRATICA DE TIMOR-LESTE
SECRETARIA DE ESTADO DOS RECURSOS NATURAIS

OneWay to zero harm

Copyright © WorleyParsons Services Pty Ltd

TASI MANE PROJECT - BETANO AND BEACO
STRATEGIC ENVIRONMENTAL IMPACT ASSESSMENT

Figure 7-16
Land uses in the Beaco development area

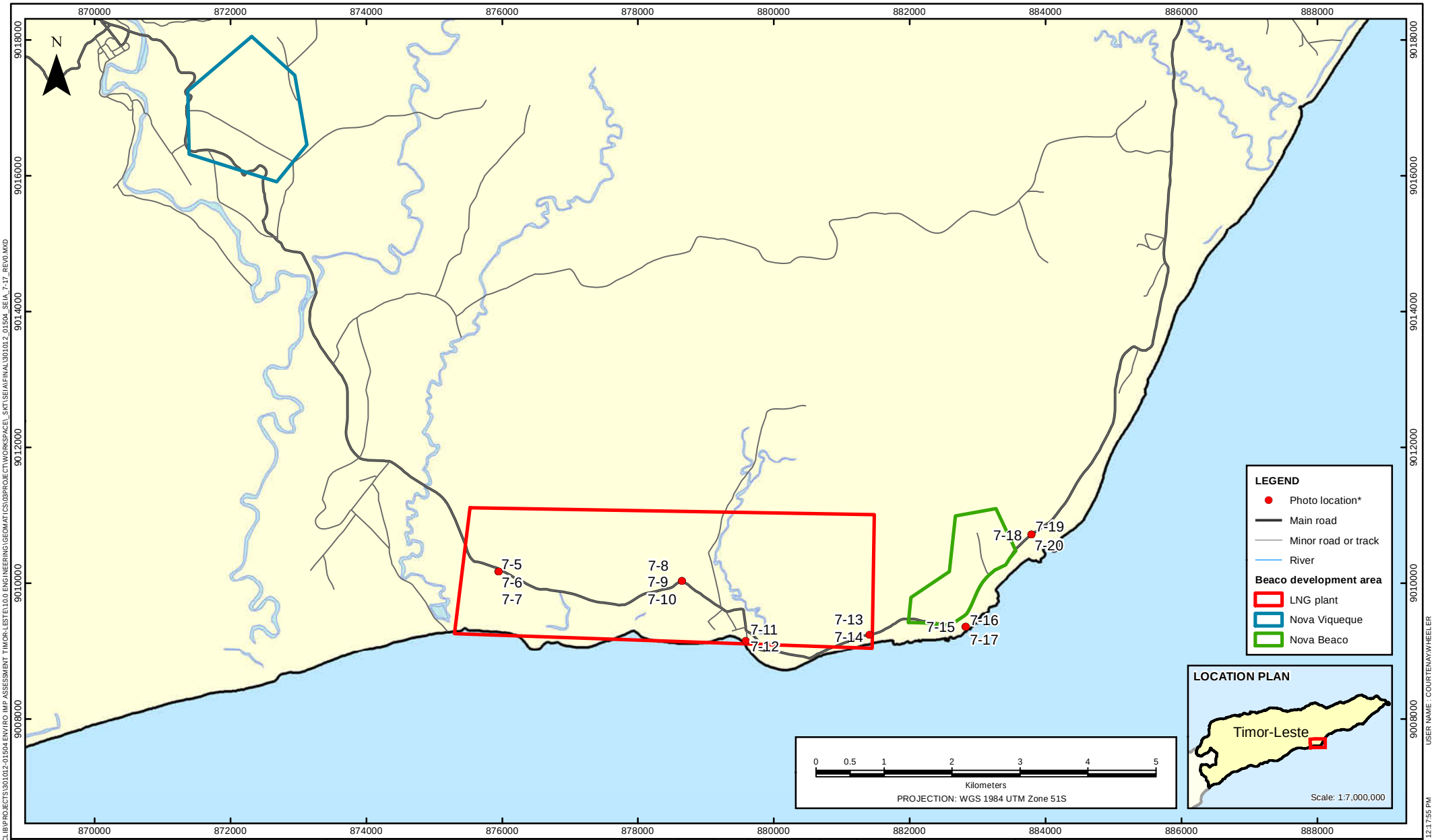
Source: Andrew Larsen, 2011

Plate 7-3 Steeply sloping lands in the mountainous terrain north of the Beaco site

Source: Andrew Larsen, 2011

Plate 7-4 The coastal plain is characterised by small scale subsistence agriculture

LOCATION: \\perworfil1\infstructlib\Projects\301012-01504 Enviro Imp Assessment Timor-Leste\2.0 Reports\2.9 SEIA - Betano and Beaco\Plates\03_Working\BP049_BP050\301012_01504_SEIA_Plate_7-3_7-4.vsd
PLOT DATE AND TIME: 31 May 2012, 12:29 PM Creator: Courtenay Wheeler



NOTES:
This map consists of:
1. Rivers: Geographic Information Group TimorLeste (2010)
2. Roads: DivaGIS (2010)

*Photographs taken at each of the photo locations are shown in plates 7-5 to 7-20

REV	DATE	REVISION DESCRIPTION	DRN	CHK	DES	ENG	APPD	CUST	
0	29/05/2012	FINAL FOR ISSUE	CS	GHi	CW	-	GH	-	A4 SHEET SCALE 1:75,000
									PROJECT No: 301012-001504

WorleyParsons resources & energy

TIMOR GAP, E.P. TIMOR GÁS & PETRÓLEO

REPUBLICA DEMOCRATICA DE TIMOR-LESTE
SECRETARIA DE ESTADO DOS RECURSOS NATURAIS

OneWay to zero harm

Copyright © WorleyParsons Services Pty Ltd

TASI MANE PROJECT - BETANO AND BEACO STRATEGIC ENVIRONMENTAL IMPACT ASSESSMENT

Figure 7-17

Beaco development area photo locations

LOCATION: \\PERWORFIL1\INFSTRUCI.IB\PROJECTS\301012-01504 ENVIRO IMP ASSESSMENT TIMOR-LESTE\100 ENGINEERING\GEOMATICS\03PROJECT\WORKSPACE_SKT\SEIA\FINAL\301012_01504_SEIA_7-17_REV0.MXD

USER NAME - COURTENAYWHEELER

PLOT DATE & TIME - 29 MAY 2012, 12:17:55 PM

Plate 7-5 on Figure 7-17 (looking south)

Plate 7-6 on Figure 7-17 (looking east)

Plate 7-7 on Figure 7-17 (looking north)

Plate 7-8 on Figure 7-17 (looking south)

Plate 7-9 on Figure 7-17 (looking east)

Plate 7-10 on Figure 7-17 (looking west)

Plate 7-11 on Figure 7-17 (looking north)

Plate 7-12 on Figure 7-17 (looking east)

Source: Gavin Fisher, 2011

LOCATION: \\perworfil1\infstructlib\Projects\301012-01504 Enviro Imp Assessment Timor-Leste\2.0 Reports\2.9 SEIA - Betano and Beaco\Plates\03_Working\BP074-BP811301012_01504_SEIA_Plate_7-5_7-12.vsd
PLOT DATE AND TIME: 31 May 2012, 7:07 PM Creator: Courtenay Wheeler

Plate 7-13 on Figure 7-17 (looking south-east)

Plate 7-14 on Figure 7-17 (looking north-east)

Plate 7-15 on Figure 7-17 (looking south-east)

Plate 7-16 on Figure 7-17 (looking east)

Plate 7-17 on Figure 7-17 (looking west)

Plate 7-18 on Figure 7-17 (looking north-west)

Plate 7-19 on Figure 7-17 (looking north-west)

Plate 7-20 on Figure 7-17 (looking west)

Source: Gavin Fisher, 2011

LOCATION: \\perworfil1\infstructlib\Projects\301012-01504 Enviro Imp Assessment Timor-Leste\2.0 Reports\2.9 SEIA - Betano and Beaco\Plates\03_Working\BP082-BP089\301012_01504_SEIA_Plate_7-13_7-20.mxd
PLOT DATE AND TIME: 31 May 2012, 7:27 PM Creator: Courtenay Wheeler

7.2.3 Environmental Impacts

Change in Land Use

The Beaco development is expected to introduce a new style of industrial development to the largely rural landscape setting that is currently characterised by low-intensity agricultural land use and fishing activities. This is expected to cause a permanent change from the current uses.

The LNG plant will introduce new and unprecedented land uses to the region. This change in land use, combined with an increase in industrial and commercial activities in the area, will significantly change the interaction with existing land uses in the area.

The development of Nova Beaco and Nova Viqueque will also result in a change in land use with visible impacts on the landscape and the lifestyle of the local residents.

The planned increase in population associated with the development may result in pressure on existing land uses and potentially increase the rate of land degradation (forest clearance, erosion and water harvesting). This will require appropriate consideration as part of an environmental assessment during the detailed design stage of the project.

Visual Impact

The Beaco development would introduce a new development to the largely rural landscape setting which is characterised by agricultural and coastal landscapes. There are no other examples of a similar development within the region, either in scale or character.

The introduction of the industrial activities that comprise the LNG plant would change the landscape significantly from the present coastal agriculture setting to one that is industrial.

For this reason, the potential visual impact of this aspect is considered in more detail for this strategic assessment than for the developments of Nova Beaco, Nova Viqueque and the upgrade works to Viqueque Airport.

The clearing of vegetation and earthworks activities to facilitate construction of the LNG plant is likely to generate the most visible impact on the landscape (Plate 7-21). The LNG plant site is currently well vegetated, and vegetation clearance and the establishment of buildings and structures will significantly alter the appearance of the area. The project has a lifespan of 50 years therefore is deemed a permanent change to the physical landscape.

Night lighting will also be a necessary component for most aspects of the project, including security, safety, and night operations and maintenance work. Given the limited distribution of electrical lighting in the area, light spillage during the operation of the LNG plant is likely to be significant. Some light-related impacts are also possible during construction; however, this will be of a smaller scale than the operational phase, and be temporary.

Visual Impact Assessment

Visual Exposure

Due to the relatively flat topography and coastal location, the LNG plant site is likely to be highly visible from both higher vantage points and at some areas of lower terrain (e.g., local roads and

settlements) in the immediate vicinity. In certain areas, the existing vegetation and the topography may offer some screening (Plate 7-21).

Based on the information available to date, Nova Beaco and Nova Viqueque are expected to be located within a rural based setting with relative remoteness which is likely to, along with the topography, provide a reasonable amount of screening. Nova Beaco and Nova Viqueque are therefore likely to have relatively moderate to low visibility.

Sensitivity

Using the order of sensitivity outlined in Section 7.1.1 above, the LNG plant site is expected to have a 'high' visual sensitivity for settlements along the primary road, which currently runs through the site (a diversion is planned). The same level of significance would likely apply to users of the southern coastline (Plate 7-22) due to the scale and coastal location of the proposed structures.

The LNG plant site is also likely to have a 'high' visual sensitivity for the existing residents of Maluru village as well as nearby farming dwellings and settlements. This would be due to scale and location of the complex, particularly due to the visibility from higher elevations and the contrast that the appearance of the development would have with the surrounding agricultural and coastal environments which are natural and visually softer landscapes.

Based on the information available to date, Nova Beaco and Nove Viqueque would likely have a 'medium to high' visual sensitivity when viewed from the surrounding area.

Significance of the Impact

The intensity of the impact on the landscape from the operation of the LNG plant is likely to be 'high' due to the scale of the development and the prominent coastal location on relatively flat topography.

In addition, the significance of the visual impact is likely to be 'substantially adverse' for most nearby settlements, including viewers those located within 500 m of the site. This is based on a qualitative evaluation for the visibility of the development which is likely to have a 'high exposure' and 'high' sensitivity. Whilst the visibility is likely to remain in the landscape of most viewsheds, the significance of the impact to receptors will lessen with distance from the site.

Based on information available to date, the significance of the impact of Nova Beaco and Nova Viqueque are likely to be 'moderate adverse' for local residents and nearby land users for the reasons outline above.

Due to the early stages of the project, the likely visual impact of the Beaco development during construction has not been evaluated in this strategic assessment.

Visibility Analysis

Maximum distance of a development is a very important factor that has to be taken into consideration in a viewshed analysis, because the greater the distance, the lower the visual impact that an object can bring to the landscape, depending on the scale, form, texture, architectural lines and colour (Matos, 2001). As mentioned in Section 7.1.1, a detailed viewshed analysis could not be undertaken at this stage due to the lack of detailed contour baseline data available; however, a calculation of the visible distance of the proposed LNG plant site from an offshore (or a completely flat topography) location can be estimated.

Source: Andrew Larsen, 2011

Plate 7-21 A view of the Timor Sea from the Beaco coastline

Source: Andrew Larsen, 2011

Plate 7-22 Dense vegetation around the Beaco development area

LOCATION: \\perworfil1\infstructlib\Projects\301012-01504 Enviro Imp Assessment Timor-Leste\2.0 Reports\2.9 SEIA - Betano and Beaco\Plates\03_Working\BP053_BP054\301012_01504_SEIA_7-21_7-22.vsd
PLOT DATE AND TIME: 4 Jun 2012, 7:59 PM Creator: Courtenay Wheeler

The visible distance can be calculated in nautical miles (nm) using the following equation (BHP, 2006):

Visible Distance (in nm) = 1.17 x the square root of the height (in feet)

If the height of the tallest structure is, for example, 20 m (65 feet), including mountains in the background, it could be viewed from 9.4 nm offshore. Plate 7-24 shows the current view of the coastline of Beaco region from the Timor Sea. An accurate calculation is recommended at the next stage once the scale (and location) of built aspects for the complex are known.

Source: Andrew Larsen, 2011

Plate 7-23 A view of the Timor Sea from the Beaco development area

Source: Andrew Larsen, 2011

Plate 7-24 A view of the Timor Sea from the Beaco development area

LOCATION: \\perworfil1\infstructlb\Projects\301012-01504 Enviro Imp Assessment Timor-Leste\2.0 Reports\2.9 SEIA - Betano and Beaco\Plates\03_Working\BP051_BP052\301012_01504_SEIA_Plate_7-23_7-24_Ch7_1.vsd
PLOT DATE AND TIME: 31 May 2012, 2:06 PM Creator: Courtenay Wheeler

7.2.4 Avoidance, Management and Mitigation Measures

In order to minimise the potential impacts on the visual amenity, the strategies in Table 7-7 should be considered as part of an avoidance, management and mitigation strategy to be developed at the detailed design stage of the project. This list is not exhaustive, and has been prepared to provide a guide at this early stage.

Table 7-7 Avoidance, Management and Mitigation Measures

Potential Issue	Measure	Description
Loss of screening vegetation	Retention of existing vegetation (where possible)	The retention, where practical, of existing landscape and vegetation will assist in partially screening the proposed development areas during construction and operation. Particular attention should be paid to the retention of the well-established vegetation around the Beaco LNG plant development area. It is recommended that the visual impact from vegetation loss be given due consideration during the detailed design stage, including the retention of existing vegetation within the development area where possible.
Vegetation restoration	Restore existing vegetation (where possible)	Where it is necessary to remove existing vegetation, such as grasses and trees, the affected area should be restored to its previous or an improved state using the same or similar vegetation species. Screening the development area using indigenous vegetation will not conceal the built aspects, but it will soften the appearance and reduce the visibility.
Appearance and visual impact	Planting of vegetative screens	Further tree plantings should be implemented along the boundaries of the proposed development areas to provide a soft screen and reduce the visibility of infrastructure. In particular, screening should be planted between the proposed development areas and the adjacent local roads, and where practical, should not interfere with existing local activities and infrastructure.
Light spill	Implement a lighting strategy	Where lighting is deemed necessary, low-level lighting should be used to reduce light spill onto sensitive land uses. It is recommended that the visual impact of lighting be given due consideration during the detailed design stage, including the use of down-lighting to angle the light source, shielding, and lighting with lower lux ratings. All lighting should be kept to a minimum within the requirements of safety and efficiency.
Glare	Use of paint finishes	The use of non-reflective paints and coatings for external surfaces should be considered to reduce reflection and glare. Uncoated galvanised metallic surfaces should be avoided where possible, and the use of colours on exterior walls that will blend in with the surrounding landscape should be encouraged.

Visual amenity considerations in site design and layout combined with the application of accepted industry practice (including adoption of environmental management controls for field development activities) will minimise such impacts.

7.2.5 Residual Impacts

The Beaco development would result in significant changes to the appearance of the landscape and existing land uses. However, if the specified avoidance and management measures are implemented, this should reduce any significantly adverse impacts.

7.2.6 Further Work

A landscape and visual impact assessment is recommended once the project design has been confirmed, in an iterative approach to minimise any adverse impacts on visual amenity. This is particularly relevant to the LNG plant in terms of structure scale, site configuration (for screening), site appearance, and finishing (where possible) to reduce the impact of its appearance.

A vegetation management plan should be developed at the next stage to minimise vegetation loss and maintain as much of the boundary vegetation as possible for soft screening of the infrastructure for the closest visual receptors. A re-vegetation strategy should also be developed at the next stage.

It is also recommended that the visual impact of lighting be given consideration at the detailed design stage of the project, including consideration of downlighting, shielding of lights and purchase of lighting with lower lux ratings.

7.2.7 Summary

The significance of the impact of the LNG plant on nearby land users is likely to be ‘substantially adverse’ due to the scale and nature of the proposal, and the likely visibility and estimated sensitivity by sensitive receptors.

The significance of the impact of Nova Beaco and Nova Viqueque is likely to have be ‘moderate adverse’ on nearby land users.

This strategic assessment provides a preliminary consideration of the potential impacts of the Beaco development in terms of the changes in land use and visual amenity impacts for identified sensitive receptors. This strategic assessment has been undertaken in accordance with published guidelines with some minor modifications to reflect the Timor-Leste context.

The implementation of appropriate mitigation measures may reduce visual impacts from the operation of the project; however further assessment would need to be undertaken to determine the extent to which potential impacts could be avoided, managed and/or mitigated.

7.3 Topography, Geology and Soils

7.3.1 Study Method

A preliminary geological and engineering geological assessment has been undertaken for the Beaco development area. The scope of the assessment is to:

- Subject the Beaco development area to a geological and engineering geology overview, including a description of the prevailing topography, geomorphology, underlying hard rock geology and overlying superficial/soft sediments (soils), as well as soil/geology and vegetation associations. This has been achieved through a combination of desktop research and a site walkover.
- Briefly assess the soil profile within the Beaco development area through excavation of a limited number of test pits. The soil profile in each test pit would be logged with the aim of describing the physical attributes of the soil and associated broad engineering geological characteristics (including soil erosion potential). Representative soil sampling was also to be undertaken for environmental chemical testing.
- Assess the prevailing geohazards within the Beaco development area, which could potentially impact on development and the environment. Potential geohazards include expansive clays, collapsible soils, dispersive/erodible soils, compressible soils, saline/sodic soils, ASS, karst conditions, asbestiform materials, slope instability, shallow bedrock, seismic conditions as well as flooding and inundation.

Recommendations to achieve a stable and functioning post-construction landform also needed to be made.

This scope has been implemented through the following:

- Desktop study: The topography, geomorphology, geology and engineering geology has been assessed by consulting available literature and previous studies covering the Beaco development area. This included the consideration of the geotechnical investigations already completed at Beaco that were primarily aimed at providing initial information for project feasibility purposes. The boreholes were spread over a wide area and were not targeted at specific infrastructure or localities.
- Site visit: The Beaco development area was visited on 15 and 16 December 2011 with the aim of assessing the study sites and confirming the sub-soil conditions encountered in the pre-excavated test pits.
- Fieldwork: Fieldwork was undertaken between 10 and 12 December 2011. A total of fifteen test pits were excavated in the Beaco development area, five at the LNG plant site, five at Nova Beaco and five at Nova Viqueque. The test pit locations were pre-selected in accessible areas which were deemed representative of the local geology. The test pits were excavated by hand to a maximum depth of 1.5 m below surface. They were logged according to an adapted version of the WorleyParsons' geotechnical logging system, thus facilitating description of the physical attributes of the soil and broad engineering geological characteristics (including soil

erosion potential). A total of 44 representative soil samples were taken from the test pits for environmental chemical testing.

- Laboratory testing: The 44 soil samples taken during the geological test pitting program were sent to ALS Environmental in Brisbane, Australia for environmental chemical testing. ALS is an Australian National Association of Testing Authorities (NATA) accredited laboratory.
- Reporting: An internal field report collating and presenting all relevant site data was produced in the WorleyParsons' Dili office. This field report was subsequently reviewed and evaluated in Perth, informing the preparation of this section of the SEIA.

Soil Chemistry Sampling

Soil chemistry sampling was conducted primarily to establish baseline soil chemical conditions across the study area. The incremental change to the soil chemical properties once the operations have been established is of primary interest and therefore the results have not been compared to assessment criteria. A comparison of future soil chemistry testing against the baseline data reported herein will provide a measure of any impact the project operations may have on the chemical profile of the soil.

Soil chemistry samples were collected from the test pit walls at depth intervals of 0.5 m from ground level, to the base of each test pit. Where possible, topsoil samples were also collected at the test pit localities.

To avoid cross-contamination of samples, a new pair of clinical rubber gloves was worn by the field staff for each sampling event. Samples were placed into individual containers labelled with the following information:

- Unique sample identifier.
- Date and time of sample collection.
- Depth below ground level (m BGL).
- Site staff name.

The list of samples collected from the Beaco development area is provided in Table 7-8.

Soil samples were placed directly into a cooler box for temporary storage until they were transferred to a freezer for longer-term storage. This storage method preserves the samples by slowing the degradation due to chemical reactions associated with exposure to the atmosphere. The samples were submitted to ALS Environmental for analysis under full chain-of-custody protocols at the end of the fieldwork program.

The samples were subject to laboratory analysis of the following criteria:

- Physical parameters: pH; electrical conductivity; and moisture content.
- Nitrogen content: total nitrogen; total Kjeldahl nitrogen (TKN); ammonia; and nitrate/nitrite compounds.
- Extractable cations: phosphorus; potassium; and sulfur.
- Total organic carbon

Table 7-8 Collected soil chemical samples – LNG Plant Cluster

Test Pit Number	Sampling Date (dd/mm/yyyy)	Sampling Time	Sample Depth (m BGL)
Test Pit LNG Plant Site I (TPLNG I)	10/12/2011	14:15 pm	0.5m 1.0m 1.5m
TPLNG II	10/12/2011	14:45 pm	Topsoil 0.5m 1.0m 1.5m
TPLNG III	10/12/2011	15:30 pm	0.5m 1.0m 1.5m
TPLNG IV	10/12/2011	16:45 pm	0.5m 1.0m 1.5m
TPLNG V	10/12/2011	17:00 pm	Topsoil 0.5m 1.0m
Test Pit Nova Beaco I (TPNC I)	12/12/2011	11:05 am	Topsoil 0.5m 1.0m 1.5m
TPNC II	12/12/2011	11:55 am	Topsoil 0.5m 1.0m
TPNC III	12/12/2011	12:00 pm	Topsoil 0.5m 1.0m
TPNC IV	12/12/2011	13:20 pm	Topsoil 0.5m 1.0m
TPNC V	12/12/2011	13:47 pm	Topsoil 0.5m 1.0m 1.5m
Test Pit Nova Viqueque I (TPNV I)	11/12/2011	14:59 pm	0.5m 1.0m 1.5m
TPNV II	12/12/2011	09:58 am	0.5m 1.0m
TPNV III	12/12/2011	8:01 am	0.5m 1.0m
TPNV IV	12/12/2011	8:36 am	0.5m 1.0m
TPNV V	12/12/2011	7:37 am	0.5m 1.0m

7.3.2 Existing Environment

Regional Topographic Setting

The topography of Timor-Leste is dominated by the Ramelau mountain range located along the central axis of the island with heights up to 3,000 m above sea level. The mountain range is dissected by deep valleys prone to flash floods. Towards the northern side, the mountains almost extend to the sea without extensive coastal plains. However, on the south coast, the mountains slope gently towards the sea, forming a wide littoral plain that is more suitable for agriculture. The plain is generally between 20 and 30 km wide, running almost the length of Timor-Leste, widening in the east. Plate 7-25 shows the typical flat coastal plain topography in the southern part of the LNG plant site.

Topography of the Beaco Development Area

The LNG plant site stretches from the high water mark above the beach, inland (northwards) along the coastal plain, before intersecting a few low hills which occupy the central and northern parts of the site (Plate 7-26). These low hills, with gentle to moderate gradients, coincide with a change in the geology. Nova Beaco, located about 1 km to the east of the LNG Plant site, occupies a similar position in the landscape (coastal plain and adjacent low hills).

In contrast, Nova Viqueque (located approximately 6 km north-west of the LNG Plant site) is draped over a prominent set of ridges dissected by incised valleys (Plate 7-27). Gradients in this area range from moderate to steep, with many recent and palaeo-landslips in evidence.

Prominent valleys run through the hilly topography north of the coastal plain before flowing out over the coastal plain as a network of shallow rivers and streams (Plate 7-28), with a few swampy or marshy depressions (Plate 7-29).

Regional Geomorphological and Geological Setting

The geology of Timor-Leste comprises predominantly limestone and metamorphosed sediments overlying ancient Proterozoic basement rocks.

Several theories attempt to explain the tectonic and formational history of the island and discussion on the geological history continues. However, all theories are consistent in that the island is composed of contributions from both the north-north-easterly moving Australian continental plate and highly deformed rocks from the Banda Terrane of the southerly moving Eurasian plate. This suggests that Palaeozoic conditions similar to that shown in the Bonaparte Gulf Basin (Northern Australia) should be present. The carbonate sedimentary rocks deposited since the Permian and the lack of non-carbonate material indicate that the area has existed as an island for a long period of time.

The underlying geology of the island has resulted in soils that are of low fertility, relatively unproductive, and susceptible to erosion. The rapid decomposition of organic matter due to the tropical climate further compounds this.

Source: Gavin Fisher, 2011

Plate 7-25 The typical flat coastal plain topography in the southern part of the proposed LNG plant site

Source: Gavin Fisher, 2011

Plate 7-26 Northern section of the LNG Plant site

LOCATION: \\perworfil1\infstructib\Projects\301012-01504 Enviro Imp Assessment Timor-Leste\2.0 Reports\2.9 SEIA - Betano and Beaco\Plates\03_Working\BP020_BP021\301012_01504_SEIA_Plate_7-25_7-26.vsd
PLOT DATE AND TIME: 30 May 2012, 11:46 AM Creator: Courtenay Wheeler

Source: Gavin Fisher, 2011

Plate 7-27 Nova Viqueque is draped over a prominent set of ridges incised by deep valleys

Source: Gavin Fisher, 2011

Plate 7-28 Shallow rivers and streams traversing the development site

LOCATION: \\perworfil1\infstructlib\Projects\301012-01504 Enviro Imp Assessment Timor-Leste\2.0 Reports\2.9 SEIA - Betano and Beaco\Plates\03_Working\BP022_BP023\301012_01504_SEIA_Plate_7-27_7-28.vsd
PLOT DATE AND TIME: 1 Jun 2012, 9:33 AM Creator: Courtenay Wheeler

Source: Gavin Fisher, 2011

Plate 7-29 Marshy depressions characterise parts of the coastal plain at the LNG Plant site

Source: Gavin Fisher, 2011

Plate 7-30 Bobonaro Scaly Clay matrix is always soft, scaly, variegated and slickensided

LOCATION: \\perworfil1\infstructlib\Projects\301012-01504 Enviro Imp Assessment Timor-Leste\2.0 Reports\2.9 SEIA - Betano and Beaco\Plates\03_Working\BP024_BP025\301012_01504_SEIA_Plate_7-29_7-30.vsd
PLOT DATE AND TIME: 30 May 2012, 11:53 AM Creator: Courtenay Wheeler

Globally, Timor-Leste is one of the most significant contributors of sediment to the world's oceans (Milliman *et al.*, 1999). Transport of sediments to the marine environment via rivers represents an important process in the global geochemical cycle and is a key component of the global denudation system (Walling & Fang, 2003). Timor, along with other islands of the Indonesian region (Sumatra, Java, Borneo, Sulawesi, and New Guinea) contributes 4.2×10^9 tonnes of sediment to the ocean via rivers annually (Milliman *et al.*, 1999). Despite only representing 2% of land area, these islands contribute 20% to 25% of global sediment input (Milliman *et al.*, 1999). The magnitude of fluvial sediment flux has significant implications for the structure, function and susceptibility of surrounding near-shore coastal marine environments.

Geology of the Beaco Development Area

Published data shows that the proposed Beaco development area is underlain by four different geological units including; the Bobonaro Scaly Clay Formation, the Viqueque Formation, the Baucau Limestone Formation and the Suai Formation.

At the LNG Plant site and Nova Beaco, the coastal plain is underlain by the Suai Formation, with the hills emerging to the north comprising the Baucau Limestone Formation. The limestone is; however, generally overlain by clay washed down from the higher-lying Bobonaro Scaly Clay Formation to the north.

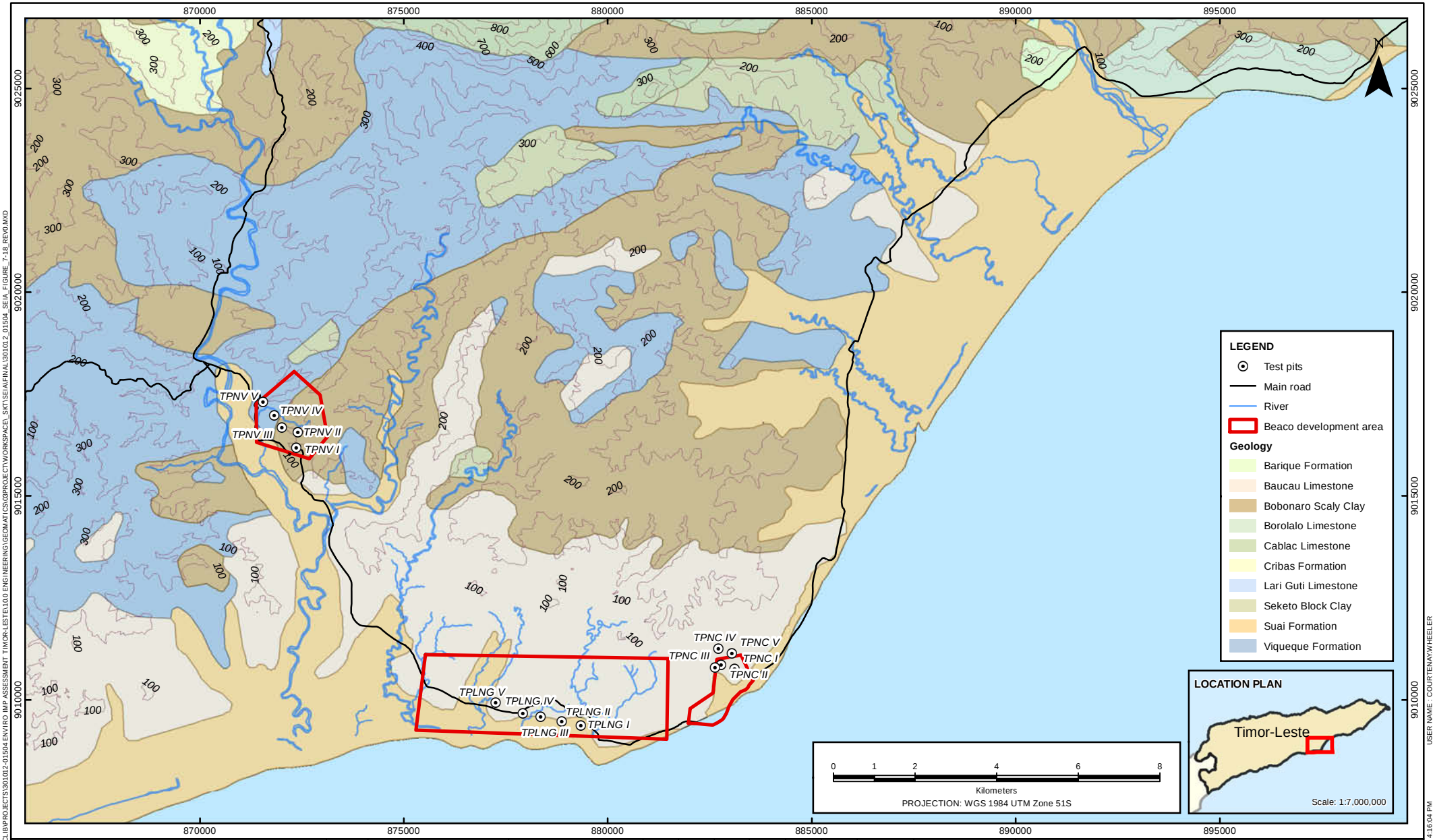
The eastern two-thirds of Nova Viqueque are underlain by the Bobonaro Scaly Clay Formation, whilst most of the western third is underlain by the Viqueque Formation. The lower south-western corner of this site extends onto the coastal plain, which is underlain by the Suai Formation (see Figure 7-18).

Bobonaro Scaly Clay Formation

Lithologically, the Bobonaro Scaly Clay Formation has two principal constituents, namely a scaly clay matrix (Plate 7-30), and a wide variety of unsorted, angular, and sub-angular exotic blocks derived from older formations.

- Scaly clay matrix: The matrix is remarkably uniform in character, being always soft, scaly, and variegated. The clay is generally dark reddish-brown in colour, but a dark olive-green variety is also common, along with black, grey, yellow and bright red clays. Slickensiding is abundantly evident. Montmorillonite is the predominant clay mineral, forming up to 35% of the whole.
- Exotic blocks: More than 90% of the exotic material seems to have been derived from formations that crop out in Timor-Leste. The size of the exotic blocks is highly variable, most of which are angular to sub-angular in shape, and chaotically distributed with random orientations.

The type locality for the Bobonaro Scaly Clay Formation occurs beside the River Lomea, east of Bobonaro Village, where steep cliffs provide an almost continuous outcrop for about 8 km. The Bobonaro Scaly Clay is more widespread and crops out over a larger area than any other formation in Timor-Leste.



NOTES:
This map consists of:
1. Rivers: Geographic Information Group TimorLeste (2010)
2. Geology: Geographic Information Group TimorLeste (2010)
3. Roads: DivaGIS (2010)

REV	DATE	REVISION DESCRIPTION	DRN	CHK	DES	ENG	APPD	CUST
0	6/06/2012	FINAL FOR ISSUE	MW	CS	-	-	GH	

A4 SHEET | SCALE 1:125,000
PROJECT No: 301012-001504

WorleyParsons resources & energy

TIMOR GAP, E.P. TIMOR GÁS & PETRÓLEO

REPUBLICA DEMOCRATICA DE TIMOR-LESTE
SECRETARIA DE ESTADO DOS RECURSOS NATURAIS

OneWay to zero harm

Copyright ©
WorleyParsons Services Pty Ltd

TASI MANE PROJECT - BETANO AND BEACO
STRATEGIC ENVIRONMENTAL IMPACT ASSESSMENT

Figure 7-18
Beaco geology map

LOCATION: \\PERWORFIL1\INFSTRUCI_IB\PROJECTS\301012-01504 ENVIRO IMP ASSESSMENT TIMOR-LESTE\100 ENGINEERING\GEOMATICS\03PROJECTWORKSPACE_SKT\SEIA\FINAL\301012_01504_SEIA_FIGURE_7-18_REV0.MXD

PLOT DATE & TIME: 29 MAY 2012, 4:16:04 PM

USER NAME: COURTENAYWHEELER

The presence of montmorillonite as the main constituent indicates that a large part of the clay was probably derived from submarine weathering of volcanic ash. The obvious source of ash is the volcanic arc north of Timor. The indigenous fossil microfauna of the clay matrix suggest that deposition occurred in a relatively shallow open basin.

Since the Bobonaro Scaly Clay is unstratified and no marker-horizons have been recognised, an accurate determination of its thickness is not possible. The base of the formation is a highly irregular unconformity generally resting on most of the older formations. Beneath the south coastal plains, the thickness may locally exceed 3,000 m, and in general the formation increases in thickness from north to south across the island.

It appears as if the Bobonaro Scaly Clay was emplaced in its present position by sliding or slumping, and is therefore an allochthonous formation. Due to the high proportion of montmorillonite (bentonite) in the Bobonaro Scaly Clay, it would have flowed very easily, as bentonitic clays are generally highly colloidal and plastic. Tectonic activity and earthquakes would provide a trigger mechanism to initiate the sliding of the unstable sediment downslope.

The erosion of this formation under tropical conditions has been severe. It gives rise to a characteristic topography of deep gullies, landslips, and rugged, knobbly hillsides where the more resistant exotic blocks protrude above the soft clay matrix. The high proportion of montmorillonite (bentonite) in the scaly clay gives it a waxy appearance when fresh, and after it has weathered, it develops a characteristic ‘jigsaw puzzle’ set of fractures due to shrinkage on drying.

Viqueque Formation

The Viqueque Formation has a highly characteristic light-toned appearance with well-defined ridges, making it readily identifiable in the field and on aerial photographs. Most of the rocks weather to form a white, puggy soil. This formation is also characterised by deeply dissected valleys and a rugged relief.

The type locality for the Viqueque Formation is the hilly country surrounding Viqueque Village. The formation is well exposed in the banks of the River Cua where it cuts through the Viqueque Anticline north of Viqueque Village.

At the type locality, the basal 130 m consists of massive white marls and grey claystones interbedded with a few chalky limestones and two beds of vitric tuff. These rocks pass up into a succession that is well bedded and becomes gradually more silty and sandy. Silty marls and silty claystones, siltstones, and sandstones predominate in the upper part of the formation (Plate 7-31).

In the type locality the formation is about 500 m thick, although the maximum thickness is probably about 800 m under the wide southern coastal plain.

The Viqueque Formation generally rests unconformably on the Bobonaro Scaly Clay, and is overlain with apparent conformity by the Seketo Block Clay and the Dilor Conglomerate. These two formations and the Viqueque Formation itself are overlain with angular unconformity by both the Baucau Limestone and the Suai Formation.

The fossil fauna of the Viqueque Formation is entirely marine and the composition and textural immaturity of the silty and sandy rocks indicate rapid deposition. The prevalence of graded bedding and graded cycles, the scarcity of current-bedding, along with the frequency of sedimentary slump

structures, all indicate a molasse type of sedimentation deposited during the emergence of Timor as an island.

Baucau Limestone Formation

This formation generally comprises hard, vuggy, cavernous, massive, white coral-reef limestone, which weathers to a pale grey colour (Plate 7-32), often characterised by karst topography and a dark reddish soil. Four main lithologies are recognised:

- Coral reef limestones: These are massive, dense *in situ* growths of coral with subordinate amounts of calcareous algae.
- Calcirudites: Massive, poorly bedded conglomerates, composed of reef debris cemented by micrite and sparry calcite, forming lenticles with the *in situ* coral.
- Calcarenites: These are interbedded with the *in situ* reefs and calcirudites. They consist almost entirely of sand grains composed of coral fragments, bryozoans, Foraminifera, calcareous algae, molluscs and echinoderms.
- Sub-mature greywacke and pebbly sandstone: These are essentially poorly sorted gravels, sands, and silts composed mainly of quartz, with lesser amounts of eruptive rock and limestone fragments. These rocks are interbedded with calcirudites and calcarenites.

The type locality for the Baucau Limestone is the series of terraced reef limestones that crop out around the town of Baucau. The formation is widespread, and forms two prominent topographical features, the Baucau plateau and the Lautem plateau. In the southern foothills of Timor-Leste, the Baucau Limestone forms scattered remnant outcrops, as is evident in the Beaco area.

The thickness of this formation is difficult to estimate because it is composed of a series of terraces that are either horizontal or dip at about 2 degrees. The terraces rise from sea-level to about 500 m.

The Baucau Limestone is unconformable at the base, and it generally overlies the Viqueque Formation, where its base transgresses the eroded late Pliocene folds of the Viqueque Formation.

Suai Formation

The Suai Formation overlies the Viqueque Formation and the Dilor Conglomerate. Although not studied in detail, it is expected that the base of the Suai Formation is of late Pliocene age, ranging up through to the Quaternary. This formation is developed in the wide coastal plain that extends from Aliambata in the east to the frontier with Indonesia in the west.

The Suai Formation is in excess of 600 m thick and, like the Viqueque Formation, probably thickens rapidly to the south, reaching its maximum offshore. The maximum thickness attained within the present limit of Timor is probably under the plain between Betano and Aliambata where it may be approximately 1,000 m thick. The base is difficult to define accurately on the information available.

The presence of Foraminifera indicates that the Suai Formation was deposited in a marine environment. Like the upper part of the Viqueque Formation, the Suai Formation may be considered to be a molasse deposit, a regressive facies formed during the emergence of Timor.

Source: Gavin Fisher, 2011

Plate 7-31 The Viqueque Formation exposed at a quarry site to the west of Nova Viqueque

Source: Gavin Fisher, 2011

Plate 7-32 Baucau Limestone is hard and usually weathers to a pale grey colour

LOCATION: \\perworfil1\infstructlib\Projects\301012-01504 Enviro Imp Assessment Timor-Leste\2.0 Reports\2.9 SEIA - Betano and Beaco\Plates\03_Working\BP026_BP027\301012_01504_SEIA_Plate_7-31_7-32.vsd
PLOT DATE AND TIME: 30 May 2012, 12:01 PM Creator: Courtenay Wheeler

The type locality for the Suai Formation is the coastal plain surrounding Suai Village. Water bores to the north of Suai Village have revealed that most of the sediments are largely unconsolidated rudites and arenites ranging from pebbly gravels to fine silts, often rich in Foraminifera. The Suai Formation is similar to the upper part of the Viqueque Formation except that consolidated sediments are absent from the Suai Formation.

The Suai Formation is generally poorly exposed and typically without relief. The beds are either horizontal or gently dipping to the south (seawards) and outcrop is mostly covered by dense vegetation.

Soil Profile

A total of 15 test pits were excavated in the Beaco development area; five at the LNG Plant site, five at Nova Beaco and five at Nova Viqueque. The locations of the test pits were pre-selected in accessible areas deemed to be representative of the local geology. The test pits were excavated by hand to a depth of 1.5 m below surface or to refusal, and generally confirm the published geology. Test pit positions are indicated on Figure 7-18. The soil profiles are summarised in Table 7-9 and selected test pits are depicted in Plate 7-33 to Plate 7-36.

Source: Gavin Fisher, 2011

Plate 7-33 Test pit TPLNG I

Source: Joana Fernandes, 2011

Plate 7-34 Test pit TPLNG V

LOCATION: \\perworfil1\infstructlib\Projects\301012-01504 Enviro Imp Assessment Timor-Leste\2.0 Reports\2.9 SEIA - Betano and Beaco\Plates\03_Working\BP028_BP029\301012_01504_SEIA_Plate_7-33_7-34.vsd
PLOT DATE AND TIME: 30 May 2012, 12:05 PM Creator: Courtenay Wheeler

Source: Joana Fernandes, 2011

Plate 7-35 Test pit TPNV I - Nova Viqueque site

Source: Gavin Fisher, 2011

Plate 7-36 Test pit TPNC V - Nova Beaco site

LOCATION: \\perworfil1\infstructlb\Projects\301012-01504 Enviro Imp Assessment Timor-Leste\2.0 Reports\2.9 SEIA - Betano and Beaco\Plates\03_Working\BP030_BP031\301012_01504_SEIA_Plate_7-35_7-36.vsd
PLOT DATE AND TIME: 31 May 2012, 11:36 AM Creator: Courtenay Wheeler

Table 7-9 Summarised soil profiles – LNG Plant

Test Pit Number and Coordinates	Depth	Description
TPLNG I (Beaco LNG Site) X = 879338 Y = 9009376	0 to 0.40 m	SILTY SAND: Fine to medium-grained sand with some low plasticity silt and some fine to medium-grained gravel (mostly calcareous concretions), dark brown, loose to medium dense, moist.
	0.40 to 1.5 m	SAND: Fine to coarse-grained sand with some fine to medium-grained gravel (mostly calcareous concretions) and some low plasticity silt, yellow-brown, loose to medium dense, becoming dense with depth, moist with wet patches.
TPLNG II (Beaco LNG Site) X = 878877 Y = 9009468	0 to 1.2 m	SILTY SAND: Fine to medium-grained sand with some low plasticity silt and trace of fine-grained gravel (mostly calcareous concretions), yellow-brown, loose to medium dense, moist.
	1.2 to 1.5 m	GRAVELLY SAND: Fine to coarse-grained sand with fine to medium-grained gravel (mostly calcareous concretions), light brown, medium dense to dense, moist with wet patches.
TPLNG III (Beaco LNG Site) X = 878354 Y = 9009579	0 to 0.95 m	SILTY SAND: Fine to medium-grained sand with some low plasticity silt, with trace calcareous gravel towards the base, light brown becoming yellow-brown with depth, loose to medium dense, moist with wet patches.
	0.95 to 1.5 m	GRAVELLY SAND: Fine to coarse-grained sand with fine to medium-grained gravel (mostly calcareous concretions), light grey-brown, medium dense to dense, moist.
TPLNG IV (Beaco LNG Site) X = 877927 Y = 9009656	0 to 1.2 m	CLAYEY SAND: Fine to medium-grained sand with some low to medium plasticity clay and trace of fine-grained gravel (mostly calcareous concretions), brown mottled grey and yellow-brown, medium dense to dense, moist.
	1.2 to 1.5 m	CLAY: Low to medium plasticity clay, yellow-brown, firm to stiff, with some fine to coarse-grained sand and trace fine gravel (mostly calcareous concretions). Moist.
TPLNG V (Beaco LNG Site) X = 877256 Y = 9009937	0 to 1.5 m	CLAY: Medium to highly plastic clay, dark grey becoming light grey-brown with depth, firm to stiff, with some fine to coarse-grained sand and trace fine gravel (mostly calcareous concretions). Moist.

Table 7-8 Summarised soil profiles – LNG Plant (cont'd)

Test Pit Number and Coordinates	Depth	Description
TPNV I (Nova Viqueque) X = 872370 Y = 9016173	0 to 0.5 m	CLAY: Medium to high plasticity clay, dark grey-black, stiff to very stiff, fissured and slickensided, with trace of fine to coarse-grained sand and trace of fine gravel (mostly calcareous concretions). Moist with wet patches.
	0.5 to 1.5 m	CLAY: Medium to high plasticity clay, brown mottled yellow-brown, reddish-brown and grey-brown, stiff to very stiff, with some fine to coarse-grained sand and some fine to medium gravel (mostly calcareous concretions). Moist.
TPNV II (Nova Viqueque) X = 872403 Y = 9016554	0 to 1.2 m	CLAY: Medium to high plasticity clay, dark grey-black, firm to very stiff with depth, fissured and slickensided, with trace of fine to coarse-grained sand and trace of fine gravel (mostly calcareous concretions). Moist. Refusal on exotic blocks within the Bobonaro Scaly Clay Formation.
TPNV III (Nova Viqueque) X = 872021 Y = 9016672	0 to 1.5 m	CLAY: Medium to high plasticity clay, brown mottled red-brown and grey, stiff to very stiff, fissured and slickensided, with trace of fine to coarse-grained sand and trace of fine gravel (mostly calcareous concretions). Moist.
TPNV IV (Nova Viqueque) X = 871827 Y = 9016973	0 to 1.1 m	CLAY: Medium to high plasticity clay, dark grey-black mottled dark brown, stiff to very stiff, fissured and slickensided, with trace of fine to coarse-grained sand and trace of fine gravel (mostly calcareous concretions). Moist with wet patches. Refusal on exotic blocks within the Bobonaro Scaly Clay Formation.
TPNV V (Nova Viqueque) X = 871551 Y = 9017306	0 to 0.9 m	GRAVELLY CLAY: Medium to high plasticity clay, dark brown mottled red-brown, stiff to very stiff, with some fine to medium gravel (mostly calcareous concretions and sandstone fragments) and trace of fine to coarse-grained sand. Moist with wet patches.
	0.9 to 1.5 m	CLAY: Medium to high plasticity clay, reddish-brown, stiff to very stiff, with some fine to medium-grained sand and fine gravel (mostly calcareous concretions and sandstone fragments). Moist.

Table 7-8 Summarised soil profiles – LNG Plant (cont'd)

Test Pit Number and Coordinates	Depth	Description
TPNC I (Nova Beaco) X = 883106 Y = 9010753	0 to 1.5 m	CLAY: Medium to high plasticity clay, dark grey occasionally mottled white, firm to stiff, with some fine to medium-grained sand and fine gravel (mostly calcareous concretions). Moist with wet patches.
TPNC II (Nova Beaco) X = 882784 Y = 9010850	0 to 1.5 m	CLAY: Medium to high plasticity clay, dark grey mottled white, firm to stiff, with some fine to medium-grained sand and fine gravel (mostly calcareous concretions). Moist with wet patches.
TPNC III (Nova Beaco) X = 882628 Y = 9010790	0 to 1.5 m	CLAY: Medium to high plasticity clay, grey-brown mottled dark brown and white, stiff to very stiff, with some fine to medium-grained sand and trace fine gravel (mostly calcareous concretions). Dry to moist.
TPNC IV (Nova Beaco) X = 882712 Y = 9011246	0 to 1.5 m	CLAY: Medium to high plasticity clay, dark grey-brown mottled red-brown and white, stiff to very stiff, with some fine to coarse-grained sand and trace fine gravel (mostly calcareous concretions). Moist.
TPNC V (Nova Beaco) X = 883044 Y = 9011126	0 to 0.5 m	CLAY: Medium to high plasticity clay, dark grey-brown mottled white, firm to stiff, with some fine to coarse-grained sand and trace fine gravel (mostly calcareous concretions). Moist with wet patches.
	0.5 to 1.5 m	CLAY: Medium to high plasticity clay, dark grey-brown mottled red-brown and yellow-brown, firm to very stiff, with some fine to coarse-grained sand and trace fine gravel (mostly calcareous concretions). Moist with wet patches.

Geology/Vegetation Associations

Teak (*Tectona grandis*) found in the Beaco region is an indicator species for the presence of limestone or calcrete. Teak usually grows on limestone outcrop or where the limestone and/or calcrete occur at a shallow depth.

Limestone underlies the hills emerging in the northern part of the LNG site and Nova Beaco. As a result, teak is commonly encountered in these areas. Although calcareous material is generally absent from the coastal plain, the occurrences of teak in this area appear to coincide with minor accumulations of calcium carbonate within the Suai Formation.

Geohazards

Significant geohazards which could impact on the Beaco development area are discussed in the following section. These may influence the economics and performance of certain infrastructure or may result in environmental impacts. It should be noted that these conclusions are based on a desktop assessment referencing available published geological information and a brief field work

phase. Detailed geotechnical investigation will ultimately be required to confirm the presence, extent and severity of these geohazards.

Expansive Clay

Expansive clays exhibit large volume changes corresponding to changes in moisture content (swelling when wet and shrinking when dry). Such volume changes are often seasonal and can result in differential movement beneath structures. Expansive clays can also have poor handling characteristics during moisture conditioning and compacting.

The Bobonaro Scaly Clay Formation is characterised by a soft, scaly, and variegated matrix. Montmorillonite, which is generally highly colloidal and plastic, is the predominant clay mineral, forming up to 35% of the whole formation. Slickensiding is abundantly evident, as are characteristic fissures due to shrinkage on drying (Plate 7-37). This clay is clearly expansive and likely falls in the 'highly expansive' category, implying significant volume changes with a change in moisture content. This is particularly significant, bearing in mind the distinct wet and dry seasons experienced in Timor-Leste.

The Bobonaro Scaly Clay Formation underlies a large portion of Nova Viqueque, and is likely to impact significantly on development in this area. The formation gives rise to highly expansive clay, which loses all cohesion when wet and becomes highly compressible, is dispersive, and very unstable in slopes when saturated. Gradients at Nova Viqueque are typically fairly steep. As a result, this site will, in all likelihood, be permanently plagued by geotechnical problems and development of this site should be reconsidered.

The northern parts of Nova Beaco are also overlain by clay originating from the Bobonaro Scaly Clay Formation. The same geotechnical constraints would be applicable at this site. However, gradients are generally not as steep, reducing the slope failure risk.

Weathering of the Viqueque Formation also produces clayey soils, and although potentially expansive, they do not appear as problematic as the clays produced by the Bobonaro Scaly Clay Formation. Development on these clays should; however, proceed with extreme caution, especially where gradients are moderate to steep.

The Suai Formation includes well-developed clayey horizons, some of which underlie the LNG site, as noted in some of the test pits on the northern part of the coastal plain. The clay, which occurs at varying depths, appears to range from low to medium plasticity, and construction will need to consider the potential effects of soil shrinkage and swelling on foundation design in this area.

The presence of clayey horizons beneath the coastal plain also results in perched water table activity and causes water to pond after rainfall events. The resultant perched water tables and marshy conditions could hamper construction activities during the wet season.

To assess the potential risk from expansive clay, ground investigations in this area should include soil plasticity (Atterberg Limits), and natural moisture content determinations to assess soil behaviour in response to changes in the moisture content. These may be supplemented with more advanced swelling tests.

Collapsing Soils

Silty sands with relatively low densities and high void ratios can be susceptible to collapse when inundated after loading, which can result in excessive settlement of structures. At the LNG plant site and the southern part of Nova Beaco, unconsolidated silts, sands and silty sands have been recorded within the Suai Formation. These soils may be prone to collapse settlement and should be investigated during future ground investigations.

Erodible/Dispersive Soils

Soil Erodibility Potential

Soil erodibility potential is the likelihood that erosion will occur when soils are exposed to water (and/or wind) during or as a result of, land-disturbing activities. Erodibility potential is highest on slopes, and when low-plasticity, silty soils or fine sands are disturbed. Nova Viqueque, as well as the upper reaches of Nova Beaco and the LNG site, are thus potentially vulnerable to soil erosion in this manner. Furthermore, despite the coastal plain being fairly flat, it is considered that areas along the fast flowing rivers and streams will be susceptible to erosion after significant rainfall events.

Soil Dispersion Potential

Soil dispersion potential is the likelihood that soils will release a cloud of fine clay particles when brought into contact with water. These clay particles may remain suspended for an indefinite period of time, resulting in turbid, ‘dirty’ water, which can affect plant and animal life. Soil dispersion can occur without the influence of slope, mechanical action or run-off velocity i.e., in ‘still water’. It is therefore, imperative that run-off from dispersive soils is retained and treated on-site wherever practicable, before release into the natural or constructed stormwater system. This can be achieved through use of sedimentation ponds during the construction period.

Dispersive soils usually contain significant amounts of clay, with at least moderate levels of chemically exchangeable sodium, if they are not buffered by salinity.

Initial analysis using the simplified Emerson Crumb Test in the field on selected clayey samples indicates that the Bobonaro Scaly Clay Formation is moderately to highly dispersive, whilst the Viqueque Formation is moderately dispersive. The areas underlain by these formations, or clay derived from them, are also undulating with moderate to steep gradients, compounding soil erosion problems (Plate 7-38).

The Suai Formation may contain slightly to moderately dispersive soils in certain clay dominated horizons. This potential phenomenon should also be thoroughly investigated during future geotechnical investigations.

Compressible Soils

As previously mentioned, Bobonaro Scaly Clay Formation produces clay which is expected to be highly compressible when saturated. The Viqueque Formation may also produce similar compressible clays. Careful consideration and thorough investigation should precede development in these areas.

Soils deposited in the vicinity of the river mouths within the LNG Plant site appear to range from silty and clayey fine sands to sandy silts and clays. Soils deposited in such environments are also typically of low strength and are compressible, requiring further investigation.

Source: Gavin Fisher, 2011

Plate 7-37 Shrinkage fissures and dispersive piping in the Bobonaro Scaly Clay Formation

Source: Gavin Fisher, 2011

Plate 7-38 Erosion of the clayey cover material overlying the Baucau Limestone at Nova Beaco

LOCATION: \\perworfil1\infstructlib\Projects\301012-01504 Enviro Imp Assessment Timor-Leste\2.0 Reports\2.9 SEIA - Betano and Beaco\Plates\03_Working\BP032_BP033\301012_01504_SEIA_Plate_3-37_3-38.vsd
PLOT DATE AND TIME: 31 May 2012, 11:43 AM Creator: Courtenay Wheeler

Acid Sulfate Soils

Acid sulfate soils are naturally occurring soils and sediments that contain iron sulphides, predominantly in the form of the mineral pyrite. These soils are most commonly found in low-lying land bordering the coast or estuarine and saline wetlands. In an anoxic state, these materials remain benign, and do not pose a significant risk to human health or the environment. However, the disturbance of ASS, and its exposure to oxygen, causes these soils to release acidic and dissolved inorganic contaminants, resulting in significant human health, environmental and economic impacts.

The high probability/high risk areas for ASS correspond to the river mouths and estuarine areas in the Beaco region. Thorough ASS investigation should precede any development in these areas. The field and soil chemical data also indicate the potential for ASS at the site.

Saline/Sodic Soils

Soils that contain sodium salts can become dispersive when wetted with fresh water (such as rainfall), as the dissolved sodium weakens the electrochemical bonds between clay particles. Such soils are also often prone to erosion and the formation of subsurface erosion ‘pipes’ if affected by earthworks. Saline soils often contain recrystallised gypsum and high void ratios that can increase the potential for collapse settlement to occur when inundated after loading. A saline environment also produces aggressive groundwater and increases the corrosion rates of steel.

Vegetation has varying degrees of tolerance to saline and sodic soil and therefore prior to disturbance, it is important to characterise and if necessary, segregate soil intended to be used for site rehabilitation.

Parts of the LNG Plant site directly adjacent to the coast may contain these types of soils and soil samples should be taken along the coastline during any future site investigation program in order to confirm this initial assessment.

Dissolution Voids (Karst)

Rocks potentially giving rise to Karst topography are well developed within the Beaco development area, the Baucau Limestone Formation being the most prominent. However, the Viqueque Formation also comprises in part, rocks and sediments of calcareous composition. In addition, parts of the intertidal zone adjacent to the LNG Plant site are characterised by calcarenite outcrop (Plate 7-39), much of which displays dissolution channels on the surface, with pitted and voided patches. A fault zone can also be traced in the calcarenite wave cut platform.

Identifying the presence of karst features, such as cavities and/or sinkholes, by geophysical investigation in conjunction with boreholes is recommended where key infrastructure straddles any of the aforementioned formations, or the coastal calcarenite.

Asbestiform Materials

Asbestos minerals are unlikely to be encountered within the sedimentary and metamorphic rocks of Timor-Leste, and even less likely to be found within the sedimentary succession of the Suai Formation, the clayey succession of the Bobonaro Scaly Clay Formation or the calcium carbonate rich rocks of the Baucau Limestone or Viqueque Formations underlying the Beaco development area.

Source: Gavin Fisher, 2011

Plate 7-39 The wave cut platform at Beaco

Source: Gavin Fisher, 2011

Plate 7-40 Recent and palaeo-landslips are commonly encountered across Nova Viqueque

LOCATION: \\perworfil1\infstructlib\Projects\301012-01504 Enviro Imp Assessment Timor-Leste\2.0 Reports\2.9 SEIA - Betano and Beaco\Plates\03_Working\BP034_BP035\301012_01504_SEIA_Plate_7-39_7-40.vsd
PLOT DATE AND TIME: 31 May 2012, 11:53 AM Creator: Courtenay Wheeler

Slope Instability

Nova Viqueque is exposed to the most significant risk of slope instability as the underlying clay succession is fairly thick and appears highly expansive. The clay is also dispersive with numerous piping features evident along the slopes, and erosion appears to easily take hold where vegetation is disturbed. When saturated, the clay appears to lose all cohesion, which has resulted in small scale landslides all over the site (Plate 7-40). To compound the above geohazards, the site is proposed to be located on fairly steep gradients. Significant ongoing slope instability problems can thus be expected, especially when vegetation is removed and roads and development platforms are cut into the slopes. For this reason it is advocated that development of the Nova Viqueque site be reconsidered and an alternative site sought.

Whilst the northern parts of Nova Beaco and the LNG site also consist of moderate to steep gradients, these areas are less prone to slope failure. In these areas, the clay overlies limestone bedrock. However, the possibility of slope failure cannot be ruled out.

In contrast, the flat coastal plain implies an insignificant risk of natural slope instability. However, cuttings and excavations within the unconsolidated Suai Formation will be susceptible to collapse, further exacerbated by the presence of shallow perched water tables. Test pits were limited to a depth of 1.5 m for this reason during the recent investigations.

Shallow Bedrock

Although shallow bedrock is generally a positive attribute for the founding of heavy structures, it could be classed as a geohazard where roads will be cut into the landscape, or where excavations must be made for underground services.

The Suai Formation underlying the coastal plain will not pose problems in this regard, nor will the soft Bobonaro Scaly Clay Formation, but the Viqueque and Baucau Limestone formations may result in localised excavation difficulties. Most of the Viqueque Formation bedrock is; however, fairly weathered, and the well cemented Baucau Limestone thus poses the greatest risk of excavation refusal.

Flooding and Inundation

The rivers flowing off the mountainous terrain to the north of the Beaco development area are all prone to high-velocity, flash flooding. These flash floods are, however, generally confined to the incised river channels and associated wide flood plains. Flood studies will nevertheless be imperative to ensure that proposed development is not impacted by flooding.

Low-lying areas adjacent to the coast could also be affected by extreme tides and storm surges. Cyclonic activity, which is common off the southern coast of Timor-Leste, would generally be the catalyst for inundation of this nature.

According to data released by the United Nations Office for the Coordination of Humanitarian Affairs (OCHA), Timor-Leste has a moderate to high exposure to tropical storms and storm surge.

Seismic Conditions

According to data released by the United Nations Office for the Coordination of Humanitarian Affairs (OCHA), Timor-Leste has a high to very high exposure to seismic activity and tsunamis, with potential earthquake intensity reaching Degree VIII on the Modified Mercalli Scale. Degree VIII implies slight damage to well-built structures; poorly-built structures are heavily damaged, whilst walls, chimneys and monuments fall.

Earthquakes have been recorded in the Beaco district (onshore and offshore), three of which have been recorded in the period from July 1992 to May 2008. Details (localities and magnitude) are provided on Figure 7-19.

Associated with the seismic risk is liquefaction of the soil. Liquefaction typically occurs where deep sandy or silty sand successions are found in conjunction with shallow water table conditions. These conditions are plausible on the coastal plain underlain by the Suai Formation.

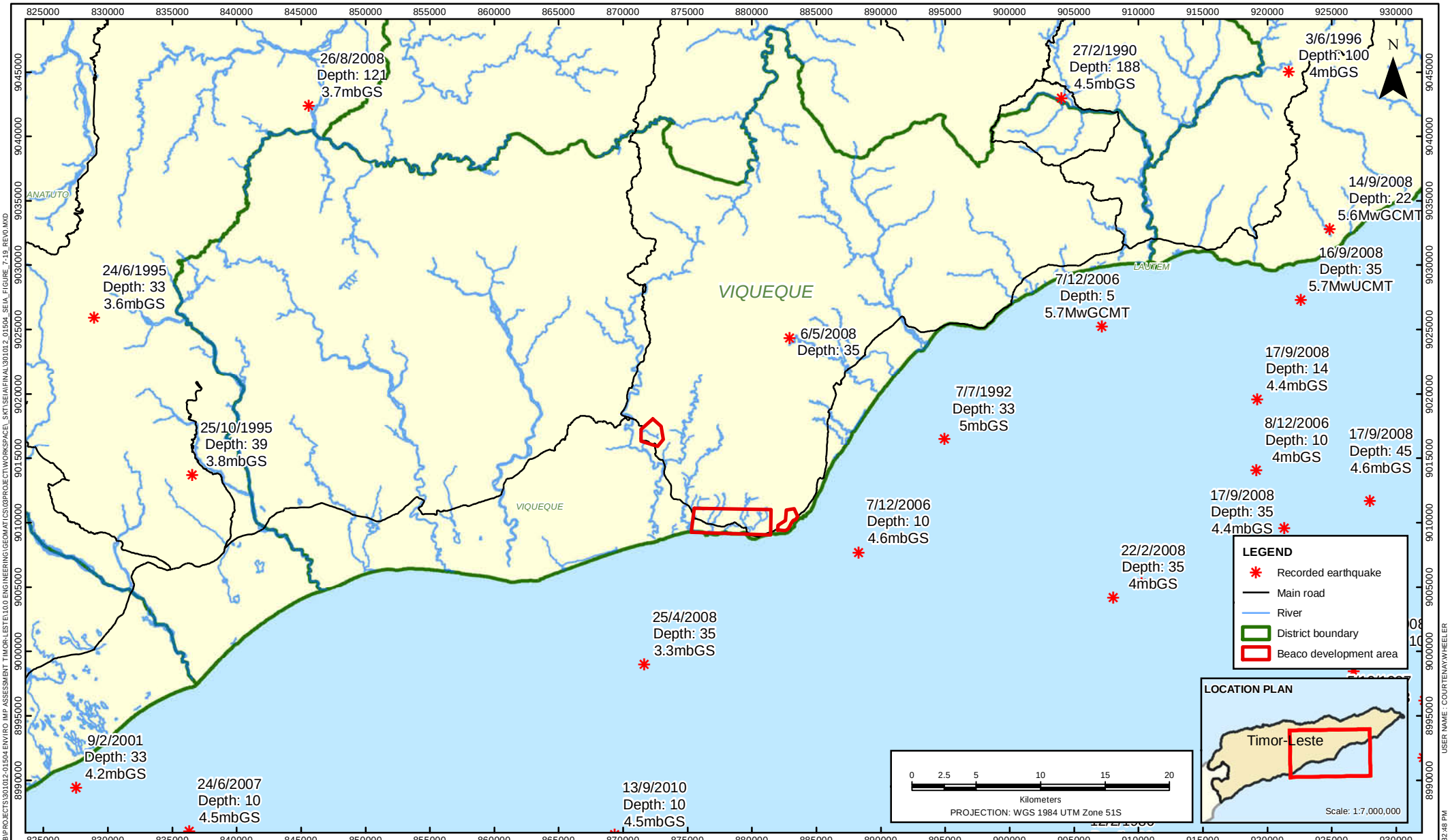
Soil Chemistry

The laboratory analysis results are summarised in Table 7-10 through Table 7-12.

The soil test results from the LNG plant site indicate consistently alkaline pH values and very low moisture, electrical conductivity and nutrients including total organic carbon in all samples. These results are consistent with coarse-textured, non-saline, low productivity soil developed on calcareous parent materials. The exception is TPLNG V, where the topsoil sample has greater than 3% total organic carbon and nutrient values are more consistent with soils of some productivity. Soil at this location has relatively higher electrical conductivity than other locations at the LNG plant site, but is still consistent with low salinity soil. Moisture in the subsoil at this location is around 13%, indicating some water holding capacity, possibly due to a higher clay content relative to other test pits across the LNG plant site.

The soil test results from the Nova Beaco site indicate consistently alkaline pH values and relatively low electrical conductivity in all samples. Total organic carbon of approximately 1.5 to 3%, and elevated nitrogen and potassium were reported in topsoil samples. These results are consistent with the natural soil chemistry associated with soils derived from calcareous materials with low salinity, and low levels of organic matter and nutrient accumulation and cycling in the topsoil, typical of tropical soil conditions where rates of organic decomposition are high. Total sulfur concentrations are low in all samples. Slightly elevated electrical conductivity values are reported in subsoil samples at TPNC II, IV and V, but values are still consistent with non-saline soil.

The soil test results from the Nova Viqueque site indicate consistently alkaline pH values and relatively high moisture contents indicating these soils are derived from calcareous materials and have some water holding capacity. In some samples the electrical conductivity is slightly elevated but still indicative of non-saline soil. No topsoil samples were collected at this location; subsoil samples are reported with low organic carbon and nutrients, as expected. Subsoil samples at TPNV I and II are reported with total sulfur values above 0.03%, which indicate the potential for acid sulfate soil at these locations.



NOTES:
This map consists of:
1. Rivers: Geographic Information Group TimorLeste (2010)
2. District boundaries: Geographic Information Group (2010)
3. Roads: DivaGIS (2010)
4. Earthquakes: US Geological Survey (2011)

REV	DATE	REVISION DESCRIPTION	DRN	CHK	DES	ENG	APPD	CUST
0	6/06/2012	FINAL FOR ISSUE	MW	CS	-	-	GH	

A4 SHEET | SCALE 1:400,000
PROJECT No: 301012-001504

TASI MANE PROJECT - BETANO AND BEACO
STRATEGIC ENVIRONMENTAL IMPACT ASSESSMENT

WorleyParsons resources & energy

TIMOR GAP, E.P. TIMOR GÁS & PETRÓLEO

REPUBLICA DEMOCRATICA DE TIMOR-LESTE
SECRETARIA DE ESTADO DOS RECURSOS NATURAIS

OneWay to zero harm

Copyright ©
WorleyParsons Services Pty Ltd

Figure 7-19
Beaco earthquake map

LOCATION: \\PERWORFIL1\INFSTRUCI\IBV\PROJECTS\301012-01504\ENVIRO IMP ASSESSMENT TIMOR-LESTE\100 ENGINEERING\GEOMATICS\03PROJECT\WORKSPACE_SKT\SEIA\FINAL\301012_01504_SEIA_FIGURE_7-19_REV0.MXD
PLOT DATE & TIME: 30 MAY 2012, 4:32:48 PM
USER NAME: COURTENAY.WHEELER

Table 7-10 Summary of soil chemical analysis (Beaco LNG Plant)

Test Pit			TPLNG I			TPLNG II				TPLNG III		
Sample Depth			**0.5m**	**1.0m**	**1.5m**	**Topsoil**	**0.5m**	**1.0m**	**1.5m**	**0.5m**	**1.0m**	**1.5m**
Parameter	**LOR[1]**	**Unit**										
Physical Parameters												
Moisture content	1.0	%	**2.0**	**2.0**	**3.0**	<1.0	**3.5**	**1.3**	<1.0	**2.2**	**1.4**	**3.1**
pH value	0.1	pH unit	**8.8**	**8.8**	**9.0**	**8.2**	**8.6**	**9.0**	**9.0**	**8.3**	**8.9**	**9.0**
Electrical Conductivity	1	µS/cm	**66**	**57**	**57**	**82**	**72**	**54**	**54**	**87**	**54**	**53**
Nutrients												
Total nitrogen[2]	20	mg/kg	**170**	**60**	**60**	**750**	**220**	**50**	**40**	**420**	**60**	**40**
Total Kjeldahl nitrogen[2]	20	mg/kg	**170**	**60**	**60**	**740**	**220**	**50**	**40**	**420**	**60**	**40**
Ammonia[2]	20	mg/kg	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
Nitrate[2]	0.1	mg/kg	**2.4**	**0.3**	<0.1	**8.3**	**1.3**	**0.1**	<0.1	**2.1**	<0.1	<0.1
Nitrite[2]	0.1	mg/kg	<0.1	<0.1	<0.1	**0.4**	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Nitrite and Nitrate[2]	0.1	mg/kg	**2.4**	**0.3**	<0.1	**8.7**	**1.3**	**0.1**	<0.1	**2.1**	<0.1	<0.1
Extractable Cations												
Bicarbonate extractable P	2	mg/kg	**23**	**10**	**2**	**60**	**10**	**4**	**4**	**4**	<2	<2
Bicarbonate extractable K	10	mg/kg	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200
Total sulfur[3]	0.01	%	**0.02**	**0.02**	**0.02**	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Organic Carbon												
Total organic carbon	0.02	%	**0.13**	**0.05**	**0.04**	**0.77**	**0.12**	<0.02	<0.02	**0.31**	**0.02**	<0.02

[1] Limit of Reporting, [2] as N, [3] as S

Table 7-10 Summary of soil chemical analysis (Beaco LNG Plant) (cont'd)

Test Pit			TPLNG IV			TPLNG V		
Sample Depth			**0.5m**	**1.0m**	**1.5m**	**Topsoil**	**0.5m**	**1.0m**
Parameter	**LOR[1]**	**Unit**						
Physical Parameters								
Moisture content	1.0	%	**5.5**	**3.1**	**3.2**	**4.7**	**13.0**	**13.8**
pH value	0.1	pH unit	**7.4**	**7.5**	**8.7**	**7.7**	**8.2**	**8.4**
Electrical conductivity	1	µS/cm	**13**	**12**	**64**	**360**	**117**	**139**
Nutrients								
Total nitrogen[2]	20	mg/kg	**550**	**220**	**120**	**3710**	**1330**	**540**
Total Kjeldahl nitrogen[2]	20	mg/kg	**550**	**220**	**120**	**3660**	**1330**	**540**
Ammonia[2]	20	mg/kg	<20	<20	<20	<20	<20	<20
Nitrate[2]	0.1	mg/kg	**0.3**	**0.3**	**0.1**	**43.4**	**0.5**	**0.2**
Nitrite[2]	0.1	mg/kg	<0.1	<0.1	<0.1	**4.9**	<0.1	<0.1
Nitrite and Nitrate[2]	0.1	mg/kg	**0.3**	**0.3**	**0.1**	**48.3**	**0.5**	**0.2**
Extractable Cations								
Bicarbonate Extractable P	2	mg/kg	<2	**28**	<2	**32**	<2	**27**
Bicarbonate Extractable K	10	mg/kg	**250**	<200	<200	**640**	**380**	**250**
Total sulfur[3]	0.01	%	<0.01	<0.01	<0.01	**0.02**	<0.01	<0.01
Organic Carbon								
Total organic carbon	0.02	%	**0.57**	**0.17**	**0.08**	**3.11**	**1.56**	**0.53**

[1] Limit of Reporting, [2] as N, [3] as S

Table 7-11 Summary of soil chemical analysis (Nova Beaco)

Test Pit			TPNC I				TPNC II			TPNC III		
Sample Depth			**Topsoil**	**0.5m**	**1.0m**	**1.5m**	**Topsoil**	**0.5m**	**1.0m**	**Topsoil**	**0.5m**	**1.0m**
Parameter	**LOR[1]**	**Unit**										
Physical Parameters												
Moisture content	1.0	%	**19.8**	**22.7**	**16.8**	**20.9**	**15.2**	**17.2**	**17.4**	**21.3**	**8.0**	**8.4**
pH value	0.1	pH unit	**8.3**	**9.1**	**8.7**	**8.8**	**8.2**	**8.8**	**8.7**	**8.2**	**8.6**	**9.0**
Electrical conductivity	1	µS/cm	**168**	**455**	**217**	**378**	**234**	**354**	**874**	**169**	**104**	**102**
Nutrients												
Total nitrogen[2]	20	mg/kg	**1760**	**460**	**630**	**450**	**2830**	**490**	**330**	**2400**	**450**	**220**
Total Kjeldahl nitrogen[2]	20	mg/kg	**1750**	**460**	**630**	**450**	**2800**	**490**	**330**	**2370**	**450**	**220**
Ammonia[2]	20	mg/kg	**80**	<20	<20	<20	<20	<20	<20	**40**	<20	<20
Nitrate[2]	0.1	mg/kg	**10.6**	**1.1**	**1.1**	**0.2**	**26.3**	**0.3**	**0.2**	**25.1**	**0.4**	**0.2**
Nitrite[2]	0.1	mg/kg	**0.3**	**0.1**	<0.1	<0.1	**1.1**	<0.1	<0.1	**0.3**	<0.1	<0.1
Nitrite and Nitrate[2]	0.1	mg/kg	**10.9**	**1.2**	**1.1**	**0.2**	**27.4**	**0.3**	**0.2**	**25.4**	**0.4**	**0.2**
Extractable Cations												
Bicarbonate extractable P	2	mg/kg	**16**	<2	**5**	<2	**11**	<2	**36**	**19**	**15**	<2
Bicarbonate extractable K	10	mg/kg	**890**	**210**	**240**	**230**	**380**	<200	**270**	**460**	<200	<200
Total sulfur[3]	0.01	%	<0.01	<0.01	<0.01	<0.01	**0.01**	<0.01	<0.01	**0.02**	<0.01	<0.01
Organic Carbon												
Total organic carbon	0.02	%	**1.93**	**0.52**	**0.72**	**0.56**	**3.10**	**0.73**	**0.25**	**2.41**	**0.42**	**0.21**

[1] Limit of Reporting, [2] as N, [3] as S

Table 7-11 Summary of soil chemical analysis (Nova Beaco) (Cont'd)

Test Pit			TPNC IV			TPNC V			
Sample Depth			**Topsoil**	**0.5m**	**1.0m**	**Topsoil**	**0.5m**	**1.0m**	**1.5m**
Parameter	**LOR[1]**	**Unit**							
Physical Parameters									
Moisture content	1.0	%	**28.0**	**15.0**	**19.2**	**16.8**	**15.6**	**16.6**	**22.5**
pH value	0.1	pH unit	**7.9**	**9.0**	**8.8**	**8.3**	**9.0**	**8.9**	**9.1**
Electrical conductivity	1	µS/cm	**111**	**273**	**1230**	**128**	**233**	**1050**	**1040**
Nutrients									
Total nitrogen[2]	20	mg/kg	**1740**	**460**	**270**	**1280**	**600**	**330**	**260**
Total Kjeldahl nitrogen[2]	20	mg/kg	**1710**	**460**	**270**	**1280**	**600**	**330**	**260**
Ammonia[2]	20	mg/kg	<20	<20	<20	<20	<20	<20	<20
Nitrate[2]	0.1	mg/kg	**34.5**	<0.1	**0.1**	**4.2**	**0.1**	**0.8**	**0.6**
Nitrite[2]	0.1	mg/kg	**0.2**	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Nitrite and Nitrate[2]	0.1	mg/kg	**34.7**	<0.1	**0.1**	**4.2**	**0.1**	**0.8**	**0.6**
Extractable Cations									
Bicarbonate extractable P	2	mg/kg	**11**	**5**	<2	**17**	**12**	<2	<2
Bicarbonate extractable K	10	mg/kg	**570**	**270**	**410**	**310**	<200	<200	**220**
Total sulfur[3]	0.01	%	<0.01	<0.01	**0.02**	<0.01	<0.01	**0.02**	**0.02**
Organic Carbon									
Total organic carbon	0.02	%	**1.71**	**0.32**	**0.18**	**1.38**	**0.48**	**0.18**	**0.15**

[1] Limit of Reporting, [2] as N, [3] as S

Table 7-12 Summary of soil chemical analysis (Nova Viqueque)

Test Pit			TPNV I			TPNV II		TPNV III		TPNV IV		TPNV V	
Sample Depth			**0.5m**	**1.0m**	**1.5m**	**0.5m**	**1.0m**	**0.5m**	**1.0m**	**0.5m**	**1.0m**	**0.5m**	**1.0m**
Parameter	**LOR[1]**	**Unit**											
Physical Parameters													
Moisture Content	1.0	%	**16.5**	**25.1**	**24.2**	**13.4**	**12.8**	**15.8**	**17.5**	**14.5**	**17.8**	**11.3**	**13.1**
pH Value	0.1	pH unit	**9.2**	**8.6**	**9.0**	**9.0**	**8.9**	**8.8**	**9.3**	**8.5**	**9.0**	**8.4**	**8.4**
Electrical Conductivity	1	µS/cm	**258**	**1840**	**1220**	**222**	**3140**	**803**	**996**	**456**	**865**	**130**	**141**
Nutrients													
Total Nitrogen[2]	20	mg/kg	**460**	**340**	**420**	**550**	**190**	**340**	**210**	**1040**	**380**	**460**	**510**
Total Kjeldahl Nitrogen[2]	20	mg/kg	**460**	**340**	**420**	**550**	**190**	**340**	**210**	**1040**	**380**	**460**	**510**
Ammonia[2]	20	mg/kg	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
Nitrate[2]	0.1	mg/kg	<0.1	**1.2**	**0.8**	**0.4**	**0.2**	**0.1**	**0.2**	**0.2**	<0.1	**0.2**	<0.1
Nitrite[2]	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Nitrite + Nitrate[2]	0.1	mg/kg	<0.1	**1.2**	**0.8**	**0.4**	**0.2**	**0.1**	**0.2**	**0.2**	<0.1	**0.2**	<0.1
Extractable Cations													
Bicarbonate Extractable P	2	mg/kg	**34**	**5**	**9**	**17**	<2	<2	**46**	<2	**19**	<2	<2
Bicarbonate Extractable K	10	mg/kg	<200	**300**	**250**	**250**	<200	**360**	**490**	**240**	**280**	<200	<200
Total Sulfur[3]	0.01	%	<0.01	**0.16**	**0.03**	<0.01	**0.56**	**0.02**	**0.02**	**0.02**	**0.02**	<0.01	<0.01
Organic Carbon													
Total Organic Carbon	0.02	%	**0.47**	**0.22**	**0.20**	**0.38**	**0.19**	**0.14**	**0.10**	**0.89**	**0.24**	**0.28**	**0.28**

[1] Limit of Reporting, [2] as N, [3] as S

Soil Contamination

During the site investigation, no obvious evidence of soil contamination was noted in the field and no indication of soil contamination is interpreted from the soil test results, although it should be noted that the field and laboratory programs were not designed for a full investigation of contamination.

7.3.3 Environmental Impacts

Contamination of the Soil and Underlying Geological Strata

Contamination of the soil can be caused by a number of development activities and can range from direct environmental and human health impacts from spills of chemicals, to secondary and tertiary environmental effects arising from the acidification of the soil.

One of the most common soil contamination risks is spillage of chemicals or waste, particularly when stored and/or transferred in liquid form. Chemicals stored for industrial purposes or as chemical waste can leak from improperly maintained above- or below-ground tanks and fuelling stations, contaminating both the underlying soil profile and groundwater.

Soil acidification can produce adverse environmental impacts on soils and groundwater. In addition, it can also adversely affect the agricultural value of the soil due to increased heavy metals and other inorganic toxins mobilised by the acidified groundwater. The primary cause of soil acidification is the oxidation of ASS. Acid sulfate soils are naturally-occurring soils that exist near the groundwater level when the organic content of the soil is high. Anoxic conditions below the groundwater level can produce high concentrations of sulphides that will readily oxidise when exposed to the atmosphere. Soil exposure to the atmosphere can occur from both direct excavation of the soil or lowering of the water table during dewatering activities for construction.

The oxidation of the sulphides in the soil results in a significant lowering of the soil pH and can cause deterioration in the health of vegetation and the surrounding ecosystem. In addition, heavy metals and other inorganic toxins stored in the soil matrix can be dissolved into the acidified groundwater and mobilised to different areas, poisoning native plant life and crops. Mangroves are known to occupy regions where both potential and actual ASS are prolific.

The extent and severity of the expansive clay, collapsing soils and dispersive soils, particularly at Nova Viqueque, will also need to be established through detailed geotechnical investigation before the impact of developing these areas can be accurately determined. At this stage, results would suggest that infrastructure will require engineering measures to counter these geohazards and that this would likely result in increased development costs.

7.3.4 Avoidance, Management and Mitigation Measures

Avoidance of soil contamination is by far the most effective method to reduce the environmental and human health impact of the project. Methods to avoid direct contamination of soils via chemical spills are in engineering design and management measures. It is recommended that, whenever practicable, above-ground storage tanks for liquid chemicals and appropriate storage containers for non-liquid chemicals are used with containment bunds that are ISO 14001 compliant. Management plans that

include training and procedures to prevent spillage during fuel and other chemicals transfer, and to address spills appropriately, are also critical for avoidance of soil and water contamination.

It is also recommended that a spills register should be established that lists at a minimum: the date and time of the spill; the quantity of the spilled material; and a description of the spilled material. Material safety data sheets (MSDS) and a dangerous goods list should be kept on site for all chemical materials used. The MSDS should specify the appropriate containment and clean-up methods for each chemical in the event a spill occurs.

For acid sulfate soil management, it is recommended that an investigation is conducted into the presence of ASS in regions identified in a desktop study as having an increased risk of potential or actual ASS being present. This investigation should be conducted in general accordance with the Guidelines for sampling and analysis of lowland acid sulfate soils in Queensland (Ahern et. al., 1998) and is likely to focus on regions around mangroves and waterways where acidification impacts would be increased. Whenever possible, it is recommended that ASS is not disturbed as it is naturally occurring and only impacts the surrounding environment when influenced by exposure to the atmosphere.

In the event that either actual or potential ASS is present in areas where excavation or dewatering cannot be avoided, it is recommended that an ASS management plan is developed specifying the management and/or treatment of ASS such that the impact to the surrounding environment is minimised. The management plan should be developed in general accordance with (Ahern et. al., 1998) or an equivalent guideline.

7.3.5 Residual Impacts

For the proposed developments, if the specified avoidance and management measures are implemented, then there should not be any significant adverse environmental impacts. It is likely that ASS may be an issue in the development of areas where mangrove vegetation is prevalent but, if managed appropriately, the resulting soil acidification should be controllable. Typically, industrial operations result in some level of contamination that may require remediation in the future; however, the engineering design of chemical storage and management procedures dictating their usage, should minimise the potential risk of a contamination event occurring.

7.3.6 Further Work

Detailed engineering geological and geotechnical work will be required to fully assess ground conditions across the Beaco development area. Such investigations would be aimed at fully understanding the geology and potential impacts on the sub-surface environment. In addition, these investigations would provide concrete inputs for preliminary designs during the next phases of the project. Two phases of investigation are advocated.

Phase 1

The first phase should consist of further site reconnaissance, followed by detailed geological mapping of the Beaco development area. Geological units should be assessed and their surface properties visually confirmed. A seismic risk study should also be included. This process would ensure optimal investigation during the next investigation phase.

Phase 2A (Onshore)

The second phase (onshore) would encompass penetrative investigation in conjunction with soil and rock testing. The following would be undertaken:

- The excavation of test pits with the aim of:
  - Identifying general subsurface conditions across the development footprint.
  - Confirming the presence and extent of geohazards within the development area.
  - Providing shallow foundation and pavement design parameters.
  - Providing information on typical excavation conditions.
  - Delineating and investigating potential sources of construction material identified during the desktop study. This will include collection of representative soil and rock samples for laboratory testing.
- Conducting hand-held Dynamic Cone Penetrometer (DCP) tests adjacent to some of the test pits. DCP testing has the advantage of being quick and is used as both a profiling tool and to determine strength properties of underlying soils to a depth of roughly 3 m BGL.
- Drilling of geotechnical boreholes in strategic locations in order to obtain an understanding of the nature of the various geological formations encountered within the Beaco development area.
- Limited hand augering may be suitable for the ASS investigation in high-risk areas.
- Geophysical studies are also recommended where structures are to be founded on any formation susceptible to karst problems (including limestone and coastal calcarenite), and to provide a non-intrusive indication of the presence and extent of any saline soil which may require characterisation.
- A detailed laboratory testing program (soil and rock).

Once the locations of the various structures have been finalised, a second, more detailed investigation phase should be undertaken, in order to obtain final design parameters for detailed design purposes.

Phase 2B (Offshore)

The second phase (offshore) will encompass a geophysical study (seismic survey), followed by a detailed drilling program in conjunction with extensive soil and rock testing. Based on the geophysical information, the drilling program would be tailored to provide accurate sub-surface data for dredging and piling (amongst other things).

Soil Chemistry

It is recommended that a detailed baseline study of the soil chemistry is conducted in regions where extensive excavation is proposed to occur. Further work related to soil chemistry required for the project is as follows:

- Additional baseline investigation of the soil chemistry highlighting the potential presence of ASS across the study area in general accordance with (Ahern et. al., 1998) or an equivalent guideline; and to verify and characterise any soil salinity and/or sodicity that may be present.
- If ASS are identified in regions where soil excavation or dewatering is to be conducted, an acid sulfate soils management plan is to be developed detailing management procedures and/or soil treatment measures to be implemented.
- If soil salinity and/or sodicity is present in areas where disturbance is planned, a soil management plan addressing segregation and storage of saline soil is to be developed. If any areas of the development site are planned to be rehabilitated, then a rehabilitation plan is to be developed prior to the disturbance of these areas to ensure that rehabilitation is not adversely affected by the presence of acidity, salinity or sodicity.

Engineering design for storage of chemicals on the proposed developments is to be complaint with ISO 14001 to enable management of potential spills/leaks.

7.4 Air Quality

The section considers the potential air quality impacts associated with the construction and operational phases of the Beaco development.

Air pollution is commonly defined as the introduction into the atmosphere of chemicals, particulate matter or biological materials that can cause adverse impacts on human health or other aspects of the environment. The proposed Beaco development could affect the local and regional air quality and the purpose of the study is to assess these potential impacts.

7.4.1 Study Method

This study was designed to establish the baseline air quality within the Beaco study area. The study method adopted for this assessment is as follows:

- Identify air quality sensitive receptors (i.e., residences, schools) in the Beaco study area.
- Collect baseline ambient air samples in the Beaco study area for laboratory analysis.
- Measure baseline particulate matter concentrations in the study area via the use of a DustTrak™ Aerosol Monitor and dust deposition gauges.
- Assess the baseline ambient concentrations of particulates and gas pollutants against the assessment criteria.
- Determine the maximum allowable increase in ground-level concentration for pollutants likely to be emitted by the Beaco development[6].
- Provide recommendations of management measures to minimise local and regional air emissions.

Study Scope

The scope of this study incorporates the entire Beaco development area as described in Chapter 4. It also incorporates the existing settlements in the Beaco, Viqueque and south Viqueque regions and the proposed residential areas of Nova Beaco and Nova Viqueque.

Assessment Criteria

Currently, the Government of Timor-Leste does not have specific legislation regarding air quality assessment and regulation. In these circumstances, it is common practice in air quality investigations to adopt assessment criteria from other applicable jurisdictions or recognised international organisations. Three internationally recognised authorities on air quality have standards or guidelines that have been adopted for this assessment: the World Health Organisation (WHO); the United States Environmental Protection Agency (US EPA); and the Australian National Environment Protection Council (NEPC).

[6] This was to be conducted by computer modelling but there was insufficient data to create a model.

The WHO has developed a series of assessment guidelines for the most common airborne pollutants. These guideline values are listed in *WHO Air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulfur dioxide. Global update 2005. Summary of risk assessment* (WHO, 2005).

The US EPA has a set of National Ambient Air Quality Standards listing a similar set of airborne pollutant standards (US EPA, 2011). In addition, the US EPA provides a list of chemical compounds classified as 'Air Toxics' with chronic inhalation exposure values for screen risk assessment indicating concentrations where long-term exposure would likely result in adverse health impacts (US EPA, 2010). The Australian NEPC developed the *National Environment Protection (Ambient Air Quality) Measure* (OLD, 2003) which lists a series of 'desired environmental outcomes' that 'allows for the adequate protection of human health and well-being'.

These three sets of ambient air quality standards have been adopted in this assessment for regions outside of industrial premises. Table 7-13 lists the assessment criteria for air quality standards based on these standards including comments regarding how they are to be assessed. However, the inventory of US EPA air toxics is too numerous to list in this document.

The occupational health and safety impacts of air quality have not been investigated in this assessment. Typically, the recommended occupational exposure limits are greater than the criteria used for environmental impact assessments.

Table 7-13 Sensitive receptor air quality assessment criteria

Pollutant	Guideline/ Standard	Averaging Period	Value*	Comments
Carbon Monoxide (CO)	US EPA	1-hour	35 ppm	One allowable exceedance per year
		Rolling 8-hour	9 ppm	
	NEPM	8-hour	9.0 ppm	
Lead (Pb)	US EPA	Rolling 3-month	0.15 µg/m^3	Not to be exceeded
	NEPM	Annual	0.50 µg/m^3	
Nitrogen Dioxide (NO_2)	WHO	1-hour	200 µg/m^3	Not to be exceeded
		Annual	40 µg/m^3	
	US EPA	1-hour	100 ppb	98th percentile over 3 years
		Annual	53 ppb	
	NEPM	1-hour	0.12 ppm	One allowable exceedance per year
		Annual	0.03 ppm	Not to be exceeded
Ozone (O_3)	WHO	8-hour	100 µg/m^3	Not to be exceeded
	US EPA		0.075 ppm	Annual 4th highest daily max 8-hour, over 3 years
	NEPM	1-hour	0.10 ppm	One allowable exceedance per year
		Rolling 4-hour	0.08 ppm	
$PM_{2.5}$	WHO	24-hour	25 µg/m^3	Not to be exceeded
		Annual	10 µg/m^3	
	US EPA	24-hour	35 µg/m^3	98th percentile over 3 years
		Annual	15 µg/m^3	Averaged over 3 years
	NEPM	24-hour	25 µg/m^3	Goal is to gather data for review
		Annual	8 µg/m^3	

Table 7-13 Sensitive receptor air quality assessment criteria (cont'd)

Pollutant	Guideline/ Standard	Averaging Period	Value*	Comments
PM_{10}	WHO	24-hour	50 $\mu g/m^3$	Not to be exceeded
		Annual	20 $\mu g/m^3$	
	US EPA	24-hour	150 $\mu g/m^3$	One allowable exceedance per year on average over 3 years
	NEPM		50 $\mu g/m^3$	Five allowable exceedances per year
Sulfur dioxide (SO_2)	WHO	10-minute	500 $\mu g/m^3$	Not to be exceeded
		24-hour	20 $\mu g/m^3$	
	US EPA	1-hour	75 ppb	99th percentile, over 3 years
		3-hour	0.5 ppm	One allowable exceedance per year
	NEPM	1-hour	0.20 ppm	One allowable exceedance per year
		24-hour	0.08 ppm	
		Annual	0.02 ppm	Not to be exceeded

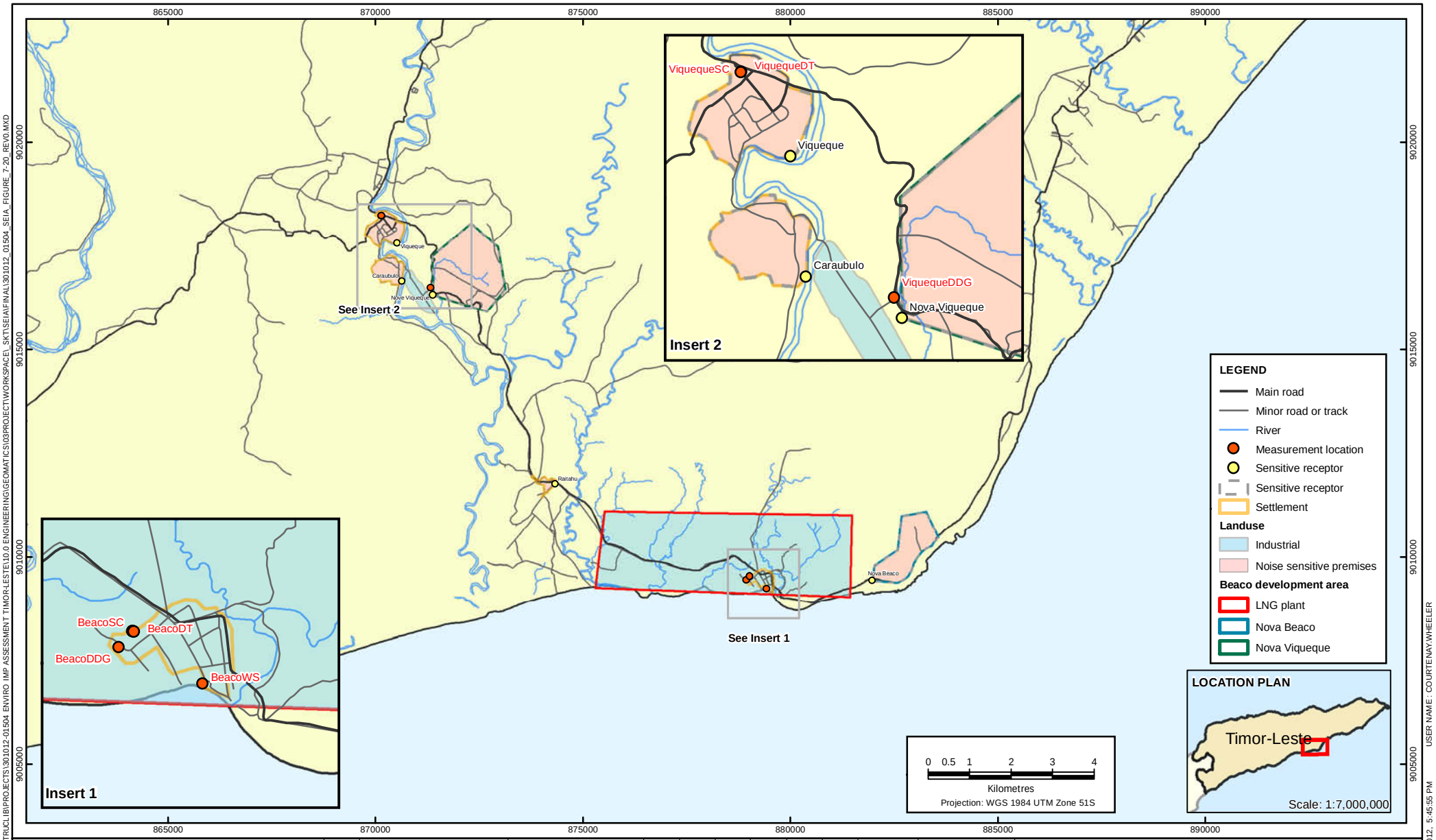
Note: * – Values in $\mu g/m^3$ assume standard temperature and pressure.

Sensitive Receptors

The location of sensitive receptors was identified in a desktop assessment of aerial photography and on-site visual inspection of the local area. Based on the desktop assessment, the region surrounding the Beaco development area is primarily used for agricultural purposes. Some residential premises were also identified. Both residential and agricultural premises are considered sensitive receptors. The on-site visual inspection focussed on locations that sensitive members of the public, for example; children and the elderly, tend to congregate (i.e., schools and hospitals/medical clinics).

The specific sensitive receptor locations where the air quality can be assessed against the criteria are listed in Table 7-14.

The Beaco study area with land use zoning and identified sensitive receptors is shown in Figure 7-20.



LOCATION: \\PERWORFIL1\INFSTRUCL\IB\PROJECTS\301012-01504 ENVIRO IMP ASSESSMENT TIMOR-LESTE\10.0 ENGINEERING\GEOMATICS\03PROJECT\WORKSPACE_SKT\SEIA\FINAL\301012_01504_SEIA_FIGURE_7-20_REV0.MXD

USER NAME: COURTENAY.WHEELER

PLOT DATE & TIME: 06 JUN 2012, 5:45:55 PM

NOTES:

This map consists of:
1. Rivers: Geographic Information Group TimorLeste (2010)
2. Roads: DivaGIS (2010)
3. Landuse zones: RDTL (2011a)
4. Noise receptors: WorleyParsons (2012)

REV	DATE	REVISION DESCRIPTION	DRN	CHK	DES	ENG	APPD	CUST
0	6/06/2012	FINAL FOR ISSUE	MW	GHi	CW	-	GH	

A4 SHEET | SCALE 1:125,000

PROJECT No: 301012-001504

WorleyParsons resources & energy

TIMOR GAP, E.P. TIMOR GÁS & PETRÓLEO

REPUBLICA DEMOCRATICA DE TIMOR-LESTE
SECRETARIA DE ESTADO DOS RECURSOS NATURAIS

OneWay to zero harm

Copyright © WorleyParsons Services Pty Ltd

TASI MANE PROJECT BETANO AND BEACO
STRATEGIC ENVIRONMENTAL IMPACT ASSESSMENT

Figure 7-20
Beaco air quality study area

Table 7-14 Beaco study area specific air quality sensitive receptors

Location	Relevant Project Area	Centroid Coordinates	
		Latitude	Longitude
Nova Beaco	Primary worker settlement.	8° 56’ 21.5” S	126° 28’ 48.0” E
Raitahu	Existing settlement.	8° 55’ 28.5” S	126° 24’ 07.0” E
Nova Viqueque	Primary worker settlement/airport upgrade.	8° 52’ 40.0” S	126° 23’ 00.0” E
Viqueque	Existing settlement.	8° 52’ 09.0” S	126° 21’ 57.0” E
Caraubulo (south Viqueque)	Existing settlement/airport upgrade.	8° 52’ 40.0” S	126° 22’ 00.0” E

Baseline Measurement Methods

The baseline air quality monitoring comprised of three separate measurements:

- Ambient air sample collection using a Summa canister for laboratory analysis.
- Monitoring of ambient airborne particulate matter less than ten micrometres in aerodynamic diameter (PM_{10}) using a DustTrak™ aerosol monitor.
- Settled dust sample collection using dust deposition gauges for laboratory analysis.

The locations for each of the measurements and equipment are listed in Table 7-15.

Table 7-15 Beaco study area air quality measurement and equipment locations

Label	Type	Location	Coordinates	
			Latitude	Longitude
BeacoSC	Summa canister	Beaco cheffe suco’s house	8° 56’ 39.5” S	126° 26’ 45.0” E
ViquequeSC		Viqueque town square	8° 51’ 59.8” S	126° 21’ 52.5” E
BeacoDDG	Dust deposition gauge	Beaco village western boundary	8° 56’ 42.6” S	126° 26’ 42.4” E
ViquequeDDG		Nova Viqueque/airport	8° 52’ 56.0” S	126° 22’ 31.5” E
BeacoDT	DustTrak™	Beaco cheffe suco’s house	8° 56’ 39.6” S	126° 26’ 45.2” E
ViquequeDT		Viqueque town square	8° 51’ 59.9” S	126° 21’ 52.3” E
BeacoWS	Weather station	Beaco village beachfront	8° 56’ 49.3” S	126° 26’ 58.3” E

Chemical Compound Samples

The baseline ambient air samples were collected in National Association of Testing Authorities (NATA) accredited laboratory supplied and evacuated six-litre capacity Summa canisters. Each canister included a uniquely numbered flow regulator and was inflated over a two-hour period. Once each sampling period was complete, the canister serial number and resulting pressure differences were recorded along with the date and time of the samples.

The locations of the collected samples were determined in general accordance with AS/NZS 3580.1.1:2007 Methods for sampling and analysis of ambient air Part 1.1: Guide to siting air monitoring equipment (AS/NZS 3580.1.1:2007). A summary of these requirements are as follows:

- The sample locations were deemed a 'peak site' where it is likely that the highest concentrations of pollutants, currently present in the study area, are expected to occur.
- The Summa canisters were placed greater than 10 m from any adjacent roadway as is required for sampling of gaseous compounds adjacent to roads with a volume of traffic was less than 10,000 vehicles per day.
- The Summa canister inlets were exposed to a minimum clear sky angle of 120° during the sampling period.

The samples were packaged and sent to ALS Environmental, a NATA accredited laboratory, under full chain of custody protocols. Certificates of analysis and quality control reports are provided in Appendix E. Laboratory analysis of the sample was conducted for the following chemical compounds:

- Oxides of nitrogen (NO_X).
- US EPA air toxics suite.

For the air toxics suite, analysis method TO-14A was used. This method uses a Nafion® drier to selectively remove water vapour from the sample. The sample gas is passed through Nafion® tubing removing water and other light polar compounds.

Concentrations of chemical compounds were reported at standard atmospheric conditions and are summarised in Table 7-16.

Airborne Particulate Matter Measurements

The baseline ambient airborne PM_{10} measurements were conducted outside of buildings or structures using a DustTrak™ 8520 Aerosol Monitor housed in a portable environmental enclosure. The DustTrak™ was calibrated within a two year period, prior to the measurements by a NATA accredited laboratory. Determination of the sampling location of the DustTrak™ was in general accordance with AS/NZS 3580.1.1:2007 and focussed on areas anticipated to have the highest concentrations of PM_{10}. The monitoring was conducted over a 24-hour period with one-minute interval logging to capture the particulate matter trends throughout a typical day.

Zero concentration checks and air flow rate checks were conducted prior to each monitoring event. The DustTrak™ was calibrated to a flow rate of 1.7 L/min as is required for peak performance in the instruction manual.

The following information was recorded for each particulate matter measurement:

- Date.
- Location coordinates.
- Measurement start and end times.
- Measurement duration.

- Notable factors relating to the condition, operation or environment surrounding the DustTrak™.

Deposited Dust Samples

The baseline settled dust samples were collected using dust deposition gauges. The sample collection was conducted in general accordance with AS/NZS 3580.10.1:2003 Methods for sampling and analysis of ambient air Method 10.1: Determination of particulate matter – Deposited matter – Gravimetric method (AS/NZS 3580.10.1:2003). These requirements are summarised below:

- The dust deposition gauge bottles were supplied by a NATA-accredited laboratory and pre-dosed with 10 mL of a copper sulfate solution to inhibit algal growth.
- When collecting the dust deposition gauge bottles, any particulate matter remaining within the funnel was washed into the bottle to ensure the entire deposited particulate matter was collected.
- Determination of the locations of the dust deposition gauges were in general accordance with AS/NZS 3580.1.1:2007.

Two dust deposition gauges were established across the Beaco study area, one at the western boundary of Beaco village nearest to the proposed LNG facility and the other in the settlement between the Viqueque airport upgrade and Nova Viqueque. The gauges were left on site to collect deposited particulate matter for a period of 54 days from 21 December 2011 to 13 February 2012 or 55 days from 21 December 2011 to 14 February 2012 for the Nova Viqueque and Beaco village gauges respectively.

Samples were collected, recording the following information:

- Dates of deployment and collection.
- Location coordinates.
- Funnel height above ground level.
- Funnel top diameter.
- Notable factors relating to the condition and contents of the gauge.

The samples were packaged and sent to ALS Environmental under full chain of custody protocols. Copies of the chain of custody document, sample receipt notifications, certificates of analysis and quality control reports are provided in Appendix F. The samples were analysed for the following suite of parameters:

- Total solids (g/m^2/month).
- Soluble matter (g/m^2/month).
- Total insoluble matter (g/m^2/month).
- Combustible matter (g/m^2/month).
- Ash content (g/m^2/month).

Air Quality Impact Modelling

Air quality impacts resulting from the construction and operational phases of the Beaco development were to be predicted using the use of computer modelling software. The input information required to conduct this modelling includes detailed engineering design data, specifying the locations and composition of emitted exhaust plumes, with emission rates of various pollutants of potential concern. Currently, engineering design information is not available for the Beaco development and as a result, air quality impact modelling could not be carried out as part of this assessment.

Data Assumptions and Limitations

Several limitations to this investigation are acknowledged:

- Due to the availability of the equipment, the air quality measurements were not conducted concurrently and the air quality profile may potentially have changed between the measurements.
- A single Summa canister sample was collected for laboratory analysis for the Beaco study area. Therefore potential variations in concentrations of chemical compounds across the study area may not have been identified. In addition, due to the time requirements to conduct a DustTrak™ monitoring period, only two PM_{10} baseline measurements were conducted across the study area. Therefore potential variations in concentrations of airborne particulate matter across the study area may not have been identified.
- A 24 hour period of particulate matter monitoring was not obtained for either measurement due to power supply problems to the DustTrak™ equipment.
- Wind speed and direction data was not available for the DustTrak™ monitoring period at the Viqueque site.
- Due to logistical and HSE limitations of site access, the length of time the dust deposition gauges were in the field was greater than the recommended 30 ±2 days and was not representative of the intended month-long period. To compensate for this, the daily particulate matter deposition results were averaged over the entire monitoring period, and likely include deposited particulate matter outside of the month-long period.
- Local people who were aware of the air quality monitoring may have altered their typical behaviour, potentially affecting the results.

Assumptions made during the assessment are as follows:

- Baseline measurements conducted during the fieldwork are representative of the ‘typical’ air quality in the region.
- There was minimal influence on the measurements by field personnel.

7.4.2 Existing Environment

Ambient Air Quality

Air pollutants are by nature primarily emitted from anthropogenic sources (i.e., related to human activity). These sources were identified during field work and are summarised below.

Across the study area but particularly in the Viqueque region, the primary observed source of air pollutants is vehicular traffic and, to a lesser extent, smoke produced from refuse disposal. The village of Viqueque has a significantly larger population than Beaco and as such is the primary source of existing pollutant emissions. Pollution sources from the village of Beaco are primarily associated with vegetation burning for agricultural purposes and the burning of refuse.

Non-anthropogenic sources are unlikely to be significant contributors to air pollutants in the study area. The primary sources of non-anthropogenic air pollutants are volatilisation of volatile organic compounds (VOCs) from the surface of vegetation, methane emissions from livestock and to a much lesser extent, the generation of NO_X via the ionisation of the atmosphere during lightning events.

Sources of particulate matter can be widespread, ranging from mechanical grinding of materials, wind-generated dust from stockpiles of material, pollutants produced from incomplete fuel combustion, to salt crystals from sea spray. In the Viqueque region, primary sources of particulate matter are likely to be from vehicle exhaust emissions, smoke from the burning of vegetation and refuse, and dust generated from construction activities (e.g., maintenance of buildings, grading of roads and paths). Vehicle wheel-generated dust was observed in the study areas during the site inspection, particularly in the Beaco region. However, this was primarily due to the dry nature and poor quality of the roads in the region. The contribution of vehicle wheel-generated dust to ambient airborne particulate matter concentrations is likely to be highly variable and subject to seasonal variation.

Baseline Air Quality Measurements

Chemical Compound Samples

The laboratory analytical results for the collected sample are presented in Table 7-16. With the exception of NO_X and SO_X, only concentrations of compounds greater than the limit of reporting are listed below. For the full list of results refer to Appendix E.

All analysed compounds under the US EPA air toxics represent trace level concentrations in the atmosphere, can be accounted for by the emissions from vehicles in the area and are much less than the assessment criteria.

Freon 12 is a compound used previously as a refrigerant and is now under the banned list of chlorofluorocarbon compounds but, in some cases, is still used as a propellant for aerosols.

Benzene, toluene, ethyl benzene and variants on xylenes (meta, para and ortho), are aromatic hydrocarbons and are commonly referred to together as BTEX. BTEX is typically emitted in the exhausts of vehicles from the combustion of petroleum products.

Nitrogen dioxide and nitric oxide are formed primarily during the combustion of fuels at high temperatures. In an air quality context, the primary sources of oxides of nitrogen are in the exhaust

emission from motor vehicles and power generation units. The concentrations of oxides of nitrogen were below the limit of reporting and can be considered to be absent from the air sample.

Sulfur dioxide is also produced by combustion of fuels that contain sulphides, for example, diesel or 'sour' natural gas that contains hydrogen sulphide (H_2S). The concentration of sulfur dioxide was not able to be determined by the laboratory due to a laboratory procedural failure.

Table 7-16 Laboratory analysis results of chemical compounds in Beaco and Viqueque air samples

Compound	CAS Number	Limit of Reporting	Assessment Criteria	Beaco Chefe suco's house 20/12/2011 5:33 p.m.	Viqueque Town Square 06/01/2012 9:49 a.m.
US EPA air toxics TO-14 (Chronic inhalation non-cancer)					
Freon 12	75-71-8	0.5 ppbv	---	0.9 ppbv	0.8 ppbv
		2 µg/m^3		4 µg/m^3	4 µg/m^3
Benzene	71-43-2	0.5 ppbv	---	< 0.5 ppbv	1.7 ppbv
		2 µg/m^3	300 µg/m^3	< 2 µg/m^3	5 µg/m^3
Toluene	108-88-3	0.5 ppbv	---	0.6 ppbv	3.4 ppbv
		2 µg/m^3	5,000 µg/m^3	2 µg/m^3	13 µg/m^3
Meta- and para-Xylene	108-38-3 106-42-3	1.0 ppbv	---	< 1.0 ppbv	1.3 ppbv
		4 µg/m^3		< 4 µg/m^3	6 µg/m^3
Ortho-xylene	95-47-6	0.5 ppbv	---	< 0.5 ppbv	0.5 ppbv
		2 µg/m^3		< 2 µg/m^3	< 2 µg/m^3
Total xylenes	1330-20-7	6 µg/m^3	100 µg/m^3	< 6 µg/m^3	8 µg/m^3
Hexachlorobutadiene	87-68-3	0.5 ppbv	---	0.8 ppbv	< 0.5 ppbv
		5 µg/m^3	90 µg/m^3	8 µg/m^3	< 5 µg/m^3
Additional parameters					
Nitrogen dioxide (NO_2)	10102-44-0	0.0001%	Refer to Table 7-13	< 0.0001%	< 0.0001%
Nitric oxide (NO)	---	0.0001%	---	< 0.0001%	< 0.0001%

Airborne Particulate Matter Measurements

The PM_{10} monitoring results for both areas are presented in Figure 7-21 and Figure 7-22. The monitoring periods are both less than 2 hours and are not long enough to establish a sufficient average PM_{10} concentration to compare against the assessment criteria.

Significant spikes in ambient PM_{10} concentrations occur during each monitoring period. However, there is insufficient information to determine the cause of these high concentration spikes.

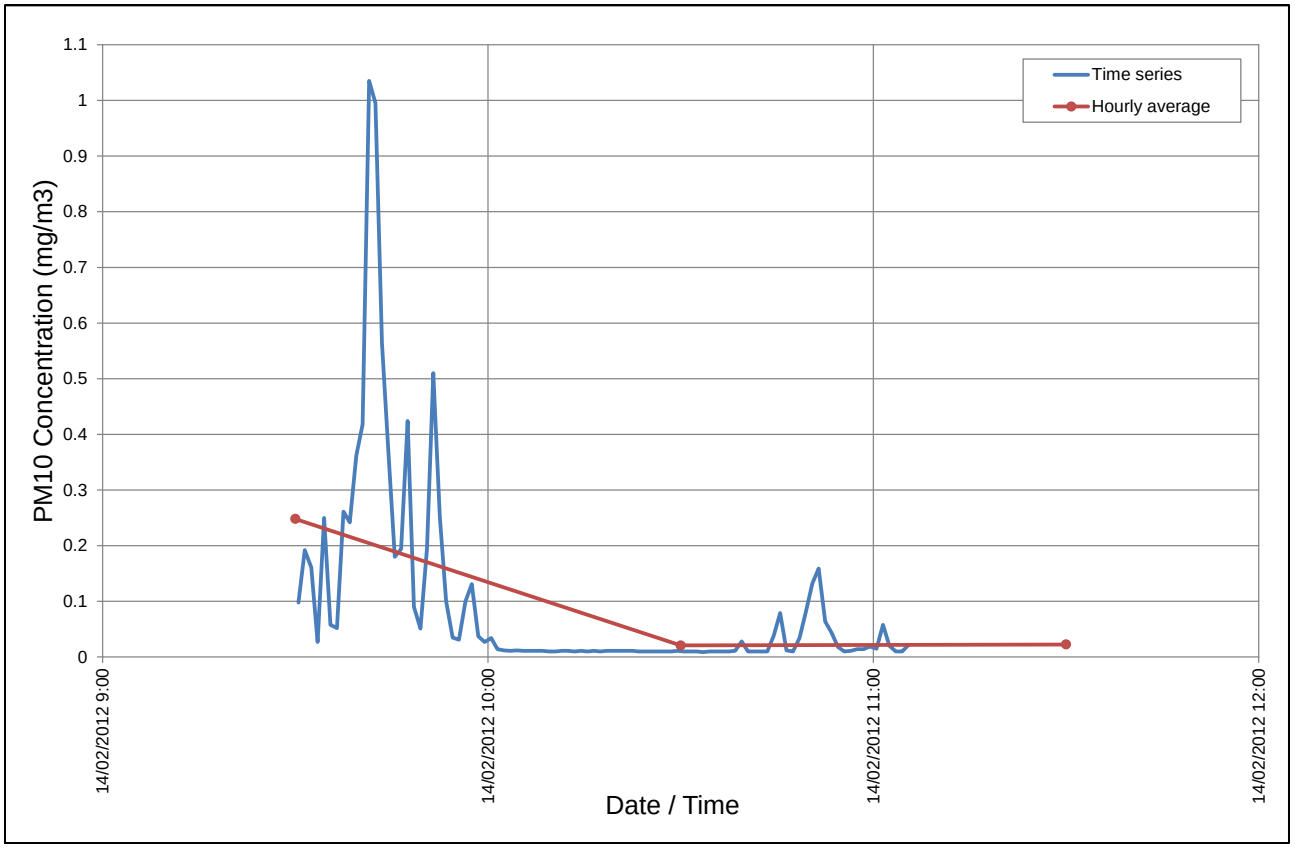


Figure 7-21 Beaco particulate monitoring time series results

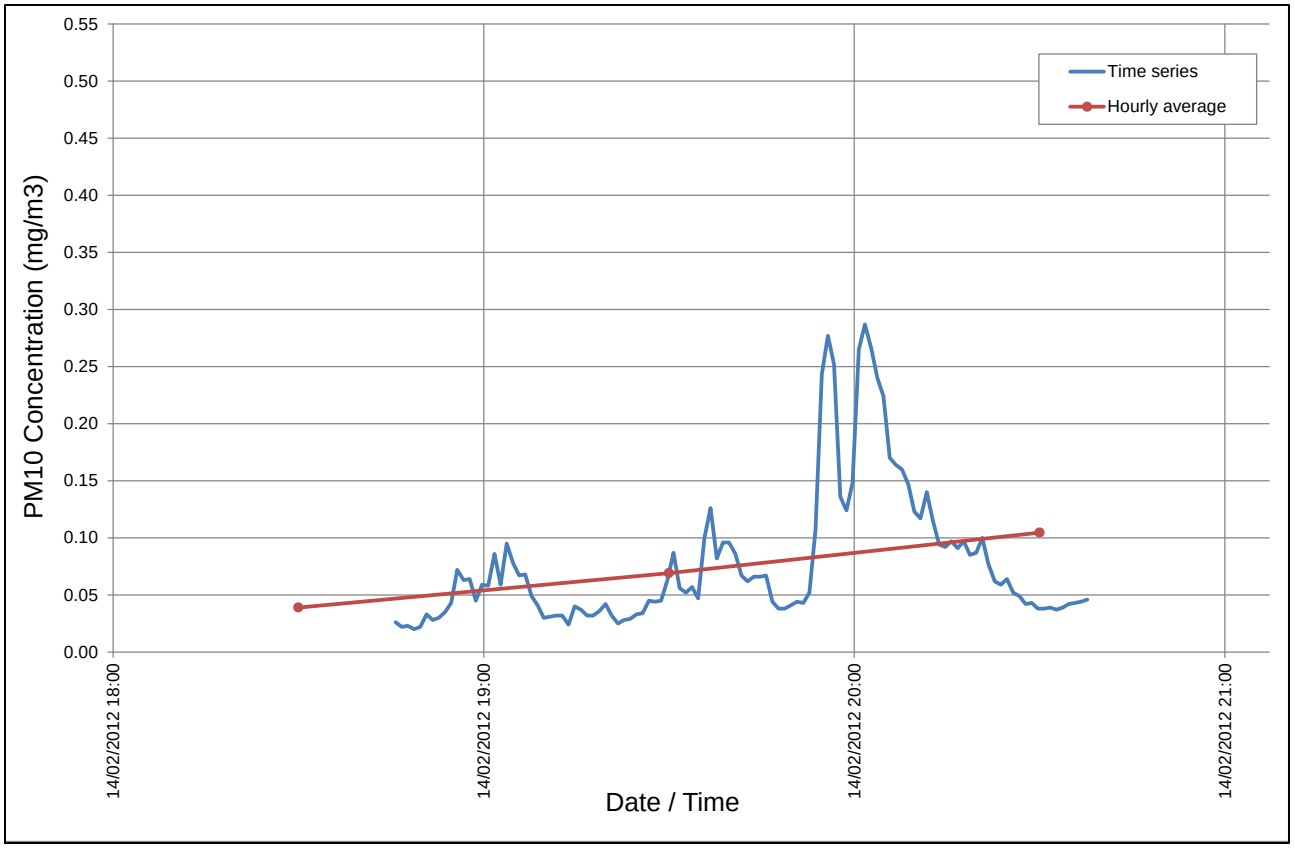


Figure 7-22 Viqueque particulate monitoring time series results

REV	DATE	REVISION DESCRIPTION	DRN	CHK	DES	ENG	APPD	CUST	PROJECT: 301012-001504
0	29/05/2012	FINAL FOR ISSUE	CS	GHi	-	GHi	GH		A4 SHEET

TASI MANE PROJECT – BETANO AND BEACO STRATEGIC ENVIRONMENTAL IMPACT ASSESSMENT

Figure 7-21
Figure 7-22

WorleyParsons resources & energy

TIMOR GAP, E.P. TIMOR GAS & PETRÓLEO

REPUBLICA DEMOCRATICA DE TIMOR-LESTE
SECRETARIA DE ESTADO DOS RECURSOS NATURAIS

OneWay to zero harm

Copyright © WorleyParsons Services Pty Ltd

LOCATION: \\perworfil1\infstructlib\Projects\301012-01504 Enviro Imp Assessment Timor-Leste\2.0 Reports\2.9 SEIA - Betano and Beaco\Figures\03_Working\BF090_BF091\

PLOT DATE AND TIME: 29 May 2012, 6:19 PM Creator: Courtenay Wheeler

Deposited Dust Samples

The laboratory analysis results are summarised in Table 7-17. For the full laboratory report, refer to Appendix F.

Table 7-17 Beaço LNG Plant Deposited Dust Samples – Laboratory Analysis Results

Analyte	Limit of Reporting	Unit	Beaço CSH[1]	Viqueque Airport
			14/02/2012	13/02/2012
Ash Content				
Total	1	mg	21	24
Deposition Rate	0.1	g/m^2/month	0.6	0.8
Combustible Matter				
Total	1	mg	16	15
Deposition Rate	0.1	g/m^2/month	0.5	0.5
Coarse Particulates				
Total	0.1	g	<0.1	<0.1
Total Soluble Matter				
Total	1	mg	2	17
Deposition Rate	0.1	g/m^2/month	<0.1	0.5
Total Insoluble Matter				
Total	1	mg	38	40
Deposition Rate	0.1	g/m^2/month	1.2	1.2
Total Solids				
Total	1	mg	40	56
Deposition Rate	0.1	g/m^2/month	1.2	1.8

Note: 1 – CSH = Chefe Suco's House

As the purpose of the dust deposition samples is primarily to establish baseline deposition rates of particulate matter across the Beaço and Viqueque areas, the deposition rates are not compared to any specific assessment criteria. Instead, these values provide a measure of current conditions to compare against during future phases of the development. Continued monitoring of the parameters specified above will allow appropriate comparisons to be made and assist in establishing dust deposition rate trends.

The various categories of particulate matter provide further information relating to the probable source(s) of the deposited particulate matter. For example, the higher proportions of ash content and combustible matter, coupled with the proximity to settlement villages where vegetation and refuse burning is common, suggest that the probable sources of the deposited matter is ash and un-combusted materials from local burning activities. The insoluble matter is also likely to be wheel-generated dust due to the proximity of the deposition gauges to local unsealed roads.

7.4.3 Environmental Impacts

In the absence of a quantitative analysis of air quality impacts, a qualitative impact assessment for the various development phases have been provided below.

Construction Impacts

Construction of the Beaco development will generate emissions to air primarily in the form of fugitive dust from the following sources:

- Excavation and earth moving activities.
- Infrastructure construction e.g., roadworks, electricity supply.
- Delivery of equipment.
- Vehicle and equipment movement.
- Vegetation and topsoil removal.
- Wind erosion from open/cleared areas or stockpile areas.

Dust emissions not only affect the environment, but can also affect human health due to the inhalation of fine particulate matter. PM_{10} and $PM_{2.5}$ particulate matter is small enough to pass the human upper respiratory tract (nose and throat) and pass into the deepest recesses of the lung. This has the potential to exacerbate pre-existing respiratory and/or cardiovascular problems that are commonly present in 'at-risk' members of the community (e.g., children and the elderly). Studies conducted by the WHO have shown good correlations of increasing mortality rates with increasing PM_{10} and ozone concentrations in urban areas (WHO, 2006).

The proximity of the construction areas to existing residential premises presents a potential human-health risk at the residential regions of Viqueque and Caraubulo (south Viqueque).

These locations will potentially be affected by construction at Nova Viqueque, particularly as the site is at a higher elevation to the existing residential areas. It is therefore, important to ensure that particulate matter generated by construction activities are kept to as low as reasonably practicable.

Operational Impacts

Operation of the Beaco development is likely to affect air quality due to the following activities:

- Gas processing and condensing operations.
- Fuel combustion in boilers or for electricity generation.
- Flaring events to dispose of waste or excess gas.
- Vehicle and equipment use.

Gas or fuel combustion affects both human health and the environmental due to emissions of chemical pollutants. The Nova Beaco and Raitahu sensitive receptors are likely to experience the highest impacts from the Beaco LNG facility due to their close proximity. Table 7-18 lists several known pollutants associated with gas or fuel combustion and some of the known human health and environmental impacts associated with these pollutants.

Table 7-18 Human health and environmental impacts of air pollutants

Pollutant	Human Health Impacts	Environmental Impacts
Carbon monoxide (CO)	Toxic gas that is poisonous and can reduce the oxygen carrying capability of blood.	Can contribute to the production of photochemical smog by the oxidation of nitric oxide (NO).
Lead (Pb)	Poisonous metal that can be inhaled when exposed to humans in particulate form.	Can cause a deterioration of the condition of ecosystems and slow the rate of decomposition of organic matter.
Oxides of nitrogen (NO_X)	NO_2 – Increased susceptibility to respiratory infections (e.g., asthma). NO_3^- – Can change blood chemistry making it unable to carry oxygen.	NO_X – Can retard growth rates of crops and increase O_3 production as photochemical smog. N_2O – Greenhouse gas and can contribute to global warming.
Ozone (O_3)	Irritation of the eyes and exacerbation of respiratory problems	Strong oxidising agent and can retard growth of plant life
Sulfur dioxide (SO_2)	Exacerbation of existing heart and lung disease especially when attached to small particulate matter	Primary contributor to acid production in the atmosphere (acid rain) that can damage crops and ecosystems
BTEX	Acute exposure can lead to skin irritation and central nervous system depression. For chronic exposure benzene in particular is a likely human carcinogen.	Known to have toxic effects on aquatic plant and animal life in acute exposures.

7.4.4 Avoidance, Management and Mitigation Measures

Construction Impacts

The following control measures can be implemented during construction to ensure airborne particulate matter does not adversely affect sensitive receptors:

- Restrict operational hours in which construction is permitted.
- Establish appropriate separation distances between dust sources and sensitive receptors.
- Apply water or wetting agents to roads and/or stockpiles of materials to reduce dust lift off.
- Seal road surfaces.
- Implement low road speeds on all unsealed roads.
- Define occupational dust policies for construction workers (e.g., dust masks when working with materials likely to generate excessive dust).
- Establish a monitoring program to asses actual dust emissions and institute remediation program to rectify problem areas.

Operational Impacts

The following control measures should be implemented during operation to ensure gaseous air emissions do not adversely affect sensitive receptors:

- Design the exhaust stacks and flares at the LNG facility (e.g., heights, diameters, temperatures, gas containers and exit velocities) to minimise the likelihood of exhaust plumes impacting the sensitive receptors.
- Select machinery with high fuel combustion efficiency and low emission technology to minimise emissions of pollutants.
- During the design phase, maximise the distance between the major emission sources (e.g., flares and electricity generators) and sensitive receptors to minimise the impacts.
- Regularly maintain vehicles and equipment to maximise their fuel efficiency.
- Fit vehicles and equipment with appropriate emission control devices (e.g., vehicle exhaust system, filters).
- Apply water or wetting agents to frequently trafficked roads and/or stockpiles of materials.
- Establish a compliance monitoring regime and define non-compliance incident investigation methods and rectification strategies.
- Seal roads with high traffic loads.

7.4.5 Residual Impacts

Construction activities are typically temporary in nature and its impacts localised. Provided all dust control measures are implemented, residual impacts from the construction of the Beaco development are considered likely to be minimal.

In contrast, gaseous air emissions from operational activities of the Beaco development have the potential to cause adverse human health or environmental impacts at the Nova Beaco and Raitahu sensitive receptors given their close proximity. Consequently, residual impacts considered could be without careful design and control measures and, as a result, this aspect requires further assessment and follow-up air quality monitoring. Proactive engagement with stakeholders is recommended to keep them informed about the progress of the Beaco development and reduce the likelihood of complaints.

In the event that mitigation and management measures have been implemented to the maximum extent practicable and the local populace still consider the impacts from the development to be unacceptable, relocation of the affected people may need to be considered, as is the case for the village of Beaco.

7.4.6 Monitoring and Reporting

The following recommendations have been made to assist in the development of an appropriate air quality monitoring and reporting programme:

- Until air quality-related legislation is defined by the GoTL, it is recommended that the project adopts monitoring and reporting procedures and standards from other governmental jurisdictions where it is clearly defined, for example the AS/NZS 3580 series.
- Detailed monitoring of meteorological parameters as specified in Section 7.1 Climate and Meteorology.
- Continuous monitoring of ambient pollutants, ambient particulate matter and deposited dust using equipment compliant with the AS/NZS 3580 series to assess compliance with the developed dust management plan and assessment criteria defined in Table 7-13 in Section 7.4.1. It is recommended that tapered element oscillating microbalances (TEOMs) or equivalent, are established at the Nova Beaco and Nova Viqueque areas during construction. Monitoring data should be collated monthly and reported to SERN. AS 3580.9.8:2008 *Methods for sampling and analysis of ambient air Method 9.8: Determination of suspended particulate matter – PM_{10} continuous direct mass method using a tapered element oscillating microbalance analyser* states the guidance methods to adopt when siting the apparatus, sampling temperatures, flow rates for the main and auxiliary inlets, averaging periods and the overarching procedure to follow when establishing a TEOM at a new monitoring site.
- Reporting on the monitored data should be conducted periodically, detailing the monitoring method, results and comparison to WHO, US EPA and NEPM guideline levels or equivalent.

7.4.7 Further work

Further work related to air quality impacts required for the Beaco development is as follows:

- Continued baseline monitoring across the study area to establish seasonal variations of chemical compound and particulate matter concentrations, and dust deposition rates.
- A detailed air quality impact assessment for both construction and operational activities including computer simulation of predicted pollutant and dust impacts across the project areas in accordance with a US EPA-approved method or equivalent.

Detailed Air Quality Impact Assessment

A detailed air quality assessment includes computer simulation modelling of predicted ground-level concentrations of pollutants of potential concern across the study area in accordance with a US EPA-approved method or equivalent.

It is recommended that air quality impact modelling is undertaken when proposed operational equipment and infrastructure specifications and locations have been confirmed. The aim of the air quality impact modelling will be to determine predicted ground-level concentrations of relevant pollutants of potential concern emitted by construction and operational activities. This modelling will enable the level of impact to be quantified across the study area and inform air quality impact management design and measures to be implemented, to ensure air quality impacts are managed to

acceptable levels. An air quality impact assessment will also assist in the development of a dust management plan, and ultimately, help to ensure that the potentially adverse impacts on human and environmental health are minimised.

The meteorological conditions of the region have a significant influence on the dispersion behaviour of pollutant plumes and needs to be taken into account when predicting ground-level concentrations. Pollutant dispersion models use meteorological information as input data sets to simulate the impacts. For example, the increased frequency and volume of rain events in the Viqueque region may potentially significantly reduce the ambient concentrations of particulate matter.

In order to conduct computer simulation of the air quality impacts emissions of both particulate matter and pollutants of potential concern need to be estimated. Particulate matter emissions can be estimated via calculations based on: the type of activity; activity rate; and any applied mitigation/control measure used. The Australian National Pollutant Inventory (NPI) Emission Estimation Technique Manuals (EETM) described in Section 6.4.7 are effective methods to estimate the emissions of particulate matter and pollutants of potential concern from construction and operational activities and are recommended to be adopted during the detailed air quality impact assessment.

Greenhouse Gas Assessment

Another aspect in relation to air quality is the assessment of greenhouse gas emissions. Under Timor-Leste environmental law, it is expected that a greenhouse gas assessment would be conducted for each new industrial development, including the Beaco development. A greenhouse gas assessment is also necessary to meet the International Finance Corporation (IFC) requirements under the World Bank group. In addition, greenhouse gas emissions have been flagged as a key issue of concern by various non-governmental organisations in Timor-Leste for the project. WorleyParsons was not commissioned to undertake a greenhouse gas assessment as part of the Strategic EIA. In addition to this, there is insufficient project data available to carry out such an assessment.

The World Bank has published a handbook to aid in the estimation of greenhouse gas emissions at a project level: *Greenhouse Gas Assessment Handbook – A Practical Guidance Document for the Assessment of Project-level Greenhouse Gas Emissions* (World Bank, 1998). This document details the required input information, formulae and calculation method to be used to determine the total greenhouse gas emissions from a facility and the methods are recommended to be adopted for any future greenhouse gas assessment.

7.5 Noise

Construction and operational noise associated with the proposed Beaco development has been identified as an environmental factor with the potential to adversely impact the surrounding environment and populace in the Beaco study area.

Currently there are no specific environmental assessment standards or legislation addressing noise or acoustic emissions in Timor-Leste.

In the absence of specific noise-related legislation in Timor-Leste, the Western Australian Environmental Protection (Noise) Regulations 1997 (WA) (DEC, 1997), have been adopted to define the study method for assessing potential noise impacts of the Beaco development. Regulation 7 of the Regulations states that 'noise emitted from any premises when received at other premises must not cause, or significantly contribute to, a level of noise which exceeds the assigned level in respect of noise received at premises of that kind'.

7.5.1 Study Method

This study was designed to obtain a baseline of the noise profile for the Beaco development area.

The study method proposed for this noise assessment is summarised as follows:

- Undertake a literature review to identify:
  - Existing noise monitoring and assessments undertaken with the Beaco study area; and
  - GoTL or other relevant noise standards;
- Identify noise sensitive receptor locations in proximity of the Beaco development area;
- Conduct baseline monitoring of ambient noise levels at the identified noise sensitive receptor locations in accordance with the Environmental Protection (Noise) Regulations 1997 (WA);
- Establish assigned noise levels for various noise sensitive premises in the study region (LAmax, LA1 and LA10);
- Develop sound power level predictions for construction and operational sound power levels at the development sites accounting for meteorological conditions;
- Undertake a comparative assessment of baseline and predicted construction and operational noise levels from the Beaco development; and
- Provide recommendations for any noise mitigation measures or buffer zones in relation to the Beaco development area.

Study Scope

The study area for this assessment includes the Beaco development, which comprises the locations listed below, as well as the surrounding residential areas as shown in Figure 7-23:

- Beaco LNG Plant.

- Nova Beaco.
- Nova Viqueque.
- Viqueque Airport upgrade work.

Literature Review

As mentioned above, the Western Australian Environmental Protection (Noise) Regulations 1997 (WA) have been adopted in order to define the study method. The Western Australian regulations, under the *Environmental Protection Act 1986*, define a standard process to assign specific allowable noise levels for each category of land use zoning. This is considered an appropriate method to set the noise levels that the resulting noise impacts are to be assessed against across the study area.

The following noise guidance documents have also been referenced within this study:

- *Guidance for the Assessment of Environmental Factors No. 8 – Environmental Noise (Draft)* (WA EPA, 2007a); and

Australian Standard 2436-2010 Guide to Noise and Vibration Control on Construction, Demolition and Maintenance Sites (AS 2436-2010).

Noise Sensitive Receptors Locations

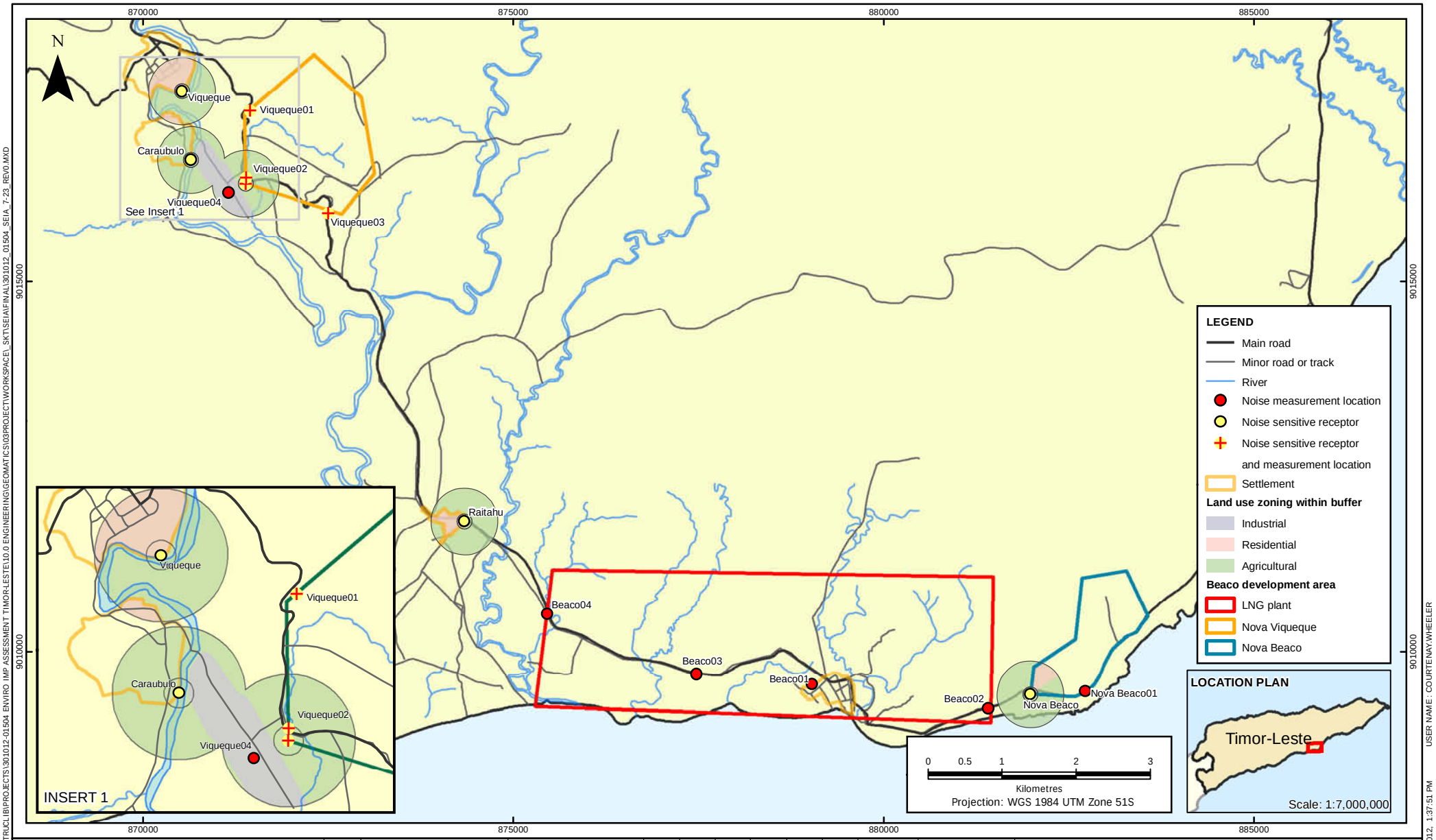
The identification of the sensitive receptor locations was conducted using a combination of desktop-level assessment from aerial photography and an on-site visual inspection of the existing local infrastructure.

The on-site visual inspection focussed on identifying the locations of noise sensitive receptors, as defined by the Environmental Protection (Noise) Regulations 1997 (WA). In addition, the locations to take baseline noise measurements included residential areas that are likely to be affected by the construction and operation of the Beaco development area.

The Environmental Protection (Noise) Regulations 1997 (WA) identify three premises categories as having different relevant assigned noise levels. These are: industrial and utility premises, commercial premises, and noise sensitive premises which are summarised in Table 7-19.

Table 7-20 shows the location of identified noise sensitive premises within the Beaco study area for the purposes of this assessment. These identified receptor locations are shown in Figure 7-23.

The existing Beaco village is not identified as a noise sensitive receptor in this case as it is intended that the village is to be entirely relocated to the Nova Beaco site.



LOCATION: \\PERWORF\L1\INFSTRUCL\IB\PROJECTS\301012-01504 ENVIRO IMP ASSESSMENT TIMOR-LESTE\10.0 ENGINEERING\GEOMATICS\03PROJECTWORKSPACE_SKT\SEIA\FINAL\301012_01504_SEIA_7-23_REV0.MXD

USER NAME: COURTENAY.WHEELER

PLOT DATE & TIME: 29 MAY 2012, 1:37:51 PM

NOTES:
This map consists of:
1. Rivers: Geographic Information Group TimorLeste (2010)
2. Roads: DivaGIS (2010)
3, Landuse zoning: RDTL (2011a)
4, Noise receptors: WorleyParsons (2012)

REV	DATE	REVISION DESCRIPTION	DRN	CHK	DES	ENG	APPD	CUST	A4 SHEET	SCALE 1:70,000
0	29/05/2012	FINAL FOR ISSUE	MW	GHi	CW	-	GH		PROJECT No: 301012-001504	

WorleyParsons resources & energy

TIMOR GAP, E.P. TIMOR GÁS & PETRÓLEO

REPUBLICA DEMOCRATICA DE TIMOR-LESTE
SECRETARIA DE ESTADO DOS RECURSOS NATURAIS

OneWay to zero harm

Copyright © WorleyParsons Services Pty Ltd

TASI MANE PROJECT - BETANO AND BEACO
STRATEGIC ENVIRONMENTAL IMPACT ASSESSMENT

Figure 7-23
Land use zoning across the Beaco study area near noise sensitive receptor locations

Table 7-19 Noise related premises categories

Industrial and Utility Premises	Commercial Premises	Noise Sensitive Premises
• Premises used for providing water, electricity, communications, etc. • Premises used by aircraft or ships, as a freight yard or for passenger transport • Industrial premises • Mine sites and quarries • Waste disposal sites • Offices, grounds and caretakers' residences which are part of the above	• Offices and retail shops • Premises in or from which meals or food are sold to the public • Service stations • Indoor amusement centres e.g., theatres • Outdoor amusement centres • Hotels which don't provide accommodation • Health centres • Hospitals with 150 or more beds • Centres for community meetings • Testing laboratories • Veterinary clinics, kennels and the like • Offices, grounds and caretakers' residences which are part of the above	• Premises occupied solely or mainly for residential or accommodation purposes • Rural premises • Caravan parks and camping grounds • Hospitals with less than 150 beds • Rehabilitation centres, care institutions and similar • Educational institutions • Premises used for public worship • Hotels which provide accommodation to the public • Premises used for aged care or child care • Prisons and detention centres • Any other premises not referred to in industrial and utility or commercial premises

Table 7-20 Identified noise sensitive receptor locations at Beaco

Location	Relevant Study Area	Centroid Coordinates		Measurement Taken at/Near Receptor
		Latitude	Longitude	
Nova Beaco	Primary worker settlement	8° 56' 21.5" S	126° 28' 48.0" E	Yes
Raitahu	Existing settlement	8° 55' 28.5" S	126° 24' 07.0" E	No
Nova Viqueque	Primary worker settlement/Airport upgrade	8° 52' 40.0" S	126° 23' 00.0" E	Yes
Viqueque	Resident settlement	8° 52' 09.0" S	126° 21' 57.0" E	Yes
Settlement south of Viqueque (Caraubulo)	Resident settlement/Airport upgrade	8° 52' 40.0" S	126° 22' 00.0" E	No

*Location was inaccessible preventing noise measurements to be undertaken.

Baseline Measurement Method

Nine baseline noise measurements were conducted at the locations listed in Table 7-21 over a period of three days: 19 to 21 December 2011. The measurement locations are shown in Figure 7-23.

Table 7-21 Beaco/Viqueque noise measurement locations

Figure 7-23 Label	Location	Centroid Coordinates	
		Latitude	Longitude
Beaco01	Beaco Village Chefe suco's House	8° 56' 38.6" S	126° 26' 45.5" E
Beaco02	Beaco LNG Plant eastern boundary	8° 56' 48.5" S	126° 28' 03.1" E
Beaco03	Beaco LNG Plant central area	8° 56' 34.7" S	126° 25' 54.4" E
Beaco04	Beaco LNG Plant western boundary	8° 56' 08.9" S	126° 24' 48.4" E
Beaco05	Nova Beaco	8° 56' 40.5" S	126° 28' 46.0" E
Viqueque01	Nova Viqueque north western boundary	8° 52' 29.0" S	126° 22' 35.1" E
Viqueque02	Nova Viqueque south western boundary	8° 52' 58.5" S	126° 22' 33.6" E
Viqueque03	Nova Viqueque south eastern boundary	8° 53' 13.8" S	126° 23' 10.0" E
Viqueque04	Viqueque Airport central area	8° 53' 05.3" S	126° 22' 26.0" E

Measurements were conducted in general accordance with the Environmental Protection (Noise) Regulations 1997 (WA). All measurements were conducted outside of buildings using a Brüel & Kjær 2238 Mediator Sound Level Meter. The sound level meter was calibrated by a National Association of Testing Authorities (NATA) accredited laboratory within the last two years and is considered appropriately calibrated to industry standards.

Where possible, measurements were conducted at the boundary of the premises, nearest to the primary proposed noise source. However, in the case where noise sources are likely to be from multiple locations, a measurement was conducted at a central representative location as shown in Table 7-21.

Measurements were conducted over 15 minute periods with the microphone positioned at a minimum of 1.2 m above the ground and greater than 3 m away from any sound reflecting surface. Measurements were attended with field personnel noting the following information:

- Date of measurement.
- Location coordinates.
- Measurements start and end times.
- Measurement duration.
- Calibration field checks before and after measurement period.
- Noise reading values including, equivalent continuous A-weighted sound pressure level (L_{Aeq}); and maximum linear peak sound pressure level ($L_{linear,peak}$).
- Any identifiable sound sources during the measurement period including particular characteristics of the identified noise (e.g., tonality, modulation or impulsiveness). In the specific case of vehicle traffic noise, the times and frequency of the noise events were also noted.

Noise measurement data was unable to be collected at or near the proposed locations for the settlement south of Viqueque (Caraubulo) as this area was inaccessible to WorleyParsons field personnel during the field work.

Determination of Assigned Noise Levels

Three noise parameters are assigned to noise sensitive premises when determining the allowable noise levels in the Environmental Protection (Noise) Regulations 1997 (WA), these are: L_{A10}; L_{A1}; and L_{Amax}. As these parameters are calculated for each sensitive receptor location, the values are likely to differ between receptors. The definitions of these parameters are as follows:

- L_{A10}: assigned level of noise not to be exceeded for more than 10% of the time (e.g., for more than 10 minutes in 100 minutes);
- L_{A1}: assigned level of noise not to be exceeded for more than 1% of the time (e.g., for more than 1 minute in 100 minutes); and
- L_{Amax}: assigned noise level not to be exceeded at any time.

The L_{A10} and L_{A1} levels allow for brief louder noises experienced at the receptor locations, provided they remain below the L_{Amax} assigned level. As it is impractical to calculate assigned noise levels for each individual structure across the study area, the calculated values apply to the generalised zoned area of premises type. The Environmental Protection (Noise) Regulations 1997 (WA) are not applicable to traffic noise on roads and do not compensate for it.

To calculate compensation noise levels, an influencing factor must be determined and applied to the parameters in Table 7-22 for each noise sensitive receptor above.

Table 7-22 Assigned noise levels

Type of Premises Receiving Noise	Time of Day	Assigned Level (dB)		
		L_{A10}	L_{A1}	L_{Amax}
Noise sensitive premises at locations within 15 m of a building directly associated with a noise sensitive use	0700 to 1900 hours Monday to Saturday	45 + influencing factor	55 + influencing factor	65 + influencing factor
	0900 to 1900 hours Sunday and public holidays	40 + influencing factor	50 + influencing factor	65 + influencing factor
	1900 to 2200 hours All days	40 + influencing factor	50 + influencing factor	55 + influencing factor
	2200 on any day to 0700 hours Monday to Saturday and 0900 hours Sunday and public holidays	35 + influencing factor	45 + influencing factor	55 + influencing factor
Noise sensitive premises at locations further than 15 m from a building directly associated with a noise sensitive use	All hours	60	75	80
Commercial premises	All hours	60	75	80
Industrial and utility premises	All hours	65	80	90

To determine the influencing factor for each noise sensitive receptor location, the proportion of industrial and commercial areas within radii of 100 m and 450 m of each receptor location is calculated. The Transport Factor (*TF*) is then determined using the following rule:

- Major road (> 15,000 vehicles/day) within 100 m, *TF* = 6
- Major road within 450 m, *TF* = 2
- For each secondary road (6,000 to 15,000 vehicles/day) within 100 m, *TF* = 2
- *TF* cannot be greater than 6.

The influencing factor (*IF*) is then calculated by:

$$IF = I + C + TF$$

Where: *I* = (% industrial area within 100 m + % industrial area within 450 m)/10

C = (% commercial area within 100 m + % commercial area within 450 m)/20

According to Regulation 9 of the Environmental Protection (Noise) Regulations 1997 (WA), if the generated noise cannot be free of annoying characteristics (i.e., tonality, modulation and/or impulsiveness), the noise source emissions are to be adjusted to compensate.

Adjustments to noise emissions are to be cumulative to a maximum of +15 dB as listed below:

- +5 dB, where tonality is present (e.g., whining or droning).
- +5 dB, where modulation is present (e.g., like a siren).
- +10 dB, where impulsiveness is present (e.g., banging or thumping).

Sound Power Predictions and Comparative Assessment of Noise Levels

Given the lack of detailed engineering specifications for the proposed noise sources, computer simulation of the predicted noise levels cannot be conducted at this stage of the project. As such, accurate prediction of noise impacts across the study area could not be determined or assessed against assigned noise levels.

Data Assumptions and Limitations

Several limitations to this noise study must be acknowledged. These are:

- Due to logistical and HSE limitations of the fieldwork, baseline noise measurements were only conducted between 0800 and 1800 hours;
- Due to the time requirements to conduct a measurement, a limited number of baseline measurements could be conducted across the study area;
- All conducted measurements were attended for security reasons;
- Unanticipated sources of noise from local onlookers were unavoidable in certain cases due to the presence of the field personnel (i.e., curious passers-by, sounding of vehicle horns, etc.);

- Local people who were aware of the measurements being conducted may have altered their typical behaviour to increase or reduce the noise emitted; and
- Environmental sources of noise beyond human control (e.g., wind, thunder, rain and local fauna) were experienced during the baseline measurements.

Access to the sensitive receptor locations identified in the desktop-level assessment of the aerial photography Table 7-20 had to be taken into account when conducting the on-site visual inspections and measurements. As mentioned above, access to the areas of land proposed for Nova Viqueque in particular was limited, and as such, baseline measurements were conducted along the adjacent main road Figure 7-23.

The following assumptions were made during the noise assessment:

- That the baseline measurements conducted during the fieldwork are representative of 'typical' noise sources at each location.
- That the influence by field personnel on measured noise levels is minimal.
- Predicted vehicular traffic volumes are not greater than 6,000 vehicles/day for all relevant roads in the study area.

7.5.2 Existing Environment

Baseline Noise Measurements

The baseline noise measurements conducted at each location provides a measure of the existing noise source profile across the Beaco study areas. The measurement results are summarised in Table 7-23 below.

Vehicle traffic is associated with the major noise sources for most measurements, in particular near the LNG plant and Nova Beaco areas. This is primarily due to the measurements being made adjacent to the roads in the area due to accessibility of the study areas. In addition, for all measurements the $L_{linear,peak}$ values were associated with vehicles passing the sound level meter in close proximity, even if vehicles weren't the primary noise source over the monitoring period. For the Viqueque02 monitoring location, a power saw was used by a local carpenter during approximately half of the monitoring period. This small-scale construction work is considered representative of typical activities of the region.

These short-term, high noise events have influenced the L_{Aeq} value and as such are disproportionately high. Therefore the L_{Aeq} values do not represent the 'background' noise profile across the Beaco study area. Considering that the $L_{linear,peak}$ values for each measurement are greater than 30 dB above the L_{Aeq} values, the incremental change in noise levels during the construction and operational phases of the development cannot be assessed when incorporating short-term high noise sources. In addition, traffic noise is inappropriate to incorporate into the cumulative impact from the Beaco development.

Further noise monitoring is required to establish a representative 'background' noise profile for the Beaco study area. It is stated in (WA EPA, 2007a) that noise levels should be logged continuously 'over a reasonably representative period, including a weekend where relevant'. The L_{A90} value, where

90% of all logged noise values are above, will be calculated and taken to be representative of the 'background' noise.

Existing Noise Sources

As stated above, the primary source of high-intensity noise observed during the baseline measurements is vehicular traffic. Other noise sources observed included:

Anthropogenic:

- Small-scale construction work (i.e., use of hand tools and power tools);
- Local populace talking/playing;
- Music (primarily played through electronic devices, particularly in vehicles); and
- Electricity generators.

Non-anthropogenic:

- Weather effects (i.e., wind, thunder and rain); and
- Animals (e.g., chickens, roosters, ducks, dogs, pigs and cattle).

In comparison to the Betano study area, the contribution of non-anthropogenic noise sources is greater, in particular for domesticated animals and native wildlife.

Table 7-23 Baseline noise measurement results (Beaco study area)

Label	Date	Coordinates	Time			Calibration (dB)		Measurements (dB)		Primary Noise Source	Traffic Counts		
			Start	End	Duration	Before	After	L_{Aeq}	$L_{linear.peak}$		MB	Car	Truck
Beaco01	19/12/2011	8° 56' 38.6" S 126° 26' 45.5" E	1335	1350	15 mins	94.0	94.0	47.3	101.4	Weather/Animals	0	0	0
Beaco02	19/12/2011	8° 56' 48.5" S 126° 28' 03.1" E	1423	1438	15 mins	94.0	94.0	51.7	101.8	Vehicle Traffic	2	0	0
Beaco03	20/12/2011	8° 56' 34.7" S 126° 25' 54.4" E	1610	1625	15 mins	94.0	94.0	53.8	96.8	Vehicles/Animals	1	0	1
Beaco04	20/12/2011	8° 56' 08.9" S 126° 24' 48.4" E	1656	1711	15 mins	94.0	94.0	51.3	88.7	Vehicle Traffic	3	0	1
Beaco05	19/12/2011	8° 56' 40.5" S 126° 28' 46.0" E	1504	1519	15 mins	94.0	94.0	56.1	107.1	Farm Animals/Weather	0	0	1
Viqueque01	21/12/2011	8° 52' 29.0" S 126° 22' 35.1" E	1058	1113	15 mins	94.0	94.0	62.9	103.9	Vehicle Traffic	4	0	2
Viqueque02	21/12/2011	8° 52' 58.5" S 126° 22' 33.6" E	1227	1242	15 mins	94.0	94.0	64.1	105.4	Power Tools	3	1	1
Viqueque03	21/12/2011	8° 53' 13.8" S 126° 23' 10.0" E	1342	1357	15 mins	94.0	94.0	57.7	105.0	Vehicle Traffic	4	0	0
Viqueque04	21/12/2011	8° 53' 05.3" S 126° 22' 26.0" E	1151	1206	15 mins	94.0	94.0	44.3	96.3	Animals/Light Construction	1	0	0

Note: MB - Motorbike or other powered two-wheel vehicle.

7.5.3 Environmental Impacts

Assigned Noise Levels

The calculated proportions of industrial and commercial zoned areas within the 100 m and 450 m radii of each noise sensitive location/receptor are listed in Table 7-24. The land use zonings near the sensitive locations/receptors are presented in Figure 7-23.

Table 7-24 Land use zoning near noise sensitive receptor locations

Location	Industrial and Utility Premises		Commercial Premises	
	100 m radius	450 m radius	100 m radius	450 m radius
Nova Beaco	0%	0%	0%	0%
Raitahu	0%	0%	0%	0%
Nova Viqueque	0.4%	35.3%	0%	0%
Viqueque	0%	0%	0%	0%
Settlement south of Viqueque (Caraubulo)	11.3%	23.5%	0%	0%

It is assumed that the volume of vehicular traffic during construction and operation will not be greater than 6,000 vehicles/day, for any relevant roads in the Beaco study area. Therefore the Transport Factor (TF) for all receptors is considered zero. The calculated parameters for each influencing factor are listed in Table 7-25.

Table 7-25 Influencing factor calculation parameters

Location	Calculation Parameter			
	Industry (*I*)	Commercial (*C*)	Transport Factor (*TF*)	Influencing Factor (*IF*)[1]
Nova Beaco	0	0	0	0
Raitahu	0	0	0	0
Nova Viqueque	3.6	0	0	4
Viqueque	0	0	0	0
Settlement south of Viqueque (Caraubulo)	3.5	0	0	4

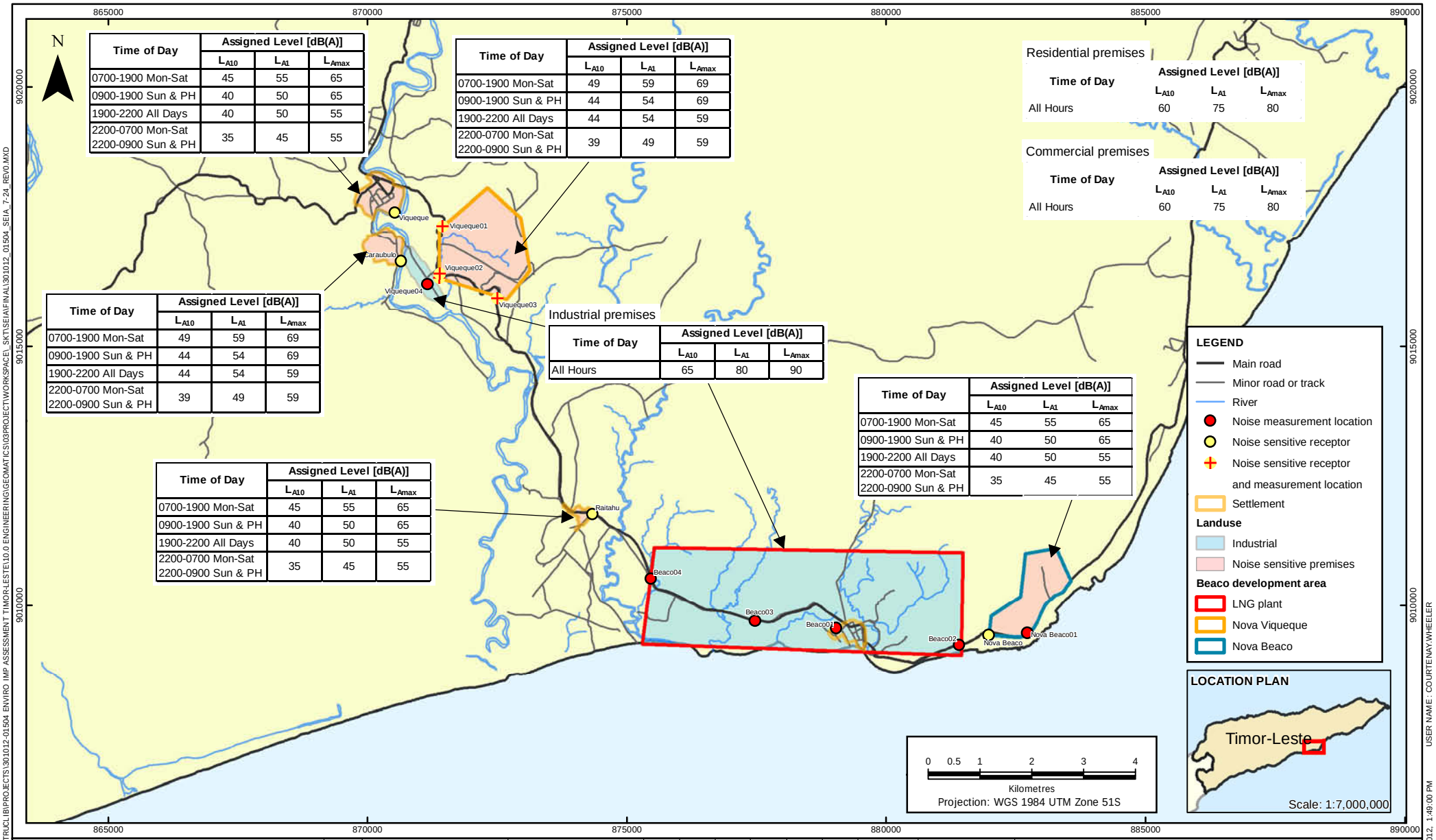
Note: 1 – Influencing Factor rounded to the nearest whole number.

The resulting allowable noise levels for each premises zone type is listed in Table 7-26.

The relevant assigned noise levels for each land use zone within the study area are presented in Figure 7-24.

Table 7-26 Calculated allowable noise levels for the Beaco study area

Type of Premises Receiving Noise	Time of Day	Location	Assigned Level [dB(A)]		
			L_{A10}	L_{A1}	L_{Amax}
Noise sensitive premises at locations within 15 metres of a building directly associated with a noise sensitive use	0700 to 1900 hours Monday to Saturday	Nova Beaco	45	55	65
		Raitahu	45	55	65
		Nova Viqueque	49	59	69
		Viqueque	45	55	65
		South Viqueque (Caraubulo)	49	59	69
	0900 to 1900 hours Sunday and public holidays	Nova Beaco	40	50	65
		Raitahu	40	50	65
		Nova Viqueque	44	54	69
		Viqueque	40	50	65
		South Viqueque (Caraubulo)	44	54	69
	1900 to 2200 hours All days	Nova Beaco	40	50	55
		Raitahu	40	50	55
		Nova Viqueque	44	54	59
		Viqueque	40	50	55
		South Viqueque (Caraubulo)	44	54	59
	2200 on any day to 0700 hours Monday to Saturday and 0900 hours Sunday and public holidays	Nova Beaco	35	45	55
		Raitahu	35	45	55
		Nova Viqueque	39	49	59
		Viqueque	35	45	55
		South Viqueque (Caraubulo)	39	49	59
Noise sensitive premises at locations further than 15 m from a building directly associated with a noise sensitive use	All hours	N/A	60	75	80
Commercial premises	All hours	N/A	60	75	80
Industrial and utility premises	All hours	N/A	65	80	90



NOTES:
This map consists of:
1. Rivers: Geographic Information Group TimorLeste (2010)
2. Roads: DivaGIS (2010)
3. Landuse zones: RDTL (2011a)
4. Noise receptors: WorleyParsons (2012)

REV	DATE	REVISION DESCRIPTION	DRN	CHK	DES	ENG	APPD	CUST
0	29/05/2012	FINAL FOR ISSUE	MW	GHi	CW	-	GH	

A4 SHEET | SCALE 1:100,000
PROJECT No: 301012-001504

TASI MANE PROJECT - BETANO AND BEACO
STRATEGIC ENVIRONMENTAL IMPACT ASSESSMENT

WorleyParsons resources & energy

TIMOR GAP, E.P. TIMOR GÁS & PETRÓLEO

REPUBLICA DEMOCRATICA DE TIMOR-LESTE
SECRETARIA DE ESTADO DOS RECURSOS NATURAIS

OneWay to zero harm

Copyright © WorleyParsons Services Pty Ltd

Figure 7-24
Assigned noise levels across the Beaco study area

LOCATION: \\PERWORFIL1\INFSTRUCLIB\PROJECTS\301012-01504 ENVIRO IMP ASSESSMENT TIMOR-LESTE\10.0 ENGINEERING\GEOMATICS\03PROJECTWORKSPACE_SKT\SEIA\FINAL\301012_01504_SEIA_7-24_REV0.MXD

PLOT DATE & TIME: 29 MAY 2012, 1:49:00 PM

USER NAME: COURTENAY.WHEELER

Construction Noise

In the absence of a quantitative analysis of estimated noise emissions, computer simulation of the predicted noise levels cannot be conducted at this stage. As such, accurate prediction of noise impacts across the Beaco study area could not be obtained and a qualitative impact assessment has been provided below.

It is likely that noise associated with construction activities for the LNG plant and Viqueque Airport upgrade would have tonal, modulated and/or impulsive characteristics associated with them. Vibrational impacts from piling activities have the potential to affect the structural integrity of adjacent buildings. Foundations and binding materials, for example, mortar, are especially susceptible to excessive vibration.

Excavation activities, including drilling, are known to be consistently high noise contributors. It is anticipated that extensive earthwork and excavation activities would be required for the construction of all the development areas, in particular Nova Beaco due to the steep terrain. The use of power tools, in particular impact hammers or 'jackhammers', have the potential to have adverse noise impacts on both construction personnel and the local populace at the sensitive receptor locations. The impulsive nature of the emitted noise from these tools and the tonality associated with other tools, for example, circular saws, would require the additional adjustment factors mentioned above to be applied.

The proximity of proposed construction areas to existing residential premises is a major factor to the potential noise level impact at the following locations:

- South Viqueque;
- Nova Beaco; and
- The existing village of Beaco (during the relocation process).

These locations will potentially be impacted by construction works associated with the airport upgrade, Nova Viqueque and the LNG plant respectively.

In the absence of an effective noise mitigation program, construction noise impacts may adversely affect the public in ways ranging from annoyance/complaints to loss of sleep.

Operational Noise

Operational noise associated with the LNG plant and Viqueque Airport upgrade may potentially adversely affect the following noise sensitive receptors respectively:

- Nova Beaco.
- South Viqueque and Nova Viqueque.

Similar to the construction phase, at the time of writing, there is no project-specific engineering data regarding the operation of the Viqueque development. Therefore, accurate prediction of the noise impacts via computer simulation is not possible at this time.

It is anticipated that tonality, modulation and high vibrational impacts would be present within the noise profile emitted from operational activities at the upgraded Viqueque Airport. Due to the orientation of the current runway, the flight path of future aircraft may be low-altitude and directly above the south of Viqueque (Caraubulo) village as they either take-off or land. Residents of Caraubulo immediately to the north-west of the airport may experience adverse health impacts and nuisance impacts from prolonged exposure to aircraft noise and associated vibration. In contrast, it is less likely that tonality or modulation will be present in the noise profile emitted by the LNG plant. Flaring activities, although short in duration and infrequent, are high in intensity and may need to be assessed separately to standard operating conditions.

Based on the assessment undertaken at this stage, it is also likely that operational noise would impact the surrounding regions on a long-term basis which will include existing and proposed noise sensitive receptors (for example, Nova Beaco and Nova Viqueque). However, given the unavailability of any engineering design specifications, the long-term noise impacts cannot be quantified and therefore determined if it is 'significantly contributing to ambient noise levels' at this stage.

Decommissioning Noise

Given the project lifespan, the decommissioning phase of the project has not been assessed. It is recommended that a decommissioning and closure plan be developed approximately 10 years prior to commencement of decommissioning, and the associated environmental impacts related to noise are assessed as part of the development of this plan.

7.5.4 Avoidance, Management and Mitigation Measures

Detailed Noise Impact Assessment

Given the lack of detailed design information, a baseline field investigation has been undertaken at this stage. The most effective management measure that should be implemented is a detailed investigation into the environmental and occupational noise impacts, including computer simulation modelling of predicted noise levels across the study area in accordance with the *Guidance for the Assessment of Environmental Factors No. 8 – Environmental Noise (Draft)* (WA EPA, 2007a).

It is also recommended that noise modelling be undertaken when proposed operational equipment specification and locations are confirmed. The aim of the noise modelling should be to determine accurate sound power levels generated from operational activities. This modelling would enable the magnitude of potential noise impacts to be determined and inform noise impact management measures that should be implemented during the operations managing noise to acceptable levels.

A detailed impact assessment can only be conducted once detailed engineering design information for the major noise sources is available. Therefore, only generalised management and mitigation measures are provided below.

As part of a detailed assessment, in accordance to Regulation 9 in Environmental Protection (Noise) Regulations 1997 (WA) an adjustment to the emitted sound levels associated with construction or operational events should be considered (refer to Section 6.5.1). This would be to account for any identified characteristics that may be present in the emitted noise (e.g., tonality, modulation or impulsiveness).

Construction Noise

Construction noise does not have as many established avoidance or mitigation measures as other types of noise. By nature, noise associated with construction activities cannot be avoided. It is also impractical to implement noise mitigation measures, for example noise barriers, for construction activities as they are more suited to longer-term or permanent installations or operations. As such, the primary method to minimise noise impacts from construction activities at sensitive receptor locations is to implement an appropriate noise management plan. It is recommended that a noise management plan specify the following:

- Construction operation hours in which construction-related noise can be emitted.
- Appropriate environmental buffer zones from noise sources.
- Occupational noise policies for construction workers.
- Recommendations for construction methods (e.g., vibrational piling versus pile driver, etc.).
- The compliance monitoring regime and non-compliance incident investigation methods and rectification strategies.

Regulation 13 of the Environmental Protection (Noise) Regulations 1997 (WA), states that construction noise falls under the 'special case regulation' category. As an example of management measures that could be implemented, the following excerpt from the regulations describes how the noise impacts are regulated in Western Australia:

Under the special case regulation dealing with construction sites –

- *A "construction site" is defined as a premises or public place on which the sole or principal activity is the carrying out of construction work;*
- *"Construction work" is clearly defined as in the* Occupational Safety and Health Act 1994*;*
- *The assigned noise levels set in regulations 7 and 8 do not apply to noise emitted from a construction site as a result of construction work on Mondays to Saturdays, under certain conditions; and*
- *Work may be done between 7 pm and 7 am and on Sundays and public holidays, under a stricter set of conditions.*

Daytime Construction

For construction work carried out between 7 am and 7 pm on any day which is not a Sunday or public holiday –

- *The construction work must be carried out in accordance with control of noise practises set out in section six of Australian Standard 2436-2010 "Guide to noise and vibration control on construction, demolition and maintenance sites" (AS 2436-2010);*
- *The equipment used for the construction work must be the quietest reasonably available; and*
- *The chief executive officer (CEO of the Department of Environmental Protection) may request that a noise management plan be submitted for the construction work at any time.*

Construction Out of Hours

For construction work done outside the hours shown above –

- *The work must be carried out in accordance with section six of AS 2436-2010;*
- *The equipment used must be the quietest reasonably available;*
- *The builder must advise all nearby occupants of the work to be done at least 24 hours before it commences;*
- *The builder must show that it was reasonably necessary for the work to be done out of hours; and*
- *The builder must submit to the CEO a noise management plan at least seven days before the work starts and the plan must be approved by the CEO.*

If a builder failed to comply with these conditions, or with the approved noise management plan, the noise from the construction site would be treated the same as noise from any other premises and would need to meet the assigned levels.

Operational Noise

Mitigation measures for noise associated with the operation of machinery are more established than for construction noise. The Guidance for the *Assessment of Environmental Factors No. 8 – Environmental Noise (Draft)* (WA EPA, 2007a), lists the following generic noise mitigation measures commonly used in construction and operational noise management:

- Procurement specifications for new equipment;
- Retrofit treatments for existing equipment or groups of items (e.g., enclosures, silencers, etc.);
- Adjustments to site layouts to increase separation between sources and receivers and to provide shielding;
- Provision of noise barriers; and
- Management procedures to control the types of equipment or operating conditions at certain times of the day or under certain weather conditions (for example, flaring events).

The procurement of appropriate equipment will have a significant effect on the anticipated noise emissions from the project areas. Selection of low-noise equipment wherever possible will assist in reducing noise impacts at the sensitive locations/receptors.

In the event that equipment is deployed in the field and subsequently determined to be excessively noisy, retrofitting equipment with noise reducing measures can significantly reduce their noise emissions. In the case of stationary noise sources like gas compressor engines, enclosures can be created around the source tailored to the specific mitigation requirements. Shielding of noise sensitive locations on-site, for example site offices, via noise barriers can be effective mitigation measures for occupational impacts; however, the design of each barrier should be specific to the location and requirements.

For the Viqueque Airport Upgrade, mitigation of aircraft noise is not easily achievable. Therefore, it is recommended that the higher-noise events (i.e., aircraft taking-off or landing) are managed by scheduling them to occur during times of day that higher noise levels are acceptable, for example between 0700 and 1900 hours Monday to Saturday.

A detailed assessment of the predicted operational noise impacts to both existing and proposed noise sensitive receptors by computer simulation should be undertaken to provide information on what mitigation measures will be the most effective for the Beaco development.

Decommissioning Noise

Given the project lifespan, the decommissioning phase of the project has not been assessed. It is recommended that a decommissioning and closure plan be developed approximately 10 years prior to commencement of decommissioning, and the associated environmental impacts related to noise are assessed as part of the development of this plan.

Noise Management Plans

Separate noise management plans should be prepared for the construction and operation phases of the Beaco development, detailing the implementation of the proposed noise mitigation measures and operational policies. The noise management plans should refer to relevant legislation and standards for guidance, for example DEC, 1997, WA EPA, 2007a and AS 2436-2010).

7.5.5 Residual Impacts

As the residual impacts cannot be quantified at this stage, a qualitative assessment of the residual impacts is provided below. With the implementation of a detailed noise impact assessment, predicted noise levels can be determined across the Beaco study area, therefore specific and appropriate mitigation and management measures can be determined and recommended in noise management plans. The implementation of suitable management plans for both construction and operational phases of the development are likely to result in residual noise impacts kept to reasonable levels and times of the day.

As stated in Section 6.5.4, construction noise is by nature not easily avoided or mitigated, hence the implementation of an effective management plan is crucial to ensure that noise impacts at sensitive receptors are minimised. This can be achieved by conducting the construction work in accordance with standardised guidelines, for example the Environmental Protection (Noise) Regulations 1997 (WA) (DEC, 1997).

Although operational noise can be mitigated more effectively than construction noise for stationary sources located at the LNG plant, it is still likely to measurably affect the noise environment at the Nova Beaco sensitive receptor in the long term due to the proximity of the receptor to the sources. Aircraft noise is also likely to measurably impact the Nova Viqueque and Caraubulo areas throughout the lifespan of the developments, however with the implementation of an appropriate noise management plan, the noise impacts should be kept to acceptable levels. Complaints may occur on occasion as perception of noise levels are subjective by nature and vary between individuals. It is recommended that all complaints are investigated and actioned appropriately. If the investigation

reveals the complaint to be valid, the contributing noise source should be addressed by applying appropriate management measure(s).

In the event that noise mitigation and management measures have been implemented to the maximum extent practicable and the local populace still consider the noise impacts from the development to be unacceptable, relocation of the affected people may need to be considered, as is the case for the village of Beaco.

7.5.6 Monitoring and Reporting

A noise monitoring and reporting program should be prepared to ensure compliance with the developed management plan. The following recommendations have been made to assist in the development of an appropriate monitoring and reporting programme:

- Until noise-related legislation is defined by the GoTL, it is recommended that monitoring and reporting procedures be adopted from other governmental jurisdictions where it is clearly defined, for example the *Environmental Protection Act 1986* for Western Australia.
- Conduct sound power level measurements, or obtain engineering specification sheets for anticipated major noise sources (e.g., major machinery, power generation turbines, etc.) prior to procurement.
- Conduct compliance monitoring of sound power levels at each of the identified sensitive receptor locations for both construction and operation phases of the Beaco development. Compliance monitoring events are to be conducted at a frequency in accordance with (DEC, 1997) and (WA EPA, 2007a) spanning the different defined time categories list below:
  - 0700 to 1900 hours, Monday to Saturday;
  - 0900 to 1900 hours, Sunday or public holidays;
  - 1900 to 2200 hours, all days;
  - 2200 to 0700 hours, Monday to Saturday; and
  - 2200 to 0900 hours, Sunday or public holidays.
- Conduct compliance measurements over a period between 15 minutes and 4 hours in length to obtain a ‘representative assessment period’ for each time category.

Once both sound power measurements of machinery and compliance monitoring events have been completed, the level of contribution from the noise source at the receptor would be calculated by the method detailed in Environmental Protection (Noise) Regulations 1997 (WA). If the noise source(s) are deemed to be ‘significantly contributing’ to a level of noise greater than the assigned noise level at the receptor, noise management measures should be undertaken.

Reporting on the monitored data should be conducted periodically - after each monitoring event detailing the monitoring method, results and calculation of noise source contribution to measured values.

7.5.7 Further Work

The recommended further work related to noise-impacts that should be prepared to assess the Beaco development is as follows:

- Conduct baseline monitoring at the identified sensitive receptor locations in accordance with (DEC, 1997) and (WA EPA, 2007a). This will supplement existing measurement data, establish 'background' noise levels at each sensitive receptor and incorporate seasonal variation in population behaviour, village growth and the development of additional new villages. Required 'background' noise levels are for the following time periods and at all sensitive receptor locations:
  - 0700 to 1900 hours, Monday to Saturday;
  - 0900 to 1900 hours, Sunday or public holidays;
  - 1900 to 2200 hours, all days;
  - 2200 to 0700 hours, Monday to Saturday; and
  - 2200 to 0900 hours, Sunday or public holidays.
- A detailed noise impact assessment of both construction and operational activities including computer simulation of predicted noise impacts on existing and proposed noise sensitive receptors across the Beaco and Viqueque study areas in accordance with Guidance for the Assessment of Environmental Factors No. 8 – Environmental Noise (Draft).
- Development of separate noise management plans in accordance with DEC, 1997, WA EPA, 2007a and AS 2436-2010 for the construction and operation phases of the Beaco and Viqueque developments detailing management procedures and mitigation measures to be implemented.
- Compliance monitoring and reporting in accordance with management plans.

The detailed noise impact assessment requires the provision of detailed engineering design specifications for the proposed works to be able to simulate the impacts adequately.

The implementation of the above further work will facilitate noise from the construction and operation of the LNG plant, Nova Beaco, Nova Viqueque development and the Viqueque Airport upgrade work and associated infrastructure to remain within acceptable noise levels across the development area.

7.6 Surface Water

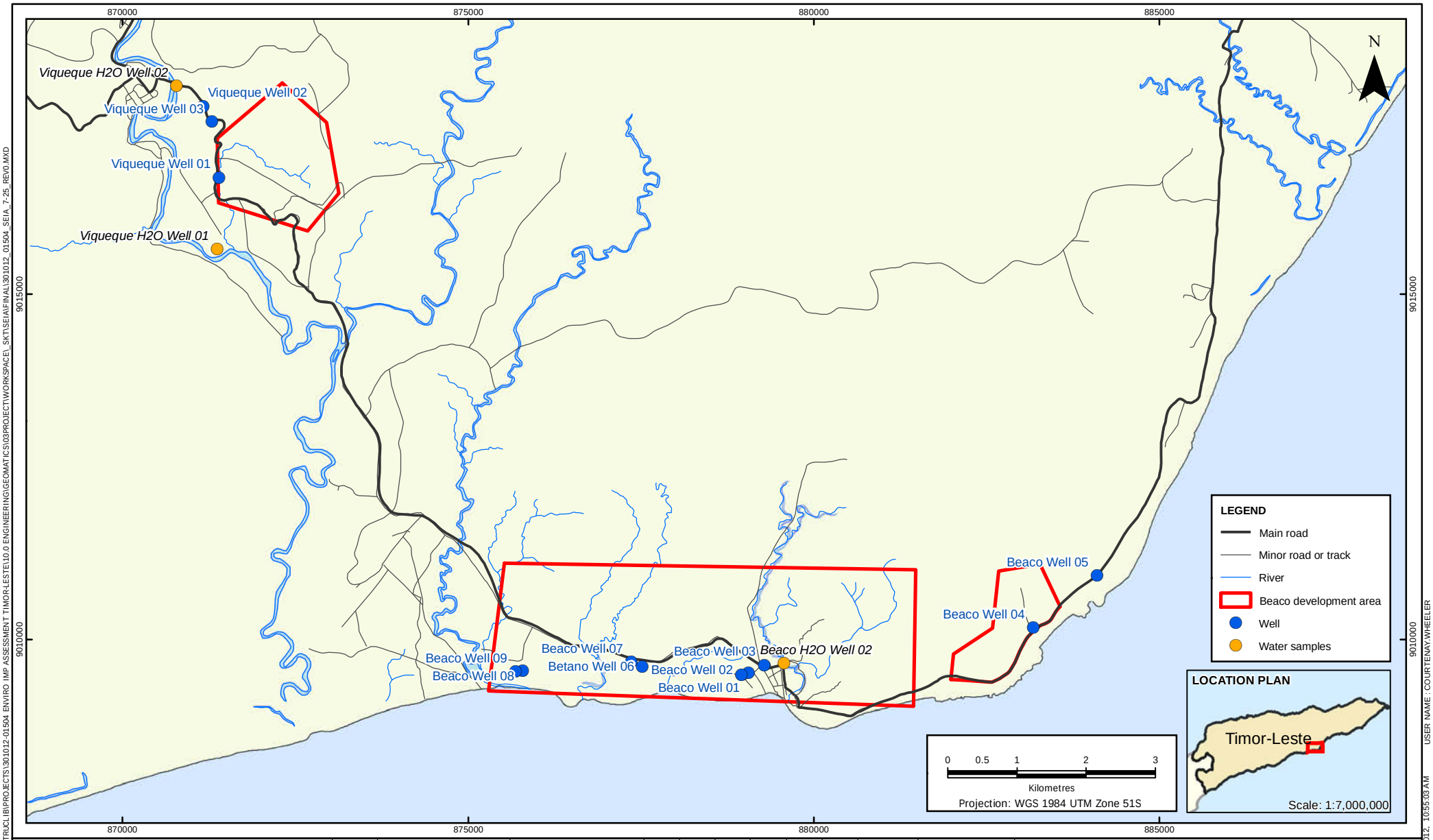
A hydrological impact assessment of the proposed Beaco LNG Plant and associated developments (Nova Beaco, Nova Viqueque and Viqueque Airport) was conducted based on a desktop review of existing data, previous reports and information obtained from a site visit in December 2011. This has allowed a limited, general description of current surface water conditions; an assessment of potential impacts due to the proposed development; a description of possible avoidance/mitigation measures; and development of an outline of future surface water investigation requirements.

7.6.1 Study Method

Available Data

Information incorporated into this assessment is listed below:

- GIS-based topographic information, which was used to delineate catchment areas for the major waterways.
- Continuous rainfall records (at 10 minute intervals) for Beaco Meteorological station for a 10 month period from March 2011 to December 2011.
- Water quality samples taken during the site visit from three locations (refer to Figure 7-25) which were tested for the following physical properties:
  - Temperature.
  - pH.
  - Total suspended solids.
  - Total dissolved solids.
  - Turbidity.
  - Electrical conductivity.
  - Salinity.
- Map showing mean annual rainfall for Timor-Leste.
- Map showing flood risk areas in Timor-Leste.
- A report prepared in 2004 for the Asian Development Bank (ADB) which assessed water resource availability and demand in Timor-Leste titled, *Assessment of Water Availability and Water Demand in Timor-Leste at River Basin Level* (ADB 2004).



LOCATION: \\PERWORFILL1\INFSTRUCL\BI\PROJECTS\301012-01504 ENVIRO IMP ASSESSMENT TIMOR-LESTE\10.0 ENGINEERING\GEOMATICS\03PROJECTWORKSPACE\L_SKT\SEIA\FINAL\301012_01504_SEIA_7-25_REV0.MXD

USER NAME: COURTENAY.WHEELER

PLOT DATE & TIME: 29 MAY 2012, 10:55:03 AM

NOTES:
This map consists of:
1. Rivers: Geographic Information Group TimorLeste (2010)
2. Roads: DivaGIS (2010)

REV	DATE	REVISION DESCRIPTION	DRN	CHK	DES	ENG	APPD	CUST
0	29/05/2012	FINAL FOR ISSUE	MW	CS	-	-	GH	-

A4 SHEET | SCALE 1:75,000

PROJECT No: 301012-001504

WorleyParsons resources & energy

TIMOR GAP, E.P. Timor Gás & Petróleo

REPUBLICA DEMOCRATICA DE TIMOR-LESTE
SECRETARIA DE ESTADO DOS RECURSOS NATURAIS

OneWay to zero harm

Copyright © WorleyParsons Services Pty Ltd

TASI MANE PROJECT - BETANO AND BEACO STRATEGIC ENVIRONMENTAL IMPACT ASSESSMENT

Figure 7-25
Water sampling sites near the Beaco development area

Limitations of Available Data

The surface water assessment was limited by a lack of suitable information. Ideally, an assessment of surface water hydrology draw on the following data:

- At least 20 years of data from daily rainfall gauging stations spread across the region. This data would underpin assessments of long-term water availability for water supply purposes.
- Data from at least one continuous recording rainfall gauging station (pluviograph) in the region capable of giving rainfall at sub-daily time intervals (hourly or minutes). This data is essential for estimating flood behavior and design of drainage facilities.
- At least 10 years of data from one or more stream flow gauging stations in the region. This data is essential for estimating flood flows and would assist in assessing long-term water availability for water supply purposes.
- Topographic information to assist in delineating catchment areas.
- Details of historical flooding at the proposed site including the extent of inundation and frequency of flooding.
- Water quality sampling results for streams in the region addressing physical, chemical and biological properties to provide baseline water quality information against which the impact of any future development would be assessed. The samples should be taken over a long enough period to demonstrate variations in water quality throughout the year in response to seasonal and landuse behavior; as well variations in response to different flow rates. Samples should be taken at sufficient locations to demonstrate variations in water quality due to different catchment conditions and landuse patterns.

A comparison of the required data with that available for the ideal study shows significant shortfalls:

Rainfall

Only 10 months of pluviograph records were available, which is too short to be of value in determining design rainfall intensities or long-term water availability.

Streamflow

There are no stream flow records available for the study.

Water Quality

The available water quality samples were for three sites only, taken on one occasion and only physical parameters were examined. Key chemical and biological parameters were not tested due to logistic issues[7]. This was not sufficient to draw any meaningful conclusions about the current water quality or to assess the likely water quality impacts arising from the planned works.

[7] Only some of the parameters of interest can be tested in Timor-Leste. Special equipment is required to acquire the samples and store them for transport to testing laboratories outside of Timor-Leste.

A detailed investigation into available data was made for the Assessment of Water Resource Availability (ADB 2004). It found that there were 64 daily rainfall stations in Timor-Leste but, data for the period after 1974 was unreliable. As a result, ADB based its study on monthly rainfall data recorded for the period from 1952 to 1974, which they obtained from the Indonesian Meteorological and Geophysics Agency (BMG). Of the six stream flow gauging stations that had been established in Timor-Leste, four had automatic continuous water level recorders and two had manually-read staff gauges. However, three of the automatic stations had equipment problems and had never recorded data and records for the other stations had been lost.

The current status of the rainfall and stream flow gauging stations is not known.

Study Method – Impact Assessment

The adopted study methods have been chosen taking into consideration the available data and are described below.

Water Resource Availability

The assessment of available water resources is based on information contained in ADB 2004. Water resource availability was assessed by the ADB using monthly rainfall runoff models that were established for each river valley and run over a 22 year period, using monthly rainfall data recorded for the period 1952 to 1974. There was no data in Timor-Leste to calibrate the models and so, a model was established and calibrated in a gauged catchment in West Timor and the derived model parameters applied in Timor-Leste.

Flood Flows

Design flows for the streams adjacent to the site have been estimated using the Rational Method and design rainfall intensities transposed from northern Australia. It is expected that design rainfalls in Timor-Leste will be lower than those that have been adopted for this report, hence the design flows are considered to be conservative estimates.

Water Quality

Only general comments on possible water quality impacts and mitigation measures could be made.

7.6.2 Existing Environment

Timor-Leste has a tropical climate dominated by the Asian monsoon. The North West (wet) monsoon occurs between November and May, whilst the South West (dry) monsoon occurs between June and October. Seasonal rainfall patterns vary between the north and south coast due to the central mountain range that generates orographic rainfall and rain shadow effects. As shown in Figure 6-19 (Section 6.6) mean annual rainfall varies across Timor-Leste from 500 mm to 3,000 mm.

The proposed site for the Beaco LNG Plant is located on the southern coast within the Viqueque district. The site is crossed by three minor waterways (Ribeira Buaran, Ribeira Benaro and Ribeira Beaco). Nova Viqueque is located approximately 10 km inland on the banks of Rio Cuhu, which has a catchment area of 268 km^2. The LNG Plant site (Figure 7-26) is located approximately 2 km to the east of the Rio Cuha.

The predominant landuse in the region is agriculture, although natural forests remain in the upper catchments and other areas that are too rugged for agriculture.

The three available water quality samples have high levels of turbidity, which is to be expected due to the high level of agriculture in the catchments. Also, soils in Timor-Leste are generally highly erodible. Information on chemical and biological properties is not available but, it is expected that the water quality would exhibit elevated levels of nutrients, biological oxygen demand (BOD) and pathogens as a result of agricultural landuse and human occupation. Water quality is also expected to varying seasonally in response to agricultural practices and rainfall. Higher pollutants loads are expected during the wet season with high levels of rainfall generating erosion and mobilizing pollutants.

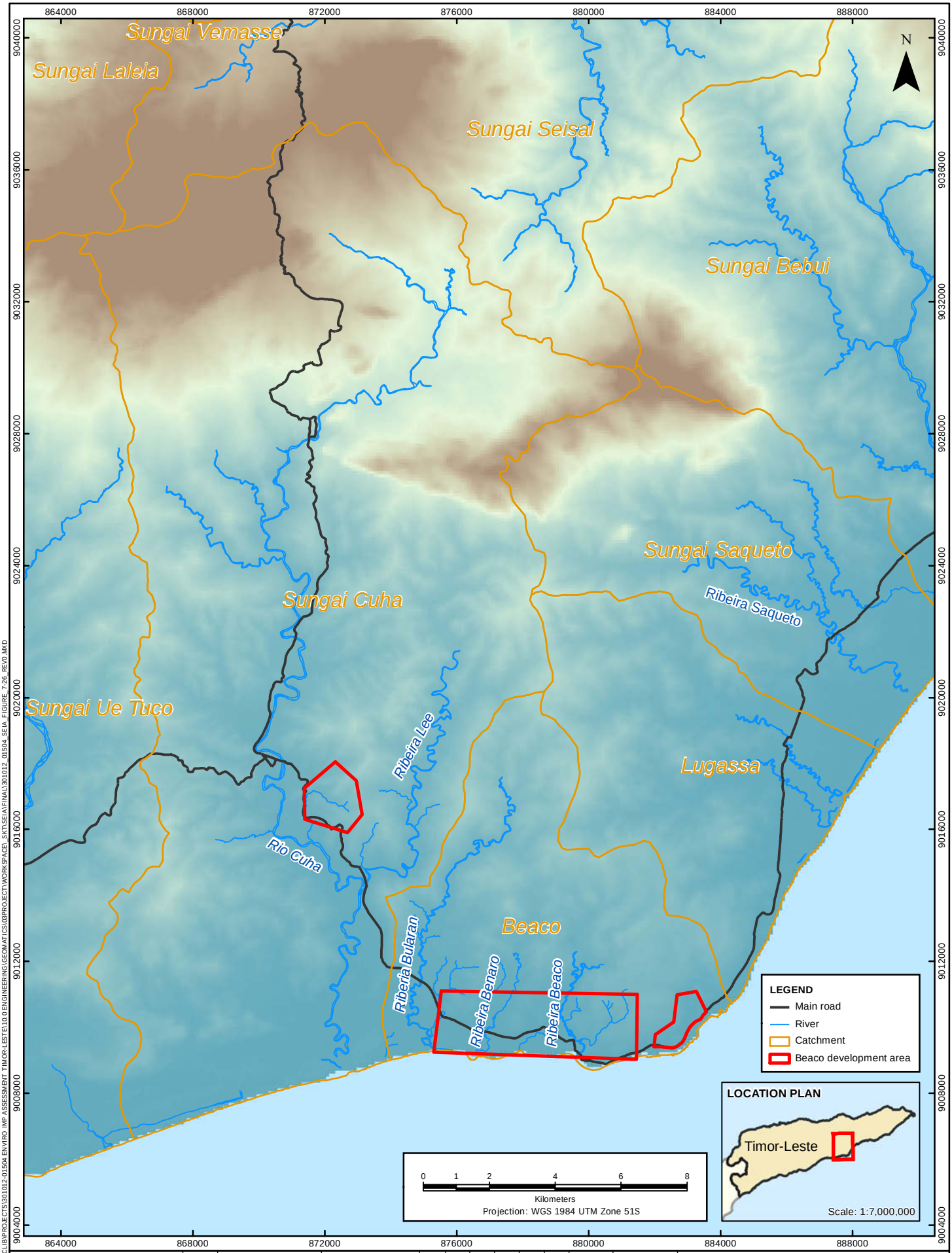
The Beaco site is located within the Irabere Hydrologic Unit. The ADB study showed that irrigation was the dominant water use and that average flows greatly exceeded the average consumptive water demands. However, demands during periods of drought may approach, or exceed flows. Key hydrologic statistics describing water availability and demand are summarized in Table 7-27. Whilst this information is useful in providing a general appreciation of water availability, caution should be exercised in applying the results to future projects, as the generated flows are based on rainfall recorded prior to 1974, which may or may not be representative of current or future climate. Furthermore, the rainfall runoff models used to generate the flows have not been calibrated to recorded streamflows and may be over predicting runoff.

Table 7-27 Key hydrologic statistics for water availability and demand, Beaco

Month	Mean Monthly Rainfall (mm)	Mean Monthly Streamflow (ML/month)	1 in 5 year Monthly Low Flows (ML/month)	Mean Monthly Irrigation Demands (ML/month)
		Rio Cuha[1]	Rio Cuha [1]	Rio Cuha [1]
Jan	197	10,400	3,100	700
Feb	216	22,800	11,400	700
Mar	184	29,900	16,100	300
Apr	209	28,300	15,100	1,700
May	311	32,300	15,600	1,700
June	244	28,000	11,200	1,100
July	164	17,900	7,000	500
Aug	52	10,500	4,600	800
Sep	21	6,100	3,200	1,000
Oct	27	4,000	2,400	1,000
Nov	70	3,400	1,800	300
Dec	187	4,400	2,200	2,100
TOTAL	**1879**	**198,000**	**94,000**	**12,000**

[1] *From ADB 2004*

The LNG site could potentially be flooded by Ribeira Buaran, which has a catchment area of approximately 30 km^2, whilst the Rio Cuhu could cause flooding of Nova Viqueque. A preliminary hydrologic assessment was undertaken to estimate peak flood flows for these watercourses, which are provided in Table 7-28. Site survey information is not available to allow an assessment of the channel capacity or likelihood of flood inundation across the LNG site or Nova Viqueque.



NOTES:
This map consists of:
1. Digital Elevation Model: SRTM (2011)
2. Rivers: Geographic Information Group TimorLeste (2010)
3. Catchment: Geographic Information Group TimorLeste (2010)
4. Roads: DivaGIS (2010)

REV	DATE	REVISION DESCRIPTION	DRN	CHK	DES	ENG	APPD	CUST
0	6/06/2012	FINAL FOR ISSUE	MW	CS	-	-	GH	-

A4 SHEET | SCALE 1:150,000
PROJECT No: 301012-001504

TASI MANE PROJECT - BETANO AND BEACO STRATEGIC ENVIRONMENTAL IMPACT ASSESSMENT

WorleyParsons resources & energy

TIMOR GAP, E.P. TIMOR GAS & PETROLEO

REPUBLICA DEMOCRATICA DE TIMOR-LESTE
SECRETARIA DE ESTADO DOS RECURSOS NATURAIS

OneWay to zero harm

Copyright © WorleyParsons Services Pty Ltd

Figure 7-26
Beaco catchment map

LOCATION: \\PERWORF1L1\INFSTRUCL1\B\PROJECTS\301012-01504 ENVIRO IMP ASSESSMENT TIMOR-LESTE\10.0 ENGINEERING\GEOMATICS\03PROJECT\WORKSPACE_SKT\SEIA\FINAL\301012_01504_SEIA_FIGURE_7-26_REV0.MXD

USER NAME: COURTENAY.WHEELER

PLOT DATE & TIME: 29 MAY 2012, 6:06:32 PM

Table 7-28 Estimated peak flows

Waterway	10 year ARI# (m^3/s)	20 year ARI (m^3/s)	50 year ARI (m^3/s)	100 year ARI (m^3/s)
Rio Cuha	750	923	1167	1370
Ribeira Buaran	124	151	190	220

 # ARI: Average recurrence intervals in years

7.6.3 Potential Environmental Impacts

Potential environmental issues related to surface water include:

- The LNG site could potentially be affected by flooding from Ribeira Buaran and Nova Viqueque could be affected by flooding from Rio Cuha. These sites may require flood protection works.
- High rates of erosion could occur from exposed areas of soil during construction of the site infrastructure.
- The development will require a water supply to meet commercial and industrial needs, as well as the domestic needs of the workforce. It is expected that the water supply will be sourced from the reverse osmosis of seawater; however, if a portion of the supply comes from surface waters, then extractions will affect the flow regime, particularly during low flow periods. Any diversion structures or in-stream storage dams could impact migration of aquatic fauna and modify habitat conditions in the impounded area.
- Following development, runoff from the site may include contaminants including sediment, litter, heavy metals and hydrocarbons which could pollute receiving waters including the adjacent streams and the near shore. Without further treatment, disposal of sewage effluent from Nova Beaco or Nova Viqueque may also pollute receiving waters.
- Following development, the volume of runoff and peak discharge rate from the site is likely to increase due to the conversion from natural vegetation to impervious surfaces. This could potentially exacerbate downstream flooding but, it is not expected to be an issue due to the proximity of the site to the downstream end of the catchment.

7.6.4 Avoidance, Management and Mitigation Measures

The following measures may be required to avoid, manage or mitigate surface water environmental impacts:

- Flood protection measures, such as flood levees and diversion channels, may be required to prevent inundation of the site by flood waters.
- An appropriate soil management and erosion control plan should be prepared and implemented during the construction phase.

- If it is proposed to extract water supplies from surface waters then environmental water requirements will need to be investigated and suitable extraction rules established, with particular regard to protecting flows during drought periods.
- Diversion structures and storage dams, if required, will need to be sited away from environmentally sensitive areas.
- Water quality control measures will be required for treatment of stormwater runoff prior to discharge from the site, which may include use of sediment and litter traps, water quality ponds, wetlands, grassed swales and oil separators (for target areas such as car parks). The aquatic ecologist should identify if there are any sensitive aquatic environments that may be affected by polluted stormwater runoff or changed flow regimes. Care may need to be taken to ensure polluted site runoff is not directed towards these habitats. The aquatic ecologist should also provide target water quality (and flow) criteria to be achieved by the water quality treatment system, based on relevant international standards (such as the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality, ANZECC 2000)* taking into account the characteristics of the receiving waters (existence of threatened species, sensitivity to modified flows and water quality, current level of degradation, future use); and
- Stormwater detention ponds may need to be installed to attenuate flows and ensure that peak discharges do not increase.

7.6.5 Residual Impacts

Following development and implementation of mitigation measures potential residual impacts include:

- A reduction in average flows and change to the flow regime as a result of any surface water extractions.
- A possible decline in water quality due to pollutants from the site not completely removed by the treatment system.

7.6.6 Monitoring and Reporting

Stormwater Quality

Following commissioning of the petroleum refinery and LNG plants monitoring programs should be implemented to assess the water quality of runoff from the site and the adequacy of the storm water treatment system. The monitoring program should persist for a period of two years to ensure that the system achieves the project water quality targets. If the system proves to be satisfactory then the monitoring program can be terminated. However, if the system does not achieve the target water quality standards then suitable augmentation measures will need to be implemented.

7.6.7 Further Work

The following investigations are required to better quantify surface water impacts and to design appropriate mitigation measures:

Survey

A survey of the proposed sites should be undertaken to accurately define ground levels. The survey should also acquire cross sections of the adjacent streams (Rio Cuhu and Ribeira Buaran) for a reach that extends to a distance of at least 2 km upstream of the site.

Hydrologic Investigations

Detailed hydrologic investigations should be undertaken to assess.

- Assess long-term water availability for surface water supplies.
- Appropriate peak design discharges for the adjacent streams.
- Assess the flood liability of the site.
- Design any flood mitigation measures required.
- Determine suitable design rainfalls for site drainage design.
- Determine suitable environmental flow/water extraction rules to protect the aquatic environment[8].

Rainfall and streamflow data should be recorded over a period of at least 12 months.

Water Quality

Water quality measurements should be collected to establish baseline water qualities for creeks and significant waterways potentially affected by the proposed development.

Soil and Erosion Management Plan

A soil and erosion management plan should be developed for the construction phase, to minimise soil erosion and transport of sediment from the site during construction.

[8] this will require input by an aquatic ecologist.

7.7 Hydrogeology

7.7.1 Background

This section provides a general description of the regional hydrogeology, an assessment of potential impacts, a description of possible avoidance, management and mitigation measures and identifies areas for further groundwater investigations.

Groundwater is an important source of water for domestic and agricultural use in urban and rural areas across the island of Timor-Leste; however, little is known about either the quantity or quality of groundwater resources, including the extent of foreseeable impacts due to industrial development (UNDP, 2009).

The proposed Beaco LNG Plant will involve a number of activities that could potentially impact groundwater resources both locally and regionally. In general terms, these can be classified in terms of groundwater quantity or flow, and groundwater quality. Groundwater is also an important component to surface water quantity and quality and linkages to surface water are discussed herein as appropriate.

7.7.2 Study Method

Typically, the first date in developing an understanding of the potential impacts of the project on groundwater resources, is a conceptual understanding of the regional geologic and hydrogeologic framework is typically first developed. An understanding of the potential aquifer, groundwater flow patterns, geochemical distribution and groundwater recharge/discharge patterns is part of that study. A preliminary conceptual model of the hydrogeological system has been developed through a desktop assessment and a brief field program to collect groundwater samples from a number of water wells throughout the Beaco development area.

Water wells were sampled opportunistically during a field visit in December 2011. Field parameters (pH, temperature and electrical conductivity) and water samples for laboratory analysis were collected at twenty wells throughout and adjacent to the proposed Beaco development. Samples were collected using 500 ml plastic bottles and were submitted to the Direcção Nacional Serviço de Agua e Saneamento (DNSAS) or National Directorate for Water and Sanitation for analysis of pH, electrical conductivity (EC), total dissolved solids (TDS), salinity, temperature and turbidity.

Assessment Criteria

Currently, Timor-Leste does not have specific legislation to protect groundwater resources. A draft national water policy was finalized in July 2004 and is yet to be adopted by the Government of Timor-Leste (USAID, 2011). In the absence of drinking water guidelines or standards, the World Health Organization (WHO) drinking water guidelines will be used for assessment (WHO, 2011) to compare groundwater collected from the water wells to an international drinking water standard.

Data Assumptions and Limitations

A limited understanding of the existing hydrogeological conditions in the project area currently exists and this current investigation was limited by the scope of work, in particular the narrow study period. The following data gaps and limitations were identified during this desktop study:

- Specific knowledge/data regarding local and regional aquifers within the proposed project area is not available; therefore no quantification of impacts has been made.
- A number of water wells have been located. However, current water users within and adjacent to the Beaco development area have not been identified and local groundwater use has not been quantified.
- There is currently limited information available on the quality of groundwater within and adjacent to the Beaco development area. Consequently, local groundwater quality and hydrogeochemical types have not been characterized.
- There is currently no data available to quantify surface water-groundwater interactions (including baseflow) within and adjacent to the proposed site.
- Estimates of groundwater extraction rates were not available and no aquifer testing was conducted at the collected water well samples.
- All assumptions are based on a brief review of existing material.

7.7.3 Existing Hydrogeological Concept

Desktop Assessment

Timor Island was formed by a collision complex between the Australian continent and the Banda Arc subduction systems. The peak of collision occurred during Late Miocene-Pliocene and resulted in wide-spread metamorphism. In late Pliocene time, Timor began to emerge as an island and four post-Pliocene units (the marine Baucau Limestone, the Poros Limestone, the Suai Formation and the Ainaro Gravels) were deposited. By the end of the Pliocene, Timor-Leste was covered with alluvial systems and local basins had developed.

Regionally, the Suai Formation outcrops beneath the Beaco development area. The Suai Formation is generally poorly exposed and not well known. North of the development, the sediments are rudite (sedimentary rocks that are composed of rounded or angular detrital) and arenite ranging to gravels (UN, 2003).

Natural groundwater springs are considered the primary source of water for domestic and agricultural uses for 60% of Timor-Leste population (AusAID, 2009) (ADB, 2001). Alluvial deposits and Cenozoic and Quaternary limestones are likely to constitute more productive aquifers than underlying metamorphic complexes and deformed Permian-Jurassic strata, although faulting may have a large impact on groundwater flow even in poorly permeable rocks (BGS, 2007). Studies indicate that the presence of groundwater along the southern coast is generally considered high relative to other areas of Timor-Leste (Monk *et al.,* 1997).

Baseline Groundwater Quantity

Regionally, the Beaco development area is situated within the hydrological region of Clere and Belulic (AWRF, 2006), which is estimated to have a total AGWR budget of 26 million cubic metres (MCM). Estimates of groundwater withdrawals per capita within the Clere and Belulic area were 57 m^3 per year, less than 0.5% of the total water resources per capita (12,486 m^3; ADB, 2004) in an average year. However, during a dry (1 in 5 low flow) year, groundwater withdrawals can account for up to 1% of total water resources due to limited water availability (7,863 m^3 per year; ADB, 2004). At this time, estimates of groundwater recharge and discharge have not been conducted.

In 2004, the Asian Development Bank (ADB) Integrated Water Resources Management (IWRM) Project estimated annual groundwater recharge, storage and sustainable aquifer yield for each of the hydrologic units. Hydrogeological units from a map of West Timor were extrapolated to Timor-Leste and a recharge factor was applied based on rock type, estimated permeability, slope and vegetation cover (ADB, 2004). Within the Clere and Belulic hydrologic region, a total sustainable yield of 25.5 MCM/year (809 L/s) and a total storage of 6,800 MCM were calculated based on an average aquifer extent of 340 km^2 and 100 m in thickness. These values indicate an abundance of groundwater within the region. However, they should be considered very approximate estimates of deep (>100 m) aquifers which are likely to be difficult and expensive for local residents to access.

Shallow wells are used extensively in villages and rural areas, especially those near the sea or on river plains. Numerous shallow wells exist across Timor-Leste, both in urban and rural areas. However, many of these were damaged or contaminated during the years of conflict either side of independence. A small number of boreholes also exist, most notably in the southern alluvial plain (BGS, 2007).

Baseline Groundwater Quality

It is expected that concentrations of inorganic constituents in groundwater will be dependent on the pH and redox (oxidizing/reducing) conditions of regional and local aquifers, and current information and assessments of potential groundwater quality are made on the basis of available geological information. Site-specific groundwater quality characterisation has not been performed, as collation of an adequate geochemical suite of groundwater samples from water wells at the Beaco development area has not been possible in the study period.

Regionally, reports of inadequate sanitation and waste management systems (Pederson and Arneberg, 1999) imply that shallow groundwater is potentially under threat from pollution, especially in urban and peri-urban areas. In rural areas, pollution from agricultural sources is also a potential problem although it is noted that limited industrial development to date in Timor-Leste would suggest that industrial pollution is currently a comparatively minor threat to water quality (UNDP, 2009).

Groundwater data, including laboratory analyses, are summarized in Table 7-29. Average temperatures of the groundwater samples ranged from 24.0 to 24.7°C, with pH values ranging from 7.4 to 7.6, which are within the WHO drinking water guideline range of 6.5 to 8.5 (WHO, 2011).

Groundwater samples were analyzed for total dissolved solids (TDS), salinity and turbidity and are also summarized in Table 7-29. TDS values ranged from 174 to 551 mg/L, with all water samples below the WHO drinking water guideline criteria of 1,000 mg/L. Salinity values ranged from 0.2 to

0.6%. There is currently no WHO drinking water guideline for salinity. Turbidity values ranged from 1.5 to 36 NTU; with the majority of samples reporting values at or above the WHO drinking water guideline criteria of 5 NTU. Turbidity values reported above the WHO guideline value indicate the presence of silt, sand, mud, bacteria and/or chemical precipitates, which may adversely affect water treatment systems, such as sedimentors or gravel filters. Where chlorination of water is practised, even quite low turbidity can prevent effective chlorination. It is also important to control turbidity in drinking water supplies for both health and aesthetic reasons (WHO 2011). Further baseline groundwater quality testing is required to appropriately characterise the conditions at the site.

Table 7-29 Groundwater Quality Analyses: Physical Parameters

	Physical Parameters Analysed						
Well Name	**pH**	**EC (uS/cm)**	**TSS (mg/L)**	**TDS (mg/L)**	**Salinity (%)**	**Temp. (C)**	**Turbidity (NTU)**
WHO DWQG[1]	6.5-8.5	---	---	1000	---	---	5
Beaco							
Beaco Well 01	7.6	1103	0.07	551	0.6	24.4	9.1
Beaco Well 02	7.5	825	0.05	412	0.4	24.7	1.5
Beaco Well 03	7.6	486	0.03	243	0.2	24.2	4
Beaco Well 04	7.5	348	0.03	174	0.2	24.0	12
Beaco Well 05	7.5	522	0.04	256	0.3	24.3	3.5
Beaco Well 06	7.4	789	0.05	394	0.4	24.7	36
Beaco Well 07	7.5	410	0.03	205	0.2	2.40	12
Beaco Well 08	7.6	522	0.04	261	0.3	24.3	8.1
Beaco Well 09	7.5	637	0.04	318	0.3	25.0	5.2

Notes:

6. --- in guideline row(s) denotes no criteria for that parameter
7. --- in detail row(s) denotes parameter not analysed
8. Shading indicates parameter above applied guideline/criteria
9. Superscript [1] denotes value exceeding World Health Organization Drinking Water Guideline, 2011

7.7.4 Environmental Impacts

It is expected that impacts to groundwater during construction and operation phases of the Beaco development will be similar.

Construction and operation of the Beaco development has the potential to adversely affect groundwater and could potentially result in one or more of the following:

- Localised changes in groundwater quality.
- Localised changes in groundwater flow patterns.
- Minimal effects on groundwater recharge and discharge.
- Site-dependent changes to surficial hydrology and water quality.

Likely sources of the groundwater impacts include:

- Construction and operation of surface facilities.

- Disposal of process water.
- Leachate from solid waste disposal (e.g., containment of wastes).
- Accidental spills or releases of chemicals and fuels.

An overview of potential impacts to groundwater resources has been provided; however, a more precise definition of impacts to groundwater quantity and/or quality cannot be quantified at this time due to the lack of sufficient information on local groundwater conditions.

Impacts to Groundwater Quality

A review of the geology within the Beaco development area indicates that shallow sediments are primarily comprised of unconsolidated pebbly gravels, sands and fine silts of the Suai Formation. Depth to the water table is between 2 to 10 metres below ground surface (mbgs) and the unconsolidated material of the Suai Formation is expected to have a relatively high permeability. Consequently, mitigation measures will need to be implemented at the earliest stage of construction to ensure that there are no adverse impacts on shallow groundwater resources for the spillage of fuels, lubricants or other chemicals.

New surface facilities for the proposed development include a LNG Plant and associated infrastructure (process and utilities such as gas reception and LNG trains), jetties, shore-based facilities, fuel tank farm, reverse osmosis system and water storage tanks, fire-fighting facilities and accommodation facilities. Accidental releases (including spills and leaks) from surface facilities could negatively impact shallow groundwater quality. The potential risk to receptors (e.g., groundwater users or surface water bodies) will depend on the spatial and temporal nature of the release, the materials released, the site-specific subsurface hydraulic conditions (e.g., depth to groundwater, groundwater flow velocity and adsorption capacity of the soil) and the effectiveness of mitigation measures at the release location.

Onsite disposal of process water also has the potential to introduce contaminants into groundwater and subsequently by groundwater discharge, to surface water systems (i.e., rivers, streams or creeks). In many rural to semi-rural areas of Timor-Leste, residents access water through shallow water wells or natural springs. The potential contamination of groundwater via disposal of process water may affect residents that use groundwater for drinking water purposes or as a potable water supply for agricultural purposes. If disposal of process-affected water is incorrectly handled, the potential to adversely affect the quality of baseflow (groundwater discharge to surface water) also exists. The disposal of process water is described in Section 7.12 Waste Management.

During construction and operation phases, non-hazardous solid waste will be generated from accommodation facilities and during site preparation and construction of surface facilities as described in Section 7.12 Waste Management. Solid waste and effluent that are expected to be generated from the project development may adversely affect shallow groundwater if not properly contained. Domestic effluents are also anticipated during the construction phase; however, it is expected that domestic effluents will be diverted to the waste water treatment plant and, as such, are not considered to be significant.

Hazardous solid waste and medical waste are also expected to be generated during construction and operation activities. These wastes can potentially affect groundwater quality if not handled properly.

Leachate of hazardous waste can potentially cause permanent deterioration of groundwater quality and should be considered a significant potential impact.

Chemicals used during the construction and operation phases of the project may contain a variety of constituents that have the potential to adversely affect groundwater quality if leaked or spilled from tanks/vessels, holding ponds, and/or malfunction of equipment (including pumps or piping). These constituents and their by-products may include various hydraulic fluid, engine coolant, diesel, gasoline, hydrochloric acid, sodium hydroxide, and corrosion inhibitors.

Impacts to Groundwater Flow, Recharge and Discharge

The topography of the island of Timor-Leste is generally mountainous and characterised by rugged terrain and small narrow valleys with decreasing elevation towards the coastline. It is expected that the topography of Timor-Leste influences the general direction of shallow groundwater flow and also influences groundwater recharge and discharge. It is expected that shallow groundwater recharge occurs regionally within mountainous areas into zones of saturation and generally follows the topography towards the coastline. Groundwater data indicates that shallow groundwater is generally considered fresh (<1,000 mg/L TDS), which suggests rainfall is likely to be the main source of recharge.

The primary impact on the groundwater flow system at Beaco is expected to be from groundwater dewatering and extraction of groundwater for industrial or domestic (i.e., drinking water) purposes. Significant lowering of the groundwater table may adversely affect existing users of groundwater in the future; primarily during dry times (low flows) of the year. Natural springs are fed by groundwater and can be threatened by a fall in the groundwater table. A continued reduction in the water table level from groundwater mining may lead to land subsidence in geologically susceptible areas.

Impacts to Groundwater – Surface Water Interaction

Groundwater is recharged from surface water precipitation and infiltration. Surface water and groundwater interaction are complex events and are susceptible to changes in surface recharge, due to variations in surface features. Interaction may be described as occurring in four basic ways:

- Streams gaining water from inflow of groundwater through the streambed.
- Streams losing water to groundwater by outflow through the streambed.
- Streams that do both, gaining in some parts and losing in others.
- Alternating between gaining and losing depending on relative stream and groundwater levels.

Adverse impacts to groundwater-surface water interactions may result in changes to surrounding surface water flow volumes due to changes (increases or decreases) in groundwater flow or impacts on surface water quality from contaminated groundwater (baseflow) contribution. Any adverse impacts on groundwater quality (noted above) could also impact surface water systems in which groundwater is the primary source of baseflow. Baseflow contributions have not been calculated as part of this study and therefore no quantification of impacts can be conducted.

Decommissioning Impacts

Given the project lifespan, the decommissioning phase of the project has not been assessed. It is recommended a decommissioning and closure plan will be developed approximately 10 years prior to commencement of decommissioning and the associated environmental impacts related to groundwater assessed as part of the development of this plan.

7.7.5 Avoidance, Management and Mitigation Measures

To mitigate the potential of adversely affecting groundwater, control measures that can be implemented to minimise the potential adverse impacts on groundwater quantity and quality include:

- Development of groundwater monitoring plans to include a site assessment, baseline monitoring and continued groundwater monitoring, as outlined in Chapter 8 Environmental Management Framework.
- Development of a comprehensive spill response plan.
- Development of an environmental monitoring plan for surface and subsurface petroleum storage and distribution facilities.
- Development of a comprehensive sanitation system and waste disposal plan that complies with internationally-recognized best practice standards.

7.7.6 Residual Impacts

At this time, there is not enough site-specific groundwater data to quantify residual impacts. However, if mitigation measures and proper management of groundwater resources are not implemented, the Beaco development has the potential to adversely affect groundwater resources and these impacts could extend past the life of the project.

Mitigation measures and groundwater monitoring can be implemented in the vicinity of surface facilities and areas of potential groundwater impacts to identify releases and minimize potential impacts. Depending on the nature and volume of the releases, the impacts could extend past the operational life of the project. However, as the conditions of potential spills/releases are unknown the duration of impact can only be predicted as long-term. Effective mitigation measures, such as monitoring, would reduce any residual impacts.

7.7.7 Monitoring and Reporting

The following recommendations are provided to assist in the development of an appropriate groundwater monitoring plan (GMP) for the groundwater monitoring and reporting program. The GMP should be developed in alignment with relevant legislation and regulations (as applicable) and international standards (e.g., WHO Drinking Water Guideline). Components of the GMP should include:

- Site Assessment
  - Identification of source, pathway and receptors.

  - Description of measures, activities and procedures that will be implemented to ensure groundwater quality and quantity is protected from potential impacts.

- Baseline Monitoring
  - Development of a groundwater monitoring well network to collect further data prior to construction of surface facilities and to establish site-specific baseline conditions for groundwater quality and quantity.
  - Establishment of site-specific triggers and limits for groundwater quality and quantity based on an established method.
- Groundwater Monitoring Plan
  - Rationale for proposed monitoring wells, including location, spatial coverage and target geological zones.
  - Selection of primary and secondary indicator parameters to be analysed at specified monitoring wells.
  - Proposal of monitoring frequency for specified monitoring wells.
  - A summary of the site-specific approaches for assessing and managing potential impacts (e.g., should an established groundwater trigger or limit be exceeded).

7.7.8 Further Work

Further work is required to further characterize groundwater quality and quantity within and adjacent to the Beaco development. This work should include:

- An assessment of existing groundwater users in the vicinity of the Beaco development area including drinking water and irrigation water users.
- A detailed site survey to identify groundwater recharge and discharge areas, potential groundwater dependent ecosystems (GDE) and current land uses.

Installation of a groundwater monitoring network to determine local groundwater conditions, including, current groundwater quality, groundwater surface elevation and flow direction, estimates of groundwater storage, potential hydraulic connection between surficial aquifers and underlying bedrock and groundwater-surface water interactions.

7.8 Terrestrial Biodiversity

WorleyParsons undertook a flora and vegetation assessment, and a vertebrate fauna assessment of the Beaco development area in December 2011 and February 2012. The full report is presented as Attachment 01.

Throughout this section, the following definitions apply:

- *Conservation status* refers to a species' status listed under the International Union for Conservation of Nature (IUCN) Red List of Threatened Species or in the Convention on International Trade in Endangered Species (CITES).
- *Conservation significant species* refers to species that have a higher risk of extinction, i.e., those listed as Critically Endangered, Endangered, Vulnerable and Near Threatened under the IUCN Red List of Threatened Species.

The legislation relevant to environmental protection and biodiversity conservation in Timor-Leste includes the following laws and regulations:

- Law No. 5, 1990 on Conservation of Biological Resources and their Ecosystems.
- Law No. 5, 1994 Concerning Biodiversity.
- Government Regulation No. 28, 1985 on Forest Protection.
- Government Regulation No. 51, 1993 on Environmental Impact Analysis.
- United Nations Transitional Administration in East Timor Regulation No. 2000/17.
- United Nations Transitional Administration in East Timor Regulation No. 2000/19.

The United Nations Transitional Administration in East Timor (UNTAET) Regulation No. 2000/19 is particularly relevant to the Tasi Mane Project as it protects endangered species, wetlands and mangroves, historical and cultural sites, biodiversity conservation, and biological resources.

7.8.1 Study Method

The flora and vegetation, and fauna study methods are summarised below. Further detail on the methods is provided in Section 3 of Attachment 01.

The field surveys were undertaken over nine days in December 2011 and seven days in February 2012 at the proposed Beaco (the focus of this section) and Betano (Section 6.8) development areas. The field surveys conducted at the proposed Beaco development area are discussed in more detail below.

Flora and Vegetation

Desktop Review

Historical information and data from previous surveys undertaken in the vicinity of the Beaco development area was reviewed. Data from the IUCN Red List of Threatened Species and CITES

was also reviewed. Locally relevant information was also sourced from reference text and academic experts.

A list was then compiled of the flora and vegetation species identified and the conservation status of these species, as listed under the IUCN Red List of Threatened Species. For species not listed on the IUCN Red List of Threatened Species, CITES was used to provide an indication of the relative global conservation status of the species.

Vegetation Field Survey

WorleyParsons undertook a broad assessment of plant communities and their distribution, floristic composition and structure in the Beaco development area. The assessment included sampling vegetation communities opportunistically at various observation points within the study area. It was not possible to complete a quadrat sampling design in the time available for the surveys.

Vegetation descriptions were adapted from those developed by Cowie (2006 and 2007) and presented in Table 2 of Attachment 01. The vegetation classes (lowland forest, highland forest, montane forest, wetland forest, coastal forest and man-made forest) and descriptions were used during the field survey to identify vegetation communities, structure and dominant species composition.

Flora Field Survey

Within the Beaco development area, a greater emphasis was placed on the flora survey than the vegetation survey. The flora field survey focussed on common and dominant species, and species of conservation and economic importance. Quantitative sampling and recording structural attributes was not undertaken given the limited timeframe for assessment.

During the field survey, WorleyParsons took photographs of live specimens and collected various samples of plant life forms including trees, shrubs, herbaceous species, vines, ferns, and epiphytes (non-ferns). WorleyParsons also recorded the conservation status of the flora species, and obtained their local Tetum names, where known.

All of the plant specimens collected were pressed for several days in a field press, before being preserved (for the short term) using a technique described by Forman and Bridson (1989) in Attachment 01. This technique is suited to the wet tropical conditions experienced at the time of survey. On return to Australia, the pressed plant specimens were submitted for gamma irradiation to meet AQIS regulations. This process took approximately four weeks for the plant species collected in December 2011, and three weeks for the plant species collected in February 2012. The species were then submitted to the Northern Territory herbarium for identification.

Fauna

Desktop Review

Similar to the flora and vegetation survey, the vertebrate fauna survey involved a review of historical information and data from previous surveys undertaken near the Beaco development area. Data from the IUCN Red List of Threatened Species, the Birdlife International Database and CITES was also reviewed. Locally relevant information was also sourced from reference text and academic experts.

Following review of this data, a comprehensive inventory of local fauna species was developed. This list will invariably include some species that do not occur in the study area, because some fauna have a limited or patchy distribution, high level of habitat specificity, are locally extinct or were erroneously identified in previous surveys. Some records, i.e., extinct species, were excluded from this inventory.

Fauna Field Survey

The focus of the fauna field survey was to identify broad fauna habitats based on vegetation associations and known landforms. Once identified, the fauna habitats were mapped and assessed for their potential to support fauna, in particular species of conservation significance. Habitats were assessed on the basis of their complexity, the presence of microhabitats (including significant trees with hollows, loose bark, fallen hollow logs and leaf litter) and other habitat features likely to provide foraging opportunities and/or shelter for fauna, such as water bodies and rocky outcrops. Five vertebrate fauna habitat assessments were undertaken across the Beaco development area.

Acoustic ultrahigh frequency equipment (Anabat) was used to record the presence of microbats. The equipment was placed in the study area to achieve a broad coverage but, is also designed to target potential maternal and breeding roosts. The location of the Anabat recordings and the habitat assessment areas are shown in Figure 7-27.

Active searching for ground dwelling reptiles and mammals was also undertaken, which included searching and recording scats, tracks and other traces; digging up burrows; turning over rocks and logs; splitting fallen timber; raking soil and leaf litter; peeling off bark; and searching rock habitats (in cracks and caves, around water bodies and in holes in fence posts).

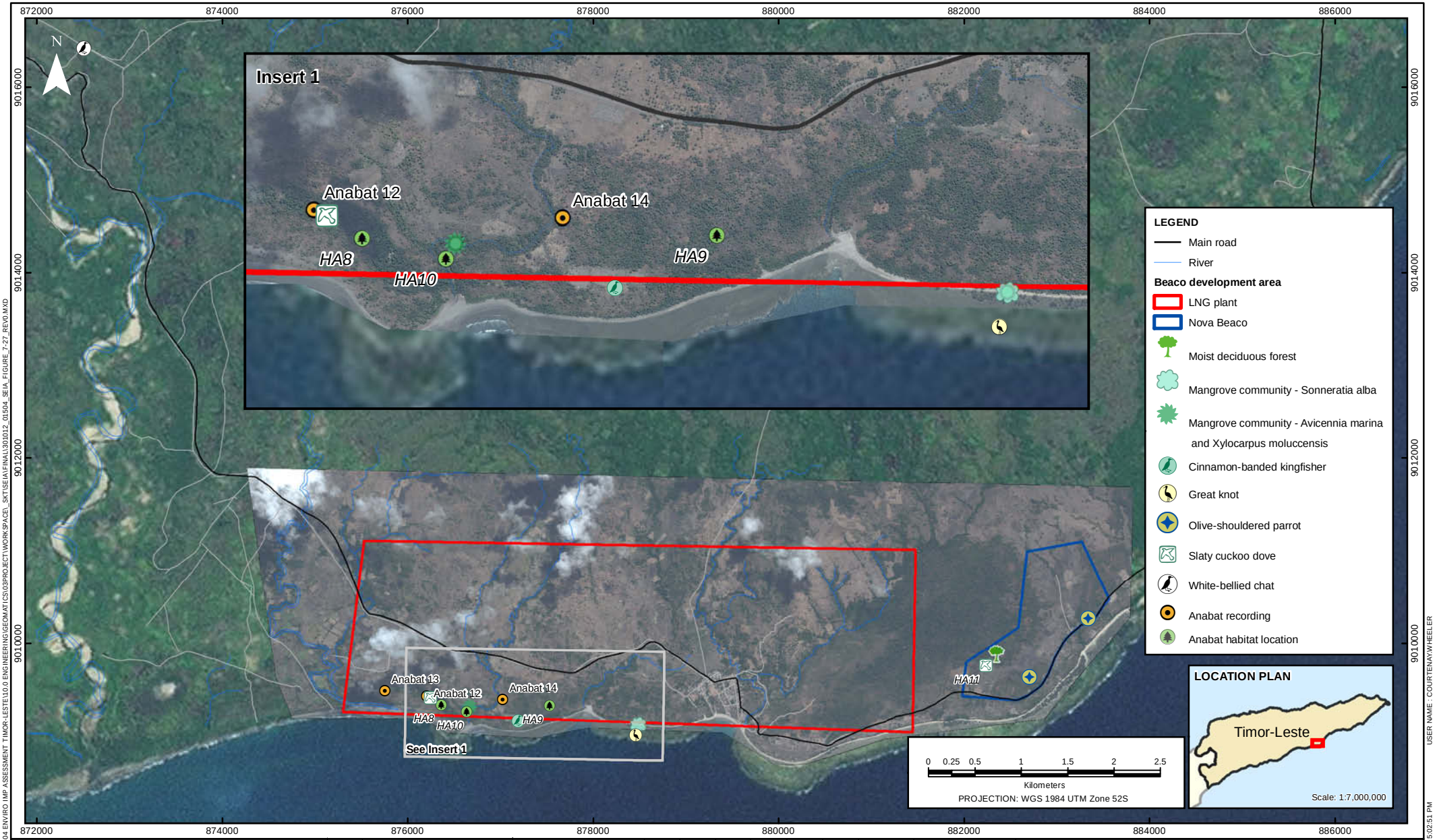
In addition, call play back was used for avian species which are known to respond to species to species calls for active identification in the study area.

Limitations

Flora and Vegetation

Due to the limited time available for field surveys, the flora and vegetation assessments were undertaken at the same time. The surveys focused on determining vegetation structure, dominant species and plants of interest. Less emphasis was placed on ferns, herbs and other non-dominant flora.

Detailed mapping of vegetation polygons was not undertaken during the field surveys as extensive ground-truthing and detailed inventories from plots/quadrats is required for this level of assessment.



NOTES:
This map consists of:
1. Imagery: Digital Globe (2008-2011)
2. Rivers: Geographic Information Group TimorLeste (2010)
3. Roads: DivaGIS (2010)
4. Vegetation communities: WorleyParsons (2012)

REV	DATE	REVISION DESCRIPTION	DRN	CHK	DES	ENG	APPD	CUST	A4 SHEET	SCALE 1:55,000
0	5/06/2012	FINAL FOR ISSUE	MW	CS	-	-	GH		PROJECT No: 301012-001504	

WorleyParsons resources & energy

TIMOR GAP, E.P. Timor Gás & Petróleo

REPUBLICA DEMOCRATICA DE TIMOR-LESTE
SECRETARIA DE ESTADO DOS RECURSOS NATURAIS

OneWay to zero harm

Copyright © WorleyParsons Services Pty Ltd

TASI MANE PROJECT - BETANO AND BEACO STRATEGIC ENVIRONMENTAL IMPACT ASSESSMENT

Figure 7-27
Beaco study area biodiversity key sites

LOCATION: I:\PROJECTS\301012-01504 ENVIRO IMP ASSESSMENT TIMOR-LESTE\10.0 ENGINEERING\GEOMATICS\03PROJECT\WORKSPACE_SKT\SEIA\FINAL\1301012_01504_SEIA_FIGURE_7-27_REV0.MXD
PLOT DATE & TIME: 05 JUN 2012, 5:02:51 PM
USER NAME: COURTENAY.WHEELER

In addition, it was not possible to record all species present at the Beaco development area given the limited survey period. Lichens, bryophytes (mosses and liverworts), epiphytes, and parasitic plants occurring high up in the tree canopy, were also not included in survey.

Flora surveys are ideally undertaken at the best time of year for detecting the most plant species, and across multiple seasons in order to capture seasonal variation. As such, the timing of the field surveys, during the wet season, has limited the plant species that were able to be recorded at the site.

Recommendations for further work, such as additional surveying and ground-truthing, have been made in Section 7.8.6 to address these limitations.

Fauna

Similar to the flora surveys, fauna surveys are ideally undertaken at the best time of year for detecting the most fauna species, and across multiple seasons in order to capture seasonal variation. As such, the timing of the field surveys, during the wet season, has limited the fauna species that were able to be recorded at the site. The length of the surveys (16 days) was also insufficient to accurately identify all species that potentially occur in the study area.

7.8.2 Existing Environment

Timor-Leste is located in the Malay Archipelago and represents the largest and eastern-most of the Lesser Sunda Islands (World Bank, 2009 in Attachment 01). The island is in the Central Melesia (Wallacea) region and its flora is considered to be transitional between the main rainforest blocks of the Sunda (Peninsula Malaysia, Sumatra, Borneo, West Java) and Sahul (New Guinea) shelves (van Welszen *et al*, 2005 in Attachment 01).

The coastal plain of southern Timor-Leste has largely been cleared in association with swidden ('slash and burn') agriculture, sandalwood harvesting, plantation estates and timber plantations. Remnant vegetation exists as highly fragmented and secondary communities. Most of the understory within remnant vegetation and agricultural land is dominated by invasive species, particularly Siam weed (*Chromolaena odorata*) and cogon grass (*Imperata cylindrica*). Grasses are extensively grazed by cattle, water buffalo, pigs and goats.

General Overview of the Beaco Development Area

The proposed site of the Beaco LNG plant lies on a coastal plain largely cleared for grazing, agriculture, teak and coconut plantations. The low lying coastal plain area is often inundated during the wet season. Remnant vegetation in this area exists as a narrow strip of coastal vegetation and small areas of coastal mangroves, riparian mangroves and remnant moist deciduous forest along the eastern boundary. Remnant moist deciduous forest comprises the western portion of the Nova Beaco site. The key vegetation communities, and their indicative boundaries, are shown on Figure 7-28.

Nova Viqueque is situated on rolling hills with some limestone outcropping visible. Vegetation is largely cleared for agriculture and water buffalo and cattle grazing. Remnant vegetation exists as patches of very open secondary vegetation or scattered trees on hill tops and in minor drainage lines.

Viqueque airstrip is grassed, adjacent to a village and is currently used for cattle and water buffalo grazing.

Vegetation Communities

Coastal Vegetation

Narrow strips of coastal vegetation occur on the beach shore and are less disturbed by grazing. Vegetation is characterised by several species of large trees including *Calophyllum inophyllum* and *Nauclea orientalis*. Smaller tree species include S*chleichera oleosa, Cerbera manghas, Cordia dichotoma, Pandanus* sp.*, Maytenus marginata, Bridelia ovata* and *Elattostachys verrucosa*. Common shrub species include *Scaevola taccada, Cordia subcordata,* Siam weed and crown flower.

In some low-lying areas, there are areas of dense forest which are characterised by a canopy height of 20 to 25 m and includes the tree and shrub species *Dolichandrone spathaceae, Litsea glutinosa* and *Tabernaemontana pandacaqui.* There are patches of *Saccharum spontaneum*, a tall grass up to 3 m in height, and other grasses, including the invasive weed Cogon Grass.

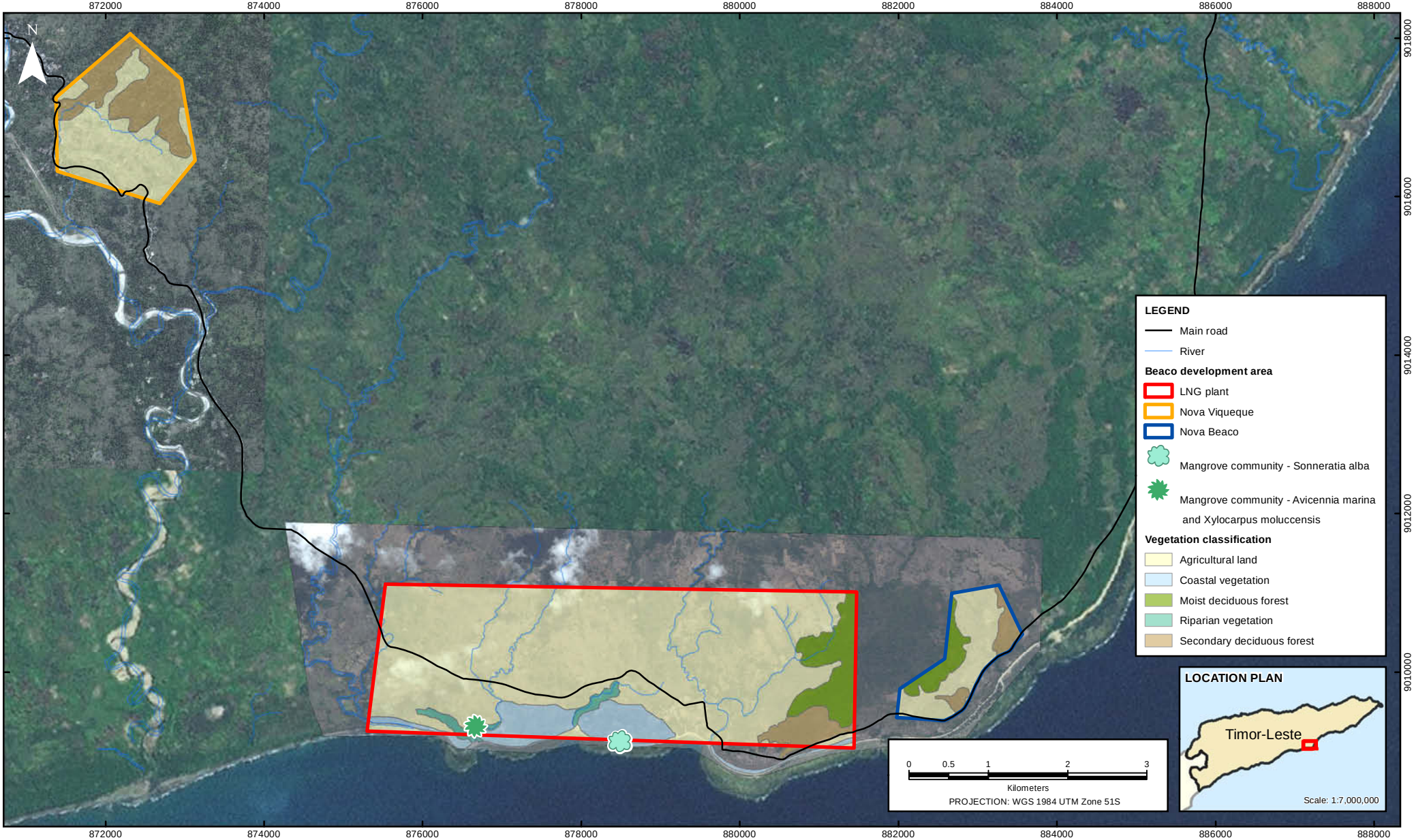
Mangroves

In the Beaco LNG Plant area a single coastal mangrove community was recorded as well as two areas of riparian mangrove communities on estuarine rivers (locations shown in Figure 7-28).

Coastal mangroves were represented by a tall stand of *Sonneratia alba* (white-flowered apple mangrove) trees that recorded on a rock substrate on the seaward edge to the west of Ponta Beaco (Plate 7-41). Trees were up to 15 m in height and were surrounded by elongated pneumatophores to 0.3 m in height.

Riparian mangrove communities were recorded along estuarine rivers or landward inlets within the Beaco development area. Dominant species include *Acanthus ilicifolius* (listed as being of Least Concern on the IUCN Red List) shrubs to 1 m in height, *Exocoecaria agallocha, Heritiera littoralis* and *Hibiscus tiliaceus* trees between 10 to 15 m in height, and sedges *Cyperus javanicus*. These mangrove communities are adjacent to a coastal forest dominated by *Borassus flabellifer* and Siam weed.

A large riparian mangrove forest community was recorded on a narrow estuarine river, within the Beaco development area and the area is known locally as ‘Belalut’ (Plate 7-42). Belalut is considered to be an important crocodile habitat by local people and is characterised by tall trees with a closed canopy.



NOTES:
This map consists of:
1. Imagery: Digital Globe (2008-2011)
2. Rivers: Geographic Information Group TimorLeste (2010)
3. Roads: DivaGIS (2010)
4. Vegetation communities: WorleyParsons (2012)

REV	DATE	REVISION DESCRIPTION	DRN	CHK	DES	ENG	APPD	CUST
0	29/05/2012	FINAL FOR ISSUE	MW	CS	-	-	GH	

A4 SHEET | SCALE 1:65,000
PROJECT No: 301012-001504

WorleyParsons resources & energy

TIMOR GAP, E.P. Timor Gás & Petróleo

REPUBLICA DEMOCRATICA DE TIMOR-LESTE
SECRETARIA DE ESTADO DOS RECURSOS NATURAIS

OneWay to zero harm

Copyright © WorleyParsons Services Pty Ltd

TASI MANE PROJECT - BETANO AND BEACO
STRATEGIC ENVIRONMENTAL IMPACT ASSESSMENT

Figure 7-28
Beaco study area vegetation communities

LOCATION: \\PERWORFIL1\INFSTRUCI\IBV\PROJECTS\301012-01504 ENVIRO IMP ASSESSMENT TIMOR-LESTE\10.0 ENGINEERING\GEOMATICS\03PROJECT\WORKSPACE_SKT\SEIA\DRAFT\301012_01504_SEIA_7-28_REV0.MXD
USER NAME - COURTENAYWHEELER
PLOT DATE & TIME - 29 MAY 2012, 2:03:37 PM

Plate 7-41 Coastal mangrove

Plate 7-42 Riparian mangrove on a narrow estuarine river

LOCATION: \\perworfil1\infstructib\Projects\301012-01504 Enviro Imp Assessment Timor-Leste\2.0 Reports\2.9 SEIA - Betano and Beaco\Plates\03_Working\BP092_BP093\301012_01504_SEIA_Plate_7-41_7-42.vsd
PLOT DATE AND TIME: 1 Jun 2012, 11:24 AM Creator: Courtenay Wheeler

Secondary Vegetation

In the Beaco LNG Plant area, secondary vegetation is characterised by very open 'regrowth' forest, over grassland and introduced weed communities. This community is common in the area and results from repeated cycles of 'slash and burn' or swidden agriculture. Most trees are deciduous at the end of the wet season. Dominant trees include *Borassus flabellifer, Corypha utan, Schleichera oleosa* and *Ziziphus mauritiana*.

The occasional cashew, sandalwood or breadfruit tree was observed. Invasive weeds comprise the understory and cattle and water buffalo graze on grasslands. There is also some ground disturbance by wild deer and wild pigs.

In the Nova Viqueque area, vegetation exists as patches of very open forest or scattered trees over grassland and introduced weed communities Plate 7-43.

Moist Deciduous Forest

On the eastern edge of the Beaco LNG site and western edge of the Nova Beaco site, large areas of remnant secondary moist deciduous forest are present. These areas are interspersed with heavily grazed grasslands with sedges and herbs on gentle hill slopes with limestone outcropping.

The forest has a canopy height of around 20 to 25 m. The overstorey and mid storey species included *Borassus flabellifer*, *Corypha utan*, *Schleichera oleosa*, *Ziziphus mauritiana*, *Dolichandrone spathacea*, teak, *Gmelina arborea,* sandalwood, *Pterocarpus indicus* and *Ficus* spp. Siam weed was prevalent in disturbed areas with an open canopy.

Agriculture

The majority of area at the Beaco LNG plant area comprised agricultural land used for subsistence farming. The primary crops grown are corn, cassava, sweet potato, peanuts, long beans, papaya, watermelon and bananas. Grazing by water buffalo, cattle, goats and pigs is widespread in the Beaco development area.

Vegetation of Conservation Interest

Mangroves are of particular conservation interest in the Beaco development area as they stabilise soils, reduce coastal and soil erosion, and provide important marine and fauna habitat. Mangroves are also valued for their economic benefits; however, they are regularly subject to felling for timber. While the mangroves are under the UNTAET Regulation No. 2000/19: Section 5 'Wetlands and Mangroves', prohibiting any destruction of this vegetation type, exploitation still occurs.

Remnant areas of moist deciduous forest are of conservation interest as they are poorly known and warrant further study. On the eastern edge of the Beaco LNG site and western edge of the Nova Beaco site large areas of remnant secondary moist deciduous forest are present.

Plate 7-43 Secondary vegetation at Nova Viqueque

LOCATION: \\pervorfil1\infstructlb\Projects\301012-01504 Enviro Imp Assessment Timor-Leste\2.0 Reports\2.9 SEIA - Betano and Beaco\Plates\03_Working\BP09\4\301012_01504_SEIA_Plate_7-43.vsd
PLOT DATE AND TIME: 4 Jun 2012, 7:24 PM Creator: Courtenay Wheeler

Flora

These results focus on the dominant flora species, conservation significant flora, economically important flora species and weed species.

A total of 201 species were identified from collected material and photographs and a species list for the Beaco development area is presented in Appendix 2 of Attachment 01.

A large number of species recorded in the Beaco development area have a widespread distribution in the tropics. Several of these are weed species and several are considered to be naturalized species. Two species listed on the IUCN Red List as Vulnerable were recorded; *Pterocarpus indicus* and *Santalum album.*

Species of Conservation Interest

Two Vulnerable listed flora species were recorded in the Beaco development areas, *Pterocarpus indicus* and *Santalum album*, which are both valuable timber species.

Pterocarpus indicus (Tetum ai-na) was present within the Beaco development area on the banks of rivers and on hills slopes. It is a tall timber species, reaching 25 to 35 m, is a briefly deciduous tree and can be useful for soil stabilization and adding nitrogen to soil. Found in lowland primary and some secondary forest, native subpopulations have declined because of overexploitation of the timber and increasing general habitat loss. Cultivated subpopulations are widely distributed throughout the tropics.

Sandalwood (*Santalum album)* was present in very low numbers in the Beaco development areas as young trees only and not at the harvestable stage.

There are 36 plant species listed on the IUCN Red List as being of Least Concern for Timor-Leste, and these are considered to have a low risk of extinction (Appendix 3 of Attachment 01). One of these species was recorded during the field survey in the Beaco development area, *Acanthus ilicifolius* (holly leaf mangrove).

The low number of plant species listed for Timor-Leste as Least Concern on the Red List (compared to the number of plant species occurring in Timor-Leste) is likely to be a reflection of the limited assessment carried out on plants in the area.

Casuarina sp. trees were recorded at Viqueque; however, in a different vegetation community to that recorded in the Suai development area. Casuarina trees were recorded as scattered trees in open coastal vegetation at Suai, and in secondary forest at Viqueque. It is likely that Casuarina trees are only important habitat trees within the Suai development area where the yellow-crested cockatoo was recorded.

Species of Economic Importance

Thirteen species were identified in the Beaco development area as having local and economic importance. These species are listed below in Table 7-30.

Small plantations or estates of coconuts, bananas, and occasionally mango were present in the Beaco development area. The ownership of trees within estates may be external to local villages.

Table 7-30 Species of local importance and/or economic interest in the Beaco development area

Common Name	Scientific Name	Tetum Name	Use/Importance
Coconut	*Cocus nucifera*	nú	Food
Cashew	*Anacardium occidentale*	caijus	Food
Banana	*Musa* spp.	hudi	Food
Breadfruit	*Artocarpus altilis*	kulu modo	Food
Mango	*Mangifera* spp.	has	Food
Candlenut	*Aleurites moluccana*	Kemiri or cami	Food
Cinnamon	*Cinnamomum* sp.	ai-canela	Spice
Teak	*Tectonia grandis*	ai-teka	Timber
Gmelina	*Gmelina arborea*	Gmelina, ai-teka Malaysia	Timber
Cassod tree	*Senna siamea*	ai-johar	Timber
Sandalwood	*Santalum album*	ai-cameli	Timber
Rosewood, Narra	*Pterocarpus indicus*	ai-na	Timber
Mangrove trumpet tree	*Dolichandrone spathacea*	ai-sirian	Timber

Teak Plantations/Woodlots

Small plantations or woodlots of teak were observed at the Beaco development area.

Weeds/Invasive Species

A total of nine major weed species were identified in the Beaco development area, as listed below in Table 7-31.

Table 7-31 Major weed species identified in the Beaco development areas

Weed Species	Common Name	Tetum Name
Chromolaena odorata	Siam weed	ai-funanmutik
Imperata cylindrica	Cogon grass	pae
Leucaena leucocephala	Coffee bush	ai-café
Lantana camara	Lantana	ai-funan meak
Acacia nilotica	Prickly acacia	bakuro malae, ai-tarak
Chrysopogon aciculatus	Golden false beardgrass	du'ut
Jatropha gossypifolia	Bellyache bush	miro
Calotropis gigantea	Crown flower	fuka
Stachytarpheta cayennensis	Snakeweed	-

Siam weed was the most widespread weed throughout the Beaco development area. It is a highly invasive weed, estimated to cover more land than any other plant species in Timor-Leste (Cowie, 2006 and 2007 in Attachment 01), and affects about one-fifth of all cropland (World Bank, 2009 in Attachment 01).

Fauna

Fauna Habitat

Four broad habitat types were identified in the Beaco development area and these include:

- Deciduous Woodland/Forest: Woodland is defined as trees and shrubs that are less than 30% of the tree canopy cover.
- Coastal: Includes three subclasses; Mangrove forest, Dune forests – mixed species and Coastal dunes and reef platforms.
- Riparian: Includes drainage lines (major and minor), drainage basins, creek lines and water catchments, associated vegetated banks.
- Swidden Agriculture: Includes man-made plantations and associated fringing vegetation and habitat.

Fauna Assemblages

Fauna assemblages were collated from the desktop review. Many of the species identified from the desktop assessment are unlikely to occur in the study areas on a regular basis since the desktop research considered a wide range of habitats. The vertebrate fauna list is presented in Appendix 5 of the Terrestrial Ecology Technical Report (Attachment 01).

Within the Beaco development area, a total of 80 vertebrate fauna species were recorded, including 2 species of amphibians, 9 species of reptiles, 59 species of birds and 10 species of mammals. These are discussed below.

Amphibians

Two species of amphibian were identified within the Beaco development area; the common Indian toad (*Duttaphrynus melanostictus*) and the common tree frog (*Polypedates* cf. *leucomystax*)

Reptiles

Nine species of reptiles were identified in the Beaco development area, including; tokay (*Gekko gecko*), Asian house gecko (*Hemidactylus frenatus*), fat-tailed house gecko (*Hemidactylus platyurus*), common wolf snake (*Lycodon capucinus*), Indonesian water python (*Liasis macklotti macklotti*) and the saltwater crocodile (*Crocodylus porosus*).

Birds

Fifty-nine species of birds were identified within the Beaco development area. The most common species included the spotted dove (*Streptopelia chinensis*), the barred dove (*Geopelia maugei*) and the streak-breasted honeyeater (*Meliphaga reticulata*). The two most common families were the *Columbidae* (pigeons and doves) and the *Meliphagidae* (honeyeaters).

Mammals

Ten species of mammal were recorded in the Beaco development area, including: the Indonesian short-nosed fruit bat (*Cynopterus titthaecheilus*), domestic dog/dingo (*Canis familiaris*), domestic pig (*Sus scrofa*), Bali cattle (*Bos javanicus*), domestic cattle (*Bos taurus*) and the domestic goat (*Capra hircus*).

Bats

Five species of bats were recorded in the Beaco development area, including the canut's horseshoe bat (*Rhinolophus canuti)* which is listed as Vulnerable on the IUCN Red List, and the little long-fingered bat (*Miniopterus australis)* which is listed as being of Least Concern. The bat analysis results are presented in further detail in Appendix 6 of the Terrestrial Ecology Report (Attachment 01).

Conservation Significant Fauna

The desktop review identified 35 species of conservation significance that either had the potential to occur, or had been previously recorded, in Timor-Leste.

Six of these species were recorded in the Beaco development area in the recent field survey, with the remaining 29 species either being 'Likely', 'Possible' or 'Unlikely' to occur in the development area (Figure 7-27, page 7-424). The conservation status of the five recorded species is listed in Table 7-32.

Table 7-32 Conservation status of the fauna species recoded during the field survey

Common Name	Conservation Status (IUCN Red List of Threatened Species)
Slaty cuckoo dove	NT (Near Threatened)
Timor (white-bellied) bushchat	NT (Near Threatened)
Olive-shouldered parrot	NT (Near Threatened)
Cinnamon banded kingfisher	NT (Near Threatened)
Canut's horseshoe bat	VU (Vulnerable)
Great knot	VU (Vulnerable)

Endemic Fauna

Timor-Leste has the highest rates of endemism recorded in Indonesia (10.3%), especially for frogs, skinks and geckos. The yellow-crested cockatoo, Timor white eye and the black banded fly catcher are all endemic to Timor-Leste.

7.8.3 Environmental Impacts

This strategic level assessment is focussed on the identification of existing ecological values at the proposed Beaco development site. Whilst the area to be cleared for the proposed infrastructure is not known, it is intended that the areas of conservation significance and habitat value identified through detailed baseline assessment, could be avoided during the infrastructure design stage.

Potential environmental impacts for flora, vegetation communities and fauna as a result of construction and operations, include, but are not limited to:

- Loss of individuals of IUCN listed species; Santalum album (sandalwood) and Pterocarpus indicus (rosewood), both valuable timber trees.
- Loss of floristic biodiversity that has not been documented.
- Secondary weed invasion after clearing, particularly Siam weed and cogon grass.
- Loss of forest and tree cover.
- Loss of important mangrove habitat.
- Loss of agricultural land and subsistence gardens.
- Loss of food crops and estates e.g., coconuts, bananas.
- Loss of timber for fuel source.
- Loss of cash crops e.g., teak, rosewood and sandalwood.
- Loss of fauna habitat, specifically important habitat for species of conservation significance.
- Increased potential of vehicle strike due upon vertebrate fauna species.
- Increased potential of noise disturbance to vertebrate fauna species, particularly nesting and roosting individuals.
- Increased potential of habitat fragmentation.
- Increased erosion potential and sedimentation due to soil disturbance.

Impacts to Conservation Significant Species

Species listed as Critically Endangered, Endangered, Vulnerable and Near Threatened under the IUCN Red List constitute species as having conservation significance. A lack of baseline data of Timor-Leste's flora and fauna indicates that not all occurrences of conservation significant species have been assessed by the IUCN. There is a possibility that further species within the Beaco development area may be considered to have conservation significance.

Two Vulnerable listed flora species have been recorded in the Beaco development area to date, *Pterocarpus indicus* and *Santalum album,* which are both valuable timber species. Six fauna species of conservation significance were recorded in the study area as reported previously in Section 6.8.2, including Canut's horseshoe bat and the great knot listed as Vulnerable and four birds listed as Near Threatened.

In addition, moist deciduous forest communities in the Nova Beaco and Beaco LNG sites represent some of the only remnant vegetation in good condition and are considered to have conservation significance. In addition, coastal and riparian mangrove communities in the Beaco development area represent some of the only remnant mangrove vegetation in good condition and are considered to have conservation significance.

7.8.4 Avoidance, Management and Mitigation Measures

Retention of Native Vegetation and Habitat

The loss of vegetation within the Beaco development is a likely consequence of the construction process. The potential impact of these alterations can be further reduced by avoiding sensitive and high conservation value habitats when selecting the development location.

Mitigation measures should be developed for construction works to reduce the extent of vegetation clearance. A reporting and responses system will be implemented to ensure that vegetation clearing activities are controlled and monitored.

It is recommended that riparian vegetation be preserved and rehabilitated to reduce erosion and maintain current flow patterns of rivers. To reduce soil erosion, those areas not in use within the Beaco development area can be rehabilitated and revegetated.

Mangroves

Construction will unavoidably remove some areas of mangrove habitat and the faunal communities they contain. The potential impacts on mangroves will be limited through the control of vegetation clearance.

Wastewater or desalination outlets should be located away from remnant mangrove vegetation.

Weed Hygiene

Weed hygiene practices should be adopted to reduce spread of weed seeds, and weed control measures to reduce the colonisation of weed species within the development area.

Protocols should be developed into an invasive weed management plan and incorporated as part of the environmental management system that should be prepared for the Beaco development area.

Vertebrate Fauna

While the habitats in the Beaco development area are already fragmented and degraded, a lack of baseline data indicates that it is possible that not all habitats have been assessed and therefore, potential impacts to fauna could result. There is also a potential for impacts from increased vehicle traffic and noise disturbance. Additional fauna surveys are required (Section 7.8.6) to gain a detailed understanding of the habitats in the study area and the level of ecological linkage with the surrounding vicinity.

7.8.5 Monitoring and Reporting

The monitoring and reporting measures for flora and fauna during construction and operations include:

- A multiple season baseline flora, vegetation and fauna assessment of the remnant vegetation is recommended.
- Surveys undertaken at different seasons during the year to record different fauna species assemblages and to capture fruiting and flowering patterns.

- A mangrove health monitoring program should be established within the remnant mangrove communities to document the health of mangrove species during the construction and operation phase of the project.

7.8.6 Further Work

Flora and Vegetation

It is recommended that additional baseline flora and vegetation assessments are undertaken at the Beaco development area, including:

- Quadrat sampling to define floristic composition and structural form of each vegetation community, particularly in mangrove and moist forest vegetation.
- Developing a checklist of flora species, including annual herbs, ferns, epiphytes, mosses, bryophytes and parasitic plants to record floristic diversity.
- Completing vegetation mapping to a scale of 1:10,000.
- Undertaking field work at other times of the year to detect a full range of species.

Fauna

It is recommended that additional fauna surveys are undertaken across seasons. It is also recommended that the duration of field trips are extended to ensure a more thorough survey. This will increase the likelihood that potentially critically endangered species are recorded.

7.9 Marine Ecology

WorleyParsons undertook a marine ecology assessment of the Beaco development area in December 2011 and February 2012. The full report is presented as Attachment 2.

There are several laws and regulations from previous administrations (UNTAET and Indonesian) that concern environmental protection and biodiversity conservation in Timor-Leste:

- Law No. 5, 1990 on Conservation of Biological Resources and their Ecosystems.
- Law No. 5, 1994 Concerning Biodiversity.
- Government Regulation No. 28, 1985 on Forest Protection.
- Government Regulation No. 51, 1993 on Environmental Impact Analysis.
- United Nations Transitional Administration in East Timor (UNTAET) Regulation No. 2000/17.
- United Nations Transitional Administration in East Timor (UNTAET) Regulation No. 2000/19.

UNTAET Regulation No. 2000/19 on protected places (30 June 2000) was established for the purpose of protecting designated areas, endangered species, wetlands, mangrove areas, historic, cultural and artistic sites, conservation of biodiversity and protection of the biological resources of East Timor. Fifteen natural areas were protected under this regulation and have been designated as Protected Natural Areas (PNAs). The majority comprise primary forest areas, coral reefs, mangroves, wetland habitat and mountain summits above 2,000 m.

7.9.1 Study Method

A total of three inshore and three offshore sediment and water quality samples were collected at sites adjacent to the proposed LNG Plant at Beaco (Figure 7-29). All samples were collected on the 12 December 2011. Inshore sites were located between 8 to 10 m depth. Offshore sites were between 20 to 35 m depth.

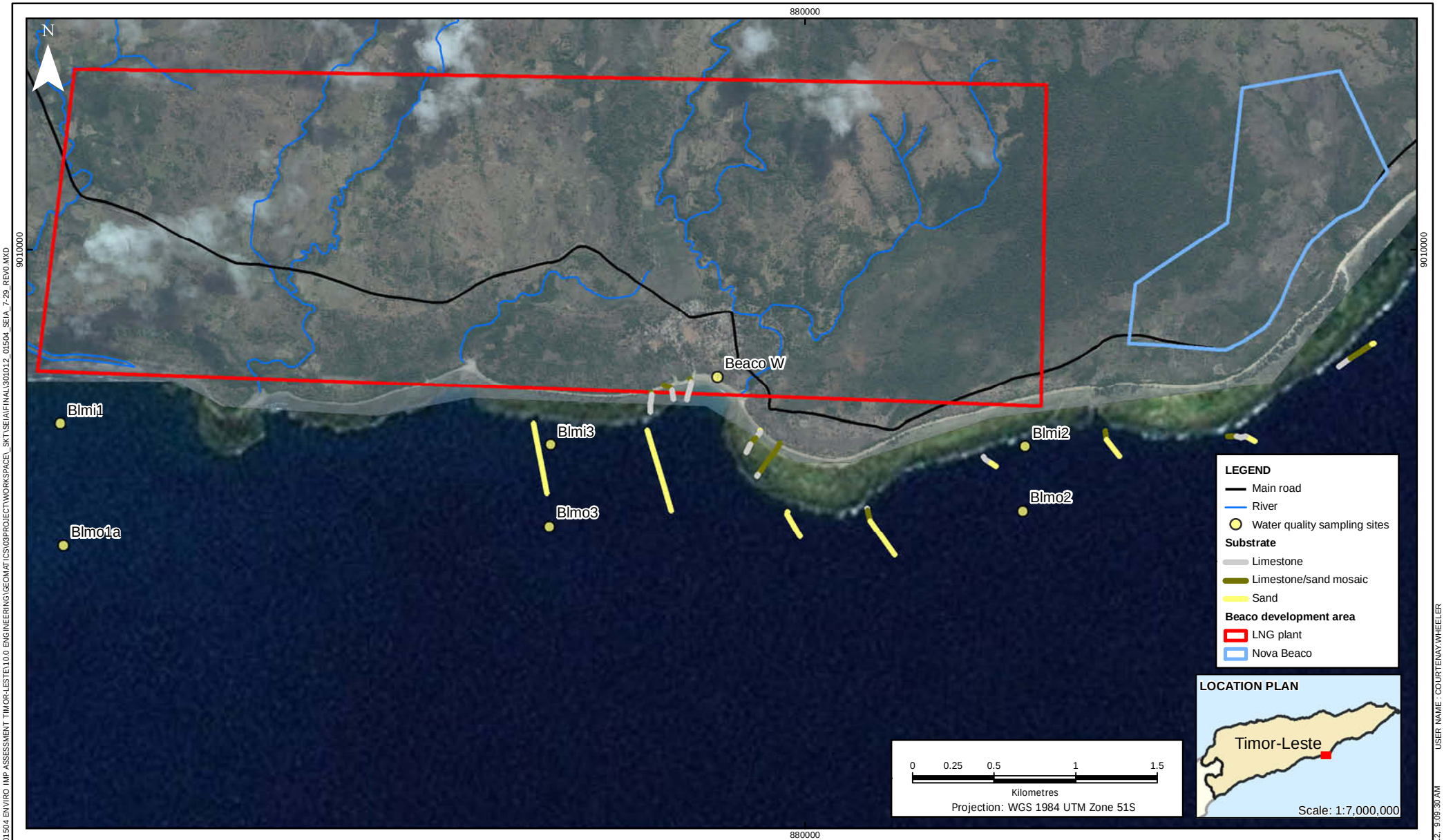
Video footage was collected over a two day period between the 10 and 20 December 2011. Towed video footage was used to obtain information on the marine benthic habitat present at the study site.

Water Quality

A physicochemical water quality profile was obtained by recording measurements at 1 m intervals from the water surface to the seabed at each of the sampling sites. Two depth profiles were recorded at each sampling site.

The following parameters were measured:

- Temperature (°C).
- Salinity (parts per thousand (ppt)).
- pH.
- Conductivity ($\mu S.cm^{-1}$).
- Dissolved oxygen (DO; % saturation and $mg.L^{-1}$).
- Turbidity (nephelometric turbidity units [NTU]).



NOTES:
This map contains:
1. Imagery: Digital Globe (2008-2011)
2. Rivers: GIGTimorLeste (2010)
3. Roads: DivaGIS (2010)
4. Substrate: WorleyParsons (2012)

REV	DATE	REVISION DESCRIPTION	DRN	CHK	DES	ENG	APPD	CUST
0	30/05/2012	FINAL FOR ISSUE	MW	CS	-	-	GH	

A4 SHEET | SCALE 1:32,000
PROJECT No: 301012-001504

WorleyParsons resources & energy

TIMOR GAP, E.P. TIMOR GAS & PETRÓLEO

REPUBLICA DEMOCRATICA DE TIMOR-LESTE
SECRETARIA DE ESTADO DOS RECURSOS NATURAIS

OneWay to zero harm

Copyright © WorleyParsons Services Pty Ltd

TASI MANE PROJECT - BETANO AND BEACO
STRATEGIC ENVIRONMENTAL IMPACT ASSESSMENT

Figure 7-29
Beaco water quality and marine tow locations

LOCATION: I:\PROJECTS\301012-01504 ENVIRO IMP ASSESSMENT TIMOR-LESTE\110.0 ENGINEERING\GEOMATICS\03PROJECT\WORKSPACE_SKT\SEIA\FINAL\301012_01504_SEIA_7-29_REV0.MXD

PLOT DATE & TIME: 30 MAY 2012, 9:09:30 AM

USER NAME: COURTENAY.WHEELER

At each sampling site, a mid-water column sample was also collected using a 1L Van Dorn sampler. Each sample was transferred into parameter-specific sample bottles and placed on ice. Parameters tested were:

- Total metals [cadmium (Cd), chromium (Cr), copper (Cu), mercury (Hg), lead (Pb), nickel (Ni), zinc (Zn).
- Dissolved Metals (Cd, Cr, Cu, Hg, Pb, Ni, Zn), ammonia, total nitrogen, total phosphorus, TPH, PAH, BOD, TSS, E.coli, chlorophyll, nitrate, nitrite, TKN, reactive phosphorus.

As no water quality guidelines exist for Timor-Leste, ANZECC/ARMCANZ guidelines (2000) for marine environments (Tropical Australia) were adopted for water quality monitoring, analysis and reporting. All toxicants were compared to the 99% species protection trigger levels.

Sediment Quality

Surface sediment samples (0 to 0.3 m) were collected using a Van Veen grab sampler. The Van Veen sampler was lowered to the seabed before being retrieved with a grab sample. Sediment samples were then geophysically logged. Each sample was then stored at 4°C and couriered to a NATA – accredited laboratory for analysis.

Parameters identified for laboratory analysis were developed based on likely contaminants to be encountered during construction and operation of the jetty and associated facilities. Sediment samples were analysed for the following parameters:

- Metals (Al, As, Cd, Cr, Cu, Fe, Pb, Hg, Ni and Zn).
- Nutrients (nitrate, nitrite, total nitrogen, total phosphorus and sulphate).
- Particle size distribution (PSD).

As no sediment quality guidelines exist for Timor-Leste, the interim sediment quality guideline (ISQG) found in ANZECC/ARMCANZ (2000) was used to assess sediment quality. Laboratory results were collated, concentrations were tabulated and any spatial trends identified. All values were then compared with relevant sediment quality criteria.

As part of the NATA requirements, the laboratory analyses for water and sediment quality included quality control testing of samples, including duplicate samples (the same sample analysed more than once), blanks (containing no levels of the analytes to be analysed), spiked samples (containing known additions of the analytes to appropriate matrices) and standard samples (samples containing known concentrations of the analytes - also known as reference standards). All samples were analysed within laboratory holding times.

Benthic Habitat

Video transects ranging between 300 to 500 m extended vertically from the shoreline in order to characterise the marine benthic habitat present at the site (Figure 7-30). Each transect commenced in a depth of approximately 2.5 m extending out to the 10 m depth contour. A total of eight transects were completed distanced approximately 600 m apart, covering approximately a 6 km section of coastline.

For the purpose of generating a habitat map, biota was defined as:

- Hard coral.
- Invertebrates.
- Algae.
- Seagrass.
- Substrate was classified as sediment (soft) or reef (hard).

Plankton

A plankton net was towed behind a vessel travelling at <1 knot over a 100 m transect at each site. Once the sample had been collected in the sieve, the contents were then transferred to a sample vial. Ethanol (100%) was added to the vial to preserve the sampled larvae.

Following treatment, the entire sample was placed in a Ward Counting Wheel, with the corresponding site label. The Ward Counting Wheel was placed under a Stereo-Microscope (Olympus SZ61 Microscope) and slowly turned under the microscope allowing the fauna to be counted and identified. Taxonomy identification was conducted using the most up-to-date references available for the geographic region. The total sample volume was sorted for plankton, fish eggs and fish larvae.

Infauna

Surface sediment samples (0 to 0.3 m) were collected using a Van Veen grab. A total of three replicates were collected per sample location.

Macroinvertebrate samples were processed and fauna identified at Benthic Australia laboratories. Following washing and sorting, the specimens were placed into a small petri-dish for taxonomic identification under a stereo-microscope (Olympus SZ61 Microscope). Taxonomy was conducted using the most up to date references available for the geographic region.

Statistical analysis of the plankton and marine benthic fauna was conducted using the methods and software packages as outlined in Section 3.5.3 of the Marine Ecology Technical Report (Attachment 2).

Data Assumptions and Limitations

The strategic level assessment is based on a draft conceptual layout of the proposed LNG Plant Complex. As the layout will be subject to further design, the assessment should be considered preliminary in nature and subject to further assessment as the proposed development, notably the configuration of the temporary marine offloading facility, is further developed and additional baseline information is collected. As an example, dredging requirements were not known at the time of assessment.

Data collection is also based on a limited field survey undertaken during the wet season.

LOCATION: \\PERWORFIL1\INFSTRUCL\IB\PROJECTS\301012-01504 ENVIRO IMP ASSESSMENT TIMOR-LESTE\10.0 ENGINEERING\GEOMATICS\03PROJECTWORKSPACE_SK\TSEIA\FINAL\301012_01504_SEIA_7-30_REV0.MXD

PLOT DATE & TIME: 29 MAY 2012, 1:29:44 PM USER NAME: COURTENAY.WHEELER

NOTES:
This map contains:
1. Imagery: Digital Globe (2008-2011)
2. Imagery: Google Earth (2010)
3. Rivers: GIGTimorLeste (2010)
4. Roads: DivaGIS (2010)
5. Biota: WorleyParsons (2012)

REV	DATE	REVISION DESCRIPTION	DRN	CHK	DES	ENG	APPD	CUST
0	29/05/2012	FINAL FOR ISSUE	MW	CS	-	-	GH	

A4 SHEET | SCALE 1:25,000
PROJECT No: 301012-001504

WorleyParsons resources & energy

TIMOR GAP, E.P. Timor Gas & Petróleo

REPUBLICA DEMOCRATICA DE TIMOR-LESTE
SECRETARIA DE ESTADO DOS RECURSOS NATURAIS

OneWay to zero harm

Copyright © WorleyParsons Services Pty Ltd

TASI MANE PROJECT - BETANO AND BEACO
STRATEGIC ENVIRONMENTAL IMPACT ASSESSMENT

Figure 7-30
Beaco marine habitat

7.9.2 Existing Environment

The southern Timor-Leste coastline consists of a combination of sandy beaches and limestone rock ledges that extend from the shoreline as intertidal reef flat areas that then slope down steeply towards the seabed. In some places along the southern coastline, water depths of 200 m can be found less than 1 km offshore. The sandy beaches consist of medium to fine sand with silt. During heavy rains, sediments are mobilised from the surrounding catchment and enter the ocean causing large sediment plumes.

Water Quality

Water quality assessment was based on a single sampling event on the 12 December 2011. Few trends were apparent at Beaco, across sites or between offshore and inshore sites. This is indicative of well mixed waters and a relatively constant water quality.

Turbidity results show no apparent trends with all values falling within the ANZECC/ARMCANZ (2000) guidelines for turbidity (1 to 20 NTU).

Concentrations of nutrients were generally below the laboratory limit of reporting (LOR) for all nearshore and offshore sites, with the exception of ammonia. Ammonia levels exceeded the recommended ANZECC/ARMCANZ (2000) trigger level at all sites. Ammonia is a source constituent of nitrogen in marine waters and is resultant from microbiological activity. These elevated levels are likely the result of fertiliser use within the predominantly agricultural catchment.

Concentrations of total and dissolved metals were generally low for most parameters across all sites and did not register above the LOR. However, much like Betano (and Suai) total and dissolved copper concentrations at most Beaco sites exceed the ANZECC/ARMCANZ (2000) guidelines value for the 99% protection of marine species. The significance of copper in the marine environment has been discussed previously in the marine ecology assessment for Betano (Section 6.9.2).

Hydrocarbons within the water column at Beaco were recorded at levels less than the LOR at both sites.

Sediment Quality

Concentrations of total nitrogen and phosphorus were relatively high in coastal sediments. Total nitrogen concentrations observed at all sampling sites were comprised of 100% organic nitrogen (TKN) which indicates that nitrogen found in sediments within the study area are of organic origin. Nutrient levels within marine sediments at Beaco are largely influenced by the accumulation of organic matter on the seabed, and this is most likely derived from particulate matter transported via riverine inputs as sediments fall out of suspension in the water column. Nutrient concentrations in sediment also tend to *increase* with *decreasing* grain size as the proportional surface area of finer sediments is greater and organic matter is more readily absorbable onto mineral surfaces.

Sedimentary metal concentrations were generally above the LOR but below the ANZECC/ARMCANZ (2000) sediment quality guidelines. Offshore sites displayed marginally higher concentrations overall for chromium, copper, lead, nickel, zinc and mercury (cadmium was below the LOR at all offshore and inshore sites). This is likely attributable to the predominantly finer grained sediments that occur at

offshore sites which display a higher affinity for binding metals, minerals and nutrients. Nickel concentrations at all offshore sites were also just above the ANZECC/ARMCANZ (2000) guideline value of 21 mg/kg.

Hydrocarbon levels in sediments were also very low and less than the LOR at both sites.

Particle size distribution of the sediments at Beaco followed general expectations, with shallower inshore sites dominated by coarser sand granules (74%) and deeper offshore sites containing a much greater proportion of fines (70%). Fine fractions within sediment compositions are likely sourced from riverine systems in the region, with fines being transported further out to sea than coarser material and eventually settling in deeper areas offshore.

Fauna and Habitat Values

The benthic habitat within the study area is dominated by sediment. Given the high elevation and seasonal rainfall in catchments draining to the south coast of East Timor, a natural high flux of fluvial sediments occurs. In addition, deforestation in the region, which is evident to varying extents in aerial photographs, is likely to have enhanced sediment supply.

Within the study area, algae, coral and invertebrates made up the biotic benthic community, which were primarily associated with hard substrate. The fringing reef identified adjacent to the Beaco study area is typical of the fringing reef systems found in South East Asia (Burke et al. 2002). The reef generally consisted of a low diversity reef flat which falls steeply into deep water. The greatest coral diversity was generally found within 5 to 8 m of the surface which then gradually declines below 8 m as depth increases and light diminishes. According to Burke et al (2002), a high diversity of coral reefs exist in southern Timor-Leste with 301-500 species identified. In the present study, however, only a low diversity of corals was found within the study area. The structure of the reef was quite immature, consisting of a thin layer of predominately plated corals growing on dead coral rubble or weathered limestone (Plate 7-44).

Reef blasting using grenades, was a common fishing method found on the Southern Timor Leste coast post Indonesian invasion. This blasting method could be an explanation as for the low diversity of corals observed at Beaco. At a depth of 8 to 15 m, invertebrates were the dominant biota present, with generally no epibiota present at depths greater than 15 m.

Seagrass communities have previously been identified in northern parts of Timor-Leste. Dense seagrass meadows were found along the reef flats adjacent to the Beaco footprint region. Meadows identified within the study area were generally limited in extent and are not considered to provide a significant resource for grazing by dugongs and turtles.

The macroinvertebrate communities during the baseline sampling event were species rich in polychaetes and crustaceans. It is common for either polychaetes or crustaceans to be the dominant benthic fauna in sandy sediments from the Australasian region (Long & Poiner, 1994; Currie & Small, 2005).

7.9.3 Environmental Impacts

It is assumed that a typical LNG development at Beaco would comprise the following key (marine based) components

- A marine terminal with dedicated berth for LNG, that requires an approach channel of suitable depth and width and a turning basin
- A materials offloading facility (MOF) for use by support vessels during construction and operation of the terminal.

Pipelines associated with the transport of hydrocarbons from offshore to the plant are not considered in this assessment.

Activities associated with construction and operation of the LNG Plant and associated infrastructure that have the potential to adversely affect the marine environment include:

- Construction and physical presence of new marine structures within the marine environment.
- Dredging and reclamation activities.
- Operation of a wastewater treatment plant.
- Construction and operational aspects associated with spills, discharges and runoff.

The activities outlined have the potential to impact marine communities through the following:

- Changes to local hydrodynamic and coastal processes.
- Changes to water quality.
- Changes to sediment quality.
- Direct and indirect changes to benthic habitats and infaunal communities.
- Changes to fisheries resources.

Water Quality

Suspension of Sediments

Many aspects of the construction process would disturb and resuspend benthic sediments, including:

- Rock placement for breakwater construction.
- Land reclamation for construction of a mof.
- Pile driving for construction of a marine terminal.
- Pipeline installation for discharge outlets.
- Dredging.
- Other in-water construction activities

Plate 7-44 Photograph showing the some of the corals and sponges present along the benthic habitat transects adjacent to the Beacu footprint area

LOCATION: \\perworfil1\infstructlib\Projects\301012-01504 Enviro Imp Assessment Timor-Leste\2.0 Reports\2.9 SEIA - Betano and Beacu\Plates\03_Working\BP097\301012_01504_SEIA_Plate_7-44.vsd
PLOT DATE AND TIME: 4 Jun 2012, 7:20 PM Creator: Courtenay Wheeler

During port operation, ship wash (waves) and propeller turbulence in shallow water can erode the shore and stir bottom sediments, resuspending sediments. This will be most evident in the turning basin when ships are berthed by the tug boats. No impacts to the coastline are envisaged, although this will depend on the proximity of the turning basin to shore.

Dredging may be required to achieve a safe navigation depth into the Beaco LNG/LPG export jetty and temporary MOF area. The volume, type of dredged material and dredging method have not yet been defined but will require further consideration to ensure that potential impacts are kept as low as reasonably practicable.

Impacts from dredging are primarily related to sedimentation and turbidity effects on benthic primary producers e.g., corals and seagrass, which can lead to indirect impacts on other species reliant on these habitat types for food, shelter and breeding. Ambient levels of turbidity and sedimentation are likely to be high along the Beaco coastline, particularly during the wet season and will require further consideration in defining water quality trigger levels for dredging.

Maintenance dredging may be required, although the frequency and volume are yet to be determined as they are dependent on the rate of sediment accumulation associated with the terminal. The resuspension of sediments can arise due to seabed excavation, loss from the dredger whilst loading, loss of material during transport and the disposal of dredged materials. The intensity and extent of impact will depend on the frequency and volume of dredging and the method of dredging and material disposal.

Land reclamation activities also have the potential to generate turbidity resulting in excessive sedimentation in adjacent coastal areas if not properly managed.

The resuspension of sediments in the water column reduces water quality due to:

- Increased concentration of suspended solids.
- Reduced light penetration.
- Increased nutrient concentration through the mobilisation of organic material, biologically available nitrogen and phosphates from the sediment.
- Increased concentrations of toxicants including heavy metals and organic compounds from sediments.

These changes in water quality can have physical, chemical and behavioural effects on marine biota (Anchor Environmental C.A. L.P., 2003), including:

- Changes in respiration and clogging of respiratory structures.
- Changes in feeding rates and clogging of feeding structures in suspension feeding organisms.
- Reduced growth rates and reproductive success due to sediment loading.
- Increased growth due to higher nutrient availability.
- Contamination and poisoning from the accumulation of heavy metals and organic compounds.

- Slowed photosynthesis and primary production due to reduced light penetration in the water column.
- Altered behaviour, such as avoidance, altered schooling behaviour, cover abandonment, or attraction (as a potential food source or cover).

Sediments within the study area are generally uncontaminated, with the levels of metals all well below ANZECC trigger values for sediment quality (ANZECC/ARMCANZ (2000). No impacts from mobilised contaminants are expected.

Sediments within the study area have relatively high concentrations of nutrients. The mobilisation of nutrients may cause a rapid increase in phytoplankton abundance leading to depleted dissolved oxygen. In open waters, currents will rapidly replenish oxygen and any impacts will likely be short-lived. . As a result, no impacts are anticipated.

Discharges, Spills and Runoff

Discharges, spills and runoff can all reduce water quality. During construction, discharges or spills may occur from construction vessels and runoff from land-based construction areas. During operation, vessels and cargo handling are sources of runoff, discharges and spills into the marine environment. Most reported oil spills occur within port and harbour areas, most are small and result from normal operations such as loading and refuelling (e.g., WA EPA, 2007b). They often arise due to faulty equipment, poor procedures and accidental or intentional discharges of wastes.

Discharges may include oily bilge and ballast water, sewage and other wastes. Spills may include lubricants, hydraulic oils, fuels and paints. Site runoff during construction would typically be sediment laden water, but may also be contaminated with concrete, paints and oils. Operational site runoff may be contaminated by spilt fuel, bulk product, paint residues and sediment.

Spills and discharges impact water quality and marine ecosystems. Spilt oils initially float, forming a thin surface layer that can quickly spread over a large area. Oils and other substances can be acutely toxic to marine biota and may contaminate fisheries resources. Repeated small spills and discharges lead to the accumulation of hydrocarbons in surface waters and sediments. Repeated small spills can have chronic effects on marine biota, including reduced growth and reproduction, ultimately reducing population viability (e.g., Dicks et al, 1982; Guzmánand Holst, 1993).The biodegradation of oil consumes dissolve oxygen from the water further reducing water quality and this can have additional impacts on marine biota.

Wastewater Treatment Plant Discharge

Some wastewater discharge is likely from the LNG facility. Water quality may be impacted by the long-term discharge of pathogens, nutrients and toxicants in treated wastewater.

Effluent from wastewater treatment plants typically contains viruses, bacteria and other microorganisms and its discharge may lead to unsanitary water quality. The magnitude of contamination depends on the level of treatment employed. Primary treated effluent can have a bacterial load of up to 10 million colony forming units (cfu) per millilitre. Secondary treated sewage typically contains 1000 to 10 000 cfu per millilitre. With an active disinfection process, this can be reduced further to less than 100 cfu per 100 millilitres. This level of treatment is suitable for

subsurface irrigation (EPA VIC, 2002) but in the marine environment may pose a threat of disease transmission through primary contact recreation and the contamination of shellfish fisheries.

The primary impact of the discharge on marine biodiversity is likely to be through increased nutrient loading. Treated wastewater contains nitrogen and phosphorus. Increased nutrient concentrations can cause increases in phytoplankton biomass, changes in species composition and impact other marine biota.

If chlorination is used as a means of effluent disinfection, residual chlorine may be acutely toxic to marine life at concentrations as low as 0.01 milligrams per litre (DEH, 1991). The use of chlorine can also lead to the formation of toxic chlorinated organic compounds which will potentially bioaccumulate in the environment.

The treated wastewater is likely to contain low concentrations of toxicants such as heavy metals, organochlorines and hydrocarbons. The long-term discharge may lead to reduced water quality, contamination of fisheries resources and the accumulation of toxicants in sediments.

Sediment Transport and Quality

Changed Hydrodynamics and Sedimentation Regime

A coastal breakwater will be required as part of the LNG facility to provide protection to the smaller support vessels.

The presence of a breakwater has the potential to interrupt sediment transport patterns along the coastline caused by alteration of the nearshore wave regime. The shoreline in the vicinity of Beaco is predominantly sand and further consideration of longshore transport of sediment will be required to determine whether impacts on intertidal habitats will be significant.

Discharges, Spills and Runoff

As discussed previously, spills, discharges and contaminated runoff may occur during construction and operation of the port. These may reduce sediment quality as well as water quality. Major spills, repeated small spills and ongoing discharges can lead to the accumulation of contaminants such as petroleum hydrocarbons, metals, organochlorines and organic materials in sediments. These substances can contaminate fisheries resources and have toxic effects on marine biota, including slowed growth and poor reproductive success of indiviuals (e.g., Dicks et al, 1982; Guzmánand Holst, 1993). Infaunal assemblages in contaminated sediments typically have lower species richness and diversity (Johnston and Roberts, 2009).

Antifoulant Contamination of Sediments

Antifouling coatings are used to prevent biofouling on vessels and some marine structures. These coatings are usually toxic to marine biota in very low concentrations and also have implications for human health. Vessel cleaning and the application or removal of antifouling coatings either in maintenance facilities or in-water can lead to the contamination of sediments and fisheries resources, and have lasting effects on marine ecosystems.

A widely used antifoulant, tributyltin (TBT) was recently banned, and the use of some other toxic antifoulants restricted, in countries that adopted the *International Convention on the Control of*

Harmful Anti-fouling Systems on Ships (IMO, 2001). However, these chemicals may still persist on older vessels and those originating from non-signatory countries. TBT causes deformation and imposex in marine gastropods and has been linked to mortality in higher order predators (Daffron*et al*, 2011).

Benthic Habitat

The construction of the LNG plant and marine terminal will disturb areas of seabed through the following activities;

- Construction of a rock breakwater.
- Construction of a marine terminal, shipping berth and turning basin.
- Land reclamation for construction of a MOF.
- Dredging

There will be a permanent loss of marine habitat associated with infilling and reclamation works. Construction of breakwaters and other maritime structures will also result in the loss of soft bottom habitat, however the presence of the jetty, berth and pilings provide new hard substrate for the settlement and colonization of marine organisms.

Most of the construction activities, including dredging, will cause localised direct impacts to a combination of soft bottom benthic communities and rock pavement habitat both of which presently occur in the intertidal and shallow subtidal zones of the project area. Disturbed areas will be recolonised by a combination of locally occurring marine species, although the recolonizing communities on the inside of the enclosed harbour will be significantly different to those that occur on the outside. This is largely due to the changes to hydrodynamic processes, affecting circulation and wave propagation caused by construction of the breakwaters.

Recolonisation of altered habitats will inevitably occur from surrounding populations, however, it is likely to include a different suite of species leading to altered community composition. This will be most evident in the dredged shipping channel and turning basin.

Infauna

The loss and alteration of sandy benthic habitat discussed above will result in loss or change of infauna assemblages in the affected areas.

Depth, water quality, sediment quality and sedimentation rates are important determinants of infaunal community structure. Changes in these parameters may result in altered community composition, as different groups of taxa are more suited to different environmental conditions. For example, bivalves are generally less abundant in high sediment-suspension/deposition environments, while some crustacea and polychaete worms are more prevalent (Anderson *et al*., 2004).

Within the study area, waters are naturally turbid due to the discharge of nearby rivers. Seasonal storms, cyclones and monsoonal flooding are common. The communities inhabiting the area will be suited to this environment and are likely to be relatively tolerant of elevated turbidity. Benthic infauna communities subject to frequent natural disturbances are likely to recover relatively quickly from a disturbance event (Dernie*et al*, 2003). Provided impacts on water and sediment quality are

comparable to natural disturbance events, community responses will follow natural recovery processes and ecological impacts will be minimal. If impacts on water and sediment quality are long-term or exceed natural levels (frequency, intensity or duration), there may be a shift in community composition or even a loss of the community and subsequent colonisation by adifferent suite of species (Miller *et al*, 2002).

Fisheries

The commercial fishing industry in Timor Leste has recently undergone major redevelopment and expansion, however the industry is predominantly concentrated on the north coast and we are unaware of any commercial operations in the study area. Artisan subsistence fishing occurs in the vicinity of the study area.

Fishing will be temporarily excluded from the area by construction and operation of the terminal.. During operation, an exclusion (safety) zone will typically be enforced when vessels are berthed.

There is potential for impacts on sediment and water quality to adversely affect fisheries resources, but any affects are unlikely to extend much beyond the project footprint. s. Heavy metals, petrochemicals, chlorinated hydrocarbons and wastewater pathogens bioaccumulate in fish and shellfish, and have the potential to exceed levels safe for human consumption, where discharge is unregulated. Sediments and water in the study area are presently uncontaminated. Provided water and sediment quality impacts are managed appropriately, contamination of fisheries resources by project activities is unlikely.

Colonisation by Invasive Marine Species

As previously discussed, construction activities will disturb and in places remove existing biota within the project area. Disturbed and stressed communities are particularly susceptible to invasive marine species for a number of reasons (Hutchings *et al*. 2002). Disturbed areas and new structures provide vacant space for colonization by opportunistic species. Disturbance can reduce biodiversity within a community and low biodiversity may reduce the community's resilience to invasion. The disturbance may also create environmental conditions in which the invasive species has a competitive advantage over indigenous species (e.g., low light climate, low water movement, or high concentration of suspended solids).

The construction of the Beaco LNG facility, including the proposed jetty terminal and marine offloading facility, will likely include the use of floating plant, such as barges and dredgers, from other domestic or international ports. These vessels have spaces and structures where marine species can attach and they are often slow moving, so antifouling is less critical to vessel performance and may not be well maintained (GISP 2008). These vessels typically have long residency times in ports and work sites. This increases their chance both of becoming infected by a potentially invasive marine species and of infecting the site if they are carrying one. Consequently, dredges and barges are considered to be a particularly high-risk vector for the translocation of invasive marine species (e.g., GISP 2008; Wells et al. 2009).

During operation the LNG terminal will receive a regular volume of commercial vessels. These vessels are a vector for the translocation and introduction of invasive marine species. Petroleum industry vessels are usually well maintained and antifouled, and spend minimal time in port, so they

are considered lower risk than dredgers and barges. However, due to the high traffic volume and their frequent transits between ports where invasive marine species are present, these vessels still pose a moderate risk (e.g., GISP 2008; Wells *et al.* 2009; API 2010). The risk is higher where vessels are moving between ports with similar environmental characteristics.

7.9.4 Avoidance, Management and Mitigation Measures

Resuspension of Sediments

Construction and operational activities will unavoidably disturb and resuspend some sediment. The impact of this was reduced by avoiding sensitive and high conservation value habitats when selecting the development location. The MOF is likely to be constructed first and then used as a contractor's construction dock for the creation of the remaining land based and marine based infrastructure.

The requirement for maintenance dredging is uncertain. Its frequency and volume will depend on the rate of sediment accumulation within the harbour. If/when maintenance dredging is required, careful dredging practice will be employed to minimise impacts, including:

- Timing of dredging and disposal operations to avoid coincidence with key lifecycle stages for local biota.
- Selection of appropriate dredger and dredging methods for the dredge volume required, including utilization of suspension reduction technologies where practicable.
- Implementation of a 'No Overflow' policy during dredge loading (where practicable).
- Minimisation of dredging volume though careful planning and avoidance of excessive deepening (to the best extent practicable).
- Careful selection of disposal sites and methods. Disposal of sediments within the adjacent area allows the natural dynamics of the system to be maintained, and also minimizes the costs transporting materials to remote disposal sites. Dredged sediments may be used for beneficial beach renourishment where appropriate.
- Record keeping.

Dredging protocols will be developed and incorporated into an environmental management if required.

Discharges, Spills and Runoff

Policies and procedures will be developed for construction works, bunkering, cargo transfer and waste management that eliminate intentional discharges to water and minimise the risk of accidental discharge or spillage. These procedures will be incorporated into an environmental management system for the Beaco LNG Terminal.

All vessels will comply with local regulations and relevant provisions of MARPOL.

A spill detection, reporting and response system will be developed to ensure prompt control and clean-up of any spills.

Spill containment equipment will be maintained on site.

Site runoff from the tank farm will be controlled with a containment bund.

Wastewater Treatment Plant Discharge

To reduce the environmental impact of wastewater discharge on the marine environment, treated wastewater will be retained on land for re-use or recycling wherever practicable and environmentally beneficial.

As there is a low risk to human health for the discharge of pathogens, primary contact recreation will be excluded within 100 m of the outlet and shellfish collection excluded within 500 m.

The design of the wastewater treatment plant is not defined. Secondary treatment of wastewater and subsequent disinfection by microfiltration, UV irradiation or ozone treatment would have the lowest impacts on the marine environment but may not be practicable. If a chlorination disinfection process is used, de-chlorination and toxicity monitoring of the discharge is recommended.

Changed Hydrodynamics and Sedimentation Regime

The alteration of hydrodynamics and sedimentation in the project area is a likely and unavoidable consequence of the construction process. The impact of these alterations can be minimised by avoiding sensitive and high conservation value habitats when selecting the development location.

Antifouling Contamination of Sediments

The contamination of port sediments by antifoulants will be minimized by controlling the application, maintenance, removal and disposal of antifouling coatings within the project area. The Australian government has developed *Antifouling and In-water Cleaning Guidelines* (DAFF, 2011) that provide a practical approach for management of antifouling. Recommendations in these guidelines include:

- The prohibition or control of certain antifoulant coatings.
- The containment and controlled disposal of all antifoulant residues and waste.
- The removal of vessels and movable structures from the water for cleaning and maintenance wherever practicable.

Benthic Habitat

Construction and operational activities will unavoidably alter benthic habitats within the project area. The impact of this was reduced by avoiding sensitive and high conservation value habitats when selecting the development location.

The constructed breakwater is likely to be a small structure but will provide some

artificial reef habitat. When mature, artificial reefs can have fish and benthic communities that are comparable to natural reefs in terms of abundance and diversity (Lincoln-Smith et al, 1994).The piles that form the marine terminal jetty structure will provide a much larger surface area for colonisation by marine flora and fauna.

Infauna

Construction will unavoidably remove some areas of benthic soft-sediment habitat and the infaunal communities they contain. Further impacts on infauna will be limited through the control of impacts on sediment and water quality.

Fisheries

Construction and operational of the supply base will unavoidably displace some fishers from the project area. The exclusion of fishing from around the LNG facility is only likely to apply when a ship is berthed.

Colonisation by Invasive Marine Species

The primary vectors for invasive marine species are vessel ballast water and biofouling.

The *International Convention for the Control and Management of Ships' Ballast Water and Sediments* (IMO 2004) provides technical standards and requirements for the control of marine pest translocation in ships' ballast.

At present there are no international conventions for the management of biofouling, however the Australian government has developed a *National System for the Prevention and Management of Marine Pest Incursions*, including:

- National biofouling management guidelines for commercial vessels (NSPMMPI, 2009a).
- National biofouling management guidelines for non-trading vessels (NSPMMPI, 2009b).
- National biofouling management guidelines for the petroleum production and exploration industry (NSPMMPI, 2009c).

7.9.5 Residual Impacts

Construction will unavoidably disturb and alter habitats in some areas of the site. The consequence of these changes are likely to be confined to the MOF and construction of terminal and have been minimised by locating the development site in an area where habitats are likely to have a relatively high tolerance to turbidity and disturbance,and are generally of low conservation value.

The risks of spills, antifoulant contamination and marine pest incursions will be greatly reduced through the implementation of specific management plans as part an environmental management system.

7.9.6 Monitoring and Reporting

Water quality monitoring adjacent to any point source discharges is recommended to determine compliance with environmental guidelines. Measurements should include a standard suite of physico-chemical parameters and contaminants. Ecological monitoring of key habitat types is also recommended during the construction and commissioning phase of the project.

7.9.7 Further Work

At present, the assessment of marine biodiversity impacts is generalised, as the extent and intensity of effects from project activities are uncertain. The development of a hydrodynamic model for the project area would allow:

- Prediction of dispersal and settlement patterns for sediments suspended by construction and operational activities.
- Prediction of sediment accumulation at the facility, allowing the assessment of maintenance dredging requirements.
- The identification of the optimal location for the wastewater treatment plant outlets and the predication of discharge dilution and dispersal patterns.

A coastal processes study is also required to quantify the interruption to sediment movement along the coast from construction of a breakwater and the risk of erosion or deposition on adjacent intertidal habitat.

The coastal process study would define the existing wave and current climate and existing sediment transport pathways. Numerical modelling would then be used to assess the impact of the proposed development on coastal processes and predict areas of morphologic change (erosion and accretion).

At present the design of the wastewater treatment plant has not been defined. The level of treatment and type of disinfection process used (if any) will have significant bearing on the facility's impact on the marine environment. Completion of the design would enable a more comprehensive assessment of impacts.

The development of procedures and management systems for the Beaco LNG plant would support a systematic and consistent approach to environmental management. These include:

- Procedures for construction works, bunkering, cargo transfer and waste management that eliminate intentional discharges to water and minimize the risk of accidental discharge, spillage and runoff.
- A process for spill detection, reporting and response.
- Protocols for the management of antifouling.
- A marine pest management plan.
- Protocols for dredging operations and dredged material disposal.

7.10 Social and Economic Values

7.10.1 Socio-Economic Objectives

The objective of the socio-economic component of the Tasi Mane Project – Beaco development (the project) Strategic Environmental Impact Assessment (SEIA) is *'to identify social and economic impacts that are likely to result from the proposed project'*. The expected output of this component of the study is:

- Population Distribution:
  - To present a demographic profile according to size, age, sex and ethnic group encountered in the baseline investigation.
- Socio-Economic
  - To present a description of the socio-economic profile of the local people.
  - To present general views and opinions of local people on the implementation of the project.
  - To solicit the degree of acceptance and opposition, as well as the condition set by the public on the proposed project.
  - Identify and describe anticipated negative and/or positive socio-economic impacts at local, regional and national level.
  - Providing recommendations for the development of potential mitigation and management measures to mitigate potential negative impacts and enhance positive impacts.

7.10.2 Study Method

Baseline Data Gathering

The approach adopted for the socio-economic component used both desktop investigations (secondary research) and participatory techniques (primary research) to gather relevant and the most up to date social and economic baseline data.

Secondary Research

Secondary research included an analysis of previous studies to identify information gaps and areas that require further investigation. Secondary research was predominantly used to inform the project setting (Chapter 3), except for the government census data that informed the demographic profile at a local level and the spatial design planning documents for Viqueque district (RDTL, 2011b) that provided information on current land use within the study area.

The National Strategic Development Plan (2011-2030) (SDP) was the key source of literature consulted in providing an overview of the national context, due to the relevance of the plan i.e., providing baseline information that is recent (2010), highlighting strengths and weaknesses of Timor-

Leste as far as development is concerned and outlining government's vision for Timor-Leste. This information provided critical input in developing appropriate recommendations for socio-economic mitigation and management measures.

Primary Research

Primary research activities (fieldwork) focussed on the villages located closest to the respective project development sites and which would, therefore, be the most directly affected. For the Beaco development this included Maluru village and Uma-Uain Craik village. These villages are defined as the study area for the Beaco development (as shown in Figure 7-31).

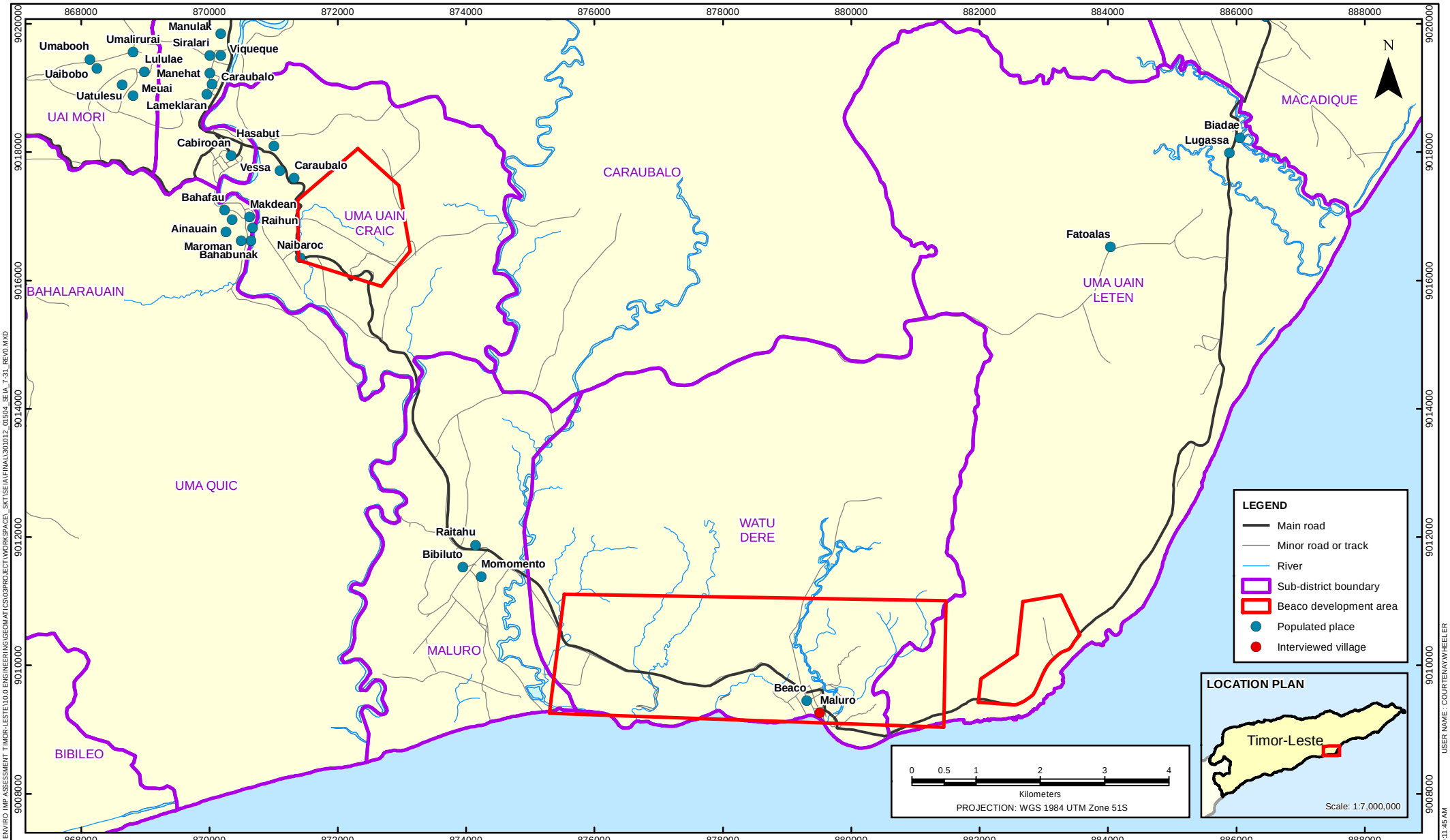
WorleyParsons' approach to gathering baseline information incorporated key informant interviews, focus group meetings, cultural mapping and GIS analysis of aerial imagery through participatory methods. A site visit was undertaken by two social specialists, working independently, to obtain more information on the surrounding socio-economic elements that could be affected by the project. The approach for each of the primary research activities can be summarised as follows.

Key informant interviews

- Interviews were held with the chiefs and the traditional council to discuss the fieldwork objectives and to notify them about the forthcoming focus group. This was done using a semi-structured questionnaire specifically designed for these key informant interviews (refer to Appendix I).
- During these key informant interviews, baseline information about the social organization in the respective villages was gathered as well as perceptions about the project.

Focus group meetings

- Baseline information about a wide range of socio-economic aspects in the Betano and Beaco study areas was gathered as well as perceptions about the project. This was done using a more detailed semi-structured questionnaire. This questionnaire included the same questions asked in the key-informant interviews as well as additional questions about socio-economic aspects in the village that could best be answered by the respective focus group attendees (refer to Appendix J).
- Chiefs were requested to invite individuals who fulfill specific roles within the village to ensure questions that were posed could be answered by the most suitable informed individuals, e.g., village elders were in the best position to answer questions about sacred sites, and teachers to answer questions about the education conditions in the village.



NOTES:
This map consists of:
1. Rivers: Geographic Information Group TimorLeste (2010)
2. Roads: DivaGIS (2010)
3. Villages: Geographic Information Group TimorLeste (2010)

REV	DATE	REVISION DESCRIPTION	DRN	CHK	DES	ENG	APPD	CUST	
0	30/05/2012	FINAL FOR ISSUE	CS	CW	-	-	GH	-	A4 SHEET / SCALE 1:80,285
									PROJECT No: 301012-001504

WorleyParsons resources & energy

TIMOR GAP, E.P. TIMOR GÁS & PETRÓLEO

REPUBLICA DEMOCRATICA DE TIMOR-LESTE
SECRETARIA DE ESTADO DOS RECURSOS NATURAIS

OneWay to zero harm

Copyright © WorleyParsons Services Pty Ltd

TASI MANE PROJECT - BETANO AND BEACO
STRATEGIC ENVIRONMENTAL IMPACT ASSESSMENT

Figure 7-31
Beaco development social and economic study area

LOCATION: I:\PROJECTS\301012-01504 ENVIRO_IMP ASSESSMENT TIMOR-LESTE\10.0 ENGINEERING\GEOMATICS\03PROJECT\WORKSPACE_SKT\SEIA\FINAL\\301012_01504_SEIA_7-31_REV0.MXD

USER NAME - COURTENAY.WHEELER

PLOT DATE & TIME - 30 MAY 2012, 10:11:45 AM

Cultural mapping

- Following the semi-structured interviewing, the focus group attendees were requested to participate in the cultural mapping exercise.
- Large maps of the applicable site were printed out, with key landmarks indicated to orientate the participants.
- Villagers were then asked to indicate sites of cultural value on these maps. These sites included sacred sites, water points, agricultural fields and dwellings.

The first team, comprising of a Worley Parsons social consultant accompanied by a Timorese interpreter and a SERN representative undertook the key informant interviews on 11 December 2011.

The second team undertook the focus group meeting and cultural mapping on 13 December 2011 with Uma-Uain Craik and Maluru villages.

Details of the key informant and focus group meetings are provided in Chapter 5.

Impact Assessment

Using the baseline information gathered findings of the stakeholder engagement process, as well as an analysis of the project plan and GIS data, potential impacts on the socio-economic environment were identified for the construction and operational phases of the project. This assessment includes positive, negative, direct, indirect, residual and cumulative impacts, taking into account concerns identified through the stakeholder consultation (Chapter 5).

As part of the assessment of socio-economic significance, consideration is given to the ability of affected parties to adapt to changes and thus maintain livelihoods over the long term. Cumulative socio-economic impacts of the project are also analysed as part of the impact assessment.

The study method adopted for the socio-economic assessment did not include application of a social impact assessment impact rating system (i.e., allocating a rating for severity, spatial scale, duration and probability) as the detailed project information required to make application of such an impact rating system feasible had not been released to WorleyParsons at the time of this study.

Mitigation and Management Measures

IFC Performance Standard 1 requires the client to establish and maintain a Social Management System appropriate to the nature and scale of the project and commensurate with the level of social risks and impacts. The management program needs to take into account the relevant findings of the social assessment and the consultation with affected communities. An effective social and environmental management system is a dynamic, continuous process initiated by management and involving communication between the client, its workers, and the local communities directly affected by the project.

An environment management framework has been developed in order to manage identified environmental impacts associated with the project (see Chapter 8). With respect to social impacts, the

mitigation measures which have been developed and presented in this section should be incorporated into the eventual Environmental Management Plan.

Data Assumptions and Limitations

Assumptions and limitations associated with the socio-economic component of the EIA include:

- Census (RDTL, 2010) statistics that were a key input into this study are predominantly presented therein as diagrams and figures and, in some cases, do not show exact percentages. Furthermore, the statistics are not accompanied by detailed descriptions or analysis, e.g., indicating how 'employed' (formal employment or also informal trading) or 'economic inactive' (only people between 16 and 65 or also people with disabilities) are defined. In other cases census findings contradict some responses received during WorleyParsons interviews. This lack of interpretation and discrepancy between census findings and WorleyParsons interviews necessitated a number of assumptions to be made. These assumptions have been pointed out in the baseline section where applicable.
- Due to the early phase of development planning, a detailed project description for Beaco development has not yet been developed. The lack of project information has resulted in certain limitations as far as impact assessment and mitigation measures are concerned. On this basis, the socio-economic sections should therefore be viewed as a strategic (preliminary) socio-economic assessment and its conclusions as indicative, rather than definite.
- Uncertainty surrounding construction expenditure, workforce projections and royalties and tax payment details made it difficult to accurately assess economic impacts. As a result, the impact section provides a high level description of economic impacts that are likely to occur based on project information available and based on actual impacts of similar projects in South East Asia and other developing countries. Once more project information becomes available, a more detailed economic impact assessment is recommended.
- Due to the preliminary nature of this assessment, rather than providing detailed management/action plans, this report provides recommendations to consider in subsequent phases of project planning that can be adapted as appropriate to the specific project design.
- Other information gaps which have limited the study include:
  - Meeting details and issues and concerns raised during previous stakeholder engagement by SERN have not been provided (A number of other stakeholder engagement limitations are discussed separately under Chapter 5).
  - Details of the resettlement approach being adopted by SERN.
  - Specific project plans for water, electricity, specific roads to be upgraded, marine areas to be off limits to local boats.
- Due to the lack of updated aerial imagery or asset and field surveys being undertaken, the full extent of physical and economic displacement could not be accurately assessed. Therefore, a rough estimation of land use within the footprint areas has been provided using out-dated 2003 aerial imagery.

- Impacts associated with physical and economic displacement are described in this SEIA and recommendations are provided for mitigation of these impacts in line with International Finance Corporation Performance Standard 5. However, WorleyParsons has not been requested to develop a resettlement action plan (RAP) since resettlement negotiations by SERN are at an early stage, separate from this SEIA. No information about the resettlement principles and the overall process being followed by government has been provided. The description of these impacts therefore does not take into consideration agreements that have yet to be finalised between the affected parties and government.

The impacts associated with the construction of other government infrastructure projects, including the highway between Suai and Beaco (~170 km), and the National Electricity Grid project, including the construction of the power plant at Betano, are excluded from this EIA scope. They are, however, considered from a cumulative impact perspective.

7.10.3 Existing Environment

District Overview

Viqueque district is located on the south coast of Timor-Leste. It borders the district of Lautem to the east, Baucau to the north, Manatuto to the west and the Timor Sea to the south. It has a population of 70,036 inhabitants (RDTL, 2010) and an area of 1,781 km². The capital of the district is also named Viqueque. The Viqueque district comprises the sub-districts of Lacluta, Ossu, Uatolari (formerly called Leça), Uato Carabau and Viqueque. In addition to the official languages of the country (Tetun and Portuguese), the majority of the population speaks Macassai.

Over and above the LNG plant that will be established in Beaco, government has started to plan the construction of a wind energy source in Larigutu in the next five years to provide power to the LNG plant and the district. Government is planning to strengthen the rice production industry in Viqueque to be self-sufficient by 2020. In the next 10 years, a regional port will be built around Beaco as well as a regional airport in Viqueque. Beaco and Viqueque will be accessible by road from Dili to support oil industry and open coastal areas for economic development and social services in the next 10 years. The local road will be established between Uatolari to Laisorolai and from Salau to Viqueque via Natarbora.

Village Level

This section of the report outlines the socio-economic situation in the Beaco study area.

Population, Demographics Profile

The total population of Uma-Uain Craik in 2010 was 2,787 while the population of Maluru was 678 (Census 2010). The number of households present in Uma-Uain Craik is approximately three times greater than that of the neighbouring Maluru with 492 and 134 households present respectively. The average household size was 5.1 persons in Maluru and 5.7 in Uma-Uain Craik. The number of males and females were similar in each of the two villages. Table 7-33 shows the total population of the two villages, including total numbers of males, females and households.

Table 7-33 Population profile in Maluru and Uma-Uain Craik

	Male	Female	Total	Total HH
Maluru	343	335	678	134
Uma-Uain Craik	1,434	1,353	2,787	492

Source: Timor-Leste Census 2010

The age distribution of Maluru and Uma-Uain Craik is similar to the villages discussed in other sections of the baseline with around 45% of the population in the 0 to 14 and 15 to 59 age groups respectively (RDTL, 2010). Around one in every ten people in Maluru and Uma-Uain Craik was aged 60 or older. Table 7-34 shows the age distribution of the two villages in question.

Table 7-34 Age distribution in Maluru and Uma-Uain Craik

	Maluru (%)	Uma-Uain Craik (%)
Age 0 to 14	44	43
Age 15 to 59	46	48
Age 60+	10	9

Source: Timor-Leste Census 2010

In terms of preferred language, for Maluru village, Makasa'e was the most common language (95%) recorded in the 2010 Census. Tetum Terik is the preferred language in 4% of the village population. Uma-Uain Craik village was very different by comparison. Tetum Terik was the preferred language for 70% of the population and around one-fifth (18%) described their mother tongue as being Makasa'e. Tetum Prasa was the mother tongue of a further 11% of villagers (RDTL, 2010).

As with Suai and Betano, many Maluru and Uma-Uain Craik youth move to Dili for work. Whether a person moves to Dili or not usually depends on the level of assistance that his/her family can offer to help with the move. People who move in, or out, of the district, tend to do so for the long term (WorleyParsons, 2011).

Land ownership and management in Maluru and Uma-Uain Craik is consistent with other areas discussed in the baseline study. Land ownership is based around the family or household. Locals are customary landholders and do not have certificates or deeds of ownership (WorleyParsons, 2011).

In order to reside in Maluru, newcomers need to abide by local rules or be married to a family member within the village. The Maluru interviewees mentioned that they have allowed some outsiders to come and settle on their land however, no customary ownership was granted to these people. In Uma-Uain Craic village, the newcomer would need to speak to the chief and then to the relevant customary landowner to explain why they want to live in the area. A decision would then be made whether the newcomer is allowed to stay in the village (WorleyParsons, 2011).

Village Organisation

There are a number of community-based organisations (CBOs) operating in Maluru village. The CBOs mentioned by fieldwork participants included; fishing, agriculture, horticulture, livestock, sewing, carpentry, bread making, Catholic group, Protestant group and the CBO which facilitates the SISCA health service (a new health program which means 'Integrated Health Services at the

Community Level' in the Tetum language). CBOs are formed through submission of a proposal and business plan to the government who then supply equipment (rather than money). Any profits from the group are shared among the members. In Uma-Uain Craik, the active CBOs are focused on agriculture, fishing and horticulture.

NGOs operating in Uma-Uain Craik are GTZ (*Gesellschaft für technische Zusammenarbeit*) (assisting with agriculture), Cailalo (assisting with micro-financing and small business development), Colegas Dapaz (with natural disaster management), and La'o Hamutuk (natural and research monitoring). According to participants, there were no NGOs operating in Maluru village (WorleyParsons, 2011).

As in Suai and Betano, there are many vulnerable people in Maluru. These include orphans who stay with the extended family, older people, particularly those who live on their own, and people with physical disabilities (some of whom have help from outside organisations). There are also many female-led households in Maluru (WorleyParsons, 2011)

Communication, Language and Travel

WorleyParsons interview respondents in Maluru and Uma-Uain Craik reportedly communicate using mobile telephones given the good reception in the area. TV and radio reception was also described as being adequate; however, few people owned functioning radios or television sets.

Village meetings are held sporadically when an announcement needs to be made. The village chief and sub-village chiefs meet on a monthly basis. Transport is available via minibus or truck and only one person owned a car in Maluru (WorleyParsons, 2011).

Economic Activities

Fieldwork participants reported that the main forms of livelihood in Maluru and Uma-Uain Craik were:

- Growing corn (maize).
- Fishing.
- Livestock herding.
- Local business.

Source: WorleyParsons Fieldwork, 2011

The 2010 Census recorded levels of employment in Maluru at 45%, with 54% of the population recorded as being 'inactive' and 1% unemployed. In Uma-Uain Craik only 37% of the population were in employment while 59% were 'inactive' and 5% unemployed. The 2010 census reports received by WorleyParsons did not specify how 'employed' or economically 'inactive' were defined; however, based on interview responses, it is reasonable to assume that informal trading (e.g., selling of crops and livestock) were included as a form of employment.

The main sources of cash income in the area are the same as in Suai and Betano. These include vegetables, livestock and corn. Small businesses also generate their own income (WorleyParsons, 2011).

Amenities

As with the villages in Suai and Betano study areas, the most commonly occurring amenity recorded in the 2010 Census (RDTL, 2010), was the mobile telephone. However, levels of ownership differ greatly between the two villages as shown in Table 7-35. Nearly three-quarters (74%) of households in Uma-Uain Craik owned mobile telephones, while only 42% of households owned a mobile telephone in Maluru. Radios were owned by one third of households in both of the villages discussed. Televisions were relatively common in Uma-Uain Craik (34% ownership) while only a small minority (4%) owned televisions in Maluru.

Table 7-35 Amenities owned by households in Maluru and Uma-Uain Craik

	Maluru (%)	Uma-Uain Craik (%)
Car/Van	3	3
Motorcycle	9	14
Bicycle	28	14
Freezer	7	8
Mobile Phone	42	74
TV	4	34
Radio	34	33

Source: Timor-Leste Census 2010

In terms of transportation amenities, bicycles were owned by 28% of households in Uma-Uain Craik and 14% of households in Maluru. Motorcycles were owned by 9% of households in Uma-Uain Craik and 14% of households in Maluru. Similar to other villages discussed in the baseline report, cars and vans were owned by only a small minority of households (3% in both villages) (RDTL, 2010).

Agricultural Activities

Similar to the Suai and Betano study areas, participants stated that everyone in the area was involved in farming as it is the main source of food. Even villagers who have another job tend to farm. Some farm plots are situated close to the village and others are a few kilometres from the village. Grazing was strictly controlled by herdsmen as it is important to stay within the village lands.

Livestock are of particular importance to local people. In Maluru the large majority (94%) of households raise animals, while a smaller majority (62%) of households raise animals in Uma-Uain Craik. As found elsewhere in Timor-Leste, the most commonly raised animals in these two villages were chickens. Table 7-36 shows the total number of each type of animal raised in the two villages.

Table 7-36 Livestock reared in Maluru and Uma-Uain Craik

	Chickens	Pigs	Sheep	Goats	Horses	Cattle/Cows	Buffalos
Maluru	1,395	704	41	308	758	388	393
Uma-Uain Craik	2,678	1,178	521	173	361	503	470

Source: Timor-Leste Census 2010

Crop production is also common in Maluru where 80% of households produce crops. By comparison, a far smaller proportion of Uma-Uain Craik households are engaged in crop production (only 27%). The low percentage of households producing crops is surprising and is in conflict with interviewee responses gathered during fieldwork and the reasoning for this needs to be assessed in future fieldwork.

The most popular crops for Maluru households are temporary fruit crops, vegetable, cassava, corn and rice. Between 70% and 80% of Maluru households produce each of these crops, which is considerably higher than the national production rate (RDTL, 2010).

In terms of cash income, fieldwork respondents mentioned that crops are sold occasionally when an excess was produced. Livestock are also sold occasionally, particularly when people were in need of cash, e.g., such as school fees.

Natural Resources

Access to improved drinking water is relatively high in Uma-Uain Craik where, according to the 2010 Census, between 80% and 100% of households has access to an improved water source. In contrast, the main water source for respondents in Uma-Uain Craik is the local river where it is collected by bucket. There are also three wells in the village, however two of these are broken and the other is used only for washing. The reason for the discrepancy between the WorleyParsons fieldwork response and the census 2010 census data for water sources in Uma-Uain Craik was unknown at the time of writing; however it may be that the wells were not broken at the time of the 2010 Census. Water contamination is a concern in the village; however, no health issues have been reported.

By comparison, between 20% and 40% of households in Maluru have access to an improved water source for drinking (RDTL, 2010). The main water source in Maluru is 20 shared wells. Each well provides water for around five families. Water appears to be scarcer in Maluru than other areas. Water appears to be safe for human consumption in both villages as no related health issues were reported.

Similar to the Suai and Betano study areas, wood is the main source of energy for cooking in both Maluru (93% of households) and Uma-Uain Craik (92% of households). In Maluru, the only other significant source of cooking energy was kerosene (6%). Secondary sources of cooking energy for households in Uma-Uain Craik included electricity (3%) and kerosene (3%) (RDTL, 2010).

In terms of lighting energy sources, the two villages were very different, with 80 to 100% of the population of Uma-Uain Craik using electricity and only an estimated 0 to 20% of the Maluru population using electricity.

Most natural resources are reported to be available freely in the Maluru area, including firewood, most thatching materials, honey, land for farming and grazing. Natural resources which are scarce include traditional medicines and black palm leaves for thatching. No resource scarcity was mentioned in Uma-Uain Craik. Traditional medicine based on natural vegetation is used in both villages and traditional doctors are present. In Uma-Uain Craik the hospitals are more popular than traditional treatments (WorleyParsons, 2011).

In Maluru, fishermen fish in the ocean rather than in fresh water due to the presence of crocodiles in the rivers. Fish provides an important cash contribution for Maluru people and if the fish are not able to be sold they are consumed. Fishing is less common in Uma-Uain Craik with only about 20 fishermen present.

Services and Infrastructure

Table 7-37 summarises the community infrastructure found in Maluru and Uma-Uain Craik.

Table 7-37 Community Infrastructure for Maluru and Uma-Uain Craik

	Maluru	Uma-Uain Craik
Kindergarten	1	-
Primary schools	5	4
Junior high school	1	-
Secondary schools	-	-
Hospital	-	-
Clinic	1	1 (mobile)
Police station	-	-
Houses of worship	1 chapel	1 chapel
Shops (approx.)	10	6
Recreation	3	1
Market	1	-
Waste dump	-	-

Source: WorleyParsons Fieldwork, 2011

According to fieldwork participants, sanitation systems are very basic in both villages, with very few flush toilets and some pit latrines. People also used vegetated areas as a latrine and piggeries were used in the disposal of waste. The 2010 Census placed Maluru and Uma-Uain Craik at different ends of the sanitation spectrum, with Maluru at the bottom (0 to 19.9%) and Uma-Uain Craik at the top (80 to 100%).

Government services are mostly free (including most schools and the hospital); however, a fee has to be paid to attend the private school in Viqueque.

As for Suai and Betano, housing largely consists of traditional dwellings and a smaller number of modern structures. The type of housing constructed is dependent on available funds. Road construction and maintenance is the responsibility of government in Maluru; however, this work is sometimes contracted to local companies (WorleyParsons fieldwork).

The 2010 Census looked at thee indicators for housing condition; external walls, roofs and floors. As far as external walls and floors are concerned, Uma-Uain Craik fell in the slightly higher category (20 to 39.9%) and Maluru at 0 to 19.9% and for roof conditions, Maluru remained at 0 to 19.9% while Uma-Uain Craik was at 40 to 59.9%.

Education

The 2010 Census shows that 25% of the Maluru population and 31% of the Uma-Uain Craik population were attending schools at the time of the census. Around one-quarter of the population in each village had attended school in the past (26% in Maluru and 24% in Uma-Uain Craik respectively). Lastly, 48% of the Maluru population and 43% of the Uma-Uain Craik population had never attended school.

The vast majority (82%) of youths aged between 15 and 24 were literate in Maluru, while 76% of youths in Uma-Uain Craik were literate. Between 40% and 60% of the total population were literate in the two villages (RDTL, 2010).

The key educational challenges discussed by fieldwork participants included a scarcity of primary and junior secondary teachers, educational resources (e.g., books) and educational infrastructure (e.g., school rooms). Issues around payment of teacher salaries contributed to the scarcity of available teachers. Some teachers work on a voluntary basis. The local secondary school in Maluru was only built three years ago (WorleyParsons, 2011).

Health

Levels of health have reportedly remained the same in Maluru over the past two years. The local health clinic works at full capacity and equipment and medicine is in limited supply. Most people in Maluru visit the health clinic rather than consulting a traditional doctor. General health is considered to have improved in Uma-Uain Craik due to the mobile clinic and increased access to the other health facilities because of improvements in road conditions (WorleyParsons, 2011).

Similar to Suai and Betano, the most common diseases present in Maluru and Uma-Uain Craik are malaria, tuberculosis, diarrhoea and leprosy. Malnutrition is also an issue in the area as is respiratory related illnesses, particularly with older people due to their smoking habits (WorleyParsons, 2011).

The key challenges in terms of health services in Maluru are the inadequate supply of medical equipment, medicine and available staff (only one nurse is employed). This affects the adequate provision of vaccinations. In Uma-Uain Craik the challenges were seen as being the lack of a permanent clinic, medicine or locally based health professionals. In Uma-Uain Craik it was mentioned that the government provide mosquito nets (one per family) (WorleyParsons, 2011).

The 2010 Census shows that, the percentage of births assisted by a skilled health provider in the last five years is 31% for Maluru and 58% for Uma-Uain Craik. In 2009, the infant mortality rate for Timor-Leste was 44 per 1000 live births. Data from the 2010 Census for infant mortality rate is not yet available (RDTL, 2010).

Cultural Heritage, and Burial Practices and Sites

Cemeteries are located in both Maluru and Uma-Uain Craik villages. There are many isolated graves in the LNG area, some of which are not clearly marked. There are also very old Portuguese buildings in the vicinity of both villages, which may possess some archaeological value (WorleyParsons, 2011).

As with Suai and Betano, everyone in Maluru and Uma-Uain Craik is from the same cultural group. Interview respondents stated there are a total of 32 sacred houses in Maluru including three major sacred houses where the community prays. Many sacred sites are located in Maluru. The following were examples mentioned by fieldwork participants:

- Big tree around the sacred house (Madatuk).
- Kibiti tree next to the river.
- A hill named Macaloso.
- Large tree called Betulari.

Three major sacred sites were mentioned by Uma-Uain Craik respondents, namely:

- Big rock (Fatukhun).

- Area where gas is released from the ground.
- Tree (Ailemi Galiria).

Interviewees reported that SERN has not recorded the location of these sites as yet. It was further reported that it is possible to perform a ritual to 'relocate' the sacred sites if the appropriate rituals are performed (WorleyParsons, 2011).

Social Problems and Crime

Petty theft of crops and livestock does occasionally occur in Maluru and Uma-Uain Craik.

The National Police are responsible for dealing with criminals; however, minor issues are resolved in a traditional manner, typically through the offering of compensation to be agreed by the two parties. Burglaries were not said to occur in Maluru. Uma-Uain Craik interviewees on the other hand reported that burglaries occurred in the village; however, people were not always reporting crime since finding the criminals was very difficult (WorleyParsons, 2011).

In all of the key informant and focus group interviews, the overwhelming response indicated that social problems and crime are not major issues in the study area. It should be noted; however, that, due to the sensitive nature of some crime-related issues (e.g., prostitution, domestic violence) questions in this regards where restricted to general statement. Further, there was no opportunity to interview women or other minority groups in isolation.

Key Perceptions about the Project

Similar to Betano village, respondents in the Beaco study area have few perceptions about the project due to the limited project information disclosed to date. The following comments were raised by respondents:

- Seek government to share more project information. They've had some consultation about the installation of wells; however, they are not aware of the extent of land required and/or the impact on marine use.
- Concern with respect to displacement of fields and fishing sites. Queried whether they will receive new jobs to replace income lost from farming and fishing.
- Concern expressed about the availability of replacement farm land, as the proposed LNG plant site appears to be in the vicinity of the only 'flat land' suitable for farming.
- There are people from Uma Uain Leten village who have settled on Maluru (Beaco) land. Maluru people have allowed them to farm there; however, the project developers should note they do not possess the customary rights for that land.
- Government tends to contract more established non-local businesses instead of local businesses. During the recruitment process, local people and businesses need to receive priority over people from other districts and foreigners, especially for positions where skills are available locally.

- Uncertain about the type of jobs that will be created by the project. Respondents would like government to share details of the type of jobs early in the process to allow individuals time to prepare themselves for these opportunities.
- Vocational training will be required to build capacity among youth to fill some positions.

7.10.4 Socio-economic Impact

This section of the report considers the potential socio-economic impacts associated with the Beaco development. Impacts were identified during the community engagement that took place during fieldwork during the desktop analysis and is an analysis of the project plan and the GIS.

As stated before, the impact and mitigation sections for Betano and Beaco should be read in conjunction with the socio-economic section of the Suai Supply Base EIA. Numerous impacts and associated mitigation measures are expected to be similar for the three sites, especially considering that this is a strategic assessment based on limited project information for Betano and Beaco. To reduce repetition, impacts have been assessed in more detail in the Betano impact and mitigation sections. Where impacts are expected to be similar for Beaco, a cross reference is provided to the Betano impact and mitigation sections. However, where there are differences in terms of significance, these are indicated in the relevant sections.

Impact 1: Employment Creation

The project will require a wide range of skills from caterers to skilled welders and engineers during both the construction and operational phases. All labour will need some site-specific training provided by the project operator. The current local unskilled labour pool will require specific skills training in order to maximise local employment uptake. If local employment is to be maximised, an assessment of required skill sets matched against their local availability will be needed, followed by specific training courses to address shortfalls. This will need to cover a large range of skills such as catering, plant operation, concreting, steel fixing, formwork etc., required early in the project, to steel erection, welding and mechanical installation in the later stages (KBC *et al.*, undated). Due to the urgency of constriction and the time required for training these programs will be of greatest impact in the operational phase.

No specific figures regarding employment for the Beaco development were received; however, the KBC report (undated) states that temporary accommodation will be built for up to 3,000 construction personnel and permanent accommodation for up to 200 operation personnel. With the use of local labour (not requiring separate accommodation) the construction and operation employment numbers may be higher. Notwithstanding the lack of detail, industry standards dictate that LNG Plant operations staff require a moderate level of skills training and experience unlikely to currently exist within the population in and around Beaco. Highly specialised skills training programs will need to be implemented to support the employment of local people during operations.

Impact Statement:

The construction activities will provide some job opportunities at a local level as well as district and national levels, mainly for unskilled labour. The construction of the Beaco development is planned as

part of the 3rd stage (2017-2023) of the Tasi Mane project. Thus, of the three developments, Beaco will have the advantage of having the most time to implement training programs before construction activities commence and using skills learned from earlier developments, at Suai and Betano.

Impact 2: Skills Development

Similar to the Suai Supply Base and Betano developments, the population in the Beaco study area will acquire skills as a result of the construction of the development. The specialised skills required by operations personnel will somewhat limit the initial operational employment opportunities for local people due to the current standards of literacy, numeracy and general education levels. The transfer of jobs to local Timorese will required the establishment of a comprehensive technical training system.

Impact Statement:

The development of skills in association with the construction of the development at Betano will improve individual marketability for future roles; however, the specialised skills required by operations personnel will place limitations on local employment opportunities in the operations phase of the project.

Impact 3: Creation of Economic Opportunities

Due to the highly specialised engineering, design and construction skills required and the scale of the project itself, only a small percentage per annum will be spent on Timorese contractors. Nonetheless, sufficient time will be available before construction of the Beaco development to implement mitigation measures such as enterprise development. Compared to Suai and Betano, there appear to be more local businesses in Maluru village, particularly in the construction industry, who could be approached and assessed as potential contractors (see mitigation measures).

At the time of writing, the project specific tax and royalty regime for the Beaco development had not been prepared and are still some years from finalisation. Nevertheless, it is expected that royalties and other taxes on production revenue and wages during operation will provide revenue for the Timorese government.

Impact Statement:

Taxes imposed during the life of the project will increase revenue for the Timorese government. This revenue, if managed effectively, can flow to the district levels and promote socio-economic growth and infrastructural development in these areas. The Beaco development will also increase the opportunities for national businesses during construction and operational phases; however, local businesses will require assistance to take advantage of these opportunities. Some local procurement programs can be implemented to target local businesses and facilitate growth in secondary and tertiary sectors of the local economy.

Impact 4: Physical Displacement (loss of dwelling structures)

Based on current plans for the placement of the LNG plant, the entire Maluru village (~678 people) will have to be resettled as well as some scattered farm dwellings in the Nova Beaco and Nova Viqueque areas (refer to Figure 7-32). These households stand to lose their existing physical, social

and/or economic assets as a result of the LNG Plant construction. The relocation of Maluru village will require the relocation of the following physical assets and infrastructure (to be verified by undertaking an asset survey):

- Dwelling structures (combination between western brick houses and traditional structures built with grass and bamboo).
- Education buildings (one kindergarten, one primary and one secondary school).
- One clinic.
- One chapel.
- Around 10 shops.
- Recreation facilities (one soccer field, two volleyball courts).
- One large market area.
- Cemeteries.
- Roads.

Furthermore, around 27 sacred houses are located within Maluru village and these will have to be relocated as well. The construction of replacement sacred houses will require many meetings and ceremonies and it is notwithstanding that the construction of a sacred house takes approximately one year to complete.

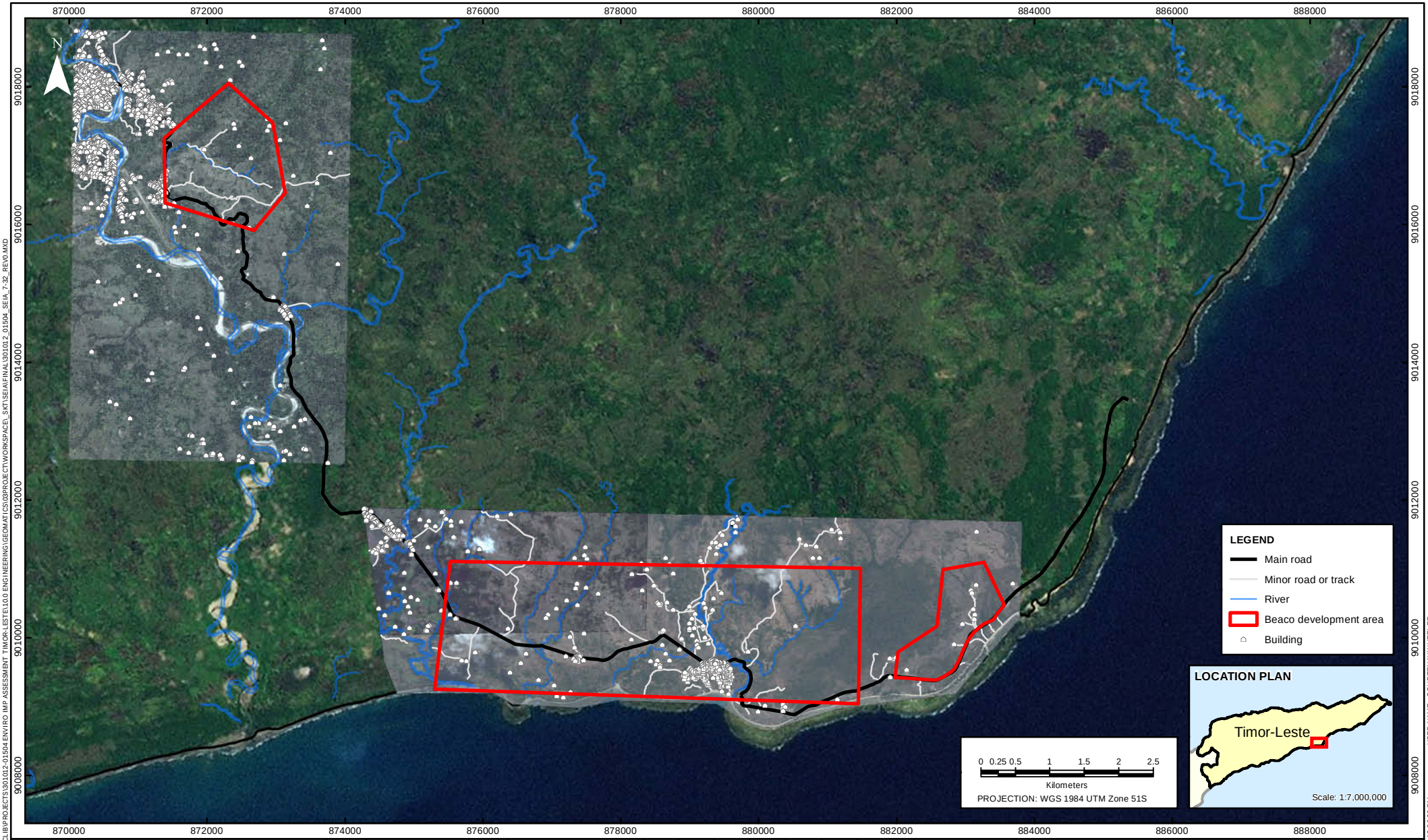
Nova Beaco will be dedicated to the resettlement of people from Maluru village, with international employees to be housed in Nova Viqueque (RDTL, 2011b).

Table 7-38 shows the current land use in the respective footprint areas for the Betano development, however the analysis is based on 2003 aerial imagery and should therefore be verified by undertaking detailed asset and field surveys (refer to mitigation measures).

Table 7-38 Current land use in Beaco development area

Infrastructure	Current Land Use
LNG Plant	Maluru village, scattered farm dwellings, fields and plantations.
Nova Beaco	Fields, plantations and scattered farm dwellings administered by the Uma-Uain Leten village.
Nova Viqueque	Appears to be an arid landscape with very little land use

Source: Analysis of 2008, 2009 and 2011 Google earth imagery



NOTES:
This map contains:
1. Imagery: DigitalGlobal (2008-2011)
2. Rivers: Geographic Information Group TimorLeste (2010)
3. Roads: DivaGIS (2010)
4. Buildings: WorleyParsons (2012)

REV	DATE	REVISION DESCRIPTION	DRN	CHK	DES	ENG	APPD	CUST	PROJECT No: 301012-001504
0	29/05/2012	FINAL FOR ISSUE	CS	MW	-	-	GH	-	A4 SHEET SCALE 1:74,000

WorleyParsons resources & energy

TIMOR GAP, E.P. TIMOR GÁS & PETRÓLEO

REPUBLICA DEMOCRATICA DE TIMOR-LESTE
SECRETARIA DE ESTADO DOS RECURSOS NATURAIS

OneWay to zero harm

Copyright © WorleyParsons Services Pty Ltd

TASI MANE PROJECT - BETANO AND BEACO STRATEGIC ENVIRONMENTAL IMPACT ASSESSMENT

Figure 7-32

Buildings and roads affected by the Beaco development

LOCATION: \\PERWORFIL1\INFSTRUCI\IBV\PROJECTS\301012-01504 ENVIRO IMP ASSESSMENT TIMOR-LESTE\100 ENGINEERING\GEOMATICS\03PROJECTWORKSPACE_SKT\SEIA\FINAL\301012_01504_SEIA_7-32_REV0.MXD

PLOT DATE & TIME: 29 MAY 2012, 12:06:20 PM

USER NAME: COURTENAY.WHEELER

Impact Statement:

Physical displacement associated with Beaco development will affect the most people of all the three sites. The entire Maluru village will have to be relocated as a result of the LNG plant construction and a number of scattered dwellings due to the construction of Nova Beaco. Impacts associated with economic displacement and loss of access to sacred sites and cemeteries (impacts 4, 5 and 6) will also be substantial for the Beaco development. The relocation of Maluru village and other dwellings within the Beaco development area will need to be treated carefully and openly to ensure that conflict does not arise. If not properly managed, this displacement has the potential to cause homelessness and destitution to individuals and families. Unlike the LNG plant that is subject to technical specifications, the Nova Viqueque and Nova Beaco sites have more flexibility to be planned to reduce the impact on physical displacement (refer to mitigation measures). The timing of the Beaco development will allow adequate time for the development and implementation of a full RAP before construction commences.

Impact 5: Loss of Land, Crops and Natural Resources

This impact relates to a loss of land affecting landowners, and resources such as crops and natural resources (including fishing and potable water) on the land affecting land users, who may or may not be the same persons as the landowners.

The Beaco development, including the areas identified for Nova Beaco and Nova Viqueque, comprises approximately 1,500 ha. Similar to the Suai study area, land is officially owned by government; however, controlled by families in the village. Landownership is a complex and sensitive issue in Timor-Leste and should be dealt with carefully.

The land is currently utilised primarily for agricultural activities (fields and grazing) and natural resources, as shown in Table 7-38 and Figure 7-33. As a consequence, there will be a loss of land its associated resources for Maluru village and for some of the Uma Uain Craic and Uma Uain Leten villages.

Based on the geospatial analysis, approximately 15% of the proposed Refinery development area is cultivated land, with 11% of cultivated land present in the Nova Beaco development area, falling to 3% in Nova Viqueque. Removal of areas of cultivated areas is likely to necessitate the identification of replacement land. The loss of this area of land will place greater demand for and pressure on agricultural land and resources elsewhere.

Farmers' vulnerability to loss of arable land should be understood in terms of the existing challenges faced by them. These may relate to inadequate irrigation systems, climate change, rodent infestation, pressure on selling prices, a lack of suitable farming machinery and an absence of a prompt response by government to the priorities identified by farmers (La'o Hamutuk, 2011). As far as the impact on fishing is concerned, the construction of the LNG plant will result in approximately 4km of coast line that will be inaccessible to the villagers. This will affect onshore fishermen (fishing from the coast); however, the impact on offshore fishermen (using boats) will depend on the location and extent of marine areas that will be dredged and exclude from use for local boats. Based on current planning, Maluru villagers will be resettled to Nova Beaco where they will be able to continue their fishing activities, albeit in potentially different fishing areas.

From the site investigation, it appears that Maluru village has less available water than the Suai and Betano study areas. Nevertheless, a study of the potential water supply options has been flagged for further work. Considering the project will require water as well as the increased number of water users (jobseekers and outside employees residing in Nova Viqueque), there will be increased pressure on water sources in the area. The project will also have to provide replacement water sources for the 20 wells that are situated within Maluru village. The construction and operation of the Beaco development will also require large quantities of water. Similar to the Supply Base, current plans are to use seawater by reverse osmosis. Direct water demands by the project are therefore unlikely to impact on community water sources.

Impact Statement:

Local villages in and around the Beaco development are reliant on arable land and natural resources (wood for fuel, building materials, medicinal plants, fruits, etc.). The loss of land to the Beaco development will reduce the area of available agricultural land and natural resources found in the land. Current land-based access to fishing areas will be lost; however, the extent to which this will be ameliorated by relocation to Nova Beaco is yet to be assessed. Access to water sources will be lost through the loss of land to the project and newcomers and water requirements by the project will increase water usage in the area, although this source of water has yet to be confirmed.

Impact 6: Loss of Commercial Trees

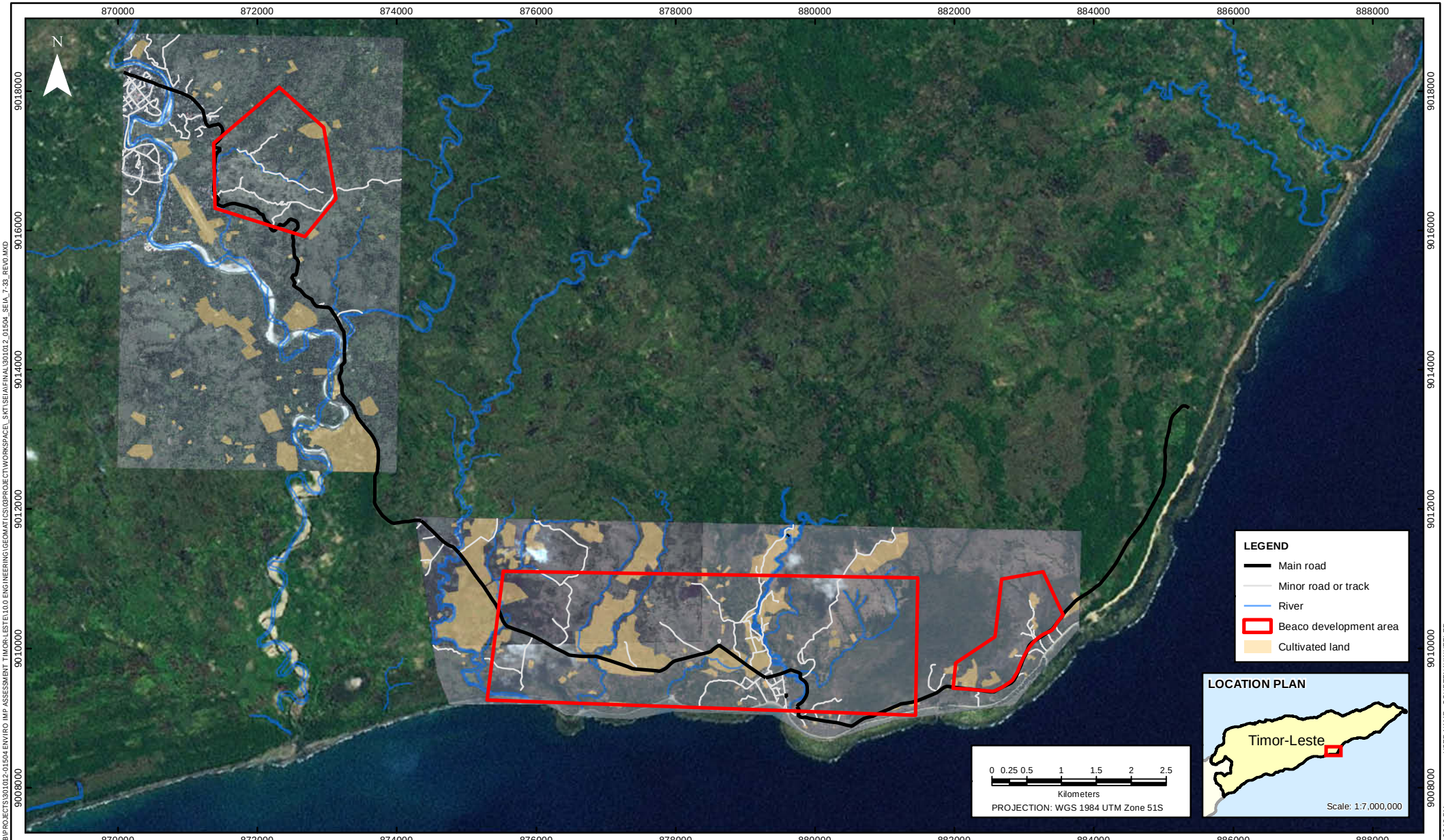
The exact number of trees within the Beaco development areas had not been recorded at the time of writing. However, based on an analysis of aerial imagery and observations during the site visit, there are some plantations in the LNG plant area and Nova Beaco, the most important being tic and coconut trees (refer to Figure 7-33).

Impact Statement:

The loss of trees can be a very severe impact depending on the individual circumstance of the owner due to the difficulty of mitigating this impact, i.e., it is not possible to provide mature replacement trees (replacement seedlings/saplings take long to reach maturity) which may result in the community being without a guaranteed food source (and in some cases, source of income) for a number of years.

Impact 7: Disturbance and/or Loss of Access to Sacred Sites and Cemeteries

Grave relocation will be a very significant impact of the Beaco development. There are a few cemeteries located within the village and interviewees reported that there are many additional scattered graves located within the Beaco development areas. It is likely that only graves located in the areas to be disturbed during construction activities will be relocated; however, others outside this area may also be affected. The relocation of the affected graves will require the exhumation of these cemeteries and scattered graves and reinterring them in a new area.



NOTES:
This map contains:
1. Imagery: DigitalGlobal (2008-2011)
2. Rivers: Geographic Information Group TimorLeste (2010)
3. Roads: DivaGIS (2010)
4. Cultivated land: WorleyParsons (2012)

REV	DATE	REVISION DESCRIPTION	DRN	CHK	DES	ENG	APPD	CUST
0	29/05/2012	FINAL FOR ISSUE	CS	MW	-	-	GH	

A4 SHEET | SCALE 1:74,000
PROJECT No: 301012-001504

WorleyParsons resources & energy

TIMOR GAP, E.P. TIMOR GÁS & PETRÓLEO

REPUBLICA DEMOCRATICA DE TIMOR-LESTE
SECRETARIA DE ESTADO DOS RECURSOS NATURAIS

OneWay to zero harm

Copyright © WorleyParsons Services Pty Ltd

TASI MANE PROJECT - BETANO AND BEACO STRATEGIC ENVIRONMENTAL IMPACT ASSESSMENT

Figure 7-33

Cultivated land affected by the Beaco development

LOCATION: \\PERWORFIL1\INFSTRUCL\BV\PROJECTS\301012-01504 ENVIRO IMP ASSESSMENT TIMOR-LESTE\100 ENGINEERING\GEOMATICS\03\PROJECT\WORKSPACE_SKT\SEIA\FINAL\301012_01504_SEIA_7-33_REV0.MXD
USER NAME - COURTENAY.WHEELER
PLOT DATE & TIME - 29 MAY 2012, 12:06:18 PM

Interviewees in Maluru indicated that there are numerous sacred sites. The following were examples of important sites mentioned by interviewees:

- Big tree around the sacred house (Madatuk).
- Kibiti tree next to the river.
- A hill named Macaloso.
- Large tree called Betulari.

Three major sacred sites were mentioned by Uma-Uain Craik respondents:

- Big rock (Fatukhun).
- Area where gas is released from the ground.
- Tree (Ailemi Galiria).

Despite interviewees reporting that some of the sacred sites could be 'relocated' if the appropriate rituals are performed, as explained earlier this issue remains very sensitive as explained earlier.

Impact Statement:

Due to the nature of the impact and the potential sensitivity related to the disturbance of culturally-significant sites such as sacred sites and scattered graves, it is expected that the impact will be highly significant.

Impact 8: Reduced mobility due to Loss of Road Network Inter-Linkages

Security around the plant area will be provided in the form of security fences, gates and gate-houses to protect the project's assets during construction and operation phase. Gates will be provided with security personnel to control access to and from the overall site including marine facilities (KBC *et al.,* undated). This fencing has the potential to disturb people's movement patterns and may result in villagers having to travel substantially longer distances to reach their fields, water points or businesses (refer to Figure 7-32).

Impact Statement:

Compared to the Suai Supply Base, this impact will be less severe due to the smaller areas affected. Nova Beaco will not be a 'closed village' and the development of a road systems will allow villagers to move around freely. The extent to which Nova Viqueque will affect movement patterns of surrounding villages is not currently known.

Impact 9: Population Influx

As with the Suai and Betano developments it can be expected that there will be an influx of people into the area seeking employment or take advantage of the economic growth during construction and operations. Currently, people living in the Beaco study area live in close-knit homogenous communities belonging to the same cultural group. Over the next couple of years, the number of people living in and around the Beaco study area might increase and due to the lack of cross-cultural

interaction experienced by the villages, they will be vulnerable to some of the changes/impacts. When the influx commences, various impacts may occur, which could include:

- Conflicts over jobs.
- Conflicts over access to resources – social infrastructure, housing, etc.
- Increased pressure on housing and social facilities.
- Overcrowding and associated health impacts (see health impact).
- Inflation.
- Increase in community health risks.
- Increase in social pathologies such as crime, prostitution, drugs abuse and alcoholism due to increased amounts of cash circulating in the study area.
- Lost sense of cultural connection with places (sense of place).
- Increase in the market for business people.

A very important aspect for the project to consider is the management of population influx (refer to mitigation measures). Due to the number of years (around five) before construction activities commence, it is possible that the size of Maluru village can increase substantially, especially if it is believed that resettlement compensation is readily available. Thus, the stakeholder engagement strategy to be developed for Beaco needs to be carefully planned (refer to mitigation measures).

From a positive perspective, the sense of place of the Beaco development will be redefined as a hub of activity and economic opportunity. This may inject a new level of energy into local communities who may be inspired to find ways to adapt to and benefit from the host of activities and opportunities associated with the Beaco development. Already, the baseline study identified the desire amongst many respondents, in particular the youth, to move away from current subsistence and rurally-defined lifestyles to a more economically engaged and active lifestyle. For these individuals, the change in the sense of place and identity is welcomed.

Impact Statement:

The project is expected to attract people into the Beaco study area due to the prospect of economic benefit. This tendency will put a strain on socio-economic infrastructure and may erode some community values and may have serious implications for future resettlement if not properly managed.

Impact 10: Increased Pressure on Government to Deliver on Infrastructure and Services

The Timor-Leste Government is in the process of implementing the National Strategic Development Plan (2011-2030). The SDP highlights several challenges faced by government in terms of social capital and infrastructure development (Chapter 3). Similar to the other sites, the Beaco development will require a lot of infrastructure support e.g., roads, electricity, and health and education facilities to accommodate newcomers. The provision of this infrastructure will be required in the medium term and will therefore place a lot of pressure on government.

Similar to Nova Suai and Nova Betano, Nova Beaco and Nova Viqueque are likely to have unique management challenges; particularly for the maintenance and the delegation management of the public infrastructure and facilities. Any special institution and management arrangements within Nova Betano and Nova Viqueque may result in an undesirable duplication of bureaucracy that could create perception of favouritism and place government administrators under pressure.

Currently there is little administrative capacity at district level. The challenge is going to be for the local administration to manage the project impacts and additional demand on services and facilities such as health, education, sanitation, roads, housing, etc. due to general population growth in the villages rather than in Nova Viqueque or Nova Beaco *per se*. With little capacity in place the tendency is for development proponents to take over the responsibility of the local authority, resulting in a governance vacuum. Depending on the timing of the project and the implementation progress of the SDP, there could be substantial pressure placed on the national and district administration without any capacity to manage the expectations. However, compared to the Suai Supply Base, there will be more time to build capacity among government officials and to put supporting infrastructure in place. Government would also be able to learn from lessons learnt during the construction of the Suai and Betano developments.

Impact Statement:

The construction of the Beaco development will place pressure on the current national and district administration; however, the impact is expected to be less significant should the time available to implement mitigation measures be properly used.

Impact 11: Community Health and Safety

The following health impacts could arise from the Beaco development:

- Increase in respiratory ailments such as tuberculosis as a result of influx of people into the area, overcrowding in settlements and poorly ventilated houses.
- Increase in respiratory ailments due to increased dust caused by construction activities and to a lesser extent operation phase activities (refer to the air quality assessment for more detail).
- Increase in vector-borne ailments such as malaria.
- Increase in sexually transmitted infections such as HIV.
- Increase in soil and water-borne diseases such as diarrhoea, typhoid and cholera.
- Increase in disease such as hypertension and diabetes.
- Increase in lifestyle risk such as alcoholism, drugs, gender and domestic violence.
- Increase in ambient noise.
- Increased pressure on health services infrastructure.

As far as safety is concerned, during the full duration of the LNG Plant construction, there will be increased traffic (mostly trucks) on access roads. The local community is not used to such heavy traffic and vehicles. Vehicular traffic will also increase on the main access roads during operation. As many of these are in proximity to local villages, there is an increased risk of accidents. As traffic in the

major crossroads increase, there will be a need for more sophisticated traffic management measures (i.e., traffic lights, pedestrian crossings and roundabouts on approaches to villages/towns). On many of the roads in the LNG Plant area, night time travel is not safe. Also, increased night traffic will bring noise pollution in the vicinity of major transport routes. The amount of traffic will be significantly affected by the extent and rate of development of the general industry around Suai. This is discussed in more detail in the transport assessment section of the EIA.

As far as impacts of noise and vibrations are concerned, there are currently a number of dwellings in close proximity to the development areas; however, since they will be relocated to Nova Beaco, these settlements will not experience any noise and vibration impacts.

Impact Statement:

The construction and operation of the Beaco development will affect the health and safety of the villages in the area although the actual extent cannot be quantified at this time. However, since Maluru village will be relocated to Nova Beaco the new location should avoid health and safety impacts on the people of this village. Nonetheless, without special measures to address them, health-related issues like pollution (water and dust) impacting non-resettled nearby dwellings, vector-related ailments and sexually transmitted diseases, could increase, especially among the communities in and around Nova Beaco and Nova Viqueque.

Impact 12: Improvement of Basic Services and Infrastructure

This development of Beaco will incorporate the LNG Plant complex and the Nova Beaco and Nova Viqueque residential developments. The existing airport at Viqueque will be refurbished to service the needs of personnel working at the LNG Plant. As a result, social infrastructure in the local area will be upgraded. The construction and operation of the Beaco development will require the following infrastructure:

Road infrastructure: Some existing roads will be upgraded and new roads may be constructed.

Energy infrastructure: With regards to energy infrastructure, the Beaco development will rely on electricity to be provided from the National Electricity Project that is currently underway.

Nova Viqueque infrastructure: Nova Viqueque will house a community centre, with an assembly hall for entertainment and sports. A commercial area with a town centre, supermarket and convenience store will be built to supply residents. Government is also planning to build other infrastructure including a hotel, international school equipped with gym, auditorium, soccer field and amphitheatre. (RDTL 2011b).

Nova Beaco infrastructure: Nova Beaco will be constructed to house people relocated from Maluru village and it intends to allow residents of Nova Beaco to continue with their daily activities as fishermen or farmers. Although most villagers in the Maluru village live in traditional houses, government is planning to build replacement houses with modern materials, (whilst still using the traditional architectural style). Town planning will also provide for open spaces and community infrastructure to be built including a church, a market, an elementary school, a junior high school and single family units (RDTL, 2011b). This new infrastructure will substantially improve living conditions for Maluru villagers (considering the under-developed status of Maluru compared to Uma-Uain Craik)

however, if not carefully managed the impact may lead to creation of secondary negative impacts (as discussed in impact 12).

Refurbishment of Viqueque airport: Similar to the Suai airport rehabilitation, the rehabilitation of the airport will not directly affect most of the local population although, it will make the area more accessible to outside investment and tourism which should increase economic opportunities to local villagers.

Other community infrastructure development and mechanisms could form part of community investment programs to be implemented by the project during the operation phase. This could include the improvement or provision of new health centres, education facilities, waste management infrastructure, sports facilities and churches.

Impact Statement:

The project should have a long-term beneficial impact on the communities around the Beaco development in terms of social infrastructural development. Infrastructure such as roads, water and electricity will enhance socio-economic development in the area, through job creation and increase in commercial activities.

Impact 13: The Construction and Operation of the Beaco Development Triggering Localised Conflict

Timor-Leste has faced many conflicts in the past, from the Portuguese colonial period to the more recent decades-long independence struggle against Indonesia. Similar to Betano study areas, Beaco villagers are also eager to receive project information to understand how the project may affect them. It is possible that left unmanaged, the large number of people that will have their homes and livelihoods affected, could express in localised discontent and potentially, civil unrest.

Similar to Nova Suai and Nova Betano, Nova Viqueque will be home to people involved in the Beaco development. Most of these people will be expatriates due to the current education and skills levels in the Beaco study area. The residents in Nova Viqueque will be housed in much better conditions than the villagers in the study area, they will also have access to modern facilities (as discussed under Impact 11) and they are likely to receive much higher incomes. The same applies to Nova Beaco residents who will have much better housing conditions than surrounding villagers who are not resettled. The improved conditions for Nova Viqueque and Nova Beaco residents could result in other local villages feeling disadvantaged.

Another aspect that could result in conflict is the fact that Uma-Uain Leten people have settled on Maluru land, specifically on the site where Nova Beaco is planned to be constructed. Beaco people have let them farm there; however, they have no customary rights to the lands. The settlement of Uma-Uain Leten people on Maluru land could create a land dispute issue, especially if resettlement of these people needs to occur.

The potential trigger points for resentment and conflicts around the project site include the following:

- Ethnic tensions surrounding village boundaries between Maluru and Uma-Uain-Leten.
- Lack of available project information.

- Loss of land and livelihoods.
- Resettlement and compensation.
- Removal of graves.
- Access to jobs and other economic opportunities.
- Weak government and inability of local authorities to maintain control.
- Lack of royalty flowing to the local administration.
- Inflation and food security.
- Influx of people.
- Lack of community development.
- Safety and health hazards.
- Poor treatment of community by security personnel.

Impact Statement:

The construction and operation of the Beaco development could lead to community resentment and have the potential to trigger conflict in a fragile environment. These conflicts may arise due to a variety of reasons e.g., inadequate compensation, unrealistic expectations and ethnic tensions, etc.

Impact 14: The Beaco Development Exacerbating Gender Equality Issues in the Study Area

Similar to the Suai and Betano study area, the development of Beaco may exacerbate gender equality issues in the study area.

Impact Statement:

Economic opportunities brought about by the Beaco development may exacerbate gender equality issues. These issues may be experienced at a workforce level and also at a community/village level.

7.10.5 Avoidance, Management and Mitigation Measures

The mitigation measures listed for the Suai Supply Base (in the EIA) and in previous sections for Betano are likely to apply to the Beaco development as well. The following additional considerations specific to Beaco are worth highlighting.

Mitigation 3: Economic Opportunities

Mitigation measures designed to enhance the opportunities for development as a result of the royalties and taxes paid to the Timor-Leste Government include:

- Building capacity of the district authority to utilise the royalties efficiently.
- To promote transparency of the royalty payments to the Timorese government and how these are distributed to the district governments.

Mitigation 4: Physical Displacement (Loss of Dwelling Structures)

The same mitigation measures listed for the Suai Supply Base apply to the Beaco development. However, developing a comprehensive RAP will be required due to the substantial scope of resettlement (physical and economic) associated with Beaco. Currently, there is adequate time available to develop an appropriate RAP and to mitigate this impact successfully.

Attempts should be made to reduce physical and economic displacement by carefully planning and designing the Nova Beaco and Nova Viqueque town layout.

Mitigation 7: Disturbance and/or Loss of Access to Sacred Sites and Cemeteries

The same mitigation measures listed for the Supply Base apply to the Beaco development.

However, a comprehensive cemetery and/or grave relocation program needs to be developed to ensure grave relocation is done responsibly and in line with relevant legislation and World Health Organisation guidelines.

Mitigation 9: Population Influx

The same mitigation measures listed for the Supply Base apply to the Beaco development. Population influx management may be more challenging given the number of years before construction commences (refer to Mitigation 12).

Mitigation 13: Potential for Jealousy Triggering Resentment or Conflict

The same mitigation measures listed for the Suai Supply Base apply to the Beaco development; however, implementing a stakeholder engagement plan in the Beaco development area is of critical importance as this will reduce the level of uncertainty surrounding the project. At the same time, the message to be communicated at a local level needs to be carefully formulated due to the early stage of development. The message should:

- Manage expectations of timing, availability of jobs, compensation and business opportunities.
- Avoid creating a gap for opportunists seeking future compensation to settle in the proposed footprint area.

7.10.6 Residual Impacts

The residual impacts described under the Betano development are likely to be similar for the Beaco development. However, more time will be available to fully implement mitigation measures for Beaco and as a result, it is likely that the severity of negative impacts will be further reduced and positive impacts will be further enhanced after mitigation.

7.10.7 Monitoring and Reporting

The monitoring and reporting procedures described under the Betano development are likely to be similar for Beaco development

7.10.8 Further Work

Of the three developments being assessed, the least information is available for Beaco. It should therefore be noted that, until more project information becomes available, the impact assessment for Beaco is of a very preliminary nature. Table 7-39 outlines the impacts and associated mitigation measures that require further work and the information required to complete the assessment.

Table 7-39 Impacts and mitigation requiring further work

Impact	Outstanding Information	Task
Impact 1: Employment Impact 2: Skills development	Beaco development workforce projections (for all phases and components of development). Detailed workforce estimates for each skills category, i.e., unskilled, semi-skilled, skilled.	Reassess impacts of direct employment on the local population. Develop skills development/workforce strategy.
Impact 3: Economic opportunities	Royalties and tax payments associated with the Beaco development. Breakdown of contracting opportunities and establish minimum requirements for local contractors to successfully bid for contracts.	Reassess economic impacts.
Impact 4: Involuntary resettlement Impact 5: Loss of land, crops natural resources (including fishing and potable water) Impact 6: Loss of commercial trees	Detailed baseline data as to the number of households in scattered dwellings, fields and trees in the project footprint area, linked to owners' details and the socio-economic dynamics of owners and their families. Roads that will be constructed or upgraded. Areas that will be off limits to fishermen.	Reassess impacts associated with physical and economic displacement, based on gap analysis undertaken for Supply Base study area. **Note:** It is very important that the resettlement and compensation principles and procedures for the three respective developments are consistent to some extent, which stresses the importance for government to undertake the gap analysis suggested under the Supply Base and to take corrective action, if necessary, before the compensation payments have been finalised. If this is not done, it is going to be difficult to adhere to Performance Standard 5 of the IFC at Betano and Beaco without protests from the affected households at Suai.

Table 7-39 Impacts and mitigation requiring further work (cont'd)

Impact	Outstanding Information	Task
Impact 7: Disturbance and/or loss of access to sacred sites and graves	Exact location of scattered graves and sacred sites within footprint areas.	Reassess impact once heritage and archaeology assessment findings have been obtained.
Impact 8: Reduced mobility due to loss of road network inter-linking grazing areas, water points	Areas to be fenced-off and approach to be adopted by government e.g., will alternative access routes be developed before fencing commence	Reassess impact once more project information has been obtained.
Impact 9: Influx of people	Type and location of construction workforce accommodation	Reassess impact once more project information has been obtained.
Impact 10: Increased pressure on government to deliver on infrastructure, service and administrative demands set by the project	Detailed infrastructure construction schedule to determine whether proposed timeframes are realistic.	Reassess impact once more project information has been obtained.
Impact 11: Community health and safety	Seek health specialist advice whether a health impact assessment should be undertaken or not.	Reassess health impacts based on specialist report (if necessary).
Impact 12: Improvement of basic services and infrastructure	Roads that will be upgraded or newly constructed. Energy supply for Beaco development construction and operation. Confirmation about accessibility of Nova Viqueque to local villagers.	Verify and potentially reassess impact once more project information has been obtained.
Impact 13: Construction and operation of the Beaco development triggering resentment (and potentially conflict)	Updated project information for the three sites. Obtain details of previous consultations undertaken by SERN.	Identify additional community perceptions about the project to accurately assess how views and concerns about the project may inform this impact, among other impacts.

7.11 Land Transport

The Beaco LNG Plant is expected to result in the increased use of land transport links between the site, other Tasi Mane project sites and other parts of Timor-Leste.

The purpose of this section is to:

- Describe the methods used to assess the potential land transport related impacts of the Beaco LNG Plant.
- Report the results of the impact assessment.
- Outline measures for mitigating and monitoring predicted impacts.

It should be noted that the proposed highway from Suai to Viqueque is not part of this study.

7.11.1 Study Method

There is currently no established guidance or methods for undertaking traffic and transport impact assessments within Timor-Leste.

The methods used to assess potential land transport impacts associated with the project are based on the UK Institute of Highway Engineers (IHT) *Guidelines for Traffic Impact Assessment (1994)* (Appendix K). Use of the standard assessment methods set out in these guidelines conforms to international practice as requirements for assessing impacts in the UK are subject to stringent European and UK legislation.

In addition to the use of these guidelines, three other guidelines were reviewed and used where appropriate. These are:

- *Guidelines for Preparation of Traffic Impact Assessment Reports Revision (2011)* Land Transport Authority (LTA), Singapore.
- Guide to Traffic Generating Developments Version 2.2 October 2002 Road and Traffic Authority, New South Wales, Australia.
- Transport Assessment Guidelines for Developments Version for Trial and Evaluation, August 2006, Department of Planning and Infrastructure, Western Australia, Australia.

It should be noted that these guidelines, and many of the methods set out within them, are based on more defined, dense urban locations where significant baseline monitoring data is available. Not all of the formulae or impact measurements set out in these guidelines have been applied to the project given the nature of the existing land transport network and the limited availability of baseline data.

Study Area

The study area comprises existing and proposed land transport infrastructure associated with the Beaco development as described in Section 4. The study area is shown in Figure 7-34 with the primary road network highlighted.

Scope

This traffic impact assessment is predominantly a desktop-based assessment of the existing road network and the land transport infrastructure proposed as part of the Beaco LNG Plant development.

The desktop assessment has been supplemented by onsite traffic observations from the study area to establish existing conditions. The impacts of the proposed development have taken into account these baseline conditions although, it is recognised that these observations only represent a "snapshot" of existing traffic patterns.

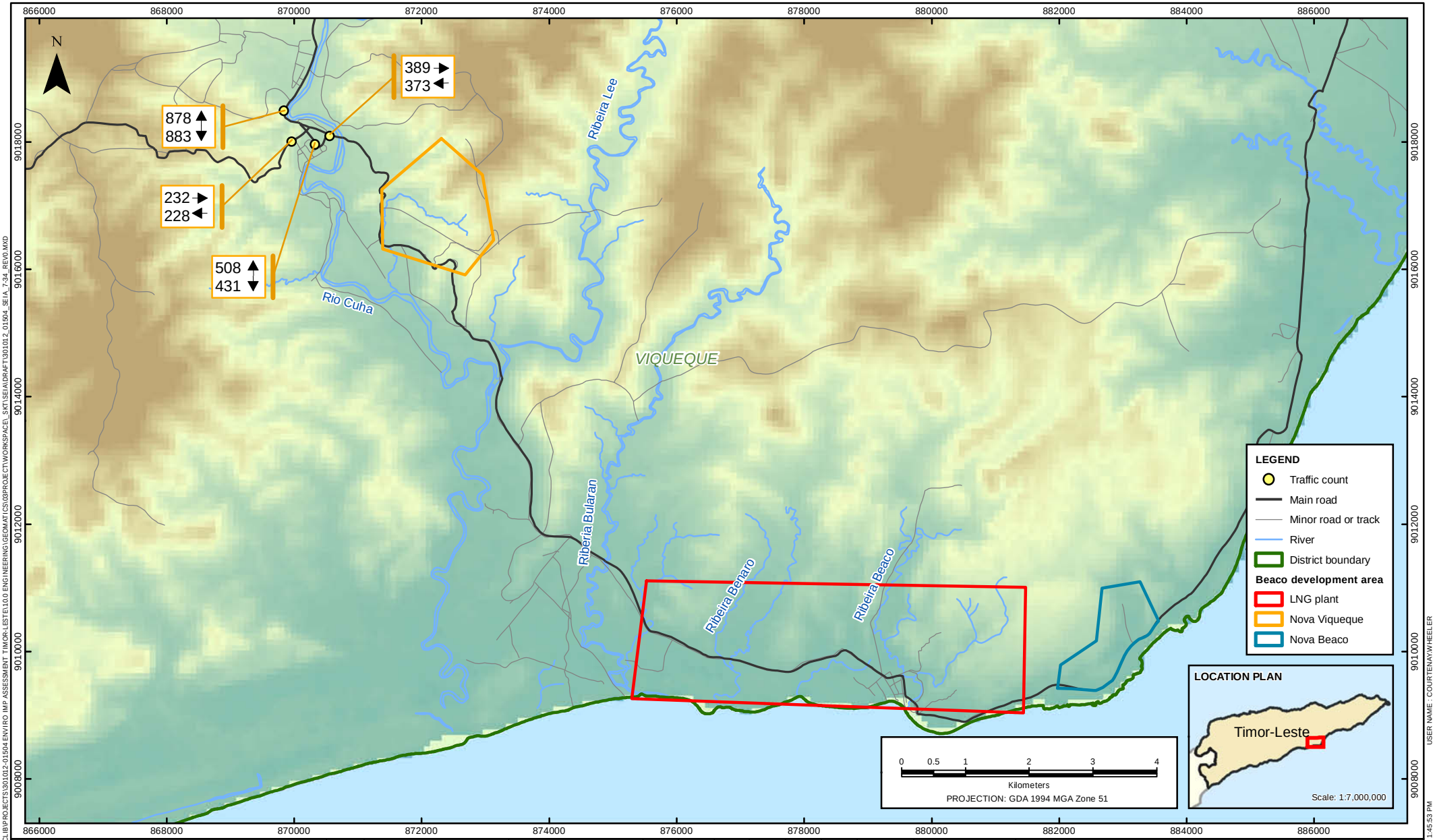
As with projects of this scale and nature, the project will be subject to more detailed planning and development which could alter the baseline assumptions and assessment outcomes. The lack of baseline data and information regarding the proposed works, has limited the accuracy of the traffic and transport assessment.

Method

As previously stated, the methodology used to assess traffic impacts is based on the UK Institute of Highway Engineers (IHT) Guidelines for Traffic Impact Assessment (1994) and three other internationally recognised traffic impact assessment guidelines.

The purpose of an impact assessment is to establish the difference between baseline conditions (as the land transport network currently exists in both infrastructure and patterns of use) and how it will look during the construction and operational stages of the project. It is also important to understand the manner in which anticipated traffic from the project will distribute and impact the study area.

From this assessment, potential mitigation measures can be reviewed and assessed which will help to reduce impacts on the existing network and sensitive receptors, such as residences, community facilities and commercial districts, in the study area.



NOTES:
This map consists of:
1. Digital Elevation Model: SRTM (2011)
2. Rivers: Geographic Information Group TimorLeste (2010)
3. Roads: DivaGIS (2010)
4. District boundaries: Geographic Information Group TimorLeste (2010)
5. Traffic count locations: WorleyParsons (2012)

REV	DATE	REVISION DESCRIPTION	DRN	CHK	DES	ENG	APPD	CUST
0	29/05/2012	FINAL FOR ISSUE	MW	CS	-	-	GH	

A4 SHEET | SCALE 1:80,000
PROJECT No: 301012-001504

WorleyParsons resources & energy

TIMOR GAP, E.P. TIMOR GÁS & PETRÓLEO

REPUBLICA DEMOCRATICA DE TIMOR-LESTE
SECRETARIA DE ESTADO DOS RECURSOS NATURAIS

OneWay to zero harm

Copyright © WorleyParsons Services Pty Ltd

TASI MANE PROJECT - BETANO AND BEACO STRATEGIC ENVIRONMENTAL IMPACT ASSESSMENT

Figure 7-34
Beaco traffic count locations and volumes

LOCATION: \\PERWORFIL1\INFSTRUCL\BV\PROJECTS\301012-01504 ENVIRO IMP ASSESSMENT TIMOR-LESTE\10.0 ENGINEERING\GEOMATICS\03PROJECT\WORKSPACE_SKT\SEA\DRAFT\301012_01504_SEIA_7-34_REV0.MXD
PLOT DATE & TIME: - 29 MAY 2012, 1:45:53 PM
USER NAME: - COURTENAY.WHEELER

Broadly, there were five key stages used in the study method to assess the land transport impacts of the project. They are:

1. Desktop assessment.
2. Onsite traffic observations and assessment of existing conditions through development of a spreadsheet model.

Traffic observations were carried out on site at both major turning locations and at link locations. The chosen sites were monitored and movements recorded.

The methods used in the traffic counts were taken from previous studies undertaken in both the UK and Australia using methods set out within guidelines previously referred to in this section.

The duration for link count observations at each site was 12 hours for two consecutive days. Turning movement observations were conducted during the morning and evening peak hours.

All the data collected from the site observations has been used to develop an overview spreadsheet model of the local land transport network. This model has assisted the identification of both existing trip generators and existing trip distribution.

The spreadsheet model was created to display the collected traffic count data and establish the volumes on transport links throughout the study area. With the base year conditions identified, the traffic volumes associated with the project are able to be assigned to specific transport links.

3. Review of the trip generation associated with the proposed development.
4. Assessment of traffic distribution in the study area by reviewing the existing traffic volumes and possible travel routes through the study area network. Impact on land transport network.

Although specific waterway crossings were not assessed as part of this study, it is envisaged that any crossing along a primary route between Suai, Betano and Beaco will need to accommodate a greater number of vehicle movements and also provide a reliable, permanent crossing.

5. Mitigation, monitoring and further work required.

Impact Assessment – Study Method

Impacts on the land transport network from development can be measured in both qualitative and quantitative means. This includes the following:

- Changes in volumes of vehicles.
- Changes in vehicle types using land transport links.
- Fluctuations in number of people accessing the study area.
- Increase or decrease in the length of the road network.
- Increase or decrease in the number of intersections.

- Changes in the number of pedestrian or cycle movements.
- Change in distance that vehicles travel.

The qualitative impact assessment is set out in Section 7.11.3.

Both the construction and operational phases of the project have been tested as separate traffic scenarios. The initial phase will establish a single train with a production capacity of 5 Mtpa. The site layout and plant configuration will be designed to accommodate a further three trains of similar size to process up to 20 Mtpa of LNG. The SDP schedules the construction of the 5 Mtpa plant to be undertaken between 2017 and 2023, although details of the actual construction period and logistics are not yet known (GoTL, 2011). The proposed construction phasing for the project is not currently available. To accurately model and assess this staged impact, a detailed traffic model is recommended.

For desktop assessment purposes, it has been assumed that the construction traffic trips occur at the same time. To reflect that there will be some level of operation during the construction phase, a nominal amount of daily light and heavy vehicles have been assigned between Suai, Betano and Beaco. Spreadsheet modelling is not accurate enough to suggest a growth rate attributed to the construction traffic, rather, the percentage change in volume on individual links is presented. An average growth across all links through the Beaco study area indicates an increase of approximately 20% over the current volumes. It should be noted that the existing daily traffic volumes are generally quite low hence, the high percentage increase.

The operational scenario tested assumes 6,400 people resident in Novo Beaco and to account for the ongoing construction phases of Suai and Betano, daily light and heavy vehicle trips have been assigned between Beaco and the other development areas. The average growth across links through the Beaco study area, are likely to result in an increase in the order of 60 to 70% over the current volumes.

Data Assumptions and Limitations

Limited data availability has increased the reliance on a series of ‘high-level’ assumptions relating to both current and future use, and condition of the road network. Specific limitations and assumptions are described below and are discussed in relation to the assessment in Section 7.11.3.

There is limited availability of traffic count information in Timor-Leste. Historical data is set out within two separate reports which provide limited information on traffic counts around the study area. These two reports are:

- *Road Sector Investment Planning in Timor-Leste*, The Louis Berger Group, Inc. Technical Working Paper October 2006 (LBG, 2006).
- *Road Sector Investment Planning in the Pacific*. An Example of Good Practice, Timor-Leste, Asian Development Bank, July 2007 (ADB, 2007).

Historical traffic count data and trends in land transport modes are important in establishing patterns in traffic use on specific roads over time. These trends provide an indication of the level of underlying growth in traffic that isn’t attributed to the project’s construction and operational phases.

7.11.2 Existing Environment

The existing land transport network in the study area is limited. As set out in ADB (2007), the core road network of Timor-Leste in 2007 comprised 1,400 km of national roads and 800 km of district roads which is a small national network when compared to those of many countries in the region. Since 2007, there has been no expansion in the core network, which is comprised of the following (road designation number is in brackets):

- National road between Viqueque and Ossu heading north from the study area (A06-02).
- National road between Viqueque and Natarbora heading west from the study area (A07-01).
- National road between Viqueque and Uatucarbau heading south and east from the study area (A08-01).

Other roads in the study area are primarily urban roads within townships and rural roads leading from either urban roads or the core network to individual properties or locations. There are no known cycle paths and limited pedestrian facilities. The majority of roads in the area are not surfaced, in poor condition and affected by seasonal weather patterns.

Desktop Assessment

There is limited existing information available on the land transport network in the study area. No strategic or statutory land transport plans are available. The primary source of information for the land transport network is ADB (2007). This report sets out information and data on the existing land transport network in Timor-Leste as well as recommendations for forward planning and strategic development of the road network.

The status of recommendations from this report is unknown. However, the plans presented in ADB (2007) for improving land transport links, did not include a significant funding allocation for core network roads within the study area.

Some traffic observations and network condition reporting is provided within LBG's Road Sector Investment Planning report (2006). Available data for roads within the study area, which informed the recommendations set out in ADB (2007) are set out in Table 7-40.

Table 7-40 Core Road Network Characteristics

From	To	Surface	Length	Width	Last Surfaced	Quality	Annual average daily traffic (AADT) (year data recorded)
Venilale	Viqueque	Paved	34.1 km	4.0 m	1996	Poor	189 (2005)
Viqueque	Natarbora	Paved	43.0 km	3.2 m	1995	Fair	51 (2005)
Viqueque	Uatucarbau	Paved/Unpaved	55.8 km	3.5 m	1993	Very Poor	98 (2005)

Onsite Traffic Observations – Existing Conditions

Onsite road conditions were assessed for the study area during site observations completed for the project.

Traffic observations were undertaken in the study area in late 2011 at a number of main locations, namely:

- Viqueque Town intersection.
- Link counts for roads to Beaco, Biloi, Bicari and Biobe.

The locations of the traffic count observations through the Viqueque area are shown in Figure 7-34 and a photograph of the Viqueque Town intersection is set out in Plate 7-45.

Observations were taken in Viqueque to understand the movements around the urbanised part of the study area. It should be noted that the data was collected in late 2011 during the start of the wet season and travel behaviour often changes during seasons, and as such, there is significant uncertainty associated with the data collected. The traffic counts are provided in Table 7-41 and reflect average daily link volumes at the locations shown in Figure 7-34.

Table 7-41 Study Area Traffic Observations 2011

Link Name	Between		Road Number	Two- way Combined	Direction 1	Direction 2
Bicari	Bicari	Viqueque	A07-01	460	232	228
Beloi	Beloi	Viqueque	A06-02	1761	878	883
Beaco	Viqueque	Beaco	A08-02	762	389	373
Biobe	Airport	Viqueque	Local Road	938	508	431

The volume of vehicles observed at each location was consistent across the two recording days. The location at which the highest daily counts were recorded was the Beloi Link.

It is apparent that no noticeable investment or significant improvement in road conditions for the core road network has occurred since the completion of the assessment by the ADB between 2005 and 2007. Core roads linking villages and towns within the study area are in poor condition with the urban and rural roads poor and subject to significant impacts from weather events.

Two examples of existing road surface conditions are shown in Plate 7-46 and Plate 7-47.

Traffic management throughout the land transport network is limited. There are no controls at intersections. Pedestrian facilities are minimal in towns and villages and are generally restricted to untreated and informal paths which have formed over years of use.

Existing Trip Generation and Trip Distribution

The predominant movements through the study area appear to be between Viqueque and Biobe suggesting a reasonable level of residential and employment land uses.

The distribution of trips through the Viqueque area local road network appears relatively consistent throughout the day, with a lack of a specific tidal movement from one area to another at any particular time of day. The 2011 surveys suggest a strong local movement between Viqueque and Biobe with approximately half of their daily volume travelling further along the coast towards either Beaco or Bicari.

Source: Gaspar Da Costa, 2011

Plate 7-45 Viqueque Town intersection

Source: Gaspar Da Costa, 2011

Plate 7-46 Beaco and Viqueque road condition

LOCATION: \\perworfil1\infstructlb\Projects\301012-01504 Enviro Imp Assessment Timor-Leste\2.0 Reports\2.9 SEIA - Betano and Beaco\Plates\03_Working\BP040\301012_01504_SEIA_Plate_7-45_7-46.vsd
PLOT DATE AND TIME: 6 Jun 2012, 3:24 PM Creator: Courtenay Wheeler

Source: Gaspar Da Costa, 2011

Plate 7-47 Beaco and Viqueque road condition

LOCATION: \\perworfil1\infstructlb\Projects\301012-01504 Enviro Imp Assessment Timor-Leste\2.0 Reports\2.9 SEIA - Betano and Beaco\Plates\03_Working\BP038_BP039\301012_01504_SEIA_Plate_7-47.vsd
PLOT DATE AND TIME: 6 Jun 2012, 3:25 PM Creator: Courtenay Wheeler

7.11.3 Environmental Impacts

This section describes the potential impacts of the project on the land transport network in the study area for both construction and operational phases. Where possible, reference is made to existing conditions set out in previous sections to provide a clear link between the impact of movement as a result of the project, as opposed to the existing and expected impacts without the project.

For the purposes of the impact assessment, it has been assumed that:

- Outside of the influence of the project, there are very few other land uses which would generate traffic levels that could affect on the land transport network. No other significant developments are known for the study area.
- Travel patterns of the local population would not be altered as the majority of trips made on the land transport network are localised and relate to key daily activities, commerce, school trips, work trips and movement between villages and key urban areas.
- There are no significant influences of inter-regional trips along the core road network. There are no significant trip generators or new links known of outside the study area which could heavily influence traffic patterns on the local transport network.
- There are no known government strategies or plans in place to change investment levels in the road network or make improvements to the land transport network conditions outside of those that may be required for the project. Transport network proposals set out in ADB (2007) do not appear to have progressed within the project area and represent very little investment in improving existing roads.

Construction Impacts

The baseline 2011 traffic volumes and distribution are shown in Section 7.11.2 Existing Environment section in Figure 7-34. Not all links will have impacts during the construction stage as there will be no significant known generation of traffic along those links. However, all of the links with additional traffic resulting from the project would see an increase in the volume of heavy vehicles. Although the 2011 count information did not record the proportion of heavy vehicles on the road network, anecdotal information, knowledge of the road network conditions and details provided in LBG (2006) indicate that there is currently very little movement of heavy vehicles in the study area.

Given the low existing traffic volumes and the deteriorated road surfaces, there will be measurable impacts on other users, adjoining land uses and on the core road network conditions. These impacts, and potential changes to trip generation and distribution across the road network, are set out below.

- Movements in the study area are expected to be primarily heavier vehicles associated with the construction of the project.
- A large proportion of the initial heavy supply and construction material is expected to be transported to site by barge although; some may be transported to site by road. The majority of the heavy vehicle trips associated with the construction phase from the quarry sites could affect the local traffic network as these vehicles may have to pass through Viqueque to access the refinery and MOF site.

- Increase in the volume of traffic along roads in the study area, primarily heavy vehicles, could result in impacts on air and noise quality along key links through Viqueque.
- The nature of existing road network conditions will also likely require slow speeds and constant deceleration and acceleration of trucks and buses increasing more localised air quality and noise impacts.
- Use of heavy vehicles on the core road network will result in a further deterioration of road network conditions as described in Section 7.11.2. Impacts will be pronounced during the wet season where sideways movement of trucks and buses along roads in poor conditions will exacerbate the existing poor condition of the majority of roads.
- Movement of heavy vehicles along all roads in the study area during heavy weather events or dusk will result in reduced safety for other road users.
- Increase in the volume of traffic passing through Viqueque in particular will result in a decreased level of safety for other road users around the Viqueque turn location. Increasing heavy vehicles in this location could affect the more vulnerable road users such as pedestrians and cyclists.
- It is predicted that approximately one-third (30%) of the construction workforce is likely to be local labour from Beaco, and 10% is assumed to arrive by light vehicle. The remaining construction personnel are predicted to arrive from Nova Beaco on buses.

Operational Impacts

Following commissioning of the LNG Plant, vehicle movements on the road network in the study area for the operational stage will see a slightly greater number of light vehicle trips than heavy vehicle trips.

Heavy supply and construction materials and vehicles may be transported to Beaco from the Suai supply base by road; however, delivery of most of the construction materials by sea is likely to be more efficient and cost-effective.

A small proportion of the newly generated trips may be made from the Suai Suppy Base and Betano Refinery to the LNG plant itself. This, combined with the daily trips from Nova Viqueque to the LNG plant, would result in a potentially significant increase in the number of vehicles travelling daily on the network between Viqueque and the LNG plant.

Traffic-related impacts would also largely be dependent on the method of distribution of the LNG/ LPG product. The land based distribution of this product has not yet been assessed. The only heavy vehicles to operate from the LNG plant to the Viqueque town centre should be buses provided for the work force, rather than tankers carrying petroleum product.

The potential changes to trip generation and distribution across the road network, are set out below.

- Of the approximate 7,000 residents located at Nova Viqueque, approximately 1,600 (23%) are likely to be workers at the LNG Plant.
- It is assumed that up to 90% of workers from Nova Viqueque would travel to the LNG Plant by bus.

- Therefore, the movement of workers from Nova Viqueque to the LNG Plant by private vehicle is predicted to be relatively low, representing approximately 10% of total staff trips from Nova Viqueque.
- It is predicted that there would be some occasional light vehicle movements to the Betano Refinery.
- Due to phased construction, there is expected to be increased movements of some light vehicles and heavy supply and construction material vehicles to Suai and Viqueque from the LNG Plant.

Impacts Summary

Impacts on the land transport network associated with the project have been measured through qualitative criteria set out within the UK Institute of Highway Engineers (IHT) Guidelines for Traffic Impact Assessment (1994) and the supporting Guidelines for the Environmental Assessment of Road Traffic (Institute of Environmental Assessment, 1991). The criteria attributed to impacts are set out in Table 7-42.

Table 7-42 Significance criteria

Significance	Criteria
Major	These effects are likely to be important considerations at a regional or district scale but, if adverse, are potential concerns to the project, depending on the relative importance attached to the issue during the decision making process. Mitigation measures and detailed design work are unlikely to remove all of the effects upon the affected communities or interests.
Moderate	These effects, if adverse, while important at the local scale, are not likely to be key decision making issues. Nevertheless, the cumulative effect of such issues may lead to an increase in the overall effects on a particular area or on a particular resource. They represent issues where effects will be experienced but mitigation measures and detailed design work may ameliorate/enhance some of the consequences upon affected communities or interests. Some residual effects will still arise.
Minor	These effects may be raised as local issues but are unlikely to be of importance in the decision making process. Nevertheless, they are of relevance in the detailed design of the project and consideration of mitigation or compensation measures.
Negligible	No effects or those which are beneath levels of perception, within normal bounds of variation or within the margin of forecasting error.

A summary of the impact categories, and the predicted level of impact on the land transport network are set out in Table 7-43.

Table 7-43 Impacts summary - land transport network

Impact	Stage	Criteria Measurement
Air and noise quality impacts.	Construction	Moderate
Deterioration of road condition due to significant increase in daily movements of heavy vehicles.	Construction	Moderate
Deterioration of roads from significant increase in daily movements of light vehicles.	Construction	Moderate
Reduction in safety for other road users	Construction	Moderate
Change in road safety for pedestrians in the study area.	Construction	Moderate
Impact on existing intersections.	Construction	Moderate
Air and noise quality impacts.	Operation	Moderate
Deterioration of roads from significant increase in daily movements of light vehicles.	Operation	Moderate
Change in road safety for pedestrians in the study area.	Operation	Moderate
Change in road safety for other road users (increased traffic volumes)	Operation	Major
Introduction of new intersections.	Operation	Minor
Impact on existing intersections.	Operation	Minor
Impact on local road network requiring improved traffic management – Nova Viqueque/ Beaco.	Operation	Minor

7.11.3 Avoidance, Management and Mitigation Measures

The potential impacts of the construction and operational phases of the project set out within T074 are subject to detailed engineering design and further development of mitigation measures. These measures would be designed to reduce the environmental impacts on the local transport network. Each of the impacts set out in Table 7-43 have been addressed individually in the following sections.

Construction

Air and noise quality impacts

- Detailed assessment of air quality issues, impacts and mitigation measures are set out in Section 7.4.
- Detailed assessment of noise issues, impacts and mitigation measures are set out in Section 7.5.

Road condition –heavy vehicles

The existing core road network in the study area is in poor condition. The impact of additional heavy vehicle use, in particular during and after rainfall, will further deteriorate the state of national and district roads.

- Key roads used for access to the construction sites should be upgraded in accordance with accepted design standards to be able to handle both the anticipated volumes and nature of the various heavy vehicles employed on the project. The surfaces should be adequate (gravel or pavement) to withstand the multiple construction phases and should reflect accepted design standards.
- Where appropriate, pedestrian crossing points should be included, in particular through the Viqueque Town and Beaco areas which will see some of the largest increases in heavy vehicle volumes. Pedestrian crossing points and controls should be provided for the most visible and obvious pedestrian routes.
- Drainage is a key issue for the maintenance of pavement conditions during the construction stage and beyond. Roads should be designed to include the requisite level of drainage that does not otherwise impact negatively on existing drainage features or properties.
- Heavy vehicles moving between the Suai, Betano and Beaco development areas should be restricted to key routes only and should not travel on local roads where possible. These local roads should also be upgraded or constructed to accepted design standards.
- Traffic management controls should be upgraded to provide priority for through movements which will reduce deceleration and acceleration of heavy vehicles where appropriate. Each intersection along the key routes to and from the LNG Plant should be examined for improvements in traffic management.
- Regular maintenance and review of pavement and drainage features should be undertaken during the construction period and repaired as required.

Road condition –light vehicles

The mitigation and management measures in the previous section will also provide mitigation for the impacts of additional light vehicle movements.

Decreased level of safety for road users around Viqueque - construction

Road network improvements proposed to cater for construction vehicles will provide some mitigation for the potential impacts around Viqueque.

- Dedicated areas for motorcycle parking should be provided away from the proposed heavy vehicle routes through Viqueque.
- A road safety audit should be completed of the design of the road network improvements through the Viqueque town location to highlight whether or not improvements could be provided.

Change in road safety for pedestrians

Increase in heavy traffic volumes and the proposed improvements to the road network will result in a changed environment for pedestrians.

- Temporary manned and controlled pedestrian crossing points should be provided at key locations where there is significant heavy vehicle traffic. These locations include in front of schools, commercial locations and community facilities.
- A Traffic Management Plan should be developed at each construction stage of the Beaco development which clearly sets out which routes vehicles can use, when these routes will be used and the volume of vehicles anticipated.

Impact on existing intersections

The road improvements proposed as part of the project will result in both positive (improved road condition) and negative (increased traffic volumes/congestion) impacts at existing intersections.

- A detailed review of the existing road network function and impacts at intersections should be undertaken as part of the design process.

Operation

Air and noise quality impacts

- Detailed assessment of air quality issues, impacts and mitigation measures are set out in Section 7.4.
- Detailed assessment of noise issues, impacts and mitigation measures are set out in Section 7.5.

Road condition light vehicles

Key roads used for access to the project should be upgraded using accepted design standards to be able to accommodate the anticipated level of traffic and provide all year round access.

- Drainage is a key issue for the maintenance of pavement conditions during the operational phase. Roads should be designed to include the requisite level of drainage that does not otherwise impact negatively on existing drainage features or properties.
- Appropriate lighting should be provided on key links where there is likely to be significant traffic flow at night.

Change in road safety for pedestrians

An assessment of the existing pedestrian desire lines along the A08-02 and A07-01 should be undertaken to understand the impacts of the new access point into the LNG Plant development area and how people will access it.

- Formalised pedestrian crossings should be provided along the A08-02 and A07-01 where there is anticipated to be movement of pedestrians across the section of road anticipated to be more heavily trafficked.

Introduction of new intersections

- Clear signage and lighting should be provided within the design of new intersections for the project access along the A08-02.
- Traffic management controls should be provided at new intersections providing priority along the A08-02.
- Pedestrian crossing points should be incorporated into intersection design.

Impact on existing intersections

- A detailed review of the existing road network function and impacts at intersections should be undertaken as part of the design process of the road network and intersection improvements proposed for the operation stage.

Impact on local road network requiring improved traffic management – Nova Viqueque/ Beaco.

- The road network design for Nova Viqueque should be completed to a high standard and include pedestrian facilities where possible.

7.11.4 Residual Impacts

Mitigation and management measures set out in Section 7.11.4 have been designed to address the key impacts on the land transport network. Not all impacts can be mitigated entirely, as the introduction of additional traffic on the road network in the study area will result in ongoing impacts and issues related to road safety and interaction of pedestrians, cyclists and motorcyclists and light and heavy vehicles associated with the project.

The most critical mitigation measure will be significantly improving the condition of the existing road network which is poor to very poor. This mitigation measure will however likely see more informal use of the road surface by pedestrians and motorcyclists as they will be attracted to all weather routes rather than some of the existing fair weather only urban or rural roads. This in turn will highlight the importance of road safety issues and management of the road network to reduce potential road trauma. These issues can be assessed and managed at a local level.

Monitoring and Reporting

The monitoring and reporting measures for the land transport network during the construction and operational phases are set out below.

- It was noted in Section 7.11.1 that there is a lack of historical traffic data for the study area and this has resulted in there being limited understanding of traffic growth or distribution patterns. In order to understand the impact of both project related construction and operation traffic on the land transport network, annual traffic observations should be undertaken on key links as identified included in Table 7-41. These observations should be recorded and made available to the GoTL along with 2011 baseline information included in this SEIA to monitor the traffic volumes in the study area.
- Annual pavement condition reports should be undertaken for all key links in the core road network to allow for programming of maintenance. These condition reports may be used to prioritise upgrades required for the project.
- Annual review of all traffic management measures, including signage and lighting, should be undertaken to maintain all traffic management controls in place. Ongoing maintenance of traffic management measures should be undertaken on an as-needed basis e.g., replacement of signage, remarking lines and markers and replacement of road safety items such as ‘cats eyes’ (raised pavement markers).
- All incidents or near miss vehicle incidents for all traffic generated by the project should be recorded, including traffic moving between the Suai, Betano and Beaco development areas during construction and all vehicles moving to and from Nova Beaco to the LNG plant and other sites during the operational stage. A management plan for dealing with the health and safety implications for all vehicle incidents and recommending improvements should be developed and updated annually.

7.11.5 Further Work

It is recommended that a full Transport Impact Assessment be undertaken for the Beaco Development, including the proposed new towns of Nova Beaco and Nova Viqueque. To enable this assessment to be prepared, it is important to gain a full and robust understanding of the current local conditions of the local study area. This baseline data collection program should include:

- Current traffic movements through all useable roads in the local area. This data should be gathered at various times during the year to form a representative baseline of traffic count data.
- Accurate population, employment and travel to work data should be gathered for the Viqueque and Biloi and Bicari areas which will inform the distribution and assignment of traffic through the road network.
- Accurate vehicle fleet composition to enable the capacity on existing infrastructure to be calculated.
- All development proposals (land and road network) in the area that would impact on people’s movements and travel behaviours.

- Full detailed plans for the operational phase of the Suai, Betano and Beaco developments should be compiled. These details should include the proposed number of trips between all sites and the proposals for routes and delivery of materials and products from each location. This will enable the impact for the wider area along the south coast to be assessed as well as the Viqueque area itself.
- Staged development of the transport network, including costings, should be updated to reflect revised plans for land uses and other proposed developments along the south coast.
- Development of a Traffic Management Plan to enable the safe planning and design of the road network through both the construction and operational phases of the project.

It is also recommended that GoTL should develop a transport master plan, complete with local infrastructure plans, strategies and policies to address potential growth in the area as a result of infrastructure and industrial improvements.

7.12 Waste Management

The focus of this section is to describe typical waste management strategies that could be employed at the Beaco LNG Plant. Waste management at the Beaco development area will rely on the development of new facilities and waste management areas as, in general, there are no suitable industrial-scale waste management facilities available there currently.

This section does not address the potential impacts of waste on air, land, water, biodiversity, land use and visual amenity, as these impacts have been described in earlier sections of Chapter 7.

Existing waste management facilities in Timor-Leste have been described in Section 6.12.1.

Section 7.12.1 details the waste types that will typically be generated during construction and operations and Section 7.12.2 provides estimates of likely waste quantities.

Sections 7.12.3 and 7.12.4 describe typical waste management strategies and processes that could be employed, including reduction, reuse and recycle, treatment and disposal, storage and transportation and monitoring.

Section 7.12.5 details the waste management facilities required at the Beaco development area to deal with the wastes described and estimated in Sections 7.12.1 and 7.12.2.

7.12.1 Waste Types

Construction

The waste types that will typically be generated at the Beaco development area during construction will largely comprise of greenwaste and industrial waste. These wastes are listed below.

Solid Waste

- Greenwaste (i.e., leaves, flowers, grass clippings and weeds), timber, topsoil and ASS from early works to prepare the site.
- Construction debris (i.e., wood, scrap metal, glass, insulation and plastic) and general industrial waste (i.e., concrete, steel, metal).
- General (domestic) waste, paper and cardboard.
- Waste clothes and fabric.
- Tyres.
- Redundant electrical goods.
- Empty drums and containers.
- Empty gas cylinders.
- Batteries.
- Medical and first-aid station waste.

- Dredging material (i.e., spoil from the shipping channels and establishment of the docks).
- Waste rock and soils.
- Ash from the incinerator.

Liquid Waste

- Domestic sewage and greywater.
- Waste oils, grease and fuels.
- Waste chemicals, paints, adhesives and solvents.
- Spent triethylene glycol, engine coolant and cleaning agents.
- Stormwater runoff.
- Brine from the reverse osmosis plant.
- Hydrotest water from the pipeline and LNG storage tank testing.
- Vehicle and equipment washdown water.

Gaseous Waste

- Gaseous and particulate emissions from earthworks and vehicle movements.

Operation

The waste types that will typically be generated at the Beaco development area during operations will comprise waste from maintaining the LNG plant complex, Nova Beaco, Nova Viqueque and Viqueque airport (Table 7-44).

It is anticipated that mercury will be generated from the feed gas and condensate although the exact quantity cannot be determined with the currently available information. The mercury will be removed by the mercury removal unit at the LNG plant using an adsorbent material. The adsorbent material will be transferred periodically to the Waste Management Area where it will be analysed to determine an acceptable disposal location.

7.12.2 Waste Quantities

An estimate of the typical waste quantities that will be generated at the Beaco development area during construction and operations is not known at this stage and will be determined during the detailed design stage. Management strategies and disposal methods are discussed in more detail in Section 17.5 and are summarised in Section 7.12.4.

7.12.3 Waste Management Hierarchy

Waste management for the Beaco development area will comply with relevant and applicable parts of the Democratic Republic of Timor-Leste's (RDTL) Government Decree Law 5/2011 on environmental licensing.

Table 7-44 Waste types generated during operations

Waste Type	Source Location			
	LNG Plant complex	Nova Beaco	Nova Viqueque	Viqueque Airport
Solid Waste				
General (domestic) waste, paper and cardboard	√	√	√	√
Spent batteries	√√	√	√	√
Oily rags and filters	√√√	-	-	√
Sludges from pigging operations	√	-	-	-
Ceramic balls, molecular sieve and activated carbon adsorbents	√√	-	-	-
Ash from high-temperature incinerator[1]	√√	-	-	-
Contaminated soil from accidental spillages	√√	√	√	√
Liquid Waste				
Domestic sewage and greywater	√	√√√	√√√	√
Waste oils (including oil from the bottom of the slops oil tank and lubricating oils), grease and fuels	√√√	-	-	√
Waste chemicals and solvents	√√	-	-	-
Waste triethylene glycol	√√	-	-	-
Stormwater runoff	√	√	√	√
Process water runoff	√	-	-	-
Brine from the reverse osmosis plant	√√	-	-	-
Ballast water from ships	√	-	-	-
Gaseous Waste				
Gaseous and particulate emissions from vehicle movements (i.e., NO_x, CO_2, PM_{10} and $PM_{2.5}$) and stationary plant sources (i.e., gas turbines, acid gas removal unit and hot oil heaters)	√√√	√	√	√

2 Ash from the high-temperature incinerator will be generated at the Waste Management Area (see Section 7.12.5).

√ Refers to the likelihood and relative volume of the waste type being generated at the source location.

The reuse, reduce and recycle hierarchy (RDTL, 2011b) will be adopted for the management of waste generated during construction, operations and maintenance activities at the Beaco development area. This hierarchy includes the following:

- **Reduce.** Avoid, eliminate or reduce practices that result in waste generation.
- **Reuse.** Reuse waste materials where practicable.
- **Recycle.** Convert waste into other useable materials.

Reduce

Processes will be designed and implemented to avoid, eliminate and reduce the generation of waste. This may include:

- Considering alternative products, i.e., substituting raw materials with less hazardous or toxic materials, and substituting materials for more environmentally friendly options.
- Using good housekeeping and operating practices, including inventory control.
- Using strict segregation processes to prevent the co-mingling of water and waste streams.
- Using low-sulfur diesel-powered equipment, where practicable.
- Ensuring equipment is maintained in accordance with the manufacturer's specifications.
- Reusing treated sewage effluent, greywater, stormwater, process water and hydrotest water as potential onsite irrigation.
- Reusing cleared site vegetation as a mulch to aid site landscaping following site earthworks.
- Clearing the smallest construction footprint possible, therefore reducing the generation of greenwaste, topsoil, dredge spoil, overburden, ASS and greenhouse gases.

Reuse and Recycle

The total amount of waste will be reduced through the implementation of recycling and reuse strategies. These strategies may include:

- Identifying reuse opportunities and assessing which materials could potentially be recycled.
- Identifying market demands for waste streams in the vicinity of Nova Beaco and Nova Viqueque (i.e., reuse of concrete to build roads).
- Installing dedicated skip bins for designated wastes around the construction site.
- Establishing a waste management area where waste can be sorted.

Potential recycling or reuse of wastes, as given in Table 7-45 may include scrap metal, glass, some industrial waste (i.e., concrete), some general (domestic) waste, drums, containers and some waste oils.

7.12.4 Waste Management Strategies

Additional waste management strategies will be adopted following implementation of the waste management hierarchy (see Section 7.12.3), and will include:

- **Treatment and disposal.** Use treatment methods to render wastes safe and dispose of products that can no longer be reused or recycled to an appropriate location.
- **Storage and transportation.** Appropriately store and transport wastes to minimise accidental releases to air, soil or water resources.
- **Monitoring.** Regularly monitor activities to ensure waste management strategies are effective.

Waste management strategies have been provided below and will be further developed as part of the project's environmental management plan (EMP).

Treatment and disposal

Waste materials generated after implementing reduce, reuse and recycling measures will be treated before disposal.

Sewage, greywater, stormwater, process water and hydrotest water will be the only wastes treated. They will all be treated by the wastewater treatment plant, before being irrigated to land and reused onsite. Treated water that is not irrigated will be discharged to the sea.

Waste disposal will be in accordance with the methods given in Table 7-45 and in a manner that, as far as practicable, avoids potential impacts to human health and the environment. Waste disposal will only occur at permitted facilities within the waste management area.

Due to the limited number of waste management facilities in Timor-Leste, incineration has been proposed as a viable option to reduce disposal volumes. It is expected that ash from the incinerated waste will be disposed of at a landfill.

Table 7-45 Generated waste types, and management and disposal methods

Waste type	Management Strategies/Treatment	Disposal Methods
Solid Waste		
Greenwaste	Stored in a bin before being incinerated.	Incinerator ash to landfill.
Construction debris – wood material	Stored in a skip before being incinerated.	Incinerator ash to landfill.
Construction debris – scrap metal	Sorted, segregated and stored in a skip.	Recycled or landfill.
Construction debris – glass	Sorted, segregated and stored in a skip.	Recycled or landfill.
Construction debris – insulation	Stored in a skip before being incinerated.	Incinerator ash to landfill.

Table 7-45 Generated waste types, and management and disposal methods (cont'd)

Waste type	Management Strategies/Treatment	Disposal Methods
Solid Waste		
Construction debris – plastic	Stored in a skip before being incinerated.	Incinerator ash to landfill.
Industrial waste (i.e., concrete, steel, metal)	Sorted, segregated and stored in a skip or a designated area.	Recycled or landfill.
General (domestic) waste, paper and cardboard	Sorted, segregated and stored in a bin.	Recycled or landfill.
Waste clothes and fabric	Stored in a bin before being removed.	Landfill.
Tyres	Stored in a skip or a designated area. Shredding and debeading by an industrial shredder.	Landfill.
Redundant electrical goods	Stripped of restricted materials then stored in a skip.	Landfill.
Drums and containers	Sorted, segregated and stored in a skip. Cleaned and crushed (using the industrial shredder).	Recycled or landfill.
Empty gas cylinders	Sorted, segregated and stored in a skip.	Recycled or landfill.
Batteries	Sorted, segregated and stored in a skip.	Recycled or returned to the manufacturer.
Oily rags and filters	Sorted, segregated and stored in a skip. The wastes are then taken to the incinerator.	Incinerator ash to landfill.
Medical waste	Incinerated.	Incinerator ash to landfill.
Topsoil	Stockpiled and managed for reuse during rehabilitation.	Reuse onsite.
Overburden and waste rock	Stockpiled and managed for reuse onsite.	Reuse onsite.
Process waste (i.e., ceramic balls, molecular sieve and activated carbon adsorbents)	Collected and stored in sealed containers. Waste will be analysed to determine acceptable disposal location (i.e., hazardous or non-hazardous section of the landfill).	Analysis of the material to determine acceptable disposal location.
Liquid Waste		
Domestic sewage and greywater	Collected and pumped to the wastewater treatment plant. Note: The option of dewatering the sewage and incinerating the sewage sludge may be considered in the future.	Wastewater treatment plant. Following treatment it will be reused onsite or discharged to sea.

Table 7-45 Generated waste types, and management and disposal methods (cont'd)

Waste type	Management Strategies/Treatment	Disposal Methods
Liquid Waste		
Waste oils, grease and fuel	Sorted, segregated and stored in individual drums. The waste oil is then taken to an oil storage tank (until it is filled, when it will then be taken to the incinerator). The other wastes are taken straight to the incinerator.	Recycled, oil storage tank or landfill.
Waste chemicals, paints and adhesives	Sorted, segregated and stored in individual drums and skips. The wastes are then taken to the incinerator.	Landfill.
Spent triethylene glycol, engine coolant and cleaning agents.	Sorted, segregated and stored in individual drums and skips. The wastes are then taken to the incinerator.	Landfill.
Stormwater runoff	Collected (using a drainage and sump system) then pumped to the wastewater treatment plant.	Wastewater treatment plant. Following treatment it will be reused onsite or discharged to sea.
Brine from the reverse osmosis plant	Discharged to the marine environment.	Pipeline discharge to sea.
Process water	Collected (using a drainage and sump system) then pumped to the wastewater treatment plant.	Wastewater treatment plant. Following treatment it will be reused onsite or discharged to sea.
Hydrotest water	Stored in pipelines or tanks that are being tested. The water will then be reused for additional hydrotesting, discharged to sea (if clean) or pumped to the wastewater treatment plant.	Reused onsite, discharged to sea (if clean) or treated at the wastewater treatment plant.

Storage

Wastes will be stored appropriately to minimise the risk of accidental releases to air, soil or water resources. Implementation of management measures may include:

- Storage of wastes in a manner that prevents co-mingling or contact between incompatible wastes (e.g., acids and alkalis).

- Storage of wastes that allows for the inspection of containers, i.e., to monitor any potential leaks or spills.
- Labelling containers for clear identification of the contents.
- Storage of chemicals, fuel, paint and adhesives in appropriately sized drums and on hard standing surfaces.
- Conducting periodic inspections of waste storage areas to ensure compliance with safety standards.
- Locating spill kits near liquid waste storage areas.
- Training all employees in spill response.
- Covering domestic waste storage bins.
- Stockpiling excess topsoil for reuse onsite. Stockpiles will be managed to ensure runoff is controlled and erosion is minimised.
- Loading and unloading waste within a bunded area, where practicable.

Transportation

Onsite and offsite waste transportation should be undertaken in a manner that minimises the possibility of spills and potential impacts to human health and the environment. Preparation of an EMP to document the procedures that apply to all aspects of waste management, including transportation will be beneficial to site management practices.

Monitoring

Monitoring activities may include the following:

- Recording and reporting the wastes generated by the project.
- Assessing the actual quantities and types of wastes compared to the predicted estimates. Following this, recommending and implementing improvements to waste management practices.
- Auditing the transportation and disposal of waste.
- Regular visual inspections of the waste management area.

These waste monitoring procedures should be further developed as part of the project's EMP.

7.12.5 Waste Management Area

A designated waste management area will need to be established in close proximity to the Beaco development area. The designated waste management area is required for the following management, treatment and disposal techniques (as given in Table 7-45):

- Sorting and segregating wastes.
- High-temperature incineration.

- Engineered landfill.
- Wastewater treatment.
- Tyre shredding (prior to disposal at a landfill).
- Drum cleaning and crushing before disposal at a landfill.

The location of the waste management area should be selected based on the following regional criteria (RDTL, 2011b):

- Free of geotechnical risks (fault area, landslide prone area or earthquake prone area).
- Reduced hydrogeological risk, which is an area with less than 3 metres ground water depth, water absorbance soil, closes proximity with water source. If these terms are not fulfilled a technical consultation is required.
- Reduced topographical risk (more than 20% land slope).
- Not within close proximity of the airport (minimum distance is 1.5 to 3 kilometres away).
- Not a conservation area.

Construction contractors and waste management companies will be responsible for the proper transport and handling of all the waste they produce. This will be detailed in the project's EMP.

Sorting and Segregating Wastes

The waste management area will include a designated area for sorting and segregating wastes.

Sorting and segregation of wastes will not always be undertaken in the waste management area as, in some instances, it may be easier to sort and segregate the wastes at the work site.

Incineration

The waste management area will include a high-temperature incinerator, designed and installed during early works.

Engineered Landfill

A local engineered landfill is required. The landfill will be constructed in the waste management area during early works. The landfill will be properly designed to take all non-hazardous and hazardous waste generated at the Beaco development area during construction and operations.

Wastewater Treatment Plant

A wastewater treatment plant is required to treat the sewage, greywater and stormwater generated at the Beaco development area and will need to be built as part of the proposed works.

Tyre Shredding

The waste management area will include an industrial shredder to shred and debead tyres before they are sent to the landfill for disposal. This will ensure there is available landfill capacity during construction and operations.

The industrial shredder can also be used to shred other waste such as drums. Tyres and drums can be stockpiled initially until a shredder is installed later in the project development schedule.

Drum Cleaning and Crushing Before Disposal at a Landfill

Drums will be cleaned and crushed (by the industrial shredder) before they are sent to the landfill for disposal. As above, this will ensure there is available landfill capacity during construction and operations.

7.12.6 Further Work

A detailed assessment of the volumes and types of wastes generated will need to be undertaken in order to appropriately size the required waste management facilities for the project.

This page has been intentionally left blank.

WorleyParsons
resources & energy

TIMOR GAP, E.P.
TIMOR GÁS & PETRÓLEO

REPUBLICA DEMOCRATICA DE TIMOR-LESTE
SECRETARIA DE ESTADO DOS RECURSOS NATURAIS

Tasi Mane Project – Betano Petroleum Refinery and Beaco LNG Plant

Strategic Environmental Impact Assessment

CHAPTER 8

ENVIRONMENTAL MANAGEMENT FRAMEWORK

301012-01504-EN-REP-0005
June 2012

8. ENVIRONMENTAL MANAGEMENT FRAMEWORK

The Government of Timor-Leste (GoTL) is committed to conducting activities for the Tasi Mane project in an environmentally and socially responsible manner and intends to implement environmental and social management practices in a systematic manner. The ultimate purpose of an environmental management system is to ensure the environmental and social impacts arising from the development of the project remain within acceptable boundaries defined by the GoTL, based on the environmental impact statement (EIS).

This chapter outlines an environmental and social management framework that could be applied throughout construction and operation of the project. It is expected that the framework will be refined over time as more detail about the actual plant designs are confirmed.

8.1 Commitment to Environmental Management

Environmental management is only as effective as the people that drive it. Leadership, commitment and accountability are important factors in achieving project success and excellence. Leaders should establish the vision and set achievable objectives and all employees at all levels, including contractors, should be held accountable for environmental performance. To meet high standards of performance, adequate resources should be assigned and employees need to be well trained.

Roles and responsibilities for environmental and social management be should clearly defined and all employees and contractors should be carefully selected, inducted and trained to ensure they are competent to perform the environmental and social duties relevant to their position. Comprehensive training and induction programs should also be developed and implemented prior to commencement of construction and operation.

8.2 Environmental Impact Assessment

The purpose of a strategic environmental impact assessment (SEIA) is to identify the likely environmental and social impacts associated with the construction and operation of a project. The SEIA is then used to inform the detailed design stage and determine the baseline conditions for the physical, biological, cultural and social environment (collectively 'the environment') in the general area of the development based on a preliminary or potentially unknown project design. One of the key objectives of a SEIA is to identify aspects that are required for a more detailed assessment.

Following a SEIA, a detailed Environmental Impact Assessment (EIA) is necessary to identify the aspects of the project that have an interaction, either negatively or positively, with the environment. The identification of environmental and social aspects, their impacts and associated avoidance, management and mitigation measures form the basis of how a project will be managed to reduce potential adverse impacts. The International Finance Corporation's (IFC)[9] have established a number of performance standards, including the world benchmark for how EIA's should be conducted. As a

9 The IFC is the largest global development funding institution, who has established policy and performance standards on social and environmental sustainability that they apply to all investment projects in developing countries to minimise impact on the environment and affected communities.

minimum, these standards could be used as a guide to undertake a detailed EIA for the Betano and Beaco projects once the project designs have been confirmed.

As planning and design for the project proceeds, these management measures will be further refined and supplemented with greater detail and technical input. To ensure all appropriate management measures are captured and implemented, a well-documented and robust management system is required.

8.3 Environmental Management Plans

Environmental management plans (EMP) are essentially action plans and are typically an intermediate step between the general requirements and commitments defined in the EIA and EIS and the specific tasks to be implemented by project staff and contractors as defined in individual work instructions. An EMP consolidates all the management and mitigation measures from the EIS, which can be given statutory effect through formal approval. Contractors working on the project would then be obligated to comply with the environmental requirements, specifications and procedures set out in the EMP's, as applicable to their specific scope of works.

The number, type and scope of EMP's can vary from project to project. EMP's should be developed for the different phases of a project, i.e., construction and operation.

The EMP's that could be developed for the Betano project include:

- Air quality management plan.
- Biodiversity management plan. This plan may include sub-plans specific to significant species, habitats or ecological values.
- Chemical management plan.
- Compensation plan.
- Cultural heritage management plan.
- Dust management plan.
- Employment and training plan.
- Noise management plan.
- Pest and disease management plan.
- Quarantine management plan.
- Rehabilitation plan.
- Resettlement action plan.
- Soil contamination management plan.
- Spill response plan.
- Stakeholder engagement plan.

- Traffic management plan.
- Waste management plan.
- Water management plan. This plan is likely to have sub-plans on:
  - Acid sulfate soils.
  - Erosion and sediment control.
  - Surface water and stormwater.
  - Wastewater.
  - Watercourse crossing.

The EMP's for the Beaco project could include:

- Air quality management plan.
- Biodiversity management plan. This plan may include sub-plans specific to significant species, habitats or ecological values.
- Chemical management plan.
- Compensation plan.
- Cultural heritage management plan.
- Dust management plan.
- Employment and training plan.
- Greenhouse gas and abatement plan.
- Noise management plan.
- Pest and disease management plan.
- Quarantine management plan.
- Soil contamination management plan.
- Spill response plan.
- Stakeholder engagement plan.
- Traffic management plan.
- Waste management plan.
- Water management plan. This plan is likely to have sub-plans on:
  - Acid sulfate soils.
  - Erosion and sediment control.
  - Surface water and stormwater.

- Wastewater.
- Watercourse crossing.

EMP's can be prepared by the proponent or third party operator. In either case, it is important the roles and responsibilities of all parties are clearly.

8.4 Work Instructions

Environmental work instructions may need to be developed for the projects. They are an implementation tool containing practical procedures for use by the workforce. They are concise and typically detail the purpose and scope of the work instruction, relevant definitions, various tasks and accountability of the responsible worker.

Examples of relevant work instructions include:

- Construction of bunds.
- Storage, segregation and disposal of waste streams.
- Refuelling procedure.
- Complaints procedure.

8.5 Environmental Monitoring Programs

Environmental monitoring programs are important to monitor the performance of project activities, measure the effectiveness of management practices and ensure compliance with legal requirements. Monitoring programs are typically developed in consultation with the relevant government agencies and incorporate any conditions of approval of the project. A thorough understanding of the baseline environmental conditions is essential and should be undertaken as the first step before designing an environmental monitoring program.

In the absence of baseline environmental conditions and a detailed project description, the purpose of typical monitoring programs are provided below.

Dust Monitoring

Dust monitoring is undertaken to assess compliance with the specified performance criteria and to minimise dust emissions at sensitive receptors i.e., permanent residences. Dust gauges are placed at appropriate locations in the vicinity of sensitive receptors.

Air Quality Monitoring

Air quality monitoring typically involves assessing the volume and composition of emissions to the atmosphere to protect air quality at sensitive receptors. Specific project infrastructure, i.e. point sources of air pollution, often include a wide range of chemical pollutants to be monitored such as from the LNG plant and refinery.

Noise Monitoring

Noise gauges are generally placed at appropriate locations in the vicinity of the sensitive receptors during construction and ongoing operations, to quantify the emissions detected during the day, evening and night time periods and assess compliance with the relevant noise criteria.

Water Quality Monitoring

The goals of an ambient water quality monitoring program are to determine the status of the aquatic ecosystem that potentially can be affected by a project and to detect any changes that may occur over time. This is achieved by conducting monitoring programs both upstream and downstream of the project activity, to assess and ensure existing water quality values and beneficial uses are maintained throughout construction and operation of the project.

Biodiversity Monitoring

Biological monitoring is undertaken to determine the presence and abundance of endangered biodiversity species. This could include the control of potentially introduced animals, plants and diseases.

8.6 Review and Reporting

Essential to any project is the need to regularly review the system to ensure its continuing suitability, adequacy and effectiveness. Mechanisms for review can include auditing, routine monitoring, incident or complaint investigations, legislative amendments and refinement of project development.

The purpose of an audit is to assess performance, typically, in relation to:

- Compliance with established standards.
- ‘Trigger levels’ that indicate continued compliance is at risk.
- Identification and assessment of environmental and social risk.
- Environmental management (i.e., EMPs, work instructions and monitoring programs).

Where audits, monitoring or investigations indicate that performance does not conform to environmental management requirements, corrective action may be required. Corrective action procedures are important in order to:

- Determine the cause of non-conformance.
- Identify and implement corrective action.
- Initiate preventative actions.
- Apply controls to ensure that preventative actions are effective.
- Record any changes in written procedure resulting from the corrective action.
- Include management responsibilities for addressing, tracking and close-out of audits, monitoring programs and investigations.

Routine reporting of environmental performance ensures stakeholders are well informed and kept up-to-date with project information. Regulatory reports are generally sufficiently detailed and conducted in a manner that demonstrates whether specific environmental performance objectives and standards are being met. The purpose of consultation reports to key community members and communities are generally twofold, providing not only updates on the status and possible changes to the project, but it also provides an avenue for stakeholders to communicate concerns, queries or feedback.

This page has been intentionally left blank.

WorleyParsons
resources & energy

TIMOR GAP, E.P.
TIMOR GÁS & PETRÓLEO

REPUBLICA DEMOCRATICA DE TIMOR-LESTE
SECRETARIA DE ESTADO DOS RECURSOS NATURAIS

Tasi Mane Project – Betano Petroleum Refinery and Beaco LNG Plant

Strategic Environmental Impact Assessment

CHAPTER 9
CONCLUSIONS AND RECOMMENDATIONS

301012-01504-EN-REP-0005
June 2012

9. CONCLUSIONS AND RECOMMENDATIONS

9.1 Conclusions

Timor-Leste is one of the world's newest and least economically-developed democracies. It has established a bold vision for its future that is currently, heavily reliant on the proposed exploitation of known oil and gas reserves in the Timor Sea.

Development of the Tasi-Mane Project and its related infrastructure is an important step in the overall development of Timor-Leste's offshore oil and gas industry and leading from that, the social and economic development of the country as a whole. The developments proposed at Betano (Refinery and Petrochemical complex) and Beaco (LNG Plant) will be subject to a staged environment assessment and approval process. This strategic environment impact assessment is the first stage of that process, intended to characterise the local environmental and social context at each site, and identify the key benefits and potential issues associated with the proposed developments.

The specialist studies that informed this study took place within a narrow timeframe, in many instances without the benefit of the historical information or baseline information necessary to place into context the observations made during the fieldwork and desktop studies. In addition, information describing the proposed infrastructure and works at each site was not available and therefore, the potential impacts identified within this report can best be described as preliminary in nature. Considered collectively, the conclusions that can be drawn in this report should be regarded with some caution as there is little doubt that, with the benefit of additional engineering design information and scientific data, the information presented and recommendations contained in this report will almost certainly change. Similary, the detailed EIA will need to be undertaken within the context of a risk framework, and include a cumulative impact assessment.

LNG plants, petroleum refineries and petrochemical plants are common in this type of setting around the world. There will be some impacts that are essentially, irreversible (such as the change in land use and clearance of native vegetation); however, this is inherent in developments of this type and normally accepted by both government and the affected community. Nevertheless, the actual type and extent of these impacts needs to be further studied to confirm what are essentially, preliminary studies and initial impressions based on experience elsewhere. It is expected that, with the application of contemporary engineering and environmental studies, the potential impacts to environment and community values can be avoided or mitigated to an acceptable standard, during the engineering design stage.

The principal impacts to the natural environment associated with the construction and operation of the project-related facilities will include:

- Construction:
  - Localised emissions of noise and dust.
  - Geohazards (dispersive/erodible soils) at Nova Viqueque and Nova Beaco.

  - Re-suspended sediment in the area resulting from dredging and construction of the breakwaters at each site.
  - The removal of some local residences and resettlement of the families living in them.
  - Clearance of native vegetation that may be important to conservation significant species.
  - Loss of farmland.
  - Coastal landscape changes and interruption of sediment transport (i.e., coastal erosion).
- Operations:
  - Potential health and safety impacts associated with increased air emissions (particulate matter and gases) from the refinery and petrochemical complex.
  - Disposal of treated sewage.
  - Storage of hazardous materials such as heavy fuel oil and diesel.
  - An offshore plume of saline wastewater from the reverse osmosis plant.
  - Domestic and light-industrial refuse disposed to landfill.
  - Particulate, gas and noise emissions to air from fixed and mobile, plant and machinery.

Furthermore, it is recommended that an iterative process of engagement with Government stakeholders, and the community, is initiated by the project proponent once the front-end engineering design process has been commenced to ensure that the potential impacts of the proposed developments are known and, where feasible, mitigated through the design process.

9.2 Recommendations

If the Government of Timor-Leste wishes to reduce the current level of risk associated with the amount and scope of information to inform its decision on whether the project should proceed, an extensive array of further work is recommended. This is discussed in detail at the end of each chapter. The most important of these recommendations are summarised in Chapter 8, Environmental Management Framework.

This page has been intentionally left blank.

WorleyParsons
resources & energy

TIMOR GAP, E.P.
TIMOR GÁS & PETRÓLEO

REPUBLICA DEMOCRATICA DE TIMOR-LESTE
SECRETARIA DE ESTADO DOS RECURSOS NATURAIS

Tasi Mane Project – Betano Petroleum Refinery and Beaco LNG Plant

Strategic Environmental Impact Assessment

CHAPTER 10
REFERENCES

301012-01504-EN-REP-0005
June 2012

10. REFERENCES

ADB, 2007. Road Sector Investment Planning in the Pacific. An Example of Good Practice, Timor-Leste. July. Prepared by the Asian Development Bank.

Ahern et. al, 1998. Guidelines for sampling and analysis of lowland acid sulfate soils (ASS) in Queensland. Revision 4.0. October. Prepared for the Queensland Acid Sulfate Soils Investigation Team (QASSIT) by Ahern C.R., Ahern M.R. and Powell B.

Alves, G., 2007. Thematic Assessment Report, the United Nations Convention on Biological Diversity (UNCBD). National Capacity Self Assessment (NCSA) Project, Timor Leste. Thematic Working Group (TWG) Consultant Report to UNCBD, January 2007.

Anchor Environmental C.A. L.P., 2003. Literature Review of Effects of Resuspended Sediments Due to Dredging Operations. Prepared by Anchor Environmental C.A. L.P. for the Los Angeles Contaminated Sediments Task Force.

Anderson *et al.*, 2004. Quantitative measures of sedimentation in an estuarine system and its relationship with intertidal soft-sediment infauna. Marine Ecology Progress Series: Volume 272, Pages 33 to 48. Prepared by Anderson M.J., Ford R.B., Feary D.A. and Honeywill C.

ANZECC/ARMCANZ (2000). Australian and New Zealand Guidelines for Fresh and Marine Water Quality.

ANZECC/ARMCANZ (2000). Water Quality and Monitoring Guidelines. National Water Quality Management Strategy.

API, 2010. API West Pilbara Iron Ore Project - Stage 1: Marine Pest Monitoring and Control Plan. Prepared by API Management Pty Ltd.

AS 2436-2010. Guide to noise and vibration control on construction, demolition and maintenance sites. May. Prepared by Committee EV-010, Acoustic Community Noise.

AS 3580.14-2011. Methods for sampling and analysis of ambient air. Part 14: Meteorological monitoring for ambient air quality monitoring applications. Australian Standard.

AS 3580.9.8-2008. Methods for sampling and analysis of ambient air. Method 9.8: Determination of suspended particulate matter – PM10 continuous direct mass method using a tapered element oscillating microbalance analyser. Australian Standard.

Audley-Charles, 1968. The geology of Portuguese Timor. Memoir of the Geological Society of London 4. Prepared by Audley-Charles, M.G.

Barnett *et al.*, 2007. Vulnerability to climate variability and change in East Timor. Royal Swedish Academy of Sciences. Ambio Volume 36, Number 5. July. Prepared by Barnett, J., Dessai, S. and Jones, R.N.

BCG, 2012. PRESS RELEASES: Report highlights six steps to help developing countries avoid the 'resource curse'. A WWW publication accessed in February 2012 at: http://www.bcg.com/media/PressReleaseDetails.aspx?id=tcm:12-97025. Prepared by the Boston Consulting Group.

BHP, 2006. Cabrillo Port Liquefied Natural Gas Deepwater Port - Revised Draft EIR. Prepared by BHP Billiton.

Bouma, G. and Kobryn, H. 2002. Assessing Vegetation Change in East Timor Using Landsat Thematic Mapper Data, Murdoch University, Perth.

Burke et al, 2002. Reefs at Risk in Southeast Asia. A WWW publication accessed at http://www.wri.org/publication/reefs-risk-southeast-asia. Retrieved February 2008. Prepared by Burke, L., L. Selig and M. Spalding.

Burt et al, 2009. Coral recruitment and early benthic community development on several materials used in the construction of artificial reefs and breakwaters. Journal of Experimental Marine Biology and Ecology: Volume 373, Pages 72 to 78. Prepared by Burt J., Bartholomew A., Bauman A., Saif A. and Sale P.F.

Carlos Lopes Ximenes, 2011. Country Analysis Paper (Draft). October. Prepared by Carlos Lopes Ximenes as an input for the third meeting of the Regional 3R Forum in Asia.

CI, 2007. Biodiversity Hotspots. Center for Applied Biodiversity Science, Conservation International.

Cowie, I., 2006. A survey of flora and vegetation of the proposed Jaco-Tutuala-Lore National Park, Timor-Leste (East Timor). Report to Birdlife International by the Northern Territory Herbarium.

Cowie, I., 2007. Survey of Flora and Vegetation of the Proposed Iralalaro Hydropower Project, Timor Leste. Report to EPANZ Services by the Northern Territory Herbarium June 2007.

CSIRO, 2010. Climate change in Timor-Leste. A brief overview on future climate projections. Prepared by the CSIRO.

Currie and Small, 2005. Macrobenthic community responces to long-term environmental change in an east Australian sub-tropical estuary. Estuarine, Coastal and Shelf Science, 63, pp.315–31. Prepared byCurrie, D.R. and Small, K.J.

DAFF, 2011. Antifouling and In-water Cleaning Guidelines. Prepared by the Department of Agriculture, Fisheries and Forestry, Canberra, ACT.

Daffron *et al.,* 2011. Antifouling strategies: History and regulation, ecological impacts and mitigation. Marine Pollution Bulletin: volume 62, issue 3, pages 453 to 465. Prepared by Dafforn, K.A., Lewis, J.A. and Johnston, E.L.

DEC, 1997. Environmental Protection (Noise) Regulations (WA). Prepared by the Department of Environment and Conservation.

DEH, 1991. Microbiological Aspects of the Disinfection of Sewage Effluents. Environment Technical Report – Policy Review Paper. Prepared by the Department of Environment and Heritage, Queensland.

Department of the Environment, Transport and the Regions, 1998. A New Deal for Trunk Roads in England: Guidance on the New Approach to Appraisal.

Dernie *et al.,* 2003. Recovery rates of benthic communities following physical disturbance. Journal of Animal Ecology: Volume 72, Pages 1043 to 1056. Prepared by Dernie K. M., Kaiser M. J. and Warwick R. M.

Dicks *et al.,* 1982. The effects of repeated small oil spillages and chronic discharges. Philosophical Transactions of the Royal Society: volume 297, number 1087, pages 285 to 307. Prepared by Dicks, B. Hartley, J. P. Straughan D. and Clark R. B.

Dolcemascolo, 2003. Climate Risk and Agriculture in Timor Loro'Sae. Prepared by Dolcemascolo, G.

DSEWPC, 2008. National Pollutant Inventory - Emission estimation technique manual for Combustion Engines. Version 3.0. June. Prepared by the Department of Sustainability, Environment, Water, Population and Communities.

DSEWPC, 2011. National Pollutant Inventory - Emission estimation technique manual for Combustion in boilers. Version 3.6. December. Prepared by the Department of Sustainability, Environment, Water, Population and Communities.

DSEWPC, 2012a. National Pollutant Inventory - Emission estimation technique manual for Fugitive Emissions. Version 2.0. January. Prepared by the Department of Sustainability, Environment, Water, Population and Communities.

DSEWPC, 2012b. National Pollutant Inventory - Emission estimation technique manual for Mining. Version 3.1. January. Prepared by the Department of Sustainability, Environment, Water, Population and Communities.

EPA VIC, 2002. Guidelines for Environmental Management: Disinfection of Treated Wastewater. Prepared by the Environmental Protection Authority, Victoria.

Forman, L. and Bridson, D., 1989. The Herbarium handbook. Kew: Royal Botanic Gardens and HMSO.

GISP, 2008. Marine Biofouling and Invasive Species: Guidelines for Prevention and Management. Compiled by Lynn Jackson on behalf of the Global Invasive Species Programme and the UNEP Regional Seas Programme.

Guidelines for Landscape and Visual Impact Assessment, Second Edition, Spon Press, 2002.

Guzmán and Holst, 1993. Effects of chronic oil-sediment pollution on the reproduction of the Caribbean reef coral Siderastrea sidereal. Marine Pollution Bulletin: volume 26, issue 5, pages 276 to 282. Prepared by Guzmán H. M. and Holst, I.

Hutchings *et al.,* 2002. Species Introductions and Potential for Marine Pest Invasions into Tropical Marine Communities, with Special Reference to the Indo-Pacific. Pacific Science: Volume 56, Issue 2, Pages 223 to 233. Prepared by Hutchings P. A., Hilliard R. W. and Coles S. L.

IAIA, 1999. Principles of Environmental Impact Assessment Best Practice. December. Prepared by the International Association for Impact Assessment.

IMF, 2005. Democratic Republic of Timor-Leste: Poverty Reduction Strategy Paper - National Development Plan, Road Map for Implementation of National Development Plan, Overview of Sector Investment Programs - Strategies and Priorities for the Medium Term. July. Prepared by the International Monetary Fund.

IMO, 2001. International Convention on the Control of Harmful Anti-fouling Systems on Ships. London. Prepared by the International Maritime Organization.

IMO, 2004. International Convention on the Control and Management of Ships' Ballast Water and Sediments. Prepared by the International Maritime Organization.

Johnston and Roberts, 2009. Contaminants reduce the richness and evenness of marine communities: A review and meta-analysis. Environmental Pollution: volume 157, issue 6, pages 1745 to 1752. Prepared by Johnston, E.L. and Roberts, D.A.

Kaiser *et al.,* 2011. The herpetofauna of Timor-Leste: a first report. Prepared by Kaiser, H., Venancio Lopes Carvalho, Jester Ceballos, Paul Freed, Scott Heacox, Barbara Lester, Stephen J. Richards, Colin R. Trainor, Caitlin Sanchez, Mark O'Shea.

KBC *et al.,* Undated. Timor LNG - Conceptualisation and Cost Estimation. Basis of Design - Study Assumptions. Prepared by KBC Advanced Technology Pte Ltd and GS Engineering and Construction. Only sub-sections of this report have been provided to WorleyParsons.

KBC, 2011. Confidential Final Report. Revision 2. Document number: 106349-0000-RPT-0001. May. Prepared by KBC Advanced Technology Pte Ltd. Only sub-sections of this report have been provided to WorleyParsons.

Keefer, 2000. Report on restoration of meteorological network – Timor Loro'Sae. Prepared by Keefer, G.D.

Kirono, D. 2010, Climate change in Timor-Leste – a brief overview on future climate projections. Prepared for the Department of Climate Change and Energy Efficiency (DCCEE).

La'o Hamutuk, 2011. Valuing Farmers' Words and Wisdom. A report on Consultation with Farmers. Interview. August. Prepared by La'o Hamutuk from the Timor-Leste Institute for Development Monitoring and Analysis.

Landscape Institute (LI) and the Institute of Environmental Management and Assessment, 2002.

LBG, 2006. Road Sector Investment Planning in Timor-Leste. A Technical Working Paper. October. Prepared by the Louis Berger Group, Inc.

Lincoln-Smith et al, 1994. Man-made rock breakwaters as fish habitats: comparisons between breakwaters and natural reefs within an embayment in south-eastern Australia. Bulletin of Marine Science: Volume 55. Prepared by Lincoln-Smith M., Hair C., and Bell J.

Long, B.G. and Poiner, I.R., 1994. Infaunal benthic community structure and function in the Gulf of Carpentaria, northern Australia. Australian Journal of Marine and Freshwater Research, 45, p.293–316.

Matos J. 2001. Fundamentos da informação geográfica. Lidel, Lisbon.

Metzner, J. K. 1977. Man and environment in Eastern Timor: a geoecological analysis of the Baucau - Viqueque area as a possible basis for regional planning. Canberra, Australian National University.

Miller *et al.,* 2002. Detrimental effects of sedimentation on marine benthos: what can be learned from natural processes and rates? Ecological Engineering: volume 19, issue 3, pages 211 to 232. Prepared by Miller, D.C., Muir, C.L. and Hauser O.A.

Milliman *et al.,* 1999. Flux and fate of fluvial sediments leaving large islands in the East Indies. J. Sea Res (Netherlands), 41, Pages 97 to 107. Prepared by Milliman, J.D., Farnsworth, K.M. and Albertin, C.

MoA, 2012a. Monthly Meteorological Bulletin: June 2004 to November 2011. Automatic weather station (Enerco 420): Betano. Accessed in 2012. Ministerio De Agricultura.

MoA, 2012b. Monthly Meteorological Bulletin: March 2008 to July 2011. Automatic weather station (Enerco 420): Viqueque. Accessed in 2012. Ministerio De Agricultura.

Monk *et al.,* 1997. The Ecology of Nusa Tenggara and Maluku. Periplus, Hong Kong. Prepared by Monk, K.A., de Fretes, Y. and Reksodiharjo-Lilley, G.

NSPMMPI, 2009a. National biofouling management guidelines for commercial vessels. Prepared by the National System for the Prevention and Management of Marine Pest Incursions, Government of Australia, Canberra.

NSPMMPI, 2009b. National biofouling management guidelines for non-trading vessels. Prepared by the National System for the Prevention and Management of Marine Pest Incursions, Government of Australia, Canberra.

NSPMMPI, 2009c. National biofouling management guidelines for the petroleum production and exploration industry. Prepared by the National System for the Prevention and Management of Marine Pest Incursions, Government of Australia, Canberra.

Oberholzer, B. 2005. Guideline for involving visual & aesthetic specialists in EIA processes, Cape Town: CSIR, Provincial Government of the Western Cape, Department of Environmental Affairs & Development. A WWW publication accessed in 2012 at: http://www.capegateway.gov.za/Text/2005/10/5_deadp_visual_guideline_june05.pdf

OLD, 2003. National Environment Protection (Ambient Air Quality) Measure. July. Prepared by the Office of Legislative Drafting, Attorney-General's Department, Canberra.

Ormeling, F. J. 1957. The Timor problem: a geographical interpretation of an underdeveloped island. Groningen, Wolters.

PDR and RSD, 2005. Gender and Nation Building in Timor-Leste: Country Gender Assessment. A WWW publication accessed in February 2012 at: http://www.adb.org/documents/reports/country-gender-assessments/cga-timor-leste.pdf. Prepared by the Pacific Regional Department and Regional and Sustainable Development Department (Asian Development Bank), and East and South East Asia Regional Office (United Nations Development Fund for Women).

Pickering and Whitmarsh, 1997. Artificial reefs and fisheries exploitation: A review of the attraction versus production debate, the influence of design and its significance for policy. Fisheries Research: Volume 31, Pages 39 to 59. Prepared by Pickering H. and Whitmarsh D.

Pondella *et al.,* 2002. Fish production of a temperate artificial reef based on the density of embiotocids. ICES Journal of Marine Science. Volume 59, Pages 88 to 93. Prepared by Pondella, D., Stephens, J., Craig, M.

RDTL and Ministry of Finance, 2010. Timor-Leste Census Report 2010. Prepared by the Democratic Republic of Timor-Leste and the Ministry of Finance.

RDTL, 2011a. Base Law on Environment. Explanatory Memorandum. Draft. Prepared by the Democratic Republic of Timor-Leste.

RDTL, 2011b. Spatial Design Planning for Southern Coast of Timor-Leste. Prepared by the Democratic Republic of Timor-Leste.

Roberts *et al.*, 2010. Impacts of desalination plant discharges on the marine environment: A critical review of published studies. In Press. Prepared by Roberts, D.A., Johnston, E.L. and Knott, N.A.

RPS, 2009. Effects of a desalination plant discharge on the marine environment of Barrow Island. Prepared by RPS Environment and Planning Pty Ltd for Chevron Australia Pty Ltd.

Sandlund *et al.,* 2001. Assessing Environmental Needs and Priorities in East Timor: Issues and Priorities. UNOPS report. Prepared by Odd Terje Sandlund, Ian Bryceson, Demetrio de Carvalho, Narve Rio, Joana da Silva and Maria Isabel Silva.

Sandlund, O., I. Bryceson, et al., 2001. Assessing Environmental Needs and Priorities in East Timor: Issues and Priorities. UNOPS report.

SERN, Personal Communication, 2012. Continuous meteorological data June to November 2011 - Automated Weather Station: Beaco. Accessed in 2012.

SKM, 2001. Sunrise Gas Project Draft Environmental Impact Statement for Woodside Energy Ltd, Sinclair Knight Merz, Perth, Australia.

Tularam and Ilahee, 2007. Environmental concerns of desalinating sea water using reverse osmosis. Journal of Environmental Monitoring: Pages 805 to 813. Prepared by Tularam, G.A. and Ilahee, M.

UK, 1994. Institute of Highway Engineers (IHT) Guidelines for Traffic Impact Assessment.

US EPA, 2009. AP-42 5th Edition: Compilation of air pollutant emission factors. Prepared by the US Environmental Protection Agency.

US EPA, 2010. Air Toxics chronic inhalation dose response values. April. Prepared by the United States Environmental Protection Authority.

US EPA, 2011. Green Book (40 CFR Part 50) - National primary and secondary ambient air quality standards. Prepared by the United States Environmental Protection Authority.

van Welson *et al.,* 2005. Plant distribution patterns and plant tectonics in Melesia. Biol. Skr. 55: 199-217. Prepared by van Welson, P.C., Ferry Slik, J.W., and Alahuhta, J.

WA EPA, 2007a. Guidance for the Assessment of Environmental Factors No. 8 - Environmental Noise (Draft). May. Prepared by the Western Australian Environmental Protection Authority.

WA EPA, 2007b. State of the Environment Report, Western Australia 2007. A WWW publication accessed in February 2012 at http://www.soe.wa.gov.au/report/marine.html. Environmental Protection Authority, Western Australia.

Walling and Fang, 2003. Recent trends in the suspended sediment loads of the world's rivers. Global and Planetary Change, 39, Pages 111 to 126. Prepared by Walling, D.E. and Fang, D.

Wells *et al.,* 2009. Introduced Marine Species in Western Australia. Department of Fisheries, Perth, Western Australia. Prepared by Wells, FE. McDonald, JI and Huisman, JM.

WHO, 2005. WHO Air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulfur dioxide - Global update 2005 - Summary of risk assessment. Prepared by the World Health Organization.

WHO, 2006. Health impact of PM10 and ozone in 13 Italian cities. Prepared by M. Martuzzi, F. Mitis, I. Iavarone, and M. Serinelli.

World Bank, 1998. Greenhouse Gas Assessment Handbook – A Practical Guidance Document for the Assessment of Project-level Greenhouse Gas Emissions. September. Prepared by the World Bank (Environmentally and Socially Sustainable Development).

World Bank, 2009. Timor-Leste: Country Environmental Analysis. July. Prepared by Sustainable Development Department East Asia and Pacific Region World Bank.