

ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT
(ESIA)
FOR ARUNDO DONAX RENEWABLE BIOMASS PROJECT
FOR BELIZE

FINAL DRAFT

Prepared for

CARIBBEAN COMMUNITY CLIMATE CHANGE CENTRE

Second Floor, Lawrence Nicholas Building,

Ring Road, Belmopan

BELIZE

Tel.: 501-822-1094, 822-1104

By

WILDERNESS GROUP CONSULTING

CONTRACT# 09/2018/GCF/BELIZE/CCCCC

April 2020

Copyright © 2020 by Caribbean Community Climate Change Centre
Published by Caribbean Community Climate Change Centre, Belmopan, Belize

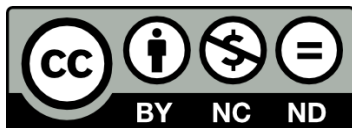
Digital Edition (October 2020)
Printed Edition (October 2020)

This work is licensed under a Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International (CC BY-NC-ND 4.0) and may be downloaded and shared as long as the Centre is credited. No use of this publication may be made for resale or for any other commercial purpose whatsoever. The Caribbean Community Climate Change Centre (CCCCC) would appreciate a copy of any publication that uses this report as a source. The views and interpretations in this document are those of the authors and do not necessarily reflect the views of the CCCCC, its Board of Executive Directors, or the governments they represent.

Caribbean Community Climate Change Centre, Ring Road, P.O. Box 563, Belmopan, Belize

Visit our website at <http://www.caribbeanclimate.bz>

ISBN-13 978-976-8269-59-1 (paperback)
ISBN-13 978-976-8269-60-7 (pdf)



ACRONYMS AND ABBREVIATIONS

ADI	Area of Direct Influence
AII	Area of Indirect Influence
ASL	Above Sea Level
BEL	Belize Electricity Limited
CCCCC/ 5Cs	Caribbean Community Climate Change Centre
COP	Convention of Parties
CSO	Central Statistical Officer
DOE	Department of Environment
ESIA	Environmental and Social Impact Assessment
ESMP	Environmental and Social Management Plan
EMP	Environmental Management Plan
FD	Forest Department
GoB	Government of Belize
GHG	Greenhouse Gases
ft	feet
in.	Inches
kva	kilovolt-amps
kw	kilowatt
kWh	Kilowatt Hour
kPa	kilopascal
LPG	liquid petroleum
Ltd.	Limited
m	meters or metres
mi	mile
OSHP	Occupational Health and Safety Plan
Pb	Lead
PPE	Personal Protective Equipment

Ppb	part per billion
SWaMA	Solid Waste Management Authority
TNC	Too numerous to count
UNFCC	United Nations Framework Convention on Climate Change
Zn	Zinc
LIC	Land Information Centre
MDGs	Millennium Development Goals
MNRE	Ministry of Natural Resources and the Environment
UNFCCC	United Nations Framework Convention on Climate Change
PM	Particulate Matter

Table of Contents

Table of Contents	4
List of Figures	8
List of Tables.....	10
1.0 Programme Description, Diagnosis and Characterization	19
1.1 Program Description	19
1.1.1 Introduction	19
1.1.2Project Description	19
1.1.3 Regional Context of the Project.....	21
1.1.4 The Local Relevance of the Project.....	22
1.1.5 Project Investment Activities.....	24
1.1.6 Project Infrastructure	25
1.2 Location.....	31
1.3 Environmental Characterization.....	36
1.3.1 Land Characteristics and Use	36
1.3.2Landscape Character.....	61
1.3.3 Air Quality	67
1.3.4 Existing Noise Levels.....	96
1.3.5 Potential Impacts and Mitigation Control – Air Quality	99
1.3.6 Geology and Soils.....	101
1.3.7 Natural and Man-Made Hazards.....	112
1.3.8 Hazards from Potential Natural Disasters	116
1.3.9 Description of Prevailing Community Waste Management Practices	120
1.3.10 Water and Hydrology	127
1.3.11 Biodiversity	159
1.3.12 Habitats	159
1.3.12 Flora	162
1.3.13 Fauna	182
1.3.14 Endangered or Threatened Species.....	183
1.3.15 Protected Areas	184

1.3.16 Summary of Potential Impacts and Mitigation and Control Measures – Biodiversity	186
1.3.17 Traffic &Infrastructure	188
1.3.18 Summary of Potential Impacts to Biodiversity and Mitigation/Compensation Measures.....	189
Literature Cited	201
2.0 SOCIAL CHARACTERIZATION.....	202
2.1 Overview	202
2.1 Towns and Communities near the Project Area	204
2.1.1 Community setting.....	204
2.1.2 Area/Zone of Influence around Project Area	205
2.1.3 Socioeconomic Characterization of Communities	207
2.2 Sources of Livelihood	217
2.3 Land Tenure and Titling.....	219
2.4 Migration and Settlement Patterns	223
2.5 Health and Education	225
2.5.1 Education	225
2.5.2Health.....	226
2.6 Archaeological/Cultural Sites and Monuments.....	227
2.6.1 Introduction	227
2.6.2 Review of Archaeological Data.....	231
2.6.3 Survey and Research Methodology	233
2.6.4 Survey	234
2.6.5 Results of the Survey	235
2.6.6 Conclusion and Recommendations	237
2.7 Services and Infrastructure.....	237
2.8 Access to Basic Health Care	239
2.9 Social Organizations and Dynamics	239
2.10 Access to Infrastructure and Roads.....	240
2.10.1 Transportation Facilities	240
2.10.2 Communication and Services	240
2.11 Vulnerable Populations	240
2.12 Indigenous Population	241

2.13 Communities and Resettlement.....	241
2.1.4 Summary of Potential Social and cultural Impacts and proposed Mitigation and Compensation.....	241
2.1.4.1 Preamble	241
2.1.4.2 Stakeholders Concerns and Issues	242
Literature Cited	247
3.0 Legal and Institutional Framework.....	248
3.1 Legal and Institutional Norms and Licensing Requirements	248
3.1.2 Regulations for the Agriculture and Industrial Sectors	248
3.2 Local Regulations Applicable to the Project.....	249
3.3 Environmental and Social Safeguard Policies, Standards and Guidelines.....	256
3.3.1 Green Climate Fund.....	256
3.2.2 IDB Environmental and Social Safeguards and policies.....	263
3.3.4 The Caribbean Development Bank.....	271
3.4 International and Regional Legislation and Policies	274
3.4.1 World Health Organization	274
3.4.2 Nationally Determined Contributions and Sustainable Development Goals	276
3.4. SDGs and H2030	276
3.5 Public/Civic Participation and Consultation	276
3.6 Stakeholders	277
Literature Cited	278
4.0 TASK 3: ASSESSMENT OF THE ENVIRONMENTAL AND SOCIAL IMPACTS OF THE PROJECT/INVESTMENT	279
4.1 PS1: Assessment and management of environmental and social risks and impacts	280
4.1.1 Identification of Environmental and Social Risks and Impacts	281
4.1.2 Mitigation Hierarchy	281
4.1.3 Assessment of Alternatives	281
4.1.4 Environmental and Social Management System	282
4.1.5 Emergency Response.....	283
4.1.6 Stakeholder Engagement and Grievance Mechanism	283
4.1.7 Social Impacts of Project.....	284
4.2 PS2: Labor and working conditions	287
4.2.1 The Working Environment.....	288

4.2.2 Occupational Health and Safety Risks	288
4.3 PS3: Resource efficiency and pollution prevention	290
4.3.1 Avoid Minimize or Reduce Project Related Pollution	290
4.3.2 Sustainable use of Resources, Including Energy and Water	293
4.3.3 Reduction of Project Related GHGs.....	293
4.4 PS 4 Community Health, Safety and Security	297
4.5 PS 6 Biodiversity Conservation and Sustainable Management of Living Natural Resources	301
4.6 PS 7 Indigenous Peoples	305
4.7 PS 8 Cultural Heritage.....	306
5.0 Assessment of Alternatives	313
5.1 Introduction	313
5.2 Methodology for Evaluation of Alternatives	314
5.2.1 Technical and Economic Analysis	314
5.2.2 Results of the Analyses.....	320
5.2.3 Environmental Analysis	321
5.3 Alternatives for Sustainable Opportunities (end products)	325
5.3.1 Potential Use as Upgraded Solid Biofuels (Pellets)	325
5.3.2 Bio-methane options.....	332
5.3.3 Bioethanol Options.....	337
5.4 Selection of Alternative Cultivation Sites.....	341
5.4.1 Avoidance of Incompatible Sites.....	341
5.4.2 Mitigation Planning	343
5.5 Conclusions and Recommendations.....	343
Literature Cited:	345
6.0 Disaster Risk Assessment and Disaster Risk Management Plan	349
6.1 Disaster Risk Assessment and Disaster Risk Management Plan	349
6.1.1 Overview of Regional Disaster Risks.....	349
6.1.2 Overview of Natural Disaster Risks	350
6.1.3 Natural Disaster Risks in Belize	351
6.1.4 Natural and Man-Made Hazards.....	354
6.1.5 Hazards from Natural Disasters.....	354
6.1.6 Risks and Vulnerability to Hurricanes and Tropical Storms	355

6.1.7 Flood Risks	357
6.1.8 Forest Fire Risks	357
6.1.9 Risk of Seismicity and Seismic Hazard.....	358
6.10 Risk of Diseases and Pandemics.....	359
6.2 Man Made Disaster Risks	360
6.2.1 Risk of Chemical Spills	360
6.2.2 Risk for Accidents	360
6.2.3 Phytosanitary Risks including Crop Management	361
6.3 Ranking of Risks and Severity of Consequences.....	361
6.4 Phytosanitary and other Crop Management Risk Assessment.....	363
6.4.1 Preface	363
6.4.2 Status in Belize	366
6.4.3 Habitat	368
6.4.4 Biology and Ecology	368
6.4.5 Impact Summary.....	372
6.4.6 Economic Impact and Environmental Impact	373
6.4.7 Social Impact	374
6.4.8 Prevention and Control	376
Literature Cited	380

List of Figures

<i>Figure 1.1: Proposed Site Plan of Structures.....</i>	<i>29</i>
<i>Figure 1.2: Experimental design Split-pilot for Arundo donax project.....</i>	<i>30</i>
<i>Figure 1.3: Map showing location of project site.....</i>	<i>31</i>
<i>Figure 1.4: Project Location</i>	<i>34</i>
<i>Figure 1.5: Location of Project sites and access roads.....</i>	<i>35</i>
<i>Figure 1.6: Map Illustrating Project Zone of Influence</i>	<i>37</i>
<i>Figure 1.7: Contour Map of Project Sites</i>	<i>41</i>
<i>Figure 1.8: Contour Lines Locations.....</i>	<i>43</i>
<i>Figure 1.9: Contour Profile Lines</i>	<i>44</i>
<i>Figure 1.10: Recommended Infrastructure Site.....</i>	<i>45</i>
<i>Figure 1.11: Arundo Donax Cultivation site Contour.....</i>	<i>46</i>
<i>Figure 1.12: 100 acre Bore Hole Locations.....</i>	<i>48</i>

Figure 1.13: Borehole Profile.....	51
Figure 1.14: 100-acre Plot Sampling Locations	52
Figure 1.15: Sampling Locations for 400-acre plot	56
Figure 1.16: Transportation Route.....	65
Figure 1.17: Monthly rainfall for BSI/ASR, Libertad, and La Milpa (Rio Bravo).	69
Figure 1.18: Mean Annual Rainfall (mm) in Belize	70
Figure 1.19: Mean monthly rainfall for BSI-ASR, Libertad and Rio Bravo.....	71
Figure 1.20: Annual mean wind rose for Philip Goldson International Airport.....	72
Figure 1.21: Summary of the Regional Climate Model Projection for Belize.....	76
Figure 1.22: Some relative changes in Caribbean Climate for Global Warming.....	77
Figure 1.23: Graph Illustrating Levels of Respirable Dust – Oct 2019.....	92
Figure 1.24: Map Showing Location of Air and Noise Testing PG Highway	93
Figure 1.25: Maya Bloc and Chortis Block in Relation to the Motagua Fault.	102
Figure 1.26: Geology Map of Belize.....	105
Figure 1.27: Geology Map of Belize Legend.....	106
Figure 1.28: Map Showing Geology of Project Region	107
Figure 1.29: Soil Map Depicting <i>Arundo donax</i> project site.	110
Figure 1.30: Map showing projected magnitude of earthquake as a result of tectonic activity.	113
Figure 1.31: Peak Ground Acceleration (m/s^3) of May 2009 Earthquake	115
Figure 1.32: USGS Intensity Map of May 2009 Earthquake offshore Honduras	115
Figure 1.33: Waste Composition in Northern Corridor-Belize.....	123
Figure 1.34: Projected Annual Solid Waste Generation Scenarios for San Lazaro/Trinidad. .	125
Figure 1.35: New River Watershed Drainage Area	128
Figure 1.36: Rio Hondo Watershed in Belize.....	131
Figure 1.37: Historic maximum water levels recorded on the Rio Hondo at Blue Creek and Douglas	133
Figure 1.38: Watersheds and land use	134
Figure 1.39: Groundwater provinces in Belize	135
Figure 1.40: Salinity of Water Bodies.	146
Figure 1.41: Hardness Results	149
Figure 1.42: Alkalinity Results	150
Figure 1.43: <i>E. coli</i> Results	152
Figure 1.44: Map Illustrating Location of Sampling Sites.....	154
Figure 1.45: Tropical Evergreen Seasonal Broadleaf low land Swamp Forest.....	160
Figure 1.48: Location of Transects	163
Figure 1.49: Vegetation Types and Location	165
Figure 1.50 Results of Botanical Data.	166
Figure 1.51: Total Rating of Open Oak/Grassland.....	168
Figure 1.52: Lowland Savannah Dense Oak.....	171
Figure 1.53: Total Rating of Lowland Broadleaf Moist Forest.....	175
Figure 1.54: Total Rating of lowland Broadleaf Scrub Forest	177
Figure 1.55: Total Ratings of Lowland Broadleaf Forest-Bajo	180
Figure 1.56: <i>Arundo donax</i> Test Sites in Relation to Protected Areas.....	185
Figure 1.57: Location of PGH and Yo Creek Roads in relation to project site.	188
Figure 2.1: Map Showing Location of Project Site	204
Figure 2.2: Map Illustrating Project Zone of Influence	205

<i>Figure 2.3: Belize 2018 Population Distribution by District.</i>	210
<i>Figure 2.4: Population of Communities of Communities in Zone of Influence</i>	212
<i>Figure 2.5: Population percentage of Communities in Zone of Influence</i>	212
<i>Figure 2.6: Ethnic Groups Representation within Zone of Influence.</i>	214
<i>Figure 2.7: Belize Labor Force Distribution by Highest Level of Education.</i>	217
<i>Figure 2.8: Employment vs. Unemployment in Belize.</i>	218
<i>Figure 2.9: Orange Walk Dist. Labor Force by Level of Education.</i>	218
<i>Figure 2.10: Orange Walk District Unemployment Among Age Groups.</i>	218
<i>Figure 2.11: Type of Land Occupancy.</i>	219
<i>Figure 2.12: Type of Dwelling Occupancy.</i>	219
<i>Figure 2.13: Agriculture and Non-agriculture Population by Percent.</i>	222
<i>Figure 2.14: Agriculture Engagement by Percent of Communities in the ADI.</i>	222
<i>Figure 2.15: Labor distributions by sex.</i>	223
<i>Figure 2.16: Education within Zone of Influence.</i>	225
<i>Figure 2.17: Map of the Development area in Northern Belize.</i>	228
<i>Figure 2.18: Close-up of the Development Area.</i>	229
<i>Figure 2.19: Map of large ancient centres close to the proposed development area.</i>	230
<i>Figure 2.20: Map of Belize and Selected Archaeological Sites.</i>	232
<i>Figure 2.21: Map of development area showing the surveyed and unsurveyed areas.</i>	233
<i>Figure 2.22: Map of proposed development area showing the two mounds in the properties.</i>	235
<i>Figure 5.1: Comparison of peak dry matter yields of field grown.</i>	318
<i>Figure 5.2: Biopropane: key Results</i>	333
<i>Figure 5.3: Principal Process Technologies in Biopropane Production.</i>	334
<i>Figure 5.4: Map Showing Distribution of Arundo donax Vegetation within Orange Walk.</i>	342
<i>Figure 6.1: Summary of the Regional Climate Model Projection for Belize.</i>	353
<i>Figure 6.2: Some relative changes in Caribbean Climate for Global Warming.</i>	354
<i>Figure 6.3: Peak Ground Acceleration (m/s³) of May 2009 Earthquake</i>	359
<i>Figure 6.4: USGS Intensity Map of May 2009 Earthquake offshore Honduras</i>	359
<i>Figure 6.5: Arundo Supply and utilization chain</i>	365
<i>Figure 6.6: Distribution of Arundo in Orange Walk District</i>	367

List of Tables

<i>Table 1.1: Estimated Budget for Arundo Donax Project. Source: CCCCC/ERCAP 2015 Project Proposal.</i>	25
<i>Table 1.2: 100-acre Plot Sampling Locations.</i>	53
<i>Table 1.3: Summary Results of Sample 3-A and 3-B- 100 Acre Lots.</i>	53
<i>Table 1.4 Sampling Locations for 400-acre plot.</i>	57
<i>Table 1.5: Summary Results of Samples 1-1 & 10-10 at 400 Acre Lot.</i>	58
<i>Table 1.6: Number of Employees and Positions to be Held.</i>	66
<i>Table 1.7: Potential Impacts of Existing Land Use and Land Use Character Changes.</i>	67
<i>Table 1.8 Summary of local weather data collected from August 21 to 26 2019.</i>	74
<i>Table 1.9 Concentration of air Contaminants</i>	81
<i>Table 1.10: Weather Data for Air Testing Sites at Zone 1- Oct 2019.</i>	83

<i>Table 1.11: Results for Air Testing at Zone 1- Oct 2019.....</i>	<i>84</i>
<i>Table 1.12: Weather Data at Zone 2 – October 2019.</i>	<i>85</i>
<i>Table 1.13: Results of Air Testing at Zone 2 – Oct 2019.....</i>	<i>86</i>
<i>Table 1.14: Weather Data at Zone 1 – March 2020.....</i>	<i>87</i>
<i>Table 1.15: Results of Air Testing at Zone 1 March 2020.....</i>	<i>88</i>
<i>Table 1.16: Weather Data at Zone 2 – March 2020.....</i>	<i>89</i>
<i>Table 1.17: Results of Air Testing at Zone 2 March 2020.....</i>	<i>90</i>
<i>Table 1.18: Results of Localized Test for Emissions of Arundo donax Biomass Burning.....</i>	<i>95</i>
<i>Table 1.19: Ambient noise levels taken at various sites around the project area</i>	<i>97</i>
<i>Table 1.20: Peak Ambient Noise Levels Reported at the Project Area.</i>	<i>98</i>
<i>Table 1.21: Decibel Readings Near the Tower Hill Factory.....</i>	<i>98</i>
<i>Table 1.22 Summary of Environmental Impacts and Mitigation and Compensation Measures for Air Quality Activities</i>	<i>99</i>
<i>Table 1.23: Northern Coastal Pain Classification</i>	<i>109</i>
<i>Table 1.24: Land classification symbols and values used by King and others.....</i>	<i>111</i>
<i>Table 1.25: Summary of Activities, Potential Impacts and Mitigation Measures - Solid Waste.....</i>	<i>126</i>
<i>Table 1.26: Historic Mean Monthly Water Stage in the New River at Tower Hill.....</i>	<i>129</i>
<i>Table 1.27 Monthly average, maximum and minimum river levels for the Rio Hondo at Douglas Village.....</i>	<i>132</i>
<i>Table 1.28: Acceptable Limits for BWSL, WHO and DOE Guidelines</i>	<i>137</i>
<i>Table 1.29: Sampling Sites, GPS Coordinates and Description.</i>	<i>143</i>
<i>Table 1.30: In-situ data sampled in February 2019</i>	<i>144</i>
<i>Table 1.31: Second Set of In-situ data sampled in September 2019.....</i>	<i>145</i>
<i>Table 1.32: Results of Laboratory Analysis Sampled in May 2019.....</i>	<i>147</i>
<i>Table 1.33: Results of Laboratory Analysis Sampled in September 2019.....</i>	<i>148</i>
<i>Table 1.34: Community Wells.....</i>	<i>153</i>
<i>Table 1.35: Water harvesting catchment type</i>	<i>155</i>
<i>Table 1.36: Estimate of available water in and around the Project Site.....</i>	<i>156</i>
<i>Table 1.37: Maximum Fresh Water Requirement for VoP Farms Ltd. Expansion</i>	<i>157</i>
<i>Table 1.38 Summary of Activities Degree of Impacts and Mitigation and Control Measures for Water Activities.</i>	<i>158</i>
<i>Table 1.39: Area Covered per Ecosystem Type.....</i>	<i>164</i>
<i>Table 1.40: Botanical Data.....</i>	<i>167</i>
<i>Table 1.41: Records of Wildlife Species</i>	<i>183</i>
<i>Table 1.42: Most Recorded Species.....</i>	<i>183</i>
<i>Table 1.43 Summary of Actions, degree of Impact and Proposed Mitigation/control measures for Biodiversity Activities.</i>	<i>187</i>
<i>Table 1.44: Summary of Activities, Impacts and Mitigation and Control Measures.</i>	<i>189</i>
<i>Table 1.45: List of Trees Recorded.....</i>	<i>191</i>
<i>Table 1.46: Average DBH (in cm) per Species and Vegetation Type.....</i>	<i>193</i>
<i>Table 1.47: Average Height (in metres) of Main Stem per Species and Vegetation Type.....</i>	<i>194</i>
<i>Table 1.48: Bird Data</i>	<i>196</i>
<i>Table 2.1: Location of communities and approximate distance to the project site</i>	<i>206</i>
<i>Table 2.2: Stakeholder Groups</i>	<i>208</i>
<i>Table 2.3: Population Estimates by Major Administrative Areas; 2014 - 2018</i>	<i>209</i>
<i>Table 2.4: Population, household and household size of nearby communities.</i>	<i>213</i>

<i>Table 2.5: Household by type of Land Occupancy.</i>	220
<i>Table 2.6: Households by Type of Dwelling Occupancy.</i>	221
<i>Table 2.7: Social Infrastructure in Zone 1.</i>	226
<i>Table 2.8: Households by Major Administrative Area and Main Source of Lightning: 2017-2018.</i>	238
<i>Table 2.9 Activitis, Potential Impacts and Proposed Mitigation and Compensation.</i>	245
<i>Table 3.1: Environmental Licenses and Permits Required by the A. Donax Project.</i>	253
<i>Table 3.2 Required standards for discharge of effluent into Class I waters.</i>	255
<i>Table 3.3: IFC Performance Standards on Environmental and Social Sustainability.</i>	268
<i>Table 4.1 below contains the criteria for rating the impacts of the project.</i>	280
<i>Table 4.2 Land Clearing Impacts.</i>	282
<i>Table 4.3 Social impacts.</i>	284
<i>Table 4.4 Residual health and safety impacts.</i>	289
<i>Table 4.5 Residual air quality impacts.</i>	292
<i>Table 4.6 Surface water impacts.</i>	295
<i>Table 4.7 Ground water impacts.</i>	296
<i>Table 4.8 Waste impacts.</i>	297
<i>Table 4.9 Residual health and safety impacts.</i>	298
<i>Table 4.10 Transportation impacts.</i>	301
<i>Table 4.11 Potential impacts to biodiversity.</i>	305
<i>Table 4.12 Summary of Mitigation Measures.</i>	307
<i>Table 4.13: Monitoring program for the Project.</i>	312
<i>Table 5.1 Summary of studies on biomass potential of Arundo donax.</i>	315
<i>Table 5.2: Comparison of Technical, Economic and Environmental Parameters for Alternatives.</i>	322
<i>Table 5.3: A comparison of the Arterran pellets highlighting the differences.</i>	326
<i>Table 5.4: Standard for Wood Pellets.</i>	328
<i>Table 5.5 Comparison of Currently Available Water-Resitant Biomass Fuels.</i>	330
<i>Table 5.6 Summary of Activities Degree of Impacts and Mitigation and Control Measures for Pelletization Activities.</i>	331
<i>Table 5.7 Summary of Activities Degree of Impacts and Mitigation and Control Measures for biopropane Activities.</i>	335
<i>Table 5.8 Summary of Activities Degree of Impacts and Mitigation and Control Measures for bioethanol Activities.</i>	340
<i>Table 6.1: Matrix using colour coding.</i>	361
<i>Table 6.2: Ranking of Risks and Severity of the Consequences.</i>	362
<i>Table 6.3: Country Report of presence of Arundo Donax in Belize.</i>	367
<i>Table 6.4: Natural enemies of Arundo donax.</i>	369
<i>Table 6.5: Plant Trade.</i>	371
<i>Table 6.6: Threatened Species example</i>	374
<i>Table 6.7: Risk and Impact Factors.</i>	375
<i>Table 6.8: Summary of Land Potential (Agricultural Value)</i>	379

Executive Summary

Renewable Energy (Biomass) supply

While Belize has local fossil fuel resources, in 2017, 48.5% of the country's energy supply was imported mostly in the form of secondary energy either as refined petroleum products or as electricity. In 2017, 73.2% of domestic energy supplied was obtained from local resources such as biomass (firewood and sugar cane bagasse), hydropower, and local fossil fuel resources. Petroleum products such as liquefied petroleum gas (LPG), gasoline, kerosene, and diesel oil accounted for 96% of the total energy imported in 2017, whereas electricity accounted for 4%.

Belize's electricity is supplied mainly through a 115-kV transmission line that covers the entire northern and western sections of the country, and is interconnected with Mexico, currently the most reliable source of energy. The southern areas of the country are partly covered by a 69 kV transmission line. Belize Electricity Limited (BEL) is the primary distributor of electricity in Belize, serving a customer base of approximately 97,714 accounts in 2018. In 2017, 36.1% of the electricity generation output was purchased on the spot market from Mexico's Comisión Federal de Energía (CFE). Previously, CFE supplied BEL up to 15 MW of firm capacity and up to 40 MW on an economic basis, but CFE cancelled its firm power agreement with BEL in 2009. In 2017, the remaining 63.9% of electricity was supplied as follows: Belize Electric Company (BECOL, 39%), Belize Co-Generation Energy Limited (BELCOGEN, 10%), Santander Sugar Energy 2.8%, Hydro Maya (2.3%), BEL's own diesel generation capacity (.99%), and the Blair Athol Power Company Limited (BAPCOL, 3.05%) on grid and BEL produced 1.5% and Farmers Light Plant 4.26% off-grid (Source: Belize Energy Balance 2017). As population growth was 1.9% per annum (SIB, 2019); studies estimate that electricity demand will grow by about 4% per annum in the coming years (BEL Report 2017), in the absence of a demand-side management program or strategy. Belize's peak energy demand reached 84.3 MW in 2014 and it is expected to grow with BEL servicing 98% of the population by 2020.

Installed capacity of electricity production was approximately 172 MW in 2016, which is enough to cover peak demand in the near term. Hydroelectric capacity is 54 MW, of which 21 MW come from run-of-the river or low storage capacity hydro plants. BAPCOL's generating capacity is approximately 10 MW. BEL owns and operates 28.3 MW of diesel-fired gas turbines. BELCOGEN and Santander Sugar Energy generate electricity by burning bagasse and have production capacity of 29.5 MW. This capacity is only available when there is an available bagasse resource from sugar processing. BEL's supply from CFE is constrained by a 60MW maximum transfer capacity of the 115 KV transmission line linking the two national systems. Moreover, BEL is currently unable to take more than 50 MW of power from Mexico without experiencing voltage regulation problems.

The *Arundo donax* project

The Caribbean Community Climate Change Centre (CCCCC) with support from the Green Climate Fund (GCF) has embarked on the project “Arundo Donax Renewable Bio-Mass Fuel for Belize”. The CCCCC has indicated that the project goal is to investigate and demonstrate the efficacy of *Arundo donax* as a renewable energy source, as part of its Energy Resilience for Climate Adaptation Project (ERCAP), using Belize as a pilot site. The project intends to utilize a fast-growing perennial rhizomatous grass (*A. donax* or Wild Cane) for cultivation on marginal lands in Belize.

Belize’s dependency on imported energy sources poses a concern regarding the country’s security of energy supply. Measures have been taken to reduce the country’s dependence on imported electricity, by enhancing the country’s hydropower capacity and other renewable energy sources.

Project purpose:

The project is conceived as part of a wider regional initiative towards the seeking of resilience measures against the impacts of the global phenomenon of climate change. The proposed concept is also consistent with the GoB goal of expanding the utilization of biomass to meet some of the country’s energy needs and achieve the dual aim of reducing the country’s carbon footprint and adapting to climate change impacts. In pursuit of that overarching objective the project aims to initially introduce a new high energy crop as a supplementary fuel for generation of electricity in Belize. Based on the outcome of the preliminary exercises, cultivation on a commercial basis for ongoing use and for expanded use elsewhere could be pursued.

A successful fossil fuel substitution project, although partial in scope, will represent significant progress towards Belize achieving its goals of becoming energy self-sufficient. Developing a commercial renewable enterprise based on the use of *Arundo donax* can bring significant benefits to Belize. The immediate benefits would be to stabilize power production from BELCOGEN, provide clean sustainable power throughout the year, create new jobs in the cultivation of *A. donax*, save foreign exchange by displacing imported Mexican power, increase energy security, reduce Belize’s greenhouse gas emissions and reduce BEL’s cost of power.

A successful Project represents significant progress towards realizing Belize’s goals of:

- i. reducing its carbon footprint by 2022
- ii. having 80% of its energy for household and industrial uses generated from renewable energy sources, while
- iii. leverage existing infrastructure to provide immediate and direct benefits in response to the national energy challenges.

Fully developing the potential of *Arundo donax* to provide a renewable source of fuel to drive the national economy can contribute significant benefits to Belize. The benefits of investing would be to:

- i. increase power production from ASR/BSI BELCOGEN,
- ii. provide clean sustainable and reliable power throughout the year at affordable rates,
- iii. create new jobs in cultivating *A. donax*,
- iv. allow for agricultural activities by farmers being displaced out of sugar production and utilize marginal lands.
- v. replace imported Mexican power,
- vi. increase energy security; and
- vii. contribute towards Belize's energy independence through the reduction of greenhouse gas emissions and the country's cost of power.

Through this project it is estimated that the total tons of CO² equivalent emissions avoided annually would be over 19309 (tCO₂). The number of direct beneficiaries is estimated at over 5,000 or approximately 2% of the total population. The indirect beneficiaries would be the entire country through lower cost per KWh of electricity.

Introduction to the environmental and social assessment and ESMP

The Centre has also embarked to supervise the preparation of the "Environmental and Social Impact Assessment (ESIA) and Preparation of an Environmental and Social Management Plan (ESMP).

This ESMP is being prepared to outline key potential impacts and changes to the environment; and to propose actions to mitigate and address these issues utilizing practical and concrete approaches that can be verified with measurable indicators and a realistic time scale by participating partners of the project.

PERFORMANCE STANDARDS ON ENVIRONMENTAL AND SOCIAL SUSTAINABILITY

Performance Standard 1: ASSESSMENT AND MANAGEMENT OF ENVIRONMENTAL AND SOCIAL RISKS AND IMPACTS. Underscores the importance of identifying E&S risks and impacts, and managing E&S performance throughout the life of a project.

Performance Standard 2: LABOR AND WORKING CONDITIONS. Recognizes that the pursuit of economic growth through employment creation and income generation should be balanced with protection of basic rights for workers.

Performance Standard 3: RESOURCE EFFICIENCY AND POLLUTION PREVENTION Recognizes that increased industrial activity and urbanization often generate higher levels of air, water and land pollution, and that there are efficiency opportunities.

Performance Standard 4: COMMUNITY HEALTH, SAFETY AND SECURITY Recognizes that projects can bring benefits to communities, but can also increase potential exposure to risks and impacts from incidents, structural failures, and hazardous materials.

Performance Standard 5: LAND ACQUISITION AND INVOLUNTARY RESETTLEMENT Applies to physical or economic displacement resulting from land transactions such as expropriation or negotiated settlements.

Performance Standard 6: BIODIVERSITY CONSERVATION AND SUSTAINABLE MANAGEMENT OF LIVING NATURAL RESOURCES Promotes the protection of biodiversity and the sustainable management and use of natural resources.

Performance Standard 7: INDIGENOUS PEOPLES Aims to ensure that the development process fosters full respect for Indigenous Peoples.

Performance Standard 8: CULTURAL HERITAGE Aims to protect cultural heritage from adverse impacts of project activities and support its preservation.

Summary of the impact assessment and proposed mitigation and compensation measures

Reference	PS	Activity	Responsible	Funding	Counterpart
2.3.1	PS1	Planning, Implementation, Enforcement and Reporting	Project Team Leader/Engineer/Staff/Permitting agencies/consultants		
2.3.2.1	PS8	Archaeological Assessment and Preparation for Construction	Project Team Leader/Archaeologist		
2.3.2.2	PS1	Land Preparation for Cultivation and Construction	Project Team Leader/engineer/workers/partners		
2.3.2.3	PS3	Basic Guidelines	Project Team Leader/consultant/workers/		

		Established for Mitigation Against Air Quality Changes and Noise Pollution	partners
2.3.2.4	PS2	Establish Acceptable Working Environment for Employees and Community	Project Team Leader/project staff/social worker
3.1.1.1	PS6	The Cultivation of <i>A. donax</i> with subsequent land use change	Project Team Leader/agriculture expert/workers/partners
3.1.2.1	PS3	The Protection of Water Resources Against Pollution and Hydrological Changes	Project Team Leader/workers/partners
3.1.3.1	PS3	Guidelines Established for Mitigation Against Air Quality Changes	Project Team Leader/workers/partners
4.1	PS6	Long Term Cultivation Will Impact Biological Species	Project Team Leader/workers/partners

4.2.1	PS4	Develop Social and Community Engagement Plan, Redress Mechanism and Reporting Mechanism	Project Team Leader/workers/partners
4.3.1	PS4	Develop Plan, for Handling, Transportation and Storage of <i>A. donax</i> and Substances/Materials for Project and Solid Waste Produced	Project Team Leader/workers/partners
4.4.1	PS6	Decommissioning and Closure of Cultivation Site and Supporting Infrastructure	Project Team Leader/engineer/workers/partners/authorities

1.0 Programme Description, Diagnosis and Characterization

1.1 Program Description

1.1.1 Introduction

The Caribbean Community Climate Change Centre (CCCCC) with funds from the Green Climate Fund (GCF) has embarked on the project “Arundo Donax Renewable Bio-Mass Fuel for Belize”. Several documents in connection with this project have been prepared, including a feasibility study, a stakeholder analysis, and other relevant documentation. The Centre has entered into contract with Wilderness Group Consulting who has partnered with several local and international experts for the preparation of the “Environmental and Social Impact Assessment (ESIA) and Preparation of an Environmental and Social Management Plan (ESMP) as part of Contract#09/2018 /GCF /Belize/CCCCC”.

The basic objective of the impact assessment is to provide a means to integrate environmental factors that would enhance project planning and execution. The assessment will measure the environmental impacts with a view of preventing adverse environmental impacts while promoting the beneficial effects of the project. The assessment also intends to identify those impacts which are likely to be generated by the implementation and operation of the project and to evaluate, as far as possible, the causes and effects of these impacts and their consequences for the environment and the local community. It also sets a benchmark for those parameters that would be impacted so that their subsequent monitoring would give out indicators on their status, whether there is a decline in quality or there are no changes.

1.1.2 Project Description

The Caribbean Community Climate Change Centre (CCCCC or 5Cs) is a regional center that supports the Caribbean Region in its efforts to address the impacts of climate variability and change. As its Mission states, the CCCCC “will support the people of the Caribbean as they address the impact of climate variability and change on all aspects of economic development through the provision of timely forecasts and analyses of potentially hazardous impacts of both natural and man-induced climatic changes on the environment, and the development of special programs which create opportunities for sustainable development.”

Keeping in line with the Centre’s mission, the Arundo Donax Project was commenced through a series of technical recommendations, and with funding successfully obtained from the Green Climate Fund (GCF). This project is now in its final stage of development, for which an Environmental and Social Impact Assessment inclusive of an Environmental and Social Management Plan (ESMP) are being developed by a consortium of consultants in association with Wilderness Group Consulting.

1.1.4 Purpose of Environmental and Social Impact Assessment (ESIA)

Industrial projects generally involve utilization of natural resources and generation of waste and polluting substances. Depletion of natural resources and discharge of pollutants are likely to affect the environment. However, this project is essential for energy production and energy security in addition to providing opportunities for the nearby farming communities and economic growth of the country. Consequently, there is a need to balance the harmonious developmental activities with the environmental concern. ESIA is one of the tools available to the planners in order for them to achieve the above goal. It is desirable to ensure that the project activity is sustainable. Hence, the environmental consequence must be characterized early in the project cycle and accounted for in the project design. The objective of an ESIA is to foresee the potential environmental and social impacts that would arise out of the proposed development and address them in the project planning and design stage.

The Environmental and Social Assessment (ESIA) and Environmental and Social Management Plan (ESMP), will:

- a) Identify all potential environmental and social impacts of the project and measures to prevent, minimize, mitigate or compensate for adverse environmental and/or social impacts;
- b) assess the legislative and regulatory environment within which the investment will operate;
- c) identify appropriate institutional/organizational arrangements for this renewable energy initiative on a sustainable basis;
- d) survey of the commercial interest from the sugar industry and other pertinent third parties
- e) describe the nature and number of beneficiaries potentially affected by the proposed project
- f) describe opportunities, risk and concerns/issues related to the proposed project.

This project seeks to address that deficiency by seeking to reduce the dependency on a volatile commodity such as fossil fuel but also offers the potential for:

- 1. The development of a new industry both at the community and company levels;
- 2. increased energy security;
- 3. increased adaptive capacity to climate change;
- 4. increasing the country's contribution to the reduction of GHG emissions;
- 5. increased competitiveness through reduction in the cost of energy; and,

6. contributing to improvements in the living standard of the country, as a whole, by providing new jobs.

1.1.3 Regional Context of the Project

Energy produced by living or organisms that were once living is called biomass energy. A variety of biomass plants (including corn and soy residues) are often used for biomass burning. Co-generation of electricity in Belize using sugarcane bagasse as its source of biomass commenced with the formation of the Belize Cogeneration Energy Limited (Belcogen) in 2007 and the subsequent cogeneration. Cogeneration increased with the additional production of energy from another sugar cane processing company, Santander Limited located in the Cayo District, through its subsidiary company, Santander Sugar Energy Ltd, (SS Energy). SS Energy signed its power purchase agreement in 2016 and began its cogeneration operations in 2017.

The ability of biomass for energy to offset fossil fuel carbon emissions as a result of carbon sequestration is believed to have a high potential since it is a cleaner technology with reduced greenhouse gas emissions. The use of biomass for energy generation has regional implications providing the level of success that the project aims to achieve.

As part of its regional mandate, the 5 Cs has taken the initiative to form alliances to develop an experimental biomass energy project through the cultivation of the Wild cane, known as the “*Arundo donax*” species. Through the collaborative efforts of the research institutions CARDI and SIRD, who are liaising with the University of the West Indies in Trinidad to conduct the taxonomic classification of the Belize specimens. This will be done by analysing specimens of the wild cane plant through the DNA sequencing and morphometric analysis. The classification process will begin by the confirmation of already identified sites where the plant is growing in the wild; followed by the collection, storing and transportation to the University, where the scientific analysis of the species will be carried out.

Biomass is considered a renewable energy (Columbia university energy blog). source because its inherent energy comes from the sun and because it can be re-cultivated in a relatively short time. Trees take in carbon dioxide (CO₂), from the atmosphere and convert it into biomass and when they die, the CO₂ is released back into the atmosphere. Whether trees are burnt or whether they decompose naturally, they release the same amount of carbon dioxide into the atmosphere. Hence it is believed that if trees harvested for biomass are replanted as fast as they are burnt, and the new trees take up the carbon produced by the combustion, then the carbon cycle theoretically remains in balance, and no extra carbon is added to the atmospheric balance sheet. Thus, biomass is arguably considered “carbon neutral.” Since nothing offsets the CO₂ that fossil fuel burning produces, replacing fossil fuels with biomass theoretically results in reduced carbon emissions.

Biomass from fast growing crops can reduce carbon dioxide if fast growing crops are grown on marginally productive lands; in this case, the re-growth of the plants offsets the carbon produced by the combustion of the crops.

This, therefore, is the concept for the *Arundo donax* project. The overall aim is to grow a fast-growing species such as the *Arundo donax* in marginal lands such that its cultivation will not compete with agriculture lands but which replace the carbon being lost through fossil fuel. *Arundo donax* being a fast-growing species (reported to have calorific value than bagasse) is expected to enhance the biomass burning at the present Belcogen plant.

1.1.4 The Local Relevance of the Project

Energy costs in Belize are among the highest in Central America. In 2011, Belize led the Central American region with the highest gasoline prices and had among the highest electricity tariffs for the residential, commercial, and industrial sectors (US\$0.223/kWh, US\$0.2278/kWh, and US\$0.169/kWh, respectively). For 2015 the electricity tariffs for the residential, commercial, and industrial sectors was lower (US\$0.14/kWh, US\$0.15/kWh, and US\$0.20/kWh, respectively).

Status of Belize Electricity Tariffs.

Belize is the smallest country in Central America by population (408,487) and the second smallest by surface area (20,418 km²). In 2007, the main consumer of energy was the transport sector (94% of total energy consumption) followed by the industrial sector (27.43% of total energy consumption). The residential, commercial, and service sectors were responsible for the remaining 25.77% of total energy consumption in 2010.

Belize has local fossil fuel resources, 63% of the country sector (46.80% of total energy consumption) followed by the industrial sector as refined petroleum products or as electricity. Crude oil equivalent to 68% of the country's energy supply was exported in 2010, as Belize has no domestic refining capacity. Domestically, 37% of energy supplied was obtained from local resources such as biomass (firewood and sugar cane bagasse), hydropower, and local fossil fuel resources. Petroleum products such as liquefied petroleum gas (LPG), gasoline, kerosene, and diesel oil accounted for 93% of the total energy imported in 2010, whereas electricity accounted for 7%. All refined oil products (gasoline, diesel, kerosene, and aviation fuel) were previously imported from Venezuela under the Petro-Caribe Agreement. Gasoline and diesel are the primary source of Belize's energy in the transportation sector. Belize is also an oil producer, with a production of around 2,000 barrels a day of which most oil is exported, though some crude oil is used directly by the industrial sector.

Belize's electricity is supplied mainly through a 115-kV transmission line that covers the entire northern and western sections of the country, and is interconnected with Mexico, currently the most reliable source of energy. The southern areas of the country are partly covered by a 69-kV transmission line. Belize Electricity Limited (BEL), which was nationalized in 2011, is the primary distributor of electricity in Belize, serving a customer base of approximately 97,714 accounts (BEL 2012). In 2012, 45% of the electricity generation output was purchased on the spot market from Mexico's Comisión Federal de Energía (CFE). Previously, CFE supplied BEL up to 15 MW of firm capacity and up to 40 MW on an economic basis, but CFE cancelled its

firm power agreement with BEL in 2009. In 2012, the remaining 55% of electricity was supplied as follows: Belize Electric Company (BECOL, 38%), Belize Co-Generation Energy Limited (BELCOGEN, 12%), Hydro Maya (2%), BEL's own diesel generation capacity (3%), and the Blair Athol Power Company Limited (BAPCOL, 1%) (BEL, 2012a). As population growth is high (2.65% per annum) (SIB, 2010), studies estimate that electricity demand will grow by about 4% per annum in the coming years (OAS, 2012) in the absence of a demand-side management program or strategy. Belize's peak energy demand reached 82 MW in 2012, and it is expected to grow despite a recent setback in the period 2011. Installed capacity was approximately 156.2 MW in 2012, and is enough to cover peak demand in the near term. Hydroelectric capacity is 54 MW, of which 21 MW come from run-of-the river or low storage capacity hydro plants. BAPCOL's generating capacity is approximately 10 MW, although it only generated power in 2010 and again in 2012. BEL owns and operates 28.3 MW of diesel-fired gas turbines. BELCOGEN generates electricity by burning bagasse and has a capacity of 13.5 MW. This capacity is only available when there is an available bagasse resource from sugar processing. BEL's supply from CFE is constrained by a 60MW maximum transfer capacity of the 115 KV transmission line linking the two national systems. Moreover, BEL is currently unable to take more than 50 MW of power from Mexico without experiencing voltage regulation problems. Figure 1 shows a more updated breakdown of energy generation and source for 2015.

Belize Sugar Industries (BSI) currently combusts bagasse in its 27.5MW BELCOGEN co-generation plant to meet its own power and steam needs. BSI also sells excess power to Belize's national power grid under a power purchase agreement (PPA) with Belize Electricity Limited (BEL), Belize's primary distributor of electricity. However, BSI's supply of bagasse is currently sufficient to fuel BELCOGEN only during the sugar season, roughly seven months of the year, so the facility remains idle for a significant portion of the year.

Therefore, this is energy production potential that is remaining idle at the same time that (i) the country is in an energy crisis and (ii) the GoB urgently needs to consider and explore options to realize a greater level of energy security that is vital for realizing the country's economic development potential. There is clearly a market for additional power, since the Government of Belize (GoB) will facilitate the sale of 100 Gigawatts hours annually, and currently BELCOGEN is only providing in the region of 60 Gigawatts hours annually.

The resultant shortfall in power supply from BELCOGEN adds to the financial burden on BEL, by reinforcing its dependence on imported power from the Mexican Federal Electricity Commission (CFE). BEL highlighted this challenge in its 2011 annual report, stating that, *"during the sugarcane's off crop, BELCOGEN can only produce 5MW compared to the 13.2MW capacity under the PPA. Without full generation from BELCOGEN, in times when the CFE supply is unavailable, BEL would barely be able to meet the country's peak power demand,"* (of 82MW)

Supplying biomass to BELCOGEN in the off-season could enable the plant to operate throughout the year, and to provide power to Belize's grid under the existing PPA. This

agreement was signed in 2007 for 15 years. The plant design was for the production of 150 Gigawatts hours per annum, representing 50 MW for internal consumption and 100 Gigawatts hours for sale to BEL. However, BELCOGEN has not been able to deliver at the agreed level due to insufficient bio-mass material and as a result; there is an ongoing pressure to renegotiate the agreement, based on the performance to date.

Increased power generated from BELCOGEN would in turn help BEL and by implication the sovereign state of Belize address some of its supply challenges, and reduce its dependence on the costlier diesel imported from Mexico. It would also yield substantial economic benefits for ASR/BSI, which could see power sales increase by nearly 22GWh/per year, yielding significant cost benefits to the country as a whole. This will come about since the rated installed capacity of the BELCOGEN facility is 27.5 MW which is comprised of 12.5 MW of back pressure turbines and 15 MW of condensing turbines. The backpressure turbines provide all power for internal use and the provision of process heat for the factory, the condensing turbines is to provide an estimated 13.5 MW for sale to the BEL. As a result of the design in the cooling system the production has been in the region of 10MW for sale. So, until the cooling system is upgraded the upper limit for power sale will be 10 MW.

The back-pressure turbines produce power for the plant and process heat. These turbines cannot be used when there is no sugar production. So, the maximum power output for export to BEL outside of the grinding season is a little more than half of the 13.5 MW that was agreed in the power purchase agreement.

This project has the potential of validating the economic and technical feasibility of using the new energy crop (*Arundo Donax*), representing a first step toward expanded cultivation for the crop that could help Belize address its energy security challenges and meet its national goals.

1.1.5 Project Investment Activities

According to the Project proposal submitted to the World Bank/Ercap, (CCCCC, ERCAP, 2015), the estimated *budget for the preliminary planning and trial phase is US\$1,306,449.00* The World Bank/ERCAP project is being asked to provide US \$1,111,838 and the CCCCC will provide US\$ 194,61.000, representing total cost of fuel and equipment compatibility testing, and a portion of administrative costs for the yields trials, pilot plantation, harvesting, processing, storage and transportation.

Table 1.1: Estimated Budget for Arundo Donax Project. Source: CCCCC/ERCAP 2015 Project Proposal.

Items	Cost US \$		
	CCCCC	WB/GEF	TOTAL
Fuel and Equipment Compatibility Test	\$39,360.00		\$39,360.00
Evaluation - Yield trials (50 acres), pilot plantation and harvesting systems testing 450 acres (access road, etc.)		\$858,534.00	\$858,534.00
Administrative, EIA and Feasibility Study			
Estimated Budget	155,251	253,304	\$408,555
TOTAL PROJECT COST	\$194,611.00	\$1,111,838.10	\$1,306,449.00

This section summarizes the cost of implementation of the Environmental and Social Impact Mitigation and Compensation costs.

The ESMP budget is estimated as follows:

- Construction equipment \$30,000
- Rapid Archaeological assessment \$10,000
- Air and water quality equipment \$50,000
- Employee environmental training \$30,000
- Cultivation, air, water and noise monitoring \$80,000
- Cultivation mitigation \$30,000
- Management of social and cultural resources \$20,000
- Management of transport, handling and storage \$30,000
- Decommission monitoring \$40,000
- Land preparation \$100,000
- Land restoration \$200,000

Total cost is \$630,000.

1.1.6 Project Infrastructure

The project components can be divided into two main categories; Component 1 being the Project Preparation Stage; and Component 2 being the Implementation Phase (Experimental Phase). The ESIA and ESMP comprise part of the preparation component.

1.1.6.1 Component 1: The Project Preparation Phase

Preliminary project conception and design commenced with the identification of funds for the various components of the project. The following sub components were the undertaken;

- i. A feasibility study that focused on the technical, financial and economic feasibility of the initiative and the identification of operational and funding modalities to enable long-term sustainability.
- ii. A Stakeholder Analysis and Management and Engagement Plan that identified stakeholders and actions for their engagement,
- iii. A Gender Study and Gender Action Plan to facilitate the mainstreaming of gender considerations into the funding proposal and implementation of the project
- iv. *An Environmental and Social Impact Assessment (ESIA) and Environmental and Social Management Plan (ESMP) that would include, but not be limited to the following:*
 - ✓ *Identification of the project's potential environmental and social impacts and identification of measures for their prevention or mitigation, or for compensation in the event of adverse impacts;*
 - ✓ *Assessment of the legislative and regulatory environment;*
 - ✓ *Identification of appropriate institutional arrangements for the sustainable development and stewardship of the Arundo donax renewable energy initiative;*
 - ✓ *Description of the number of beneficiaries potentially affected by the proposed project;*
 - ✓ *Identification of opportunities, risk and concerns or issues related to the proposed project;*
 - ✓ *Preparation of Emergency Management and Evacuation Plan (EMP), Draft Disaster Management Plan (DMP), Draft Occupational Health and Safety Plan (OHSP), and Draft Environmental Monitoring Plans.*

1.1.6.2 Component 2: Complementary Tests and Trial Plots Phase

Fuel Compatibility Test

This component consists of delivery of 150 tons of dried and shredded Arundo donax fuel from stands already growing in natural habitats across Belize with the aim of determining the calorific value or efficiency of *Arundo donax* during combustion in the Belcogen plant. The

trials involved testing different proportions of *Arundo donax* with bagasse in order to observe their relative performance.

Species Classification

The classification of the Belize variety growing in local riparian habitats will be done through the collaborative efforts of the research institutions CARDI and SIRD, and the University of the West Indies. CARDI AND SIRD are liaising with the University of the West Indies (UWI) or the collection, storage and transportation of the herbarium specimens so that UWI can carry out the taxonomic classification of the Belize variety of the wild cane plant through the DNA sequencing and morphometric analysis.

Complementary Experimental Plots

A complementary phase of the project, being supported through separate financing, will include trial plots.

As a complementary support to the project, total of 36 plots, each 150 feet square, separated by 10 feet buffers are being planned using various criteria for fertilization, no fertilization, varieties and planting distances, among other parameters (see Figure 1.1).

The preliminary phase of the project includes the preparation of sample plots to enable the selection of the best specimens of “seed” material for the cultivation. Two varieties will be extracted from identified locations in various districts, including the Orange Walk, Belize, Stann Creek and Toledo Districts. Two varieties of wild cane have been identified in Belize that will be included in the selection trials. However, these varieties are only identified separately from physical attributes such as coloration and flowers.

Four experimental plots, each having 150 feet blocks of cultivation separated by a 10-foot physical barrier is being planned. Figure 1.1 illustrates the layout of this plan. The first block will have one variety, followed by the second variety in the second block, as shown in Figure 1.2. Cultivation trials with and without fertilization and using planting distances of 0.5 feet, one (1) feet and two (2) feet will be installed. This system will be applied to both varieties.

The baseline data on water and soil chemical analysis will be taken from the areas where the plants are removed, as well as the soil from the area where they are being planted.

Decommissioning Phase of Complementary Plots

The project is being designed as a long-term trial beyond five years, with the project cycle extending beyond that. Already, however, methods for effective decommissioning of the complementary trial plots will be investigated such as removal by physical harvesting, and the use of fire or chemical application. This will allow the project management to put in place a decommissioning plan that will allow for the use of the most efficient method for removal of the species and re-habilitation of the project site.

1.1.6.3 Project Implementation Phase

As soon as project approval is obtained and the necessary permitting licenses are secured; project implementation will commence. This will include the conducting of final rapid surveys, equipment procurement, hiring of staff and installation of facilities, and finally the land preparation and project implementation cultivation of *Arundo donax*.

Site Layout

The project management site will utilize 100 acres in close proximity to the 400 acres research plot for the following: **(Figure 1.1)**

- 1) One (1) security booth at the entrance of the property measuring 100 sq. ft (10 ft X 10 ft)
- 2) Two (2) living quarters, each measuring 616 sq. ft. (22 ft X 28 ft.) inclusive of bathrooms for use by the workers. Each building will be equipped with a 1000-gallon water storage tank.
- 3) Two (2) drying sheds measuring 6000 sq. ft. for drying the *Arundo donax* bagasse product.
- 4) One (1) storage sheds measuring 6000 sq. ft. for storage of bagasse.
- 5) Half (.5) acre parking lot.

PROPOSED SITE PLAN FOR A. DONAX (100 ACRE LOT)

PLAN VIEW OF DETAIL A

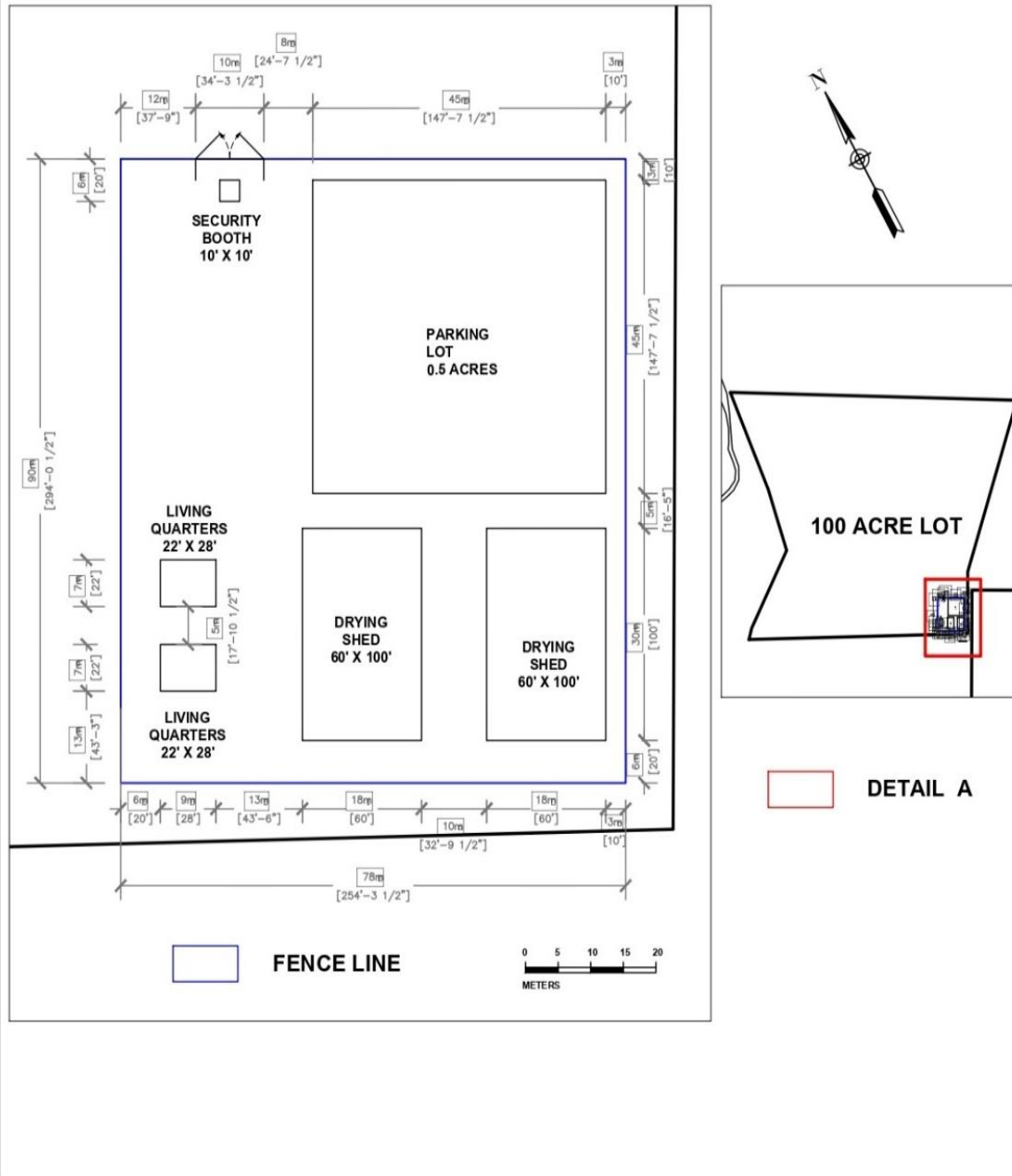


Figure 1.1: Proposed Site Plan of Structures

1.2 Location

The general location of this site is the area between two kilometers and four kilometers on the Orange Walk – Yo Creek Road. Specifically, it is located 834 meters from the Blue Creek and 2837 meters from the Rio Hondo. This area is widely used for cane farming but has some pockets of vegetated areas that are not being farmed, some being unsuitable for sugar cane cultivation. Communities located in proximity to the project site are Yo Creek, San Lazaro, Trinidad, August Pine Ridge and Santa Cruz Villages. Orange Walk town is approximately 9 miles away. The site is accessed from Orange Walk Town via the Yo Creek road, and the community that has an access road to the project site is San Lazaro village (Figure 1.3)

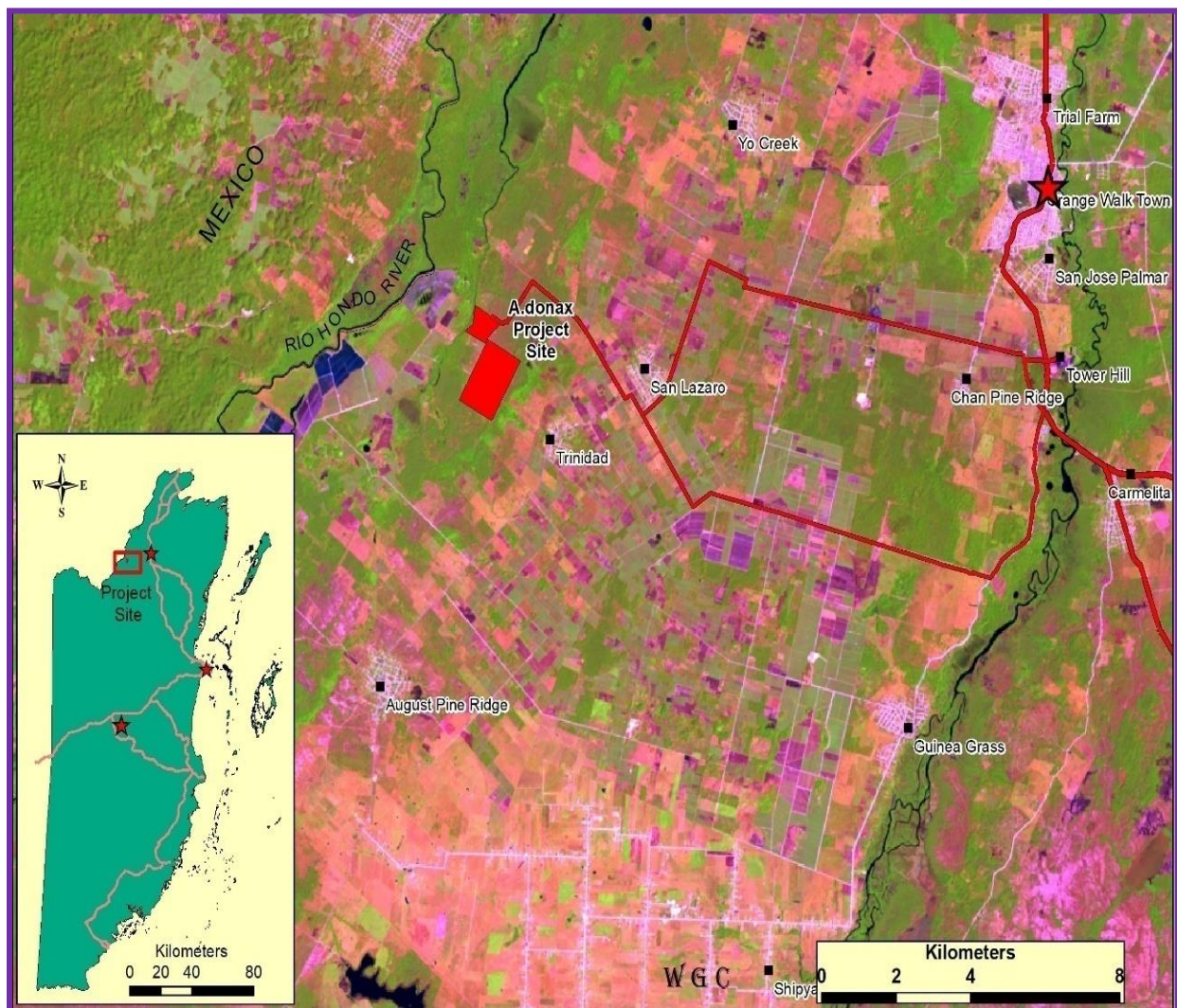


Figure 1.3: Map showing location of project site



Plate 1.2a: The Eastern Boundary line of Parcel 2.



Plate 1.2b: Typical savannah at eastern side of Parcel 1.



Plate 1.2c: The plot where the research plot is being planned.



Plate 1.2d: Typical Vegetation Site

The *Arundo donax* site is located in the Orange Walk District about three kilometres from San Lazaro village and 1.5 kilometres from Trinidad village and is comprised of two adjacent parcels, one of approximately 100 acres and the other 400 acres. San Lazaro village is in close proximity to project site, which is the reference point for the project since the entrance is a road access just outside this village (**See Figure 1.3**). The site is accessed from Orange Walk Town via the Yo-Creek road, which is a paved road, and then a feeder road is used to access the actual project site (**See Figure 1.3**).

Most importantly, it is less than 20 miles from the BELCOGEN Facility to which the crop is to be delivered. There are no residents in the proposed cultivation area. Orange Walk Town, which is the significant urban area, is about 10 miles east of San Lazaro. The Rio Hondo, which is the border with Mexico, is about 1.7 miles away at its closest point. A small creek, Blue Creek, that's about 4-6 meters in width, is the nearest water source to the project.

The land is part of the Northern Plains Land Systems and it has topography ranging from 6 to 12 meters ASL. Soil characteristics display Dark and Light Sandy Topsoil on top in different areas, but all were followed by Dry Stiff Grey Clay. Approximately half of the lands are savannah shrub lands and the remaining half comprises shrub lands with more dense vegetation cover. The two (2) extends of the *Arundo donax* project properties, where the northern end runs along with the creek which is nearly adjacent to the 100-acre property. It should be noted the 100-acre property is relatively low-lying as compared to the larger 400-acre property. The site is a parcel of land comprising of Lowland savannah, Lowland broad-leaved moist scrub forest, Lowland broadleaf moist forest determined to be marginal and unsuitable for agricultural purposes. Most of these lands are marginally suitable for agriculture crops and comprise mostly of shrublands and disturbed shrublands, with some savannah displaying stunted growth vegetation.

This area is widely used for cane farming but has some pockets of vegetated areas that are not being farmed, some being unsuitable for sugar cane cultivation.

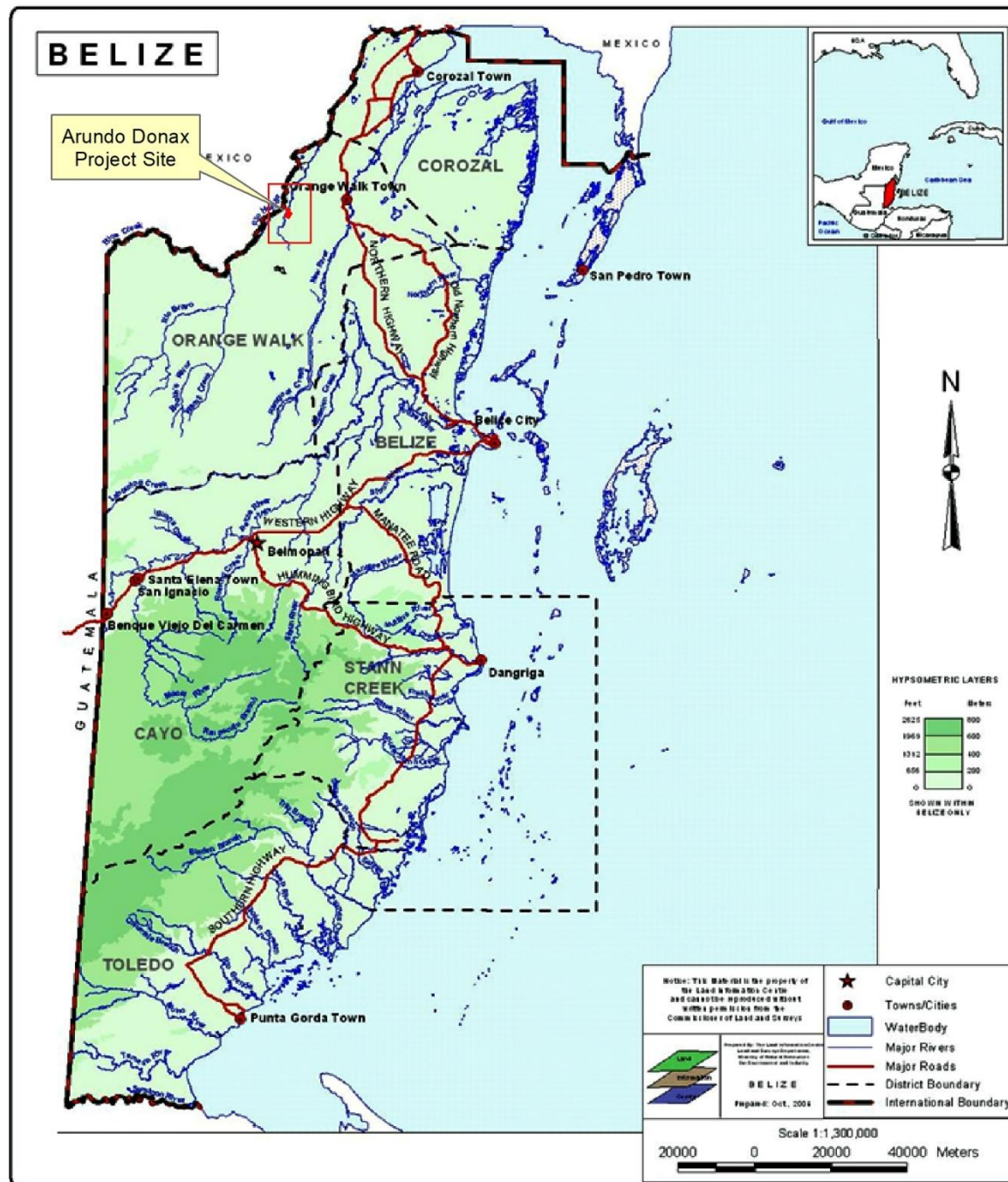


Figure 1.4: Project Location

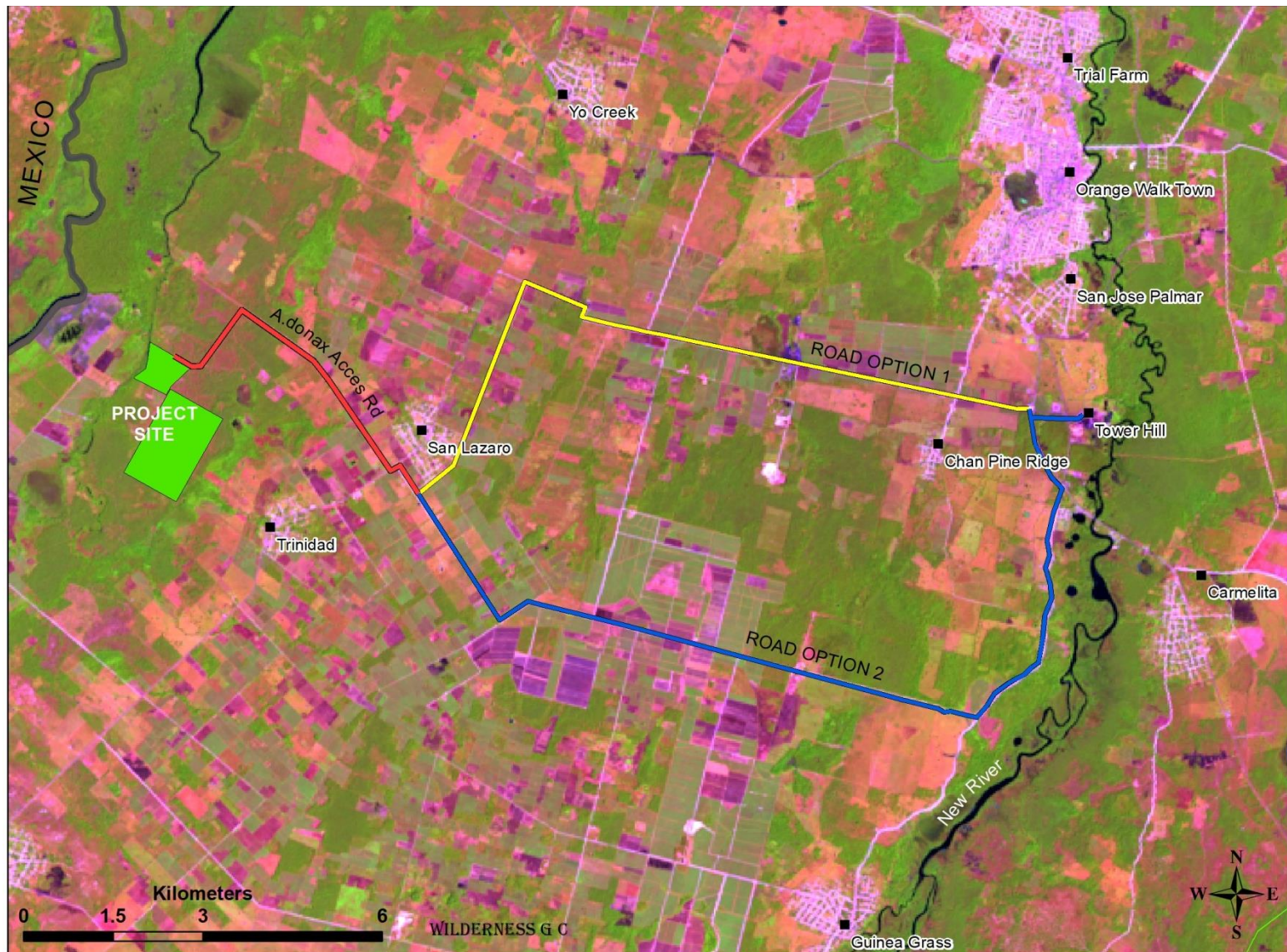


Figure 1.5: Location of Project sites and access roads.

1.3 Environmental Characterization

1.3.1 Land Characteristics and Use

1.3.1.1 Characterization of Area of Influence

The project pilot site is located 834 meters from the Blue Creek and 2837 meters from the Rio Hondo. This area is widely used for cane farming but has some pockets of vegetated areas that are not being farmed, some being unsuitable for sugar cane cultivation. Communities located in proximity to the project site are Yo Creek, San Lazaro, Trinidad, August Pine Ridge and Santa Cruz Villages. Orange Walk town is approximately 9 miles away. The site is accessed from Orange Walk Town via the Yo Creek road, and the community that has an access road to the project site is San Lazaro village (Figure 1.3). Chapter 2.0 “Social Characterization” discusses these communities and their social characteristics in greater detail.

Villages in the Area of Direct Influence (ADI) or “Zone 1” of zone of influence include Yo Creek, Santa Cruz, San Lazaro, Trinidad and August Pine Ridge Villages (Figure 2.2). The Area of Indirect Influence (AII) includes the villages of Trial Farm, Orange Walk Town, San Jose Palmar, Tower Hill, Chan Pine Ridge, Carmelita and Guinea Grass.

As a general classification, however, the area of influence extends to the entire Orange Walk District and even to the Corozal District since these two districts practice cane cultivation, but also the entire country can be indirectly classified as its wider area of influence due to the economic implications such as energy cost, and climate contributions of biomass to energy projects.

Figure 1.6 illustrates the DAI AND the AII; for which communities within the DAI. It is also important to note that the country on a whole may be influenced by this project one way or another as a result of the socio-economic implications, including carbon sequestration and its contribution to climate change, and the economic implications of lower costs of electricity as well as the benefits that the project success would contribute to Belize’s energy independence and sustainability development options in the energy sector.

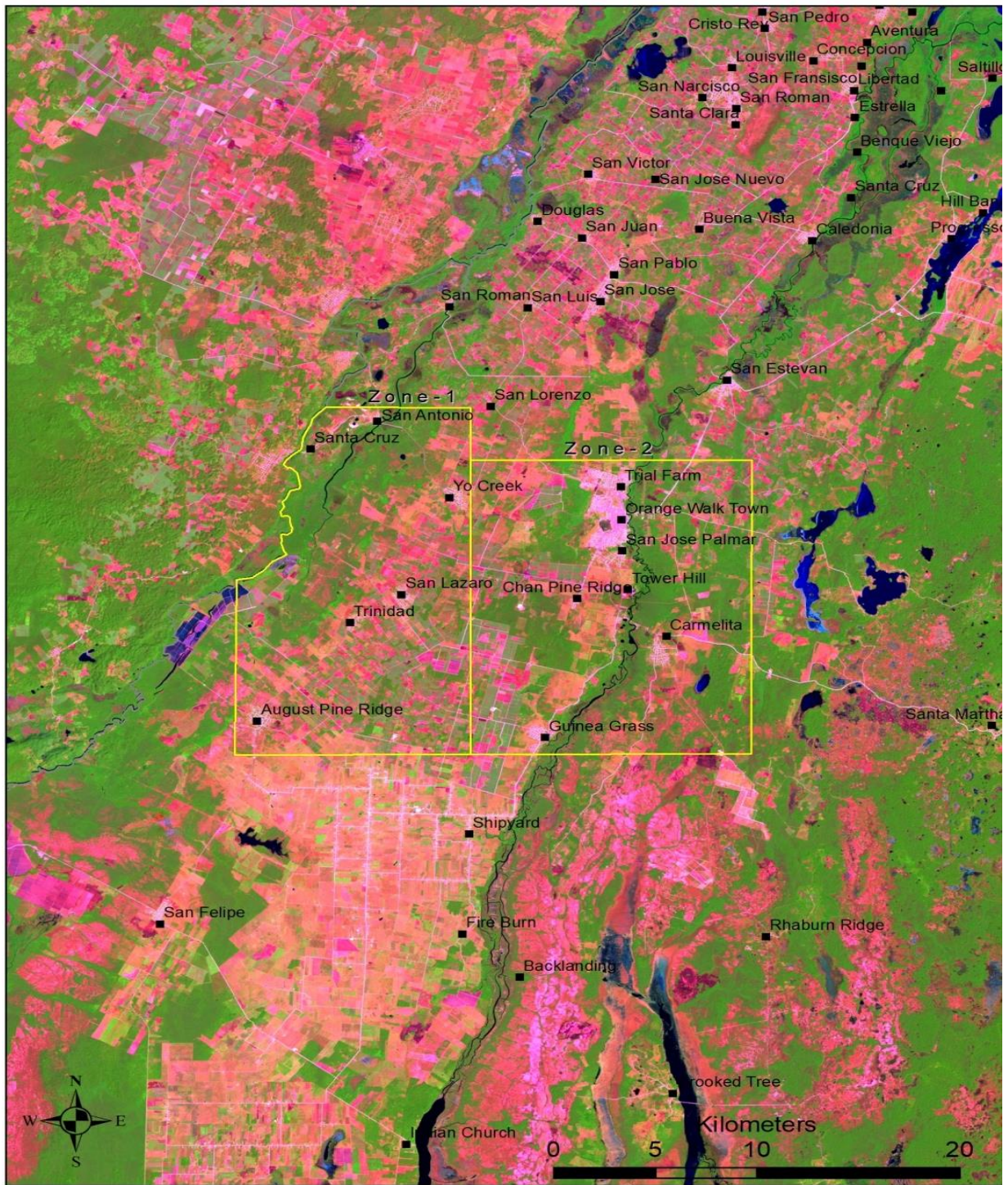


Figure 1.6: Map Illustrating Project Zone of Influence

1.3.1.2 Land Characteristics

Biodiversity and Habitats – Summary

The reader is advised to see section 1.3.10 for greater details of the survey methodology of the biodiversity and ecosystem surveys as well as description of species identified within the project area.

The establishment of study transects were based on the images and Ecosystem Classification, at least three vegetation or ecosystem types were identified: Lowland savannah, Lowland broad-leaved moist scrub forest, Lowland broadleaf Moist forest. Also, aerial photographs captured using a drone were used to get a clear idea of the diversity of the area and this guided the placement of study transects.

A total of 61 plant species were identified by local common name in the field, one set is identified as Unknown and is made of a variety of species represented by a few individuals. Literature search and expert knowledge was later used to identify as many species by their scientific name. The data can also be used to get an idea of the understory and the condition of the area. The 100-acre parcel was found to be severely degraded due to past and recent fires as well as clearing. The 400-acre parcel was also impacted by fires and human activity but was in a more “natural” state than the 100-acre parcel. The 400-acre parcel has 27.2 acres cleared of all its vegetation on the south west corner. This clearing is recent and done using bulldozer and fire. The most important species was Oak (*Quercus oloides*) with 355 (28%) of the 1,236 stems counted. Oak was present though out most the site. The next most important species were Logwood (*Haematoxylum campechianum*) with 77 stems (6%) and Craboo (*Byrsonima crassifolia*) with 75 stems (6%).

Habitats

Based on the images and Ecosystem Classification, at least three vegetation or ecosystem types were identified: Lowland savanna, Lowland broad-leaved moist scrub forest, Lowland broadleaf Moist forest. These ecosystems displayed habitats as follows: Savanna - Open Oak/Grassland, Lowland Savannah – Dense Oak, Lowland Broadleaf Moist Forest, Lowland Broadleaf Scrub Forest, and Lowland Broadleaf Forest – Bajo.

Savanna - Open Oak/Grassland

Only 12 tree species with 256 individuals were found within the Open Savannah which is characterized as an open stand of Oak trees interspersed with patches of Palmetto (*Azoreopne* --). Five species dominate the plant community. These species are Oak (47%), Yaha (*Curatela americana*) 20%, Craboo (*Byrsonima crassifolia*) (16%) and Calabash (*Crescentia cujete*) and a few Caribbean pine (*Pinus caribaea*) 4%. No species of high commercial or conservation value was found in this vegetation type.

Lowland Savannah – Dense Oak

The Lowland Savannah with dense Oak is made up of 26 named species and one set of unknowns for a total of 278 stems. This area has as dense understory of shrubs and vines but also has open areas with Palmetto. Two species make up 66% of all the stems counted in the Dense Oak Savannah. The number of Oaks counted was 157 (56%) while Craboo accounted for 31 (11%). Other species present but not common include Botan (*Sabal mauritiiformis*), Black Poisonwood (*Metopium brownei*) and Mangillo (spp) and Calabash with 3% or less.

Lowland Broadleaf Moist Forest

The Lowland Broadleaf Moist Forest is made up of 30 named species and one Unknown for a total of 91 individuals. The vegetation is dense with vines and small shrubs. Some areas were damaged by fire or cleared of forest. This forest is associated with a small creek (Blue Creek?) on the western side. This water source is probably influencing the species mix in this site. The dominant species is Logwood (*Haemotoxylum campechianum*) with 13 (14%) individuals but is closely followed by Bullet Tree (*Bucida busera*) and the Botan palm with 10 (11%) individuals each. Oak trees are also in this forest given its adjacency to the Savannah ecosystem. There was one sample of Zericote (*Cordia dodecandra*) which is a prize species used in craft making.

Lowland Broadleaf Scrub Forest

This Lowland Broadleaf Scrub Forest had 41 named species and a set of 5 Unknowns for a total of 379 stems. This forest has a dense understory. The dominant species were Oak and Logwood. Oak accounted for 72 (18.9%) individuals while Logwood had 58 (15%) individuals. Other species related to harsh soil and hydrological conditions such as Madre cacao (*Gliricidia sepium*) and Pi (*Gyneranthus lucida*) were relatively common with 21 (6%) and 19 (5%) individuals sampled.

Lowland Broadleaf Forest – Bajo

The Lowland Broadleaf Forest – Bajo was represented by 35 named species and one unknown set. A total of 241 individuals were counted. Five species made up more than 55% of the individuals with Santo Domingo (*Pachira aquatica*) being the most dominant 36 (15%) individuals followed by White Poisonwood with 26 (11%) individuals, Pi (*Gyneranthus lucida*) 25 (10%) individuals and Bullet tree (*Bucida busera*) with 24 (10%) individuals. The Botan palm was relatively common with 22 (9%) individuals.

Fauna

Summary of Birds Seen or Heard

Due to the nature of bird observation, most birds were detected by sound, particularly in the Lowland Broadleaf Forest. A total of 105 species of birds were recorded. The vegetation type with then most species was Savannah with Dense Oak. The Lowland Broadleaf Moist Forest had the lowest species number with 42. The table below provides a summary of the number of species and the total number of individuals recorded.

Topography

The project site is characteristically comprised of the Northern Coastal Plain (King et al, 1992). This part of the northern coastal plain consists of flat plains, undulating plains and high plains.

The site is well drained and has a gentle slope ranging from eight (8) to twelve (12) meters ASL. The area is generally more elevated than its surroundings, allowing water to drain easily to lower elevations north, south and east of the property.

Figure 1.7 is the contour map that was generated using Google Earth; and ground truthing with 100-meter survey lines using survey technology. It shows the two (2) extends of the *Arundo donax* project properties, along with the creek on the northern end, which is nearly adjacent to the 100-acre property. It should be noted the 100-acre property is relatively low-lying as compared to the larger 400-acre property. This could be a result of it being a natural run-off zone which would feed the creek during a period of downfall.

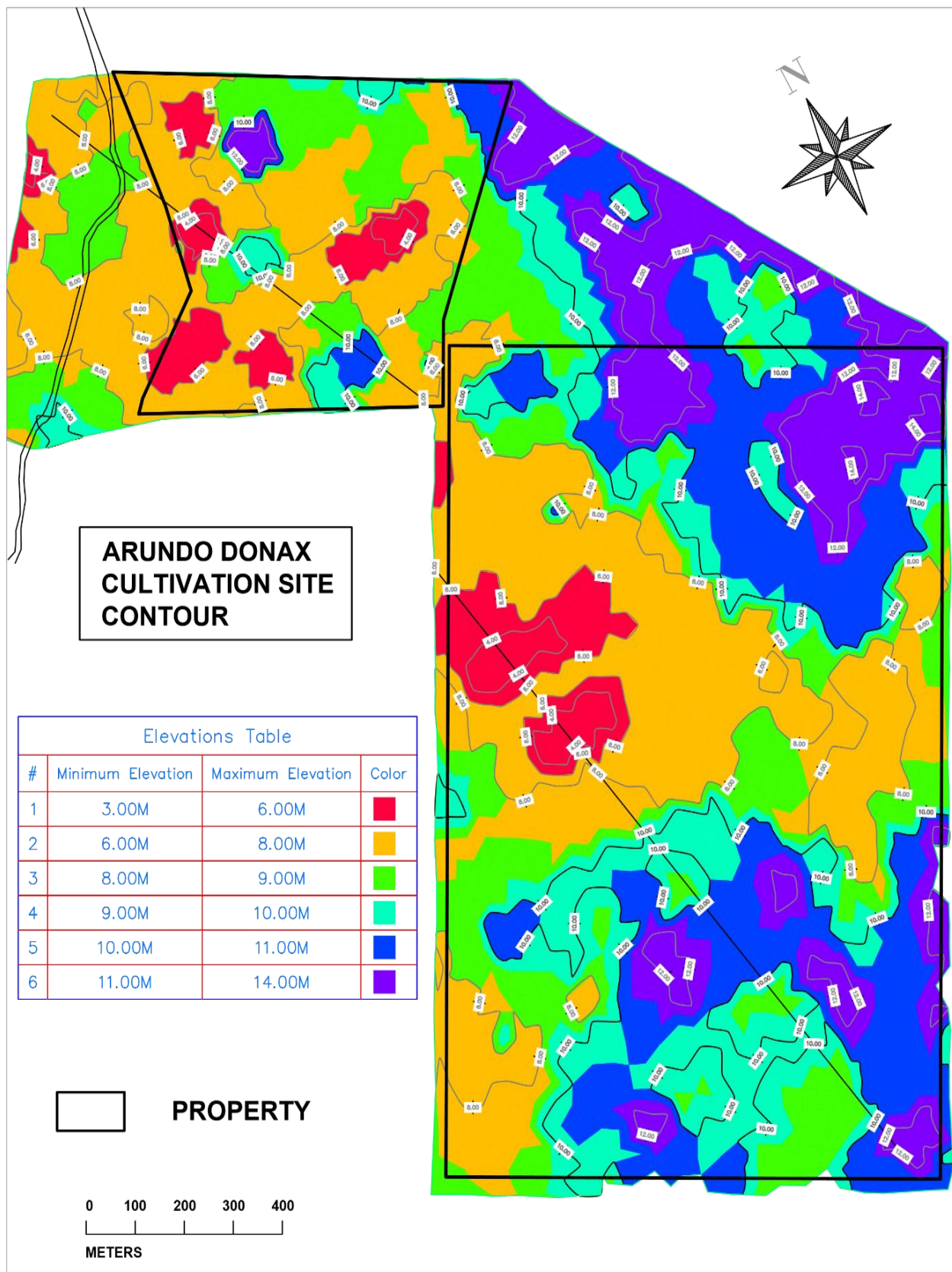
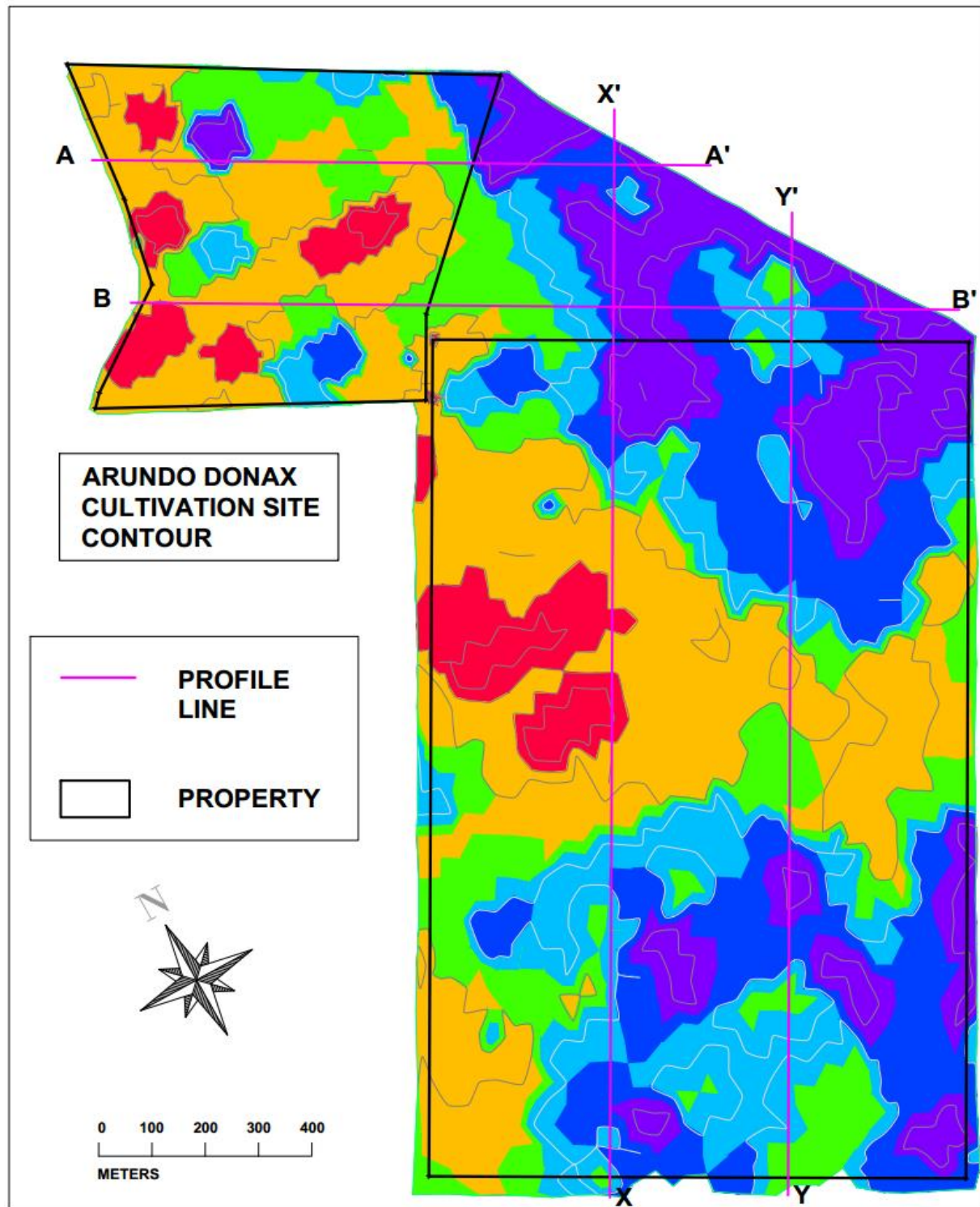


Figure 1.7: Contour Map of Project Sites

The contour profiles in lines A and B, corresponding to the 100-acre plot of land shows a relatively low-lying area on the western side nearer to the creek as opposed to surrounding eastern areas, which is noted by the 6-8-meter heights on the west as opposed to the 10-12-meter heights on the east. There is also a mound that can be viewed in Contour line A-A' which jumps to approximately 12 meters in height, which is surrounded by ~8-meter height flat land (**See Figure 1.7, 1.8**).

With respect of the 400-acre plot of land however, the land varies between 8-12 meters in height on the northern and southern corners of the property. There is a “basin” located within the centre of the property, which shows small areas that drop as low as 4 meters (as shown in X-X'). Contour line Y-Y' shows a similar basin-like area within the centre of the plot, however it is not as pronounced as line X-X' (**See Figure 1.7& 1.8**).



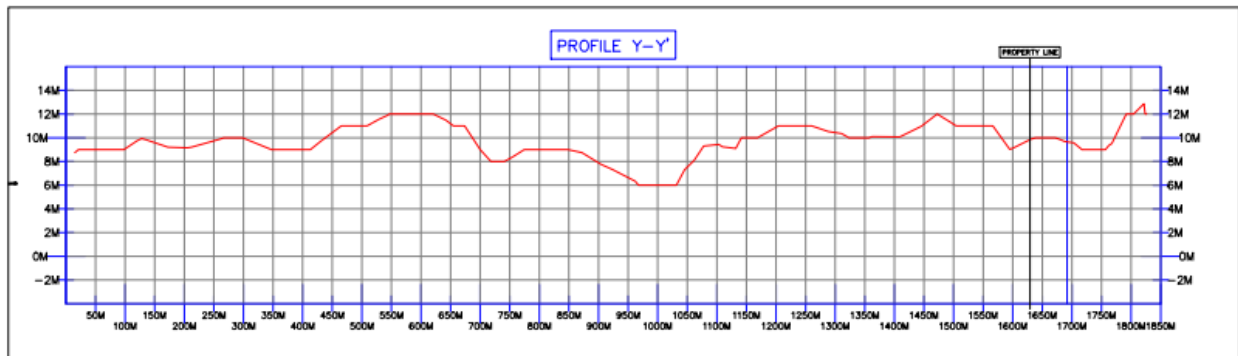
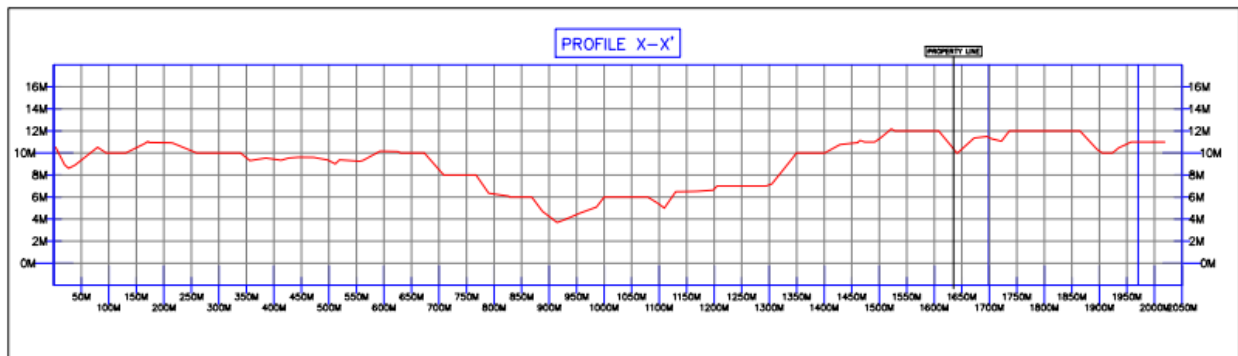
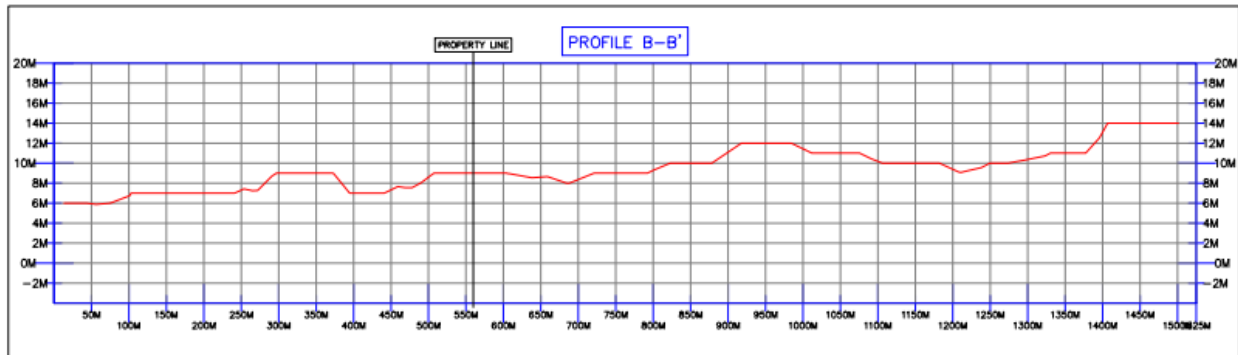
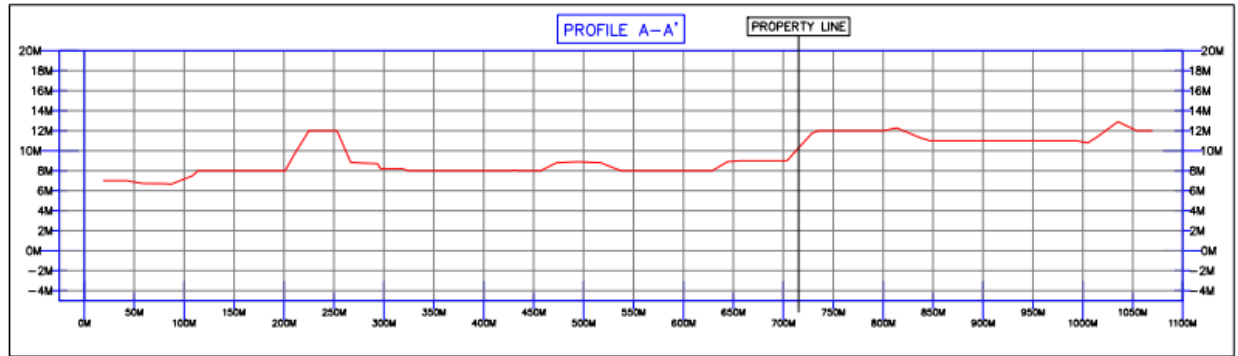


Figure 1.9: Contour Profile Lines

As a result, it is recommended that any large-scale industrial building be placed on the eastern edge of the 400-acre property due to its greater elevation with respect to the rest of the land. This location is highlighted in **Figure 1.10** by the red circle. This choice would assist in any flooding issues that may arise for the building itself therefore protecting any materials being stored.

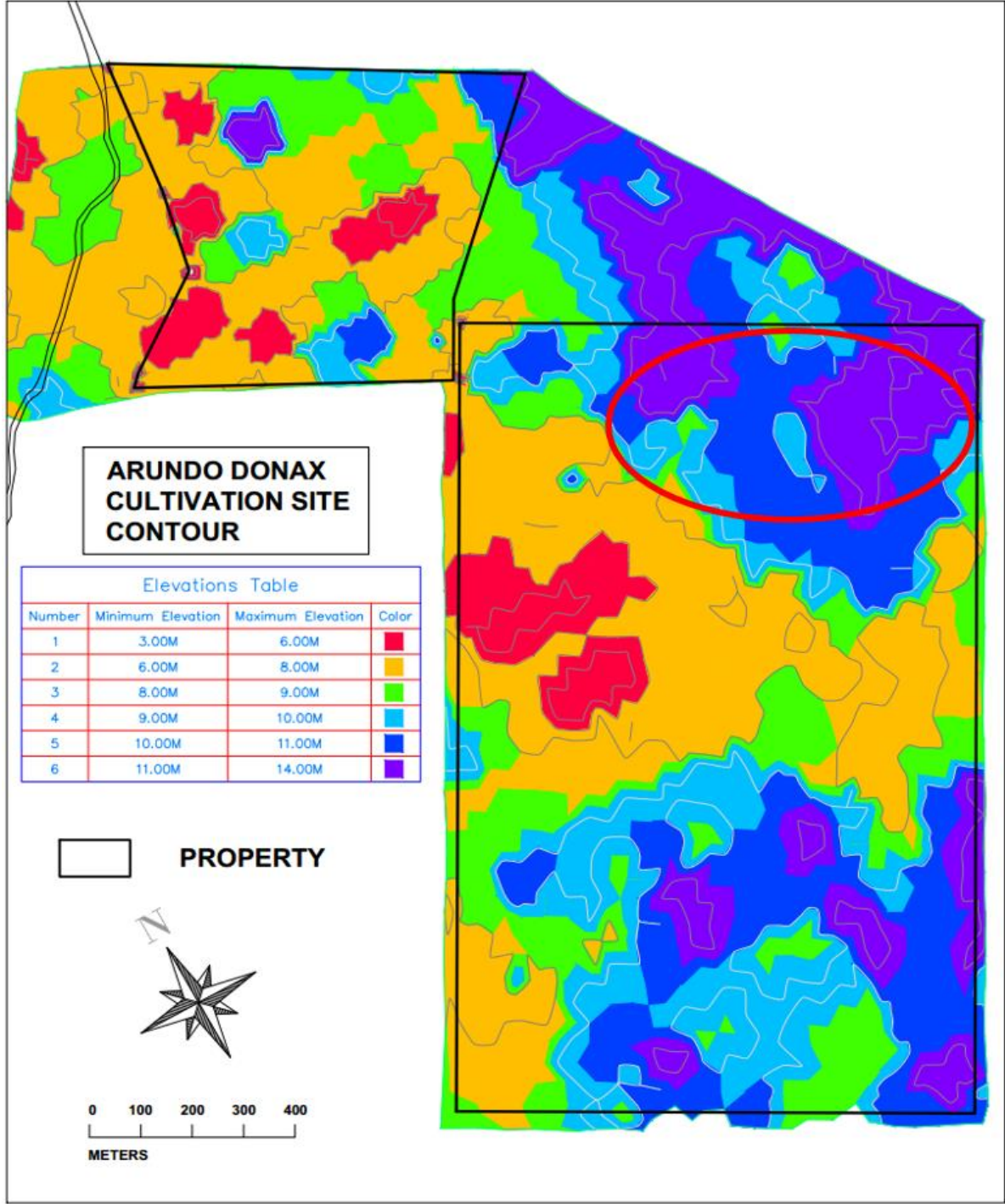


Figure 1.10: Recommended Infrastructure Site

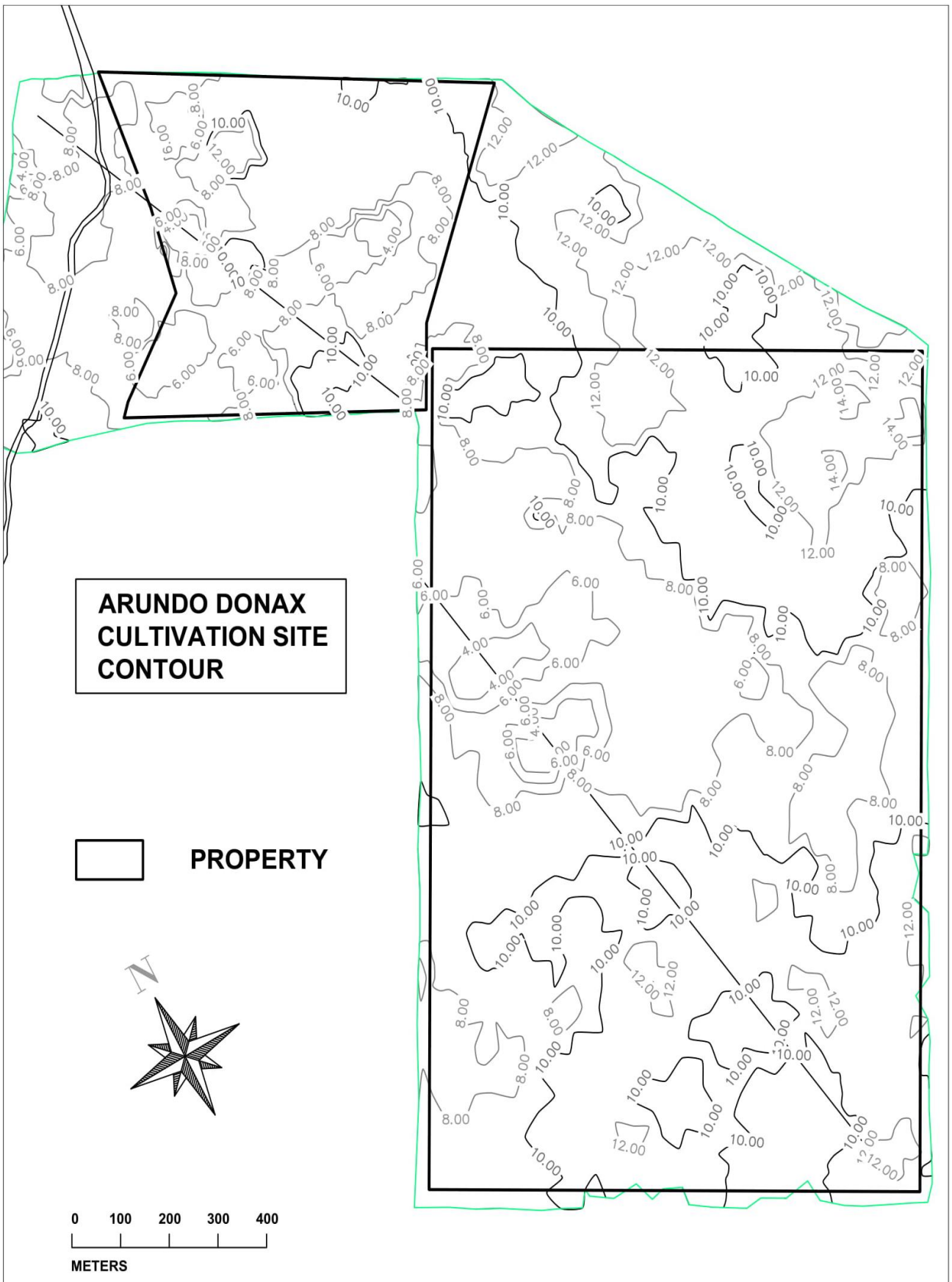


Figure 1.11: Arundo Donax Cultivation site Contour

1.3.1.3 Soil Characteristics

Soils

Most of Belize north of the Maya Mountains is underlain by limestones that get progressively younger towards the north of Belize. The main soils are black and very dark grey clays which crack and crumble when dry. Many of these are quite shallow but deeper soils are found close to swamp margins. In places where there is sand in the limestone or a sandy deposit overlying it, the soils appear similarly dark but have coarser textures and crack less. All of these dark soils are neutral or alkaline and are well supplied with calcium and magnesium, with some of them also having moderate potassium and phosphorus supplies.

The area overlies the Orange Walk Group Formation Limestone with the Louisville Plain Land System (King and others, 1992).

Existing Land Uses

The site itself has no current land use, and was devoid of infrastructure development; with the exception of informal land use such as hunting, and the extraction of timber products such as firewood and construction woods. The site is traversed by a series of informal trails used by hunters, and wood gatherers, mostly at a low scale, because the area does not support important animal species of hunting value. Hunting trails are mostly used to venture into adjacent parcels.

There are no structures within the project site, and the community has no claims and neither does it have agriculture interests because of its characteristic marginal lands, and therefore, not being suitable for agriculture. Plates 1.2 a, to 1.2d shows photographs of the existing parcel.

The land use in the immediate area of interest beside the two land plots is mostly being used as either sugar cane (*Saccharum officinarum*) fields or farm lands (including pastures). There are even sites of *Arundo donax* plants that can already be seen growing in the wild along the road to the San Lazaro, Trinidad area.

Neither the project site itself nor the surrounding land areas are not considered sensitive for such types of development as proposed by the *Arundo donax* biomass to energy project.

Soil Bore Hole Results

A series of soil analysis were conducted, namely, borehole analyses, soil analysis and heavy metals analysis. The purposes of these soil surveys were to verify the soil structure and composition so as to determine the suitability for the cultivation of the *Arundo donax*, but also to

verify the stability of the soil for road and other infrastructure installation to support the project. The following are the results of the analysis conducted.

As can be seen in **Figure 1.12**, 4 boreholes were made in the area of the 100-acre plot where it was suggested that the building infrastructure be placed and thus used to gather geological data for building foundation. Due to the type of soil, the holes were no deeper than 24" (BH4), while the others were less than 10" in depth. As can be seen in the data, BH 1 – 3 had the same characteristics, shallow layer of sandy top soil followed by stiff clay. BH 4 had similar conditions but with a layer of very fine dry white sand in-between the sand top soil and the stiff clay. This is being considered as Option 1 for the infrastructure location, while the recommendation from the contour section map that it be placed on the highest area of the plot will be considered as Option 2.

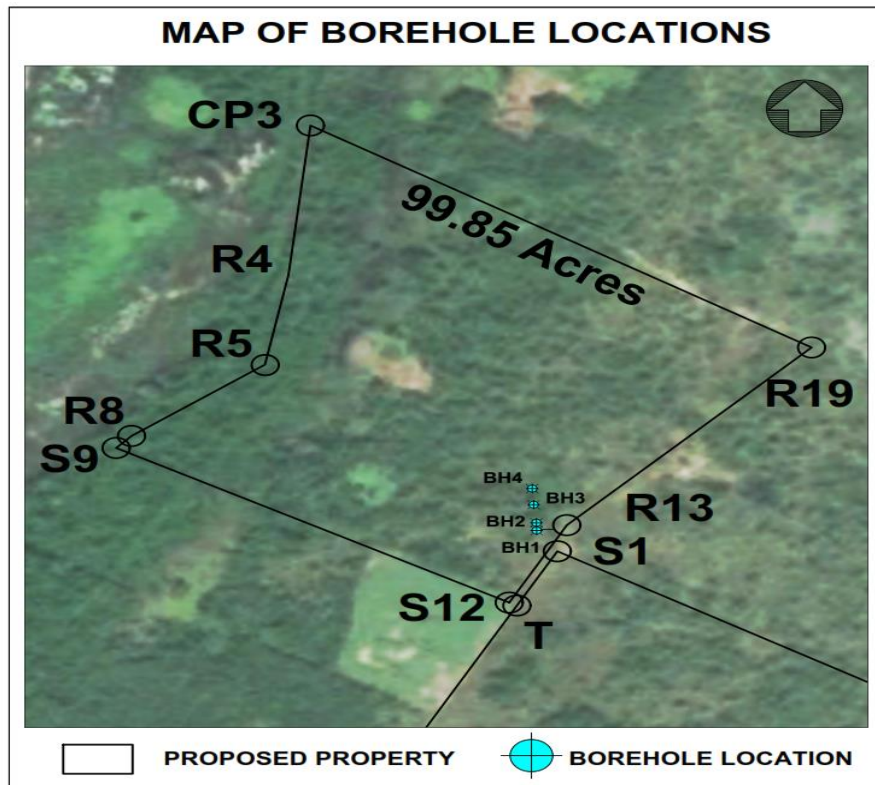


Figure 1.12: 100 acre Bore Hole Locations

Plate 1.3 a) BOREHOLE #1



BOREHOLE #1

(Total Depth of 8")

Light Sandy Topsoil for 3"

Dry Stiff Grey Clay for 5"

Plate 1.3b) BOREHOLE #2



BOREHOLE #2

(Total Depth of 7")

Light Sandy Topsoil for 3"

Dry Stiff Grey Clay for 4"

BOREHOLE #1.3c



BOREHOLE #3

(Total Depth of 7")

Dark Sandy Topsoil for 2"

Dry Stiff Dark Clay for 5"

BOREHOLE #1.4c



BOREHOLE #4

(Total Depth of 24")

Dark Sandy and loamy sandy
Topsoil for 8"

Very Fine Dry White Sand for 11"

Dry Stiff Grey Clay for 5"

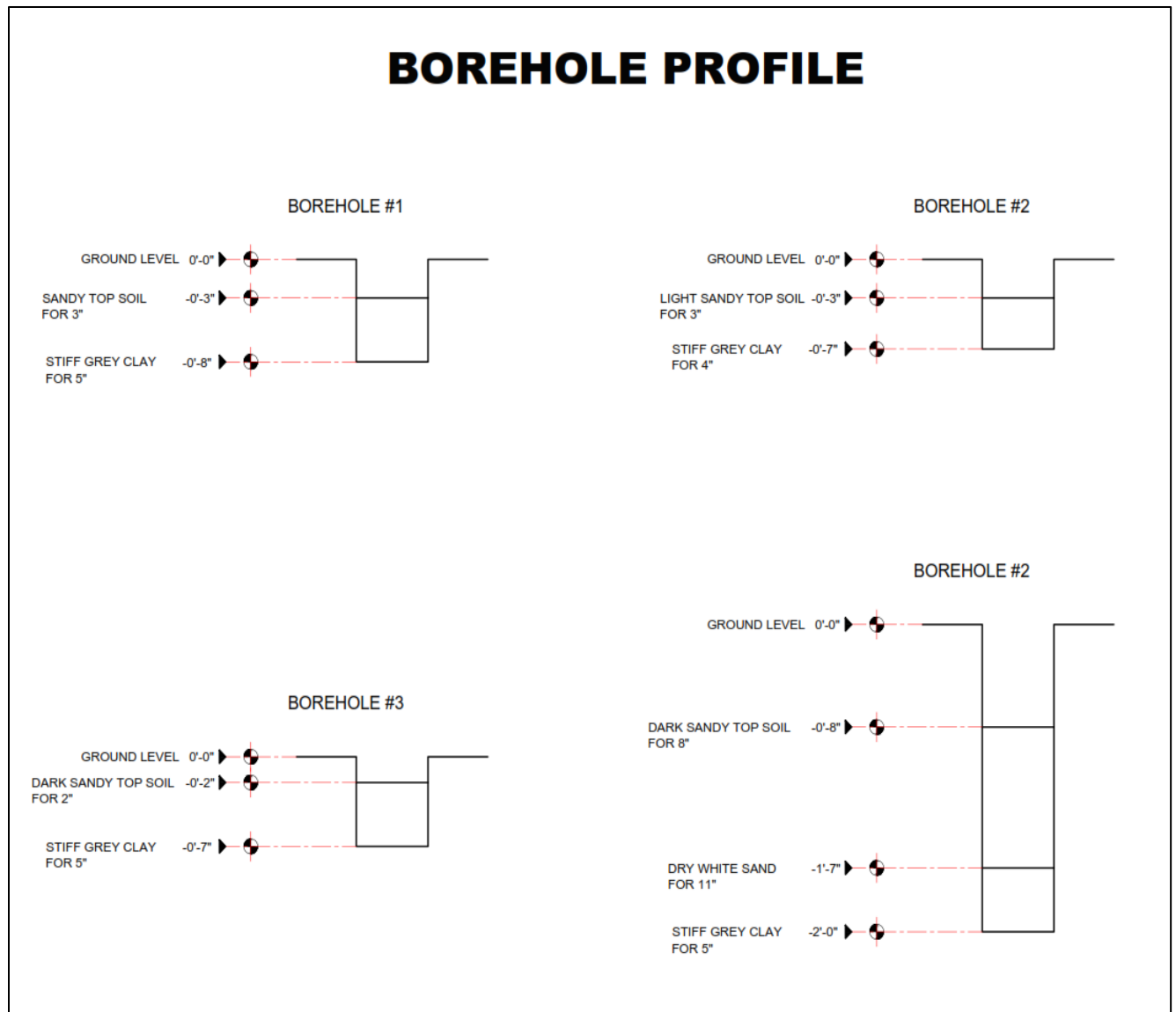


Figure 1.13: Borehole Profile

The findings of the borehole tests that were carried out indicate that it is possible to install a shallow foundation but not a pile foundation. This is because the borehole had met a layer of highly stiff grey clay/lime, and as a result, a pile foundation may not be necessary due to the compressive strength of the clay beneath the ground. Using a shallow foundation would, therefore, cut down costs and labour during the construction period and design of the building.

Soil Analysis Results: 100-acre Plot

Figure 1.14 shows the location of the five (5) sampling sites that were taken on the 100-acre property. Table 1.2 shows a summary result of two samples taken in the 100 acre lots. **Annex A** is the entire soil analysis report for both lots. Notably, of the five (5) sampling sites, only four of the sites were sent for agricultural testing as it was deemed unnecessary to test Site C due to having highly similar geological characteristics to the other sites. However, Sample C instead was sent for a heavy metal analysis so as to measure a general estimate for the 100-acre plot of land. As a result, the sites of A, B, D, and E were sent to the agricultural laboratory for testing with site C being sent for heavy metals.

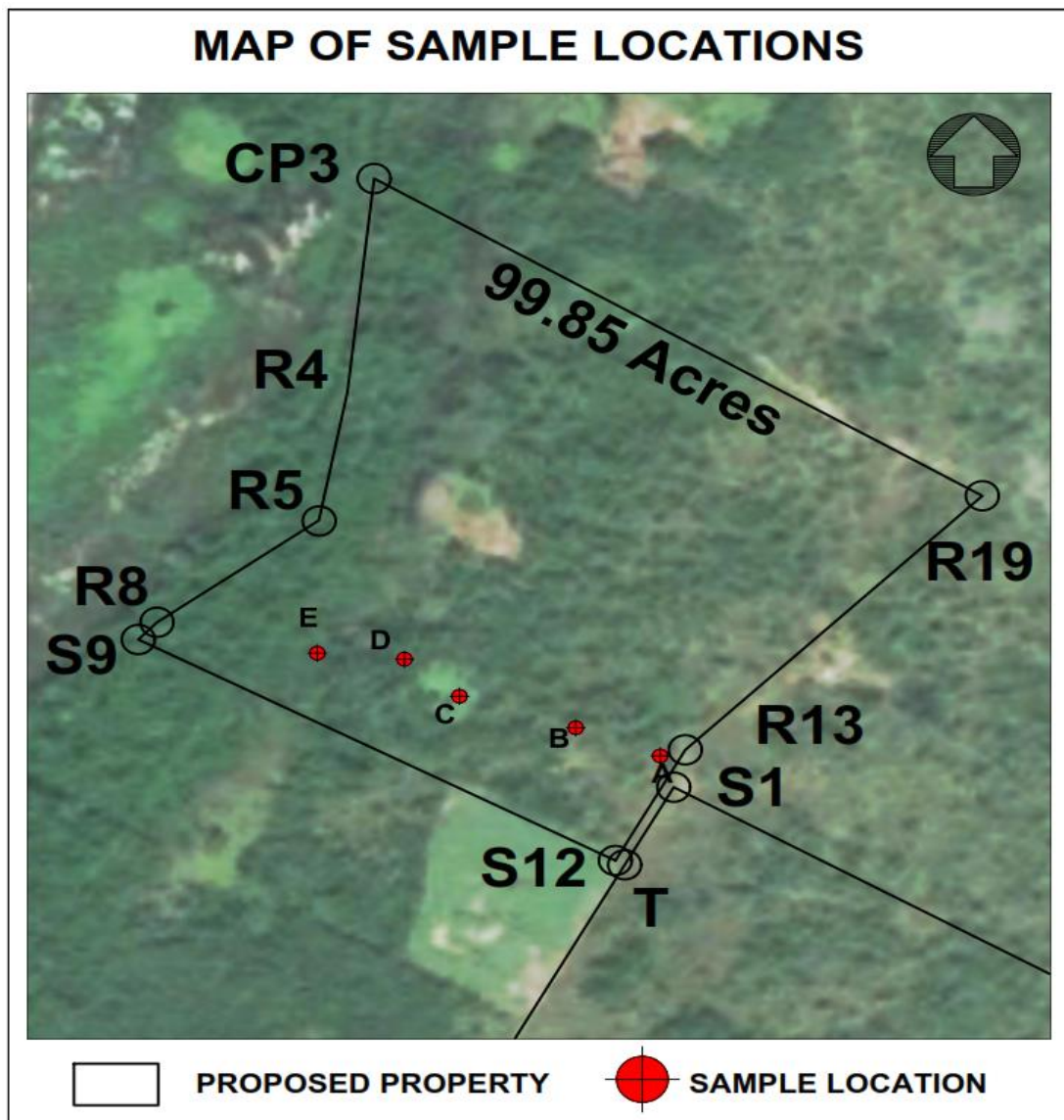


Figure 1.14: 100-acre Plot Sampling Locations

POINT INFORMATION FOR THE MAP ABOVE

Table 1.2: 100-acre Plot Sampling Locations.

SAMPLE LOCATION	EASTING	NORTHING
A	319771.676	1996175.801
B	319674.178	1996212.340
C1, C2	319540.087	1996253.424
D	319476.580	1996301.715
E	319375.959	1996309.507

*****Easting & Northings are in meters (UTM-WGS84) *****

Table 1.3: Summary Results of Sample 3-A and 4-B- 100 Acre Lots.

100 Acre Lot		Sample 3-A		100 Acre Lot		Sample 4-B	
Elements		meq/100cm ³	lbs/acre	Elements		meq/100cm ³	lbs/acre
Act. Acidity	A.A	0.3		Act. Acidity	A.A	0.2	
Calcium	Ca	2.9	1044	Calcium	Ca	4.5	1620
Magnesium	Mg	0.43	93	Magnesium	Mg	0.56	121
Potassium	K	0.35	294 K ₂ O	Potassium	K	0.29	244 K ₂ O
Sodium	Na			Sodium	Na		
Ca/MG Ratio	Ca/Mg	6.7	6.7	Ca/MG Ratio	Ca/Mg	8	
Mg/K Ratio	Mg/K	1.2	1.2	Mg/K Ratio	Mg/K	1.9	
		ug/cm ³				ug/cm ³	
Nitrogen	N	3	58	Nitrogen	N	3	5
Phosphorus	P	19	77	Phosphorus	P	16	65
Sulfur	S	117	211	Sulfur	S	67	121
Boron	B	0.72	1.3	Boron	B	0.85	1.5
Copper	Cu	1.9	3.4	Copper	Cu	1.2	2.2
Iron	Fe	4	7	Iron	Fe	97	174
Manganese	Mn	23.2	41.8	Manganese	Mn	18.4	33.1
Zinc	Zn	0.8	1.4	Zinc	Zn	0.7	1.3
Other				Other			

Discussion of Results of soil borehole analyses

Any agricultural recommendations stated here must be cleared by an agricultural engineer first before any operations are carried out.

pH Analysis

Notably, the pH levels of the 12 samples are within the range of 5.2 – 6.2, which shows that the soil is acidic. This may pose a problem as *Arundo donax* thrives within alkaline soils. As a result, lime/nitrogen may need to be applied to the soil before any agricultural activities in order to bring up the pH of the soil. It should be noted however that *Arundo donax* is considered a hardy plant and therefore it is possible that it may survive within acidic conditions.

Mineral Analysis

It can be directly noted that various minerals within the collected samples are below the optimum limit for agriculture within the 100-acre plot of land. This is expected as the lands are considered marginal in terms of cultivation potential.

For example, within Sample A, the levels of Calcium, Magnesium, Potassium, Nitrogen, Phosphorus, Copper, Iron and Zinc are below the optimal limit, with several of the levels additionally being below the critical limit. As a result, in order to increase the agriculture potential of this property various minerals would need to be tilled into the ground at location A.

However, by further analysing the data it can be noted that in lands closer to the creek, the greater the levels of minerals. As the Calcium, Magnesium, Phosphorus, Copper, Iron and Zinc all generally increase gradually leading up to Sample E.

The levels of Iron were just above the optimal limit in samples B, D and E; Copper and Zinc rises as well but stays below the optimal value.

Phosphorus (P) levels are at optimal values in Samples D and E, which are the locations closer to the creek than B and A. Conversely, Sulphur (S) levels display an opposite trend being at its lowest at Samples D and E while being at its highest at Sample A. Sulphur remains within the optimal threshold throughout the sites sampled, and, therefore, its concentration does not pose a major concern. Nitrogen (N) levels are noted to be far below the critical limit for all Samples and, therefore, will need to be tilled into the soil before crops can be planted. This is because it is known that P, S and N are all vital minerals for plant growth.

The greatest increase in concentration values seems to be of the elements of Calcium and Magnesium however, as they both display significant increase in areas closer to the creek, (Samples D and E). Magnesium levels increase from below the critical limit (Sample A), to the optimal threshold within Samples (D and E). Calcium concentrations increase heavily to the point where the optimal threshold is exceeded in Sample E. As a result, the advised Ca/Mg ratio is exceeded in 3 of the 4 samples. The levels of Potassium remain relatively equal within the samples with the exception of Sample E, which displays levels almost half of the critical limit.

From the results it can be concluded that the location of Sample D has the “richest” levels of mineral composition as opposed to the other samples, since it displays the highest number of minerals within the “acceptable levels” category. The land must generally be brought up to an optimal level within all mineral values in order to create an ideal scenario for agriculture. Therefore, taking into account this mineral data, it can be recommended to “mix” the soils nearer to the creek with the areas that are farther away, in order to create an even mixture of the mineralogical composition.

Heavy Metal Analysis

The heavy metal levels of Cobalt (Co), Chromium (Cr), Cadmium (Cd), Lead (Pb) and Nickel (Ni) were tested for Samples C1 and C2 at the specified location. It should be noted that Sample C1 is located near the surface and C2 is below ground.

In Sample C1 it is noted that there are greater levels of Lead at 17.6 ppm as opposed to the other heavy metals that were tested, as the next closest value to this is Chromium at 14.3 ppm.

It is not expected that these values should affect the growth of *Arundo donax* negatively as noted by (Han et al, 2005); which showed that *Arundo donax* is capable of surviving in harsh heavy metal conditions with levels of 100 ppm (mg/kg) for Copper, Lead, Cadmium, etc. However, with a very high level of Chromium at 100 ppm, *Arundo donax* is heavily stunted and withers away in a short period of time.

As a result, the levels of heavy metals shown within the samples taken are not expected to affect the crops adversely.

In terms of high temperature corrosion within the bio-mass energy applications however, heavy metals can cause variable levels of corrosion due to various processes. While data in terms of the level/amount of heavy metals that causes the corrosion is scarce, it is known that by coating the furnace tubes with a nickel-alloy reduces the corrosion of inside the tubes significantly (Alipour, 2013). This is because the nickel alloy changes the corrosion mechanisms, which leads to the dramatic reduction.

It is noted that for stainless steel coatings the primary corrosion mechanisms were a mixture of both chlorine attack and potassium-lead attack, while the nickel-alloy coating only had potassium-lead attack mechanisms (Alipour, 2013). Therefore, in considering that lead levels of the samples are generally the highest within the samples, some form of protection may need to be looked into, such as the nickel-alloy coating for the furnace tubes.

Soil Analysis Results: 400-acre Plot

Figure 1.15 below shows the location of the sixteen (16) samples from the twelve (12) sampling sites that were taken on the 400-acre property. Notably, of the sixteen (16) samples, only twelve (12) of the samples were sent for testing as it was deemed unnecessary to test a few of the sites due to being located within soils of similar geological composition and characteristics as the others. As a result, the sites 1, 2, 3, 5, 6, 7, 9, 10, 11, and 12 were tested. Table 1.4 is a summary of the results of the two samples taken. Annex A contains the remaining soil analysis report in its totality.

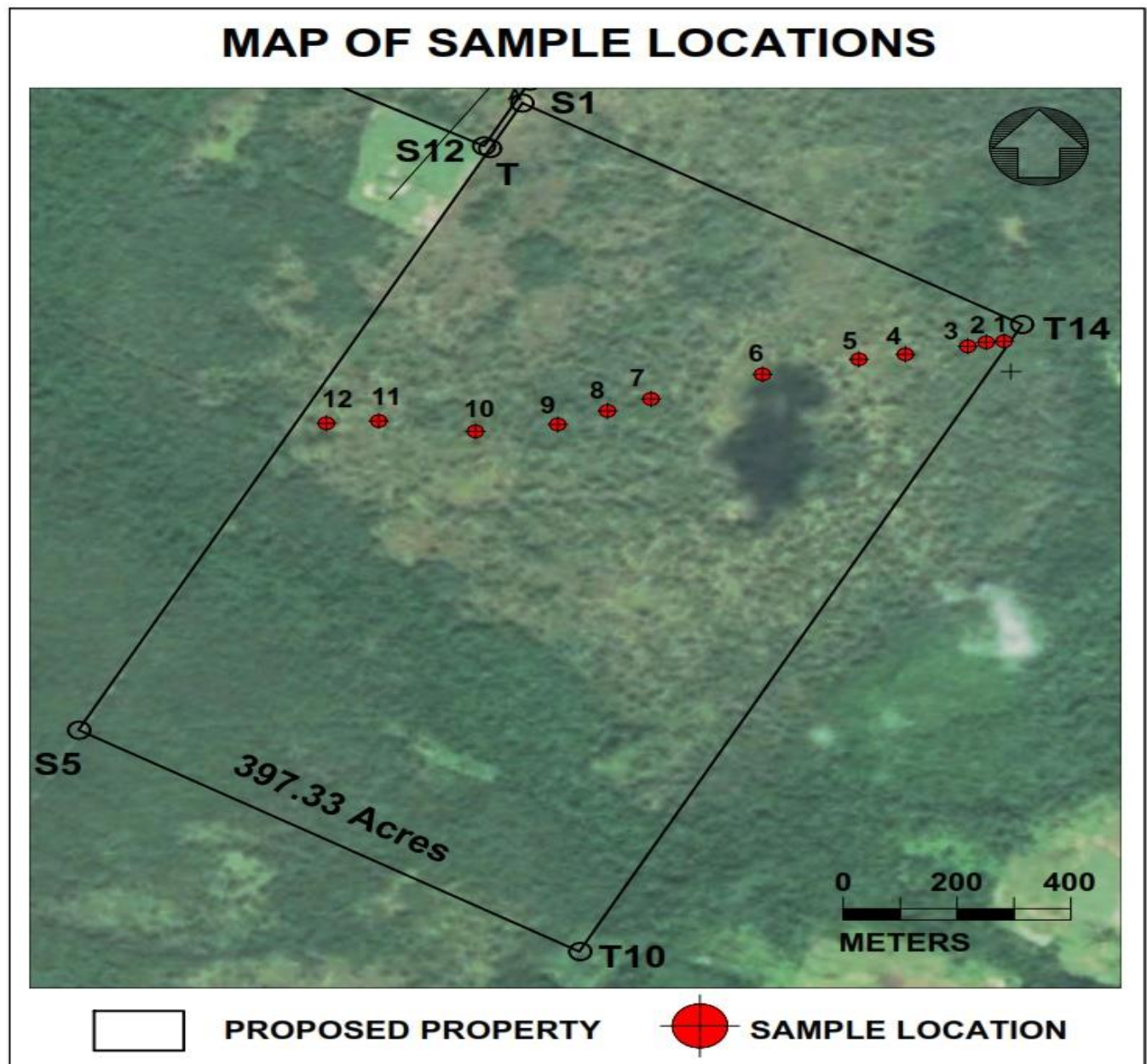


Figure 1.15: Sampling Locations for 400-acre plot

POINT INFORMATION FOR THE MAP ABOVE

Table 1.4 Sampling Locations for 400-acre plot.

SAMPLE LOCATION	EASTING	NORTHING
1	320633.728	1995605.707
2	320602.472	1995603.559
3	320569.991	1995594.780
4A, 4B	320460.128	1995576.639
5A, 5B	320326.624	1995555.285
6	320209.198	1995532.345
7	320013.443	1995477.584
8A, 8B	319936.962	1995451.059
9A, 9B	319849.435	1995420.983
10	319704.972	1995405.710
11	319534.919	1995428.640
12	319442.962	1995423.511

*****Easting & Northings are in meters (UTM-WGS84) *****

The A and B prefix to the numbering is a field specification stating that the sample was collected from the top of the borehole (A), and the bottom of the borehole (B)

Table 1.5: Summary Results of Samples 1-1 & 10-10 at 400 Acre Lot.

400 Acre Lot		Sample 1-1		400 Acre Lot		Sample 10-10	
Elements		meq/100cm ³	lbs/acre	Elements	Symbols	meq/100cm ³	lbs/acre
Act. Acidity	A.A	0.3		Act. Acidity	A.A	0.3	
Calcium	Ca	5.7	2051	Calcium	Ca	4	1440
Magnesium	Mg	0.83	180	Magnesium	Mg	0.69	150
Potassium	K	0.1	84 K ₂ O	Potassium	K	0.16	134 K ₂ O
Sodium	Na			Sodium	Na		
Ca/MG Ratio	Ca/Mg	6.9		Ca/MG Ratio	Ca/Mg	5.8	
Mg/K Ratio	Mg/K	8.3		Mg/K Ratio	Mg/K	4.3	
		ug/cm ³				ug/cm ³	
Nitrogen	N	3	5	Nitrogen	N	3	5
Phosphorus	P	26	106 P ₂ O ₅	Phosphorus	P	34	139 P ₂ O ₅
Sulfur	S	30	54	Sulfur	S	100	180
Boron	B	0.83	1.5	Boron	B	0.65	1.2
Copper	Cu	1.8	3.2	Copper	Cu	2.9	5.2
Iron	Fe	31	55	Iron	Fe	28	50
Manganese	Mn	20	36	Manganese	Mn	15.7	28.3
Zinc	Zn	1.2	2.2	Zinc	Zn	1.2	2.2
Other				Other			

Discussion of Results of borehole analyses – 400-acre plot

Any agricultural recommendations made here must be verified by an agricultural engineer prior to any operations that are carried out based on such recommendations.

pH Analysis

Notably, the pH levels of the 12 samples are within the range of 5.0 – 5.8, which shows that the soil is acidic. This poses a problem as *Arundo donax* thrives within alkaline soils. As a result, lime/nitrogen may need to be applied to the soil before any agricultural activities in order to bring up the pH of the soil. It should be noted however that *Arundo donax* is considered a hardy plant and therefore it is possible that it may survive within acidic conditions.

Mineral Analysis

The twelve samples that were sent to the lab had shown variable results throughout the area in terms of the mineral content. Most notably is the extremely low to almost nil values of nitrogen (N) within the soils for all samples, which is not ideal for agriculture purpose since Nitrogen, Potassium and Sulphur are known to be vital minerals for plant growth. Therefore, it is recommended that nitrogen be tilled into the soil before agricultural activities are started. Separately however, the levels of Potassium and Sulphur are within their optimal values throughout the twelve (12) samples that were tested with only samples 2, 7 and 9A showing sub-optimal levels of Potassium.

The values of Calcium, Magnesium and Potassium vary generally throughout the samples collected and analyzed. Calcium, which shows the widest reported range, varies between optimum levels and sub-optimal levels throughout the sampling locations with samples 1, 9A, 9B and 10 being the only samples with above-optimal levels. Notably, the calcium levels between 9A (near-surface) and 9B (below-ground) vary drastically and as a result there is the possibility of higher levels of calcium within the earth near this location. The magnesium level at location 9 also has a similar trend, where it rises greatly to an optimal level but only at this specific sample. Magnesium levels throughout the rest of the sample locations are well below optimal range with all of the samples being even below critical level. This is also seen with the Potassium levels which most (10 out of 12) are well below the optimal range as well with a few variances in values.

The levels of Copper are varied throughout varied the sampling, with some samples being just above the optimal limit and others being just below. However, there is a significant increase in copper levels in sample 5A, which displays results well over the optimal range. According to the topographical map, sample location 5 is located in the higher area of property which may have some effect on it. Unlike the copper levels however, the iron and zinc levels are relatively steady/stable. As the iron levels for all 12 samples are just above the optimal limit for agriculture, while the zinc levels for all 12 samples are all well below the optimal limit. This may prove some level of homogeneity within the 400-acre plot for zinc and iron levels within the soil.

Therefore, in noting the presented mineral data, there would be some merit to ploughing the land in order to create a better homogeneity between the surface and below-ground minerals, in addition to tilling adequate amounts of nitrogen (nitrates) into the soil.

Heavy Metal Analysis

The heavy metal levels of Cobalt (Co), Chromium (Cr), Cadmium (Cd), Lead (Pb) and Nickel (Ni) were tested for Samples C1 and C2 at the specified location, and it should be noted that Samples 4A and 8A are near the surface and 4B and 8B are below ground.

In Sample 4A it is noted that there are greater levels of Lead at 11.0 ppm as opposed to the other heavy metals that were tested, as the closest value afterwards is Chromium at 6.5 ppm in Sample 8B. Afterwards, the values of the other heavy metals throughout the four (4) samples remain lower than 4 ppm.

These values should not affect the growth of *Arundo Donax* as noted by (Han et al, 2005), which showed that *Arundo Donax* is capable in surviving in harsh heavy metal conditions with levels of 100 ppm (mg/kg) for Copper, Lead, Cadmium, etc. However, with a very high level of Chromium at 100 ppm, *Arundo Donax* is heavily stunted and withers away in a short period of time.

As a result, the levels of heavy metals shown within the samples taken are not expected to affect the crops adversely.

In terms of high temperature corrosion within the bio-mass energy applications however, heavy metals can cause variable levels of corrosion due to various processes. While data in terms of the level/amount of heavy metals that causes the corrosion is scarce, it is known that by coating the furnace tubes with a nickel-alloy reduces the corrosion of inside the tubes significantly (Alipour, 2013). This is because the nickel alloy changes the corrosion mechanisms, which leads to the dramatic reduction.

It is noted that for stainless steel coatings the primary corrosion mechanisms were a mixture of both chlorine attack and potassium-lead attack, while the nickel-alloy coating only had potassium-lead attack mechanisms (Alipour, 2013). Therefore, in considering that lead levels of the samples are generally the highest within the samples, some form of protection may need to be looked into, such as the nickel-alloy coating for the furnace tubes.

Geology- summary

Section 1.3.5 contains greater detail of the geology of the project site.

Belize's geology has been divided into two broad formations: the older Maya Mountains or Mayas Series, which are of Paleozoic age and the younger Cretaceous to Eocene age limestones and non-calcareous sediments which form the lowlands north and south of the Maya Mountains (Dixon, 1956).

The older Paleozoic rocks are composed of “graywackes, quartzites, slates, phyllites and shales with some schists and gneisses” (Dixon, 1956). In the southwest of Belize, these rocks are overlain by the Macal Series, which are Upper Pennsylvanian to Middle Permian in age, which are then overlain by limestones of Cretaceous – Eocene age, the youngest of the rocks (See Geology Map).

The Northern Coastal Plain land region, which includes Corozal and Orange Walk, consists of karst topography dominated by cavernous limestones. Ground and surface water are abundant, and with the exception of a relatively high hardness, ground water quality is generally acceptable as a source of potable water in most places.

The Orange Walk has extensive deposits of white marl which contain marine shells and fragments of coral, interbedded with siltstones, sands and clays. These limestones are said to be of Miocene-Pleistocene age of the Orange Walk Group, and may be overlain by recent alluvium. The Geology Map of Belize (Cornec, 2003); details the Late Tertiary Limestones of the Red Bank and Orange Walk Group as comprising of clays, gypsum, sand, chert, marls and limestone. This formation is overlain by alluvium.

1.3.2Landscape Character

1.3.2.1 Existing Views and Character of Landscape

Based on the images and Ecosystem Classification, at least three vegetation or ecosystem types are prominent: Lowland savannah, Lowland broad-leaved moist scrub forest, Lowland broadleaf Moist forest. Aerial photographs were captured using a drone were used to get a clear idea of the status of the area.

As mentioned in the location section, the two nearest villages are or will not be affecting any sensitive area, tourism or growth/expansion of any of the two villages. Additionally, as can be noted from the photographs below, there is some minor agricultural activity in the immediate vicinity.



Plate 1.3.2a: Photograph of Clearing as part of the agronomic trial replicates.



Plate 1.3.2b: Photograph of Aerial View of Savanna – 400 acres site.



Plate 1.3.2a: Aerial View of Blue Creek, Moist Forest and Savanna – 100-acre site.



Plate 1.3.2c: Photograph of Aerial View of Lowland Broadleaf Forest - Bajo and Scrub.

1.3.2.2 Site Suitability for A. donax cultivation

Site suitability based on location

Alternative sites were evaluated by the experts from the 5 Cs by visiting sites that had existing *A. donax* vegetation growing naturally. This was followed by the use of geographic information systems provided by the Land Information Center (LIC) of Belize and from the Cathalac Research Institution based in Panama. Several sites in the Stann Creek District were identified, but the feasibility of transportation of the biomass to the Belcogen plant was obviously prohibitive; thus, eliminating these sites. Further planning allowed the team to select sites within the Orange Walk District in a close proximity to the Belcogen facility, but avoiding the risks for flooding and similar disasters.

There were two stages of site selection using the avoidance method. During this process, other lands that are suitable and have *Arundo donax* vegetation were identified but later eliminated using these criteria. In order to accomplish this, it was necessary to identify available property suitable for *A. donax* cultivation and to eliminate all sites that are at risk to flooding and excessive inundation; and those that would conflict with other land uses. This was done by the preparation of a map showing the location of *A. donax* and other areas in the Orange Walk District. A series of criteria were then used to eliminate potential sites to avoid: (1) protected areas, (2) flood hazard risk (including storm surge), (3) fire hazard, (4) national waters, (5) agriculture farms (banana and sugar cane), (6) soil types; and (7) Transportation access. This process ensured that potential sites avoided from the onset all the above risk factors. Therefore, the avoidance of flood prone areas, for example, is in itself an avoidance technique that is also mitigation against flood risks.

During project planning, consideration was also given to criteria such as physical location in terms of proximity to the BELCOGEN Plant, transportation availability in terms of roads and other infrastructure, as well as the elimination of parcels that are subject to total inundation and that are vulnerable to flooding were selected. Therefore, the avoidance of high-risk sites was done via this process, resulting in the selection of the existing sites.

Site selection based on Crop Suitability

Research first focused on identifying lands not being used for agriculture that had certain characteristics, including already growing species that could be evaluated for biomass feedstock. This resulted in the identification of *Arundo donax*, and *Acacia magnum*. *Arundo donax* was selected since it was considered more suitable primarily because it is not considered an invasive species, has proven systems of control, has high energy yields, grows on marginal lands and displays natural resistance to drought, flood fires and pests. Research also indicated that the crop can grow in lands that are in proximity to the BELCOGEN plant.

In addition, research indicated that *Arundo donax* as a biofuel substitute displayed characteristics such as surpassing bagasse in terms of potential crop yields and calorific value. It was also found to have lower ash content than bagasse, which could make its combustion even cleaner than bagasse, while its higher moisture content makes it hardy in terms of its resistivity to fires during cultivation (ERCA Environment and Risk Management Plan *Arundo Donax* Belize, Final Report, 2016).

Suitability due to Access roads and transportation routes

The site is accessed through San Lazaro village via an access road that leads to the project site. For the *Arundo donax* to be delivered to Belcogen, the easiest and fastest route (Route 1) is through Orange Walk Town. Alternatively, the Belcogen factory can be reached via Route 2 (**Figure 1.6**).

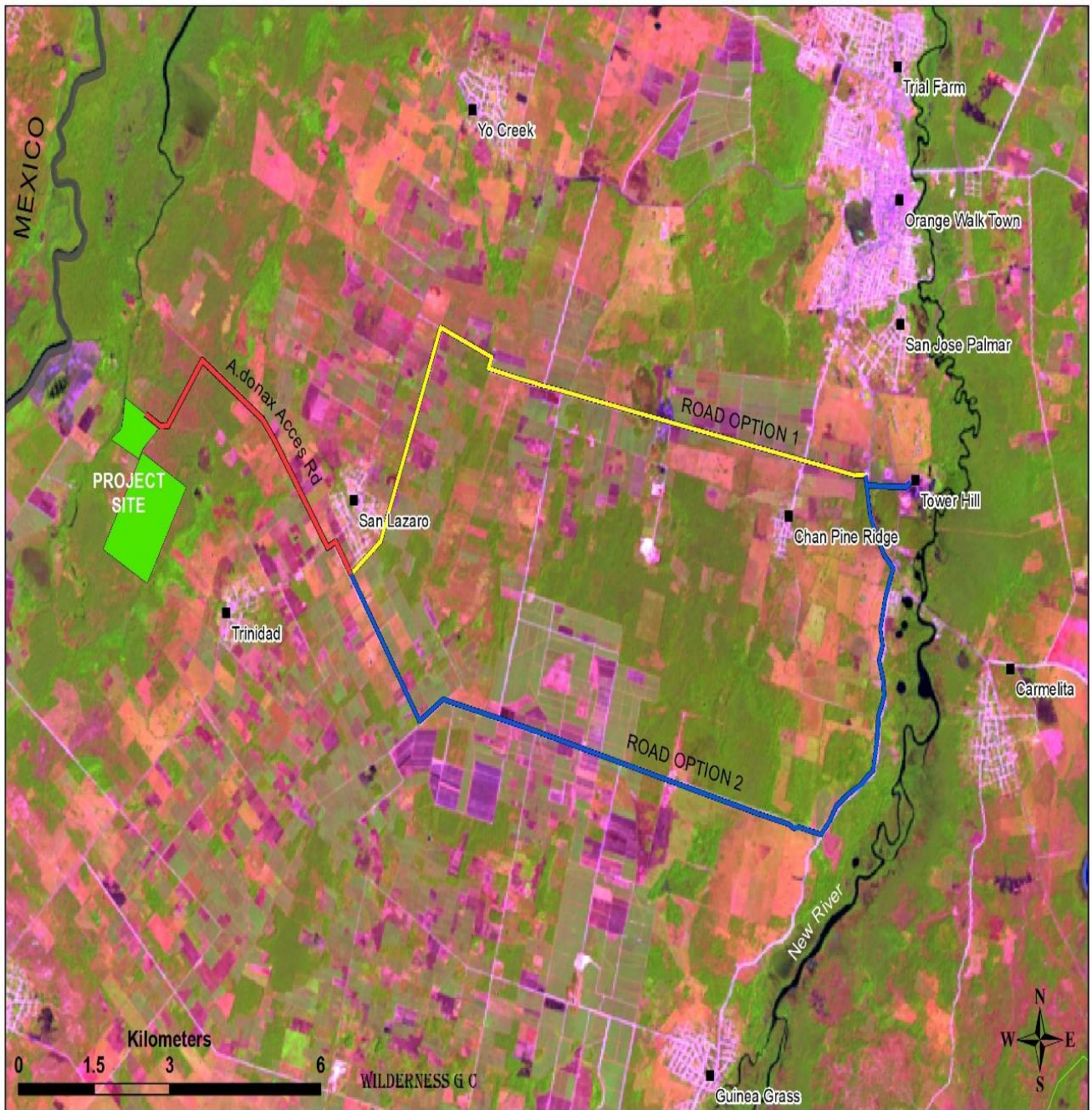


Figure 1.16: Transportation Route

Management Structure

The project will be managed by four (4) persons who will be hired on a contractual basis as follows:

Table 1.6: Number of Employees and Positions to be Held.

Position	Amount
Project Manager	1
Technical Officer	1
Field supervisors/officers	1
Field Workers	1

1.3.2.3 Land Characteristics and Landscape

Character - Potential Impacts and Mitigation Planning

Considering that the site and property has passed the physical and logistics screening criteria to meet the level of suitability as acceptable for the cultivation and management of *Arundo donax*; the issue of potential impacts and proposed mitigation and compensation requires consideration for adoption and implementation of these mitigation and compensation strategies.

Based on the site selection criteria for suitability due to proximity to the Belcogen plant, accessibility, as well as the availability of land etc, there is then the need for the mitigation against possible natural disaster. While the potential sites do not fall within an area of high risk for disasters, there is a low risk for flooding in some parts of the property. There is also a need to plan for such unavoidable phenomenon, primarily hurricanes and storms. As a result, the site disaster planning will focus primarily on the development of a hurricane preparation and evacuation plan for the employees operating within the project sites. Furthermore, as part of the Disaster Management Plan, a fire management plan has been drafted. The draft documents detailing the hurricane plan and fire plan are located in Chapter 6.0 of the ESMP, which constitutes a part of the deliverable of the present ESIA/ESMP consultancy.

Table 1.7: Potential Impacts of Existing Land Use and Land Use Character Changes.

Activities	Degree of Impact	Mitigation Measure
Land Clearing	<ul style="list-style-type: none"> • Removal of Top soil • Increased Erosion 	<p>Land clearing activities will involve the removal of all the vegetation and exposing the top soil.</p> <ul style="list-style-type: none"> • The cleared vegetation will be shredded and returned to the land as smaller pieces of biomass – some of which will be incorporated into the soil. • The burning of the waste vegetation will not be allowed. • The remaining vegetation stands will be maintained in their original form. • Land clearing will be carried out during the dry season. This will minimize the creation of ruts that can eventually lead to increased erosion. • Land clearing will be done in phases so as to reduce the impacts. •
Landscape Changes	Alteration of visual character of landscape	<ul style="list-style-type: none"> • A buffer zone will be left intact around the property to reduce negative visual impacts, and to reduce erosion. • Land clearing will be done in phases so as to reduce the impacts.

1.3.3 Air Quality

1.3.2.1 Meteorology

Climate, Weather and Rainfall

Belize has six districts, Corozal and Orange Walk, considered the northern region or sometimes described as the northern corridor by other project planners. The central region or corridor comprises the Belize and Cayo Districts; and the southern corridor comprises the Stann Creek and Toledo Districts.

The climate of Belize is characterized by two seasons: a rainy and a dry season. In Belize, most of the year's rainfall occurs during the period June to November, which defines the rainy season. Mean annual rainfall across Belize ranges from 60 inches (1524mm) in the north to 160 inches (4064mm) in the south. Except for the southern regions, the rainfall is variable from year to year.

Northern Belize reports far less rainfall than southern Belize. The average monthly rainfall average is relatively low when compared to the rest of the country. However, this also varies from year to year. Based on the isohyets map produced by the National meteorological Service (NMS), the project site receives rainfall ranging from 60 inches (1524 mm) to 80 inches (2032 mm) per year. During the peak of the dry season, (from April to May), this region should not expect a lot of rainfall in a normal year. However, for the remainder of the year (June to December), the area may expect up to 55 inches (1,427 mm) of rainfall. During the dry season, there are three critical months: February, March and April, during which, the area receives less than 5 inches of total rainfall (109.6 mm).

The Isohyets map of Belize (NMS), Figure 2 shows that the eastern area of the northern districts are included in the 60 (2032 mm) to 80 inches (2032 mm) of rainfall and the second part facing west is within the 60 inches (2032 mm) isohyets. Therefore, the proposed project area receives on an average, less annual rainfall than most of the country (60 inches).

Belize has a moist tropical climate with marked wet and dry seasons. A cool transition period separates the two main seasons, and extends from November through February. It is characterized by incursions of cooler, continental air masses and associated frontal systems that migrate southwards into northern Central America and the western Caribbean. The frontal activity often generates convective outbreaks on its approach, then intermittent precipitation as the cooler air mass is modified and recedes to the northeast.

In the wet season (June – November), mean monthly rainfall can vary between 150 to 400 mm, with highest rainfall totals in the south. Mean annual rainfall increases from the north to the south of the country, with a mean annual of about 1,400 mm (55 inches) in the northern districts to near 3,864 mm (152 inches) in the south, around the Punta Gorda Agricultural Station at 5 Miles (**Figure 1.16**). In the dry season (March – May), most of the country receives less than 100 mm of rainfall per month. The coastline of Belize is also vulnerable to hurricanes during the months of May through to October or early November. Torrential rainfall accompanying these storms contribute significantly to the high wet season rainfall totals (Frutos, 2014). Mean, annual rainfall in the Project area is about 60 inches (1,524 mm).

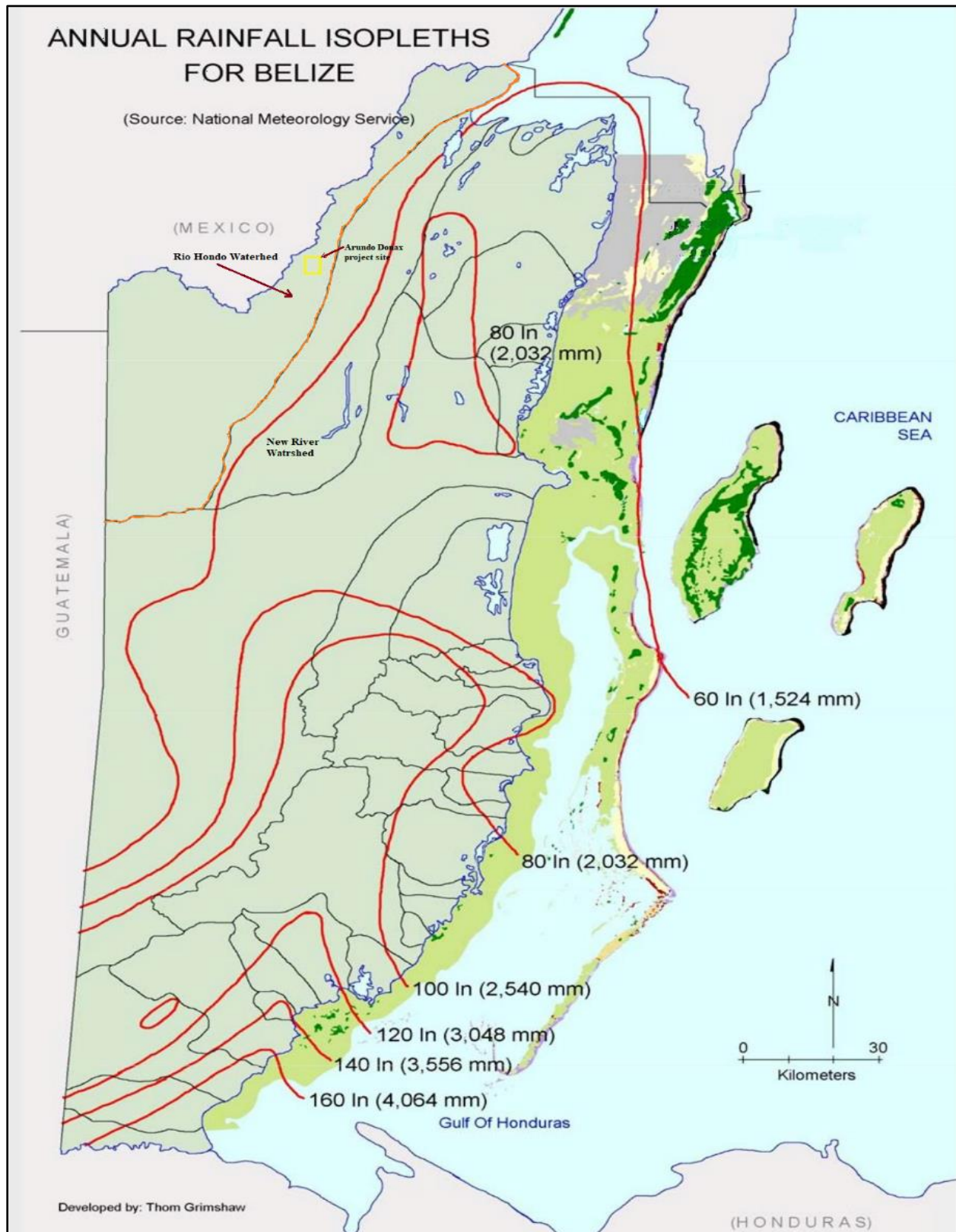


Figure 1.17: Monthly rainfall for BSI/ASR, Libertad, and La Milpa (Rio Bravo).

The annual rainfall distribution is bi-modal over northern Belize with peak rainfall in August and October (See **Figure 1.18**, monthly average rainfall for ASR/BSI, Tower-hill). The record, one-day rainfall in the Tower-hill area was 200 mm in 2001 associated with land falling Hurricane Chantal, while for Lap Milpa, the record one-day rainfall was 448 mm associated with Hurricane Keith in 2000. The record one-day rainfall for the Philip Golson Airport was 457 mm, also during the 2000 Hurricane Keith event (Golder & Associate, 2017).

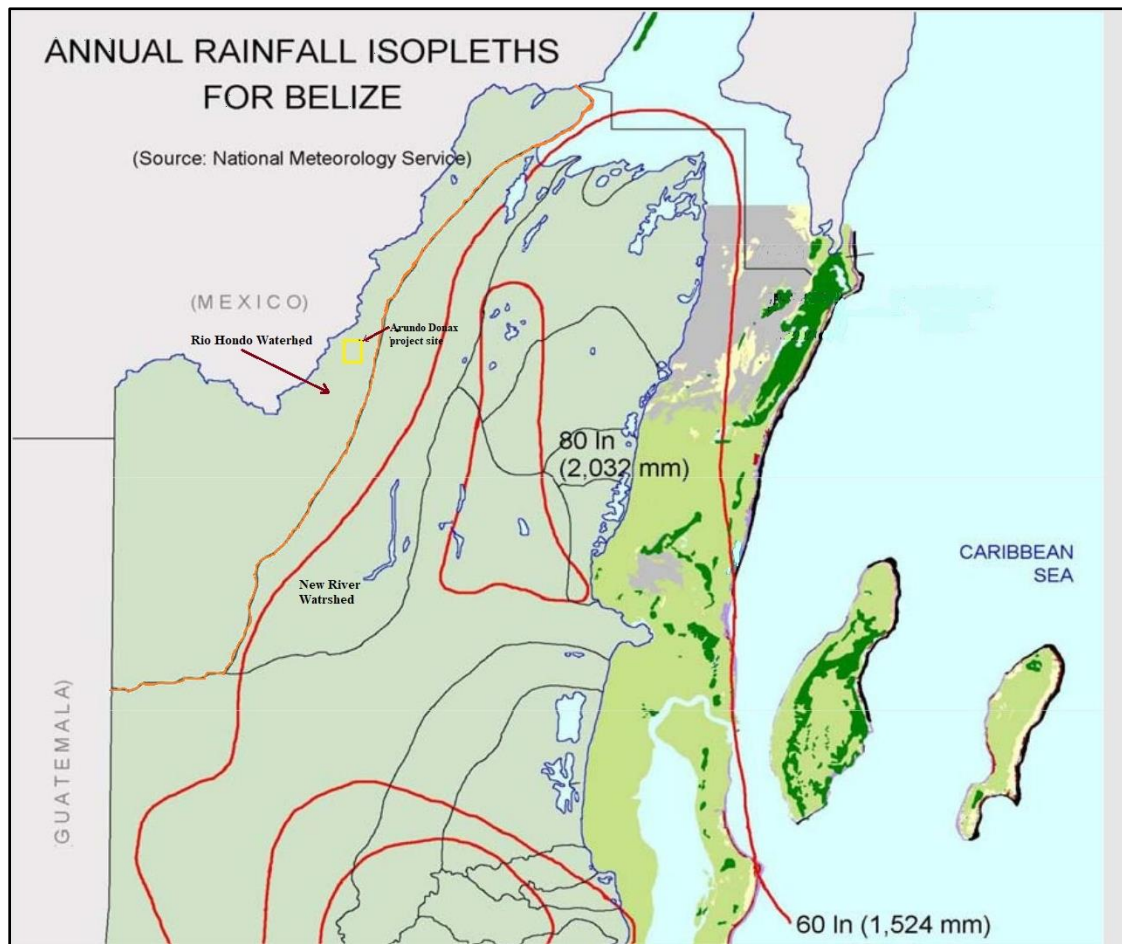


Figure 1.18: Mean Annual Rainfall (mm) in Belize

The rainfall at these northern localities is bimodal, with peaks in June and October, and a marked dry season from February to May.

Persistent easterly to northeasterly trade winds dominate the western Caribbean region during the rainy season, while brisk and drier southeasterly airflow suppresses rainfall during the drier months.

Temperatures vary according to elevation, proximity to the coast, and the moderating effects of the northeast trade winds off the Caribbean. Daily average temperatures in January, the coldest

month of the year, vary from 24°C along the coast to 22°C in the interior at Central Farm, and 20°C in the Baldy Beacon area of the Mountain Pine Ridge. Average temperatures in the coastal plains range from 24° C in January to 28° C in July. Monthly average evapotranspiration peaks in April (about 160 mm) and dips December and January (about 95 mm).

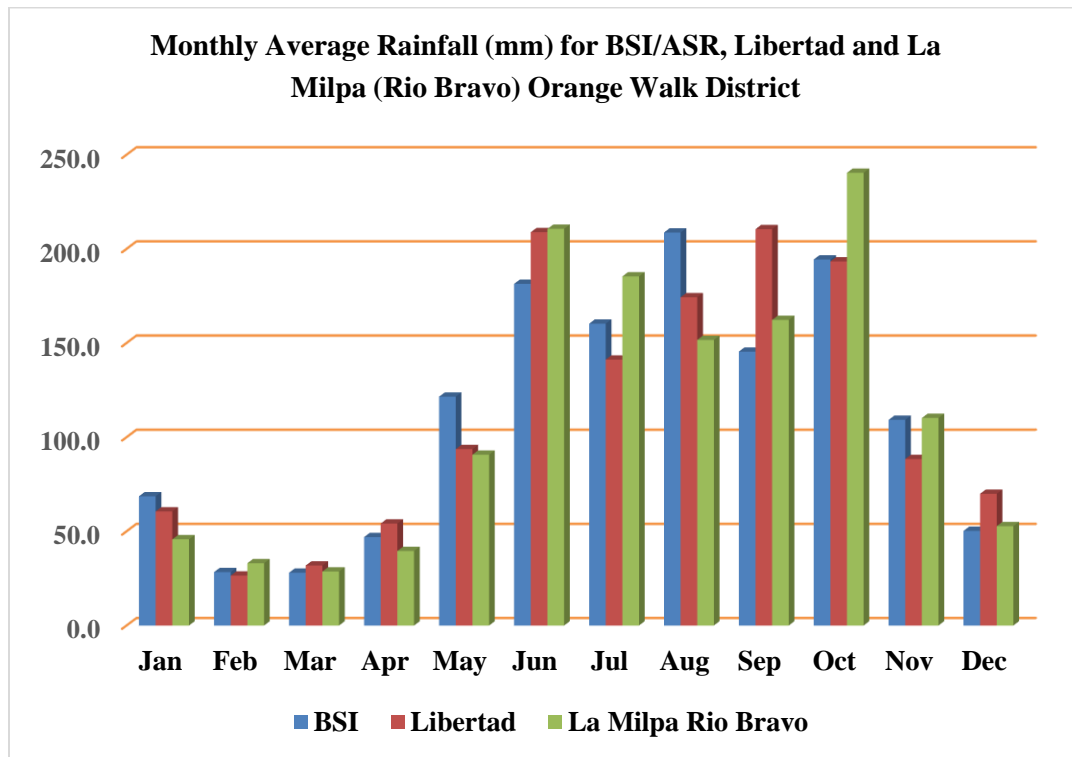


Figure 1.19: Mean monthly rainfall for BSI-ASR, Libertad and Rio Bravo

Extreme maximum temperatures in excess of 38°C often occur in the exposed interior and northern districts in April and early May, the height of the dry season. The annual mean Relative Humidity is 82%, but conditions can become oppressively humid from June until September, especially over coastal and northern regions.

Surface Winds

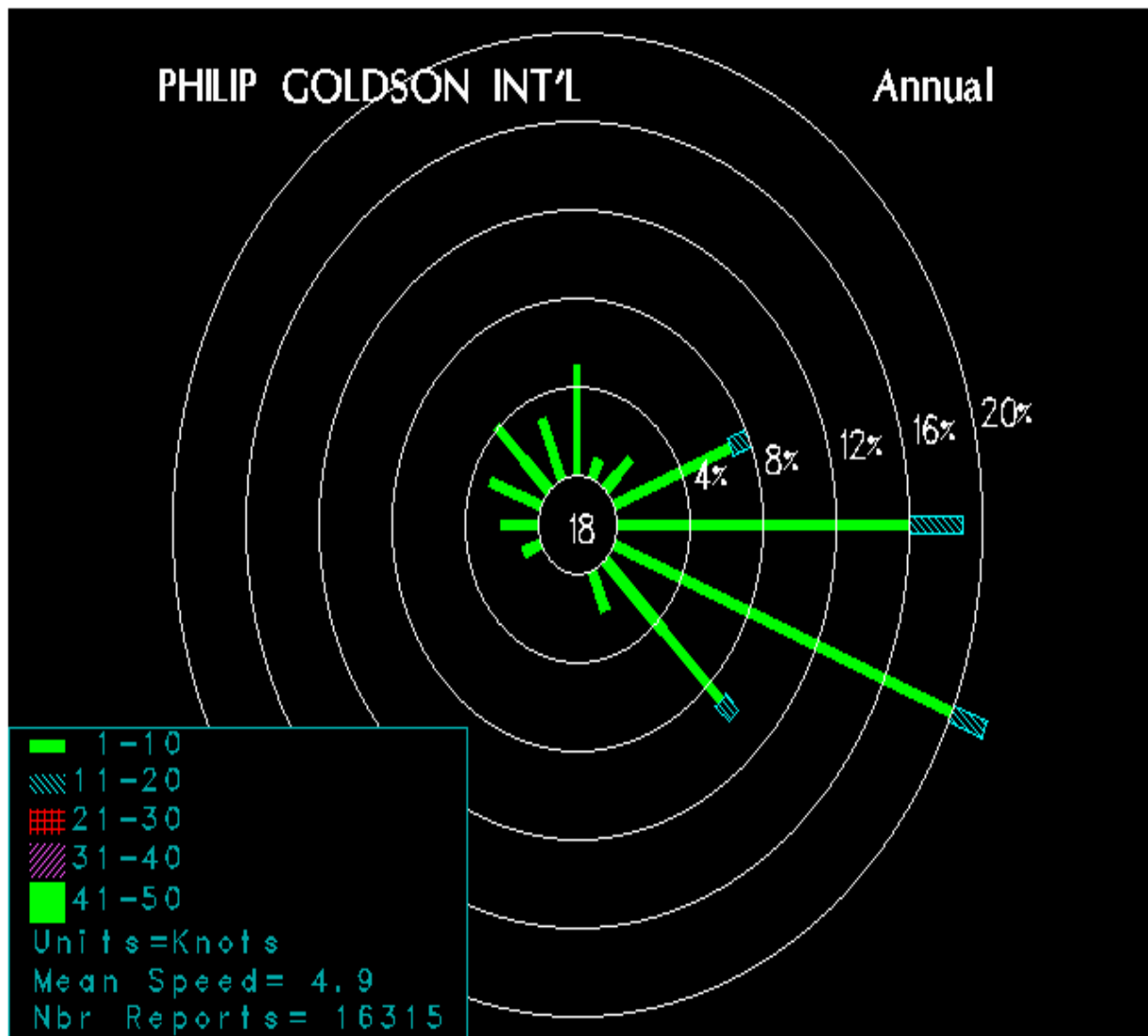


Figure 1.20: Annual mean wind rose for Philip Goldson International Airport

The prevailing wind across the northwestern Caribbean and Belize is a northeasterly to easterly trade on the southern limits of the West Atlantic Subtropical High. The annual mean wind rose (**Figure 1.20**) generated from daily and monthly surface wind observations for 1500 UTC at the Philip S. W. Goldson International Airport.

(PSWGIA) shows that an east-southeasterly wind is dominant 20 % of the time, followed by an easterly 16 % of the time, and a north-easterly 8% of the time. Wind speed is generally in the range of 1 to 10 knots (mean 4.9 knots), with smaller frequency of 10 to 20 knots. Historically,

the maximum surface winds occurred in September (excess of 70 knots), followed by July (60 knots) for the period 1961-1996 (Source NMS, Belize). These maximum winds in September and July were associated with land-falling tropical cyclones.

Local Weather

Using an Accurite Weather Station, weather data was gathered near communities within the zone 1 area of influence. Table 1.8 summarizes local weather data collected from August 21 to 26 2019.

Table 1.8 Summary of local weather data collected from August 21 to 26 2019.

Day (August 21-26) 2019	2019	Tower Hill	Yo Creek	San Lazaro	Trinidad
Wednesday 21					
	Weather condition	Partly cloudy	Partly cloudy	Partly cloudy	Partly cloudy
	Temperature (°F)	High 88°	High 88° Low	High 87°	High 87°
	Humidity	69%	69%	72%	71%
	Wind direction	E SE	E SE	E SE	E SE
	Wind speed	9 MPH	9 MPH	9 MPH	9 MPH
Thursday 22					
	Weather condition	Partly cloudy	Partly cloudy	Partly cloudy	Partly cloudy
	Temperature (°F)	High 91°	High 92	High 92°	High 92°
	Humidity	70%	70%	70%	70%
	Wind direction	E SE	E SE	E SE	E SE
	Wind speed	11 MPH	12 MPH	11 MPH	11 MPH
Friday 23					
	Weather condition	Partly cloudy	Partly cloudy	Partly cloudy	Partly cloudy
	Temperature (°F)	High 93°	High 94°	High 95°	High 94°
	Humidity	64%	63%	63%	63%
	Wind direction	E SE	E SE	E SE	E SE
	Wind speed	10 MPH	10 MPH	10 MPH	10 MPH
Saturday 24					
	Weather condition	Partly cloudy	Partly cloudy	Partly cloudy	Partly cloudy
	Temperature (°F)	High 94°	Hgh 95°	High 95°	High 95°
	Humidity	66%	66%	66%	66%
	Wind direction	E SE	E SE	E SE	E SE
	Wind speed	8 MPH	8 MPH	8 MPH	8 MPH
Sunday 25					
	Weather condition	Mostly sunny	Mostly sunny	Mostly sunny	Mostly sunny
	Temperature (°F)	High 94°	High 94°	High 94°	High 95°
	Humidity	65%	64%	64%	64%
	Wind direction	E SE	E SE	E SE	E SE
	Wind speed	9 MPH	9 MPH	9 MPH	9 MPH
Monday 26					
	Weather condition	Mostly sunny	Partly cloudy	Partly cloudy	Partly cloudy
	Temperature (°F)	High 93°	High 93°	High 93°	High 93°
	Humidity	65%	65%	65%	65%
	Wind direction	E SE	E SE	E SE	E SE
	Wind speed	11 MPH	11 MPH	11 MPH	10 MPH
Tuesday 27					
	Weather condition	Mostly sunny	Mostly sunny	Mostly sunny	Mostly sunny
	Temperature (°F)	High 93°	High 93°	High 93°	High 93°
	Humidity	65%	65%	64%	64%
	Wind direction	E SE	E SE	E SE	E SE
	Wind speed	11 MPH	11 MPH	11 MPH	11 MPH
Wednesday 28					
	Weather condition	Partly cloudy	Partly cloudy	Partly cloudy	Partly cloudy
	Temperature (°F)	High 90°	High 90°	High 90°	High 90°
	Humidity	70%	70%	70%	70%
	Wind direction	E SE	ESE	E SE	E SE
	Wind speed	10 MPH	10 MPH	10 MPH	10 MPH

Extreme Weather and Climate Change

Climate Change and climate variability will impact agriculture systems and practices such as soil fertility and land preparation; pest and disease control; and water requirements (excess and deficits). Higher temperatures will cause increased stress on current livestock breeds, and crop types and varieties. Climate Change and climate variability will very likely result in less rainfall overall, but the most detrimental effect is likely to come from the variation in the seasonal distribution of rainfall, leading to more periodic droughts and extensive floods. The project zone in the Trinidad area of the Orange Walk district is vulnerable to these projected climate extremes.

The results of analysis on climatic trends and future climate model projections for the western Caribbean region, including Belize, indicated that over the past 50 years temperatures have been rising steadily and are projected to continue along this trend. Rainfall variability has increased, and will likely become more pronounced in the future. Increases in seasonal evapotranspiration rates have been noted over the recent past, while significant decrease in wet season moisture surpluses is foreseen. Global sea levels have risen over the past 130 years and are forecast to continue rising during the 21st century (CCCCC/BEST, 2015).

Analysis of Climate Change projections suggested that, under the A2 scenario (worst case) Belize will experience temperature increases of near 2 °C by the 2050s and almost 4 °C by the 2080s, relative to the baseline period 1961-1990. The Regional Climate Models (RCM) projections for 2050 show percent change in rainfall in the order of -20 % to – 30 % from the reference period 1961-1990 under the A2 scenario, and around -50 % to -60 % change from normal by 2080.

In a recent climate modeling study, Cherrington *et al.* (2014) examined 13 latest-generation downscaled global climate models (GCMs) to see the effects of climate change, land use change and runoff for watersheds in Belize for the year 2050. The study showed that the potential change in rainfall patterns will range from -24.9% below the historical norm to 23.7% above the historical norm, with an average of 7.6% below the historical norm. Additionally, for 2050, the land use change scenarios indicate potential declines in forest cover across the entire geographic domain of 1.3% in a best-case scenario, to 22.6% in a worst-case scenario – relative to 2010 forest cover. Intersecting land use change scenarios with select climate change scenarios (5 of the 19), the results indicate that for the Belize River – the most populated watershed – with increased deforestation, runoff could potentially increase by 85.2% (under a slightly wetter climate) or, conversely, decrease by 12.1% (under a drier climate), whereas with decreased deforestation, runoff could potentially decrease by 40.4% (under a drier climate), or increase by 37.1% (under a slightly wetter climate).

These projections into the future highlight the possible effects Global Warming will have on the environment, exacerbated by anthropogenic activities. The effects of increased climate variability and extreme climatic conditions will put additional stress on rainfed agriculture cropping systems in the near, medium and long term. **Figure 1.21** is a summary of the regional climate model projection for Belize.

- ❑ **Temperature:** 2-4°C increase in temperature projected for 2050 to 2080
- ❑ **Precipitation:** -20 to -30% by 2050 & -50 to -60% by 2080 – Increased in spatial and temporal variability
- ❑ Heat waves; longer and intense droughts
- ❑ **Sea Level Rise:** 0.32 to 0.63 m by 2080
- ❑ **Storm surge: 2040 – 2065**
 - Category 2 hurricane 2.47 m
 - Category 5 hurricane 5.87 m
- ❑ **Storm surge: 2081 – 2100:**
 - Category 2 hurricane 2.91 m
 - Category 5 hurricane 6.31 m
- ❑ Increased frequency of major hurricanes (Cat 3 or stronger)

Figure 1.21: Summary of the Regional Climate Model Projection for Belize.

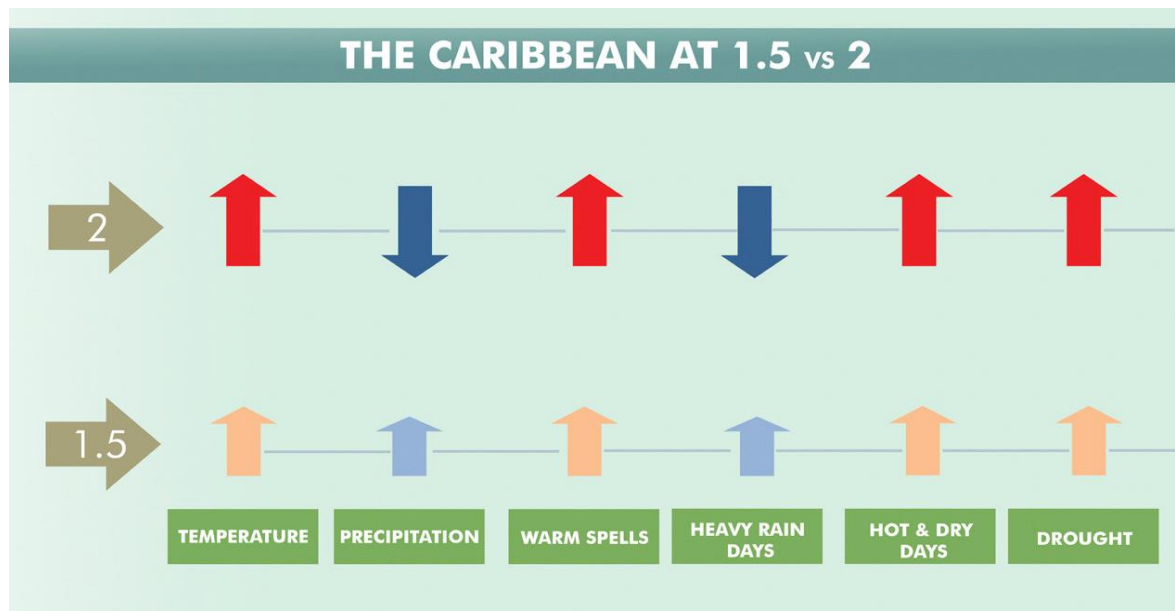


Figure 1.22: Some relative changes in Caribbean Climate for Global Warming

*Up/down arrows indicates increase/decrease relative to a 1971-2000 baseline. Size/Shading indicates magnitude/intensity of projected change. (Source: CCCCC, 2016).

1.3.3.2 Existing Ambient Air Quality

Dust and Particulate Matter – Construction phase

While it is expected that air emissions will result from the project, this is confined mostly to impacts during the combustion activity of the *Arundo donax* biomass at the Belcogen plant. Several tests aimed at collecting baseline data on several parameters have been done at sites near the Belcogen plant, and the zone of influence of the project.

Dust emissions and particulate matter pollution is likely to result during the site clearance, excavation of trenches and installation of equipment. However, these levels will be negligible and only the opening of a section of the access road within the compound will result in minor dust emissions during construction. Dust from this road will be minimal due to compaction, but will also be cumulative. Dust levels during the construction phase are not expected to be high above normal levels. Other dust will emanate from the upgrading of the access road, but will be a short-term temporary event.

Generation of exhaust emissions – Construction phase

Exhaust emissions are likely to be generated during the construction period by the various construction machinery and equipment. Motor vehicles used to mobilize the work force and materials for construction would cause air quality deterioration by emitting pollutants through gaseous exhaust emissions.

Potential for Air Pollution – Implementation phase

Potential air pollutants in the form of sulphur oxide and dioxide, carbon dioxide, nitrogen oxides, methane, CFCs, particulate matter amongst others will result from the combustion process. However, soot particles and fine dust may pose a health risk to employees, for which best management practices will be put in place such as the application of health and safety practices and the improvement of the air stack being operated by the Belcogen plant.

Air Emissions – Implementation Phase

Air emissions from the combustion process can result in potentially hazardous health effects. The lighting of a fire results in moisture being eliminated and as the fire burns hotter, chemical reactions occur that produce gases. Smoke contains the portion of these gases that are not burnt. Smoke is a complex mixture of many chemicals including carbon dioxide, water vapour, carbon monoxide, particles, hydrocarbons, nitrogen oxides and many other compounds. The actual composition of smoke depends on the type of wood and vegetation being burnt, the temperature of the fire and the wind conditions.

Particles from smoke tend to be very small – less than one micrometer in diameter. In comparison, a human hair is 70 micrometers in diameter. Biomass burning also produces carbon monoxide. The concentrations of carbon monoxide are highest when the fire is smouldering.

Thick smoke from biomass burning does not necessarily cause health problems for everyone exposed to it. Most healthy people recover quickly from exposure to smoke and do not suffer long-term effects. There are a number of factors that determine whether exposure to smoke results in health problems: the concentrations of the air pollutants, the length of exposure, age, individual susceptibility and whether or not there is pre-existing lung or heart disease.

It should be noted, however, that the combustion process at BSI/BELCOGEN uses “suspension” burning so there is a high ratio of air (O₂) to biomass to enable efficient combustion. It should be explained that the preliminary emissions test using the incinerator did not have the benefit of efficient/effective air supply (due to the low powered blower used). Neither was there any mitigation since the equipment’s filter system was not functional.

Smoke has a range of health effects – from eye and respiratory tract irritation to serious disorders such as breathing problems, bronchitis, increase in severity of asthma, cancer and premature death. The very fine particles in smoke can go deep into the lungs and fine particles, by themselves or in combination with other air pollutants, can make pre-existing diseases of the heart and lungs worse. Where there is short-term exposure to smoke, the particles are the most significant threat to public health.

High levels of carbon monoxide are poisonous to humans. However, carbon monoxide arising from smoke events does not usually reach levels that pose a risk to the general population, although fire fighters and people with heart disease can be at risk.

As is expected, ambient air testing of emissions at the project site and surroundings were detected at low to non-existent. Since the site is located away from large population centers, and away from industries, only a few sites showed very low levels of these emissions.

Air Quality Testing

On site sampling of existing air was done using three instruments. Sites were tested primarily to establish baseline parameters to establish baseline data for monitoring during project operation. Sites were tested for Nitrous oxides (NO_x), Nitrogen dioxide (NO₂), Sulfur dioxides (SO₂), Hydrogen Sulphide (H₂S), Carbon monoxide (CO), Carbon dioxide (CO₂), (Particulate matter 10), and combustible gases (LEL).

Measurements for Hydrogen Sulphide (H₂S) were obtained using the Sensidyne equipment and using reactive chemical gas detector tubes manufactured by Sensidyne. Particulate matter was done using a Casella Cel – 712 Dust Pro unit. The sampling method of the Sensidyne equipment is via the use of a metered “bellows style” pump to draw a precise amount of air through each tube. The tube was then observed for any changes of coloration indicating the presence of these gases. There was no detectable level of H₂S.

The remaining gases were tested using a Honeywell Micro-Max Pro tester (Plates 10 a to 10 c). The results are shown in Table 10-4 and the location of sites sampled is illustrated in Figure 7-4.

The levels measured for airborne particulate matters were very low, as shown in Table 10-3. Particulate matter is a mixture of various substances. These substances occur in the form of solid particles or as liquid drops. Some particles are emitted directly into the atmosphere. Other particles result from gases that are transformed into particles through physical and chemical processes in the atmosphere. A variety of emission sources and meteorological conditions contribute to ambient particulate matter. Similarly, combustion by fires can contribute to particulate matter.



Plate 1.3.3a: View of Microclip Gas Detector and Casella Dust pro Equipment Used in Air testing.



Plate 1.3.3b: Testing of Biomass Burning in Progress.



1.3.3c: Waste Disposal Along Access Road.



1.3.3d: Outdoor weather station used for weather data in Orange Walk.

The project activities that may lead to air pollution include:

- i) dust from vehicular movement, construction, soil exposure to wind,
- ii) dust from the mixture of concrete works and similar products,
- iii) smoke as a result of local burning of debris and waste material (organic)
- iv) flue gas a result of co-generation
- v) smoke from the Belcogen plant
- vi) particulate matter from the plant
- vii) Hydrocarbon particles as a result of heavy equipment and vehicular transportation (minimal).
- viii) Greenhouse gas emissions as a result of processing plant.

Particulate Matter

There are major concerns for human health from exposure to suspended air particles. For example, the effects of PM-10 include: effects on breathing and respiratory systems, damage to lung tissue, cancer, and premature death. The elderly, children, and people with chronic lung disease, influenza, or asthma, are especially sensitive to the effects of particulate matter.

PM 10. or Particulate matter is the term for solid or liquid particles found in the air. Some particles are large or dark enough to be seen as soot or smoke. Others are so small they can be detected only with an electron microscope. PM10 Mass - The PM10 standards are expressed as a weight of PM10 particles per volume of air (micrograms per cubic meter, $\mu\text{g}/\text{m}^3$). According to the US Environmental Protection Agency (US EPA, 2013), the new standard for particulate matter focuses on smaller particles that are “likely responsible for adverse health effects because

of their ability to reach the lower regions of the respiratory tract.” The PM-10 standard includes particles with a diameter of 10 micrometers or less (0.0004 inches or one-seventh the width of a human hair). EPA’s health-based national air quality standard for PM-10 is 50 µg/m³ (measured annual mean) and 150 µg/m³ (measured as a daily concentration). Belize’s pollution control standards for some of the parameters, including a few that were tested using the home-built incinerator are listed in Table 1.9. These guidelines are less stringent than international guidelines.

The World Health Organization (WHO) also has guidelines for air quality. The 2005 *WHO Air quality guidelines* ([https://www.who.int/news-room/fact-sheets/detail/ambient-\(outdoor\)-air-quality-and-health](https://www.who.int/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health)), offers global guidance on thresholds and limits for key air pollutants that pose health risks. The Guidelines indicate that by reducing particulate matter (PM₁₀) pollution from 70 to 20 micrograms per cubic metre (µg/m³), we can cut air pollution-related deaths by around 15%.

WHO Guideline values are as follows:

Fine Particulate Matter (PM_{2.5})

10 µg/m³ annual mean
25 µg/m³ 24-hour mean

Coarse Particulate Matter (PM₁₀)

20 µg/m³ annual mean
50 µg/m³ 24-hour mean

Table 1.9 Concentration of air Contaminants

Concentrations in micrograms per meter cubed (ug/m ³)				
Classification	SPM	SO ₂	CO	NO _x
A. Industrial and Mixed Use	550	120	5000	120
B. Residential and Rural	200	80	2000	80
C. Sensitive	100	30	1000	30

Nitrogen oxides. Nitrogen dioxide belongs to a family of highly reactive gases called nitrogen oxides (NO_x). These gases form when fuel is burned at high temperatures, and come principally from motor vehicle exhaust and stationary sources such as electric utilities and industrial boilers. A suffocating, brownish gas, nitrogen dioxide is a strong oxidizing agent that reacts in the air to form corrosive nitric acid, as well as toxic organic nitrates. It also plays a major role in the atmospheric reactions that produce ground-level ozone (or smog). It can cause respiratory

illnesses. They are produced from the reaction of nitrogen and oxygen gases in the air during combustion, especially at high temperatures. In areas of high motor vehicle traffic, such as in large cities, the amount of nitrogen oxides emitted into the atmosphere as pollution can be significant. These gases occur in various forms including Nitrogen dioxide and nitrogen oxides (0.5 to 30 ppm).

Sulfur dioxide. Sulfur dioxide belongs to the family of gases called sulfur oxides (SO_x). These gases are formed when fuel containing sulfur (mainly coal and oil) is burned, and during metal smelting and other industrial processes. The health concerns associated with exposure to high concentrations of SO₂ include effects on breathing, respiratory illness, alterations in pulmonary defences, and aggravation of existing cardiovascular disease.

Carbon Monoxide. This is a colorless, odorless, poisonous gas formed when carbon in fuels is not burned completely. It is a by-product of highway vehicle exhaust. Vehicular emissions in large cities can result in high concentrations of CO, particularly in local areas with heavy traffic congestion. Other sources of CO emissions include industrial processes and fuel combustion in sources such as boilers and incinerators. Despite an overall downward trend in concentrations and emissions of CO, some metropolitan areas still experience high levels of CO.

Results of Real Time Air Testing for Gases and Particulate Concentration (TSP)

Total suspended air particles were measured using a Cassella Cel – 712 Microdust Pro instruments. This instrument is capable to measure PM 10 and PM 2.5 separately, but it requires additional parts not available at the time of testing. However, total suspended air particles are a good indication of particles in the air.

Particles ranging in size from 0.1 micrometer to about 30 micrometers in diameter are referred to as total suspended particulate matter (TSP). TSP includes a broad range of particle sizes including fine, coarse, and super coarse particles. Therefore, Total Suspended Particulate matter (TSP) particles refer to the entire aerosol size range.

Weather data for each site was obtained using an Accurite brand weather station. Weather data is important because factors such as wind direction and wind speed often determine the direction and velocity of a plume, and therefore, the particulate matters that it carries. The first sets of tests were carried out during the month of October, 2019. However, during this time only the Belcogen factory was milling bagasse, and the ASR/BSI sugar mill was not processing sugar cane. Therefore, another set of tests was done on the 5th of March, when at the time both mills were processing. The results, including weather data for each site are found in Tables 1.10 to 1.17.

Maximum value (Max)

This represents the maximum particulate concentration that occurred in any 1 second period since the measurement Run was started.

Average

The average value represents the average particulate concentration since the measurement Run

was started.

As expected, parameters tested were very low, and further testing will be conducted prior to commencement of works at the project site. Parameters tested were negligible low or non-detectable or even at the highway site.

Table 1.10: Weather Data for Air Testing Sites at Zone 1- Oct 2019.

PARAMETER		SITE A (Santa Elena, Cayo – control site)	SITE 1 (San Antonio Rio Hondo)	SITE 2 (Yo Creek)	SITE 3 (San Lazaro)	SITE 4 (Trinidad)
GPS Coordinates	N	17° 09' 21.1608"	18° 07.830'	18° 05.435'	18° 02.262'	18° 01.545'
	E	89° 03' 49.7592	88° 40.421	88° 38.518'	88° 39.796'	88° 41.160'
Weather data (10/09/2019) (d/m/y)						
Time		7:00 am	10:30 am	11:00 am	11:20 am	11:30 am
Temperature °F		84	94	95	95	95
Wind Speed (miles per hour, mph)		2	2	5 to 7	5	5
Wind Direction		North – to South east	East – to South east	North-to North east	North-to North east	North- to North east
Rainfall (Only at time of testing)		0.11 mm	0	0	0	0.1 mm
Atmospheric pressure (kilopascal, kPa)		100.0	100.1	100.1	100.1	100.0
Humidity (%)		90	92	87	85	88
Heat Index (%)		89	114.8	95	94	95

Table 1.11: Results for Air Testing at Zone 1- Oct 2019.

PARAMETER	SITE A (Santa Elena, Cayo – control site)	SITE 1 (San Antonio Rio Hondo)	SITE 2 (Yo Creek)	SITE 3 (San Lazaro)	SITE 4 (Trinidad)
Date: 10/09/2019 (d/m/y)					
NO (ppm)	0	0	0	0	
NO2 (ppm)	0	0	0	0	
SO2 (ppm)	0	0	0	0	
H2S (ppm)	0	0	0	0	0
CO (ppm)	0	0	0	0	0
O2 (%)	20.9	20.9	20.9	20.9	20.9
Lower Explosive Limit (LEL, for combustible gases)	0	0	0	0	
Particulate matter (PM)					
Duration of Test (minutes)	30	20	10	10	10
20 second average (mg/m ³)	0.018	0.007	0.036	0.003	0.001
Measured Average (mg/m ³)	0.01	0.005	0.003	0.003	0.001
Maximum (g/m ³)	0.360	.009	0.042	0.004	0.027

Table 1.12: Weather Data at Zone 2 – October 2019.

PARAMETER		Site 5 (Start of Bypass PG Highway)	Site 6 Downtown O. Walk)	Site 7 (Boundary Road at New DOE Office)	Site 8 Puma Gas Station	Site 9 Chan Pine Ridge	Site 10 Tower Hill Factory & PG Highwa y Intersec tion	Site 11 Near Toll Bridge
GPS Coordi nates	N	18° 109.699'	18° 07.830'	18° 05.435'	18° 02.262'	18° 01.545'	18° 02.612'	18° 01.698'
	E	88°. 561020'	88° 40.421	88° 38.518'	88° 39.796'	88° 41.160'	88° 33.974'	88° 33.439'
Weather data (10/09/2019) (d/m/y)								
Time		7:00 am	1:30 am	2: pm	2:30 pm	3:00pm	3:30 pm	4:00 pm
Temperature °F		84	94	95	95	92	88	88
Wind Speed (miles per hour, mph)		2	2	5 to 7	10	12	7	2
Wind Direction		North – South east	East - South east	East-South east	East – South east	East - South east	East - South east	East - South east
Rainfall (Only at time of testing)		.11 mm	0	0	0	.1 mm	0	0
Atmospheric pressure (kilopascal, kPa)		100.0	100.1	100.1	100.1	100.0	100.1	100.1
Humidity		90	92%	87	85	88	84	84
Heat Index		89	114	95	94	95	94	96

Table 1.13: Results of Air Testing at **Zone 2 – Oct 2019.**

PARAMETER	Site 5 (Start of Bypass PG Highway)	Site 6 (Downtown O. Walk)	Site 7 (Boundary Road at New DOE Office)	Site 8 Puma Gas Station	Site 9 Chan Pine Ridge	Site 10 Tower Hill Factory & PG Highway Intersection	Site 11(Near Toll Bridge)
Date: 10/09/2019 (d/m/y)							
NO (ppm)	0	0	0	0	0	0	0
NO2 (ppm)	0	0	0	0	0	0	0
SO2 (ppm)	0	0	0	0	0	0	0
H2S (ppm)	0	0	0	0	0	0	0
CO (ppm)	0	0	0	0	0	0	0
O2 (%)	20.9	20.9	20.9	20.9	20.9	20.9	20.9
Lower Explosive Limit (LEL, for combustible gases)	0	0	0	0	0	0	0
Particulate matter (PM)							
Duration of Test (minutes)	30	20	10	10	10	10	10
20 second average (mg/m ³)	0.012	0.062	0.055	0.014	0.115	0.048	0.025
Measured Average (mg/m ³)	0.014	0.047	0.063	0.027	0.082	0.037	0.025
Maximum (g/m ³)	0.172	0.219	2.405	0.087	0.877	0.385	0.179

Table 1.14: Weather Data at Zone 1 – **March 2020.**

PARAMETER		SITE 1 (San Antonio Rio Hondo)	SITE 2 (Yo Creek)	SITE 3 (San Lazaro)	SITE 4 (Trinidad)
GPS Coordinates	N	18° 07.830'	18° 05.435'	18° 02.262'	18° 01.545'
	E	88° 40.421	88° 38.518'	88° 39.796'	88° 41.160'
Weather data (05/03/2020) (d/m/y)					
Time		10:00 am	10:30 am	11:00 am	11:30 am
Temperature °F		82	82	82	84
Wind Speed (miles per hour, mph)		6 to 12	7 to 19	12 to 15	8 to 14
Wind Direction (from)		North – North east	North-North east	North-North east	North- North west
Rainfall (Only at time of testing)		0	0	0	0
Atmospheric pressure (kilopascal, kPa)		101.9 kPa	101.8 kPa mbar	101.8 kPa mbar	101.8 kPa
Humidity		72%	73	73	70
Heat Index					

Table 1.15: Results of Air Testing at **Zone 1** March 2020.

PARAMETER	SITE 1 (San Antonio Rio Hondo)	SITE 2 (Yo Creek)	SITE 3 (San Lazaro)	SITE 4 (Trinidad)
Date: 05/03/2020 (d/m/y)				
NO (ppm)	0	0	0	
NO2 (ppm)	0	0	0	
SO2 (ppm)	0	0	0	
H2S (ppm)	0	0	0	0
CO (ppm)	0	0	0	0
O2 (%)	20.9	20.9	20.9	20.9
Lower Explosive Limit (LEL, for combustible gases)	0	0	0	
Particulate matter (PM)				
Duration of Test (minutes)	20	10	10	10
20 second average (mg/m ³)	0.001	0.03	0.00	0.001
Measured Average (mg/m ³)	0.001	0.003	0.00	0.001
Maximum (g/m ³)	.001	0.479	0.00	0.01

Table 1.16: Weather Data at Zone 2 – March 2020.

PARAMETER		Site 5 (Start of Bypass PG Highway)	Site 6 Downtown O. Walk)	Site 7 (Boundary Road at New DOE Office)	Site 8 Puma Gas Station	Site 9 Chan Pine Ridge	Site 10 Tower Hill Factory & PG Highwa y Intersec tion	Site 11 Near Toll Bridge
GPS Coordi nates	N	18° 109.699'	18° 07.830'	18° 05.435'	18° 02.262'	18° 01.545'	18° 02.612'	18° 01.698'
	E	88°. 561020'	88° 40.421	88° 38.518'	88° 39.796'	88° 41.160'	88° 33.974'	88° 33.439'
Weather data (05/03/2020) (d/m/y)								
Time		9:00 am	9:10 am	9:20 am	8:00am	8:30pm	8:20 am	8:15am
Temperature °F		83	80	80	82	80	78	78
Wind Speed (miles per hour, mph)		5 to 11	7	5 to 7	10	9 to 12	7	6 to 8
Wind Direction		North – going north west	Northwest going - South east	North-going to South west	Northwest going East – South east	Northwe st/west going– South/so uth east	North- northwe st going- South east	North- northwe st to Southea st
Rainfall (Only at time of testing)		0 mm	0	0	0	0	0	0
Atmospheric pressure (kilopascal,k Pa)		102.1	101.7	101.7	101	102.2	101.6	101.7
Humidity		75	83%	88	72	71	88	87

Table 1.17: Results of Air Testing at **Zone 2 March 2020.**

PARAMETER	Site 5 (Start of Bypass PG Highway)	Site 6 Downtown O. Walk)	Site 7 (Boundary Road at New DOE Office)	Site 8 Puma Gas Station	Site 9 Chan Pine Ridge	Site 10 Tower Hill Factory & PG Highway Intersection	Site 11(Near Toll Bridge)
Date: 05/03/2020 (d/m/y)							
NO (ppm)	0	0	0	0	0	0	0
NO2 (ppm)	0	0	0	0	0	0	0
SO2 (ppm)	0	0	0	0	0	0	0
H2S (ppm)	0	0	0	0	0	0	0
CO (ppm)	0	0	0	0	0	0	0
O2 (%)	20.9	20.9	20.9	20.9	20.9	20.9	20.9
Lower Explosive Limit (LEL, for combustible gases)	0	0	0	0	0	0	0
Particulate matter (PM)							
Duration of Test (minutes)	10	20	10	10	10	10	10
20 second average (mg/m³)	0.008	0.016	0.015	0.014	0.00	0.004	0.025
Measured Average (mg/m³)	0.555	0.865	0.347	0.027	0.000	0.241	0.025
Maximum (g/m³)	1.102	1.714	0.862	0.087	0.00	0.479	0.479

As a general observation, the measurement of particulate matter is highly dependent on the wind speed and wind direction. During the March 2020 testing, the consultants observed the movement of the plume from the ASR plant. On that particular day, the winds were brisk, as can be seen from the table, which shows that in some instances wind speed was up to 12 mph. Also, while at the Toll Bridge site (north side of bridge), for several minutes most of the plume was visibly seen blowing away towards the south east, away from Orange Walk Town itself. However, while waiting, at approximately 8:30, the wind direction changed briefly and blew directly at the area near the bridge. Prior to this, the instrument was reading zero particulate matter for several minutes. As soon as the wind direction shifted the plume towards the area where the consultants were located (north of the Toll Bridge); the readings changed to an average of 0.004 mg/M³ and a maximum of 0.479 mg/M³, (Table 1.17).

At the same time, it was noted that the highest value for particulate matters on that day was measured at a downtown area, which peaked at 1.714 mg/M³. While the wind direction influencing plume was not noted to be blowing here, it was later found to be more than likely the result of a fire that was in progress north of the bridge near the new bypass section of the highway. This fire was being used to clear a land parcel. This was perhaps the same reason why the maximum value of 1.102 mg/m³ was also recorded at that site.

Since wind directions at the zone 1 area, villages are far beyond the reach of the plume, and from the local pollution from Orange Walk Town, most villages tested had values of zero or very low values. Some of these villages, especially at Yo Creek and San Lazaro, were tested several times to ensure that the results were correct during that time, in all instances proving that yes, the air quality was clean at the time (Table 1.15).

During project implementation, it is recommended that further testing is done, and that the results are compared with values obtained in this ESIA to be able to establish baseline data. Care must be taken to observe wind speed and wind direction, as well as existing conditions within the municipalities (conditions such as the burning of waste etc).

The reader should also note that the recommended WHO and EPA exposure is also dependent on exposure time, in other words, if a polluting plume is constantly impacting an area with levels beyond those recommended, then this may pose health hazards.

As a comparison, the suspended air particles recorded in Santa Elena, Cayo during the peak of the “burning season” (which was reported as one of the worst in the last few years Belize); was recorded at 0.812 mg/m³ and 0.957 mg/m³ (recorded on the 23rd April 2020). It should be noted that this level was way above the 50 ug/m³ (equivalent to 0.05 mg/m³) safe limits for coarse particulate matter (PM 10), according to the WHO guidelines.

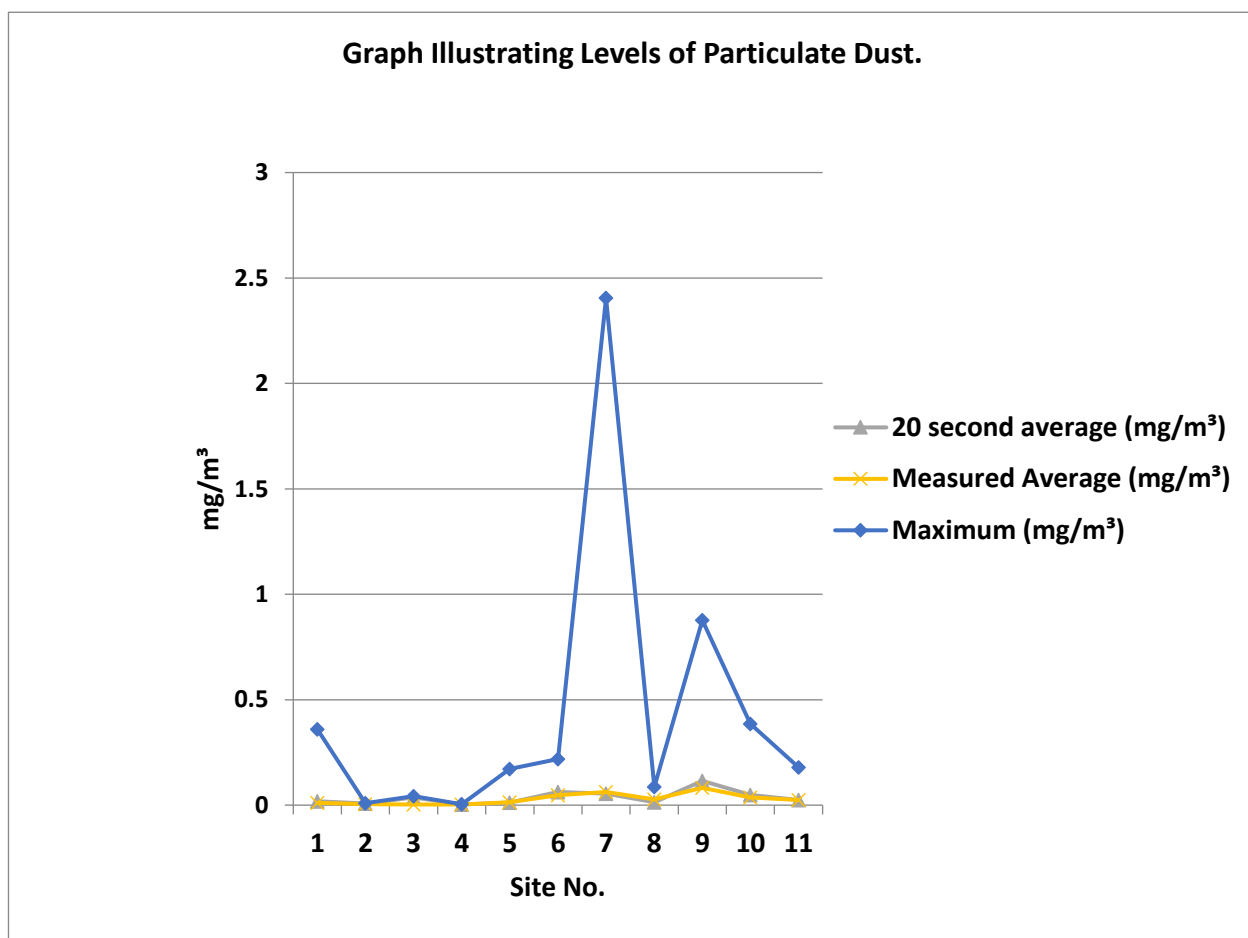
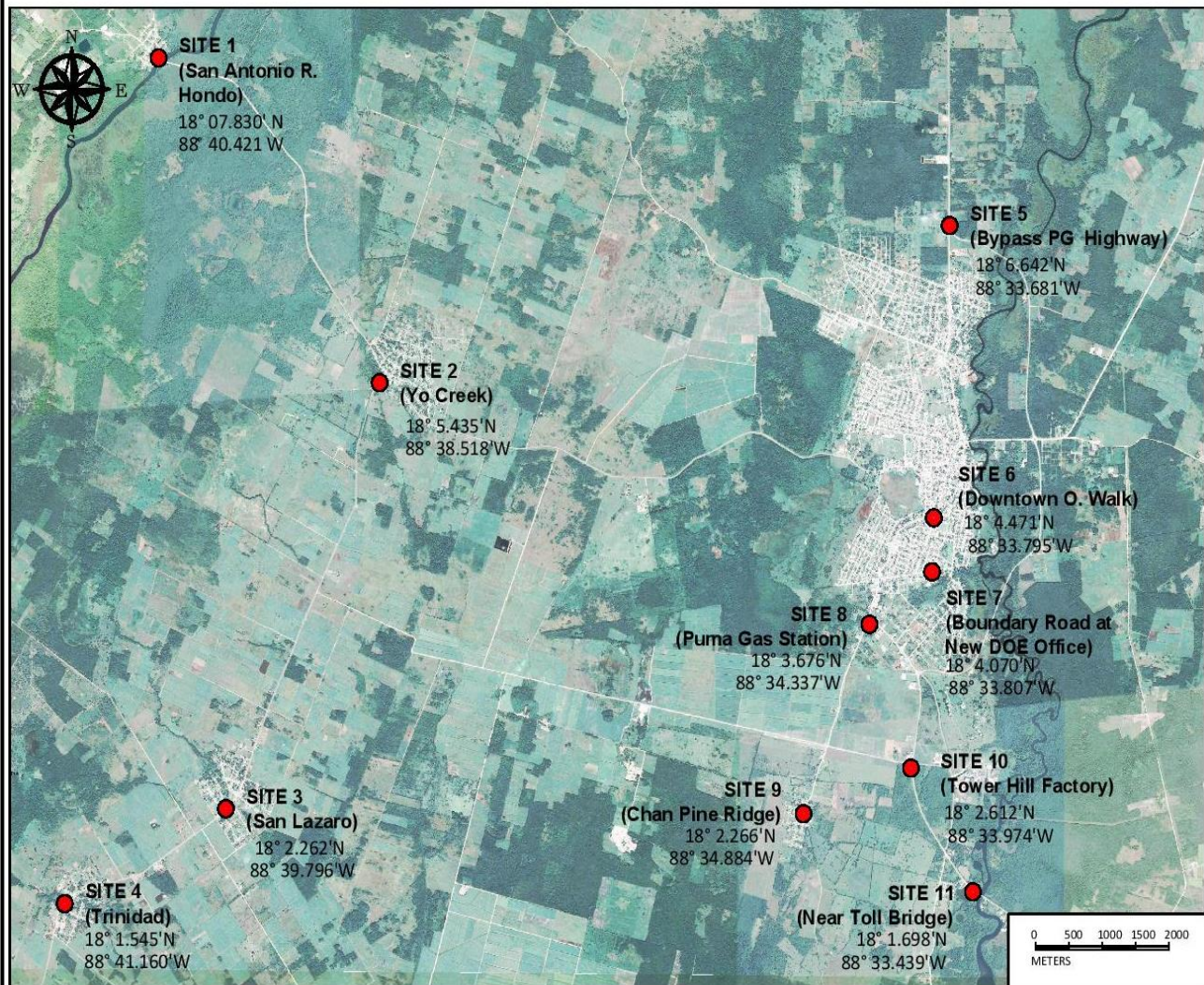


Figure 1.23: Graph Illustrating Levels of Respirable Dust – Oct 2019.

Location of Air Testing Sites



 SITE LOCATION

Figure 1.24: Map Showing Location of Air and Noise Testing PG Highway

Results of Biomass Burning in Incinerator

A pilot test was conducted using a newly constructed incinerator. The incinerator was constructed locally using locally available technology.

Table 1.18, shows the results of a demonstration combustion test of the dried *Arundo donax* biomass using a locally built incinerator. The incinerator is being developed using various filtering devices to be tested in order to fine-tune the system such that the emissions are within acceptable standards for incineration. The testing of the emissions from the *Arundo donax* burning was as a trial to identify potentially hazardous gases and emissions of particulate matter that will result during the combustion of the biomass. Development of the incinerator is yet incomplete, but significant data of the biomass emissions was gathered at about 3 meters distance of the incinerator.

The weather data reveals that the wind speed was low, at 2 miles per hour (mph); temperature was 85° and wind direction from the north – north east. Weather data was gathered using an Accurite brand Weather Station. Gases tested were Hydrogen Sulphide (H₂S), Carbon Monoxide (CO), and Combustible fuels (LEL). These gases were tested using a Microclip Gas Alert monitor manufactured by BW Technologies. Particulate matter (PM) was tested using a Casella CEL – 712 Microdust Pro Instrument, manufactured in the United Kingdom by the Casella CEL company.

Table 1.18 shows that both H₂S and CO were significantly high. A control site at the compound of Wilderness Group Consulting was used for the testing of these emissions. At the control site, weather parameters were similar to that where the incinerator is located. That the alarm was triggered due to the elevated H₂S and CO gas emissions. H₂S was 2.6 ppm and the CO was 20 ppm.

The particulate matter was also high, and also the alarm was triggered when using the equipment. At the control site, (Table 1.26), it can be seen that particulate matter was 0.011 g/m³ and the maximum was 0.36 g/m³. The tests lasted 33 minutes and 7 kilograms of dried biomass was burnt at a temperature ranging from 475 to 556 °F. Temperature was tested using an infrared thermometer. Particulate matter averaged 921 mg/m³ and the maximum was 7.52 g/m³, both these levels are very high and exposure to this level of particulate matter can be deleterious to the health if exposed for extended periods.

Table 1.18: Results of Localized Test for Emissions of *Arundo donax* Biomass Burning.

PARAMETER	SITE A (Santa Elena, Cayo – control site)	Kontiki San Ignacio (Biomass burning with *Incinerator)
Weather data (10/09/2019)		
Time	9:00 a.m.	10:00 a.m.
Temperature	85°F	86°F
Wind Speed	2 mph	2 mph
Wind Direction	North-north west	North-north west
Rainfall	0	0
Atmospheric pressure	1000 mb	1000mb
Humidity	93%	94%
Gases		
H ₂ S (ppm)	0	2.6
CO (ppm)	0	20
O ₂ (%)	20.9	20
LEL (%)	0	0
Particulate matter (PM)		
Duration of Test	30 mins	33 mins.
Measured Average	.011g/m ³	921 mg/m ³
Maximum	0.360 g/m ³	7.52 g/m ³

Occupational Health Risks

During operation of the proposed project and its components, it is expected that workers may likely encounter occupational health hazards due to work related activities.

The project activities that may lead to air pollution include dust from vehicular movement, construction, soil exposure to wind, and similar products, dust from storage sites, particularly during dry windy conditions, hydrocarbon particles as a result of heavy equipment and vehicular transportation; and, greenhouse gas emissions as a result of anaerobic decomposition of effluent. No polluting chlorofluorocarbons (cfc's) will be used on site.

However, the most serious health risk comes from the production of particles and dust and other noxious particles during burning of the biomass at the cogeneration plant. A full evaluation of available best management practices has been done and as part of the EIA, an Occupational Health and Safety Management plan (OHSP) has been drafted, as well as an emergency evacuation plan and a disaster management plan, focusing primarily on hurricane evacuation. The OHSP is aimed primarily at the protection of staff and employees, as well as visitors from any health risks and to ensure safety at the work place. The Emergency Evacuation Plan has been prepared as part of the ESIA; and such is the OHSP. These plans complement each other, but the HSMP outlines practices to be carried out for the protection of workers inside the tunnel and at the crushing plant. Some of the principles and processes are summarized herein.

The plan also includes the use of protective gear that must be worn to protect from these particles in order to reduce health risks. All equipment and protective gear will be provided by the company, and their use should be mandatory while working near the cogeneration plant. The reader is advised to see the ESMP, which presents details of the emergency plans and the OHSP. As a priority, the OHSP and procedures prior to commencement of operations, and these will be evaluated and fine-tuned during the first three months of operations.

In summary, the following are important elements of the ESMP

- The cogeneration plant should adopt technology to control dust emissions
- Equipment such use will be mandatory
- Training of personnel in emergency evacuation and medical first aid will be mandatory for all workers and will be scheduled according to the needs of the company

1.3.4 Existing Noise Levels

At the project site, noise will mostly be a minor concern to wildlife, and to employees. Noise will only be generated during the operation of equipment. Within the compound noise will result from vehicular transportation during the movement of materials. The project location area is uninhabited, and the village that is physically nearest to the project is Trinidad, approximately two kilometers away on a straight line. San Lazaro is approximately four kilometers away. Only the 100-acre parcel is where the employees will reside, for which noise is to be monitored but projected to be very low. Work time takes place during daylight activity.

In order to establish baseline data, a digital sound meter was used to determine ambient noise levels at several locations in and around the property. Table 1.19 specifies the ambient noise levels as required by Belize's noise legislation. Figure 1.23 shows the location of sites tested for

noise levels and air emissions.

Ambient noise levels were taken at the project site and compared to noise levels during operation of the generator and tractor. All levels reported are maximum peak levels during investigation. Since the area is uninhabited and undeveloped, therefore, background noise levels were very low, quiet during most times, with ambient noise levels set at 65 decibels. Noise level from the vehicle engine (diesel motor) was 69 decibels adjacent to the vehicle and at 10 meters, and the noise level was recorded at 75 dba (Table 1.20, 1.21).

Table 1.19: Ambient noise levels taken at various sites around the project area

Noise Level According to the dB (A) Scale (as defined by the International Electronics Commission).		Structure A		Structure B		Structure C		Structure D		Structure E	
Duration of Noise		D	N	D	N	D	N	D	N	D	N
1	More than 9 hrs	60		60		70		70		85	
2	More than 3 hrs, less than 9 hrs	70		70		75		75		90	
3	More than 30 mins	75		75		80		80		100	
4	More than 30 mins		45		45		45		45		90
5	More than 15 mins and less than 1 hr	70		70		90		90		105	
6	More than 10 mins and less than 30 mins		45		50		50		50		90
7	More than 5 mins and less than 15 mins	70		85		100		90		90	
8	More than 2 mins and less than 5 mins	90		95		100		100		95	
9	Less than 10 mins		50		70		70		70		80
10	Less than 2 mins	100		100		105		100		110	
	Noise from infrequent (less than 4 times per week) explosions	109		109		114		114		114	
D = Day; N = Night											

Source: Environmental Protection Act Chapter 328 Revised Edition 2003 of the Substantive Laws of Belize, "Chapter 238 Pollution Regulations".

Structure A: any building used as a hospital, convalescent home, old age home, or school.

Structure B: any residential building.

Structure C: any building in an area that is used for residential and one or more of the following purposes: commerce, small scale production, entertainment.

Structure D: any residential apartment in an area that is used for the purposes of industry, commerce or small-scale production.

Structure E: any building used for the purposes of industry, commerce, or small-scale production in an area used for the purposes of industry, commerce, or small-scale production.

Table 1.20: Peak Ambient Noise Levels Reported at the Project Area.

Site 1 - Ambient Noise level (100-acre plot)	Site 2 – Access Road at Intersection with San Lazar Road	Site 3 – San Lazaro Village	Site 4 Trinidad Village
55 dBA	60 dBA (on access road)	70 dBA (ambient level)	70dBA
70 dBA (with diesel engine operating at idle speed)	69 dBA with engine at idle speed 10 meters away		

Care is taken for safety during operation of tractors, as in emergency cases, the driver cannot listen to emergency warnings and instructions.

Table 1.21: Decibel Readings Near the Tower Hill Factory.

Ambient Noise Tower Hill Factory Near Highway	Site 2 – Road Near Toll Bridge	Site 3 Yo Creek Village
65 dBA	65 dBA (on access road)	60 dBA (ambient level)
79 (with passing of large vehicles)	69 dBA with passing of	75 dBA (Land Mower 100 ft away)

1.3.5 Potential Impacts and Mitigation Control – Air Quality

As mentioned before, the detailed mitigation and compensation is elaborated in Chapter 4.0 Assessment of the Environmental and Social Impacts of the Project.

One important mitigation that requires consideration by the management of the Belcogen plant is the need for improvement of the air particles treatment system at the Belcogen Plant, perhaps with the improvement in the performance of scrubbers so as to reduce the risk of health-related illnesses; and to alleviate concerns from the community.

Table 1.22 Summary of Environmental Impacts and Mitigation and Compensation Measures for Air Quality Activities.

Activities	Degree of Impact	Mitigation Measure
Health and Safety	<ul style="list-style-type: none">• Increase ambient noise levels• Chemical applications• Increase particulate matter• Vapor emission	<ul style="list-style-type: none">• Reduce equipment noise by installing and maintaining sound proofing or noise abatement devices.• Ensure PPE are being worn where applicable• Install dust traps at storage site to minimize the amount of particulate matter.• Ensure refueling or dispensing is carried out in an open area.• The additional staffing includes an assistant project manager who responsibility will be primarily to ensure the risk management practices are successfully implemented. Also added to the human resources are security and safety personnel who will be responsible for the Project site as well as monitoring transfers of any <i>Arundo donax</i> plant material from the area.• Security and safety personnel will be retained via contracts
Air Quality	<ul style="list-style-type: none">• Suspended particulate matter• Wildfires and waste burning• Exhaust emissions• Combustion Emissions	<ul style="list-style-type: none">• Ensure proper construction of roads to reduce suspended particulate matter. Wet road where possible.• Ensure that the biomass material is as dry as possible for it to combust properly. A dry biomass produces a clean fuel• Similarly, keep the biomass material as clean as possible during drying.• Wildfires produce smoke and as such the project will prevent this by having a buffer area.• There is very little possibility that a ground fire could make it across the buffer zone even in the presence of very high winds and dried biomass fuel on the ground.• Ignition of the harvested biomass can only be

		<p>achieved at high temperature. If ignition does occur while drying, then the smoke alarms would alert the workers.</p> <ul style="list-style-type: none"> • The monitoring of emissions and dust levels are being planned as part of the ESMP.
--	--	---

1.3.6 Geology and Soils

1.3.6.1 Regional Geological Setting

The geology of Belize is dominated by the Maya Mountains, an uplifted block of late Palaeozoic Santa Rosa Group sediments and volcanic and Jurassic red-beds intruded by intermediate to felsic intrusive of various ages. North and south of the Maya Mountains, the topography is more subdued and the geology is composed of Cretaceous and younger carbonates, sediments and alluvium.

Belize's geology has been divided into two broad formations: the older Maya Mountains or Mayas Series, which are of Palaeozoic age and the younger Cretaceous to Eocene age limestones and non-calcareous sediments which form the lowlands north and south of the Maya Mountains (Dixon, 1956).

The older Palaeozoic rocks are composed of “greywackes, quartzites, slates, phyllites and shales with some schists and gneisses” (Dixon, 1956). In the southwest of Belize, these rocks are overlain by the Macal Series, which are Upper Pennsylvanian to Middle Permian in age, which are then overlain by limestones of Cretaceous – Eocene age, the youngest of the rocks.

The Macal Series is divided by Dixon into two groups: (i) Macal Shale Group, and (ii) Macal Sandstone Group. The Macal Sandstone Group is below the Macal Shale group and consists of “conglomerates at the base, followed by grits and sandstones, with shale intercalations” (Dixon, 1956). Dixon estimates the sandstone group at approximately 500 feet thick, and it passes up into the Macal Shale Group.

The Macal Shale Group consists of black carbonaceous and calcareous shales with flaggy sandstones and shales and sandstones. The lower horizons of this group are rich in fossils, but the upper horizons display less fossils, and the fossils of the upper horizons tend to be pyritic, and in the form of casts (Dixon, 1956).

Tectonically, Belize is located on the southern part of the Yucatan (Maya) Block, which is separated from the Chortis block to the south by the Motagua-Polochic Fault System which runs through Guatemala (Pindell and Barrett, 1990). It is along this structure that the northern margin of the Caribbean Plate moved eastward for the present Pacific Ocean area to its present position from the early Cretaceous. This movement has produced thrust faulting and structural deformation in southern Belize.

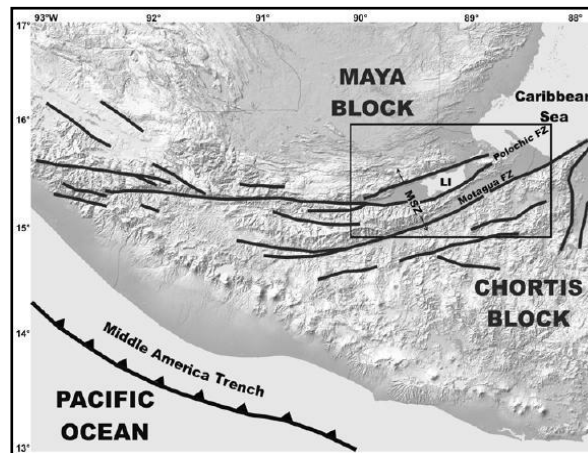


Figure 1.25: Maya Bloc and Chortis Block in Relation to the Motagua Fault.

Previous to the Jurassic, the region was subjected to a regime of compressional tectonics, (J. Cornec, pers.com.), in evidence in the deformation of the Santa Rosa sediments in the Ceibo Chico area. This may be related to the late Palaeozoic collision of the North and South American Plates during the formation of Gondwanaland.

The oldest rocks in Belize are quartz-feldspar gneisses which outcrop in the Macal River in the area of the Mollejon Hydro Project, and appear to correlate with the Chuacus Group rocks of Guatemala. These gneisses have been intruded by Devonian granite which underlies a large part of Mountain Pine Ridge and which is the oldest of the bodies that make up the intrusive complex there.

The Pennsylvanian-Permian Santa Rosa Group underlies most of the Maya Mountains and is composed of a volcanic unit overlain by a thick sequence of clastic sediments. The volcanic unit is a thick sequence of andesite to rhyolite tuffs and flows which outcrops in the southern part of the Maya Mountains roughly centred on the Main Divide. These rocks are referred to as the Bladen Volcanic Member of the Santa Rosa Group.

Previous work indicated the volcanics to be disconformably overlain by the Permian age sediments, but mapping by Castle showed the volcanic-sediment contact to be a conformable one. The bottom of the clastic unit is assigned a Wolfcampian-Early Leonardian (early Permian) age on the basis of conodont and fusulinid dating by the Natural History Museum. As such, the volcanics are given an age of late Palaeozoic to early Permian.

Local exposures of volcanic tuffs and flows have been noted within Santa Rosa clastic sediments in the Mountain Pine Ridge, and minor occurrences of late Palaeozoic volcanic rocks are known in Guatemala.

The clastic sediments of the Santa Rosa Group are composed of carbonaceous argillites and lesser coarse clastics with minor limestone units near the top of the section. Thick turbidite sequences occur in the lower part of the clastics in the Smokey Branch area. The Santa Rosa Group rocks extend westwards from Belize into Guatemala and southern Mexico, and late Palaeozoic argillites are known in eastern Mexico as far north as Tampico.

Contemporaneous with the Santa Rosa Group sediments are a number of granitic intrusive at Mountain Pine Ridge. A later intrusive event occurred in the Triassic which intruded muscovite granites into the Hummingbird-Mullins River and Cockscomb regions of east-central Belize, and again into the Mountain Pine Ridge area.

Thick red-beds of the Jurassic Todos Santos Formation were deposited across much of northern Central America and Mexico. In Belize, this sequence is relatively thin, to a maximum of 60 Meters, and is named the St Margaret Creek Formation.

Platform carbonates of Cretaceous and younger ages were deposited across the entire region. Though subsequent erosion has exposed most of the Palaeozoic rocks in the Maya Mountains horst the carbonates, and lesser Cretaceous-Tertiary marine clastics of the Toledo Formation in the south of Belize, cover the rest of the surface of Belize.

1.3.6.2 Geology of Project Site

The Northern Coastal Plain land region, which includes the Orange Walk and Corozal Districts consist of karst topography dominated by cavernous limestones. This area is abundant in ground and surface water, and with the exception of a relatively high hardness, ground water quality is generally acceptable as a source of potable water in most places.

The Corozal District and parts of Orange Walk has extensive deposits of white marl which contain marine shells and fragments of coral, interbedded with siltstones, sands and clays. These limestones are said to be of Tertiary (neogene) age of the Orange Walk Group, and may be overlain by recent alluvium. The Geology Map of Belize (Cornec, 2003); details the Late Tertiary Limestones of the Red Bank and Orange Walk Group as comprising of clays, gypsum, sand, chert, marls and limestone. This formation is overlain by alluvium.

The project site comprises three main geologic formations. These are the Neogene (Tertiary) age Orange Walk Group Limestones (designated as “L_{ow}”; figure 1.25), and Red Bank Group Limestones (designated as “L_{rb}”, figure 1.25) by Cornec (J. Cornec, 2010a). These are overlain

by recent alluvial deposits, which are also found more extensively within hydrological surface formations such as creeks and lagoons.

The Orange Walk Group

The project site is comprised of the younger Cretaceous Limestone called the Orange Walk Group Marls (Designated Ltow in Figure 1.25). The geology map of Belize, compiled by Jean Cornec, (J. Cornec 2010a); shows that the project site is comprised of the Orange Walk Group Marls (Ltow, Figure 1.25) and the lands west of the project consist of the recent quaternary alluvial deposits. The Ltow marls are the dominant geologic feature at the project site and surroundings.

The Orange Walk group marls include marls, micritic, corals and coquinal limestones, which have oysters, gastropods, corals, pelecypods, fish scales, echinoid spines, fish scales and chara seeds. Gypsum clay and sand are also present.

Red Bank Group

The Red Bank Group of marls contains bentonitic clays, gypsum (and chalcedony pseudomorph), sands, chert and chalcedony. It also has fossiliferous beds with echinoid spines, barnacles and pelecypods.

The quaternary alluvium (designated Q in Figure 1.25), located west of the project, and along surface creeks includes chert and quartz gravel terraces, crystal gravel, modern reef, calcareous sand and mud as well as volcanic ash falls (Cornec 2010a).

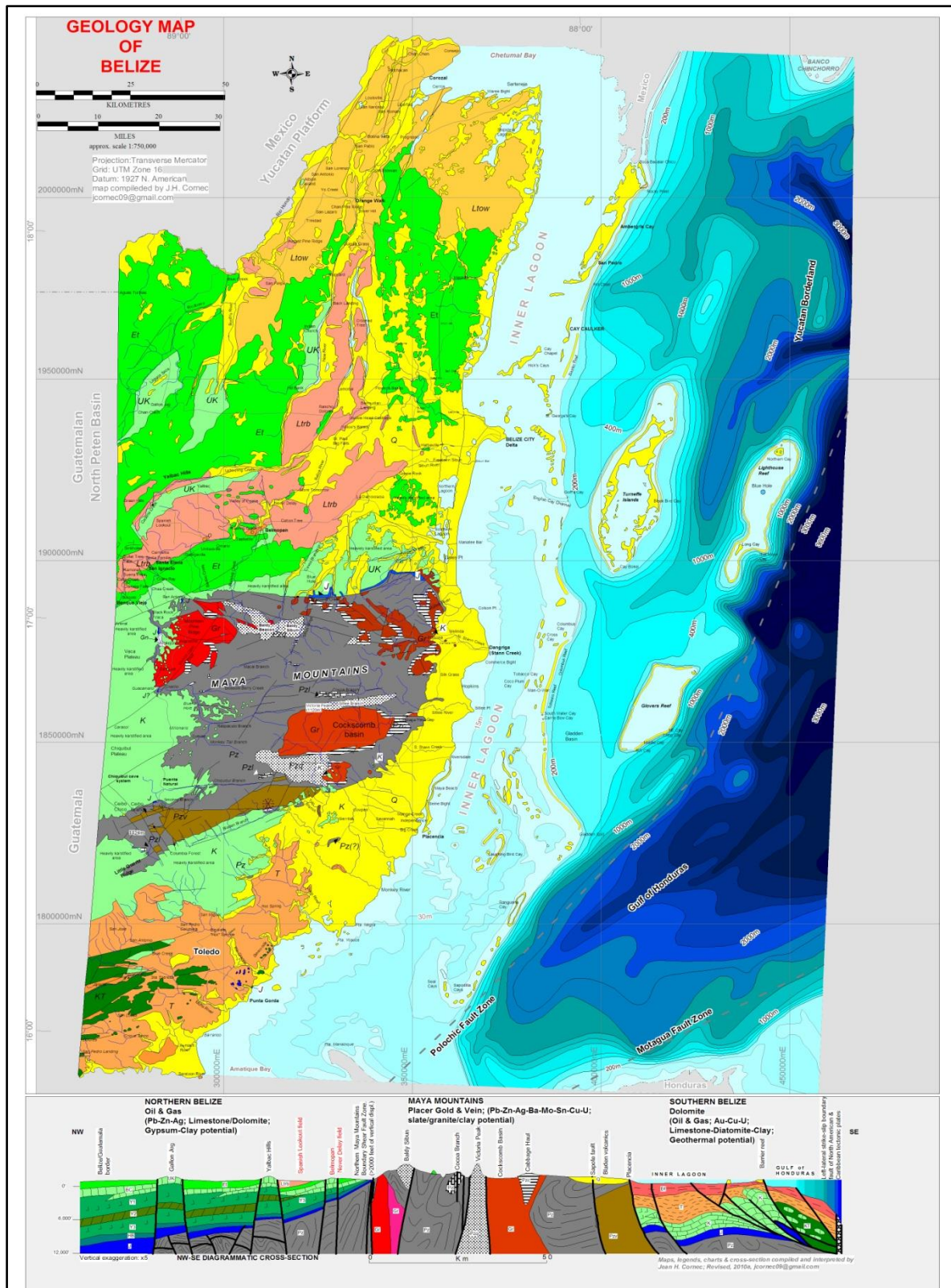


Figure 1.26: Geology Map of Belize

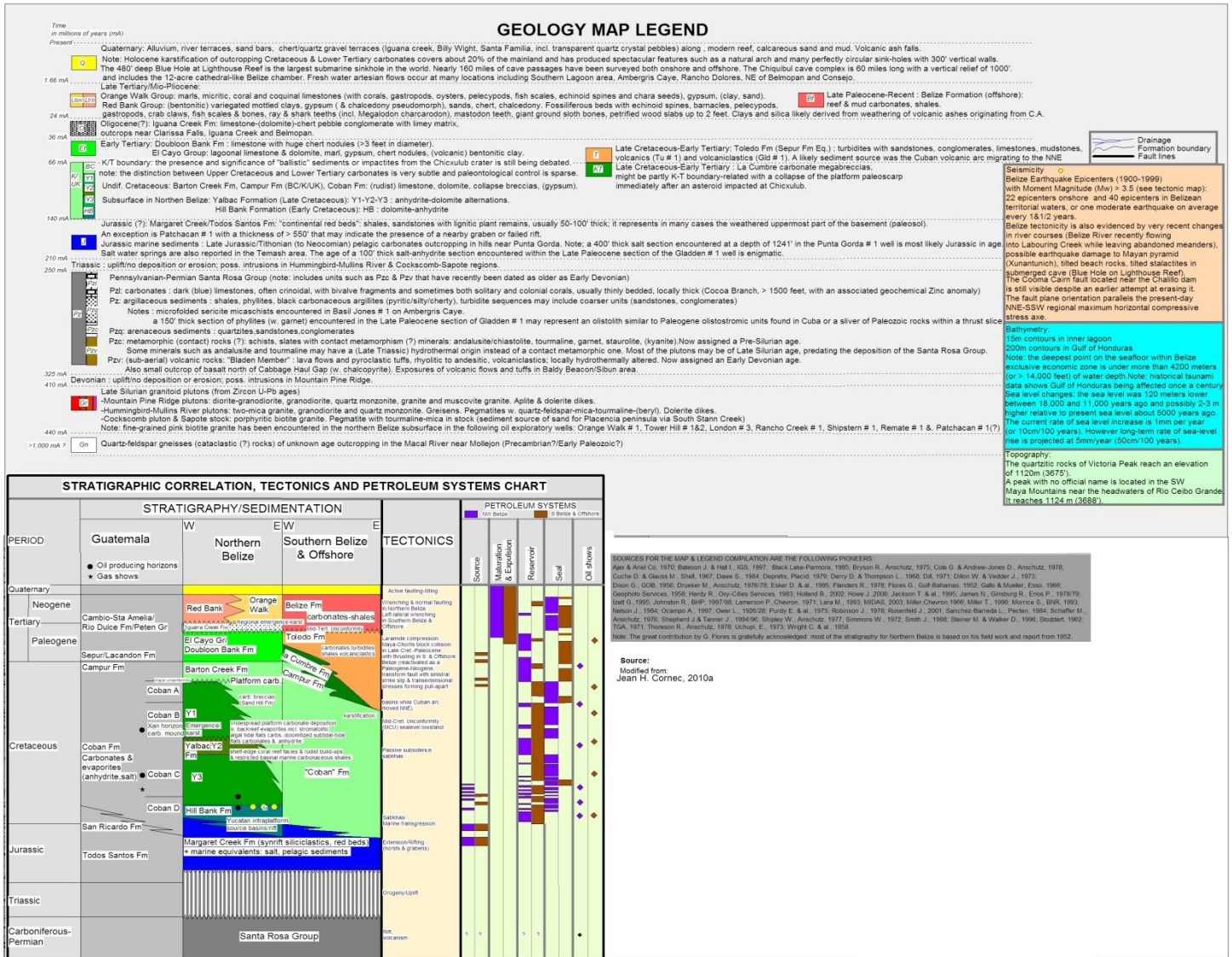


Figure 1.27: Geology Map of Belize Legend

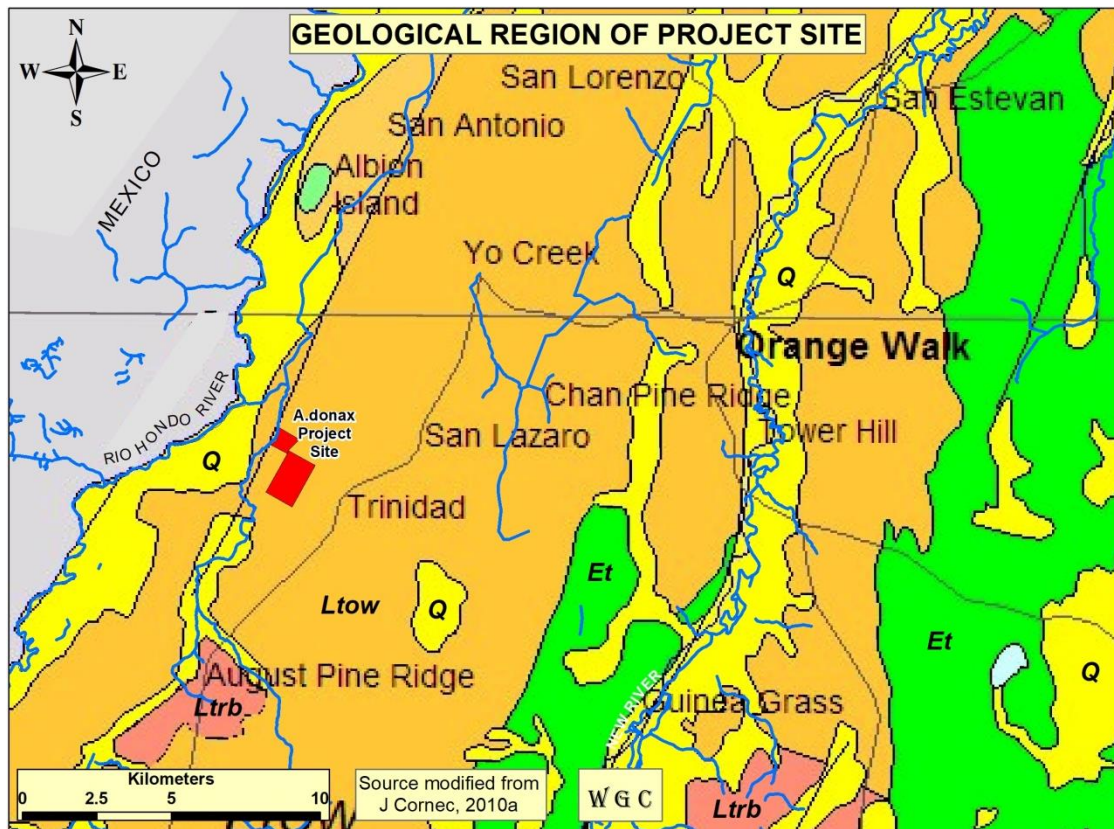


Figure 1.28: Map Showing Geology of Project Region

1.3.6.3 Soils and Erodibility of Soils

According to the Land Resource Assessment of Northern Belize Volumes I and II, 1992 (King et al, 1992); the project property is located within the Northern Coastal Plain Land Region. This land region consists mostly of the “flat to undulating land in Northern Belize and the Belize Valley” (King et al, 1992, p 35). The parent material of the soils within and near the project site is primarily the Cenozoic limestone (King et al, 1992). This Cenozoic limestone would date to the Miocene to Pleistocene era. Rainfall in this area ranges from 1,300 to 2,000 mm per year, and the elevation ranges from 20 to 100 meters above mean sea level.

The project region, including the project site consists of three main land systems, of which two have good agriculture values (Table 1.23), while one has little or no agriculture value. These land systems are subdivided into main sub units, of which there are five such sub units within the project boundaries; three having good agriculture values.

These Land Systems and their agriculture values are:

- (1) Lazo Plain Land System (OZ) with two sub units: (i) Undulating plain(n), and
- (ii) Lower Slope (w), but a small area facing south has Undulating plain land system within the property,

- (2) San Felipe (FP), with two sub units being: (i) Undulating Plain (u) and Redeposited old alluvial wash (pW). The Undulating plain land system is the majority soil type that is found within the property, covering approximately 90 % of both parcels.
- (3) Shipyard Plain, which has three sub units being: (i) Flat plain (n); (ii) Lower slope (w); and, (iii) Undulating plain (u). Only the Flat plain of this land unit is found at the rear of the property.
- (4) Hondo Swamp (OH), which has sub units being : (i) Marsh Forest Plain

Table 1.15, provides detailed description of these land systems. Table 1.24, has the explanatory notes for the codes used in the Land Resource Assessment (King and others, 1992).

The Lazaro Plain land system has some potential for agriculture, given a value of 2 (meaning that it has “chances of financial success” (Table 1.24). However, only a small strip of the property at the rear of each parcel displays the undulating plain from this land system.

The San Felipe Plain has practically no agriculture value, (agriculture value of 4) with financial success being “marginal” even with management. This land system (undulating plain of the San Felipe plain) covers approximately 90% of the project area, and is the reason that it is classified as marginal lands.

In addition to the undulating plain of the FP land system; there is a small strip of land having the soil type described as the pw, redeposited old alluvial wash. This strip of land also has low agriculture value of 4. Despite this, however, it has a low conservation value of 4.

Table 1.23: Northern Coastal Plain Classification

Table 2.5.1: Land Classification of Project Area according to Land Resource Assessment (After King and others, 1992).

Land Region: Northern Coastal Plain.

Land System	Main Sub units	Current land Use	Main Soil Types	Agriculture Value	Main Limiting Factors	Conservation Value	Suitability for Beans	Suitability for Mechanized Maize	Suitability for Milpa (shifting cultivation)	Suitability for Sugar Cane	Provisional Recommendations
<i>OZ: – Lazaro Plain</i>	<i>(u): - Undulating plain</i>	<i>Sugarcane & limited pasture</i>	<i>BV: Lazaro>Pixoy</i>	<i>2</i>	<i>Nutrients, Moisture</i>	<i>4</i>	<i>S2mn</i>	<i>S2mn</i>	<i>S1-S2nm</i>	<i>S1</i>	<i>Sugarcane, vegetables, tree crops, pasture</i>
<i>FP: San Felipe Plain</i>	<i>(u): - Undulating plain</i>	<i>Limited; sugarcane, pasture</i>	<i>Felipe; Boom+, tok BV: Erindale</i>	<i>4</i>	<i>Wetness, moisture, nutrients</i>	<i>3>2</i>	<i>N1wn>N2n</i>	<i>N1wn>N2n</i>	<i>N2wn</i>	<i>S3wn-N2n</i>	<i>None</i>
<i>FP: San Felipe Plain</i>	<i>(pW): Redeposited old alluvial wash</i>	<i>None</i>	<i>Haciapina>Sennis</i>	<i>4</i>	<i>Nutrients, drainage, root room</i>	<i>4</i>	<i>S2b-N2w</i>	<i>N2wn>S3wn</i>	<i>S2*W-n2wn</i>	<i>N2wn>S3w</i>	<i>Pine, pasture, rice</i>
<i>OK: Shipyard Plain</i>	<i>(n): Flat plain</i>	<i>Sugarcane; pasture & sorghum</i>	<i>Yalbac; Louisville</i>	<i>2 to 3</i>	<i>Workability; root room, moisture, nutrients</i>	<i>2 + 4</i>	<i>S2n>S3wn</i>	<i>S2nk-S3k</i>	<i>S1-S3mn</i>	<i>S1-S2nm</i>	<i>Arable pasture</i>
<i>OW: Hondo Swamps</i>	<i>(h) Marsh Forest Plain</i>	<i>Very limited sugarcane</i>	<i>Pucte + Sibal</i>	<i>4-5</i>	<i>wetness</i>	<i>3>1</i>	<i>N2w</i>	<i>N1w-N2w</i>	<i>S2*wn-N2w</i>	<i>S2w-N2w</i>	<i>None</i>

Interpretation of Symbols (From Land Resource Assessment, King et al, 1992).

The Land Resource Assessment uses letters over the color coding of the map and a classification system for agriculture soils in Belize using a series of explanatory alphabetical and numerical symbols for interpretation of land use maps produced as part of the documentation. These include numerical values for agriculture value of soils, conservation values of soils, and a combination of alphabetical and numerical symbols for land suitability values. **Figure 1.28** is a map showing agriculture land systems classification used for lands within and surrounding the proposed agriculture project. A list of the symbols used to describe the classification can be found below (**Table 1.17**).

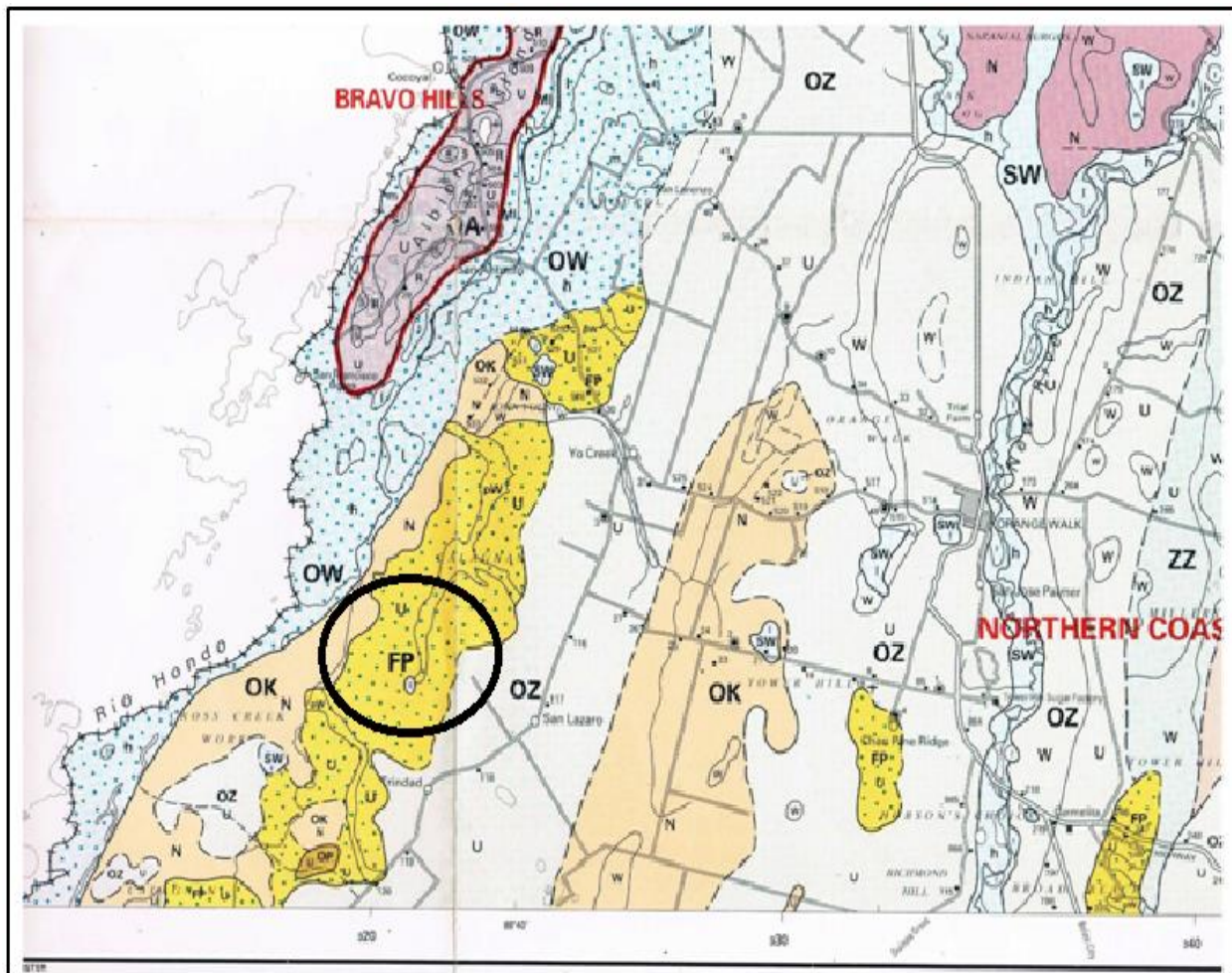


Figure 1.29: Soil Map Depicting *Arundo donax* project site.

Table 1.24: Land classification symbols and values used by King and others

Soil Types:

BV	=	Belize Valley Soil Types
SC	=	Stann Creek Soil Types

Agricultural Values:

1	=	Major portion of area has high to very high-income potential
2	=	Chances for financial success good
3	=	Chances for financial success moderate with the probability subject to skilled management
4	=	Chances for financial success marginal even with skilled management and high inputs
5	=	Chances for financial success extremely small

Conservation Values:

1	=	High priority for conservation
2	=	Moderate priority for conservation
3	=	Marginal conservation value
4	=	Very low conservation value

Land Suitability Values:

<i>S1</i>	=	<i>Highly suitable</i>
<i>S2</i>	=	<i>Moderately suitable</i>
<i>S3</i>	=	<i>Marginally suitable</i>
<i>N1</i>	=	<i>Currently not suitable</i>
<i>N2</i>	=	<i>Permanently not suitable</i>

Land Suitability Limitations:

<i>a</i>	=	<i>access</i>	<i>m</i>	=	<i>moisture availability</i>
<i>a'</i>	=	<i>access to sea</i>	<i>n</i>	=	<i>nutrient availability</i>
<i>a''</i>	=	<i>access to processing facility</i>	<i>p</i>	=	<i>pollution</i>
<i>b</i>	=	<i>size of manageable unit</i>	<i>q</i>	=	<i>mechanization potential</i>
<i>c</i>	=	<i>cold temperatures</i>	<i>r</i>	=	<i>rooting conditions</i>
<i>d</i>	=	<i>soil degradation hazard</i>	<i>s</i>	=	<i>slope</i>
<i>e</i>	=	<i>erosion hazard</i>	<i>w</i>	=	<i>wetness</i>
<i>f</i>	=	<i>flood hazard</i>	<i>z</i>	=	<i>excess of salts</i>
<i>k</i>	=	<i>soil workability</i>	<i>z-</i>	=	<i>insufficient salinity</i>

Unstable or Erodible soils

The soil cover, having a high percentage of sand, is erodible, when exposed by removing of vegetation. However, soil stability will be stabilized through the root system of the *A. donax* plant, but via practices such as landscaping and the sustainable use of buffer zones that use native vegetation. The monitoring of these native buffer zones will be carried out to ensure their stability and to ensure that they are not degraded in a way to contribute to soil erosion. The soil has been described as comprising of a top layer (up to depths of 8 inches), of dark grey soil with medium to loam and loamy sand at the top layer, while the second layer (up to 14 inches depth), displays fine to medium fine sand, and the bottom layer comprising of a high percentage of very dark grey clay (along with sascab, which is a white clay limestone). Therefore, the soil profile does indicate a combination of sandy loam and sandy clay at the top layers that are susceptible to erosion when these lands are denuded of native vegetation. However, within the project site and the vicinity there are no visible signs of significant erosion, primarily because industrial activity is low to non-existent.

It is known that root systems, especially of grass species do stabilize soils, and this, along with buffer zone and the use of native vegetation will help in ensuring that soils are stabilized and soil lost is minimized.

1.3.7 Natural and Man-Made Hazards

Natural hazards include seismic events, faults, sink holes, flooding, tropical storms, hurricanes, extreme weather (primarily extreme rainfall events such as tropical waves); drought, and drought – related phenomenon such as forest fires, and chemicals or hazardous materials.

Man-made hazards include the risk of fires due to anthropogenic activities, accidents, and spills due to operation of equipment.

1.3.7.1 Seismicity and faults

Based on regional seismic activity, most of Belize is not known to be a tectonically active country. According to Jean Cornec, geologist; “Belize’s small faults are inactive and therefore have not shown recent activity” (J. Cornec personal communication, December 2019). These faults are not known to display tectonic activity as other larger faults in the region. However, the location of several active plates with fault zones in countries neighbouring Belize does result in local tectonic activity that also ripples to Belize at low levels. In 2009, for example, an earthquake caused by the movement of the North American and Caribbean Plate; which runs from the Caribbean Sea and past an area near the boundary with Belize and Guatemala, resulted in a magnitude 7.3 quake offshore. This quake resulted in some damage to structures in Belize, with a magnitude felt ranging from 4.0 to 6.5 in some parts of the country; primarily the southern districts of Toledo and Stann Creek that are located closer to this fault.

The country’s seismic hazard increases as one goes from north to south (**Figure 1.29**).

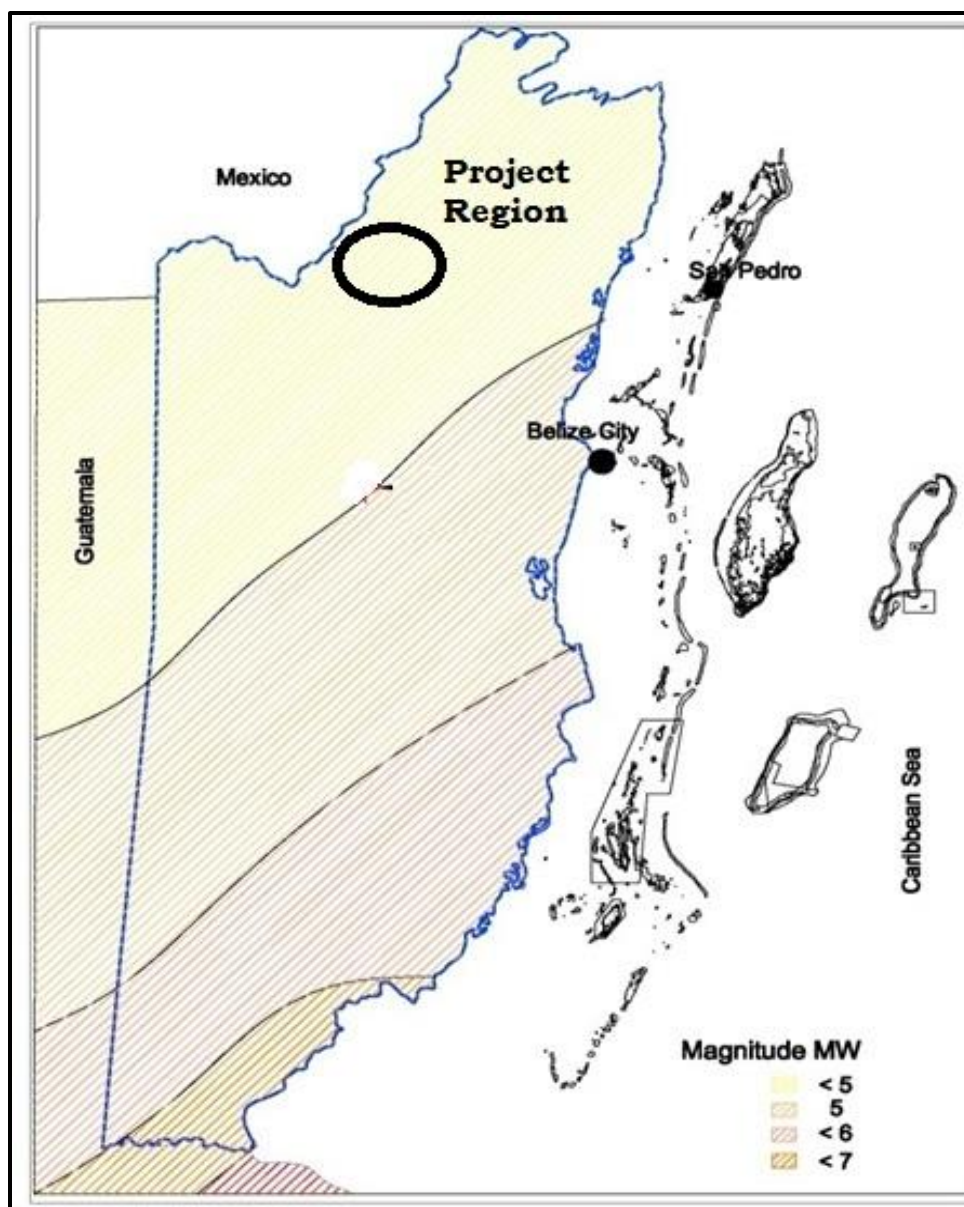


Figure 1.30: Map showing projected magnitude of earthquake as a result of tectonic activity.

As can be seen, the magnitude of less than 5 on the Richter's scale can be expected at or near the project site based on historic seismic events.

Quake of May 2009

According to the United States Geological Survey (USGS, 2009), several people were killed, many injured and more than 130 buildings were damaged or destroyed in northern Honduras as a result of the May 28 2009 earthquake offshore Honduras. At least 5 buildings destroyed and 25 damaged in Belize. This earthquake was felt in much of Belize, El Salvador, Guatemala and Honduras. It was also felt in the Bahamas, Cayman Islands and Virgin Islands and in parts of Colombia, Costa Rica, Cuba, Jamaica, Mexico, Nicaragua and Panama. Seiches were reported in swimming pools at La Ceiba and Roatan and ground cracks and possible liquefaction was observed at Monkey River, Belize (USGS, 2009).

Tectonic Summary

According to the USGS, the location and focal mechanism of the Honduras earthquake of May 28, 2009, imply that the shock occurred as the result of “left-lateral strike-slip faulting on the Swan Islands Transform Fault, a segment of the boundary between the North America and Caribbean plates” (USGS, 2009).

Previous strong earthquakes along the North America/Caribbean plate boundary include the destructive Guatemala earthquake of February 4, 1976, (Magnitude 7.5); which produced more than 23,000 fatalities in that country. The 1976 earthquake occurred on the Motagua fault, a segment of the plate boundary that lies in southern Guatemala, several hundred kilometres southwest of the plate boundary that ruptured in the May 28, 2009 shock (USGS, 2009).

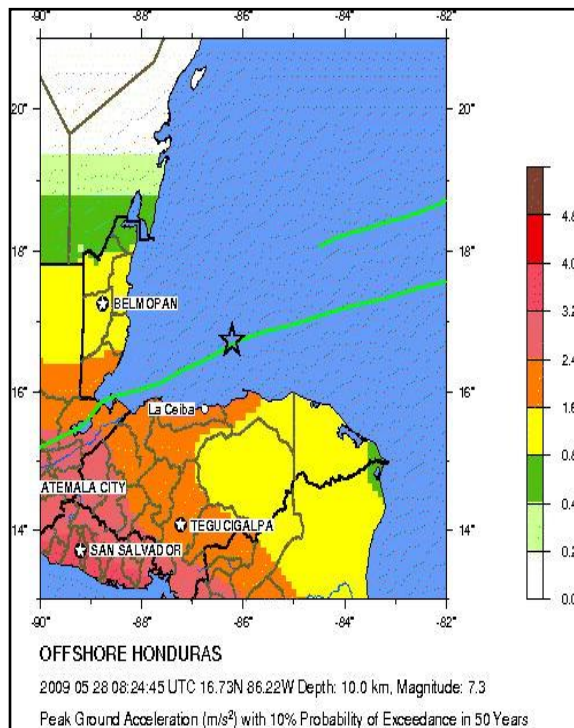


Figure 1.31: Peak Ground Acceleration (m/s²) of May 2009 Earthquake

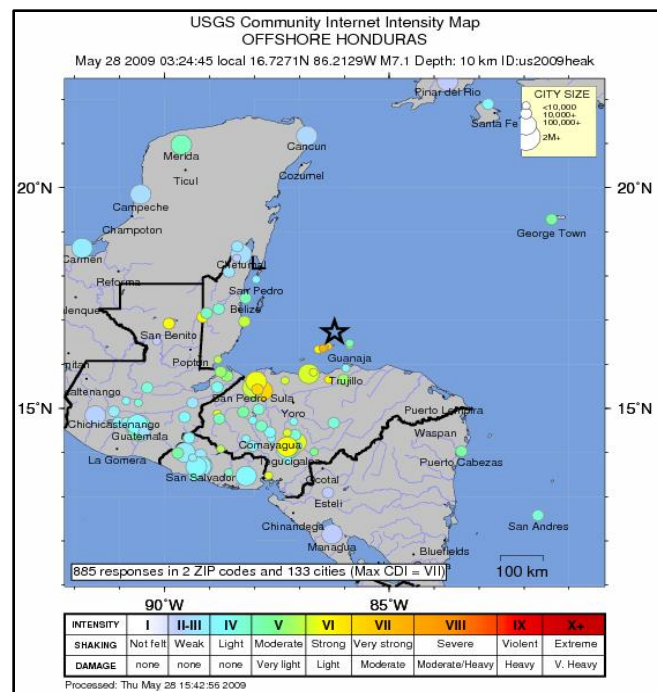


Figure 1.32: USGS Intensity Map of May 2009 Earthquake offshore Honduras

Mitigation measures against seismic activity are difficult to plan for due to the unpredictability of seismic activity; its intensity and its location. At the *Arundo donax* site, low seismicity has historically been the case. Structures are not expected to be greater than two story buildings, and most being single story.

1.3.7.2 Other Man-Made Hazards

The project site is not known to have any other man-made hazards such as sink holes, and the area where cultivation will take place is not known for flooding. There are no known other man-made hazards within or near the project site. However, the northern half of Belize is known to have cavernous limestones, and porous caves, some which have water flowing through. These are not known near or at the project site, and are found closer to the sea shore.

1.3.8 Hazards from Potential Natural Disasters

Belize is located in the Tropical to Sub-tropical zone; for which it has a fairly high vulnerability to natural disasters stemming from weather- and weather-related phenomena such as tropical storms, hurricanes and floods. At the same time, the increased global temperature anomaly will also increase the risk of forest fires, another natural disaster.

This section summarizes the project's vulnerability to natural disasters. As part of the Environmental and Social Management Plan (ESMP), an Emergency Evacuation Plan, an Emergency Management Plan and an Occupational Health and Safety Plan have been drafted. These are detailed in Annex A to the ESMP Report.

1.3.8.1 Vulnerability to Hurricanes

Due to its geographic location, and low-lying topographic characteristics, the Caribbean Region, including Belize (primarily its coastal zone) is at risk to the effects of climate change. According to Usher, (Usher 2000), the changes in the hydrological cycle in Belize as a result of climate change, would be characterized by changes in sea levels, the intensity of hurricanes and its accompanying storm surge, and changes in rainfall patterns and temperature. These changes may result in the following impacts:

- Exacerbated erosion of the coastline and accompanying beach loss;
- Coral bleaching as a result of temperature rise,
- Potential negative impacts, including depletion of sea grass beds from resulting fresh water runoff (including siltation etc.),
- Alteration or destruction of mangrove communities due to changes in precipitation and seasonality, resulting in the alteration of the productivity of mangrove ecosystems,
- Increased inundation as a result of sea level rise, with consequences such as salt-water intrusion,
- Inundation and salinization of agriculture lands, resulting in net decrease in productivity,
- The destruction of aquaculture activity resulting from pond destruction due to storm surge and freshwater intrusion,
- Vulnerability to flooding and soil erosion of low-lying communities,
- Loss in net tourism economic activities as a result of the combined effects of climate change (damage to coral reef etc.).
- Impact on human health due to the change in patterns of infectious diseases,

especially in water supplies and food.

- Extreme dry conditions in savannah ecosystems.

These impacts are not confined to a specific site and are in fact of a regional and national scale, and the results of these potential impacts can be described as cumulative impacts of climate change, rather than resulting from individual project development.

Planning for disaster management and climate change adaptation for an investment such as the *Arundo donax* project should focus along two primary planning actions: (1) Avoidance of disaster-prone areas; and (2) Disaster Planning (Mitigation).

In recent years Belize has been affected either directly or indirectly by several tropical systems (including a tropical depression) with some making landfall in neighbouring countries, which resulted in flooding, storm surge and some wind damage. These tropical systems included Fourteen (14) storms over a period of eighteen (18) years; as follows:

- Hurricane Mitch, October 1998, making landfall in Honduras as a major hurricane;
- Hurricane Keith, October 2000, making landfall in Ambergris Caye as a major hurricane;
- Tropical storm Chantal in August 2001, made landfall near the Belize/Mexico border, causing moderate wind damage, wave action and high rains;
- Hurricane Iris in October 2001, made landfall near Placencia, Belize as a major hurricane;
- Hurricane Dean in 2007, made landfall as a major hurricane approximately 25 miles from the Belize/Mexico border;
- Tropical Storm Arthur in late May 2008, made landfall in Northern Belize.
- Tropical Depression 16, formed off the coast of southern Belize, causing historic flooding (October 2008);
- Hurricane Alex, in June 2010, made landfall in Northern Belize as a tropical storm, later forming into a hurricane in the Gulf of Mexico,
- Hurricane Karl, 2010, made landfall north of Chetumal Mexico, as a tropical storm;
- Tropical Storm Matthew, in September 2010 made landfall near the Honduras/Nicaragua border but caused flooding and rainfall damage in Stann Creek and Toledo;
- Hurricane Richard, in October 2010, made landfall in the Belize District as a category one hurricane, but maintained its tropical force winds well inland, causing damage in the Belize and Cayo Districts;

- Tropical Storm Harvey, made landfall in Belize as a tropical storm in August 2011;
- Hurricane Ernesto made landfall in Mexico, about 45 miles north of the Belize/Mexico border, only causing rainfall in Belize;
- Hurricane Earl made landfall in Belize on August 4th 2016 as a category I hurricane.

The period 1998 to 2012, included the passing of Hurricane Iris, one of the most destructive storms in terms of wind damage. Iris made a direct hit to the Stann Creek and Toledo Districts. Even Hurricanes Richard (2010), and Hurricane Earl (2016) being moderate category one hurricane impacted the Belize and Cayo Districts in 2010, resulting in significant damage to property and agriculture. Hurricane Iris caused widespread devastation from wind damage, while Hurricane Keith impacted directly the island of Ambergris Caye with resulting wind and rain damage to property. Arthur impacted the Stann Creek District with floods resulting in devastation to bridges and private property, including crops, homes, and even taking several human lives. Hurricane Mitch and Tropical Storm Chantal resulted in flood damages to northern Belize. Tropical Depression 16 was a rainfall and flood event, completely inundating numerous villages in both Orange Walk and Stann Creek for weeks.

Floods resulting from Arthur, and TD 16 (2008) caused historic floods from intense rainfall all over Belize; with human casualties in the Stann Creek District.

As in most parts of coastal Belize, a direct hurricane landfall in or near coastal population centers makes these communities highly vulnerable to the effects of wind, storm surge and flooding, as has been demonstrated in recent history.

Similarly, the Caribbean Disaster Mitigation Project (CDMP) has determined that due to Belize's shallow offshore shelf, the low-lying areas are at high risk of destructive storm surges. The 1995 CDMP report has also determined that *Because of the geographic location of Belize in the Atlantic Basin, and the geometry of the Gulf of Honduras and Central America, there is a strong north/south gradient to the occurrences of storms. The northern coast of Belize is exposed to more frequent and more intense storms than the southern part. For example, tropical storm events are expected to occur in Punta Gorda on average every 6 years, while in Ambergris Cay they typically occur twice as often, every 3 years (CDMP, OAS, 1995).*

1.3.8.2 Other Natural Disasters

Belize is also vulnerable to other weather phenomenon, particularly flooding and drought-related fires.

Flooding

In 2008 Tropical Depression 16 (TD 16) resulted in significant flood damages especially in the Stann Creek Districts where it resulted in the loss of infrastructure (bridges and roads), crops and even several lives lost due to flash floods.

The year 2013 was an unusual year in terms of rainfall patterns. Most of the months for that year resulted in rainfall way above normal, resulting in widespread flooding throughout the country. Flooding, therefore, is an ever-present risk that requires mitigation planning.

Forest Fires

Forest fires, as well as other vegetation or “bush” fires, while not uncommon during the dry season in Belize; tend to have higher proliferation during extended dry periods, and pose significant risk to property. Fire hazards are greater in shrublands, and in areas with pine and pine savannah vegetation. The *Arundo donax* site is not only located in an area of less rainfall and drier conditions, but the vegetation presents higher risk of fires.

1.3.7.3 Summary of Potential Impacts of Natural and man- made Disasters

Greater details of these activities are found in Chapter 4.0 as well as the ESMP.

The potential impacts from natural and man-made disasters are numerous. While the risks are low for man-made disasters; Belize has been known, as described above, as a hurricane risk country, with secondary effects of flooding and wind damage which have been well documented. Non-hurricane or storm impacts of flooding are also known to take place during extreme weather events such as heavy rainfall, often brought about by the passing of tropical depressions etc.

Summary of Mitigation Measures

1) Avoidance

There were two stages of site selection using the avoidance method. In order to accomplish this, it was necessary to identify available property suitable for *Arundo donax* cultivation and to eliminate all sites that are at risk to flooding and excessive inundation; and those that would conflict with other land uses. This was done by the preparation of a map showing the location of *Arundo donax* and other areas in the Orange Walk District. A series of criteria were then used to

eliminate potential sites to avoid: (1) protected areas, (2) flood hazard risk (including storm surge), (3) fire hazard, (4) national waters, (5) agriculture farms (banana and sugar cane), (6) soil types; and (7) roads. This process ensured that potential sites avoided from the onset all the above risk factors. Therefore, the avoidance of flood prone areas, for example, is in itself an avoidance technique that is also mitigation against flood risks.

During project planning, in addition to these criteria, the criteria of physical location in terms of proximity to the BELCOGEN Plant, transportation availability in terms of roads and other infrastructure, as well as the elimination of parcels that are subject to total inundation and that are vulnerable to flooding were selected. During this process, other lands that are suitable and have *Arundo donax* vegetation were identified but later eliminated using these criteria. Therefore, the avoidance of high-risk sites was done via this process, resulting in the selection of the existing sites.

2) Disaster Planning

While the potential sites do not fall within an area of high risk for disasters, there is a need to plan for such unavoidable phenomenon, primarily hurricanes and storms. As a result, disaster planning will focus primarily on the development of a hurricane preparation and evacuation plan for the employees operating within the project sites. Furthermore, as part of the Disaster Management Plan, a fire management plan had been drafted. The draft documents detailing the hurricane plan and fire plan are expected to be updated and completed prior to or before full project implementation. The reader is advised to see the ESMP as mentioned before.

1.3.9 Description of Prevailing Community Waste Management Practices

1.3.9.1 Waste Management in Belize

The country of Belize has taken significant steps to improve solid waste management through the implementation of various solid waste management initiatives led by the Belize Solid Waste Management Authority (BSWaMA). Under this solid waste program, a comprehensive solid waste management plan was implemented for the Western Corridor in 2011; and recently for the Northern and Southern Corridors. This included the construction and management of the National Sanitary Landfill located at Mile 31, George Price Highway. Belize's solid waste plans are divided into the Western Corridor component (Belize and Cayo Districts), the Northern Corridor (Corozal and Orange Walk), and the Southern Corridor (Stann Creek and Toledo).

However, the country still faces challenges in the solid waste sector because the rest of the country still lacks the solid waste management infrastructure and transportation plans to support the solid waste management plans. Nonetheless, the solid waste management plan has extended to the Northern and Southern Corridors of Belize, which includes Orange Walk as previously

mentioned and contractual arrangements are being made for the construction of several transfer stations. One such transfer station will be constructed at the existing dump site serving Orange Walk Town and surrounding villages. This site is located near the airstrip, approximately 10 kilometers through access roads from the project site and approximately 7 from the villages of San Lazaro and Trinidad.

Municipal waste is generally defined as waste collected by municipalities or other local authorities. Typically, MSW includes:

- Household waste;
- Garden (yard) and park waste; and
- Commercial/institutional waste.

The Belize Solid Waste Management Authority Act established the Solid Waste Management Authority and a Board of Directors of the Solid Waste Management Authority (BSWaMA). The BSWaMA is a body corporate with perpetual succession and a common seal and with power as such to enter into contracts, to hold property, to sue and be sued in its corporate name and to do all things necessary for the purposes of the Act. The BSWaMA and the Board is charged with the responsibility to deal with all matters pertaining to and conducive to the management of solid waste in Belize. Its functions include the designation of “service areas”, (with the approval of local authorities), to arrange for the collection and disposal of solid waste within a service area, (through contractual services or otherwise), and to enact and implement policy and guidelines conducive to adequate solid waste management throughout the Country. Existing service areas are primarily areas being served by the municipalities (Town and City Councils). The Western Corridor is served by waste disposal services including waste management at the National Sanitary Landfill that presently serves Belize City and the communities along the George Price Highway Corridor. This landfill receives daily garbage waste from transfer stations in San Ignacio, San Pedro, Caye Caulker, Burrell Boom and Belize City.

The Belize Solid Waste Sector includes waste generated from households, garden, and commercial/institutional waste. However, in estimating total solid waste generated at the household level, the generation rates did not include generation rates for commercial/institutional waste, as due to the nature of waste management in Belize; these rates are lower than household generation rates.

Dump sites in rural areas are considered informal and even “illegal in that these constitute the dumping of waste in areas that are not sanctioned by the BsWAMA, and other relevant authorities. Nonetheless, this is the practice that is unavoidable due to the lack of complete coverage of the solid waste management program, and the lack of resources by communities to pay for collection and transportation of waste to municipal dumps.

1.3.9.2 Waste Generation Rates and Waste Composition

The BSWaMA led a study that included the estimation of waste composition and waste generation rates in the Western Corridor communities. This study by Hydroplan & BSWaMA, established (BSWaMA/Hydroplan, 2011), established rates at 1.07 kg/per capita per day, for the Western Corridor region. These rates were used for the recalculations from 1994 to 2009. Another study, conducted by Hydea S.p.A & BSWaMA resulted in another average for the northern and southern corridors. This regional study established an average of 0.365 kg/capita/day in both northern and southern corridors, considering all population centers sampled (including 4 villages). The study noted that the waste generation rates were significantly lower than those of the previous Hydroplan/BSWaMA study for the Western Corridor. It is also noted that both the Hydroplan BSWaMA and the HYDEA/BSWaMA studies used different methodologies, and were conducted in different time periods; therefore, the average of these studies does not accurately represent a national average of waste generation.

In terms of the already established waste composition based on both studies (Hydroplan & Hydea, BSWaMA), both of these studies showed quite similar rates of waste composition; differing by only 5% in one waste category, for example.

The country of Belize has locally available data or country specific data on most sector of the solid waste stream.

Waste in the Western Corridor by percent composition was determined to be; Food (29%), Plastics (23%), Paper (20%), Nappies (12%), Garden (9%), Textile (4%), Wood (3%) (Source: BSWaMA/ Hydea 20116).

The “rest” category consists of miscellaneous waste that is not normally categorized in any of the other categories, and comprises small quantities of miscellaneous waste.

Waste Composition in Northern Corridor - Belize. Source: Hydea/BSWaMA, 2016.

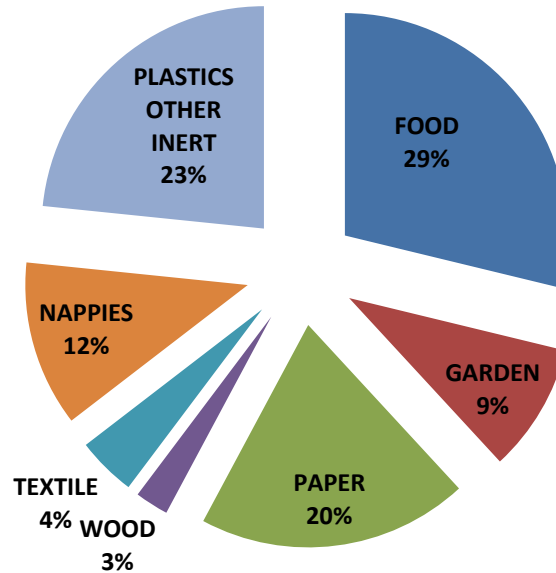


Figure 1.33: Waste Composition in Northern Corridor-Belize.

1.3.9.3 Solid Waste Practices in Nearby Communities.

As mentioned earlier, rural communities (villages, settlements, farms, and housing subdivisions) mostly do not have a formal solid waste collection method in this part of the country. Local collectors are hired to dispose of garbage along rural roads. Many citizens dispose of the domestic waste themselves, using locally available transportation. Unfortunately; the sides of access road leading from near San Lazaro to the *Arundo donax* site are also used for waste dumping.

This is unsightly, and poses health hazards to the communities, but in the absence of established waste management practices, this is their only option, along with the localized burning and burying of waste.

The two nearest villages are San Lazaro and Trinidad. San Lazaro has a population of 1052 and Trinidad has a population of 571 based on the 2010 census. Based on the annual growth rate of 2.6%, both of these communities will have a population of approximately 2098 persons by the year 2020. The Hydea/BSWaMA study of 2016 determined that waste generation rates for the Orange Walk Municipality was 0.43 kg/capita/day and a village studied resulted in the rate of 0.22 kg/capita/day. If the rate of 0.43 is applied, it means that both these villages are producing an estimated 900 kgs/capita/day or 328,496 kgs annually or approximately 328 metric tons annually. These figures are shown in figure 1.3.4.

Waste recycling practices are presently non-existent in the communities near the project. The two nearest communities (San Lazaro/Trinidad) are the ones using the access road for waste disposal, but most of the waste is attributed to the community of San Lazaro.

As part of the social component of the A. donax project, an advisory committee that will serve to enhance community involvement and that will also serve as an advisory capacity for redress and compensation is being recommended. This committee will have participation of the Belize School of Agriculture (BHA), located along the access road serving San Lazaro, Trinidad and other villages. This road is known as the Yo Creek Road.

As part of the advisory committee, two pilot projects have been identified and have been discussed with the management of the BHA. These projects are for the establishment of pilot projects for separation of solid waste into recycling material and non-recycling material and a second project for the piloting of a compost facility to utilize biodegradable waste such as food waste. The projects will be piloted at the high school level; and separated waste will then be stored and transported to the transfer station, which is under final stages of installation. Compost material from composting will be utilized for gardening etc. If successful, then these projects can be further extended at the entire community levels. These pilot projects, and subsequent community recycling and re-use strategies would reduce solid waste considerably.

1.3.9.4 Proposed Waste Management Initiatives.

As a part of the management of the proposed project, it is recommended that a waste management plan be discussed and proposed with both villages near the project in order to reduce waste disposal and for overall benefit of the communities. The details of this plan are made complex by the necessity to involve the BSWaMA, the DOE, and Health Authorities, and the leadership of both villages. This will take time to formulate, but funds for a pilot project to consider segregation of recyclable and non-recyclable waste can be set aside. The initial focus should be in the recovery of compost material for a composting pilot project that will reduce waste volumes and may contribute to the production of compost that can be applied at the project site.

Within the BSWaMA's long term plans are for the establishment of a transfer station at the old dump site near the Tower Hill Airstrip. Waste collection will be put in place and waste to be collected will be sorted and separated for recycling and final disposal at the Belize National Landfill.

In Belize, the recycling rate has not been established, but based on the results of studies mentioned earlier, as shown in figure 1.3.3, above, the recyclable and biodegradable waste is more than half of the waste generated by domestic sources. Recycling success, and thus the rate of any recycling program depends on a number of factors, including the management regime installed for such recycling initiatives, the market demands for recycling material, the availability of will and funds for the collection, storage and transportation of potentially recyclable material, among other issues. As a result, the percent of waste being recycled in Belize is unknown. However, three scenarios were considered in a long-term planning strategy aimed at recycling, re-use and improved management of solid waste for the two nearest villages. The results of each scenario are shown in figure 1.3.4. This figure shows the total projected waste up to the year

2040 and the projected results in scenarios that would include 30%, 50% and 70% recycling. As can be seen from figure 1.3.4, in the year 2030, the two communities would be generating approximately 425 metric tons (mt) of waste. The volume expected during this year decreases to 370 mt for the scenario of 30% recycling, a further decrease to 334 mt tons for the 50% recycling scenario and to 297 mt for the 70% scenario. These figures would represent the following decrease from non-recycling estimates in mt of solid waste for the year 2030: 30% recycling – 55 mt; 50% recycling – 91 mt; and 70% recycling – 128 mt. The figures are significant considering the environmental implications and the economic implications of a reduction of the volume of solid waste that translates into resources required for its transportation and final disposal.

Therefore, the pilot projects being considered, will contribute to the communities' participation with positive impacts such as the increased public awareness and participation in environmental stewardship, as well as to economic and health benefits of the reduction of the volume of solid waste disposal.

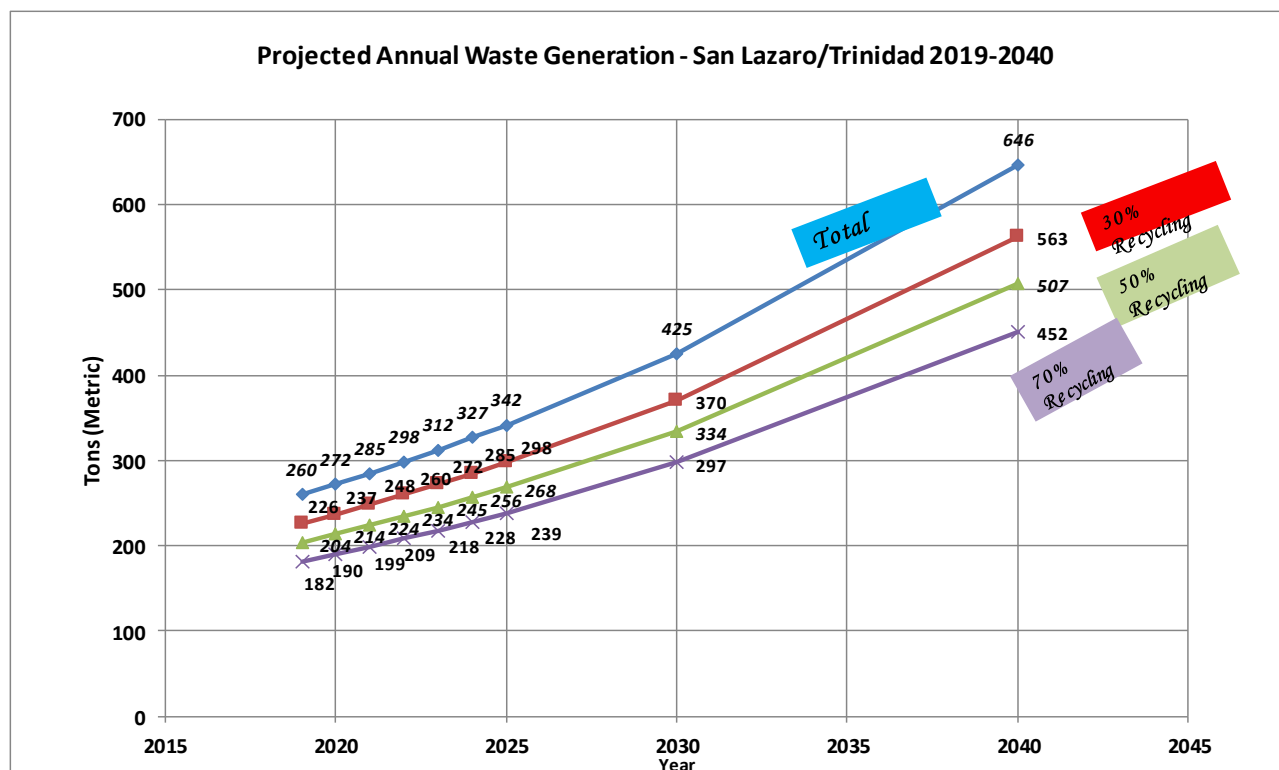


Figure 1.34: Projected Annual Solid Waste Generation Scenarios for San Lazaro/Trinidad.

1.3.9.5 Summary of Potential Impacts of Solid Waste Disposal and Compensation

The potential impacts of activities that generate solid waste include: the risk of contamination of soil and water resources from the chemical disintegration of solid waste material; the risk of contamination of soil and water resources with potentially hazardous substances and waste material; the creation of habitats for pests and insects that become nuisances and health hazards

to the community; the possible loss of aesthetic quality of the local environment from dumping of waste; and the increased risk of fires from lightning and sunlight during peak heat events. Table 1.25 below summarizes the potential impacts of activities and proposed mitigation measures. Chapter 4.0 contains greater details of the proposed mitigation and control measures, and so does the ESMP.

A key pilot project described in section 1.3.8.4 Proposed Waste Management Initiatives; will serve as an important mitigation measure aimed at community participation, community behavioral changes and the improved management of waste management practices at the local level.

Table 1.25: Summary of Activities, Potential Impacts and Mitigation Measures - Solid Waste.

Activities	Degree of Impact	Mitigation Measure
Solid Waste Generation	<ul style="list-style-type: none"> • Water Pollution • Soil Pollution • Habitats for pests and insects • Deterioration of visual landscape of community • Risk of fire hazards 	<ul style="list-style-type: none"> • Implement community initiative for recycling/reuse of waste via various mechanisms as described above. • Waste generation must be mitigated and as such as waste management plan will be developed to address this important concern. • For solid waste, the garbage bins should be strategically placed within the worksite and operation construction site. • The bins should be adequately designed and covered to prevent waste from becoming airborne, accessed by vermin and to minimize odor. • The bins should be emptied regularly, and all material scheduled for disposal and properly bagged. • Provide portable sanitary conveniences for the workers for control of sewage waste. A ratio of approximately 20 workers per toilet should be used. • All storage sites should be serviced regularly.

1.3.10 Water and Hydrology

1.3.10.1 Surface Run off and Drainage

The Arundo Donax project site west Trinidad Village in the Orange Walk District is located in the mid Rio Hondo watershed. The area is well drained through natural slope of the landscape, having a gentle slope towards Cross Creek (often called Blue Creek), which is a tributary of the Hondo River, that eventually drains into the Caribbean Sea.

The New River Watershed

There are four main river systems draining northern Belize. The greater section of the sinuous courses of all four is through swamp and lagoon, and the flow is slow and low energy. Because of the karstic and Broken Pine Ridge character and low relief of the landscape, it becomes difficult to accurately delineate the water partition of the watersheds.



Figure 1.35: New River Watershed Drainage Area

The New River has the largest catchment area of about 1,400km² or about 466,001 acres. The river rises from the Yalbac Hills and flows through swamps and marshy terrain, to the New

River Lagoon, which extends over a distance of 30 km from Hill Bank to Shipyard (see New River watershed map, **Figure 1.34**). The lagoon and river downstream meanders in a general NNE direction, probably maintained by tectonics fault lines North of the lagoon, the New River maintains a defined though sinuous and often braided channel to the discharge point into the Chetumal Bay. Historical measured flow on 2 April 1991 was: 10 m³/s, 4.0, 3.6, and 3.5 m³/s on 1, 7 and 14 May, 1991, respectively. **Table 1.26** is the monthly average and maximum and minimum stream flow (m³/s) for the New River at the Toll Bridge. In severe flood conditions with a 5-year return period, water levels often rise to 3 meters, flooding the approach and surrounding areas of the Tower Hill Bridge, and may persist for several days to weeks.

Table 1.26: Historic Mean Monthly Water Stage in the New River at Tower Hill

Tower Hill Bridge 8931		Stream flow calculated from manually read water levels (m³/s)												
River Level Manually Read [m]														
Period		1992-2009												
Months		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
MEAN at Douglas Rio Hondo		9.95	9.08	8.07	8.52	8.78	13	16.8	17.3	16.1	36.2	28.4	15.5	15.5
MAX. at Douglas Village		42	23.7	15.9	43	41	113	123	114	45.1	226	140	131	226
YEAR		1999	2006	2006	1999	2009	2008	2006	2006	2006	2000	2000	1992	2000
MIN. at Douglas Village		3.57	0.75	1.97	3.85	0.099	1.23	1.97	3.39	3.04	5.52	6.44	2.8	0.099
YEAR		1997	2004	1996	1997	1997	2004	1994	1994	1996	1996	1999	1999	1997

(Source: NHS, 2010 Belize; R. Frutos 2014)

The computed annual mean flow is 15.5 m³/s; with the mean maximum flow in October and the mean minimum discharge occurring in May.

The Rio Hondo Watershed

The Greater Rio Hondo Watershed is a tripartite watershed shared by Mexico, Belize, and Guatemala. The main tributaries in Belize are the Blue Creek, the Rio Bravo and the Booths River (See Rio Hondo watershed map, **Figure 1.35**).

The Rio Hondo forms Belize's northern boundary with Mexico. Belize shares this watershed with Mexico and Guatemala. The Rio Hondo drains an area of approximately 13,465 km². Approximately 2,978 km² or 22.1% of this watershed lies within Belize, 7,614 km² or 56.5% within Mexico and 2,873 km² or 21.3% lies over northern El Petén, Guatemala. The Rio Hondo originates near the 300-metre contour in northern Petén and south-eastern Mexico. As indicated, the Belizean tributaries to this river are the Rio Bravo and Booths River, and the portion of the Blue Creek Belize shares with Mexico. The main channel of this river begins near the confluence of the Booths River and the Cross Creek (also known as Blue Creek) after which it traverses the low-grade Northern Plains to the Chetumal Bay.

The Hydrology Unit (National Meteorological Service) operates two hydrological stations along this river (see **Figure 1.35**). At the lower station at Douglas Village (8921), the average annual stage is 1.46 meters while 4.25 meters (2000) and 0.93 meters (1999) are the maximum and minimum water levels respectively. No rating curve was established for this station however, a point measurement approximates the mean flow at 81.73 m³/s (stage = 1.78metres). The second hydrological station is located at Douglas village.

Rio Hondo Watershed Belize Portion Only

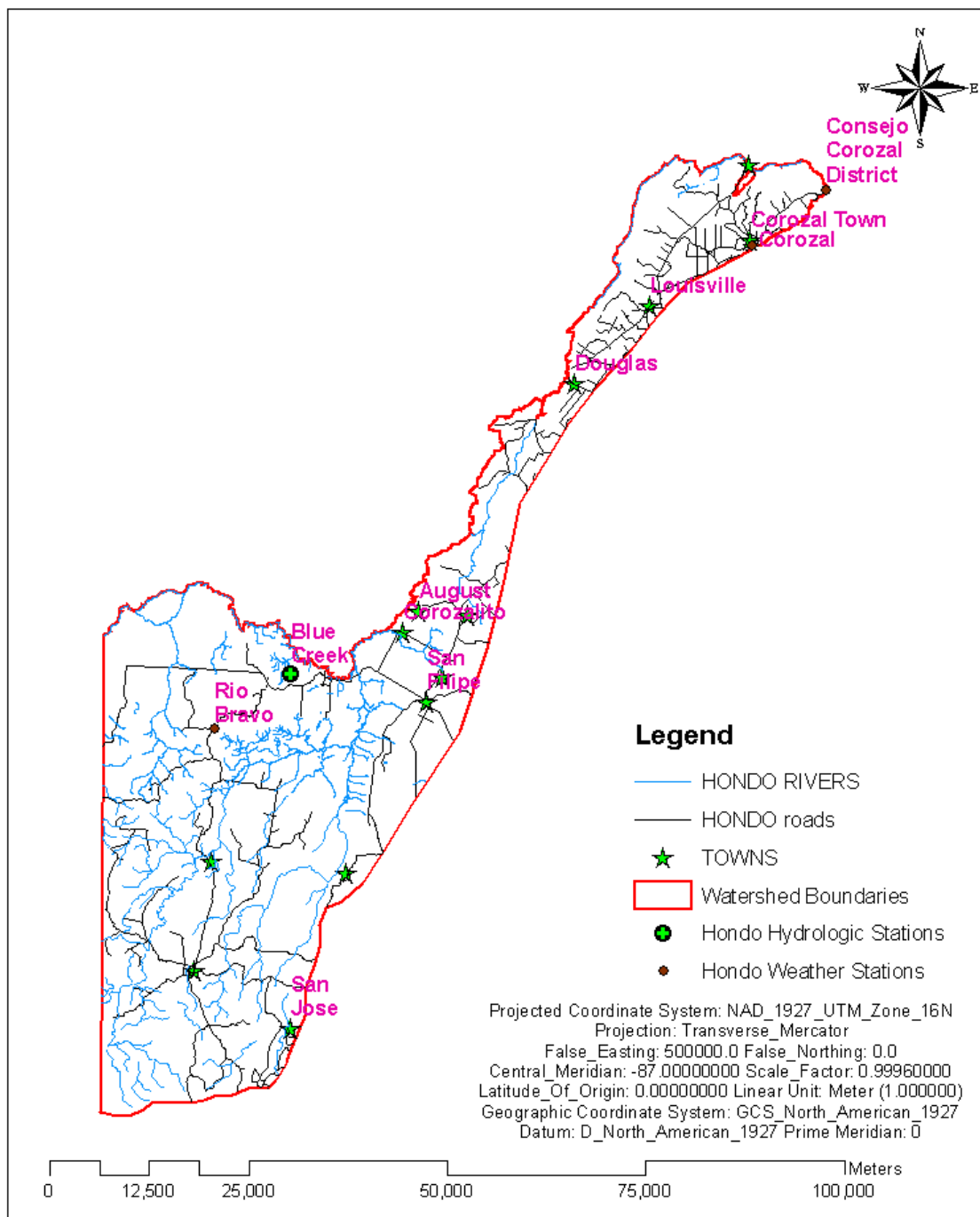


Figure 1.36: Rio Hondo Watershed in Belize

Table 1.27 is the mean monthly and historic maximum / minimum river stages (in meters) for Douglas Village for the period 1997 to 2009. Table 1.27 shows a plot of monthly maximum water levels at Blue Creek and Douglas. The highest stages at both localities coincide with the peak rainfall at these localities in the months of June and October. As can be seen, maximum stage heights at Cross Creek are higher than at Douglas, primarily because of the confined banks at Blue Creek compared to the flatter terrain and the wider river channel in the Douglas Village area, that is NE of the *Arundo donax* project site near Trinidad Village.

Table 1.27 Monthly average, maximum and minimum river levels for the Rio Hondo at Douglas Village

Douglas 8921													
River Level Manually													
Read [m]													
Period	1997-2009												
Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
MEAN Douglas Rio Hondo	1.23	1.3	1.38	1.39	1.43	1.55	1.5	1.53	1.58	1.9	1.54	1.26	1.48
MAX. Douglas Rio Hondo	1.6	1.72	1.72	1.62	1.76	3	2.36	2.81	2.43	4.25	3.96	1.57	4.25
YEAR	1998	2001	1999	1999	1998	2008	2006	2001	2001	2000	2008	1997	2000
MIN.	0.94	0.78	0.85	0.96	1.11	1.19	1.23	1.17	1.3	1.13	0.88	0.9	0.78
YEAR	2005	2004	2007	2001	2002	2007	2005	2001	2004	2009	2005	2005	2004

(Source: NHS, 2010 Belize; R. Frutos 2014)

During extreme rainfall events, the project site becomes waterlogged, and pluvial flooding partially inundates the marshy zone along Cross Creek that runs through the property. Additionally, the section of the Orange Walk Town-San Felipe Road where Cross Creek traverses the road is prone to flash floods in wet conditions. However, this area is several kilometers from the project's access road and from the project site.

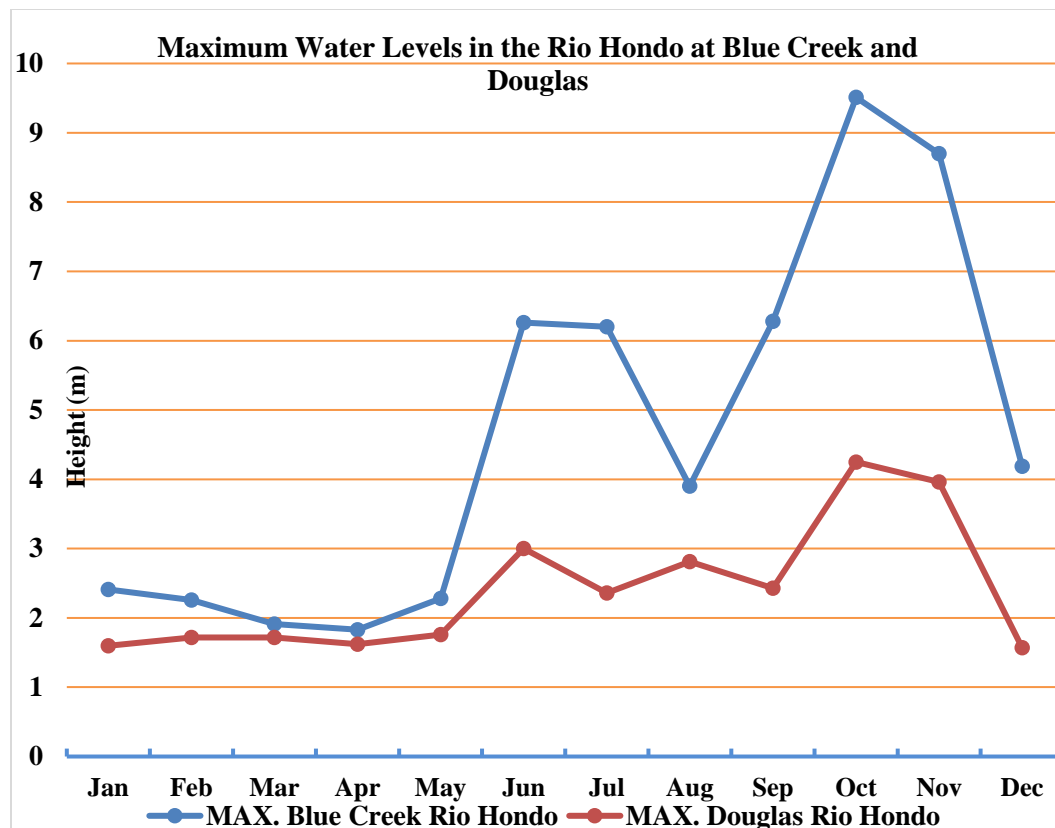


Figure 1.37: Historic maximum water levels recorded on the Rio Hondo at Blue Creek and Douglas

The greater proportion of the New River and Rio Hondo watershed is under sugarcane plantation as can be observed from the Land Use map in **Figure 1.37**. Broadleaf deciduous forest dominates the upper watershed and savannah/scrubland extends in an N to S swath over the eastern section east of the lagoon and the New River. Agriculture use in the SW Rio Hondo Watershed in the Blue Creek area is predominant pastures and rice cultivation under flood irrigation.

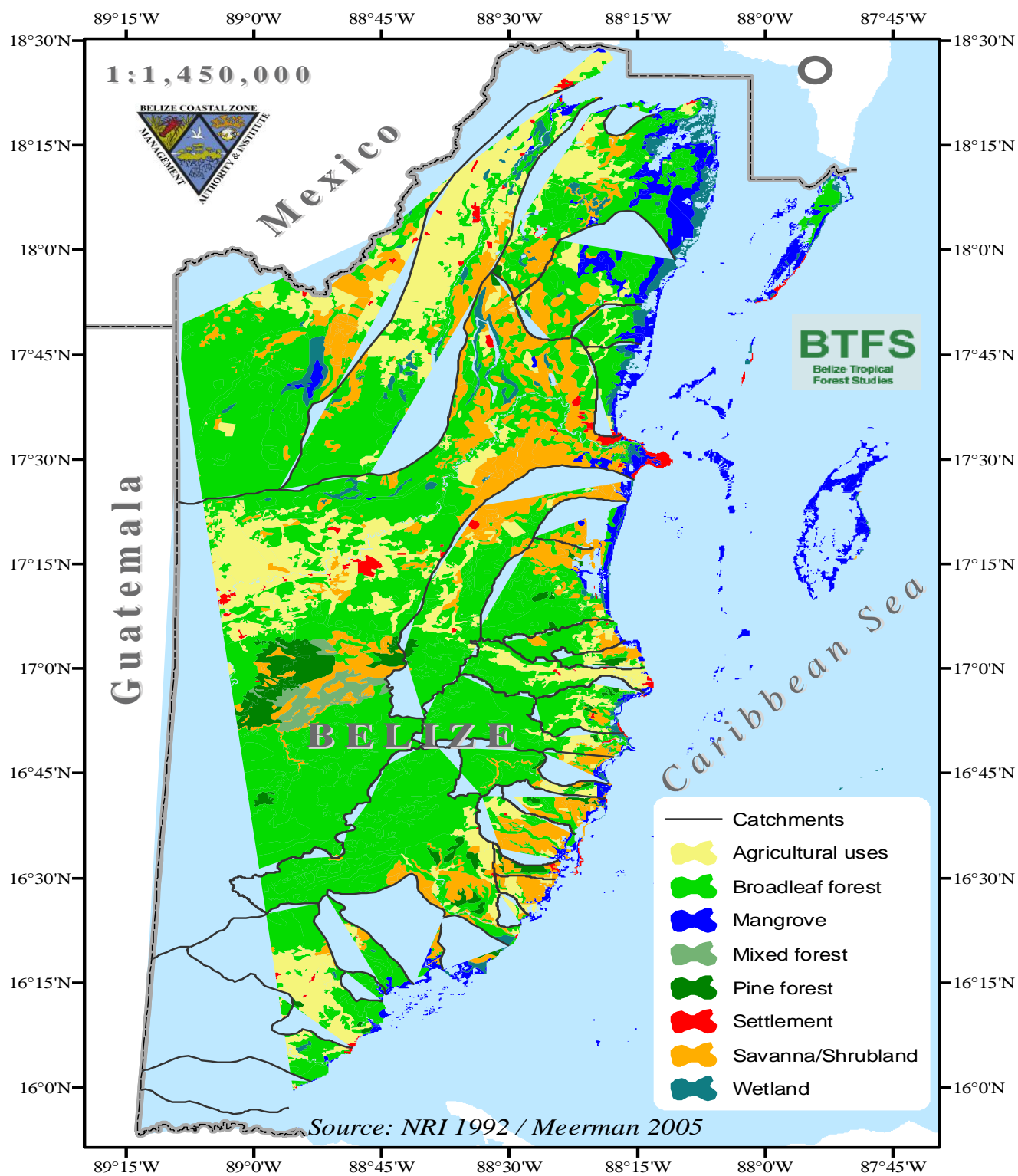


Figure 1.38: Watersheds and land use

Groundwater

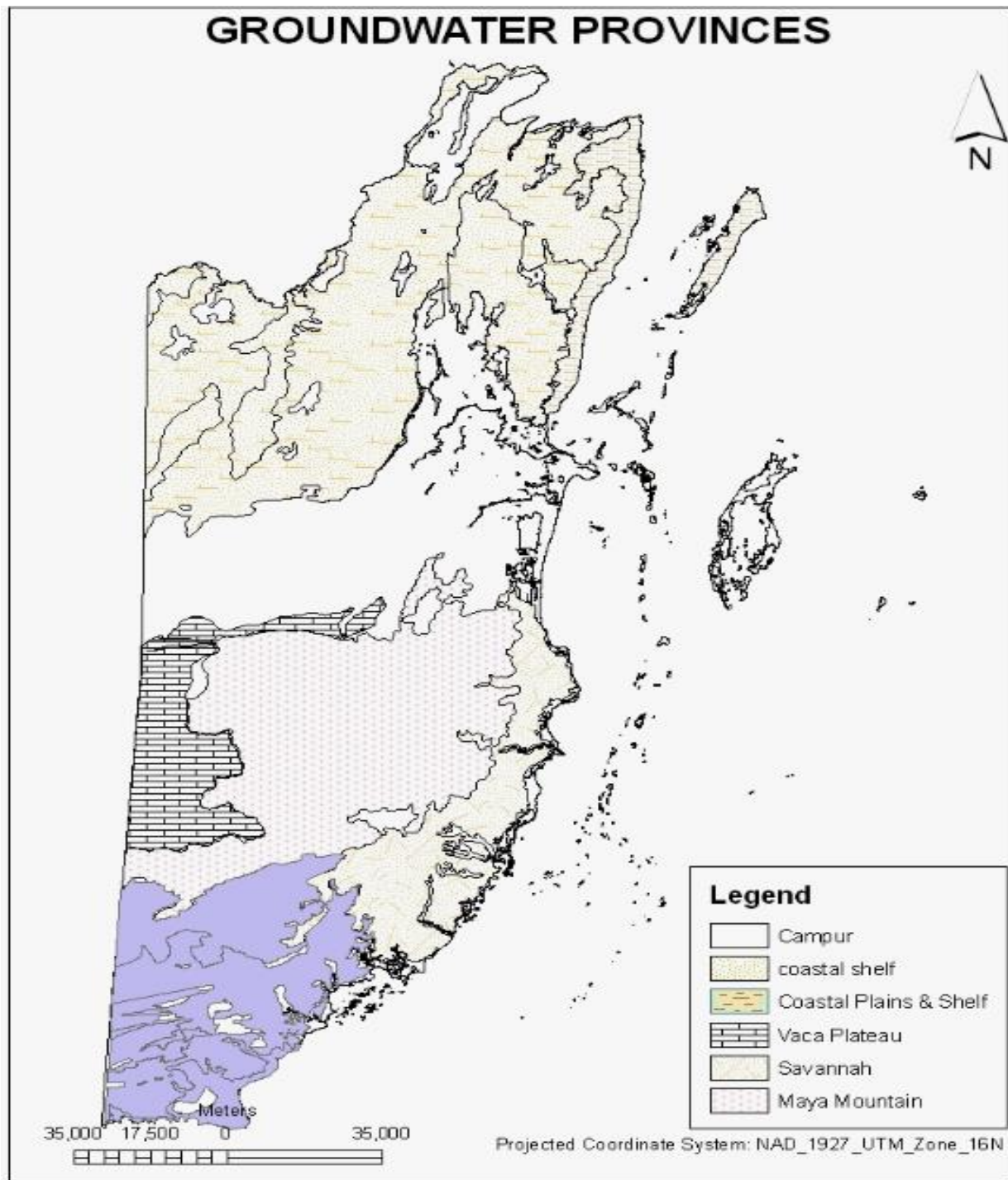


Figure 1.39: Groundwater provinces in Belize

The New River and mid-lower Rio Hondo watershed sits over the Coastal Plains and Shelf groundwater provinces of northern Belize — Orange Walk and Corozal districts. This groundwater province is characterized as generally plentiful in about 65 % of areas in the Orange Walk District (Buckalew, et al., 1992). Small to large quantities are available from tertiary limestones and marl. Reported well yields range between 75 to 4,550 L/min (19.8 to 1,202 gal/min). Some areas which are locally fractured are suitable for hand pump and tactical wells which may be used for municipal water supply and for irrigation. In the Carmelita Village area, one well was perforated with a potentiometric level around 13 m below the surface. The yield was estimated at 100 gallons/min.

It is estimated that about 25% of the Orange Walk District has plentiful fresh groundwater that is locally available. The aquifer in the Rio Bravo Hills is generally fractured cretaceous limestones and dolomites. Springs are common especially in the Rio Bravo and Booth's River Escarpment. Many unproductive wells have been drilled in these areas because of failure to encounter water-bearing fractures.

The groundwater within the Orange Walk District is generally fresh, but very hard with high sulfate content. In some areas of the District the sulfate content is high enough to cause the water to be brackish. Groundwater pollution problems arise from biological contamination from human and animal wastes, chemical contamination from infiltration of agro-chemicals from sugar cane plantation, and leachate from waste dumps of the sugar processing plants near Tower Hill.

1.3.10.2 The Quality of Locally available Waters

Three types of water use are identified for agriculture operations, namely: water for domestic use, water for irrigation and water for processing plant(s). The proprietors of the *Arundo donax* cultivation project do not intend to irrigate the crop in the short or medium period. The agronomic practice will be mechanized, rain-fed farming system. If irrigation is planned in the distant future, then water for irrigation will have to be sourced from the Rio Hondo, or alternatively, from ground water sources, as was the practice in papaya industry. This would require pump testing for the water supply wells.

Water for domestic use will also be minimal, primarily for farm workers and security personnel. Two farm overseers and guards will work on a rotation basis at the guardhouse. They may have family members at the farm house when on duty, but no person or family will be residing at the farm house permanently. All farm business, affairs, and repair of farm equipment will be conducted on site. Consequently, water for domestic use and farm personnel will be bottled water, rainwater and or potable water from nearby Trinidad Village RWS.

Baseline Water Quality

In-situ water quality assessments were conducted using the YSI Professional Plus Water probe at several sites within and near the Arundo Donax project site on different dates running from late 2014 to the first quarter of 2015. The designated sample sites are listed in the **Table 1.31**.

Table 1.28 shows the BWSL, WHO and DOE acceptable limits and guidelines for surface and groundwater.

Table 1.28: Acceptable Limits for BWSL, WHO and DOE Guidelines

<i>Parameter</i>	<i>Acceptable Limits (BWSL)</i>	<i>Guideline Values (WHO) / DOE</i>	<i>Remarks on water quality parameters</i>
<i>Temperature</i>	25 °C	None / ≤ 33 °C	
<i>pH</i>	6.5 – 7.5	6.5 – 8.5 / 6 - 9	Value of 7 indicates neutral condition
<i>Color</i>		15 TCU	Less than 10 units is unnoticed, water with 100 units resemble black tea
<i>Turbidity</i>	5 units	5 NTU	Pure distilled water turbidity is 0 NTU
<i>TDS</i>	500 mg/L	1,000 mg/L	TDS of 0-1000 is considered fresh and non-saline
<i>Conductivity</i>	N/A	none	Range 50–1000 $\mu\text{S}/\text{cm}$ found in natural fresh water
<i>Hardness (total)</i>		none	Water with hardness less than 120 mg/L is deemed desirable, in excess of 500 mg/L undesirable for domestic and industrial use
<i>Alkalinity</i>	250 mg/L	N/A	Generally acceptable water range for alkalinity is 30 – 500 mg/L
<i>Biological Oxygen Demand (BOD)</i>		/ 50 mg/L	DOE effluent standards
<i>Chemical Oxygen Demand (COD)</i>		100 mg/L	DOE effluent standards
<i>Chlorine (free)</i>	N/A	5 mg/L	
<i>Coliform (total)</i>	1/100 ml	0/100 ml	
<i>E-coli</i>	1/100 ml	0/100 ml	
<i>Nitrate - N</i>	10 mg/L	10 mg/L	
<i>Chloride</i>	250 mg/L	250 mg/L	250 mg/L is the acceptable value for drinking water
<i>Fluoride</i>	0.5 – 1.5 mg/L	1.5 mg/L	

<i>Phosphate</i>	N/A	None / 5	
<i>Sulfate (SO₄)</i>	250 mg/L	250 mg/L	Concentrations up to 500 mg/L acceptable
<i>Magnesium (Mg⁺)</i>	N/A	none	
<i>Aluminum (Al³⁺)</i>	N/A	0.2 mg/L	
<i>Calcium (Ca²⁺)</i>	N/A	none	
<i>Iron (Fe)</i>	0.3 mg/L	0.3 mg/L	
<i>Lead (Pb)</i>	N/A	0.01 mg/L	

(Source: Environmental Water Quality Monitoring Program (NARMAP) Final Report, June 1995, DOE/USAID; DOE Effluent limitation (Amendment) Regulations 2009).

Temperature (°C)

High water temperature indicates thermal pollution and influences most physical, chemical, and biological processes. Many water quality parameters vary with temperature, for example Dissolved Oxygen (DO).

Pressure (mmHg)

The YSI Professional Plus Water probe measures ‘true’ (uncorrected) values of air pressure in mmHg. True BP = [corrected BP] – [2.5 * (local altitude in feet above sea level/100)]. Weather service readings are usually not “true”, i.e., they are corrected to sea level, and therefore cannot be used until they are “uncorrected”. At mean sea level the average pressure is 1013.5 hPa or 760 mmHg.

Hydrogen Ion Concentration, pH (Standard Units)

pH in water is related to soil makeup and inorganic content. Depending upon the relative hydrogen ion concentration water can be either basic or acidic.

The pH of surface waters is important to aquatic life because pH affects the ability of fish and other aquatic organisms to regulate basic life-sustaining processes, primarily the exchanges of respiratory gases and salts with the water in which they live. Failure to adequately regulate these processes can result in numerous sub-lethal effects (e.g., diminished growth rates) and even mortality in cases when ambient pH exceeds the range physiologically tolerated by aquatic organisms. The pH of water affects the normal physiological functions of aquatic organisms, including the exchange of ions with the water and respiration. The normal pH range that is considered satisfactory for fish and other freshwater aquatic organisms is 6.0 - 9.0.

Turbidity (Nephelometric Turbidity Units or NTU) is a measure of the suspended particles such as silt, clay, organic matter, plankton and microscopic organisms, which are usually held in suspension by turbulent Brownian flow. It is impractical to assign a range of values to turbidity; however, non-detectable turbidity may be approximated by pure distilled water or “0” (zero) NTU.

The amount of solid materials in suspension may result from natural erosion, runoff, and algal blooms, although some of this material may be the result of anthropogenic activities. The concentration and particle size may cause significant variation of turbidity values. Turbidity is normally high during the rainy season runoff. High turbidity reduces the photosynthesis of submerged, rooted aquatic vegetation and algae; this reduced plant growth may in turn suppress fish productivity.

Turbidity therefore, can affect aquatic biological communities. Water quality guidelines suggest that discharges resulting from human activities should not alter ambient turbidity levels.

Total Dissolved Solids (TDS, mg/L)

TDS is an index of the amount of dissolved substances in water. The presence of such solutes alters the physical and chemical properties of water. For the purpose of the survey, the range of TDS from 0 – 1000 mg/L is considered fresh and non-saline. The base flow of a waterway acquires mineral constituents in the form of dissolved salts in solution, such as sodium, chloride, magnesium, sulfate, etc. In periods of high runoff, overland flow contributes dissolved materials to water sources. In addition, significant contributions to the TDS are anthropogenic in the form of municipal and industrial effluents, and agriculture runoff.

Established guidelines on the concentration of TDS relate to taste and palatability rather than detrimental health effects on man or aquatic organisms. TDS concentrations of 500 mg/L or less have been designated as an objective level for drinking water.

Conductivity (or Specific conductance/cm) is a numerical expression of the ability to conduct an electrical current in water. It is measured in micro Siemens per centimetre ($\mu\text{S}/\text{cm}$) corrected to a standard temperature, usually 25 °C. The conductivity of water is dependent on its ionic concentration and temperature. Conductivity provides a good indication of the changes in water’s composition, especially in its mineral concentration. It is particularly sensitive to variations in dissolved solids, but provides no indication of the relative quantities of the various components. As more dissolved solids are added, the water’s specific conductance increases. Specific conductance in natural waters has been found to range from 50 to 1500 $\mu\text{S}/\text{cm}$. Groundwater usually have elevated specific conductance. The specific conductance in surface water is usually highest when groundwater infiltration provides significant portion of the stream flow and is lowest in the wet season due to dilution. No guidelines have been established to regulate specific conductance since high values are found to correlate with total dissolved solids.

Salinity (ppt)

Salinity is defined as the total concentration of dissolved ions in water. Salinity often is expressed in milligrams per litre (mg/L), but in aquaculture, it is more convenient to express salinity in parts per thousand (ppt). One can divide salinity values expressed in mg/L by 1000 to get parts per thousand; e.g., 5,500 mg/l = 5.5 ppt.

Salinity of freshwater often is considered to be 0 ppt, but most inland waters contain from 0.05 to 1 ppt salinity. In arid regions, inland waters may be highly saline. Water containing more than 0.5 ppt salinity usually is not suitable for domestic purposes, and 1 ppt salinity will impart a salty taste. Seawater has a salinity of 30 to 35 ppt. Estuarine water may range from near 0 ppt to more than 30 ppt. Fastⁱ classified waters based on salinity is as follows: freshwater < 0.5 ppt; oligohaline 0.5–3.0 ppt; mesohaline 3.0–6.5 ppt; polyhaline 16.5–30.0 ppt; marine 30.0–40.0 ppt; brine or hypersaline, > 40.0 ppt.

Dissolved Oxygen (DO, Dissolved Form or Per cent Saturation; mg/L or %)

The stream system both produces and consumes oxygen. It gains oxygen from the atmosphere and from plants as a result of photosynthesis. Running water, because of its churning, dissolves more oxygen than still water, such as that in a reservoir behind a dam. Respiration by aquatic animals, decomposition, and various chemical reactions consume oxygen.

Oxygen is measured in its dissolved form as dissolved oxygen (DO). If more oxygen is consumed than is produced, dissolved oxygen levels decline and some sensitive animals may move away, weaken, or die.

DO levels fluctuate seasonally and over a 24-hour period. They vary with water temperature and altitude. Cold water holds more oxygen than warm water (APHA, 1992) and water holds less oxygen at higher altitudes. Thermal discharges, such as water used to cool machinery in a manufacturing plant or a power plant, raise the temperature of water and lower its oxygen content. Aquatic animals are most vulnerable to lowered DO levels in the early morning on hot summer days when stream flows are low, water temperatures are high, and aquatic plants have not been producing oxygen since sunset.

DO is normally measured either in milligrams per liter (mg/L).

Oxygen Demand (BOD, mg/L)

Biochemical oxygen demand (BOD) measures the amount of oxygen consumed by microorganisms in decomposing organic matter in stream water. BOD also measures the chemical oxidation of inorganic matter or the extraction of oxygen from water via chemical reaction (APHA, 1992). A test is used to measure the amount of oxygen consumed by these organisms during a specified period of time (usually 5 days at 20 °C). The rate of oxygen

consumption in a stream is affected by a number of variables: temperature, pH, the presence of certain kinds of microorganisms, and the type of organic and inorganic material in the water.

Wastewater from sewage treatment plants often contains organic materials that are decomposed by microorganisms, which use oxygen in the process. The amount of oxygen consumed by these organisms in breaking down the waste is known as the biochemical oxygen demand or BOD. Other sources of oxygen-consuming waste include storm water runoff from farmland or urban streets, feedlots, and failing septic systems.

BOD directly affects the amount of dissolved oxygen in rivers and streams. The greater the BOD, the more rapidly oxygen is depleted in the stream. This means less oxygen is available to higher forms of aquatic life. The consequences of high BOD are the same as those for low dissolved oxygen: aquatic organisms become stressed, suffocate, and die.

Oxidizing and Reducing Potential (ORP, mV)

Oxidizing and Reducing Potential (ORP) of water sample is a measure of the presence of oxygen in the water column. Excess chlorine in waste water effluent will result in a large positive ORP value and the presence of hydrogen sulfide will result in large negative value of ORP.

ORP values range from 230 – 250 mV in the slow moving and deeper water columns at Sample Sites # 1 and # 2, to near 220 at the shallower, riffle area of the Laboring Creek. The value at Young Gail Creek (Sample Site #5) was near 228 mV, and at VoP natural spring it was 230 mV.

Orthophosphate (Phosphate, mg/L)

If too much phosphate is present in the water algae and weeds will grow rapidly, may choke the waterway, and use up large amounts of precious oxygen (in the absence of photosynthesis and as the algae and plants die and are consumed by aerobic bacteria.) The result may be the death of many fish and aquatic organisms. Phosphorus is one of the key elements necessary for growth of plants and animals. Phosphates (PO_4) are formed from this element. Phosphates exist in three forms: orthophosphate, metaphosphate (or polyphosphate) and organically bound phosphate.

Criteria: The following criteria for total phosphorus were recommended by US EPA (1986):

- 1) no more than 0.1 mg/L for streams which do not empty into reservoirs,
- 2) no more than 0.05 mg/L for streams discharging into reservoirs, and
- 3) no more than 0.025 mg/L for reservoirs.

Nitrogen (Total, mg/L)

Ammonium (NH_3 or NH_4^+ ammonium ions, mg/L $\text{NH}_4\text{-N}$)

Dissolved ammonia is the reduced form of nitrogen in solution. Ammonia is a highly soluble, colourless, gaseous compound and can exist as NH_3 or NH_4^+ (ammonium ion) depending on solution temperature and pH. Ammonia and related oxidized nitrogen compounds are a major limiting nutrient in most aquatic systems, an increase of which may result in eutrophication. High concentration of ammonia is typically indicative of agriculture pollution or anaerobic degradation of nitrogen containing compounds.

Nitrite (NO_2^- , mg/L)

Nitrate enters the surface and groundwater as part of the nitrogen cycle in the hydrosphere and biosphere. Nitrogen may be found in surface and groundwater as nitrate (NO_3^-), nitrite (NO_2^-), and ammonia (NH_3). These species are reported as either nitrate for which the guideline is 45 mg/L, or as molecular nitrogen (N) having a guideline of 10 mg/L (WHO and USEPA). Waters having a concentration of 45 mg/L or more of Nitrite is undesirable for domestic use since it causes methemoglobinemia in infants (PAHO-BLZ, 1994).

Nitrogen finds its way into the earth through several media: through nitrogen fixation by certain leguminous plants, decomposition of plants and animal carcasses and debris, through nitrate fertilizers, from sewage discharges on land or from sewage lagoons. Nitrate concentration in groundwater ranges from 0.1 – 10 mg/L reported as molecular nitrogen. It is possible to have concentrations ranging from up to approximately 600 mg/L as a result of barnyard runoff or nitrate fertilizers.

Water Quality

Water quality refers to the chemical, physical, and biological, characteristics of water. It is a measure of the condition of water relative to the requirements of one or more biotic species and or to any human need or purpose. The *Arundo donax* is specie that grows primarily around water bodies since it has an affinity for water.

Four water sampling sites were selected, based on accessibility and that may possibly be impacted by project activity. Water samples for laboratory analysis were taken, and in-situ parameters tested at each site. These samples were collected from four sites as follows and shown in **Table 1.29**:

- San Lazaro Creek – or Cross creek is located just north of the project site. This creek eventually flows into the Rio Hondo.
- Trinidad Spring – this site is a spring that is further south of the project site and is a natural artesian body of water similar to a pond.
- A Pond or Cenote – this site is just south of the project site and consists of two ponds or cenotes. These are typical water bodies along the Rio Hondo River and are usually isolated.
- San Antonio – Blue River or Booths River is the hydrological name of this sampling site located in the village of San Antonio. The river is also known as the Rio Hondo because

it branches off to the south and emerges back just north of the village. This area along with Cross Creek is known as Albion Island of northern Belize.

Table 1.29: Sampling Sites, GPS Coordinates and Description.

GPS Coordinates of Water Sampling Sites				
Site/Sample Number	1	2	3	4
Location	Cross Creek	Trinidad Spring	Lagoon/Cenote	San Antonio R. Hondo
GPS Coordinates				
N	18° 03.948'	18° 00.833'	18° 01.341'	18° 07.830'
E	88° 42.143'	88° 43.469'	88° 43.978'	88° 40.421

N.B. Water Sample Site Locations are shown in Figure 1.24.

The San Antonio site would potentially reflect any changes as a result of the project activity; particularly if mitigation measures are not efficient. The others such as the Cross Creek will be used as baseline data. Two sets of data were collected, one in February and one in September (both in 2019). While February was intended to be the analysis representing the dry season, the prolonged drought that the northern half of the country experienced in 2019 meant that the September samples still represented fairly dry conditions, and very low precipitation rain had been received up to the time of sampling. As such it is safe to say that the Cross Creek, and especially the spring represented ground water, with little or no precipitation influence. The second set of water samples analyzed also included fluoride, as well as chemical oxygen demand (CDO), and biological oxygen demand (BOD).

In Situ Water Quality

Using portable dissolved oxygen and conductivity meters, several parameters were taken in situ. These included temperature, pH, Conductivity, chloride, salinity and dissolved oxygen (DO), (Tables 1.30, 1.31, 1.32, 1.33). Dissolved oxygen is an important parameter because this indicates oxygen that is available for living organisms to survive in the aquatic environment. River systems and streams in northern Belize are known to have average oxygen levels of above 4 mg/l. Oxygen levels at all the sites, except for the spring sample, for the project were above the indicated 4 mg/l threshold. The spring sample is expected to have low DO because there has not been time for aeration from ambient air. The lagoon showed highest level of DO perhaps because of the larger surface area interacting with the ambient air due to wind speeds.

A turbidity meter was also used on site and indicated low levels of turbidity as measured in Nephelometric Turbidity Units (NTU), which is the unit used in these instruments, as opposed to

sechi disc readings, which are visual readings using depth and visibility. Turbidity is the reduced light penetration caused mostly from particles, including silt, sand and decaying matter. Turbidity levels range from 1.0 to 19 NTU, with the highest being at Cross Creek.

Table 1.30: In-situ data sampled in February 2019

IN SITU WATER QUALITY RESULTS					San Antonio Rio Hondo Bridge	
		Cross Creek	Trinidad Spring	Lagoon	Surface	3.5 ft. Deep
Site/Sample No.	Units	1	2	3	4a	4b
Date of Sampling		18/02/2019	18/02/2019	18/02/2019	19/02/19	19/02/19
Time of sampling		2:00 PM	2;30 PM	3:00 PM	4:00 PM	4:00 PM
Temperature	Celsius (°C)	29.9	27.2	31.5	29.7	29.0
Barometric Pressure (mm Hg)		749.8	749.5	749.3	751.2	751.1
Dissolved Oxygen (DO)	Percent	80	5	109	87	83
Dissolved Oxygen (DO)	ppm	5.9	5.4	7.9	6.5	6.2
Dissolved Oxygen (DO)	Mg/l	5.9	0.4	7.8	6.5	6.2
Specific Conductance (sp)	(us/cm)	2110	2968	2986	2024	2028
Conductance	us/cm	2303	3092	3354	2208	2206
Total Dissolved Solids (TDS)	Mg/l	1371.5	1929	1941	1315.7	1318.05
Salinity	Parts per thousand (ppt)	1.07	1.54	1.54	1.02	1.02
pH	Units	8.59	8.17	8.76	8.61	8.61
FNU		19205	6.7	3.0	0.7	1.0
Turbidity	Nephelometric turbidity units (NTU)	19.3	6.7	3.0	0.7	1.0
Total Suspended Solids (TSS)	Mg/l	1.2	0.4	0.9	1.04	1.51

Table 1.31: Second Set of In-situ data sampled in September 2019

IN SITU WATER QUALITY RESULTS					San Antonio Rio Hondo Bridge	
	Units	Cross Creek	Trinidad Spring	Lagoon	Surface	3.5 ft. Deep)
Site/Sample No.		1	2	3	4a	4b
Date of Sampling		11/9/2019	11/9/2019	11/9/2019	11/9/2019	11/9/2019
Time of sampling		12:00 PM	12:30 PM	1:00	10:00 AM	10:10 AM
Temperature	Celsius (°C)	30	26.9	32.4	29.7	29.0
Barometric Pressure (mm Hg)		749.8	753.8	763.1	751.2	751.1
Dissolved Oxygen (DO, %)	Percent	71	20	94	84	83
Dissolved Oxygen (DO)	Mg/l	5.3	1.6	6.7	6.1	5.9
Specific Conductance (sp)	(us/cm)	2137	2938	3066	2144	2148
Conductance	us/cm	2339	3043	3500	2394	2377
Total Dissolved Solids (TDS)	Mg/l	1391.7	1907.2	1992.2	1397.7	1397.6
Salinity	Parts per thousand (ppt)	1.09	1.52	1.59	1.09	1.09
pH	Units	7.01	7.01	7.01	7.01	7.01
Turbidity	Nephelometric turbidity units (NTU)	2.37	2.7	6.9	211	201.0
Total Suspended Solids (TSS)	Mg/l	1.2	0.6	0.9	1.09	1.1

As can be seen from **Tables 1.30 and 1.31** all the surface waters tested are not fresh water rather brackish water (mesohaline). The salinity levels are indicative of hydrogeology of the area where there are a lot of salt mineralization (hardness) taking place.

The ph. levels of the insitu samples revealed that the waters a slightly basic with a normal alkalinity concentration. The buffering capacity is within normal range.

Total dissolved solids (TDS), is a measure of the dissolved combined content of all inorganic and organic substances present in a liquid in molecular, ionized, or micro-granular (colloidal solution) suspended form. Total dissolved solids are differentiated from total suspended solids (TSS), in that the latter cannot pass through a sieve of 2 micrometers and yet are indefinitely suspended in solution.

Salinity is the saltiness or dissolved salt content of a body of water, and is normally measured in ppt (parts per thousand). However, freshwaters that are very low in saline content are sometimes measured in ppm. The salinity of waters is normally classified as follows: freshwater = less than 0.5 ppt, or 0.005 ppm. Brackish water = 0.5 to 30 ppt, saline waters = 30 to 50 ppt and brine water is greater than 50 ppt. Ocean water normally ranges from 30 to 35 ppt.

Salinity in and at the project site was found to be fairly high. It is possible that pockets of sea water are influencing the salinity; or it can also be that porous limestone leads to salinity from sea water. The sample showing the lowest salinity was the sample at the San Antonio site, which is the site closer to the sea, or downstream from the project. This was 1.02 ppt in February and increasing slightly to 1.09 ppt in September. The spring water showed salinity of 1.52 ppt in September and 1.54 ppt. The highest salinity was in the lagoon sample, showing 1.59 ppt in September. Further investigations should be done to verify the source of the salinity.

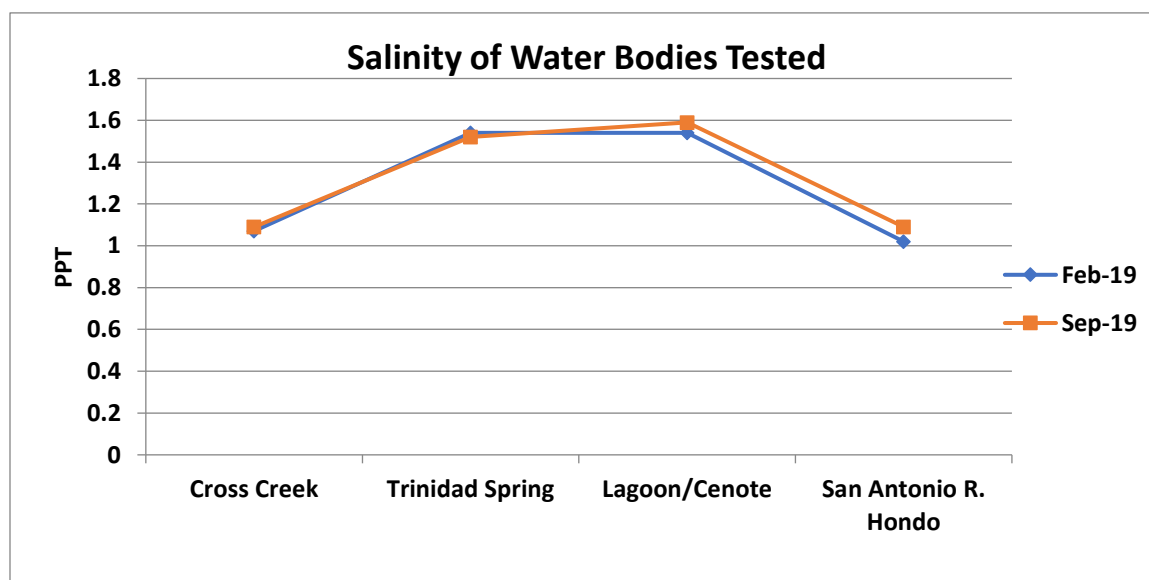


Figure 1.40: Salinity of Water Bodies.

Other Ex Situ Parameters

Another set of samples collected on the same day were also analyzed by the Bowen and Bowen Laboratory (**Table 1.32, 1.33**) for several parameters. Both of these sets were compared with each other to get a better comparison of the water quality characteristics over a period of time. The reader should note that Annex A to the ESIA report will show the official results for the laboratory analyses done by the Bowen and Bowen Laboratory. These results should form the basis for comparison to future monitoring.

Table 1.32: Results of Laboratory Analysis Sampled in May 2019.

Sample Number			#1	#2	#3	#4
Sample Description	Units	Date	Cross Creek	Spring	Pond Cenote	San Antonio
Total Hardness	mg/L	6/5/2019	1,225.00	1,800.00	1,925.00	1,180.00
Alkalinity	mg/L	6/5/2019	206	216	92	200
Nitrogen, Total	mg/L	6/5/2019	<0.5	<0.5	<0.5	<0.5
Nitrite	mg/L	6/5/2019	0.019	0.012	0.017	0.012
Nitrates	mg/L	6/5/2019	1	1	1.2	1.1
Phosphate	mg/L	6/5/2019	0.34	0.035	0.019	0.012
Sulfate	mg/L	6/5/2019	872	1,452	1,689	908
Ammonia	mg/L	6/5/2019	0.03	ND	0.02	0.02
Calcium (Ca)	mg/L	6/5/2019	410	520	586	372
Magnesium (Mg)	mg/L	6/5/2019	48.8	122.1	112.3	61.1
Chlorine (Cl)	mg/L	6/5/2019	0.02	<0.02	<0.02	<0.02
Escherichia coli (E coli)	100 ml	6/5/2019	64	90	12	36
Enterococci	100 ml	6/5/2019	4	<2	<2	<2

Table 1.33: Results of Laboratory Analysis Sampled in September 2019

Sample Number			#1	#2	#3	#4
Sample Description	Units	Date	Cross Creek	Spring	Pond Cenote	San Antonio
Total Hardness	mg/L	11/9/2019	1336	2010	2035	1375
Alkalinity	mg/L	11/9/2019	216	225	87	194
Nitrogen, Total	mg/L	11/9/2019	0.7	<0.5	<0.5	ND
Nitrite	mg/L	11/9/2019	0.014	0.011	0.01	0.013
Nitrates	mg/L	11/9/2019	1	0.9	0.9	1.1
Phosphate	mg/L	11/9/2019	0.05	0.13	0.43	0.04
Fluoride	Mg/L	11/9/2019	1.09	1.63	1.80	1.16
Sulfate	mg/L	11/9/2019	1,027	1,382	1,769	987
Ammonia	mg/L	11/9/2019	ND	ND	ND	ND
Calcium (Ca)	mg/L	11/9/2019	438	603	651	405
Magnesium (Mg)	mg/L	11/9/2019	59	123	99	89
Chlorine (Cl)	mg/L	11/9/2019	ND	ND	ND	ND
Oxygen Demand, Chemical	mg/L	11/9/2019	1.0	ND	15	7.9
Oxygen Demand, Biochemical	mg/L	11/9/2019	ND	3	2	1.7
Escherichia coli (E coli)	100 ml	11/9/2019	103	132	565	210
Enterococci	100 ml	11/9/2019	13	145	64	199

The laboratory results show that the waters are relatively free of contamination. This is essential since these waters are remotely influenced by indirect activities such as agriculture. The following sections further describe the water quality in context to the existing environment.

- Hardness is the sum of calcium and magnesium concentrations expressed in terms of mg/l as calcium carbonate (CaCO₃). The principal natural sources of hardness in water are dissolved polyvalent metallic ions from sedimentary rocks, seepage and runoff from soils. Calcium and magnesium, the two principal ions, are present in many sedimentary

rocks, the most common being limestone and chalk. The results show that the water samples were very high in hardness since the values greater than 180 mg/l are considered very hard water. These types of water may also shorten the life of plumbing fixtures and lessen the effectiveness of certain cleaning agents. As can be seen from the Figure 1.40, the hardness level increased from the month of May to September by an average of 10%. In this case it is indicative of the extended dry season and the evaporation factor that affects surface waters. In instances, the water sampled from the pond or lagoon showed the highest concentration.

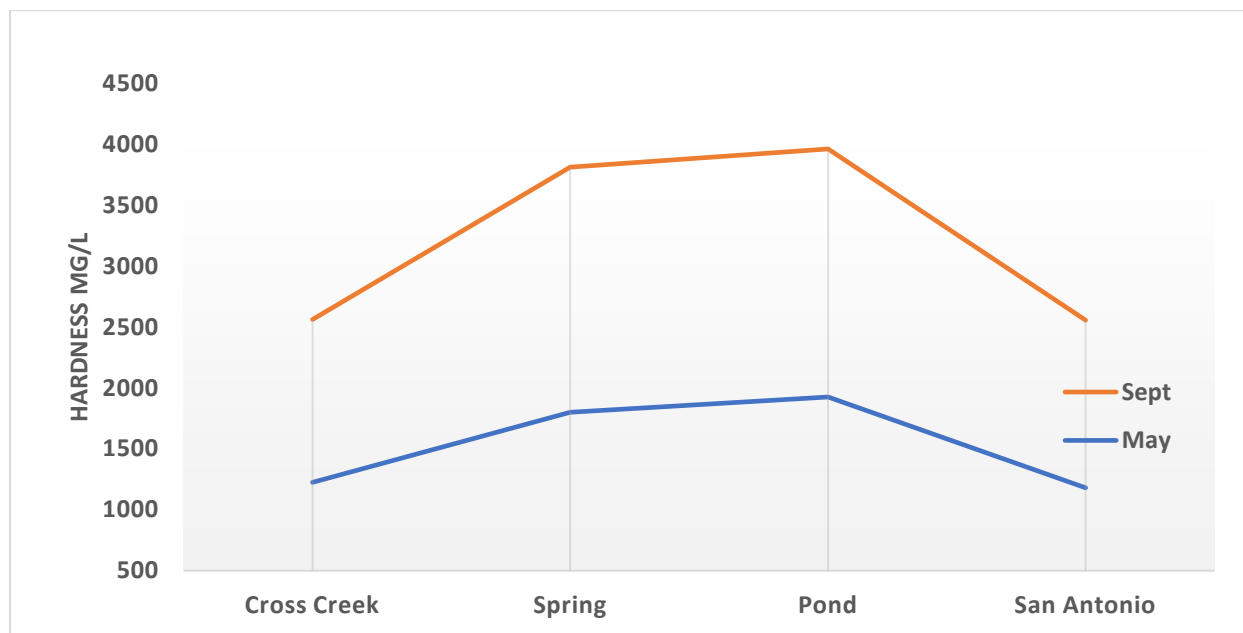


Figure 1.41: Hardness Results

- Alkalinity is a measure of the water's ability to neutralize acidity. An alkalinity test measures the level of bicarbonates, carbonates, and hydroxides in water and test results are generally expressed as "ppm of calcium carbonate (CaCO_3)". The desirable range for irrigation water is 0 to 100 ppm calcium carbonate. The amount of Alkalinity that should be in our water is 20-200 mg/L for typical drinking water. Alkalinity is basically dissolved minerals in the water that help neutralize the water we drink. Water alkalinity and pH are not the same. Water pH measures the amount of hydrogen (acid ions) in the water, whereas water alkalinity is a measure of the carbonate and bicarbonate levels in water. For all water sources, it is the alkalinity that actually determines how much acid to use, not the pH. The results showed that the alkalinity levels are within drinking water parameters. Therefore, these sources can be used as a water source for cattle as well as irrigation of crops. The results show similar patterns for both the month of May and September with the spring sampling site showing the highest alkalinity concentrations.

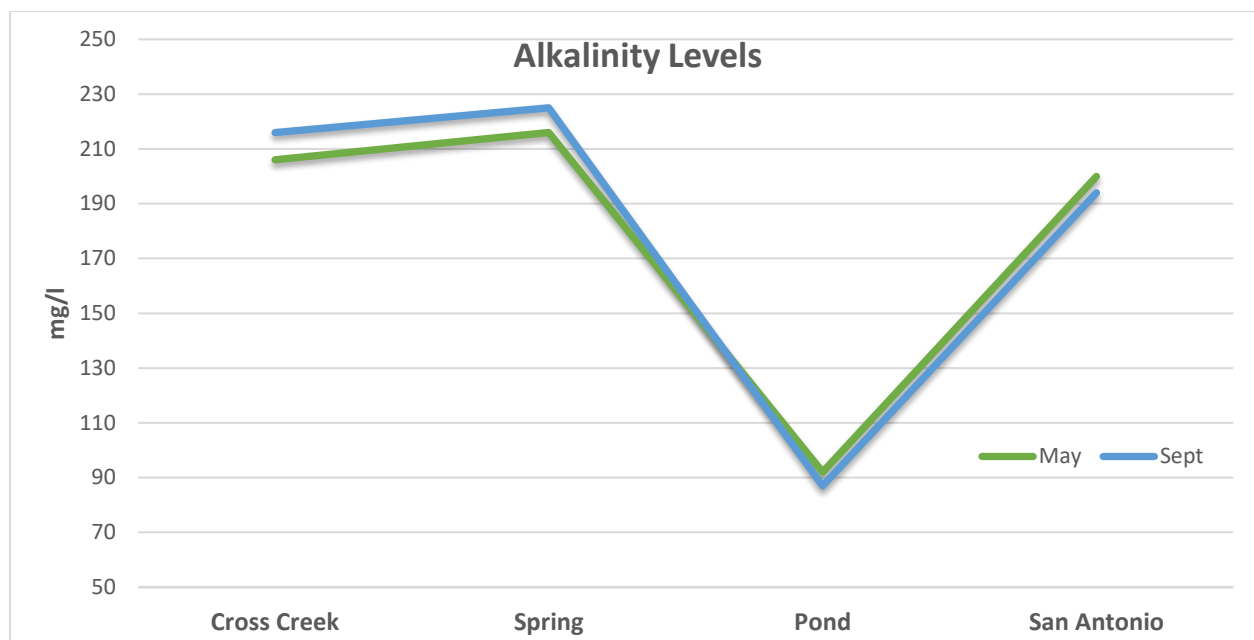


Figure 1.42: Alkalinity Results

- Total nitrogen is the sum of total kjeldahl nitrogen (a method for the quantitative determination of nitrogen contained in substances ammonia, organic and reduced nitrogen) and nitrate-nitrite. It can be derived by monitoring for organic nitrogen compounds, free-ammonia, and nitrate-nitrite individually and adding the components together. Total nitrogen is often reflective of nutrients from organic material, faecal matter (both human and animal), and detritus etc. Values recorded were low and below the normal threshold levels in both sampling months.
- Nitrates and nitrites are commonly found in natural waters. Nitrate and nitrite are naturally occurring ions that are part of the nitrogen cycle. The nitrate ion (NO_3^-) is the stable form of combined nitrogen for oxygenated systems. Although chemically unreactive, it can be reduced by microbial action. The nitrite ion (NO_2^-) contains nitrogen in a relatively unstable oxidation state. Chemical and biological processes can further reduce nitrite to various compounds or oxidize it to nitrate. Nitrate can reach both surface water and groundwater as a consequence of agricultural activity (including excess application of inorganic nitrogenous fertilizers and manures), from wastewater treatment and from oxidation of nitrogenous waste products in human and animal excreta, including septic tanks. Normally 10 mg/l nitrate or higher is an indication of contamination (Hounslow, 1995). Concentrations in surface water can reach high levels as a result of agricultural runoff, refuse dump runoff or contamination with human or animal wastes. The concentration often fluctuates with the season and may increase when the river is fed by nitrate-rich aquifers. The natural nitrate concentration in groundwater under aerobic conditions is a few milligrams per litre and depends strongly on soil type

and on the geological situation. The increasing use of artificial fertilizers, the disposal of wastes (particularly from animal farming) and changes in land use are the main factors responsible for the progressive increase in nitrate levels in groundwater and surface water supplies. Since all-natural waters sampled were well below these levels, it is safe to say that for this period there was very little to no contamination from fertilizers, effluent or other wastewaters near these sites for both the May and September sampling frequency (**Table 1.32 and 1.33**).

- Phosphate levels are also an indication of contamination with fertilizers or human waste. Phosphates are the naturally occurring form of the element phosphorus, found in many phosphate minerals. Inorganic phosphates are mined to obtain phosphorus for use in agriculture and industry. In ecological terms, because of its important role in biological systems, phosphate is a highly sought-after resource. Once used, it is often a limiting nutrient in environments, and its availability may govern the rate of growth of organisms. This is generally true of freshwater environments, whereas nitrogen is more often the limiting nutrient in marine (seawater) environments. Addition of high levels of phosphate to environments and to micro-environments in which it is typically rare can have significant ecological consequences. Phosphate levels were very low in the natural water bodies (**Table 1.32 and 1.33**).
- Sulphates can be found in the environment as a result of atmospheric and terrestrial processes. Major natural contributors of sulphate to the environment are Sulphur released from erosion of evaporite deposits and sulphide containing rocks and minerals. During this cycle sulphate is taken up by plants and microorganisms, and is later consumed by animals, thereby moving Sulphur through the food chain. Natural environmental limits are 250-500 mg/L but the results show elevated levels. This can be attributed to the low flow streams and decaying organic matter. Nevertheless, this parameter is not indicative of pollution.
- E. coli is a type of faecal coliform bacteria commonly found in the intestines of animals and humans. E. coli is short for Escherichia coli. The presence of E. coli in water is a strong indication of recent sewage or animal waste contamination. Sewage may contain many types of disease-causing organism. Faecal coliform by themselves are usually not pathogenic; they are indicator organisms, which means they may indicate the presence of other pathogenic bacteria. Pathogens are typically present in such small amounts it is impractical monitor them directly.

The samples tested for this parameter showed that all samples showed some contamination, although the laboratory staff recommends being cautious with the results because of the delayed time of the analysis. To verify this, further tests during the pilot

project will be done. Faecal coliform testing is the accepted water quality and water standards test for many agencies, including the U.S. Environmental Protection Agency (US EPA). According to the EPA'S standards, drinking water counts for faecal coliform should be no more than 0 colonies for every 100 ml filtered. For total body contact such as swimming, the US EPA standards for freshwater is set at a maximum of 126 per 100 ml filtered (and 33/100 ml enterococci), and for marine waters, enterococci densities should not exceed 35 per 100 ml (EPA Website, 2002). As seen from E. Coli results, the maximum recorded count was for the pond/cenote for the September samples. Moreover, the latter was higher for all sampled sites which again can be attributed to the extended dry season and the need for wildlife to frequent the area for survival. Nevertheless, both results show that there is the need to disinfect should it be considered for potable water purposes.

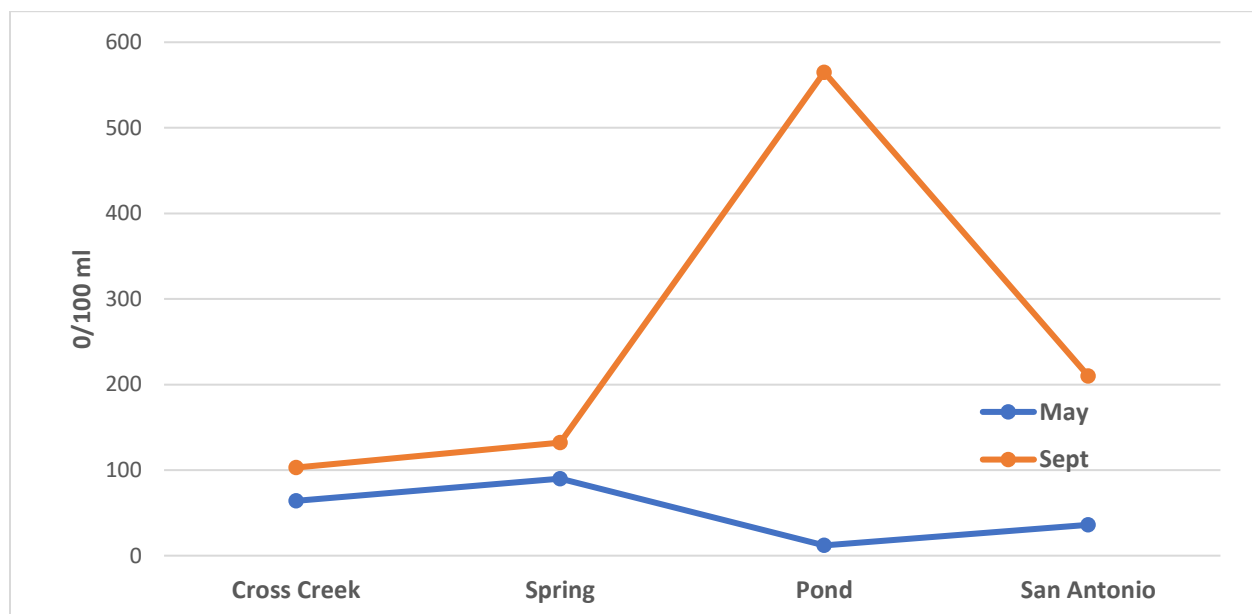


Figure 1.43: E. coli Results

- COD or Chemical Oxygen Demand is the total measurement of all chemicals (organics & in-organics) in the water or waste water; BOD or Biological Oxygen Demand is a measure of, the amount of oxygen that require for the bacteria to degrade the organic components present in water or waste water. The COD test is often used to monitor water treatment plant efficiency, although it can be used to estimate available oxygen in natural waters. The COD is the amount of oxygen consumed to chemically oxidize organic water contaminants to inorganic end products. Biochemical Oxygen Demand (BOD, also called Biological Oxygen Demand) is the amount of dissolved oxygen needed (i.e. demanded) by aerobic biological organisms to break down organic material present in a given water sample at certain temperature over a specific time period. The Chemical and Biological

Oxygen Demand for the sampled sites was only tested for the month of September and the results showed that the water bodies are indicative of low activity or no direct anthropogenic activity. The highest recorded results were 17 ppm in COD for pond/cenote, followed by 7.9 ppm at the San Antonio Rio Hondo site. These results, while still very low, do show slightly less available oxygen for decomposition, meaning a slightly higher level of pollution than that of the spring and creek water, which are fairly free of pollution, except for fecal coliform contamination as shown above.

According to the World Health Organization (WHO), the recommended limit of fluoride in waters is 1.5 mg/l and the typical range in groundwater is 0.01 to 4 mg/l (Fawell and others, 2006). According to the WHO, low levels of fluoride are beneficial to teeth at low concentrations, (0.5 to 1.5 mg/l) but damaging at elevated concentrations. Damages include dental fluorosis as well as crippling skeletal fluorosis (Fawell and others, 2006). As can be seen from the results in table 1.45, the fluoride levels were just above 1 mg/l, which are within safe levels for drinking water standards.

Well Logs

There is also some data available from the various wells that circumvent the project area. Some of these wells are community wells that provide potable water to the respective communities such as Yo Creek, San Lazaro, Trinidad Village to name a few. The table below (Table 1.34), shows the respective community well and the corresponding depths and yield.

Table 1.34: Community Wells.

Well	Depth	Water Level (Static level)	Well Yield (gpm)
Yo Creek	-100	-100	
San Lazaro	-80	-37	190
Trinidad	-114	-25	80

GPS Coordinates of Water Sampling Sites

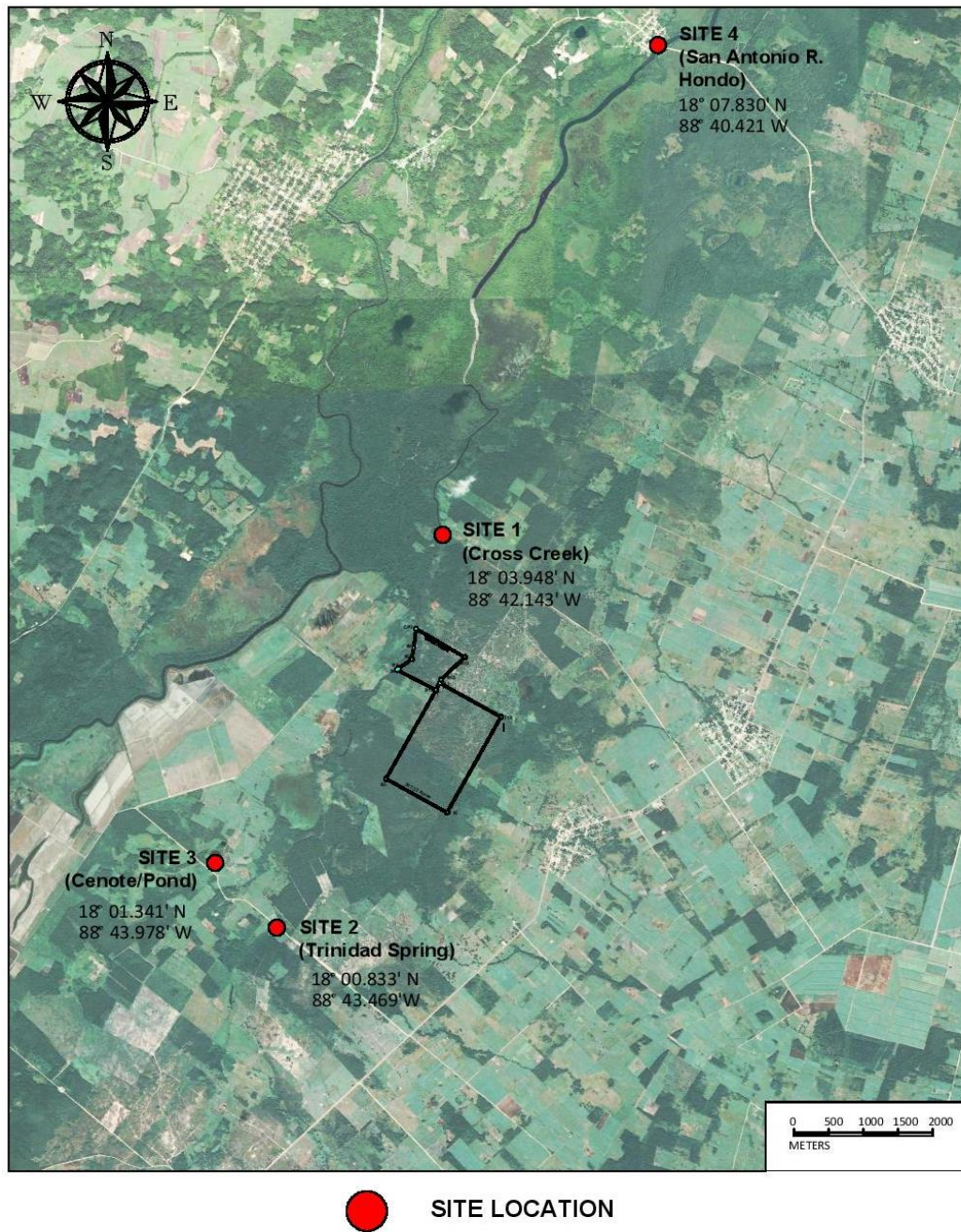


Figure 1.44: Map Illustrating Location of Sampling Sites.

1.3.9.3 Sources of available water

Available freshwater sources in the *Arundo donax* farm for domestic and crop needs are the following:

- 1) Rainfall
- 2) Groundwater
- 3) Bottled water from local sources
- 4) Cross Creek (Often called Blue Creek)

Availability

Rainfall harvesting

Water harvesting is a viable water supply option for domestic use. At present the roof catchment is minimal at the main Farm area in the vicinity of the project site. The construction of a large roof structure to house or maintain farm equipment could provide additional catchment surface to harvest rainwater for domestic use in the future.

An estimate of potential supply of rainwater from catchment area is given by:

$$\text{Rainwater Harvest} = (\text{Mean yearly or monthly rainfall}) \times (\text{area}) \times (\text{catchment (roof) coefficient})$$

Table 1.35: Water harvesting catchment type

Type of Catchment	Roughness Coefficient (n)
Corrugated roof (zinc, other metal)	0.7 - 0.9
Bare soil	0.2 - 0.75
Untreated ground and landscape, slope < 10% gradient	0.0 – 0.3

Estimate can also be made of the water catchment potential for 497.1 acres of farmland in the Arundo Donax project site, which generally is partitioned as: infiltration and percolation into the subsurface, surface runoff, evaporation and loss directly into streams and lagoons. Some of the runoff could be captured in retaining ponds for use on the Farm.

Groundwater: Coastal Plain and Shelf Province of northern Belize

Fresh water is generally plentiful in the Coastal Plain and Shelf province. Small to large quantities are available from thick, porous Tertiary limestones and marls (Buckalew et al. 1998). Wells penetrating the unconfined aquifers range from depths of 14 to 50 metres with static levels ranging between 10 and 28 metres below the surface. Deeper confined limestone aquifers were identified as deep as 585 metres below the surface.

Yields from the perched and unconfined aquifers average 75 l/min. The deeper and confined aquifers yield on average 331 l/min while maximum yields are near 4550 l/min. Water quality is characterized by an average hardness of 372 mg/l and an average sulphate content of 69 mg/l.

Based on reported groundwater yields (in the early 90s) from one of the ASR/BSI wells in Chan Pine Ridge (Tower Hill 1) was 400 US gal/min (1,820 l/min). Tower Hill 3 some distance away was yielding 500 USgal/min (2,270 l/min) for a drawdown of 56 ft (17 m) and 700 US gal/min (3,180 l/min) resulting in a drawdown of 104 ft (32 m) (King, et al. 1992). At the CIBCL project site, one well, namely Well #1 (location: 0337198 1990953) at a depth of approximately 13 m, had an estimated yield of 100 US gal/min.

Bottled Water

Workers will be provided with bottled water or they bring their own water supply to the workplace when on duty.

Table 1.36: Estimate of available water in and around the Project Site

Source	Capacity per Annum (m ³)	Capacity per Annum (US gallons)	Remarks
Rainwater (Roof 24 ft x 30 ft) Mean Bmp Rainfall	94.66	25,007.2 (21,486.0) *	Variable, depend on roof catchment and capacity of holding tanks. Water harvest for roof area of 24 ft x 30 ft on Farm site using mean monthly rainfall BSI/ASR
Groundwater			
Rio Hondo	22,245,273,648	5,876,580,654,667/gpd**	(Source: Tunich Nah 2014)
Total available			

*Computed rainfall harvest not included in total. Just an example with actual rainfall for 2009

** gpd US gallons per day.

Total Water Demands

Domestic Use

“domestic use” in relation to the abstraction of water means the use of such water for – drinking, washing, cooking and sanitary purposes in connection with a residence; or farming, gardening, the watering of stock or pen-keeping in connection with a household where the entire area of land does not exceed 5 acres” (PART I, NIWRA, 2010)

On a daily basis domestic water supply at the farm operation area will be minimal. This will be mostly for two guards and visitors.

During land preparation period (May) and harvest time (October and April), the number of farmer workers could be as high 25 persons, mostly from the local communities who will be commuting to the fields.

Table 1.37: Maximum Fresh Water Requirement for VoP Farms Ltd. Expansion

Need		Persons	Period	Gal. per person per day	Total per annum (gallons)	Total per annum (m³)
	Domestic (Human use)	6		50	109,500	414.5
	Irrigation	NA	NA	NA	NA	NA
	Gardening & Washing of Equipment			20	43,800	166
Total				70	153,300	580.5

Irrigation water use

Generally, water needs for Arundo Donax production will be from seasonal rainfall. Water needs for a future irrigation system may be stored in ponds, but this is a backup option that is not being considered as yet. No irrigation is foreseen at the moment since the area is known to retain water in the subsoil and also is tolerant to low rainfall.

1.3.10.3 Potential Impacts to Water Resources and Mitigation and Control Measures.

The project's activities may lead to the following potential impacts:

- Water pollution can be derived from the generation of wastewater from the sanitary facilities as well as from the maintenance of the equipments. Wastewater generation can cause nutrient enrichment within a body of water making it unsuitable for recreation or domestic use.
- Sedimentation of retention ponds and drainage areas from both surface runoff and from percolation of contaminated waters.
- Pollution through increased sedimentation of the natural flow and drainage paths in the vicinity of the project area could result in the lack of fresh water available for native fauna.
- Contamination of water bodies and drainage paths
- Chemical contamination from project-related activities to existing surface water bodies and drainage paths by the project could result in contamination of fresh water stocks available for native fauna.
- Contamination of surface and groundwater from fuel leaks and spills or contaminated surface water run-off from Project infrastructure or wash down areas.
- Contamination of groundwater from the vertical seepage of irrigation water containing agrochemical residues.
- Potential oil leaks/spills may travel vertically through the soil. The well will be sealed and protected.

Table 1.38 Summary of Activities Degree of Impacts and Mitigation and Control Measures for Water Activities.

Activities	Degree of Impact	Mitigation Measure
Water Resources	<ul style="list-style-type: none"> • Sedimentation of drainage areas • Contamination of water bodies • Contamination of ground water 	<ul style="list-style-type: none"> • The water that will be utilized for cultivating the crop will be natural rain water that will be retained within the project area and prevented from drainage outside by the Buffer Zone/Access Road barrier. • No water will be utilized for the Biomass cultivation from the nearby Blue Creek, nor will any water from the project be drained into the creek. • The drainage will be constructed within the cultivate area to adequately distribute water and also clear used water from washing machinery and equipment. • The water will drain and remain within the 400-acre project area contained by the Buffer Zone. • The project will dig a single small well for supplying water for washing machinery and equipment as well as another project uses. • As a means of preventing water run-off. The buffer zones, which are elevated to 12 to 18 inches above the plantation area, will also contain water utilized for cultivating the <i>Arundo donax</i> during the

		<p>cultivation.</p> <ul style="list-style-type: none"> • Should the tank or the well run out of water during the dry season, water will be transported from the nearest village, San Lazaro, about 7 miles away from the project area. • In addition, the biomass project will contain water within the buffer zone and will not release any water to the nearby waterways including the Blue Creek. • The water used to wash equipment will run into the drains that are located between the inner sides of the access road/buffer zone. • Only approved agrochemicals will be used at the project site. • Best management practices for the construction and siting of access roads will be selected during road construction and clearance of associated sites at all times.
--	--	--

1.3.11 Biodiversity

The biodiversity component of the Rapid Ecological Assessment focused on a few groups of organisms that can be easily observed or measured. These were plants and birds as well as mammals, reptiles and amphibians opportunistically. A four-person team was organized to collect field data over a four-day period. An initial field visit of the area allowed the team to get information on the general biophysical characteristics of the area. Additionally, Google Earth and Bing Map images along with the Ecosystem Classification for Belize Updated 2017 (Meerman & Sabido 2001., Central American Ecosystems map: Belize. Volume II Ecosystems map and Description) were used to establish transects within the various vegetation types within the project boundary. The establishment of study transects were based on the images and Ecosystem Classification, at least three vegetation or ecosystem types were identified: **Lowland savanna, Lowland broad-leaved moist scrub forest, Lowland broadleaf Moist forest**. Also, aerial photographs captured using a drone were used to get a clear idea of the diversity of the area and this guided the placement of study transects.

1.3.12 Habitats

Based on the images and Ecosystem Classification, at least three vegetation or ecosystem types were identified: Lowland savanna, Lowland broad-leaved moist scrub forest, Lowland broadleaf moist forest. Description of the three ecosystems that were assigned to the site under the Ecosystems of Belize Map 2001 (updated 2017), are described below.


Legend Code	42
UNESCO Classification code	<u>I.A.2.g.(1).(a).T</u>
Name	<u>Tropical evergreen seasonal broadleaf lowland swamp forest: High variant.</u>
Altitude	< 250 m.
Geology and soil	Over calcareous rock.
Water regime	III drained
Rainfall	Average rainfall less than 2000 mm per year with a pronounced dry season from February through May.
Fire exposure	Limited to areas with slash and burn cultivation.
Description	 <p>This forest type is low in stature with a broken canopy with a distinctive deciduous element. Where the canopy is open there is a distinctive herbaceous layer dominated by sedges sometimes including <i>Scleria bracteata</i>.</p>
Frequent plant species	Frequently encountered trees include <i>Amyris elemifera</i> , <i>Bactris spp.</i> , <i>Bucida buceras</i> , <i>Calophyllum brasiliense</i> , <i>Croton pyramidalis</i> , <i>Croton reflexiflora</i> , <i>Dracaena americana</i> , <i>Metopium brownei</i> , <i>Coccoloba reflexiflora</i> , <i>Coccoloba acapulcensis</i> , <i>Coccoloba cozumelensis</i> , <i>Manilkara zapota</i> , <i>Gliricidia sepium</i> , <i>Ouratea nitida</i> , <i>Sabal mauritiiformis</i> , <i>Simarouba glauca</i> , <i>Swietenia macrophylla</i> and <i>Zygia</i> sp. Thick woody vines are sometimes present. Includes some areas that are locally called "bajos". Logwood <i>Haematoxylon campechianum</i> , typically occurs in the wetter, more open sections.
Faunistic comments	
References	Schultze & Whitacre 1999, Wright et al. 1959: 21, 21a, 22, Iremonger and Brokaw 1995: I,1,1,1,1,1 Picture: New River, Orange Walk district, J. Meerman.

Figure 1.45: Tropical Evergreen Seasonal Broadleaf low land Swamp Forest



Legend Code	63
UNESCO Classification code	<u>V.A.2.b.(2).</u>
Name	<u>Short-grass savanna with shrubs</u>
Altitude	< 50 m.
Geology and soil	The soils all have in common that they have a pale colored, course textured topsoil sharply overlying a compact, brightly red and white mottled finer textured subsoil. The soils are all acid and very deficient in nutrients (King et al. 1992).
Water regime	The very dense subsoil prevents vertical water movements causing the landscape to be partially inundated during the wet season and extremely dry in the dry season.
Rainfall	Average rainfall generally less than 2500 mm per year with a pronounced dry season from February through May.
Fire exposure	The extreme drought in the dry season caused by the soil conditions makes this ecosystem extremely vulnerable for fires. Some areas burn more than once a year. The wetter conditions in most of the Toledo district do not favor extensive fires and although favorable soil conditions exist, savannas in the Toledo district are extremely limited in extend. Documentation of lowland broadleaf forest fires started by lightning is rare (Middleton et al., 1997). Consequently, fire in tropical lowland forests has traditionally been considered as human induced (Janzen, 1986; Koonce & Gonzalez-Caban, 1990).
Description	 <p>Typical Belizean lowland savannas are found on gently sloping alluvial deposits in the coastal plain. The combination of poor nutrient availability, extremes in water availability and recurring fire regime has resulted in a species poor but highly specialized ecosystem. The aspect of this community is quite variable. Moss (1998) classified 12 different savanna land classes from cutting grass marsh through to pine woodland. The scrublands generally appear as islands of small, densely packed trees and shrubs in a grassland area; in some areas the islands are large and merging, in others they are quite separate.</p>
Frequent plant species	 <p>The graminoid vegetation is usually being dominated by sedges. Frequent woody species are <i>Acoelorrhaphe wrightii</i>, <i>Calyptanthus</i> sp., <i>Cameraria latifolia</i>, <i>Chrysobalanus icaco</i>, <i>Clidemia</i> sp., <i>Crescentia cujete</i>, <i>Curatela americana</i>, <i>Erythroxylum guatemalense</i>, <i>Gliricidia sepium</i>, <i>Hippocratea excelsa</i>, <i>Metopium brownei</i>, <i>Miconia</i> sp., <i>Mimosa albicans</i>, <i>Pinus caribaea</i>, <i>Quercus oleoides</i> and <i>Roupala montana</i>. There is a strong herbaceous component with typically: <i>Bletia purpurea</i>, <i>Borreria</i> sp., <i>Cassytha filiformis</i>, <i>Chamaecrista</i> spp., <i>Cipura campanulata</i>, <i>Coutoubea spicata</i>, <i>Drosera capillaris</i>, <i>Eriocaulon</i> sp., <i>Passiflora urbaniana</i>, <i>Xyris</i> sp. and <i>Zamia polymorpha</i>. Grasses reported from this ecosystem include: <i>Aristida appressa</i>, <i>Axonopus poiophyllus</i>, <i>Eragrostis maypurensis</i>, <i>E. acutifolia</i>, <i>E. elliottii</i>, <i>Gymnopogon spicatus</i>, <i>Leptocoryphium lanatum</i>, <i>Mesosetum filifolium</i>, <i>Panicum rudgei</i>, <i>Paspalum peckii</i>, <i>P. pulchellum</i>, <i>Sporobolus cubensis</i> and <i>Trachypogon plumosus</i>. Sedges include mostly <i>Rhynchospora</i> spp., but also <i>Bulbostylis paradoxa</i> and <i>Fimbristylis vahlii</i>. Wet places usually have <i>Eleocharis</i> spp. and <i>Cyperus ligularis</i>. The latter mostly near the coast.</p>
Faunistic comments	The short-grass savannas are characteristic habitat for a number of bird species such as the Fork-tailed Flycatcher <i>Tyrannus savanna</i> , the Grasshopper Sparrow <i>Ammodramus savannarum</i> and the Aplomado falcon <i>Falco femoralis</i> .
References	<p>Meerman 1999a, Wright et al. 1959: 19, 19a, 19b, Iremonger & Brokaw II.1.1.2.3.</p> <p>Picture top: Western Highway, Cayo district. J. Meerman</p> <p>Bottom: <i>Passiflora urbaniana</i>. Belize district. J. Meerman</p>

Figure 1.46: Short Grass savanna With Shrubs


Legend Code	43
UNESCO Classification code	<u>I.A.2.g.(1).(a).L</u>
Name	<u>Tropical evergreen seasonal broadleaf lowland swamp forest: Low variant.</u>
Altitude	< 100 m.
Geology and soil	Generally over calcareous rock. Some hog-wallow micro-relief exists as a result of repeated wetting and drying of the soil.
Water regime	Ill drained, often waterlogged for part of the year.
Rainfall	Average rainfall less than 2000 mm per year with a pronounced dry season from February through May.
Fire exposure	Limited to areas with slash and burn cultivation.
Description	Swampy stands of low, thin stemmed trees and shrubs without emergents. Usually associated with 1A2g(1)(a)T and closely related to IIIA1bL. There is a distinctive deciduous element.
	
Frequent plant species	Frequently encountered trees include <i>Acacia</i> sp., <i>Acoelorrhaphe wrightii</i> (usually occurring in dense clumps), <i>Bucida buceras</i> , <i>Calliandra</i> sp., <i>Calyptrocalyx</i> sp., <i>Cameraria latifolia</i> , <i>Chrysobalanus icaco</i> , <i>Clidemia</i> sp., <i>Crescentia cujete</i> , <i>Erythroxylum guatemalense</i> , <i>Haematoxylon campechianum</i> , <i>Hampea trilobata</i> , <i>Helicteres guazumifolia</i> , <i>Hirtella racemosa</i> , <i>Hymenocallis littoralis</i> , <i>Licania hypoleuca</i> , <i>Miconia</i> spp., <i>Mimosa hemendieta</i> , <i>Mouriri exilis</i> , <i>Rinorea</i> sp., <i>Xylopia frutescens</i> and <i>Zygia</i> sp.
Faunistic comments	
References	Meerman 1999c, Wright et al. 1959: 15, 23; Iremonger and Brokaw 1995: I.1.1.1.1.2. Picture: Old Northern Highway. J. Meerman

Figure 1.47: Tropical evergreen broadleaf lowland swamp forest.

1.3.12 Flora

1.3.12.1 Transect Surveys

A total of 11 transects were established – 6 in the Lowland savanna, 1 in the Lowland broad-leaved moist scrub forest, 3 in the Lowland broad-leaved moist forest and two traversed Lowland savanna and Lowland broad-leaved moist forest.

Transects were placed on a north south orientation for 200 metres in length, except for Transect 9 that was placed diagonally due to hit areas with some trees as this area appeared to have lost its tree cover due to fires and human interventions. Data within the savanna was collected from a distance of 20 meters on either side, or 10 meters in the broadleaf forest.

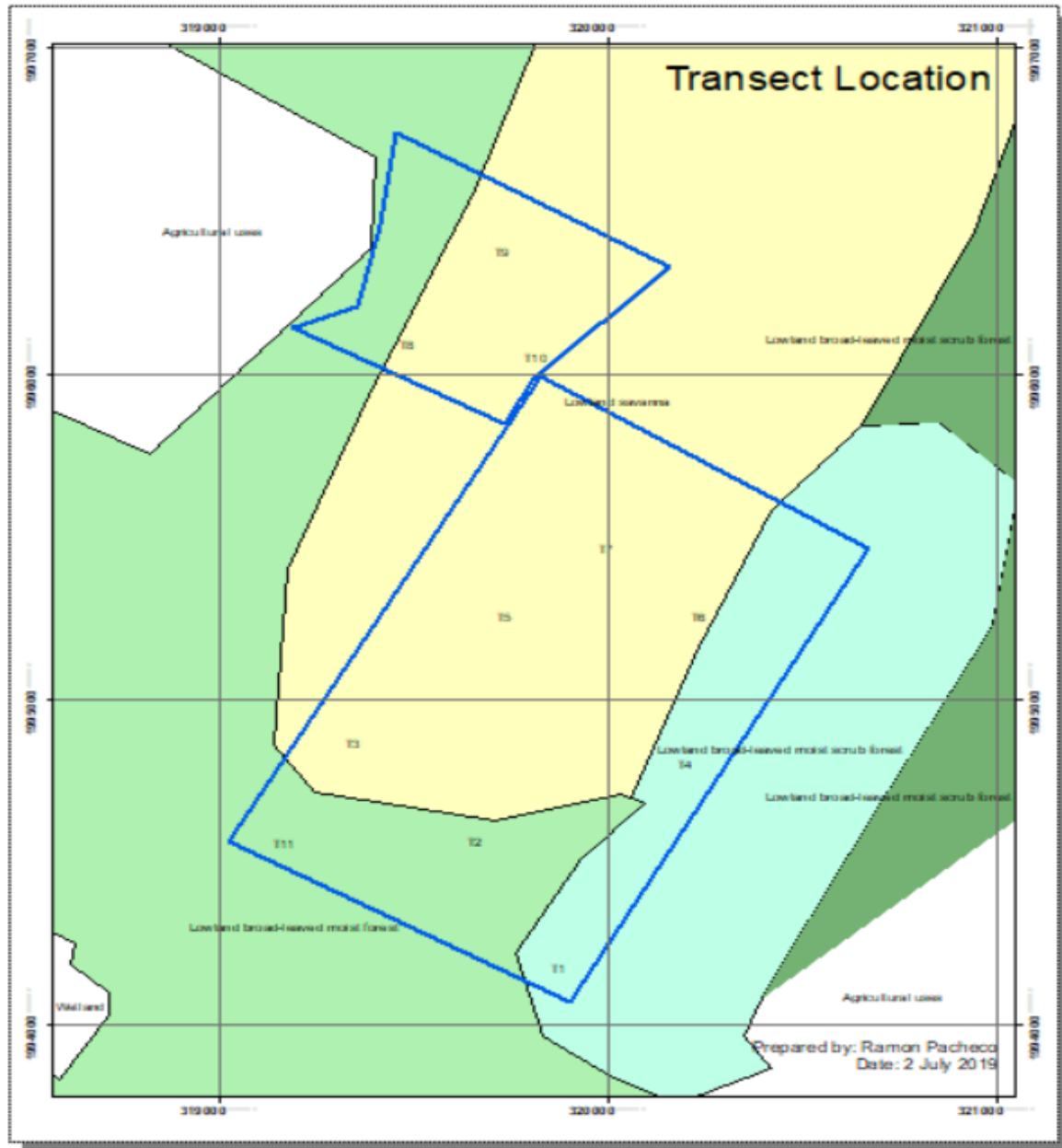


Figure 1.48: Location of Transects

1.3.12.2Plants

Data on trees with diameter at breast height (DBH = 1.3 meters height) $\geq 10\text{cm}$ was systematically collected. Data collected included:

- Species name – where possible
- DBH
- Stem Height
- Crown Form
- Snags
- Understory at every 50meter point
- Photographic evidence at each 50meter point

This information was later used to determine the number of species, relative height of the forest, the relative abundance of species. The data was also used to fine tune and realign the vegetation/ecosystem type boundaries.

1.3.12.3 Vegetation Types assigned to the area and area sampled

The field visits, aerial photos and data provided information to determine the six vegetation types found in the area and matched as much as possible to the result from the Ecosystems of Belize 2017 Map. The table below provides details on the area per ecosystem and the area sampled.

Table 1.39: Area Covered per Ecosystem Type.

Ecosystem	Transect #s	Total Area in acres	Area Sampled acres (%)
Savanna – Open/Oak	4, 5, 6	223.64	5.9 (2.6%)
Savanna – Dense Oak	7, 9, 10	94.4	5.9 (6.2%)
Lowland Broadleaf Forest - Scrub	1, 11	77.8	1.97 (2.5%)
Lowland Broadleaf Forest - Bajo	2, 3	54.4	1.97 (3.6%)
Lowland Broadleaf Forest - Moist	8	24.7	0.98 (3.9%)

The total area sampled was 16.72 acres or 3.5% of the site of the vegetated area of 473 acres since 27 acres was the bulldozed clearing. The Savanna ecosystem was the most prevalent with 318 acres. Lowland Broadleaf Forest covered 154 acres. The Savanna ecosystem was the most prevalent with 318 acres. Lowland Broadleaf Forest covered 154 acres.

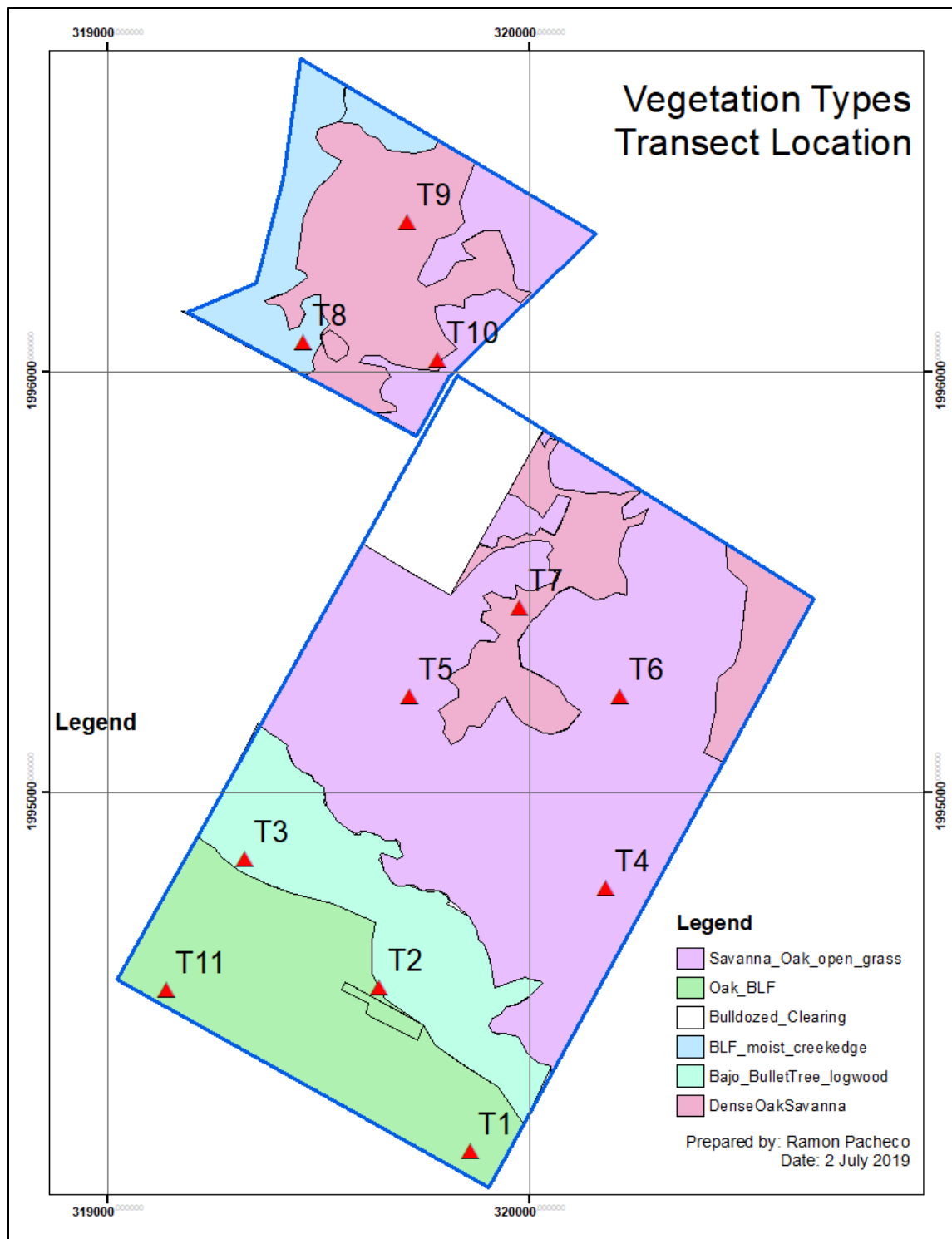


Figure 1.49: Vegetation Types and Location

1.3.12.4 Results of Botanical Data

A total of 61 plant species were identified by local common name in the field, one set is identified as Unknown and is made of a variety of species represented by a few individuals. Literature search and expert knowledge was later used to identify as many species by their scientific name. The data can also be used to get an idea of the understory and the condition of the area. The 100-acre parcel was found to be severely degraded due to past and recent fires as well as clearing. The 400-acre parcel was also impacted by fires and human activity but was in a more “natural” state than the 100-acre parcel. The 400-acre parcel has 27.2 acres cleared of all its vegetation on the south west corner. This clearing is recent and done using bulldozer and fire. The most important species was Oak (*Quercus oloides*) with 355 (28%) of the 1,236 stems counted. Oak was present though out most the site. The next most important species were Logwood (*Haematoxylum campechianum*) with 77 stems (6%) and Craboo (*Byrsonima crassifolia*) with 75 stems (6%).

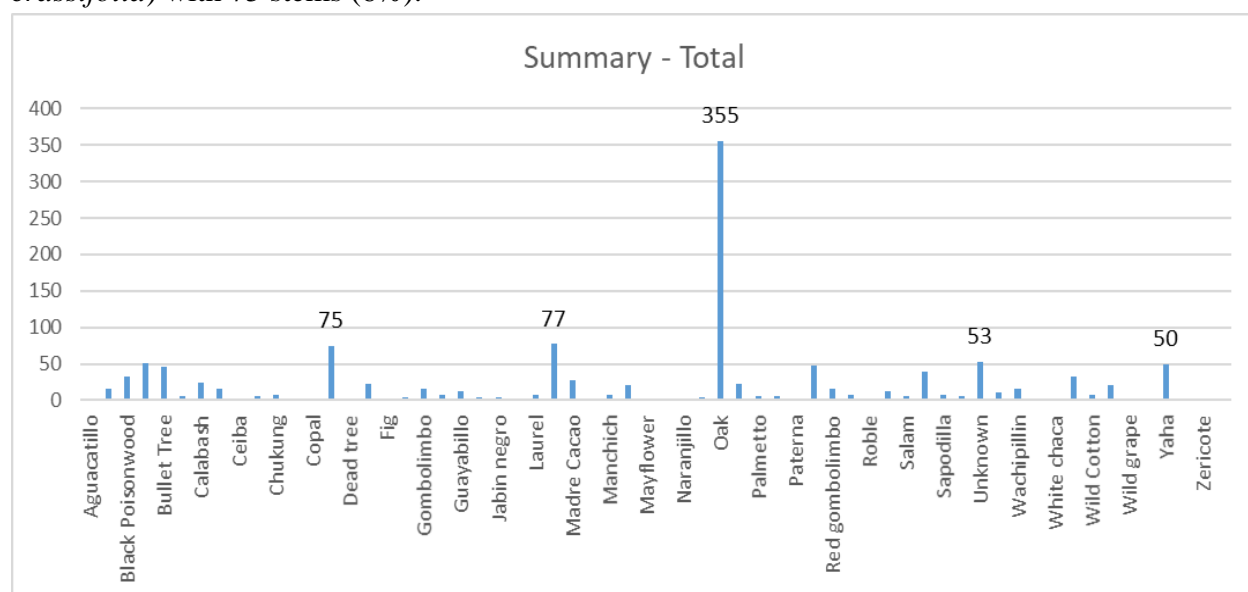


Figure 1.50 Results of Botanical Data.

Species of high commercial value and species of high conservation value are insignificant to absent in the data. The only high value species found was Mahogany (*Sweitenia macrophylla*), but only two stems were counted in the entire site.

Botanical Data – DBH and Stem Height (Ht) average DBH for the entire site was 20.85 cm with the vegetation type having the largest average DBH being the Savanna Dense Oak with 20.68cm. The vegetation type with the smallest DBH value was the Lowland Broadleaf Scrub forest with 18.2cm.

The average stem Ht for the entire site was 3.42m with the vegetation type having the longest average stem Ht being the Lowland Broadleaf Moist forest with 4.59m. The vegetation type with the shortest stem Ht value was the Savanna – Open Oak with 2.62m.

Table 1.40: Botanical Data

Vegetation Type	BLF-Bajo	BLF_Moist	Savannah Dense Oak	Savannah Open Oak	BLF_Scrub	Grand Total
Average DBH	19.64	18.77	22.68	22.42	18.20	20.38
Average Ht	3.64	4.59	2.92	2.62	3.90	3.42

In general, the trees in this site are thin boled with most trees being less than 30 cm DBH - 1015 individuals. Only 195 had a bole greater than or equal to 30cm DBH. From timber perspective, within the entire 500 acres, only 9 individuals of two species (Oak and Bullet tree) would qualify for harvesting being 60 cm DBH or greater. This area is certainly not a Production Forest as only Bullet tree with 3 individuals qualified as a harvestable commercial species.

Savanna - Open Oak/Grassland

Only 12 tree species with 256 individuals were found within the Open Savanna which is characterized as an open stand of Oak trees interspersed with patches of Palmetto (*Aceloreaphe* -). Five species dominate the plant community. These species are Oak (47%), Yaha (*Curatela americana*) 20%, Craboo (*Byrsonima crassifolia*) (16%) and Calabash (*Crescentia cujete*) and a few Caribbean pine (*Pinus caribaea*) 4%. No species of high commercial or conservation value was found in this vegetation type.

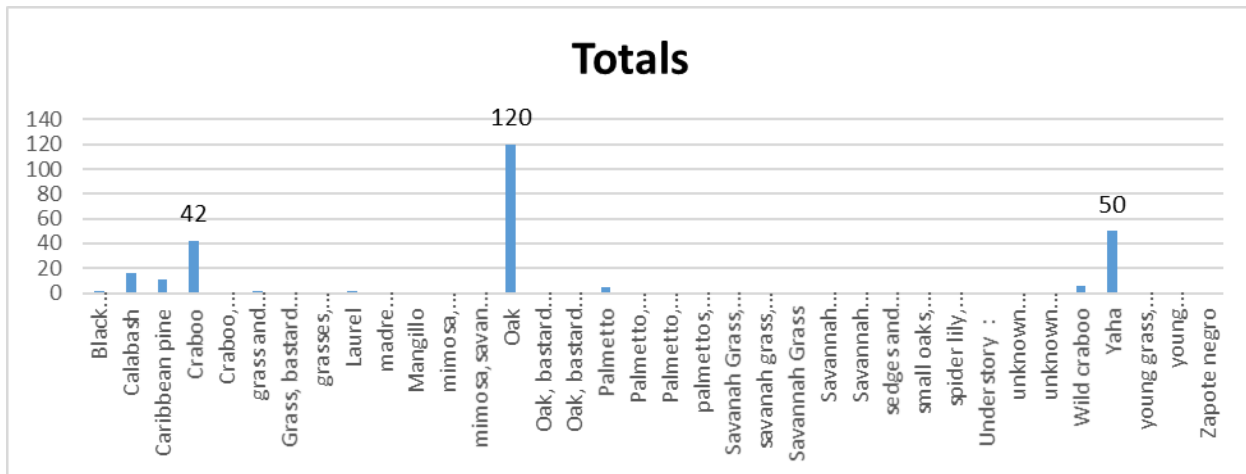


Figure1.51: Total Rating of Open Oak/Grassland

The understory of the Savanna Open/Grassland was dominated by grasses, mimosa, Palmetto, Craboo, Oak and vines. Other species identified in smaller numbers were sedges, Capulin, Madre cocoa and Spider Lily. The area has disturbed by fires and cutting of trees, e.g. Caribbean Pine.







Lowland Savannah – Dense Oak

The Lowland Savannah with dense Oak is made up of 26 named species and one set of unknowns for a total of 278 stems. This area has as dense understory of shrubs and vines but also has open areas with Palmetto. Two species make up 66% of all the stems counted in the Dense Oak Savanna. The number of Oaks counted was 157 (56%) while Craboo accounted for 31 (11%). Other species present but not common include Botan (*Sabal mauritiiformis*), Black Poisonwood (*Metopium brownei*) and Mangillo (spp) and Calabash with 3% or less.

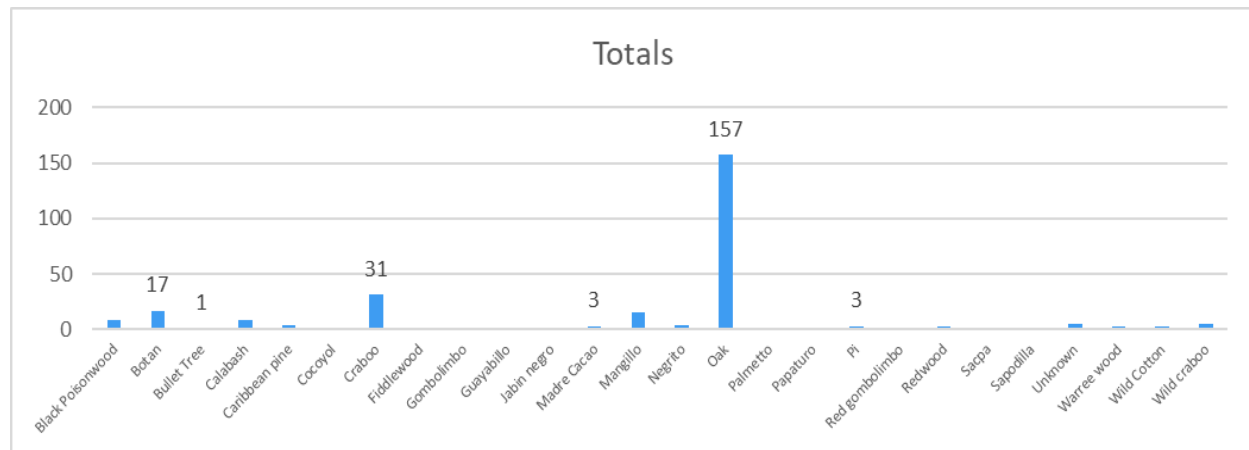


Figure 1.52: Lowland Savannah Dense Oak

The understory of the Savannah with Dense Oak was relatively diverse. Grasses, Palmetto, sedges, Black poisonwood, and craboo were more common. Other species identified were capulin (*Helicteres gauzumifolia?*), Oak, Wild cotton, Wild pineapple, Barbajolote (*Cojoba graciliflora*), Cacho de venado, Bullhorn acacia, Madre cacao, calabash, vines (morning glory, passion flower), Sapodilla, and Warree wood. This area has disturbed by fires and cutting of trees, e.g. Oak and Caribbean Pine.







Lowland Broadleaf Moist Forest

The Lowland Broadleaf Moist Forest is made up of 30 named species and one unknown for a total of 91 individuals. The vegetation is dense with vines and small shrubs. Some areas were damaged by fire or cleared of forest. This forest is associated with a small creek (Blue Creek?) on the western side. This water source is probably influencing the species mix in this site. The dominant species is Logwood (*Haemotoxylum campechianum*) with 13 (14%) individuals but is closely followed by Bullet Tree (*Bucida busera*) and the Botan palm with 10 (11%) individuals each. Oak trees are also in this forest given its adjacency to the Savanna ecosystem. There was one sample of Zericote (*Cordia dodecandra*) which is a prize species used in craft making.

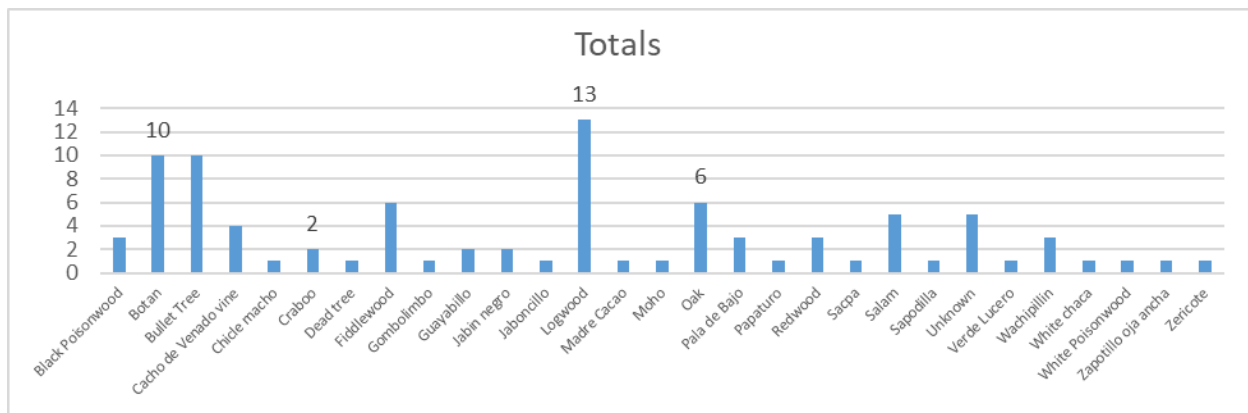


Figure 1.53: Total Rating of Lowland Broadleaf Moist Forest

The understory of this vegetation type consisted of Dog balls, Papaturro, Salam, and Black Poisonwood. Botan, Bullhorn acacia, Caimito, Coccoloba, Cow foot vine, Guayavillo, Mosote, grasses, Nancillo, Oak, Palmetto, sedges, Siwapate, White Chaca and Zapote hoja ancha. Some parts of this area have been cleared for agriculture use.





Lowland Broadleaf Scrub Forest

This Lowland Broadleaf Scrub Forest had 41 named species and a set of 5 Unknowns for a total of 379 stems. This forest has a dense understory. The dominant species were Oak and Logwood. Oak accounted for 72 (18.9%) individuals while Logwood had 58 (15%) individuals. Other species related to harsh soil and hydrological conditions such as Madre cacao (*Gliricidia sepium*) and Pi (*Gymanthes lucida*) were relatively common with 21 (6%) and 19 (5%) individuals sampled.

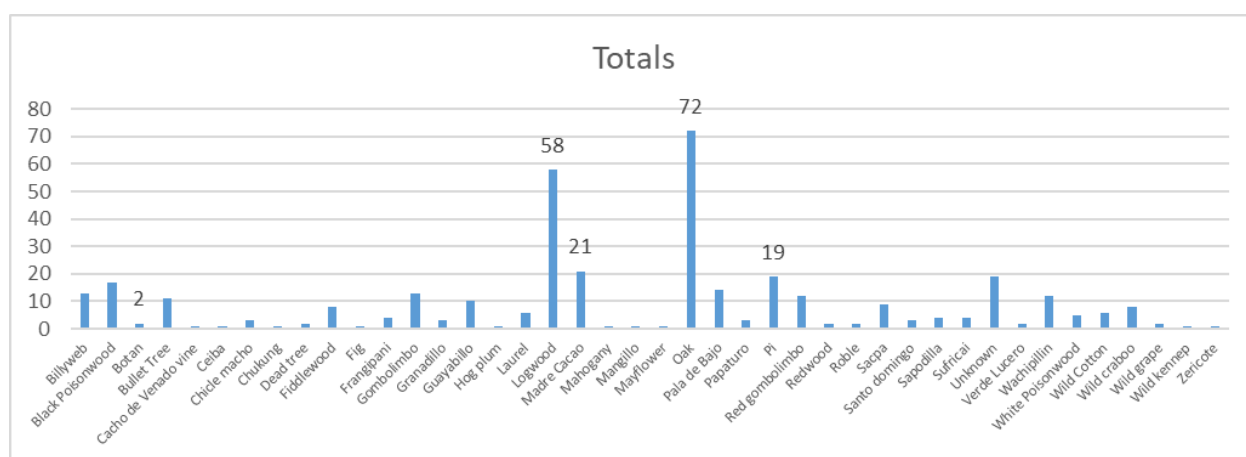
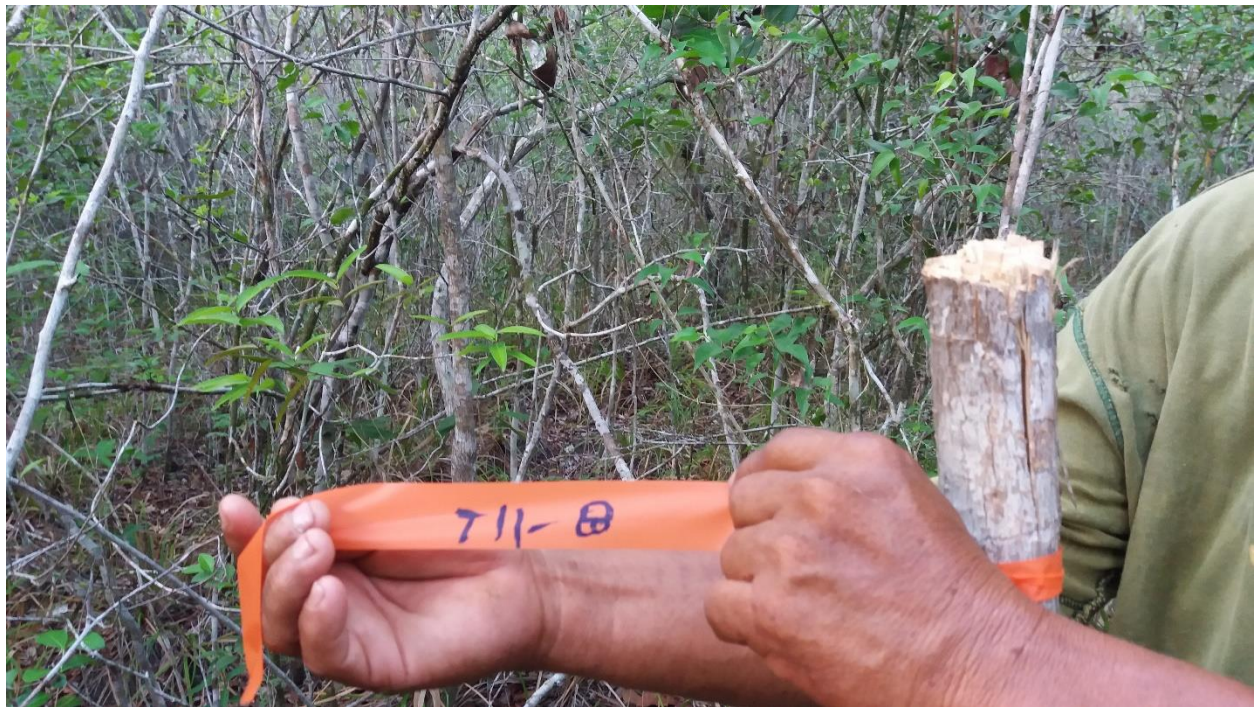


Figure 1.54: Total Rating of lowland Broadleaf Scrub Forest

The understory of this vegetation type consisted of Grasses, Sedge, Black Poisonwood, orchids, Glassy wood, Xate, Oak, Manchich, Palmetto, Madre Cocoa, Logwood, Craboo, and vines. This area is in a relatively natural state. The transition zone between this and the Savanna has been altered by fires.





Lowland Broadleaf Forest – Bajo

The Lowland Broadleaf Forest – Bajo was represented by 35 named species and one unknown set. A total of 241 individuals were counted. Five species made up more than 55% of the individuals with Santo Domingo (*Pachira aquatica*) being the most dominant 36 (15%) individuals followed by White Poisonwood with 26 (11%) individuals, Pi (*Gyneranthus lucida*) 25 (10%) individuals and Bullet tree (*Bucida buxera*) with 24 (10%) individuals. The Botan palm was relatively common with 22 (9%) individuals.

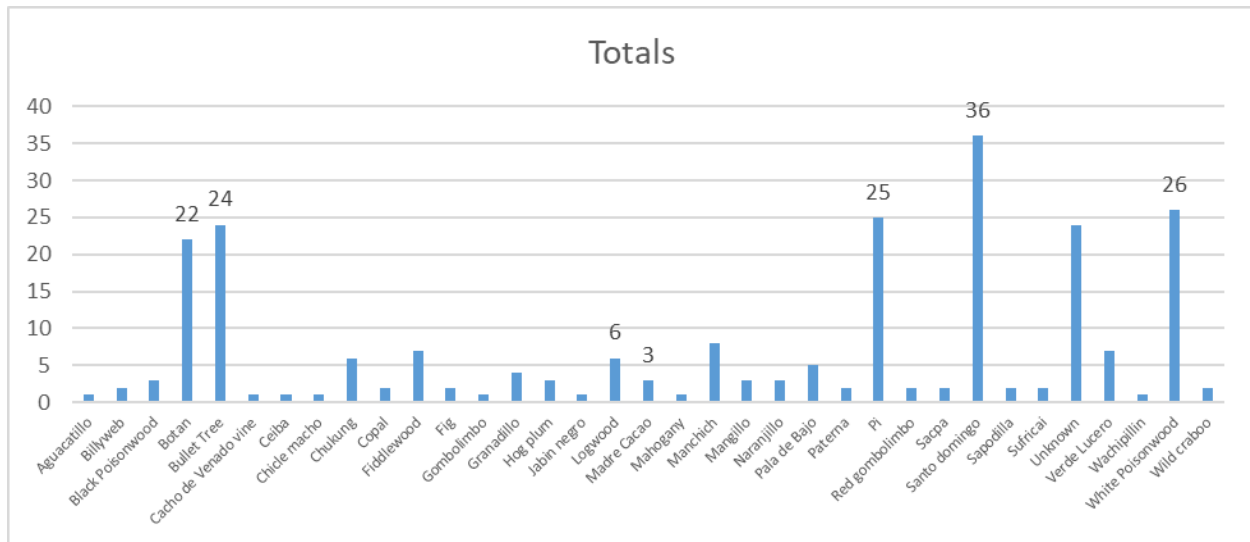
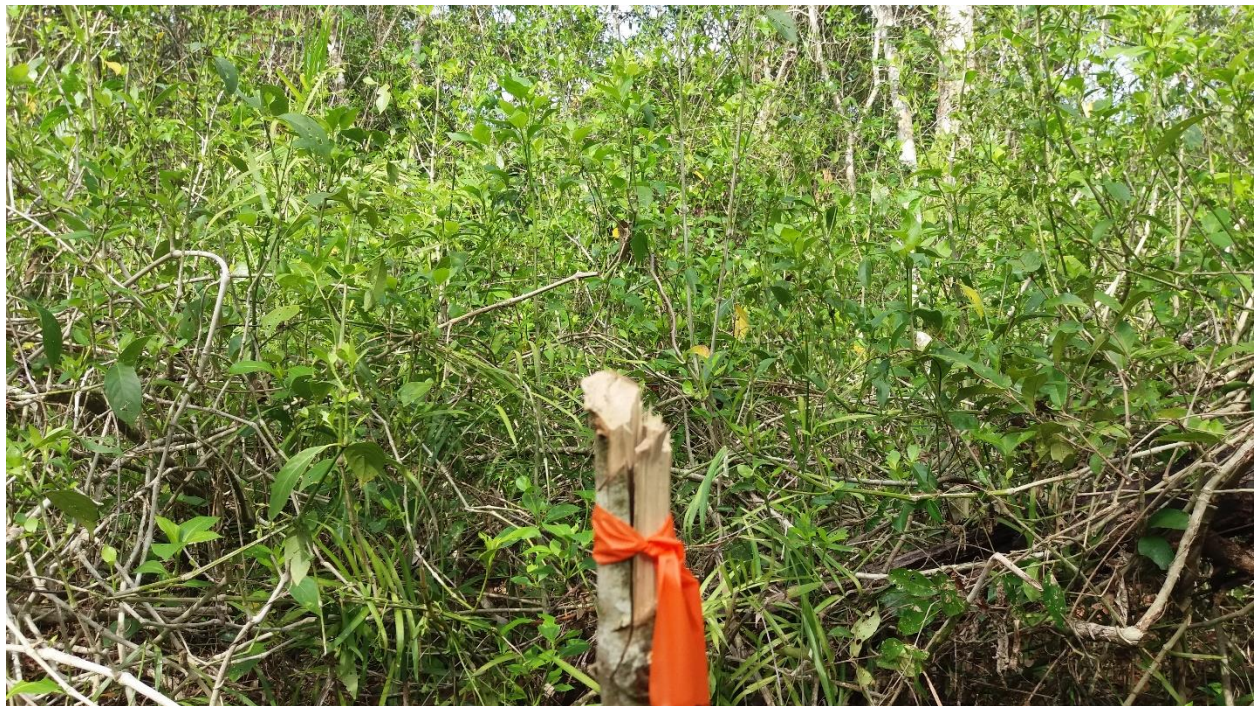


Figure 1.55: Total Ratings of Lowland Broadleaf Forest-Bajo

The understory of this vegetation type consisted of Botan, Bullet tree, Basket tie, Black Poisonwood vines, grasses, Logwood, sedges, bromeliads, and Xate.







1.3.13 Fauna

1.3.13.1 Wildlife

Summary of Birds Seen or Heard

Due to the nature of bird observation, most birds were detected by sound, particularly in the Lowland Broadleaf Forest. A total of 105 species of birds were recorded (Table 1.41). The vegetation type with then most species was Savanna with Dense Oak. The Lowland Broadleaf Moist Forest had the lowest species number with 42. The table below provides a summary of the number of species and the total number of individuals recorded.

Table 1.41: Records of Wildlife Species

	BLF-Bajo	BLF-Moist	BLF-Scrub	Savanna - Dense Oak	Savanna - Open Oak	Grand Total
Number of Species	60	42	54	68	54	112
Count of Species	174	78	118	248	181	799
Top 3 species	Spot breasted wren, Barred Antshrike, Ivory billed woodcreeper	Black headed trogon, Green jay, Brown jay	Black headed trogon, Ivory billed woodcreeper, White fronted parrot	Brown jay, White bellied wren, Black headed trogon	White fronted parrot, Brown jay, Spot breasted wren	Spot breasted wren, Black headed trogon, White bellied wren

Overall, the 10 most recorded species are presented in the table below. No bird recorded is listed as Critically Endangered or Endangered (NPASP – Protected Areas System Assessment & Analysis: Critical Species; (Meerman J. C. 2005).

Table 1.42: Most Recorded Species

No	Species	Count of Species
1	Spot breasted wren	46
2	Black headed trogon	40
3	White bellied wren	33
4	White fronted parrot	33
5	Brown jay	32
6	Ivory billed wood creeper	28
7	Barred Ant shrike	27
8	Couch's kingbird	23
9	Golden fronted woodpecker	23
10	Green backed sparrow	22

1.3.14 Endangered or Threatened Species

Other wildlife was practically none-existent within the site. A howler monkey was heard outside of the site. The howler monkey (*Alloutta pigra*) is an endangered species but it does not inhabit the project ecosystems, perhaps because food is sparse and vegetation is disturbed and

not supportive of large mammals. One agouti (*Dasyprocta punctate*) was seen. One lizard, an *Amieva*, was also observed.

1.3.15 Protected Areas

The *Arundo donax* test parcels are not within the buffer or area of influence of any protected area. As can be seen in the map below, the closest protected area is the Crooked Tree Wildlife Sanctuary which is more than 20 kilometres away. The *Arundo donax* test parcels are also completely out of the proposed northern biological corridors linking key protected areas in the north of the country. Historic and present land use trends would seem to indicate that the area of northern Belize in which the proposed *Arundo donax* site is found will not form part of any protected areas or biodiversity conservation network.

However, it is important to note that all the ecosystem types found within the *Arundo donax* test parcels are represented within the protected areas shown on the map. For example, the Rio Bravo Conservation and Management Area which is managed by Programme for Belize has good representation of all the ecosystem types found within the *Arundo donax* test site and the adjoining “marginal lands”.

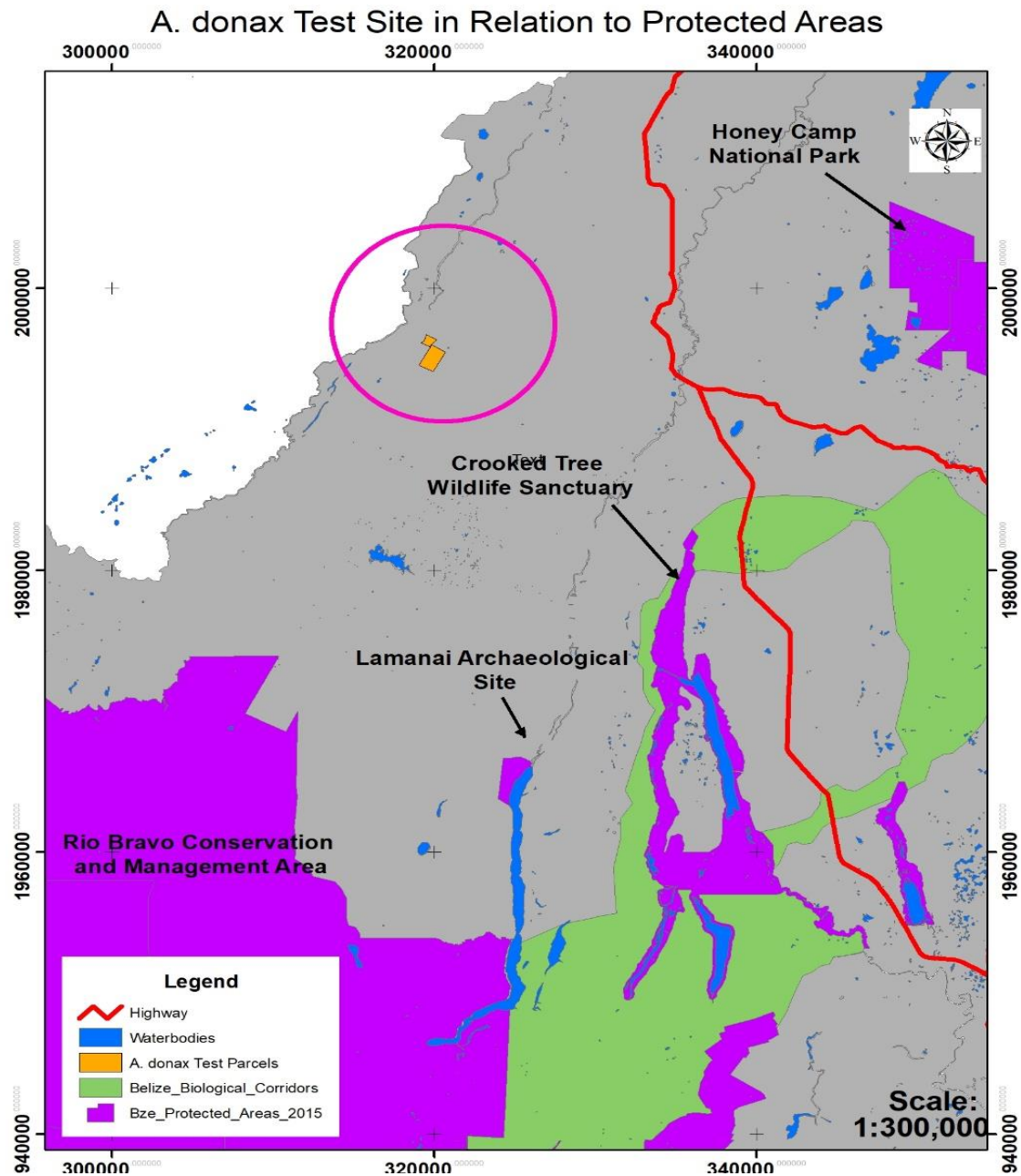


Figure 1.56: Arundo donax Test Sites in Relation to Protected Areas.

N.B. Circle denotes location of Arundo donax site.

1.3.16 Summary of Potential Impacts and Mitigation and Control Measures – Biodiversity

Potential Impacts to biodiversity (flora/fauna) are summarized herein as the detailed impacts and proposed mitigation/control are found in Chapter 4.0 and in the ESMP.

- *Reduced Species Abundance.* Clearing vegetation will be necessary during implementation of the Project. The clearing process will remove plants from the broader species populations in and around the area which may have adverse effects on plant species abundance on a local level.
- *Reduced Conditions Favorable for Plant Growth.* Vegetation clearing, vehicle movements and day-to-day operational activities will generate dust. This has the potential to reduce conditions favorable for plant growth (e.g., reduction in photosynthesis and transpiration due to an accumulation of dust on plant surfaces or damage to plants from reactive dust particles) with subsequent reduced plant health.
- *Introduction of New Weed Species and Weed Infestations.* Vegetation clearing, land disturbance and vehicle movement has the potential to increase weed populations or create conditions that are conducive to the establishment of weed species within the Project area. Vehicle and equipment movement also has the potential to introduce weed species, usually these are resistant strains that get accustomed to dust conditions and often line the roadways.
- *Introduction of new weeds species and increased weed density reduced Species Abundance due to clearing.* New weeds will be suppressed by regular land preparation which will destroy these weeds. Where they are a problem during the growing season they will be removed by disking or by spraying with an herbicide. There should not be an increase in weed infestation given the active planting taking place.
- *Reduced Conditions Favorable to Plant Growth Due to Dust*

Table 1.43 Summary of Actions, degree of Impact and Proposed Mitigation/control measures for Biodiversity Activities.

Activities	Degree of Impact	Mitigation Measure
Biodiversity and Wildlife Alteration	<ul style="list-style-type: none"> • Impacts to Threatened Species • Reduced Species Abundance • Reduced Conditions for Favorable Plant Growth 	<p>The surveys conducted for the area shows that the area has already been severely disturbed from an ecological standpoint. Natural disasters, such as hurricanes and bush fires, as well as human activities, such as illegal logging and slash and burn agriculture, has impacted the project site. Therefore, the mitigation measures to be employed include:</p> <ul style="list-style-type: none"> • Limit the unavoidable impact by maintaining the vegetation buffer zone. • Confine the biomass project to the designated area. Keep the rhizomes from spreading laterally into agricultural land resulting in the replacement of native species of vegetation. • Exposed areas should be replanted and landscaped as soon as possible to reduce soil erosion, sediment, and organic runoff. • The remaining vegetation stands will be maintained in their original form. • Illegal removal of forest products from the site will not be allowed • Vehicles will be routinely washed before they access the planting site. Only approved seeds will be used. Regular land preparation will restrict the growth of these weeds. • Limit the time for land preparation to reduce time of exposure.

1.3.17 Traffic & Infrastructure

The site is accessible from the Phillip Goldson Highway (PGH); which was formerly called the Northern Highway. As its former name states, the highway provides access to the northern districts and communities to the rest of the country. The project area is accessed via the Yo Creek Road as shown in figure 1.55. An access road also connects the project.

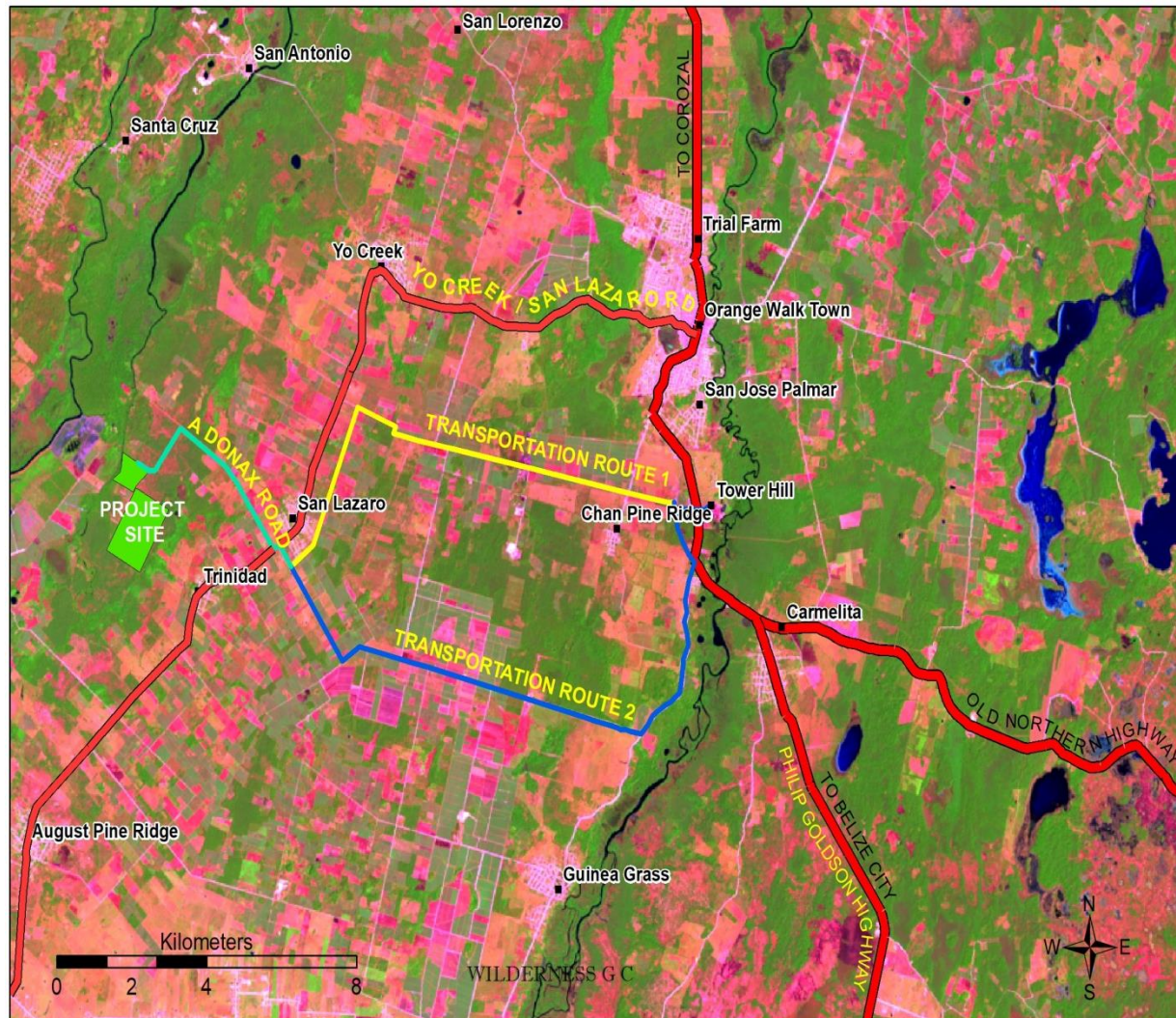


Figure 1.57: Location of PGH and Yo Creek Roads in relation to project site.

Traffic using cars, light trucks and heavy vehicles such as larger trucks, trailers and tractors have access to the Yo Creek Road and to the project site. As part of the pilot project supporting the A. Donax project, the access road has undergone some improvement and will be expected to be further improved for better access. The Yo Creek Road is paved, as well as the PGH. The access road is an all-weather unimproved road, but one that is accessible to vehicles even without four-wheel drive systems.

1.3.18 Summary of Potential Impacts to Biodiversity and Mitigation/Compensation Measures.

Potential environmental impacts as a result of traffic and transport could include:

- Traffic accidents
- Accelerated degradation of road surfaces
- Increase in native fauna deaths due to collision
 - *Traffic Accidents.* Appropriate signs will be placed around the access site. Additionally, the access road will be constructed so that there is visibility to traffic from both sides.
 - *Accelerated Degradation of Road Surfaces and dust proliferation.* The access roads will almost certainly suffer from wear and tear; however, this is a natural consequence of its use and the project will implement a road maintenance plan. Wear and tear is expected to cause minor damage to roads and tracks which will be easily remediated with appropriate road maintenance procedures.
 - *Risk of collision with domestic or other animals.* Increased vehicular movement always increases the risk of collision with animals, either domestic or other. This may pose hazards to drivers and motorists but may also result in the loss of pets or agriculture value animals. This situation can best be addressed through controlled worker health and safety practices, and in unavoidable situations, through the redress mechanism.

Table 1.44: Summary of Activities, Impacts and Mitigation and Control Measures.

Activities	Degree of Impact	Mitigation Measure
Transportation and Traffic movement	<ul style="list-style-type: none"> • Traffic Accidents • Accelerated degradation of road surfaces • increase in native fauna deaths • Accidental spillage of materials • Collision with animals and pets 	<ul style="list-style-type: none"> • Speed signs will be placed within the project site as well as during the transportation of vehicles and personnel. • The access road will be improved and new roads within the project site constructed to ensure proper visibility and sloped so as to minimize ground disturbances and erosion potential. • Access roads within the property will be made to the minimum width possible without threatening driver safety. • Best management practices for farm roads to be implemented at all times. • Each load will be locked for transportation in order to ensure that no spillage occurs between the collection site and the planting (<i>Biomass Pilot</i> project) site.

		<ul style="list-style-type: none"> • The vehicle will be inspected including tires by project personnel prior to transportation to ensure that there is no crop material outside the container truck. • The chipped material of approximately half inch sized pieces will be discharged directly into tractor drawn trailers for transportation to the on-site storage area. • Communication between management of the BELCOGEN facility will determine the volume and timing for the transportation of the biofuel to the existing power plant facilities. • Any destruction of farm animals or pets will be addressed through the redress mechanism
--	--	---

ANNEXED TABLES FOR FLORA AND FAUNA REPORTS

Table 1.45: List of Trees Recorded

Index	Common Name	Scientific name (Sn)	Count	Uncertain Sn
1	Aguacatillo	<i>Persea caerulea?</i>	1	?
2	Billy Webb	<i>Acosmium panamense</i>	15	
3	Black Poisonwood	<i>Metopium brownie</i>	33	
4	Botan	<i>Sabal mauritiiformis</i>	51	
5	Bullet Tree	<i>Bucida buceras</i>	46	
6	Cacho de Venado - vine		6	
7	Calabash	<i>Crescentia cujete</i>	24	
8	Caribbean pine	<i>Pinus caribaea</i>	15	
9	Ceiba	<i>Ceiba pentandra</i>	2	
10	Chicle macho	<i>Manilkara chicle</i>	5	
11	Chukung	<i>Pithecellobium lanceolatum</i>	7	
12	Cocoyol	<i>Acrocomia aculeata</i>	1	
13	Copal	<i>Protium copal</i>	2	
14	Craboo	<i>Byrsonima crassifolia</i>	75	
15	Dead tree		3	
16	Fiddlewood	<i>Vitex gaumeri</i>	22	
17	Fig	<i>Ficus spp</i>	3	
18	Frangipani	<i>Plumeria spp</i>	4	
19	Gumbo-limbo	<i>Bursera simaruba</i>	16	
20	Granadillo	<i>Platymiscium yucatanum</i>	7	
21	Guayabillo	<i>Rinorea hummelii</i> or <i>Calyptanthus chytraculia</i>	13	
22	Hog plum	<i>Spondias mombin</i>	4	
23	Jabin negro	<i>Vachellia cornigera</i>	4	
24	Jaboncillo	<i>Saurauia yasicae</i>	1	
25	Laurel	<i>Licaria peckii</i>	8	
26	Logwood	<i>Haematoxylum campechianum</i>	77	
27	Madre Cacao	<i>Gliricidia sepium</i>	28	
28	Mahogany	<i>Swietenia macrophylla</i>	2	
29	Black Cabbage Bark	<i>Lonchocarpus castilloi</i>	8	
30	Mangillo	?	20	
31	Mayflower	<i>Tabebuia pentaphylla</i>	1	
32	Moho	<i>Trichospermum grewiaefolium</i>	1	
33	Naranjillo	?	3	
34	Negrito	<i>Simarouba cf. amara</i>	4	
35	Oak	<i>Quercus oleoides</i>	355	

36	Pala de Bajo	?	22	
37	Palmetto	<i>Acoelorrhaphe wrightii</i>	6	
38	Papaturro	<i>Coccoloba belizensis</i>	5	
39	Paterna	?	2	
40	Pi	<i>Gymanthes lucida</i>	47	
41	Red gombolimbo	<i>Bursera simaruba</i>	15	
42	Redwood	<i>Erythroxylum areolatum</i>	7	
43	Roble	<i>Tabebuia rosea</i>	2	
44	Sacpa	<i>Byrsonima crassifolia</i>	13	
45	Salam	<i>Lysiloma latisiliquum</i>	5	
46	Santo Domingo	<i>Pachira aquatica</i>	39	
47	Sapodilla	<i>Manilkara zapota</i>	8	
48	Sufricai	<i>Mosannonna depressa</i>	6	
49	Unknown		42	
50	Unknown bajo species		10	
51	Unknown with fruit		1	
52	Verde Lucero	<i>Esenbeckia pentaphylla</i>	10	
53	Wachipillin	?	16	
54	Warree wood	<i>Caesalpinia gaumeri</i>	3	
55	White chaca	<i>dendropanax arboreus</i>	1	
56	White Poisonwood	<i>Sebastiania confusa</i> or <i>Cameraria latifolia</i>	32	
57	Wild Cotton	<i>Cochlospermum vitifolium</i>	8	?
58	Wild craboo	<i>Bourreria cf. oxyphyllaria</i>	21	
59	Wild grape	<i>Coccoloba belizensis</i> ? <i>Cameraria belizensis</i> ?	2	
60	Wild kennep	<i>Talisia oliviformis</i>	1	
61	Yaha	<i>Curatella americana</i>	50	
62	Zapotillo oja ancha	<i>Pouteria spp</i>	1	
63	Zericote	<i>Cordia sebestena</i>	2	
64	Zapote negro	<i>Manikara spp</i>	1	
	Grand Total		1245	

Note: Scientific name in red provided by Dr Nick Brokaw.

Table 1.46: Average DBH (in cm) per Species and Vegetation Type

Species	BLF-Bajo	BLF_Moist	Savannah Dense Oak	Savannah Open Oak	BLF_Scrub	Grand Total
Aguacatillo	12					12
Billyweb	23				18	19
Black Poisonwood	26	18	17	16	23	21
Bullet Tree	38	30	18		24	33
Cacho de Venado vine	15	13			10	13
Calabash			13	16		15
Caribbean pine			26	29		28
Ceiba	16				20	18
Chicle macho	24	12			17	17
Chukung	13				13	13
Cocoyol			36			36
Copal	15					15
Craboo		15	14	13		14
Dead tree		25			15	18
Fiddlewood	15	13	11		14	14
Fig	16				12	14
Frangipani					12	12
Gombolimbo	11	10	19		14	14
Granadillo	15				16	16
Guayabillo		12	10		13	13
Hog plum	27				19	25
Jabin negro	13	33	18			24
Jaboncillo		15				15
Laurel				25	17	19
Logwood	27	18			19	20
Madre Cacao	12	13	16		14	14
Mahogany	15				12	14
Manchich	24					24
Mangillo	17		14	16	12	15
Mayflower					14	14
Moho		11				11
Naranjillo	18					18
Negrito			14			14
Oak		23	28	30	26	28
Pala de Bajo	13	14			17	16
Palmetto						
Papaturro		15	11		13	13
Paterna	12					12

Pi	15		12		14	14
Red gombolimbo	17		11		16	16
Redwood		14	12		17	14
Roble					16	16
Sacpa	15	14	15		15	15
Salam		23				23
Santo Domingo	21				19	21
Sapodilla	24	11	19		17	19
Sufricai	15				12	13
Unknown	17	16	15		13	15
Verde Lucero	19	14			17	18
Wachipillin	12	16			16	16
Warree wood			22			22
White chaca		14				14
White Poisonwood	13	11			14	13
Wild Cotton			16		17	16
Wild craboo	15		16	20	13	16
Wild grape					11	11
Wild kennep					12	12
Yaha				14		14
Zapotillo oja ancha		26				26
Zericote		20			13	16
Zapote negro				16		16
Grand Total	19.64	18.77	22.68	22.42	18.20	20.38

Table 1.47: Average Height (in metres) of Main Stem per Species and Vegetation Type

	Species	BLF-Bajo	BLF_Moist	Savannah Dense Oak	Savannah Open Oak	BLF_Scrub	Grand Total
1	Aguacatillo	2					2
2	Billyweb	6				5	5
3	Black Poisonwood	4	6	3	5	4	4
4	Botan	4	8	6		2	5
5	Bullet Tree	4	4	4		4	4
6	Cacho de Venado vine	3	2			2	2
7	Calabash			2	1		2
8	Caribbean pine			6	7		7
9	Ceiba	8				6	7
10	Chicle macho	4	4			3	3
11	Chukung	4				3	4

12	Cocoyol			1			1
13	Copal	2					2
14	Craboo		3	2	2		2
15	Dead tree					3	3
16	Fiddlewood	3	5	4		3	4
17	Fig	4				6	5
18	Frangipani					2	2
19	Gombolimbo	8	2	6		6	6
20	Granadillo	5				7	6
21	Guayabillo		6	5		6	6
22	Hog plum	5				3	4
23	Jabin negro	10	7	4			7
24	Jaboncillo		2				2
25	Laurel				2	5	4
26	Logwood	3	3			3	3
27	Madre Cacao	4	7	3		3	4
28	Mahogany	11				2	7
29	Manchich	4					4
30	Mangillo	2		2	2	2	2
31	Mayflower					4	4
32	Moho		8				8
33	Naranjillo	6					6
34	Negrito			4			4
35	Oak		3	3	3	3	3
36	Pala de Bajo	4	5			5	5
37	Palmetto						
38	Papaturro		3	2		3	3
39	Paterna	3					3
40	Pi	3		3		5	4
41	Red gombolimbo	6		4		5	5
42	Redwood		4	6		9	6
43	Roble					5	5
44	Sacpa	3	3	4		3	3
45	Salam		3				3
46	Santo Domingo	4				4	4
47	Sapodilla	5	6	2		3	4
48	Sufricai	3				2	2
49	Unknown	3	4	4		3	3
50	Verde Lucero	2	5			4	3
51	Wachipillin	4	8			5	5
52	Warree wood			5			5
53	White chaca		5				5

54	White Poisonwood	3	7			4	3
55	Wild Cotton			5		7	6
56	Wild craboo	6		4	3	4	4
57	Wild grape					3	3
58	Wild kennepe					3	3
59	Yaha				2		2
60	Zapotillo oja ancha		5				5
61	Zericote		5			7	6
62	Zapote negro				2		2
	Grand Total	3.64	4.59	2.92	2.62	3.90	3.42

Table 1.48: Bird Data

Record	Species	Scientific name	Status (IUCN Red List Categories)	BLF-Bajo	BLF-Moist	BLF-Scrub	Savanna - Dense Oak	Savanna - Open Oak	Grand Total
1	Acorn Woodpecker	<i>Melanerpes formicivorus</i>	LC					1	1
2	Aztec parakeet (Olive throated)	<i>Eupsittula astec</i>	LC	2			4	2	8
3	Bare Throated Tiger Heron	<i>Tigrisoma mexicanum</i>	LC	1					1
4	Barred Antshrike	<i>Thamnophilus dolius</i>	LC	12	3	2	6	4	27
5	Black Bellied Whistling Duck	<i>Dendrocygna autumnalis</i>	LC				1	2	3
6	Black cowled oriole	<i>Icterus prothemelas</i>	LC	1			4	1	6
7	Black faced ant-thrush	<i>Formicarius analis</i>	LC	3		1	2		6
8	Black headed saltator	<i>Saltator atriceps</i>	LC			2		1	3
9	Black headed trogon	<i>Trogon melanocephalus</i>	LC	6	6	8	13	7	40
10	Black vulture	<i>Coragyps atratus</i>	LC	2	1		1	3	7
11	Blue black grassquit	<i>Volatinia jacarina</i>	LC				1	5	6
12	Blue bunting	<i>Cyanocompsa parellina</i>	LC	1		1	1		3
13	Blue gray gnatcatcher	<i>Poliophtila caerulea</i>	LC			1	1	3	5
14	Boat billed flycatcher	<i>Megarynchus pitangua</i>	LC		1				1
15	Bright rumped attila	<i>Attila spadiceus</i>	LC	1		2	1		4

16	Brown crested flycatcher	<i>Myiarchus tyrannulus</i>	LC	1	1		1	1	4
17	Brown jay	<i>Cyanocorax morio</i>	LC	3	4	1	15	9	32
18	Buff bellied hummingbird	<i>Amazilia yucatanensis</i>	LC				1		1
19	Caribbean dove	<i>Leptotila jamaicensis</i>	LC			3			3
20	Chestnut colored woodpecker	<i>Celeus castaneus</i>	LC	1					1
21	Clay colored thrush	<i>Turdus grayi</i>	LC	2	2	2	4		10
22	Couch's kingbird	<i>Tyrannus couchii</i>	LC		1	1	13	8	23
23	Dusky capped flycatcher	<i>Myiarchus tuberculifer</i>	LC		2	1	6	3	12
24	Gartered trogon	<i>Trogon caligatus</i>)	LC	1		1	1	1	4
25	Golden fronted parrot	<i>Melanerpes aurifrons</i>	LC			1			1
26	Golden fronted woodpecker	<i>Melanerpes aurifrons</i>	LC	2	2	2	10	7	23
27	Gray breasted martin	<i>Progne chalybea</i>	LC	1			1	1	3
28	Gray crowned yellow throat	<i>Geothlypis poliocephala</i>	LC				2		2
29	Gray hawk	<i>Buteo plagiatus</i>	LC				4	2	6
30	Gray headed dove	<i>Leptotila plumbeiceps</i>	LC		1				1
31	Gray throated chat	<i>Granatellus sallaei</i>	LC	3					3
32	Grayish saltator	<i>Saltator coerulescens</i>	LC			1	1	1	3
33	Great Kiskadee	<i>Pitangus sulphuratus</i>	LC	1			1		2
34	Great Tinamou	<i>Tinamus major</i>	NT	5		1	4	2	12
35	Green backed sparrow	<i>Arremonops chloronotus</i>	LC	6	3	4	6	3	22
36	Green jay	<i>Cyanocorax yncas</i>	LC	3	5	3	2		13
37	Greenish elaenia	<i>Myiopagis viridicata</i>	LC	1		2	1	2	6
38	Groove billed ani	<i>Crotophaga sulcirostris</i>	LC	2			1		3
39	Hooded oriole	<i>Icterus cucullatus</i>	LC				1		1
40	Ivory billed woodcreeper	<i>Xiphorhynchus flavigaster</i>	LC	11	4	8	3	2	28
41	Keel billed toucan	<i>Ramphastos sulfuratus</i>	LC				1		1
42	Laughing falcon	<i>Herpetotheres cachinnans</i>	LC	1	1	1	1	2	6
43	Lesser greenlet	<i>Pachysylvia decurtata</i>	LC	4					4

44	Lesson's Motmot	<i>Momotus lessonii</i>	LC			1			1
45	Lineated Woodpecker	<i>Hylatomus lineatus</i>	LC					1	1
46	Long Billed Gnatcatcher	<i>Ramphocaenus melanurus</i>	LC				1		1
47	Long billed gnatwren	<i>Ramphocaenus melanurus</i>	LC	9	1	5			15
48	Mangrove vireo	<i>Vireo pallens</i>	LC			2		2	4
49	Masked tityra	<i>Tityra semifasciata</i>	LC		2		4	1	7
50	Middle America Screech Owl	<i>Megascops guatemalae</i>	LC		1				1
51	Morelet's seedeater	<i>Sporophila moreletii</i>	LC	4	4		8	6	22
52	Northern beardless tyrannulet	<i>Camptostoma imberbe</i>	LC	1		1	4	2	8
53	Northern bentbill	<i>Oncostoma cinereigulare</i>	LC	4	1	2	6		13
54	Northern cardinal	<i>Cardinalis</i>	LC		3		6	5	14
55	Northern royal flycatcher	<i>Onychorhynchus mexicanus</i>	LC	1					1
56	Olivaceous woodcreeper	<i>Sittasomus griseicapillus</i>	LC	1			1		2
57	Olive sparrow	<i>Arremonops rufivirgatus</i>	LC			1	7	8	16
58	Pale billed woodpecker	<i>Campephilus guatemalensis</i>	LC	1		1			2
59	Pale vented Pigeon	<i>Patagioenas cayennensis</i>	LC		2	1	1		4
60	Plain chachalaca	<i>Ortalis vetula</i>	LC	1	1			3	5
61	Red billed pigeon	<i>Patagioenas flavirostris</i>	LC	4	1	3	7		15
62	Red Crowned Ant Tanager	<i>Habia rubica</i>	LC	1					1
63	Red legged honeycreeper	<i>Cyanerpes cyaneus</i>	LC	1	1				2
64	Red lored parrot	<i>Amazona autumnalis</i>	LC			2	2	4	8
65	Red throated ant tanager	<i>Habia fuscicauda</i>	LC	8		3			11
66	Roadside Hawk	<i>Rupornis magnirostris</i>	LC					5	5
67	Rose throated tanager	<i>Piranga roseogularis</i>	LC			2			2
68	Ruddy ground dove	<i>Columbina talpacoti</i>	LC			1	2	5	8
69	Ruddy Woodcreeper	<i>Dendrocincla homochroa</i>	LC	1					1
70	Rufous browed peppershrike	<i>Cyclarhis gujanensis</i>	LC	1				4	5

71	Rufous tailed hummingbird	<i>Amazilia tzacatl</i>	LC	1		1	2		4
72	Russet napped woodrail	<i>Aramides axillaris</i>	LC					1	1
73	Scaled Pigeon	<i>Patagioenas speciosa</i>	LC				1		1
74	Short Billed Pigeon	<i>Patagioenas nigrirostris</i>	LC		1	1			2
75	Slate headed tody flycatcher	<i>Poecilotriccus sylvia</i>	LC	5	1				6
76	Smoky brown woodpecker	<i>Leuconotopicus fumigatus</i>	LC	1		1			2
77	Social flycatcher	<i>Myiozetetes similis</i>	LC	1			3	1	5
78	Spot breasted wren	<i>Pheugopedius maculipectus</i>	LC	15	4	5	13	9	46
79	Squirrel cuckoo	<i>Piaya cayana</i>	LC		1	1			2
80	Sulphur bellied flycatcher	<i>Myiodynastes luteiventris</i>	LC		1		4	3	8
81	Tawny winged woodcreeper	<i>Dendrocincla anabatina</i>	LC	3					3
82	Thicket tinamou	<i>Crypturellus cinnamomeus</i>	LC	1	2	2	5	1	11
83	Tropical gnatcatcher	<i>Poliophtila plumbea</i>	LC	1		5	1		7
84	Tropical kingbird	<i>Tyrannus melancholicus</i>	LC	1				1	2
85	Tropical mockingbird	<i>Mimus gilvus</i>	LC				1		1
86	Turkey vulture	<i>Cathartes aura</i>	LC	1	1		1	1	4
87	Vaux Swallow	<i>Chaetura vauxi</i>	LC					1	1
88	Wedge tailed sabrewing	<i>Campylopterus curvipennis</i>	LC	1					1
89	White bellied wren	<i>Uropsila leucogastra</i>	LC	6	2	5	15	5	33
90	White crown parrot	<i>Pionus senilis</i>	LC				1	1	2
91	White fronted parrot	<i>Amazona albifrons</i>	LC		1	7	10	15	33
92	White tailed kite	<i>Elanus leucurus</i>	LC		1				1
93	White tipped dove	<i>Leptotila verreauxi</i>	LC	5	3	1	6	4	19
94	White winged dove	<i>Zenaida asiatica</i>	LC		1		2		3
95	Wood stork	<i>Mycteria americana</i>	LC		1				1
96	Yellow bellied tyrannulet	<i>Ornithion semiflavum</i>	LC				1		1
97	Yellow billed cacicque	<i>Amblycercus holosericeus</i>	LC	2		2			4
98	Yellow green vireo	<i>Vireo flavoviridis</i>	LC	2	3	3	4	7	19

99	Yellow olive (flat bill) flycatcher	<i>Tolmomyias sulphurescens</i>	LC	3			2		5
100	Yellow tailed oriole	<i>Icterus mesomelas</i>	LC	6			4	3	13
101	Yellow throated euphonia	<i>Euphonia hirundinacea</i>	LC	1		2			3
102	Yucatan Bobwhite	<i>Colinus nigrogularis</i>	LC			1	2	4	7
103	Yucatan flycatcher	<i>Myiarchus yucatanensis</i>	LC	1		3	3	1	8
104	Yucatan jay	<i>Cyanocorax yucatanicus</i>	LC			1			1
105	Yucatan woodpecker	<i>Melanerpes pygmaeus</i>	LC	2	1	3	3	4	13
Total				174	78	118	248	181	799

Note: The IUCN Red List Categories and Criteria

The IUCN Red List Categories and Criteria are intended to be an easily and widely understood system for classifying species at high risk of global extinction. It divides species into nine categories: **Not Evaluated (NE)**, **Data Deficient (DD)**, **Least Concern (LC)**, **Near Threatened (NT)**, **Vulnerable (VU)**, **Endangered (EN)**, **Critically Endangered (CR)**, **Extinct in the Wild (EW)** and **Extinct (EX)**.

Literature Cited

Belize Electricity Ltd. Annual Report 2017.

Castalia Report. 2014. "Final Report: Overcoming Barriers of Belize's RE and EE Potential (Vol. 1)" Washington D.C.

Martin, D. and Osmel Manzano. 2010. *Towards a Sustainable and Efficient State*.

McNish, B. and Isabel Granada. 2013. *Transport Sector in Belize*. Technical Note No. IDB-TN-607

Han, Zhiping & Hu, Zhenghai. (2005). Tolerance of *Arundo donax* to heavy metals. *Ying yong sheng tai xue bao* = The journal of applied ecology / Zhongguo sheng tai xuexue hui, Zhongguokexue yuan Shenyang yingyong sheng tai yanjiusuo zhu ban. 16. 161-5.

Alipour, Yousef. "High temperature corrosion in a biomass-fired power boiler: Reducing furnace wall corrosion in a waste wood-fired power plant with advanced steam data." PhD diss., KTH Royal Institute of Technology, 20

APHA: American Public Health Association, Washington, DC.

Government of Belize, Ministry of Energy Reports 2012, 2015 & 2017.

Government of Belize. *Belize Disaster Management Plan*. July 1997.

Government of Belize, National Emergency Management Organization (NEMO). *Hurricane Preparedness Bulletin*. Belmopan, Belize, 2005.

Government of Belize. National Emergency Management Organization. *National Emergency Management Plan*, 2004.

NEMO, Belize Website [HTTP://WWW.NEMO.ORG.BZ/DEO/STANNCREEK.PHP](http://www.nemo.org.bz/deo/stanncreek.php)

Usher, Wayne. *National Climate Change Adaptation Issues in Belize*. Ministry of Economic Development, Belize. September 2000.

CDMP, *Atlas of Probable Storm Effects in the Caribbean Sea*. Caribbean Disaster Mitigation Project (CDMP), Models and data output by Watson Technical Consulting, Inc. Editing and presentation by Ross Wagenseil, Ph.D. March 2000.

Government of Belize and UNDP. Belize Country Report Second National Communication to The UNFCCC Greenhouse Gas Inventory. Belmopan, 2007.

National Climate Change Office, Ministry of Forestry, Fisheries and Sustainable Development. *Belize's Draft Third National Greenhouse Gas Inventory*, 2015.

2.0 SOCIAL CHARACTERIZATION

2.1 Overview

The World Bank in 2016 did a Belize Systematic Country Diagnostic where given the limited data they found that poverty levels in Belize are high and substantively above the average for Latin America and the Caribbean. Since the early 2000s, GDP growth has been very close to the rate of growth of the population (estimated at 2.5%) which has led to the almost stagnation of GDP per capita for the last 12 years or so. Poverty data, which is available only for the years of 2002 and 2009 for the most recent period, show an increase in the share of the population below the poverty line from 34% to 42% between these two data points. Poverty is a rural phenomenon in Belize as rural poverty rates reached 55% in 2009 as compared to 28% in urban areas. This performance is notable with that of the Latin-American Caribbean region as a whole where poverty has declined from 42% in 2002 to 30% in 2009 lifting more than 80 million from poverty.

Based on the data available, the incidence of poverty shows the bottom 40 of the population is mostly situated in rural areas with the highest rates of extreme poverty found in the districts of Corozal and Toledo. Poverty seems to be higher in these areas as a result of having households headed by individuals with low levels of schooling, exhibiting lower female participation in the labor market and belonging to ethnic minorities. Income inequality is also moderately high with a Gini coefficient of 0.42 in 2009, but this is based on an old survey and the recent stagnation of real per capita in the country suggest that this might have increased in more recent years.

Belize is also extremely vulnerable to climate change and natural disasters, its ability to promote faster poverty reduction and greater shared prosperity will depend on how well the country deals with its main sources of vulnerability. Their findings show that these vulnerabilities have external and internal reasons. External factors can be a blessing and sometimes a curse. The recent debate on the country's potential to start exploration of offshore oil is a classic example given that Belize is also the home of the largest live coral barrier reef in the world. As tourism and agriculture are the country's major sources of income and employment, the dangers associated with offshore oil exploration pose serious risks to Belize's varied ecosystems and to the livelihoods of a significant portion of the population.

Belize's small size makes the country vulnerable to terms of trade shocks and creates output volatility which can affect long-term growth negatively. As the country imports most of what it consumes and relies on a few sources of foreign exchange, it remains pretty much vulnerable to the fluctuations of commodity prices and the performance of its few trade partners. The small size also means that the country has few opportunities to grow (*the availability of arable land in Belize at 700 Km* (Enterprise Survey, 2011)² in 2009 is extremely low) as it faces a situation of lack of economies of scale. Economic size is also an important predictor for low savings, and the situation in Belize confirms this stylized fact. Gross domestic savings have averaged about 10% of GDP in the recent past which is at least 50% lower than the LAC average of 15%. With

limited savings, investments remain low as well, and growth prospects conditioned on the ability to innovate, increase productivity, and diversify products and partners. Another important external factor that can impact the country's ability to grow, contribute to increase its debt levels, and impact savings is its ***high degree of exposure to natural hazards***.

Two important endogenous factors that can affect long-term growth in Belize are associated with the quality of its capital and labor. The diagnosis has shown that weaknesses in infrastructure can exacerbate the impacts of natural disasters on the economy. In addition, the poor quality of education has a direct impact on the quality of the labor force. The lack of secondary road networks and the ***vulnerability of the whole energy sector*** to strong winds mean that a single storm can leave the country paralyzed and in the dark for long periods of time, impeding the movement of cargo and people thus hurting growth and affecting negatively the livelihoods of Belizean citizens.

Strengthening resilience to natural disasters and climate change along with improvements in the existing infrastructure in Belize are critical to support the twin goals to end extreme poverty, and promote shared prosperity in poorer segments of society. ***Belize is one of the countries in the world which is most affected by weather-related events and other natural hazards***. Combined, Belize incurs annual losses of close to 4% of GDP due to natural disasters. These losses add to fiscal pressures and constrain wealth accumulation. Climate change is expected to increase the frequency and intensity of weather-related events. Poor communities are disproportionately vulnerable to economic shocks and reduced mobility, particularly the minority groups in the southern and northern parts of the country. The vulnerability in the road networks, due to the lack of redundancy, results in agricultural communities unable to access the larger markets in Belize City and Belmopan, students unable to attend schools, and goods not able to make it into rural communities. ***These problems are compounded by the fragility of the energy network*** that can easily be damaged by severe storms which have hit Belize with frequency in the past and should remain a threat in the future. Investing in disaster risk management will help to protect the limited assets of poor communities from natural disasters and climate change related events and to improve the access and the economic livelihoods of poor and vulnerable communities.

In addition, firm-level data (Enterprise Survey, 2011); reveal that 36.4 percent of enterprises identify electricity as a major constraint. Electricity rates for commercial and industrial enterprises range from USD 0.33 – 0.44, depending on consumption levels. These are considerably high, similar to the rates observed in the Caribbean, but higher than rates in Central American countries, which rely mostly on hydro sources.

2.1 Towns and Communities near the Project Area

2.1.1 Community setting

The project pilot site is located 834 meters from the Blue Creek and 2837 meters from the Rio Hondo. This area is widely used for cane farming but has some pockets of vegetated areas that are not being farmed, some being unsuitable for sugar cane cultivation. Communities located in proximity to the project site are Yo Creek, San Lazaro, Trinidad, August Pine Ridge and Santa Cruz Villages. Orange Walk Town is approximately 9 miles away. The only other town in proximity is Corozal town, some 35 miles from the project site. The site is accessed from Orange Walk Town via the Yo Creek road, and the community that has an access road to the project site is San Lazaro village (Figure 2.1)

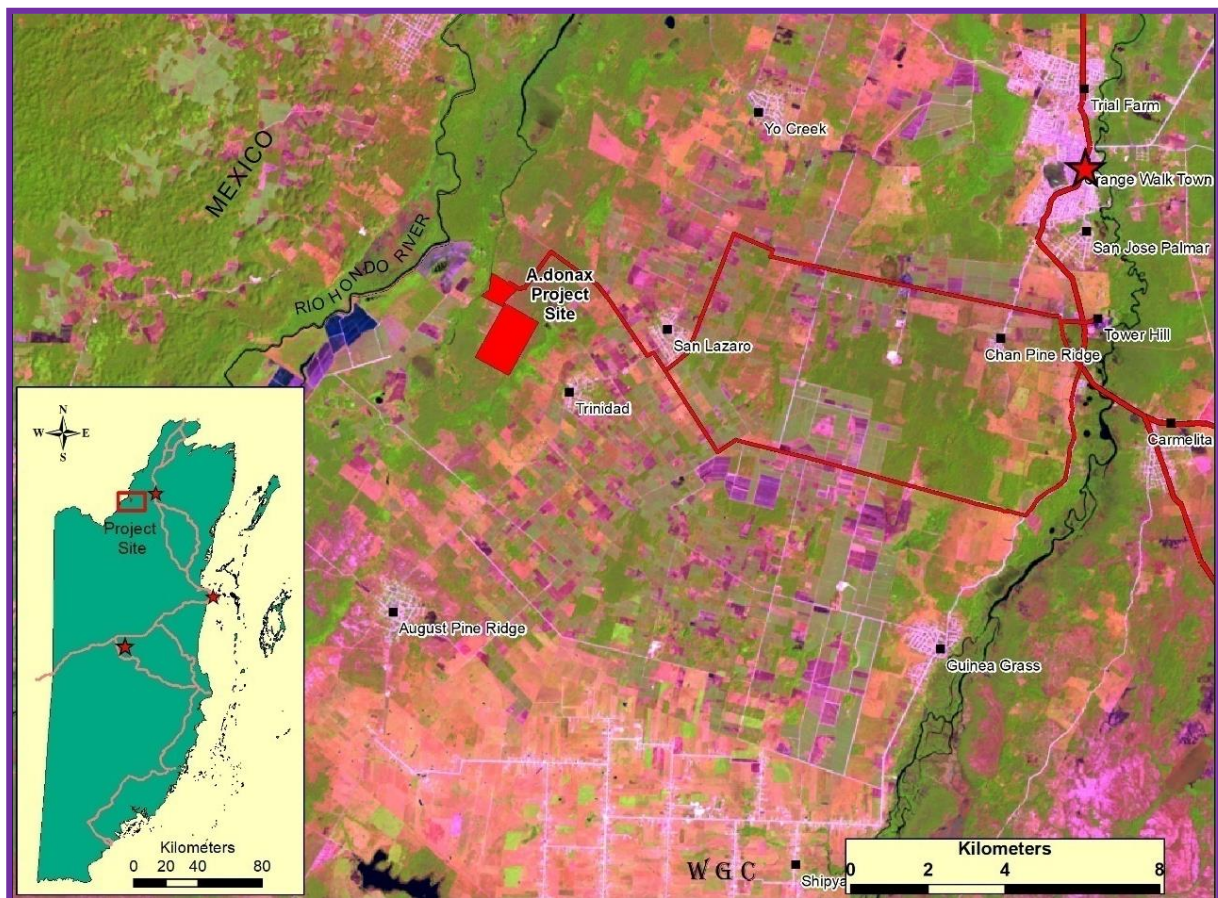


Figure 2.1: Map Showing Location of Project Site

2.1.2 Area/Zone of Influence around Project Area

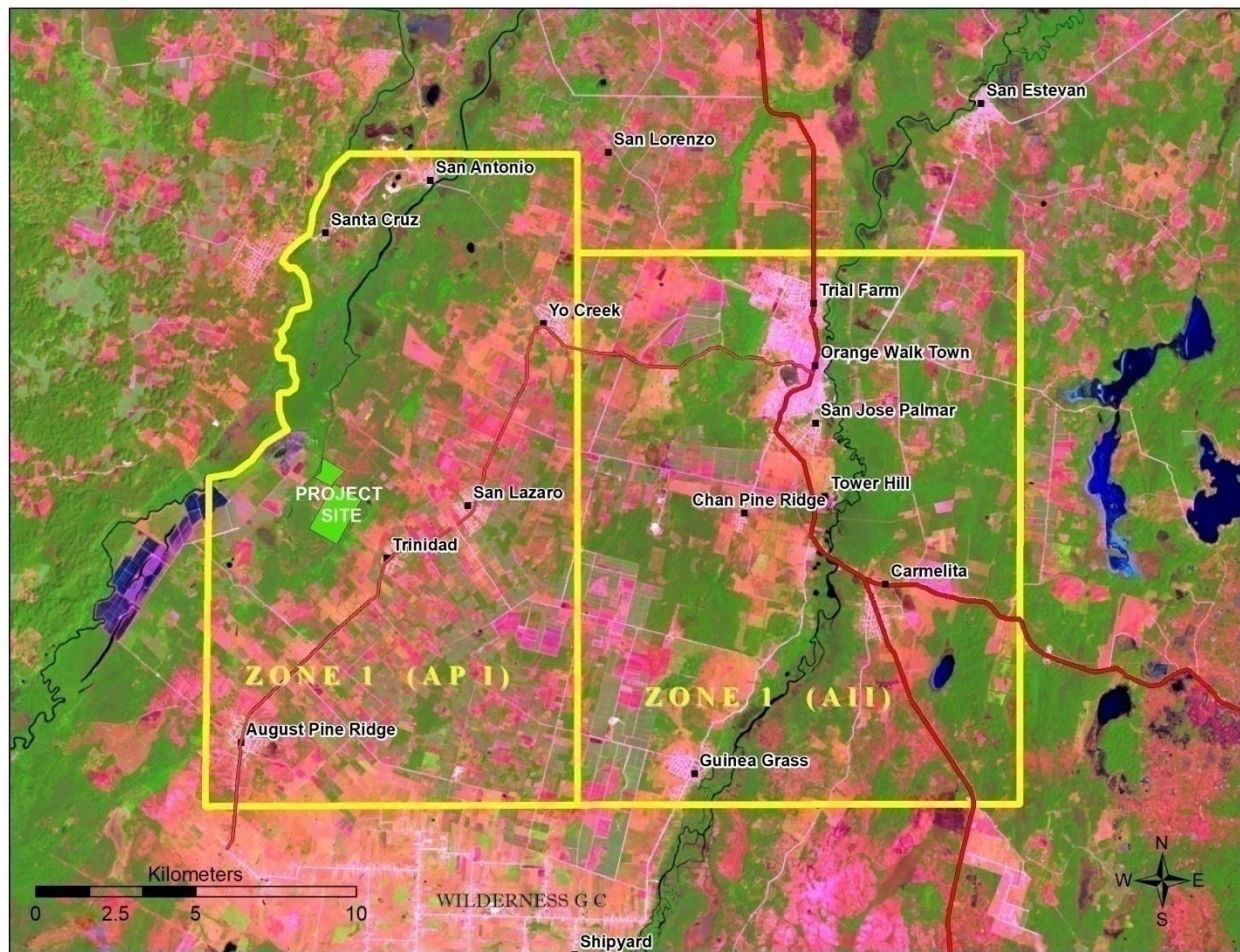


Figure 2.2: Map Illustrating Project Zone of Influence

Villages in the Area of Direct Influence (ADI) or “Zone 1” of zone of influence include Yo Creek, Santa Cruz, San Lazaro, Trinidad and August Pine Ridge Villages (Figure 2.2). The Area of Indirect Influence (AII) includes the villages of Trial Farm, Orange Walk Town, San Jose Palmar, Tower Hill, Chan Pine Ridge, Carmelita and Guinea Grass.

It is also important to note that the country on a whole may be influenced by this project one way or another. Table 2.1, list communities, and shows the approximate ground distance in miles and approximate location (coordinates) to the site while Table 2.2 list the general stakeholder groups.

Table 2.1: Location of communities and approximate distance to the project site

Village/Community	Distance (Ground length) to Project Site (miles)	Location (Coordinates)
Project Site	-	18°03'26.09" N88°42' 02.21" W
ZONE 1 - ADI		
Yo Creek Village	4.67	18°02'27.90" N88°39' 51.59" W
Santa Cruz Village	4.29	18°06'56.61" N88°42' 23.68" W
San Antonio Village	5.46	18°07'56.68" N88°40' 32.90" W
San Lazaro Village	2.67	18°02'23.92" N88°39' 43.01" W
Trinidad Village	2.24	18°01'14.83" N88°41' 09.89" W
August Pine Ridge Village	5.60	17°58'32.02" N88°43' 40.97" W
ZONE 2 - AII		
Orange Walk Town	9.35	18°04'35-60" N88°33' 29.40" W
Trial Farm Village	9.6	18°05' 47.96" N88°33' 20.11" W
San Jose Palmar Village	8.89	18°00' 00.99" N88°31' 28.26" W
Tower Hill Village	9.42	18°01' 42.29" N88°33' 31.96" W
Chan Pine Ridge Village	7.78	18°01' 01.87" N88°35' 12.88" W
Guinea Grass Village	8.91	17°58'07.13" N88°35' 52.05" W

Source DAVCO 2016

2.1.3 Socioeconomic Characterization of Communities

This project will alter the social and cultural environment immediately near it, as well as the natural environment; and will also create or enhance economic, health, educational, recreational and other benefits that are essential for community development. Positive impacts from the project such as carbon sequestration, economic benefits from direct or indirect energy benefits, technology transfer etc., were not elaborated in this section.

The project aims to increase the development of the country's renewable energy resources and improve energy efficiency and conservation in order to promote the transformation to a low carbon economy. It also has the potential to create new jobs through the piloting activities associated with the project, as well as direct labor and employment, and the possibility of numerous jobs after full commercialization of the biomass to energy sector.

Other economic benefits will develop from the annual foreign exchange savings as a result of greater energy independence especially from direct reduction on the supply of electricity from Mexico.

Pilot projects for waste management controls, including recycling and composting also have the potential to increase economic activity through waste reduction and improved waste management and also through the increase of agriculture product efficiency as a result of composting initiatives.

The local environment can be enhanced as a result of improved waste management practices, leading to a reduction of nuisance from pests, and the reduction of the risk for diseases, and the proliferation of odor and unaesthetic neighborhoods.

Table 2.2 shows the group of stakeholders that have been identified as those that have been consulted and considered participants of the project. It is clear that due to the nature of the project, the area of influence is not limited to the ADI, but is national.

Table 2.2: Stakeholder Groups

STAKEHOLDER GROUPS	
Community members or households:	<p>While not limited to the Northern Districts, this category includes residents of Yo Creek, Santa Cruz, San Lazaro, Trinidad and August Pine Ridge Villages, inclusive of youth, women, farmers and community leaders such as teachers and heads of churches or other faith-based organizations.</p> <ul style="list-style-type: none"> -all Belizeans if it contributes to lowering energy costs i.e. electricity rates -provides employment for villagers and downstream to other communities -provides an alternative activity for farmers who have marginal lands
Cane Farmers	<ul style="list-style-type: none"> ➤ Belize Sugar Cane Farmers Association ➤ Progressive Sugar Cane Farmers Association ➤ Corozal Sugar Cane Producers Association
Policymakers and Regulators:	<p>This group accommodates the project, ensuring that it aligns with national priorities, and provides the needed permits and certifications as required under the relevant laws, such as research permits and environmental clearance. This group includes the ministries responsible for:</p> <ul style="list-style-type: none"> ➤ Economic Development, ➤ Climate Change, ➤ Energy, ➤ Agriculture, ➤ Environment ➤ Forestry ➤ Forestry ➤ BELTRAIDE ➤ PUC ➤ BSI ➤ BAHA ➤ BEL
Research and Technical Units	<p>This group involves organizations and agencies involved in research and data collection in areas related to agriculture, energy and climate change such as:</p> <ul style="list-style-type: none"> ➤ Sugar Industry Research and Development Institute, ➤ Orange Walk Agricultural Station, Ministry of Agriculture, ➤ University of Belize ➤ ASR ➤ Belize High School of Agriculture
Project proponents	<p>This group includes:</p> <ul style="list-style-type: none"> ➤ Caribbean Community Climate Change Centre, ➤ The Government offices responsible for oversight of Energy and Climate Change activities, ➤ American Sugar Refinery/Belize Sugar Industries Group and its subsidiary, the Belize Co-Generation Company, ➤ Belize Electricity Limited. ➤ National Climate Change Office ➤ World Bank

STAKEHOLDER GROUPS

➤ GCF

2.1.3.1 Community Demographics

In order to put this proposed development into the perspective of the national context, it is important to present some statistics for the country of Belize. In April 2018, Belize's population was estimated at 395,882 with 197,943 males and 197,939 females. (Table 2.3) It consists of 56 percent of persons 24 years and under, which is a relatively young population. The Orange Walk District is home to 13% of Belize's population (Figure 2.3) and is the second largest district in terms of total area in comparison to other districts in Belize.

Table 2.3: Population Estimates by Major Administrative Areas; 2014 - 2018

Belize Population Estimates by Major Administrative Areas; 2014 - 2018					
Area	2014	2015	2016	2017	2018
Country Total	358,899	368,310	377,968	387,879	398,050
Urban	161,434	165,463	169,598	173,841	178,195
Rural	197,465	202,847	208,370	214,038	219,855
Corozal	44,613	45,530	46,472	47,437	48,429
Corozal Town	11,427	11,722	12,024	12,334	12,652
Corozal Rural	33,186	33,808	34,447	35,103	35,776
Orange Walk	48,744	49,466	50,208	50,968	51,749
Orange Walk Town	13,692	13,687	13,683	13,679	13,674
Orange Walk Rural	35,052	35,779	36,524	37,290	38,075
Belize	107,494	110,644	113,878	117,196	120,602
Belize City	60,184	60,963	61,762	62,582	63,423
San Pedro Town	15,484	16,444	17,429	18,440	19,477
Belize Rural	31,825	33,238	34,687	36,175	37,701
Cayo	85,243	87,876	90,579	93,352	96,197
San Ignacio/Santa Elena	20,027	20,582	21,151	21,736	22,335
Benque Viejo	6,497	6,589	6,684	6,781	6,880
Belmopan	18,326	19,458	20,621	21,814	23,038
Cayo Rural	40,394	41,247	42,123	43,022	43,944
Stann Creek	38,728	39,865	41,032	42,230	43,459
Dangriga	10,002	10,108	10,217	10,328	10,442
Stann Creek Rural	28,726	29,757	30,816	31,902	33,017
Toledo	34,077	34,928	35,800	36,695	37,614
Punta Gorda	5,795	5,910	6,027	6,148	6,272
Toledo Rural	28,282	29,018	29,773	30,547	31,342

Source: Statistical Institute of Belize

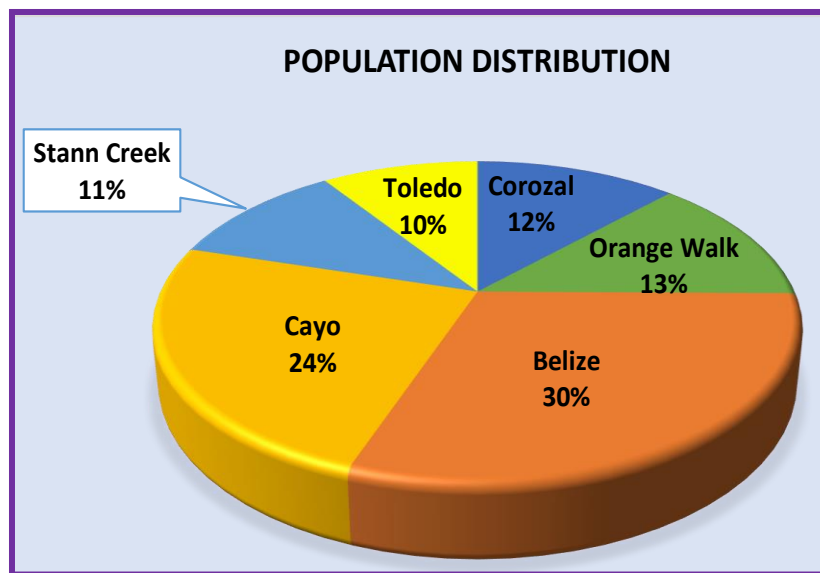


Figure 2.3: Belize 2018 Population Distribution by District.

The Orange Walk District has an area of 1,829 square miles (4,636 square km) and is located north-northwest of the Belize District. This is the second largest district in terms of total area in comparison to other districts in Belize and lies between the Belize and Corozal districts to the east, Mexico to the north and Guatemala to the west. The land is highly cultivated with sugar cane and vegetables by local farmers, while Mennonite farmers dominate the cultivation of sorghum, rice, corn red and black beans and soy-beans. The district is also productive in terms of livestock, notable cattle, pigs, and poultry.

According to the Statistical Institute of Belize, the Orange Walk District had an estimated population of 51,749 persons for the 2018 post censal population estimates; 13,674 of these persons lived in the urban area of Orange Walk Town while 38,075 lived in rural areas. (Table 2.3)

The project pilot site is located at coordinates 18° 03' 26" N 88° 42' 02" W; 834 meters from the Blue Creek and 2837 meters from the Rio Hondo. Communities located in Zone 1 of the project site are Santa Cruz, San Antonio Rio Hondo, Yo Creek, San Lazaro, Trinidad, and August Pine Ridge Villages (Figure 2.4). The project site is accessed from Orange Walk Town via the Yo Creek road, and closest community, which is the reference point for the project, (through which road access is available to the project), is San Lazaro Village.

Trinidad Village is the nearest community geographically to the project site. According to the 2010 Housing and population census, this village had a population of five hundred seventy-one (571) persons. Of that total two hundred eighty-seven (287) persons are males, while two hundred eighty-four (284) persons are females. Together they constitute one hundred forty-three (143) households, with an average household size of four (4.0) persons. (Table 2.3) This population represents two (2%) percent of the population within the zone of influence, (Figure 2.5).

San Lazaro Village is also close to the project site. This is the community where the access road to the project site is located. According to the 2010 Housing and population census had a

population of one thousand sixty-two (1062) persons. Of that total five hundred thirty-eight (538) persons are males, while five hundred twenty-four (524) persons are females. Together they constitute two hundred thirty-two (232) households, with an average household size of four and six tenths (4.6) persons. (Table 2.4) This population represents three (3%) percent of the population within the zone of influence. (Figure 2.5)

Yo Creek Village according to the 2010 Housing and population census had a population of one thousand four hundred twelve (1412) persons. Of that total seven hundred twenty-eight (728) persons are males, while six hundred eighty-four (684) persons are females. Together they constitute three hundred twenty-nine (329) households, with an average household size of four and three tenths (4.3) persons. (Table 2.4) This population represents five (5%) percent of the population within the zone of influence, (Figure 2.5).

August Pine Ridge Village according to the 2010 Housing and population census had a population of one thousand seven hundred ninety-seven (1797) persons. Of that total nine hundred twelve (912) persons are males, while eight hundred eighty-five (885) persons are females. Together they constitute three hundred ninety-eight (398) households, with an average household size of four and five tenths (4.5) persons. (Table 2.2) This population represents six (6%) percent of the population within the zone of influence. (Figure 2.4)

Santa Cruz Village, according to the 2010 Housing and population census, Santa Cruz Village had population of 259 persons. Of that total 133 persons are males, 126 persons are females. Together they constitute 57 households, with an average household size of four and five tenths (4.5) persons. (Table 2.4) This population represents one (1%) percent of the population within the zone of influence, (Figure 2.4)

San Antonio according to the 2010 Housing and population census, San Antonio Village had a population of 403 persons. Of that total 213 persons are males, 190 persons are females. Together they constitute 119 households, with an average household size of three and four tenths (3.4) persons. (Table 2.4) This population represents one (1%) percent of the population within the zone of influence, (Figure 2.4).

With reference to ethnicity, eighty-four (84%) percent of the population around the project site are Mestizo/Hispanic, followed by seven (7%) percent Creole, and one (1%) percent each for Garifuna, Maya, East Indian and Asian, (Figure 2.6).

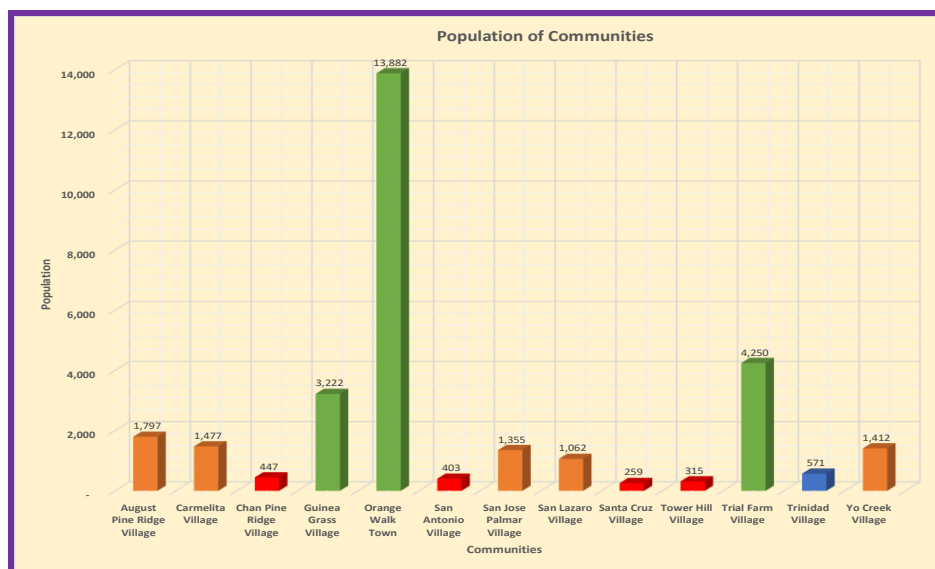


Figure 2.4: Population of Communities of Communities in Zone of Influence

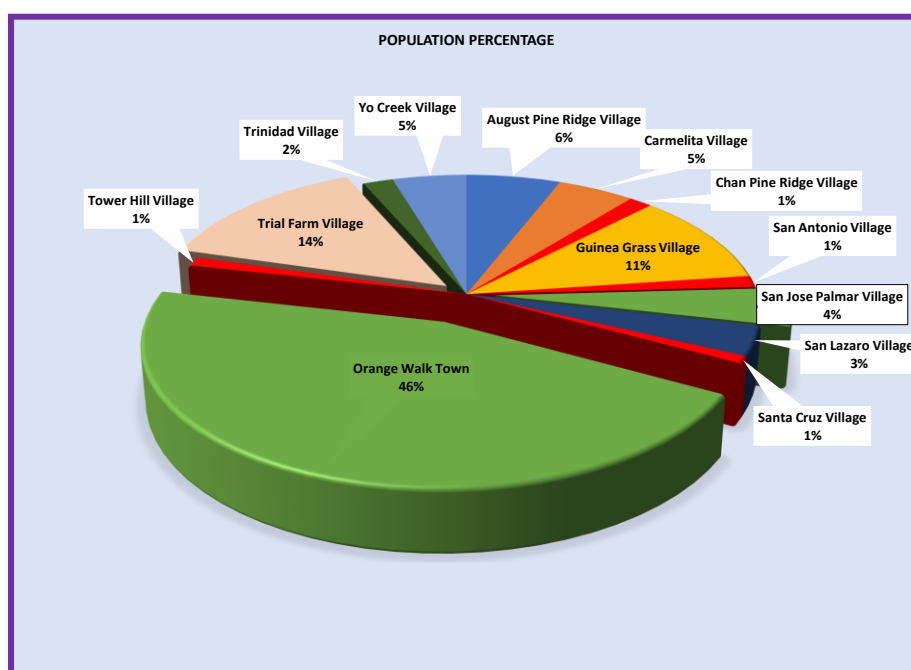


Figure 2.5: Population percentage of Communities in Zone of Influence

Table 2.4: Population, household and household size of nearby communities.

Municipality	Males	Females	No. of HH	Avg. HH Size	Population
August Pine Ridge Village	912	885	398	4.5	1,797
Carmelita Village	728	749	334	4.4	1,477
Chan Pine Ridge Village	235	212	104	4.3	447
Guinea Grass Village	1,600	1,622	607	5.3	3,222
Orange Walk Town	6,800	7,082	3,378	4.1	13,882
San Antonio Village	213	190	119	3.4	403
San Jose Palmar Village	699	656	307	4.4	1,355
San Lazaro Village	538	524	232	4.6	1,062
Santa Cruz Village	133	126	57	4.5	259
Tower Hill Village	167	148	80	3.9	315
Trial Farm Village	2,144	2,106	1,004	4.2	4,250
Trinidad Village	287	284	143	4.0	571
Yo Creek Village	728	684	329	4.3	1,412

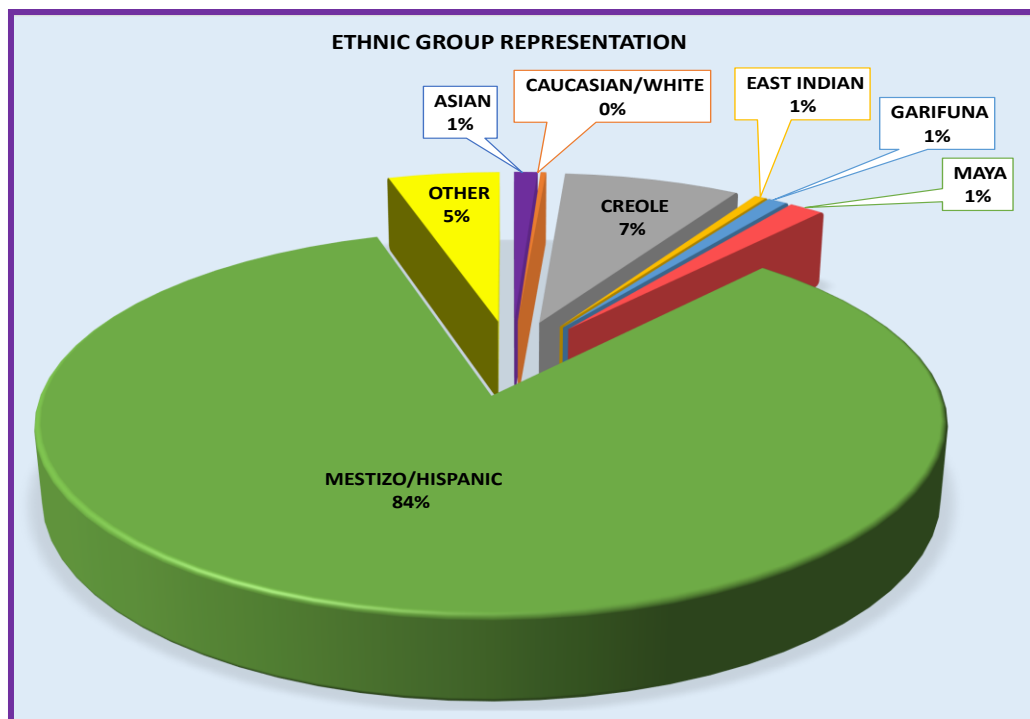


Figure 2.6: Ethnic Groups Representation within Zone of Influence.

2.1.3.2 Gender

The Belize Country Gender Assessment 2016 (CGA) presents a statistical profile, outlining some of the core indicators on gender equality across household, family and economic areas:

- a) The 2010 National Census estimated the total resident population of Belize at 324,528 persons, with 1,957 of those living in institutions, and 118 living on the street. The majority of Belizeans live in rural areas, with the exception of those living in the Belize (69,041) and Cayo (54,197) districts. The household population was recorded at 322,453. 161,227 of those recorded in the 2010 Census were male (50%) and 161,226 females (50%), indicating an absolute sex parity. An overall population growth of 3.4% was noted from the 2000 Census record (Statistical Institute of Belize, 2010).
- b) The 2013 Labour Force Survey recorded the labor force at 148,736, or 46.1% of the total population. Four out of every five men of working age (84,511 men in total) were included in the labor force, compared to only one in two women of working age (48,869 women in total), revealing a distinctive sex-segregation in the formal labor market.

Moreover, the unemployment rate for females far exceeds that of males, at 20.4% and 6.7% respectively.

- c) United Nations Development Programme (UNDP) Human Development Index (HDI) ranks Belize 84th among 187 countries, with a value of 0.732.
- d) Of the population surveyed for the 2010 Country Poverty Assessment (CPA), 70% of males declared that they were the head of household, while 30% of females declared that they were the head. This percentage composition was consistent across all consumption quintiles. Of the 79,492 households in Belize, 27.6 percent (21,939) were headed by females, compared to 24.0 percent in the 2000 Census. Of the 207,205 persons 15 years of age surveyed in 2010, 119,265 declared never having been married, 75,849 being legally married, 3,199 being divorced. As the survey did not provide statistics on common-law, visiting partner, married but not in union relationships, the CGA assumes that a number of non-marital and other types of unions are also present.
- e) The maternal mortality rate is relatively high compared to other BMCs, at 45 deaths to 100,000 live births.
- f) The completion of primary schooling is low in Belize, at a total of 43%. The percentage of males who complete primary schooling is lower than that of females, at 38% and 48% respectively, despite a high enrolment rate of both males and females, at 92.5% for males, and 92.4% for females.

The CGA found extensive gender issues in the education sector in Belize, affecting both boys and girls, with significant potential impacts upon their economic viability and life chances, and national development outcomes. Approximately 92% of eligible children attend primary school, with a mere 48% completion rate for girls, and 38% completion rate for boys. At the secondary level, only 40% of all eligible secondary aged students across the country are in school. The Corozal district has the highest completion rate for both girls and boys, at 82.7% and 70.0% respectively. The CGA found that there is considerable pressure on boys to help support their families from an early age. Girls are also often needed to help at home to enable their parents to go out to work, or need to work themselves. Approximately 37% of men and women in Belize have never attended school.

A number of deeply embedded gender issues are evident within the education system:

- i. The limited participation and completion of schooling of males, has not translated into an overall absence in the labor market. For example, despite their lower educational participation and completion rates, males out-number females in the formal labor market;
- ii. The rise in male youth crime has exacerbated rate of incarceration of young men;

- iii. As of 2010, an average of 1,400-1,500 teenage mother births was recorded per year. Although there is a policy that allows girls to stay in school if pregnant, this policy is neither well known nor enforced.

The following issues are deemed to be of critical importance:

- i. Deficiencies in the health institutional framework, resulting in limited community-level access to health care and services, access to sexual and reproductive health services, and mental health services.
- ii. Persisting gender inequalities embedded in the education system, impacting on the life chances of males and females, including gender differences in the choice of programmes, and by extension, their productive access to the labor market. Boys' and girls' drop out from school for different reasons, which further affects their successful life chances.
- iii. Prevailing gender inequalities in the labor market, in which men and women participate differently in the formal and informal economy, including women receiving lower employment opportunities and rates of pay. Men and women benefit differentially in periods of economic growth, and they are impacted differentially by economic downturns.
- iv. The social welfare institution and its related programmes fail to take account of the varying participation of women and men in the economy, and therefore its safety net provisions fail to ensure equitable gender outcomes, particularly in supporting the most vulnerable women. Children are further adversely affected by the absence of gender sensitivity in social welfare, including child maintenance, which presents challenges for their development potential.
- v. Females in Belize hold less land titles than men (where statistics are unavailable to specifically outline land ownership), own less businesses (particularly in the formal economy), and access less loans. Women's lower access to productive resources underscores their limitations in ensuring adequate living standards, ensuring food security, and alleviating household poverty.
- vi. Women are predominantly victims/survivors of gender-based and sexual violence. The perpetrators of violent crimes, including crimes against women, are overwhelmingly men.
- vii. While women's representation is increasing, both at the national and community governance levels, e.g., in appointments to the Senate, women continue to experience limited participation and representation and in leadership and decision-making.

2.2 Sources of Livelihood

Labor market statistics play a vital role in socio-economic planning. Therefore, for this a development such as the one being proposed by 5C's, it is important to have an idea of the availability of labor.

The Belize labor force is relatively educated with more than three quarters having some level of education (primary education thirty-seven (37%) percent, secondary twenty-six (26%) percent, tertiary twenty-one (21%) percent, no formal education fourteen (14%) percent and not reported two (2%) percent]. Therefore, using the criterion that a person 14 years or older with a standard 5 or better education is literate, it is clear that eighty-four (84%) percent of the labor force within the country is literate (Figure 2.7).

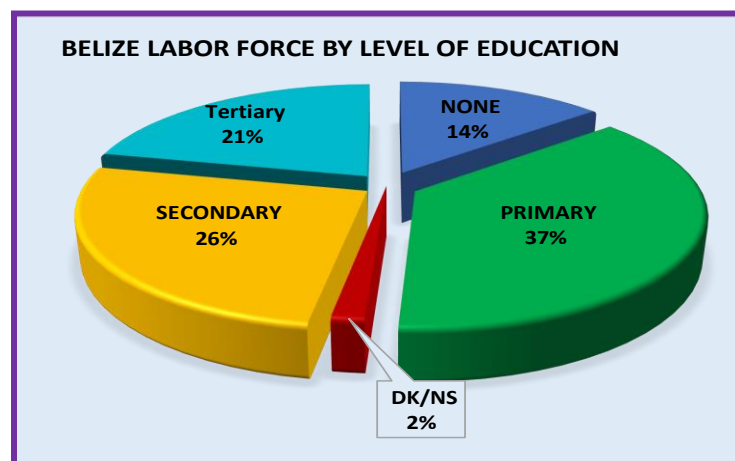


Figure 2.7: Belize Labor Force Distribution by Highest Level of Education.

As of April 2018, according to the Statistical Institute of Belize, ninety-one (91%) percent of the total labor force within the country are currently employed, while the unemployment rate is nine (9%) percent (Figure 2.8). The number of unemployed was higher among males, but females still represent sixty-four (64%) percent of the unemployed population. The unemployment rate among the youths (14-24 years) was twenty-one and three tenths (21.3%) percent, being the most susceptible to unemployment when compared to the other age brackets.

Orange Walk District on the other hand reveals that fifty-two (52%) percent of the population have a primary school education, eleven (11%) percent a secondary school education, fifteen (15%) percent a tertiary education, and twenty (20%) percent have no formal education (Figure 12).

The Orange Walk District unemployment rate among youths (14-24 years) is twelve and two tenths (12.2%) percent (Figure 2.10). This suggests that implementation of an upscale activity and any industry that may develop should include measures to actively engage youth.

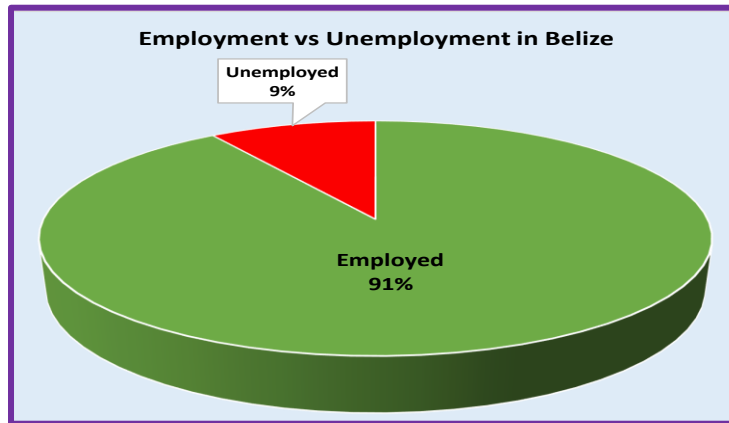


Figure 2.8: Employment vs. Unemployment in Belize.

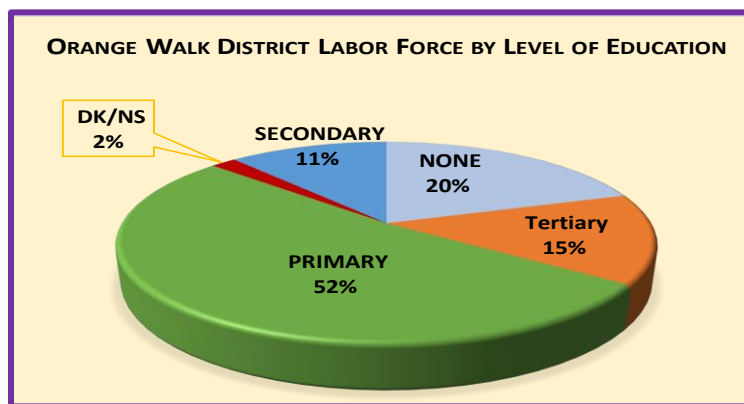


Figure 2.9: Orange Walk Dist. Labor Force by Level of Education.

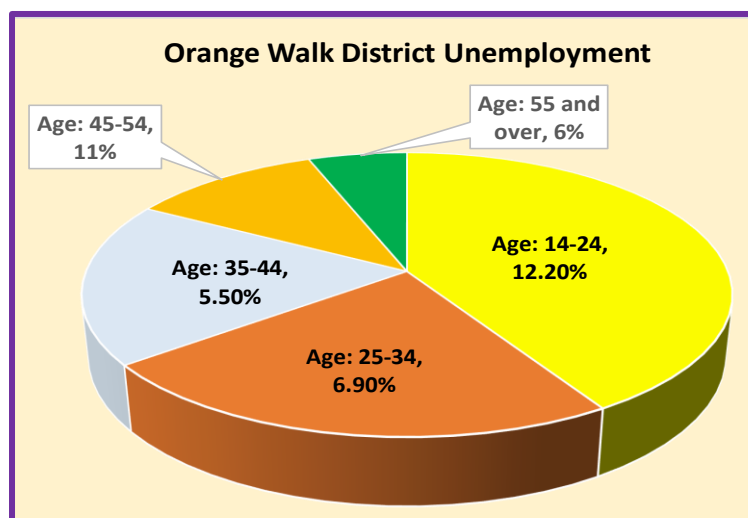


Figure 2.10: Orange Walk District Unemployment Among Age Groups.

2.3 Land Tenure and Titling

Within the zone of influence, 52% of the families own their land, while 35% are leasing their land from the Government of Belize, and 13% reported as other are either renting from others or squatting (Figure 2.11). On the other hand, in terms of dwelling, 55% reported that they own without a mortgage, while 14% have their property mortgage to a financial institution, and 18% are renting (Figure 2.12).

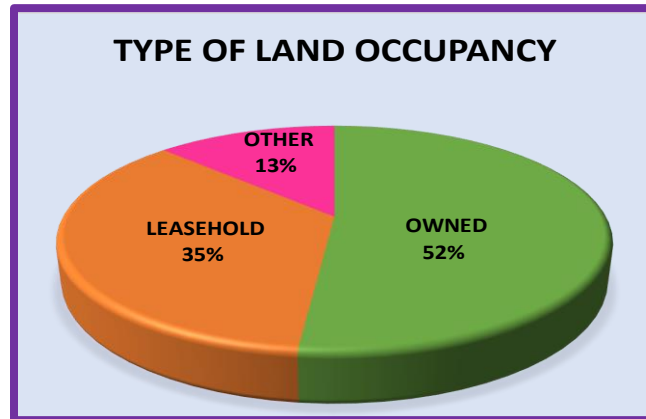


Figure 2.11: Type of Land Occupancy.

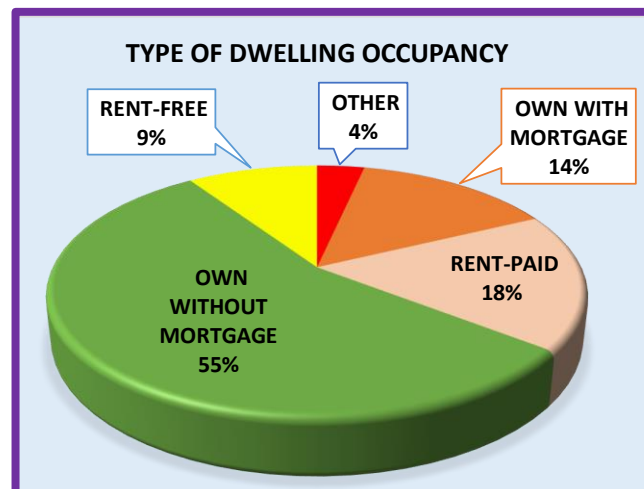


Figure 2.12: Type of Dwelling Occupancy.

Table 2.5: Household by type of Land Occupancy.

HOUSEHOLDS BY TYPE OF LAND OCCUPANCY					
Community	Owned	Leasehold	Other	Not Reported	Total
August Pine Ridge Village	65	256	14	1	336
Carmelita Village	92	128	4	-	224
Chan Pine Ridge Village	32	53	2	3	90
Guinea Grass Village	137	292	67	4	500
Orange Walk Town	1,781	354	48	19	2,202
San Antonio Village	30	65	5	1	101
San Jose Palmar Village	228	5	3	1	237
San Lazaro Village	73	115	2	-	190
Santa Cruz Village	10	40	1	-	51
Tower Hill Village	25	14	1	-	40
Trial Farm Village	383	234	28	10	655
Trinidad Village	35	20	-	-	55
Yo Creek Village	116	125	2	5	248

Source: SIB, 2010 Housing and Population Census.

Table 2.6: Households by Type of Dwelling Occupancy.

HOUSEHOLDS BY TYPE OF DWELLING OCCUPANCY						
Community	Own with Mortgage	Own Without Mortgage	Rent-Paid	Rent-Free	Other	Total
August Pine Ridge Village	35	301	24	37	1	398
Carmelita Village	23	201	48	59	3	334
Chan Pine Ridge Village	12	77	6	7	2	104
Guinea Grass Village	80	419	22	80	6	607
Orange Walk Town	645	1,557	880	222	74	3,378
San Antonio Village	9	92	2	14	2	119
San Jose Palmar Village	52	186	40	27	2	307
San Lazaro Village	24	165	16	22	5	232
Santa Cruz Village	13	38	-	6	-	57
Tower Hill Village	2	38	12	25	4	80
Trial Farm Village	100	556	177	133	37	1,004
Trinidad Village	-	55	5	15	68	143
Yo Creek Village	27	221	21	21	39	329

Source: SIB, 2010 Housing and Population Census.

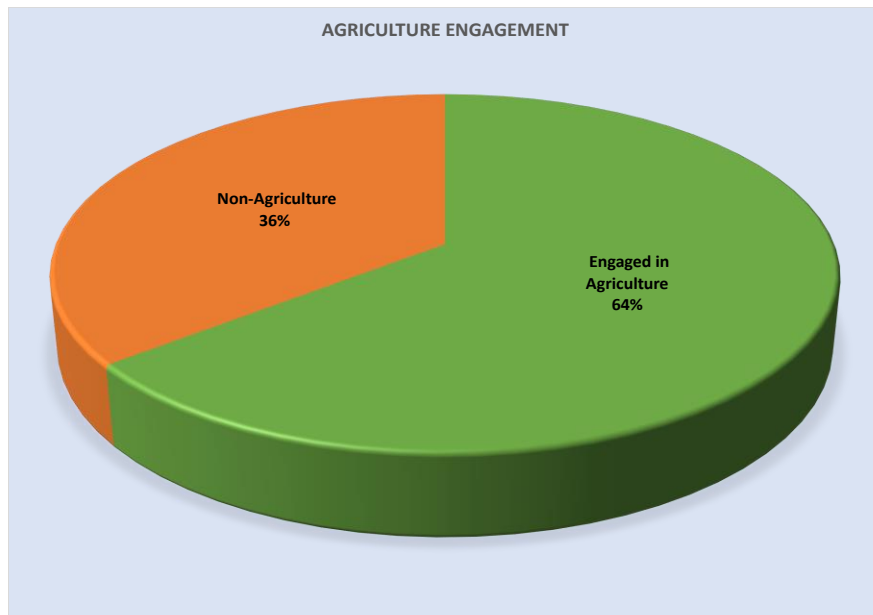
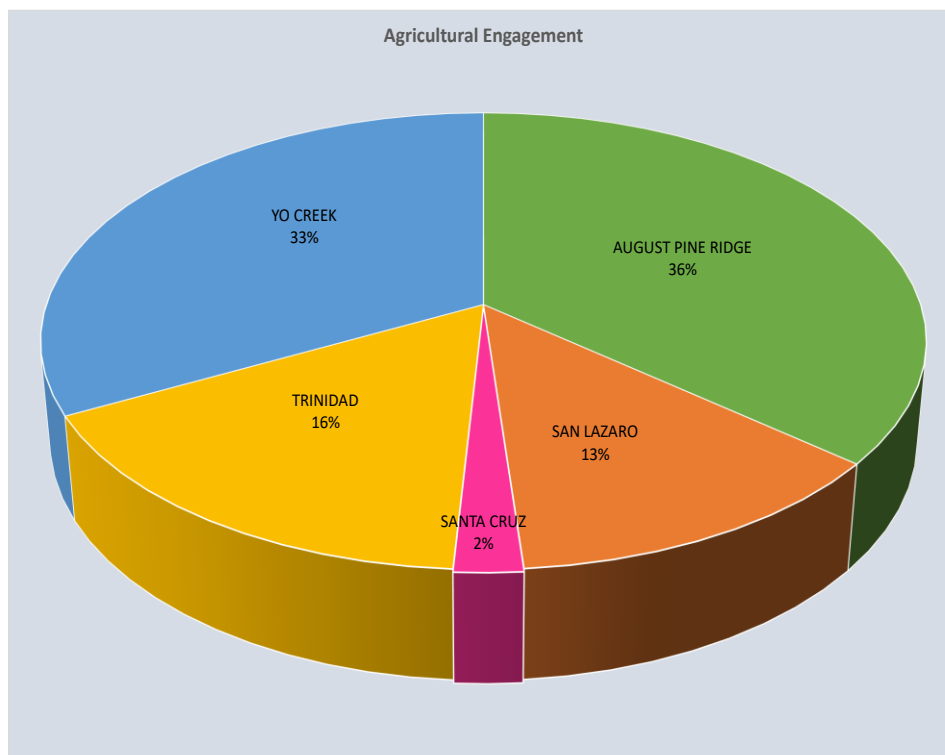


Figure 2.13 Agriculture and Non-agriculture Population by Percent.



2.14 Agriculture Engagement by Percent of Communities in the ADI.

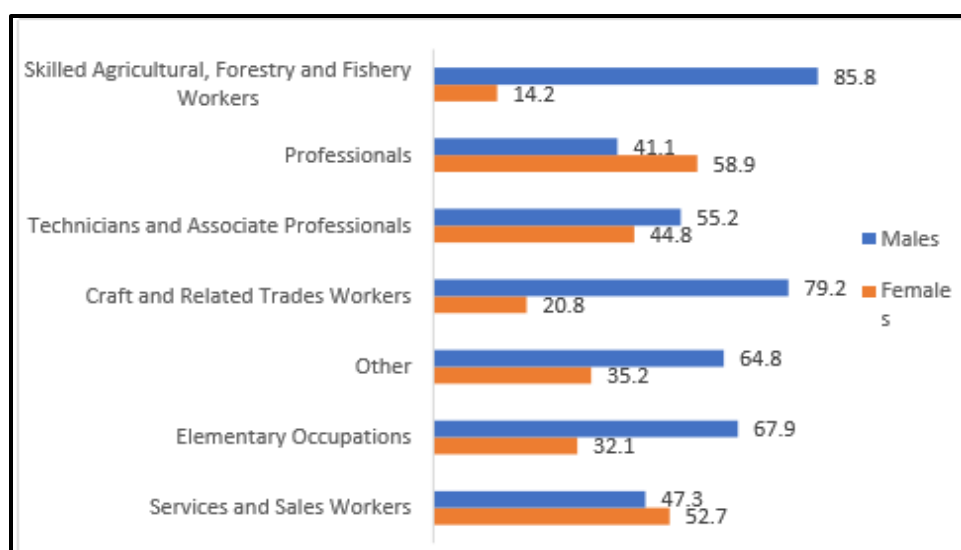


Figure 2.15 Labor distributions by sex.

As can be seen from Figures 2.13 and 2.14, 64% of the land owners within the area of immediate influence are engaged in agriculture. This includes August Pine Ridge with the highest percent of land owners, being 36% that are engaged in agriculture; Yo Creek with 31%, Trinidad, 16%, San Lazaro, 11% and Santa Cruz, 2%. Also, from figure 2.15, it can be seen that males form the majority of the agriculture labor sector; but nonetheless women are quite involved in most sectors, and the agriculture forestry and fisheries sector represent a little over 14% female involvement.

2.4 Migration and Settlement Patterns

Migrants, representing a fifth of the labor force, appear to fill a gap in the labor market and occupy mostly low skill jobs. Migration in Central America is a common phenomenon. Belize is no exception as the country has been experiencing net inward migration since early 2000s. While 14.7% of Belizean population were foreign born, migrants represent approximately a fifth of the labor force. Migrants are coming to Belize mostly from Central America – 40% of born abroad are from Guatemala, El Salvador and Honduras (Lindauer 2014). Migrants tend to have a higher labor market participation rate (69%) than locals (65%), and the unemployment rate of foreign born was almost two times lower than that of locals, 8.2% and 16.2% respectively in 2014. As in many other countries, migrants tend to fill a gap in the labor market by taking up the low skilled jobs that the better educated locals do not want; 54% of employed migrants had below primary education compared to 42% of locals.

Over the past fifteen years, immigration has contributed significantly to population growth and labor force growth. Belize is an emigrant sending country and, at the same time, one of the three main immigrant receiving countries in Central America. The country's geographical location enhances the arrival and entry of immigrants from neighbouring countries by sea, land or air. It is attractive to immigrants from the region due to a stable economic situation, higher living standards and job availability. As of 2012, the last year for which migration data is available,

migrants comprised 20% of the working age population and 24% of the employed population. Guatemalans comprised over 10% of the labor force, while Salvadorans, Hondurans and Mexicans together accounted for another 6%. These migrants are not distributed equally across Belize; 60% are in the densely-populated districts of Cayo and Belize, and another 23% are in the sparsely-populated southern districts of Stann Creek and Toledo (Belize Labor Force Survey, 2012).

Belize also receives migrants from outside the continent who come to work on the entertainment industry and other businesses. Extra-continental labor migrants are primarily temporary workers from India and Turkey employed in various casinos and business establishments within the Corozal Free Zone. In 2012, the majority (63.4%) were between the ages of 20- 39 years of age earning less than \$179.99 Belize dollars weekly. Females earn substantially less. Permanent labor migrants also come from the Central American northern triangle although the US also contributes to the workforce.

Migration to Belize is likely driven by a relatively evenly distributed combination of motives and incentive factors. Among the push or motive factors are political instability, widespread gang-related violence and limited employment opportunities in prominent origin countries. Several pull or incentive factors likely attract migrants to Belize. First and foremost, increased stability and security facilitate more consistent employment in Belize. Second, Belize's proximity and relatively porous borders minimize transaction costs for aspiring migrants, especially from adjacent Guatemala. This pull factor manifests in an over-representation of migrants in the Belizean district bordering Guatemala. Third, poor land management institutions in Belize enable arriving migrants to install themselves on unclaimed land and engage in small-scale agricultural production or micro-enterprises. Fourth, Belize has a GDP per capita significantly higher than that of any major origin country, facilitating an improved standard of living for migrants. Belize also has a history of being an important transit country for migrants headed to the United States, which may have helped initiate migration flows. Though transit to the United States from Belize has become prohibitively difficult for undocumented migrants, potential wage differentials, increased security, and widespread opportunity have continued to attract migrants from neighbouring countries.

Local migration to the communities of the IAF is limited due to the existing conditions of land tenure. Land ownership within the communities is mostly clearly defined, and new land owners would face the availability of privately held lands that would only sell at the market value. However, due to the agriculture base of the communities, lands for sale are limited in the area, and therefore, new migration is not common.

2.5 Health and Education

2.5.1 Education

Education is relatively accessible within the Orange Walk District. Within every community there is a primary school which is either a government managed, or a Church-State managed school. In the village of August Pine Ridge there is the August Pine Ridge RC School. Yo creek Village has the Yo Creek Sacred Heart R. C. School and Compassion Primary School. The village of San Lazaro is home to the San Lazaro Methodist Primary School, and the Belize High School of Agriculture which is a secondary institution. All teachers are paid by the Government of Belize to educate the children at the primary level up to Standard Six (comparable to U.S Grade 8).

It is important to note that the Belize Education and Training Act 2010, in section 59 states:

Every person having control of a child, who is five years old by the first day of September and who has not exceeded the age of fourteen, shall cause the child to regularly and annually attend some public or non-public school for the entire term during which the public school in the district in which the person resides, or the school to which the child is assigned to attend, is in session, until the child reaches the age of fourteen years, unless the child has graduated or is excused as provided in sections 60 (2) (a) and 61 (2) (a), (b) and (c).

Statistics have revealed that the Educational level varies within the area of influence. However, it is revealed that a large portion of the population, forty-three (43%) percent, have a primary school education, while eleven (11%) percent have a secondary school education, 8% post-secondary and 3% university, (Figure 2.16).

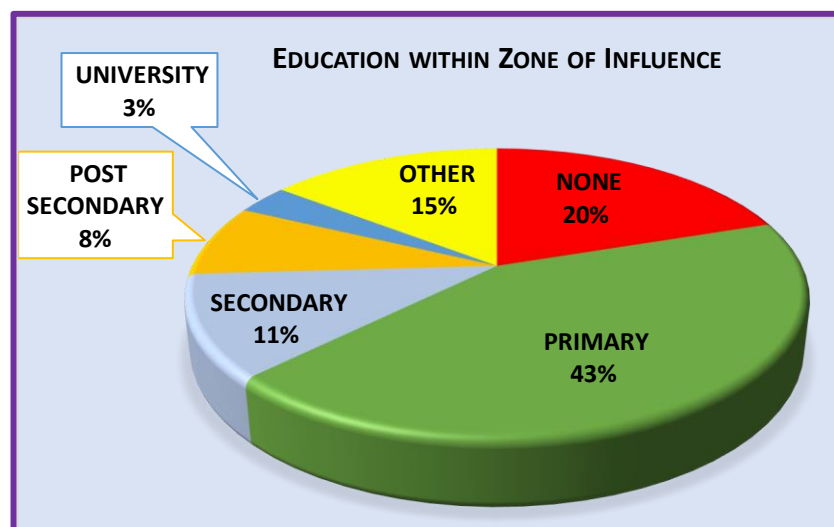


Figure 2.16: Education within Zone of Influence.

In the village of August Pine Ridge there is the August Pine Ridge RC School. Yo creek Village has the Yo Creek Sacred Heart R. C. School and Compassion Primary School. The village of San Lazaro is home to the San Lazaro Methodist Primary School, and the Belize High School of Agriculture which is a secondary institution. All teachers are paid by the Government of Belize to educate the children at the primary level up to Standard Six (comparable to U.S. Grade 8).

Belize High School of Agriculture

This high school is located near the communities of San Lazaro and Trinidad and provides secondary education to all rural communities of Orange Walk District, who are interested in Agriculture. Being close to the project site would be conducive to educate young people about biomass and renewable energy with respect to the advantages they present in ameliorating climate change.

This school has been engaged during the consultation process, and actively participated as a resource for preparation of logistics for the consultation meeting. More importantly, however, the school is being engaged through pilot projects for waste management described in the waste sector and the ESMP.

2.5.2Health

The project area lies approximately 9 miles from Orange Walk Town where the Northern Regional Hospital, which is a public Institution, is located. This hospital is equipped to handle basic medical specialties such as internal medicine, basic surgery; paediatrics and OB-GYN. Additionally, in Orange Walk, there are many private clinics inclusive of the Northern Medical Specialty Plaza Limited which is a private facility that offers more comprehensive health treatment than the Northern Regional Hospital. For major illnesses or accidents, patients who cannot afford treatment at a private facility, are taken to Karl Heusner Memorial Hospital which is a tertiary care hospital in Belize City fifty-five (55) miles away.

Table 2.7: Social Infrastructure in Zone 1.

Community	School	Fire Station	Police Station	Health Center	Community Center
August Pine Ridge Village	2	0	0	0	1
San Antonio Village	1	0	0	0	1

San Lazaro Village	2	0	0	0	1
Santa Cruz Village	1	0	0	0	1
Trinidad Village	3	0	0	0	1
Yo Creek Village	3	0	0	0	1

Most villages lack certain community infrastructure such as health centres and fire service facilities. However, all villages have access to telecommunication facility mainly through cellular telephones or internet facility.

All surrounding communities have a community health worker and have mobile clinics.

2.6 Archaeological/Cultural Sites and Monuments

2.6.1 Introduction

In June of 2019 the Belize Archaeological Services (BAS) was contracted to conduct an archaeological assessment and impact analysis on one portion of a property, to be developed by in connection with the *Arundo donax* biomass to energy project.

The study area is located at 15 km West Southwest of Orange Walk Town, and 4km West Northwest of the Trinidad Village (Figure 2.17). The entire property is composed of two parcels, one **99.8** and **397.3** acres (Figure 2.17). In accordance with the Belize Environmental Compliance Protocols, and with the National Institute of Culture and History Act Chapter 331, Revised Edition 2003, the purpose of our study was to provide an inventory of archaeological sites within the specified area, to identify any features of archaeological significance (both historic and prehistoric) that would be affected by the future development of the area, and to make provisions and recommendations for the protection or mitigation of any such features that would be impacted by planned development.

The parcel of land comprising shrub lands, lowland savannah and disturbed shrub land determined to be marginal and unsuitable for agricultural purposes both in modern days and in antiquity. The land is part of the Northern Plains Land Systems and it has topography of approximately 17 to 19 meters ASL. Soil characteristics display well drained sandy to loamy sandy soil with varying degrees of soil cover. Approximately half of the lands are savannah shrub lands and the remaining half comprises shrub lands with denser vegetation cover similar to low lying *bajos*.

The area is almost devoid of human occupation, likely due to the vegetation and soil morphology. The tow closest ancient centres are located 10.9 km to the east northeast (Cuello) and 12.5 km south southeast (El pozito) (Figure 2.19). Further afield are two other centres, Lamanai at 32 km south and Blue Creek at 29 km to the south southwest.

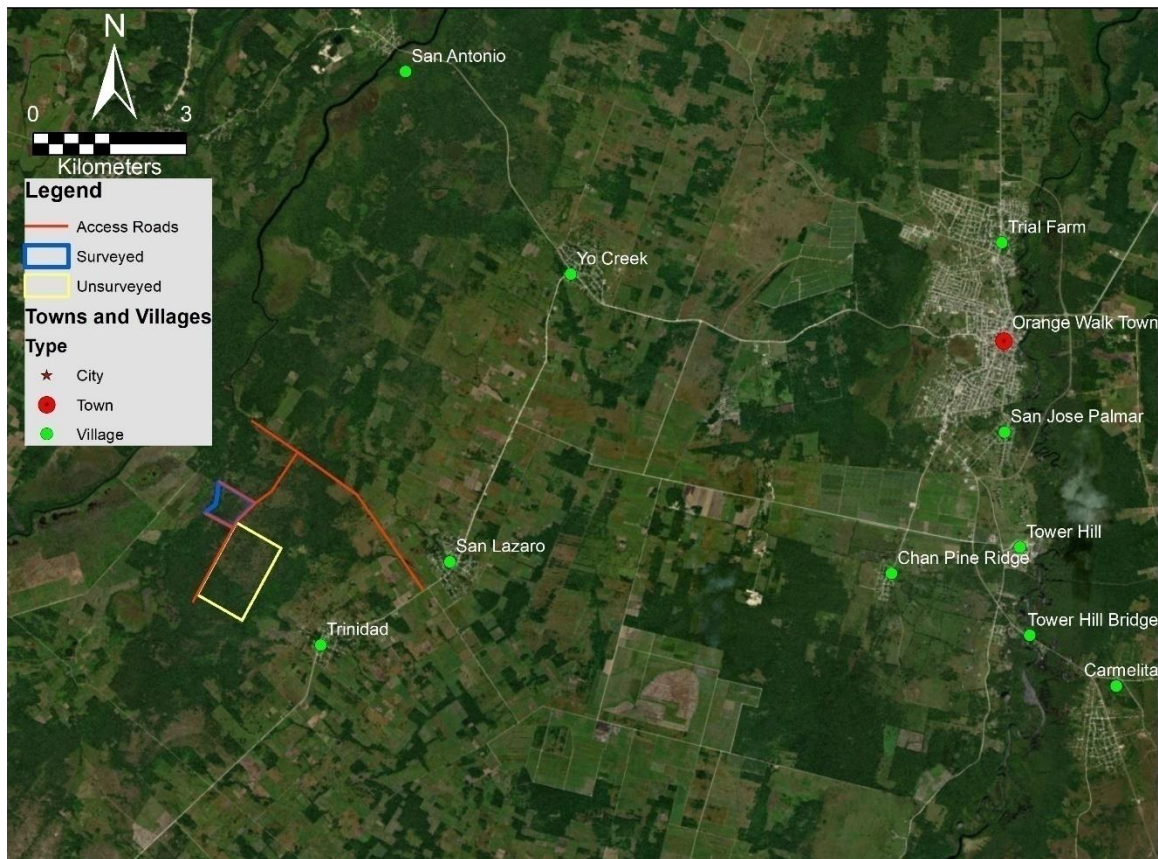


Figure 2.17: Map of the Development area in Northern Belize.

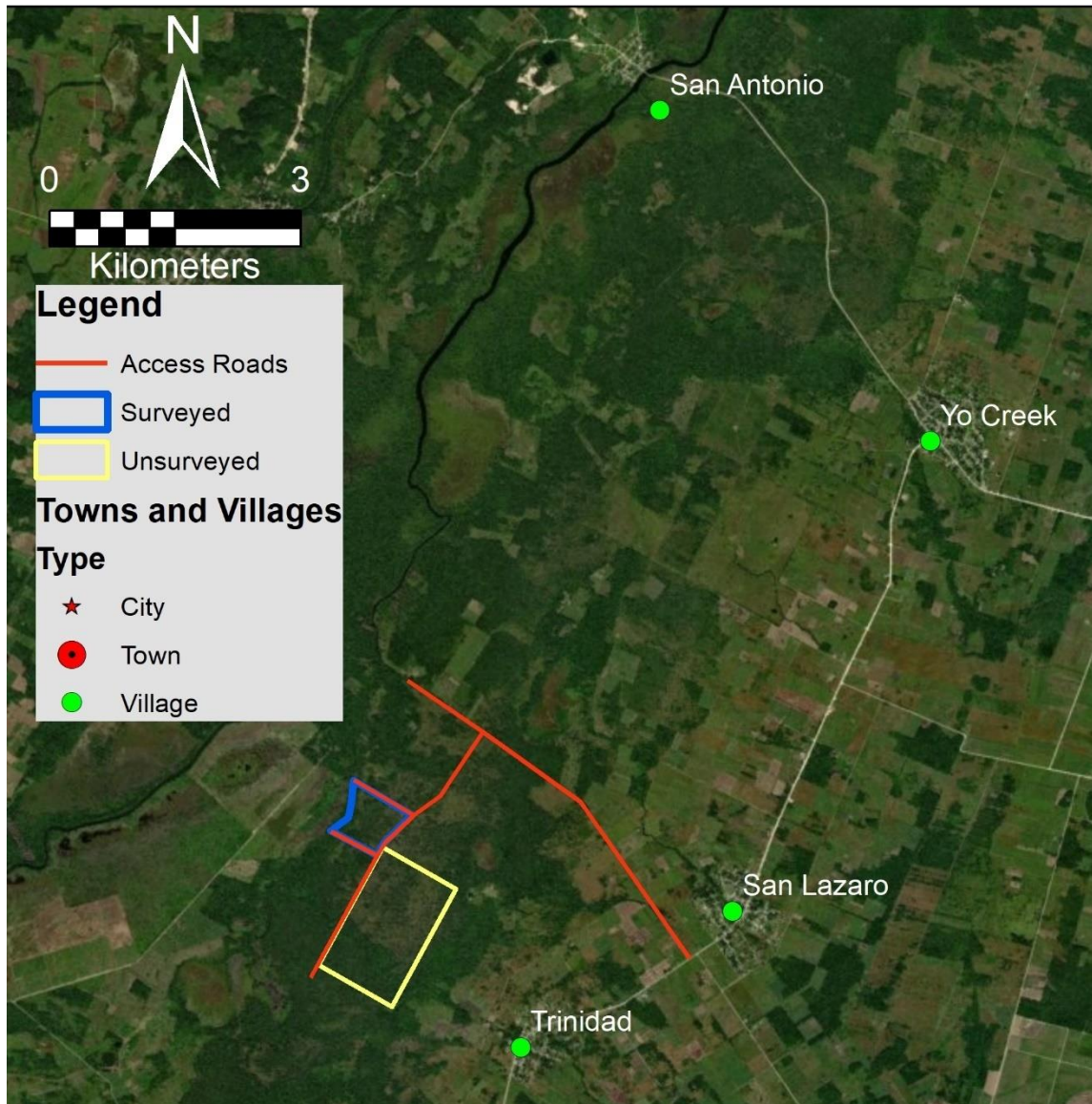


Figure 2.18: Close-up of the Development Area.



Figure 2.19: Map of large ancient centres close to the proposed development area.

2.6.2 Review of Archaeological Data

As we noted above one of the primary purposes of this archaeological survey was to provide an inventory of archaeological sites in the proposed development properties. In Belize, archaeological sites generally fall under one of three designated types: Preceramic, Prehistoric Maya, and Historic period settlements.

1. Preceramic sites are subdivided into two categories, Paleo-Indian and Archaic. The former includes the camp sites of the first human inhabitants of Belize which dates from 12,000 to 7,000 B.C. The subsequent archaic phase spans the period from 7,000 to 1,300 B.C. Both of these phases pertain to occupants who culturally are considered pre-Maya inhabitants.
2. Prehistoric Maya occupation extends from at least 1200 B.C. to the time when contact with the first Europeans was made around 1500 A.D.
3. The Historic Period spans from 1500 to 1900 A.D. and encompasses the time from Spanish contact to the early phase of British colonial settlement.

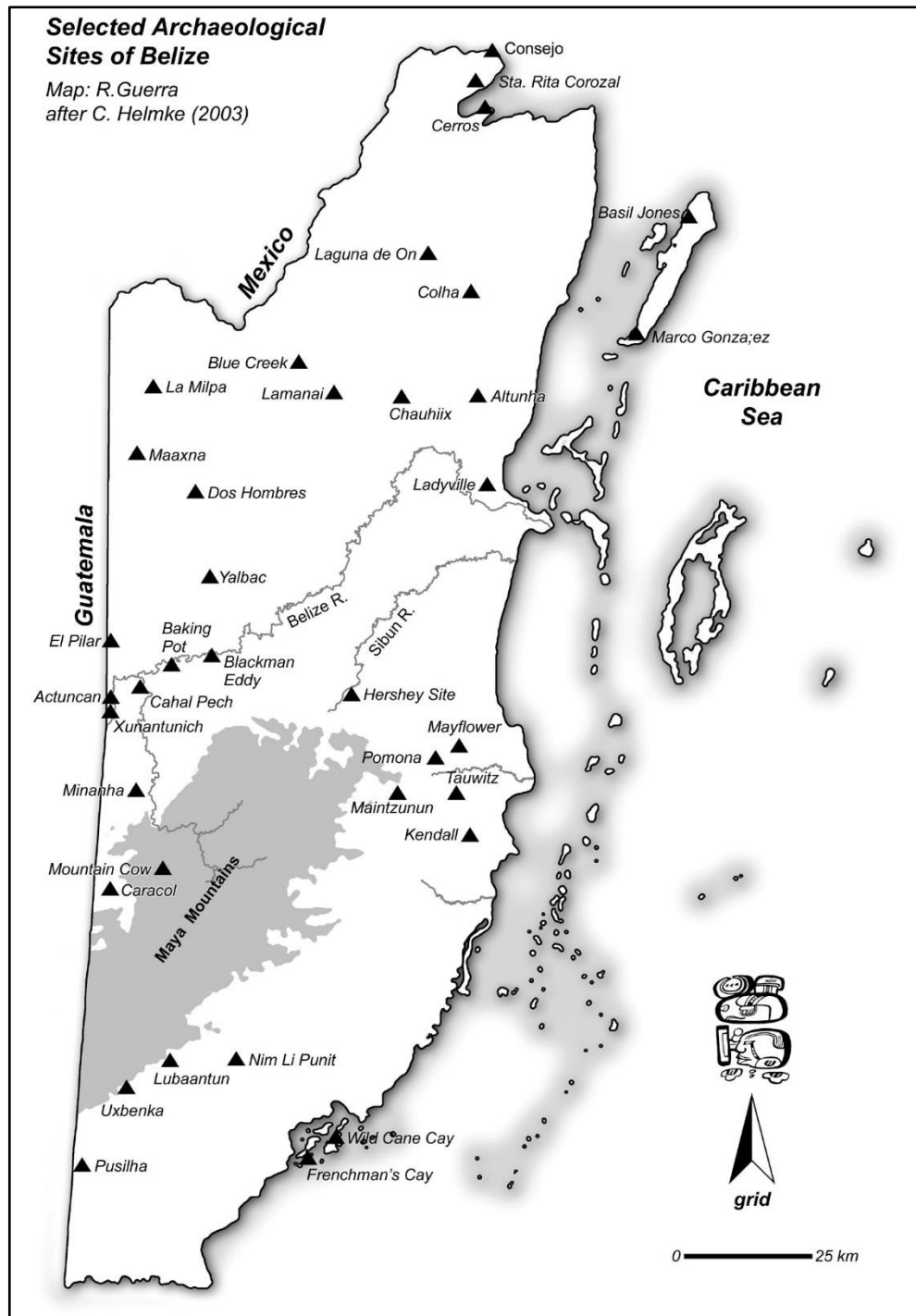


Figure 2.20: Map of Belize and Selected Archaeological Sites.

2.6.3 Survey and Research Methodology

The entire perimeter of both parcels was cleared to identify the 40-foot road access. The entire parcel was surveyed using pedestrian survey. In addition, a small portion, 24 acres, of the larger parcel, was also bulldozed (Figure 2.18). This portion of the parcel was surveyed as well as the project members were already on site and the bulldozing had cleared to the modern ground surface (Figure 2.19), allowing for a rapid assessment of the area.

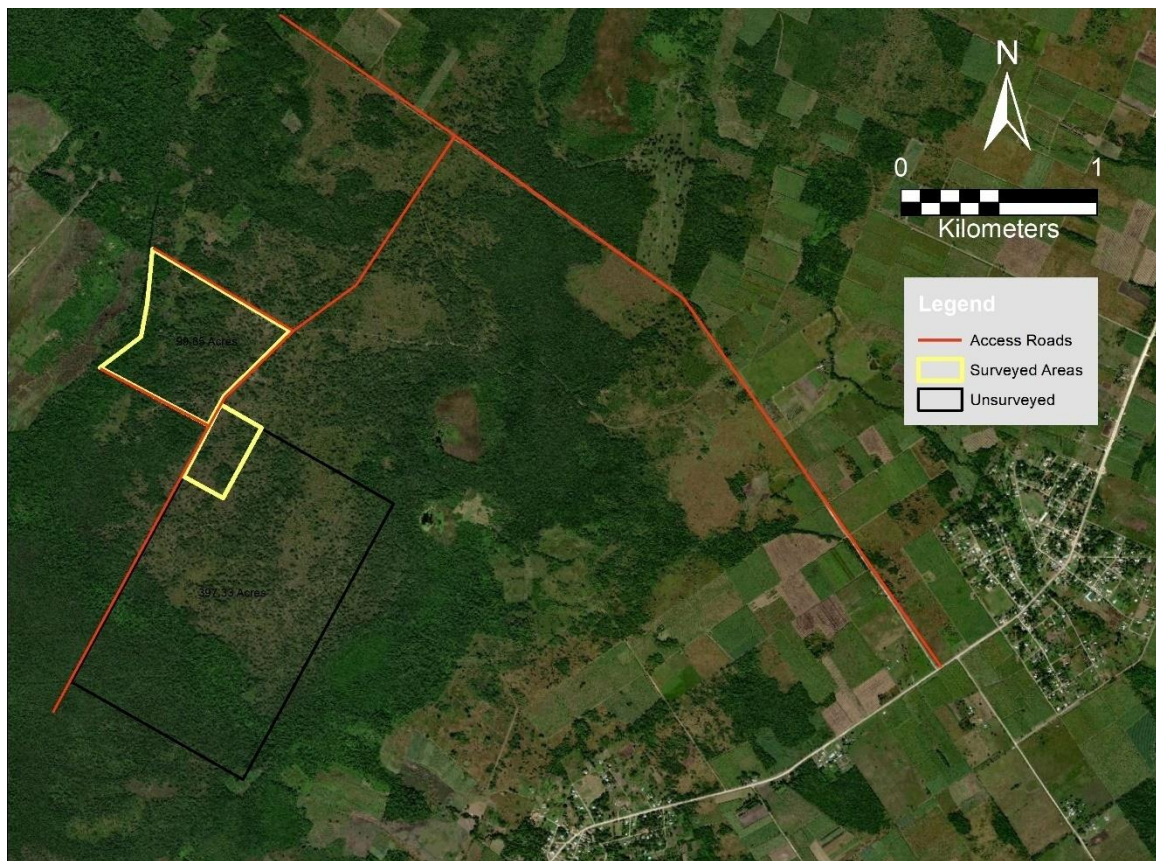


Figure 2.21: Map of development area showing the surveyed and unsurveyed areas.



Plate 2.6a: Photo of the bulldozed area.

The smaller parcel was investigated through the use of parallel transects using the cleared NE-SE boundary as a baseline. In order to facilitate the pedestrian survey along the property, perpendicular transects were created at a distance of 100m (328ft). A total of six (6) transects, 650 meters long were opened to investigate the area.

In addition, several truck passes were identified within the property and were also used as transects where possible. All transects were reconnoitered to identify archaeological features visible above surface.

The results of the pedestrian survey of the 99.8 acres' parcel and the 24 acres cleared land are described in detail in the results section of this report.

2.6.4 Survey

Our survey was conducted with a three (3) person crew over the course of two days. The archaeological survey served to assess the total extent of archaeological remains within the project area, focusing on locating and recording all structures, sites and cultural features within the area that would be impacted by any development. A summary description of the results of these investigations is provided below.

2.6.5 Results of the Survey

Wherever there are prehistoric settlements that will potentially be impacted by road construction, these are highlighted and GPS points are provided for them.

In the 99.8-acre parcel, no visible archaeological remains were identified. The lowland savannah and *Bajo*-vegetation indicate that the area was very likely unsuitable for farming due to the high acidity level of the soils and the tendency for seasonal floods. It is unlikely that the ancient Maya may have inhabited or farmed this area. It is more likely that the area was utilized as a resource extraction zone for pine resin, pine needles and marshland fauna.

In the cleared portion of the second parcel, two mounds were identified (Figure 2.22). Upon close inspection of the mounds, no archaeological materials were noted on the mound or the surrounding vicinity. A quick test pit on the top of the mounds indicated that they were composed of a 5 cm layer of humus overlying soft limestone. This indicates to us that these mounds were not constructions mounds by the ancient Maya. No archaeological remains were visible in the rest of the 24-acre property. As with the smaller parcel it is likely that the ancient Maya never inhabited or farmed this area.

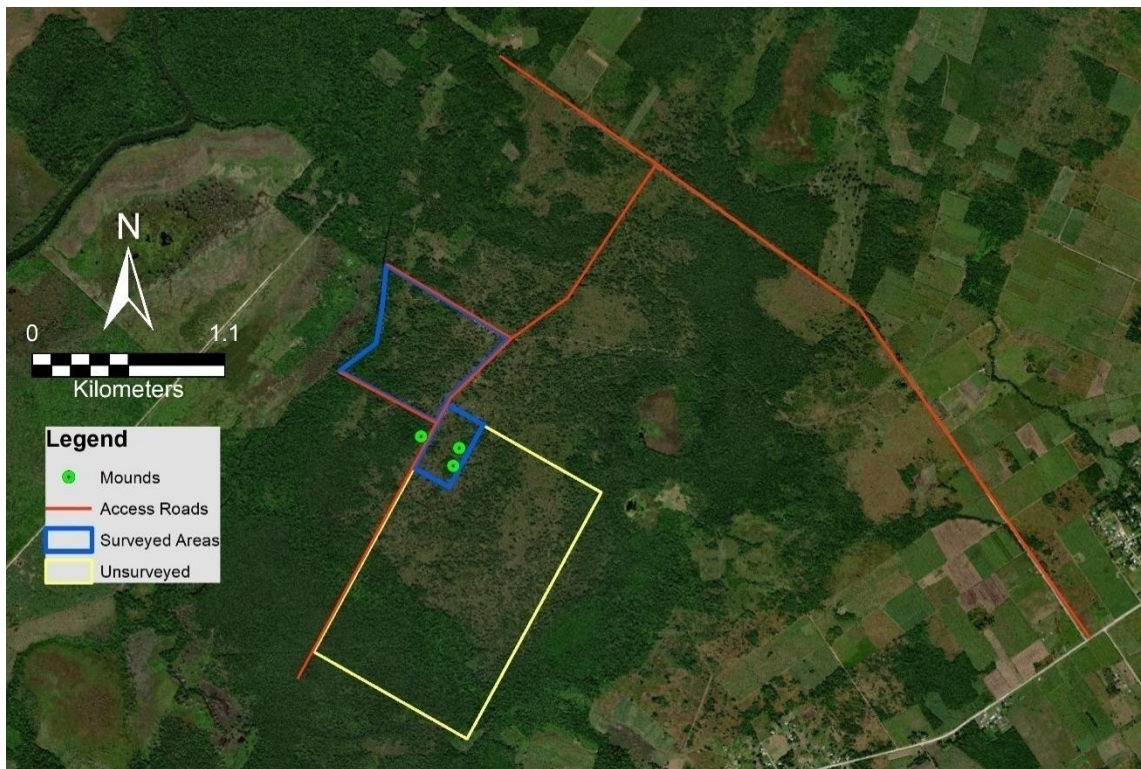


Figure 2.22: Map of proposed development area showing the two mounds in the properties.



Plate 2.6b: Photo of the bulldozed area showing the two mounds in the background.



Plate 2.6c: *Photo of the Perimeter of the Surveyed area.*

2.6.6 Conclusion and Recommendations

Archaeological research in north-western Belize indicates that several large centres developed not too far from the proposed development area. However, the immediate area around the proposed development, circa 8-12 km, appears to have little to no permanent ancient habitation.

Our survey also determined that no mounds attributed to settlement of habitation were visible on the properties. This does not mean that there are no archaeological remains in the area. It is still possible that small scatter of artefacts, from the Paleo-Indian or Archaic period sites, may still be uncovered during land clearing and construction. In addition, this survey was designed to find surface archaeological features. As such it is also possible that there may be hidden sites or structures from the ancient Maya period. Lastly, since the survey did not cover the entirety of the larger property it may be possible to find archaeological remains in the unsurveyed portions of the properties. As such we make the following recommendations for the development of the area.

Any land clearing within the surveyed area should be supervised by a trained archaeologist. Should any archaeological remains be identified, the land clearing should be halted and the area assessed to identify the extent of the remains. Mitigation measures should be taken to recover as much material as possible before the land clearing recommence. If any construction should occur, again a trained archaeologist should be present for the excavation of pits, footings and foundations of buildings. If any archaeological remains be identified, the construction efforts should be halted and the area assessed to identify the extent of the remains. Mitigation measures should be taken to recover as much material as possible before the construction recommences.

If the larger property should be developed, as planned, it is our recommendation that a full archaeological assessment be conducted before any development occurs. This report does NOT clear this property for land clearing and/or construction. It is our opinion that there is a possibility that there may be archaeological remains from the Paleo-Indian and/or Archaic period occupation, in this larger area. As such, it would be necessary for transects, along the longer side of the property, to be cut at 100m intervals to accommodate a full archaeological assessment of the area.

2.7 Services and Infrastructure

Communication and services are well established in the area with public and private telephones, personal cellular phones, and internet facilities. All of the villages have 24-hour electricity. Cable television is also available in Yo Creek, and most of the communities. All villages have access to the internet. Potable water is available to all villages within the project site.

Table 2.8 shows the population households with access to various sources of electricity, including from the BEL grid, generators and from gas systems. While 453 have access to the BEL grid, 283 depend on generators, and 228 used gas lamps in the year 2018. Surprisingly, the vast majority of households, totalling 31,833 households have no access to electricity. These are primarily, living in rural areas, and farms.

Table 2.8: Households by Major Administrative Area and Main Source of Lighting: 2017-2018.

Households by Major Administrative Area and Main Source of Lighting: 2017 - 2018. Source: Statistical Institute of Belize 2019.							
		2017			2018		
		Total	Urban	Rural	Total	Urban	Rural
Corozal	Electricity from BEL	9,794	3,174	6,620	9,352	3,071	6,281
	Electricity from public generator	-	-	-	320	19	301
	Electricity from private generator/solar energy	385	-	385	392	-	392
	Gas Lamp	33	-	33	23	-	23
	None	591	83	507	541	18	523
	Other or Not Stated	8,784	3,008	5,777	10,031	3,325	6,706
Orange Walk	Electricity from BEL	-	-	-	453	-	453
	Electricity from public generator	1,188	11	1,177	482	-	482
	Electricity from private generator/solar energy	-	-	-	-	-	-
	Gas Lamp	733	86	647	228	-	228
	None	30,727	21,598	9,129	31,833	21,765	10,068
	Other or Not Stated	-	-	-	151	-	151
Belize	Electricity from BEL	148	85	63	107	-	107
	Electricity from public generator	-	-	-	59	-	59
	Electricity from private generator/solar energy	748	120	628	269	190	79
	Gas Lamp	17,334	11,131	6,203	20,512	12,329	8,183
	None	-	-	-	1,127	439	687
	Other or Not Stated	837	-	837	69	-	69
CAYO	Electricity from BEL	40	-	40	104	-	104
	Electricity from public generator	1,593	421	1,172	574	157	416
	Electricity from private generator/solar energy	9,620	2,887	6,733	10,791	2,716	8,075
	Gas Lamp	-	-	-	85	-	85
	None	176	28	149	171	20	151
	Other or Not Stated	38	-	38	68	-	68
Stann Creek	Electricity from BEL	492	19	473	430	103	328
	Electricity from public generator	4,878	1,494	3,384	5,465	1,497	3,968
	Electricity from private generator/solar energy	-	-	-	978	-	978
	Gas Lamp	748	8	740	362	11	351
	None	19	-	19	35	-	35
	Other or Not Stated	2,195	17	2,178	690	-	690
Toledo	Electricity from BEL	5,373	1,384	3,989	4,878	1,494	3,384
	Electricity from public generator	1,124	-	1,124	NA	NA	NA
	Electricity from private generator/solar energy	NA	NA	NA	NA	NA	NA
	Gas Lamp	620	-	620	748	8	740
	None	-	-	-	19	-	19
	Other or Not Stated	566	17	549	2,195	17	2,178

2.8 Access to Basic Health Care

The project area lies approximately 9 miles from Orange Walk Town where the Northern Regional Hospital, which is a public Institution, is located. This hospital is equipped to handle basic medical specialties such as internal medicine, basic surgery; paediatrics and OB-GYN. Additionally, in Orange Walk, there are many private clinics inclusive of the Northern Medical Specialty Plaza Limited which is a private facility that offers more comprehensive health treatment than the Northern Regional Hospital. For major illnesses or accidents, patients who cannot afford treatment at a private facility, are taken to Karl Heusner Memorial Hospital which is a tertiary care hospital in Belize City fifty-five (55) miles away.

Most villages lack certain community infrastructure such as health centres and fire service facilities. However, all villages have access to telecommunication facility mainly through cellular telephones or internet facility.

All surrounding communities have a community health worker and have mobile clinics. However, table 2.7 shows that health centers are not found in these villages.

2.9 Social Organizations and Dynamics

Social organizations include the village council, which is elected every three years. Village councils are formed by the election of a chairperson and six (6) members who run the affairs of the village. These affairs pertain to the administration of water boards, fund raising and social cultural events, including the celebration of national holidays (primarily the Independence day), and the maintaining of open playgrounds clean.

In this light, the Village Council Act (Chapter 88 of the Substantive Laws of Belize, Revised Edition 2000) empowers village leaders and villagers to make bye-laws for wide functions in villages. Section 23 of the Village Council Act empowers the Village Council to make by-laws for the rule and good governance of the village.

Another large group of associations are the cane farming associations, which comprises three large main bodies in Northern Belize. These are the Belize Sugar Cane Farmers Association, Progressive Sugar Cane Farmers Association and the Corozal Sugar Cane Producers Association.

The National Emergency Management Organization (NEMO) has upgraded its ability to deal with national disasters by the construction of a national headquarter in Belmopan, the establishment of a coordinated national body, with District Emergency Management Organizations (DEMO). Annual exercises in hurricane preparedness are conducted, and attempts made at improvement of the system. Exercises include hurricane and Tsunami simulations, rescue and recovery exercises as well as evacuation of personnel.

All villages have a Village Emergency Management Organization (VEMO) that coordinates with NEMO during an emergency. If necessary, its residents are transported to a hurricane shelter with the district.

In terms of conservation organizations, the well-established NGO, **Programme for Belize** is a Belizean, non-profit organization, established in 1988, to promote the conservation of the natural heritage of Belize and to promote wise use of its natural resources. The Rio Bravo Conservation and Management Area is its flagship project where Programme for Belize demonstrates the practical application of its principles. PfB has secured 260,000 acres of forested land in north-western Belize, designated as the Rio Bravo Conservation and Management Area (RBCMA) that was otherwise destined for clearance (PfB 2009). Approximately half of this land is managed as a reserve for the protection of biodiversity and natural habitats. On the RBCMA, PfB conducts research, conservation education, professional training and promotes environmental awareness amongst visitors. National parks and reserves as islands in a sea of agriculture are not however adequate responses on their own to the issue of tropical forest conservation.

2.10 Access to Infrastructure and Roads

2.10.1 Transportation Facilities

Access to the all communities in Zone 1 is via the Yo Creek Road. Traffic to the region of the proposed development has increased over the years due to the paving of the Yo Creek road that goes all the way to Blue Creek Village. Additionally, there is increase traffic during the sugar cane delivery season, as farmers transport their product to the mill

This area is serviced by several small bus lines that transport the residents of the area to Orange Walk Town on a daily basis, many private vehicles traffic this area as well. Access to the project site however is via an all-weather dirt road.

Many citizens own their own private cars, trucks and motorcycles but there is also the transportation service thru regular buses from the main towns and cities to all villages. Commuters can travel by bus to most parts of the country, and are provided with access to bus services that link up with other buses serving other routes. Similarly, buses serve the community schools, and these are managed by the Ministry of Education. Children commute to schools along the Yo Creek Road. The BHA has two buses that run from San Felipe to the school and from Yo Creek to the School to facilitate school children.

2.10.2 Communication and Services

Communication and services are well established in the area with public and private telephones, personal cellular phones, and internet facilities. All of the villages have 24-hour electricity. Cable television is also available in Yo Creek, and most of the communities. All villages have access to the internet. Potable water is available to all villages within the project site.

2.11 Vulnerable Populations

In the communities of the immediate zone of influence, as well as those in other areas have access to health care facilities, policing, among other emergency services.

One such vulnerable group is the elderly. The social structure in the area is such that families practice the extended family modality; thereby the elderly are mostly provided with care at home; and their health care is done facilitated by local health centres and hospitals.

2.12 Indigenous Population

The communities of the area of influence are not considered indigenous since, while native, the communities have high level of migration from other countries and do not practice land use as other groups considered indigenous elsewhere in Belize. These communities do not own and neither do they claim communal lands, but instead are owners of lands through the national land system.

2.13 Communities and Resettlement

There are no communities affected by resettlement or that will require relocation to other areas as a result of the proposed project. Only employees will need to be housed at worker's quarters that will be provided by the project. For employees at the management level, housing is available on a market demand basis.

2.1.4 Summary of Potential Social and cultural Impacts and proposed Mitigation and Compensation.

2.1.4.1 Preamble

The main challenge for social sustainability in Belize stems from a non-inclusive growth model. In spite of reasonably robust economic growth rates, unemployment remains relatively high in Belize while poverty and human development outcomes seemed to have worsened according to the latest data available. The most remote and isolated areas in the country tend to have the lowest welfare indicators. Education outcomes are poor and returns to schooling almost non-existent suggesting that urgent attention needs to be given to reform of the education system. Crime and violence are also high and are believed to affect disproportionately the bottom 40% - although data collection in this area remains difficult and existing household surveys do not seem to capture that effect with precision. Through job creation, economic growth and cheaper electricity as well as foreign exchange earnings, the project will result in positive benefits and the local and national levels.

Any development project, however, may result in potentially negative impacts, some which can be mitigated against and other that can be avoided, and in some instances, project requirements such as re-designing of components can also serve to mitigate against potential impacts.

This section summarizes key socio-cultural risks and potential impacts that may arise from the *Arundo donax* biomass cultivation project.

2.1.4.2 Stakeholders Concerns and Issues

The following is a summary of Stakeholder's concerns (based on stakeholder analysis) which will be addressed directly in the ESIA and ESMP. Source: Stakeholder Analysis (P. Mendoza 2018).

Agriculture and Food Security

From the perspective of the stakeholders the main concerns relate to the following:

- a) The potential for the conversion of land currently under cultivation for food crop to be used for the production of *Arundo donax*. In this regard the Ministry has indicated that it could not be supportive of an industry that would see large-scale land conversion as it would undermine food security.
- b) The perceived need to understand and guard against potential negative impacts of having *Arundo donax* cultivation in close proximity with sugar cane crop, with specific questions and assertions being- a. Whether there is a possibility that pests that are harmful to sugarcane and being effectively controlled will find safe haven among the *Arundo donax* plants, thereby undermining control measures.
- c) Whether there is a possibility of cross-pollination.

Resource and Risk Management

The most critical resource use issues that arose relate to land and to potential ecological impact of *Arundo donax*, as described below.

a) *Land Use*

- 1) To utilize only marginal lands
- 2) Interest in the location and tenure status of the plot.
- 3) Definition of marginal lands.

Environmental and Ecosystem Health

Stakeholders are acutely aware of the need for careful management of the *Arundo donax* crop to avoid unintentional propagation. Some specific issues and recommendations related to risk management are set out below.

- 1) Respondents from the Ministry of Agriculture, the Forest Department, SIRDI, cane farmers association and the community focus group meetings have all flagged a need for a clear exit strategy, should the *Arundo donax* cultivation not prove viable. Based on the various questions and recommendations in these discussions, the strategy should clearly outline the measure to be taken to remove any *Arundo donax* completely.
- 2) The view that although the plant is hardy, the fact that it tends to propagate in riparian and low-lying areas may be an indicator that its water consumption may be high.
- 3) Use of harvesting technique that would involve burning as this would result in emissions.
- 4) Question of measures to be taken to ensure the protection of sugarcane crop, as they have experienced that the root system threatens the survival of the sugar-cane.

Gender and Resource Control

Assigned gender roles within the communities of the North are transitioning, yet control of resources continues to reflect the traditional arrangements.

The following are identified key aspects of the gender roles and relationships that have bearing on the economic life of the communities.

- 1) There are virtually no women on the board of the cane farmer's associations despite the data on registered cane farmers drawn from the Sugar Industry Management Information System (SIMIS) show female cane farmers make up 40% of the total number registered.
- 2) Where women are actively engaged in managing or working their own farms, they are recognized as being highly effective, mainly because they are disciplined about following good agricultural practices and are seen as good financial managers.
- 3) Women are heavily involved in managing the finances of the cane farming businesses and are observed as being the main ones who do banking for the families' farming business.

Youth and Aging

The investigations also reveal that there are no persons under 25 years of age on any the boards of any of the three cane farmers' associations, nor on the village councils in the Yo Creek and San Lazaro communities. SIMIS data shows less than 5% of cane farmers under the age of 25, and those between 25 and 30 years of age account for less than an additional 3% of the total.

Cane farmers aged 50 years and more make up 62.5% of the total number of registered farmers, indicating an aging industry and no clear succession planning.

Perspectives on the role of youth and contributors to their low involvement in cane farming and community level leadership are set out below.

- 1) Cane farmers ensure they can educate their children and encourage them to move away from the industry because they view it to be too arduous.
- 2) Another contributing factor was the policy of the sugar board that prevented registration of new member's cane farmer as long as there was enough production to be distributed among already registered farmers. The Association successfully challenged this ruling, so that now anyone can be registered as a long as he or she can produce and deliver cane.
- 3) Young people prefer to be office workers rather than farmers
- 4) There is not enough technology used in the farming industry to attract young people.
- 5) Young people are not willing to take on the level of responsibilities needed to effectively serve as community leaders, and therefore rarely run for village council positions.
- 6) Some respondents cited the Fair-Trade related program as a contributor to the changes in the level of youth engagement in the industry. Whereas it had been traditional to have children accompany parents to the cane fields, particularly on the weekends, measures to eliminate child labour practices incorporated in the fair-trade program militates against this.

Other Issues Considered Socio-cultural in Nature

Other issues that have emerged and are addressed in the ESMP include:

The issue of community health and safety;

Occupational health and safety of employees and visitors to the project site;

The risks for hazards such as fires, and other man made hazards (chemical exposures, and substance spills etc).

Table 2.9 Activities, Potential Impacts and Proposed Mitigation and Compensation

Activities	Degree of Impact	Mitigation Measure
Bio security Impacts /Ecosystem health & unintended propagation	<ul style="list-style-type: none"> • Unintended propagation due to improper field cultivation and handling • Washing and cleaning of all equipment to prevent unwanted • Propagation. 	<ul style="list-style-type: none"> • The rhizomes, which are the promulgates in <i>Arundo donax</i>, will not be extracted, and will remain in the ground. • The <i>Arundo donax</i> stalks, which will be utilized for biomass energy use, will be cropped, chipped, dried and shredded in a manner such that it will be converted to a fibrous material similar to bagasse; which is also not capable of propagation in such a form. • The design of the harvesting approach is such that the extracted and processed material is incapable of further propagation. • At no time will harvesting within the project area result in the rhizome of the plant being extracted from the soil. • Through the piloting projects, the elimination of unwanted plants will be fine-tuned using various methodologies • A risk management plan will be put in place.
Health and Safety – Community and Occupational	<ul style="list-style-type: none"> • Increase ambient noise levels • Chemical applications • Increase particulate matter • Vapor emission • Transportation impacts • Risk of fire escapes • Occupational risks 	<ul style="list-style-type: none"> • Adopt OHSP that has been developed. This plan includes for protection of employees at the work place and off the work place as well as provides for the supply of PPE • A community redress mechanism through the establishment of an advisory community committee is being established (this will oversee participation, pilot projects and redress in the event of damage or loss by the community as a result of project activity) • Install dust traps at storage site to minimize the amount of particulate matter. • Adopt fuel handling policies established. • The additional staffing includes an assistant project manager who responsibility will be primarily to ensure the risk management practices are successfully implemented. Also added to the human resources are security and safety personnel who will be responsible for the Project site as well as monitoring transfers of any <i>Arundo donax</i> plant material from the area. • Security and safety personnel will be retained via contracts • Provisions will be made for communications

		<p>and electricity, especially given the remote location.</p> <ul style="list-style-type: none"> • Sanitation facilities will also be made available to address that human need. Likewise, wash area and restrooms will be constructed. • New roads that will be constructed will comply with national standards. • Erection of appropriate signage will be done to address safety. • There is the possibility for the construction of worker housing employees and security personnel.
Natural and made disasters	Risk of hurricanes, fires, and emergencies	<p>Adopt the fire plans and emergency plans to protect community and employees</p> <p>Review and adopt emergency management plans and evacuation plans</p>
Cultural and social	The risk of damage to undiscovered archaeological/cultural resources	<p>A rapid archaeological survey to be conducted prior to project commencement.</p> <p>Adopt a policy to report and stop all work in the event of an archaeological find.</p> <p>Practice gender equality and establish policies that will ensure fair employment to all candidates</p>

Literature Cited

Statistical Institute of Belize, Belize Labor Force Survey, April 2018

Statistical Institute of Belize, Belize Labor Force Survey Report, April 2014

Belize Education and Training Act 2010

Statistical Institute of Belize, Housing and Population Census 2010

Government of Belize, Ministry of Education <http://www.moe.gov.bz/>

Enterprise Survey 2011

Lindauer, David (2014), “Labor Market Performance in Belize”, Technical Note IDB-TN-608, IADB.

Belize Labor Force Survey, April, 2012.

3.0 Legal and Institutional Framework

3.1 Legal and Institutional Norms and Licensing Requirements

The Belize Constitution Act, Chapter Four of the Laws of Belize, Revised Edition 2000, is the supreme law of the country. In September 1981, it established Belize as a Sovereign Democratic State in Central America and the Western Caribbean Region. The Constitution establishes the Governor General as the representative of Her Majesty the Queen of England, who has executive authority over Belize (Part V, Section 36 of the Constitution).

The Governor General appoints as Prime Minister the leader of the party with the majority seats in the House of Representatives. The Governor-General, on the advice of the Prime Minister, appoints the Ministers of Government and the Senate from among members of the House of Representatives or as stipulated by law. The constitution also states that there shall be a Legislature comprised of two Houses (House of Representatives and a Senate). The house of representatives is tasked with the approval of legislation.

There are much comprehensive legislation (including laws, regulations and guidelines) to guide sustainable development in Belize. Every government ministry that has assigned portfolio has its own legislation in the form of acts, bylaws, orders or statutory instruments. The laws of Belize are enforced by government Units, Departments, Authorities or quasi-governmental bodies.

3.1.2 Regulations for the Agriculture and Industrial Sectors

3.1.2.1 Public Utilities

The Ministry of Public Service, Energy and Public Utilities has the responsibility of regulating the electricity, telecommunication and water sectors through the Public Utilities Commission (PUC) and the Ministry of Natural Resources through the National Integrated Water Resources Authority (NIWRA). Until recently, the Belize Electricity Limited (BEL) was the sole provider of electricity at the national level using petroleum products and renewable energy sources. Belize Electricity Limited distributes electricity through the national grid. However, other entities such as Santander Sugar Energy Limited, generates electricity for its own consumption and provision to the national grid using bagasse, a renewable source not accounted into the national greenhouse gases emissions. The Belize Telemedia Limited (BTL) and Speed net Communications Limited provide telecommunication services country wide. Various television companies also provide internet services country wide at competitive rates. Belize Water Services (BWS) Limited is the only company tasked with providing water and sewerage services at the national level. Water services in the villages are managed by village water boards which are governed by the Village Councils Act. The Government of Belize owns majority shares in BEL, BTL and BWS.

3.2 Local Regulations Applicable to the Project

The key policies and regulations that govern the electricity and water sectors are:

- **Electricity Act, Chapter 221, Revised Edition 2000**, created the Belize Electricity Limited that functions as a legal monopoly since it was granted a 15-year license to generate, transmit, distribute, and supply electricity in Belize with an automatic 10-year recurring license beginning in 2015. Private entities need a license if they generate more than 75 kilowatts of power.
- **The Public Utilities Commission Act, Chapter 223, Revised Edition 2000** established the PUC giving it authority over the electricity, water, and telecommunications sectors. The Act sets out the PUC's composition, governing rules, and general functions. It enables the PUC to issue regulations on rates and procedures for reviews, appeals, accounts, and reports. Both electricity and water rates are regulated by the PUC.
- **The Water Industry Act, Chapter 222, Revised Edition 2003**. This Act, which was approved in 2001, replaced the Water and Sewerage Act, Chapter 185 of the Laws of Belize. The Water Industry Act gives the Minister of Natural Resources the responsibility for promoting a national policy for water, and the PUC the right to grant licenses for providing water and sewerage services. The Water Industry Act also sets out the function and duties of the PUC for that sector, the responsibilities of the licensees, and regulations for water pollution control specifying holding and discharge areas.
- **The Village Councils Act, Chapter 88, Revised Edition 2003** governs the village councils. It sets out the legal procedures for establishing a council, electing members, the powers and duties of council and regulations for the village water boards. Furthermore, Part VII: 01 of this Act establishes how the village water boards should be composed, the responsibilities and powers of the boards, the rates to be charged for water supplied, and the accounting procedures for the boards.
- The **Water Resources Management Act of 2006** established a National Water Resources Commission, which reports to the ministry responsible for water resources. The Commission is responsible for developing a National Water Resources Management Master Plan and allocating water resources by issuing licenses for water extraction and use.

Building of Structures

- The **Belize Building Act 2003** established the Central Building Authority (CBA) to control building operations in the interest of public health and safety. The CBA conducts plan reviews and issues no-objections to building permit applications which are complying, conduct land development site and buildings inspections, provide guidance and information to developers, provide technical support for policy development, new regulations and enforce existing regulations.

Land Clearing

Land clearing needs permission from the Forest Department, legal provision by the Forest Act, **Belize Forest Act**, Chapter 213 Revised Edition 2000, if it will involve natural forest vegetation. Land clearing for agriculture is a form of development which requires the removal of native cover, including trees, bushes and boulders from the land surface. The land must then be tilled in order to get a workable seedbed into which a crop can be seeded. Land preparation includes the removal of roots, stumps and rocks which can enhance water pollution, erosion and habitat loss.

Land Use Legislation - National lands Act 191, Revised Edition 2003

According to the National Lands Act Chap 191, Rev. Ed. 2003, national lands mean “all lands and sea bed, other than reserved forest within the meaning of the Forests Act, including cayes and parts thereof not already located or granted, and includes any land which has been, or may hereafter become, escheated to or otherwise acquired by the Government of Belize.”

Solid Waste Management Authority Act Chap. 224 Rev. Ed. 2000

The **Solid Waste Management Authority (SWMA)** has broad powers for the collection and disposal of solid waste. SWMA can declare a “service area” to be provided with solid waste collection service pursuant to this Act. The Authority shall devise ways and means for the efficient collection and disposal of solid waste employing modern methods and techniques and exploring the possibility of recycling waste materials. The act also requirements privately held facilities to properly dispose of their waste materials. For the project, this entails the domestic portion of waste was well as all categories including construction, biomass and other waste streams that must be disposed properly.

Wildlife Protection Act Chap. 220 Rev. Ed. 2000

The Wildlife Protection Act regulates the hunting of wildlife as game or for other use. The act specifies species protected against hunting by listing of the species under the “Schedule”. This act allows for the establishment of regulations controlling hunting by the declaration of closed hunting areas, determining periods for the prohibition of hunting, the prohibition of hunting of specified animals of specific size limits etc. Hunting will not be allowed within the Sapodilla Springs site, since this increases the risk for fires, and the risk for accidents.

Forest Act

The **Forest Department** is the regulatory agency with responsibility for Belize’s forest resources. The Forest Department is responsible for the implementation of the Forest Act, 1960, the National Parks Systems Act, 1981, the Wildlife Protection Act, 1981 and the Forest Fires Protection Act. This important Agency also administers the enforcement and implementation of wildlife protection functions mandated under the Wildlife Protection Act, 1981. The Forest Act authorizes the Minister to declare forest reserves, and to de-reserve forest reserves. The act also authorizes Forest Officers from the Forest Department with wide functions to regulate the forest industry.

Disaster Preparedness and Response Act, Chapter 145 of 2000

The Disaster Preparedness and Response Act are often referred to as the NEMO Act. This is an important legislation for coastal developments in the light of its hurricane risks. This legislation grants authority to NEMO as follows:

- (a) Review and assess the various programs and activities of the Government of Belize which have an impact on the mitigation of, preparedness for, response to and recovery from emergencies and disasters in Belize, and make recommendation to the Minister on the likely activities and programs on disaster preparedness and coordination;
- (b) Develop national policies to foster and promote the mitigation of, preparedness for, response to and recovery from emergencies and disasters in Belize;
- (c) Gather timely and authoritative information concerning the conditions and trends in the quality of the environment, both current and prospective, as these relate to the likelihood of disasters in Belize;

Environmental Impact Assessment

- The **Environmental Protection Act (EPA), Chapter 328, Revised Edition 2000**, legally established the Department of the Environment (DOE) which was formed in 1989. The EPA Act mandated the DOE to oversee all national environmental matters including urbanization, mining, petroleum development, agriculture and aquaculture. The EPA requires an Environmental Impact Assessment (EIA) to be prepared by all persons responsible to undertake projects that may significantly affect the environment and to follow the rules as set out in the EIA Regulations - **Environmental Impact Assessment Regulations, Environmental Impact Assessment (Amendment) Regulations, 2007**.
- Air emissions are regulated under the **Environmental Protection Act Chapter 328 Revised Edition 2003** of the Substantive Laws of Belize, “Chapter 238 Pollution Regulations”. This legislation prevents the emission and deposition of a contaminant from domestic, commercial, agricultural, recreational, industrial or any other source, without the issuance of a permit with conditions to do so. This permit is issued by the Department of the Environment. The law also regulates the discharge standards via emission standards. Emissions are in the form of particulate matter, sulfur dioxide, nitrogen oxides, and water pollutants. The Pollution Regulations do not specify standards for emissions that are specific to landfill or disposal sites. However, it does regulate the approval of a site to be used for treatment and final disposal of solid and liquid wastes. Regulation 6 (1) prohibits the direct emissions in general of contaminants from any industry. The emission of these contaminants requires permitting and licensing requirements; through a process of authorization and reporting.
- **The Environmental Protection (effluent limitations) Regulations, 1995**: Statutory instrument no. 94 of 1995 and its subsequent amendment of 2009 are key regulatory frameworks governing the discharge of effluents from industrial activities. The Effluent

Limitations Regulations came into effect in 1996. These regulations were enacted to control and monitor discharges of effluent into any inland waters or the marine environment of Belize. These Regulations prohibited the discharges of effluent from new and altered point sources and established a licensing system for discharging effluents under specific conditions. This meant that through the licensing system, industries would have to improve their treatment of effluents before discharging into the environment. The Effluent Limitations Regulations also established the requirement for the treatment of effluent, as well as limitations or standards for physical and chemical parameters to be monitored for various industries.

- **The Environmental Protection (Effluent Limitations) (Amendment) Regulations 2009 (S.I. 102 of 2009)** were amended to primarily include provisions for the treatment of domestic wastewater and the categorization of Class I and II Waters that differentiate waters with unique ecological characteristics that are sensitive to impacts of domestic wastewater from those that are less sensitive to the impact of domestic effluent. This amendment also made improvements for effluent standards for both industrial and domestic effluent. This legislation came into effect on August 8th 2009. As per this legislation “Industrial Effluent” means any liquid water or water discharged from any industrial or commercial premises. Each water type (Class I or II) has its limitations as per domestic discharge of effluents. Any person discharging domestic effluent into any of the above classes (I or II), is required to treat this domestic water as per the standards set in Schedule III, which defines the standards for discharge into both Class I and Class II waters. The requirements for a license to discharge effluents are met by the applicant filling in the form as specified in Schedule Five (Regulation 14 (2) (Form A) of the Effluent Limitations Regulations, 1995, and a license is issued as per (Form B) of the same Regulation 14 (2).
- **The Public Health Act (Chapter 40) Revised Edition 2000.** The Public Health Act empowers the Director of Health Services to make an inquiry into any matters in connection to public health and makes regulations for sanitation and prevention of nuisances from dirty properties or premises. The Director of Health Services and Public Health Officers may enter any premise within a reasonable time to inspect any premises within a Town or Village in order to ensure that health and sanitation of premises and property do not become a nuisance. The act also authorizes the Town or Village Councils, as well as any member of the Police Department to assist Public Health Officers in the inspection process. This also applies to nuisances caused by overgrown bushes in properties, and the keeping of excess refuse. This law also authorizes health officers to inspect premises in order to ensure that the property is kept in a sanitary manner.

Table 3.1: Environmental Licenses and Permits Required by the A. Donax Project

Agency	Legislation/License Permit	Highlights
Department of The Environment	Environmental Protection Act Chapter 328 Revised Edition 2000	Established the DOE with powers to control pollution (liquid and solid waste); control dumping of solid waste; regulate the movement of hazardous waste,
Department of The Environment	Environmental Impact Assessment (Amendment Regulations, 2007)	Regulates development through application of the EIA process. The vetting of EIAs is done by the National Environmental Appraisal Committee (NEAC) whose membership is listed in the EIA Regulations
Department of The Environment	Environmental Protection Act Chapter 328 Revised Edition 2003 of the Substantive Laws of Belize, “Chapter 238 Pollution Regulations”	Controls pollution by establishing emission standards for various industries; the act also allows for the control of dumping of waste at sea. This regulation will set standards for the air quality emissions of the Belcogen plant.
Department of The Environment	Environmental Protection (effluent limitations) Regulations, 1995, and the Environmental Protection Act Chapter 328 Revised Edition 2003	This regulation sets standards for effluent disposal, including from waste treatment facilities. An effluent discharge license should be applied for by the project.
Department of The Environment	Hazardous Waste Regulations 2009	Regulates the location of hazardous waste treatment centers; collection and transportation of hazardous waste, and classification of hazardous waste; and the prohibition of disposal and treatment of hazardous waste in poorly planned sites. Any hazardous material to be disposed of will require applying to the

Agency	Legislation/License Permit	Highlights
		DOE for approval.
<i>Central Building Authority</i>	Construction of Structures -No Objection for Construction of Buildings	<i>For installation of buildings</i>
Belize Electricity Limited	Access to Electricity	<i>May or may not be required for powering structures</i>
Ministry of Health and Public Health Department	Public Health Act (Chapter 40) Revised Edition 2000.	This act addresses general public health issues. It also authorizes the Public Health Officers to regulate nuisances, including refuse in premises. No license required by the project but this authority reserves the right to inspect work sites for health and safety.
Solid Waste Management Authority	Solid Waste Management Authority Act (Chapter 224) Revised Edition 2000	Established the SWMA, and the Board of Directors to govern the affairs of the SWMA. This agency authorizes the use and disposal of solid waste. Cooperation is being sought through consultation for a waste separation/recycling program.
Water Abstraction	National Integrated Water Resources Commission	Required in the future, if a well will be installed.
License for fire arms	Police Department	Security services personnel
Social Security Act/Social Security Board	Payment of Social Security Contributions	Required for all employees
Forest Department	Forest salvage license	Required to salvage timber from large trees (if any to be removed)

The requirements for a license to discharge effluents are met by the applicant filling in the form as specified in Schedule Five (Regulation 14 (2) (Form A) of the Effluent Limitations Regulations, 1995, and a license is issued as per (Form B) of the same Regulation 14 (2).

Table 3.2 Required standards for discharge of effluent into Class I waters.

Schedule III (Discharge into Class I Waters)	
Parameter	Effluent Limit
TSS	30 mg/L
BOD 5	30 mg/L
pH	5-10 ph Units
Fats, oil and grease	15 mg/L
Faecal coliform	200 mpn/100 ml
E. coli (freshwater)	126/100 ml
<i>Enterococci</i> (saline water)	35/100 ml

Source: The Environmental Protection (Effluent Limitations) (Amendment) Regulations 2009 (S.I. 102 of 2009).

3.3 Environmental and Social Safeguard Policies, Standards and Guidelines

As part of the analysis of the social institutional framework for the preparation of the ESIA, existing international policies, standards and guidelines were looked at specifically for the Green Climate Fund, World Bank, International Finance Corporation (IFC), Inter-American Development Bank (IDB), Caribbean Development Bank (CDB) and the World Health Organization. Following is a review and summary:

3.3.1 Green Climate Fund

The Arundo donax Renewable Bio-mass Fuel for Belize Project proposed activities fall with the context of the GCF Environmental and Social (ESS) Standards (IFC Standards). The general goal is expanding the utilization of biomass to meet some of the country's energy needs and achieve the dual aim of reducing the country's carbon footprint and adapting to climate change impacts. Through this project it is estimated that the total tons of CO² equivalent emissions avoided annually would be over 19309 (tCO₂).

- **Environmental and Social Policy**

GCF establishes this overarching Environmental and Social Policy (hereafter policy) that articulates how GCF integrates environmental and social considerations into its decision-making and operations to effectively manage environmental and social risks and impacts and improve outcomes. The policy is comprised of several components that include:

Objectives, Scope and Principles

- *Policy Objectives:* GCF effectively and equitably manages environmental and social risks and impacts and improves outcomes of all GCF-financed activities. This policy presents the commitments of GCF and articulates the principles and standards to which GCF will hold it accountable. The policy also articulates the commitments of GCF to sustainable development, elaborates how GCF integrates environmental and social issues into its processes and activities, and sets the roles and responsibilities including the requirements to deliver these commitments.
- *Scope of Application:* The policy applies to all GCF-financed activities and to both public and private sector entities. The activities supported by GCF may include programmes, projects and subprojects. The financial instruments may vary and may include grants, concessional loans, guarantees and equity investments. The Environment and Social Policy applies to three engagement levels which include the strategic and institutional level, at the entities level and at the activities level. Where accredited entities or implementing entities are implementing activities jointly with other institutions, GCF will encourage accredited entities and the other institutions to explore a common approach, for the assessment and management of the environmental and social risks and impacts.
- *Guiding Principle of the Environmental and Social Policy:* this is comprised of several principles that guide how the GCF will implement the ESMS and achieve the objectives of the policy. Some of these principles include: Integration of environmental and social sustainability, transboundary risk and impact approach, scaled risk-based approach, fit-

for-purpose approach, equality and non-discrimination, mitigation hierarchy and coherence, gender-sensitive approach, labour and working conditions, indigenous peoples, human rights, biodiversity and links with relevant policies and practices of GCF.

Overview of roles and responsibilities

Overview of GCF roles and responsibilities: Within the context of its mandate and consistent with its own policies, GCF will carry out the following roles and responsibilities to meet the objectives of this policy.

- Accreditation
- Managing environmental and social risks throughout the life cycle of GCF-financed activities.
- Information disclosure, stakeholder engagement and grievance redress

Overview of roles and responsibilities with respect to the accredited entities: GCF will take steps to ensure that the requirements of this policy are applied to both the development of activities and their implementation once approved.

- In the case of activities proposed for GCF financing, GCF will require the accredited entities to undertake all necessary measures. It will provide and implement the environmental and social management system to manage the environmental and social risks and impacts associated with the activities, allows meaningful and inclusive multi-stakeholder consultation and engagement throughout the lifecycle of activities.
- GCF will require the accredited entities to confirm that the measures to manage environmental and social risks and impacts, including, as relevant, information disclosure, stakeholder engagement, and grievance redress, are incorporated in the agreements with executing entities including tendering documents and contracts.
- GCF will require the accredited entities to take all necessary measures to ensure the compliance with all applicable laws, including the laws, regulations, and standards of the country in which the activities are located, and/or obligations of the country or countries directly applicable to the activities under relevant international treaties and agreements.
- Entities that are functioning as financial intermediaries are exposed to environmental and social risks through the activities of their borrowers, grantees, and investees. GCF will require the intermediaries to manage the environmental and social risks associated with the supported activities.

General requirements for environmental and social risk management

- Accreditation: GCF operates through accredited entities, including those functioning as financial intermediaries.
- Environmental and social management system: The accredited entities will put in place an effective environmental and social management system to assess the environmental and social risks and impacts associated with the activities and the means to subsequently manage these effectively and equitably. The environmental and social management

system of the accredited entities will be in accordance with the requirements of the GCF ESS standards and applicable policies of GCF.

- Screening and risk categories: GCF, pursuant to the ESS standards, requires accredited entities – whether their role is as an implementing entity or an intermediary entity – to screen activities that include programmes, projects and subprojects, and following the result of the screening, to assign appropriate risk categories consistent with their environmental and social management systems and the GCF ESS standards.
- Environmental and social due diligence: GCF will conduct its environmental and social due diligence as part of its assessment of activities proposed for funding consideration. The purpose of GCF due diligence is to understand and evaluate how the environmental and social, including transboundary, risks and impacts are screened, assessed and planned to be mitigated and managed by the accredited entities.
- Environmental and social assessment: GCF will require the accredited entities to undertake assessment of environmental and social, including transboundary risks and impacts to ensure that the activities proposed for GCF financing meet their environmental and social safeguards pursuant to the ESS standards of GCF and this policy.
- Operational changes: GCF will require the accredited entities to notify GCF when there are major changes in the activity design and execution, policy, and regulatory setting, receiving environment and community, unanticipated environmental risks and impacts, or other circumstances that raise or potentially raise the environmental and social risk category of GCF-financed activities.
- Monitoring and reporting: GCF, through its Secretariat, will carry out monitoring and reporting functions related to the environmental and social performance of the accredited entities and the supported activities as required in the GCF monitoring and accountability framework.

Information disclosure, stakeholder engagement, and grievance redress

- Information disclosure: The Governing Instrument affirms that GCF will operate in a transparent and accountable manner guided by the principles of efficiency and effectiveness.
- Stakeholder engagement: GCF will require accredited entities, including intermediaries, to ensure the effective engagement of communities and individuals, including transboundary, vulnerable and marginalized groups and individuals that affected or potentially affected by the activities proposed for GCF financing.
- Grievance redress mechanisms: The approach of GCF is to provide for grievance and redress at GCF, accredited entity, and activity levels.

Other Relevant Activities

Readiness support

Is a funding programme that enhances the countries ownership/access to the Fund, provides resources for firming the institutional capacities of NDAs, focal points and Direct Access Entities to engage with the Fund through grants or technical assistance. The aim is to help vulnerable countries, including Least Developed Countries (LDCs), Small Island Developing

States (SIDS), and African States. The Readiness Programme may provide up to USD 1 million per country per year of which NDAs or focal points may request up to USD 300,000 per year to help establish or strengthen an NDA or focal point by the Fund's requirements.

The GCF Board has distributed up to USD 3 million per country for the formulation of national adaptation plans and/or other adaptation planning processes by NDAs or focal points, which set priorities to address adaptation to climate change. Furthermore, GCF can provide capacity building for national or regional organizations that are nominated by their local NDAs. Support can be provided to an entity to seek accreditation with the Fund, including the fast-track accreditation process, which can be used to build the capacities of Direct Access Entities that are already accredited.

Readiness funds will be allocated in coordination and approval of, the relevant NDAs/ focal points.

Programme Outcomes

1. Strengthening country capacity

Support for building the capacity of the developing countries NDAs or focal points with outcomes including strengthened coordination mechanisms, establishing 'no objection' procedures, and ensuring the monitoring, oversight and streamlining of climate finance.

2. Engaging stakeholders in consultative processes

Support the development of stakeholder's engagement based on the country's priorities. This includes support for the development of that country's programme which identifies priorities for engagement with GCF, and annual reviews of the GCF portfolio.

3. Direct access

Support activities of Direct Access Entities including: accreditation of Direct Access Entities, post-accreditation support, and the development of work programmes for accredited entities. It is made to help national and regional entities with assessments of their institutional capacity, fiduciary, Environmental and Social Safeguards (ESS) and gender standards that meet GCF accreditation standards.

Along with PwC, a consultancy firm, GCF has signed a service contract to provide technical assistance to Direct Access Entities seeking accreditation which can be provided in any region, NDAs can also access it to ensure delivery of a package of support to Direct Access Entities. Outputs include an in-depth assessment of the entity, followed by support to create an action plan to help with preparation to apply for accreditation.

4. Access to finance

The Programme recognizes outcomes that can access climate finance in developing countries which can include ensuring that programmes implement high-impact priorities recognized in Intended Nationally Determined Contributions (INDCs) and other national strategies, as well as ensuring alignment of funding proposals, which includes adaptation with the country's priorities.

5. Private sector mobilization

Support can cover measures to gather private/capital market financing for the programmes, and enable private sector input in public-private partnerships. The outcomes may include engaging the private sector in the consultative process, approving private sector funding proposals, and creating enabling environments for investments.

Accreditation Process

GCF organizes climate finance by working with organizations, those organizations that have specialized capacities in climate action can apply to become GCF Accredited Entities. They can be private, public, non-governmental, sub-national, national, regional or international bodies. They should have clear, detailed and actionable climate change projects/programmes to present to GCF progressing mitigation and adaptation as well as meet GCF standards based on financial standards, environmental and social safeguards, and gender. Those who are accredited develop funding proposals to be considered by the Fund and oversee, supervise, manage and monitor their respective GCF-approved projects/programmes.

There are two types of GCF Accredited Entities: Direct Access Entities and International Access Entities.

- Direct Access Entities are sub-national, national or regional organizations that are nominated by developing countries (NDAs) or focal points. Organizations nominated can be eligible to receive GCF readiness support. This funding prepares organizations in developing countries to become Accredited Entities, as well as helping those that have been accredited strengthen their capacities.
- International Access Entities can include United Nations agencies, multilateral development banks, international financial institutions and regional institutions. GCF considers these organizations to have the reach and expertise to handle a variety of climate change issues, including those crossing borders and thematic areas. They do not need to be nominated by developing countries NDAs / focal points.

Project preparation

The Project Preparation Facility (PPF) supports Accredited Entities in project/programme preparation; its aim is to support entities, and micro-to-small size category projects. From it a total of USD 40 million has been made available for the initial phase, with requests subject to a cap of USD 1.5 million. Support will be equal to the funding proposal being developed, and to the activities in the PPF application.

If approved, support is granted in the form of grants and repayable grants, equity may be considered for private sector projects. Funding proposals with the PPF should be submitted to the GCF Board within two years of the approval of a PPF request.

Project preparation includes the early stage of project identification, concept development and establishing the enabling environment, then the mid- and late-stage which includes project due

diligence and project structuring. Each phase has different needs; therefore, it is important to review the outstanding requirements of project as well as assess the type of support it will require.

PPF support is limited to the following activities:

1. Pre-feasibility and feasibility studies, as well as project design;
2. Environmental, social and gender studies;
3. Risk assessments;
4. Identification of programme/project-level indicators;
5. Pre-contract services, including revision of tender documents;
6. Advisory services and/or other services to financially structure a proposed activity;
7. Other project preparation activities provided that sufficient justification is available.

The PPF application must include a clear paragraph explaining how the project fits in with the country's priorities and ensures full country ownership. Due to this the accredited entities should consult with the respective (NDA) or focal point on the project or programme at an early stage.

Project funding

GCF does not implement projects itself, but through partnerships with Accredited Entities. The Fund utilizes financial tools to realise these projects which includes grants, concessional debt financing, equity and guarantees. Accredited Entities cover the core of GCF's funding proposal cycle, they are responsible for presenting funding applications to GCF, and overseeing, supervising, managing and monitoring the approved projects and programmes however they do not need to act as direct implementers of funding proposals. Executing Entities can do this on behalf of that Accredited by channelling funds and carrying out the funded activity. Through this Accredited Entities maintain oversight of Executive Entities' GCF-related activities.

GCF project approval is based on supporting developing country's priorities; those countries nominate the NDAs or focal points to act as communicators with GCF. Every project agreed to be funded must be endorsed, and expressed via a no objection letter, by the NDA or focal point.

GCF identifies that developing countries may face constraints in developing climate finance proposals; hence they established the Project Preparation Facility to support Accredited Entities preparing projects and programmes. The facility is targeted to support Direct Access Entities, and micro-to-small size category projects.

Generation of Funding Proposals

Accredited Entities develop funding proposals, with consultation of NDAs or focal points, based on the differing climate finance needs of specific developing countries. Accredited Entities sometimes take requests for Proposals issued by GCF to fill gaps in climate financing. GCF may accept proposals from entities not accredited; those non-accredited entities however will have to team-up with Accredited Entities when formally submitting proposals to GCF, those that submit proposals through the Requests for Proposals can be prioritized when applying for accreditation.

Requests for Proposals:

1. Micro- Small-, and Medium-Sized Enterprises Pilot Programme

The enterprises pilot programme was established by the GCF Board in 2016 as part of the Private Sector Facility. The programme aims to support micro-, small-, and medium-sized Enterprises in addressing mitigation and adaptation challenges.

2. Enhancing Direct Access

The GCF Board approved an initial allocation of USD 200 million for 10 pilots funding proposal adopting Enhance Direct Access implementation modalities.

3. Mobilising Funding at Scale Pilot Programme

The GCF Board has gotten up to USD 500 million for the Mobilising Funding at Scale Pilot Programme to identify innovative, high-impact projects and programmes that mobilize private sector investment in climate change activity.

Simplified Approval Process

Some small-scale projects may be submitted for consideration under the Simplified Approval Process (SAP). Under the SAP, the documentation and review processes for bringing projects/programmes implementation are reduced and simplified. Accredited Entities, NDAs or Focal Points and their partners may submit concept notes under the SAP if the project or programme meets three main eligibility criteria:

- Ready for scaling up and have the potential for transformation, promoting a paradigm shift to low-emission and climate-resilient development;
- A request for financing to the GCF of up to USD 10 million of the total budget;
- Environmental and social risks and impacts are classified as minimal to none.

Implementing projects

The first step in project implementation is an agreement made between GCF and the implementing Accredited Entity, on the legal measures to get the funds flowing called a Funded Activity Agreement (FAA). The GCF then transfers financial assistance to the Accredited Entity through a loan, grant, equity, or guarantee, of which GCF completes a series of financial disbursements during the project duration.

This allows GCF to assess the impacts of the climate finance initiatives and monitor its efficient and effective delivery. The assessments are done to ensure the projects are effective in dealing with climate change, and do not causes negative effects.

During implementation Accredited Entities should comply with grant conditions and covenants, while also observing the implementation schedule of the project, this is done to ensure timely implementation by the Accredited Entities and enable additional disbursements by GCF. The GCF maintains an overview of the project progress through its requirement for Accredited

Entities to produce evaluation reports at regular intervals, this includes one at the mid-point of the project, and a final evaluation after the project has closed.

3.2.2 IDB Environmental and Social Safeguards and policies

The environmental and social impacts caused by the implementation of the climate change project are hereinafter assessed following the suggestions of the IDB Policies and Directives listed below:

- Environmental and Safety Compliance Policy Directive B1 “Bank Policies”;
- Environmental and Safety Compliance Policy Directive B2 “Country Laws and Regulation”;
- Environmental and Safety Compliance Policy Directive B3 “Screening and Classification”;
- Environmental and Safety Compliance Policy Directive B5 “Environmental Assessment Requirements”;
- Environmental and Safety Compliance Policy Directive B6 “Consultations”;
- Environmental and Safety Compliance Policy Directive B7 “Supervision and Compliance”;
- Environmental and Safety Compliance Policy Directive B9 “Natural Habitats and Cultural Sites”;
- Environmental and Safety Compliance Policy Directive B10 “Hazardous materials”;
- Environmental and Safety Compliance Policy Directive B11 “Pollution Prevention and Abatement”;
- Public Information and Disclosure Policy (OP-102);
- Disaster Risk Management Policy (OP-704);
- Gender Equality in Development Policy (OP-761);
- Indigenous Peoples Policy (OP-765); and
- Resettlement Policy (OP-710).

IDB Policies Applicable to the Proposed Climate Change Project

Policy Directive B1 “Bank Policies”. According to this Policy, the Bank will only finance operations and activities that comply with the directives of its Policy, and consistent with the relevant provisions of other Bank policies. The Bank also has sectoral policies, particularly those sectors that can generate significant impacts, or are affected by the environment. Among these sectoral policies, are the Energy (OP-733) policy and the Electric Energy Policy (OP-733-1). The proposed climate change project will be guided under these policies.

Policy Directive B2 “Country Laws and Regulation”. This Policy requires the borrower of the operations to ensure that they are designed and carried out in compliance with environmental laws and regulations of the country where the operations should be implemented. These regulatory provisions with the Belizean laws and Regulation are discussed in Section 3.2.

Policy Directive B3 “Screening and Classification”. According to this policy directive, all the operations financed by the Bank must be screened and classified according to their potential environmental impacts with the aim to select the appropriate level of environmental assessment to be prepared. Safeguard categorization is determined according to the following considerations:

Category A: An operation will be classified as Category “A” when it is likely to cause significant negative environmental and associated social impacts, or have profound implications affecting natural resources. These projects will require an Environmental Impact Assessment (EIA).

Category B: Operations are those that are likely to cause mostly local and short-term negative environmental and associated social impacts and for which effective mitigation measures are readily available will be classified as “B.” These projects will require an environmental and/or social analysis, focusing on specific issues identified during the screening process. This will also require an environmental and social management plan.

Category C: Those operations that are likely to cause minimal or no negative environmental and associated social impacts will be classified as Category C. For the most part, these are operations that do not involve works or result in physical modification of the environment. These operations do not require an environmental or social analysis beyond the screening and scoping analysis but will require the establishment of safeguards and monitoring requirements. The provisions of the present proposed project may be classified in the *Category C*, but a final determination is done using the *Associated Facilities Decision-Making Tree*”.

Policy Directive B5 “Environmental Assessment Requirements.” According to this Policy Directive, the Preparation of Environmental Assessments (EA) and associated management plans and their implementation are the responsibility of the borrower. The Bank will require compliance with specified standards for Environmental Impact Assessments (EIAs). In order to manage Environmental and Social (E&S) impacts and risks, an Environmental Assessment Environmental and Social Environment Plan for the proposed project was prepared in summary. Project development will require a more in-depth E&S, with social inclusion plan.

Policy Directive B6 “Consultations” According to this Policy Directive, as part of the environmental assessment process, Category “A” and “B” operations will require consultations with affected parties and consideration of their views. If the proposed project falls within the *Category B*, then this Directive requires at least one consultation with affected parties, preferably when the impact assessment is being reviewed, in order to inform, gather comments, and adjust the assessment and the corresponding environmental and social management plan. Consultations should provide, at a minimum, information to affected parties and a dialogue regarding the project scope and proposed mitigation measures.

Policy Directive B7 “Supervision and Compliance.” According to this Policy Directive, the Bank will monitor the borrower’s compliance with all safeguard requirements stipulated in the loan agreement. The ESMP, included in the present EA, provides the safeguard, mitigation and monitoring measures for being incorporated in the loan agreement.

Policy Directive B9 “Natural Habitats and Cultural Sites”. According to this Policy Directive, the Bank will not support operations that, in its opinion, significantly convert or degrade critical natural habitats or that damage critical cultural sites. It should be noted that the proposed projects none of the sites fall within these categories. The sites are already existing sites, and the impacts are outside of any protected areas.

Policy Directive B10 “Hazardous materials” According to this Policy, Bank-financed operations should avoid adverse impacts to the environment and human health and safety occurring from the production, procurement, use, and disposal of hazardous material, including organic and inorganic toxic substances, pesticides and persistent organic pollutants (POPs). As per the provisions of the proposed project, it is not anticipated that any hazardous materials will be used, as far as possible, in the construction of the facilities envisaged and the planting of the mono crop. Moreover, the EIA provides directives for recycling of the hazardous waste, potentially collected at from the use of old batteries avoiding any risk for the health of the workers and for the environment.

Policy Directive B11 “Pollution Prevention and Abatement” Following this Policy Directive, the Bank-financed operations will include as appropriate, measures to prevent, reduce or eliminate pollution emanating from their activities. The Bank requires clients to follow source-specific emission and discharge standards recognized by multilateral development banks. Taking into account local conditions and national legislation and regulations, the environmental assessment report or environmental and social management report will justify the standards selected for the particular operation. This policy also calls for the agreed mitigation measures for the Bank to require that the borrower “where feasible and cost effective, adopt cleaner production processes, energy efficiency or renewable energy. “The bank also “encourages the reduction and control of greenhouse gas (GHG) emissions in a manner appropriate to the nature and scale of operations” (IDB, 2011). Both the policy for adopting cleaner technology and the reduction of greenhouse gases are characteristics of the climate change proposed alternative energy project.

Access to Information Policy

The policy requires that the Bank make publicly accessible information that it creates and certain information it receives during the course of doing business, provided the information is not contained on a list of Exceptions or subject to negative override as described elsewhere. The IDB will disclose documents and information on the Bank’s web site as the principal means of disclosing information (IDB, 2011).

IDB Disaster Risk Management Policy

According to the scope of this Policy, the policy provides two lines of actions as follows:

- (i) The prevention and mitigation of disasters that occur as a result of natural hazards, through programming and proactive project work at regional, national and local levels; and
- (ii) Post disaster response to the impacts of natural hazard events, and physical damage (such as structural collapse and explosions), resulting from technological accidents or other types of disaster resulting from human activity.

IDB Policy on Social Matters - OP 710

OP-710, on Involuntary Resettlement (1998), applies to all situations in which people are physically displaced or lose their source of livelihood (fisheries, agricultural land, employment, business outlets, etc.) as a result of land acquisition. The policy applies, for example, in situations in which people lose agricultural land or small businesses, whether or not their housing is not affected. The basic considerations of the Policy also apply where people are temporarily displaced. In the event a loan agreement would be signed by the Government of Belize (GOB) and IDB, the IDB policy OP-710, on Involuntary Resettlement would apply to the Project financed by the loan. The key principles of the Policy are:

- Avoid or minimize the need for resettlement.
- Ensure that the affected population can achieve an equivalent or improved standard of living within a reasonable time
- Fully compensate all transitional losses. These include all legal costs, transport costs and loss of income resulting from displacement.
- Minimize the disruption of social networks and economic opportunities. As far as possible the affected population should be encouraged to maintain their social networks.
- The project should provide opportunities for development. Wherever possible, the affected population should be the first to benefit from the opportunities provided by the project.
- Vulnerable Groups. It is particularly important to ensure that vulnerable groups are adequately protected. They include poor ethnic minorities, such as indigenous peoples, Landless rural poor, and small farmers or squatters who lack full legal title to the land they use or occupy.

Key requirements of the Policy include:

Preparation of a Plan. When displacement is unavoidable, a Resettlement Plan must be prepared to ensure that the affected people receive fair and adequate compensation and rehabilitation.

Dimension. When the number of people to be resettled is very small, the affected group is not vulnerable, or the institutional setting and the marketplace offer reasonable opportunities for the replacement of assets or income, and intangible factors are not significant, a resettlement plan as such may not need to be prepared, and relocation addressed instead prior to the project through mutually agreed contractual covenants.

Compensation. Appropriate compensation and rehabilitation options must provide a fair replacement value for assets lost, and the necessary means to restore subsistence and income, to reconstruct social networks and compensate for transitional hardships.

Livelihoods. OP-710 may be (and is, in the context of current global good practice) broadly interpreted to cover both physical and economic displacement, including impacts on income and means of livelihood. Specifically, livelihoods should be restored to the pre-resettlement standard.

Consultation. Preparation of a resettlement plan should include consultations, carried out in a timely and socio-culturally appropriate manner, with a representative cross-section of the displaced and host communities, to begin in the design phase and continue throughout the execution and monitoring of the plan.

Indigenous Communities. Indigenous communities may only be affected where: (1) Resettlement will result in direct benefits to the affected community relative to their prior situation; (2) customary rights are fully recognized and fairly compensated; (3) compensation options include land-based resettlement; and (4) affected persons have given their informed consent to the resettlement and compensation measures.

Vulnerability. Care should be taken to identify the most vulnerable subgroups and ensure that their interests are adequately represented in this process.

Monitoring and Evaluation. The resettlement component must be covered in the progress reports on the overall project. Monitoring and evaluation requirements and their timing must be specified in the resettlement plan and loan agreement.

Adherence to highest standard. Particularly for projects that fall within the designated Environmental Assessment (EA) category “C”, which implies the highest environmental and/or social impacts, and thus requires the undertaking of a Social Assessment of any relevant livelihoods activities and adherence to the highest possible standards of impact management and mitigation under the Policy. In cases in which Belizean law and practice differ from IDB policy, special Project-specific arrangements have been developed under this plan to ensure compliance with the higher standard. IDB Specialists will provide technical assistance and monitoring as necessary to ensure that the project fully complies with the requirements of both Belizean Law and IDB policy.

3.3.3 International Finance Corporation (IFC) Environmental and Social Due Diligence Process

The International Finance Corporation (IFC) is a sister organization of the World Bank and member of the World Bank Group. It is described as the largest global development institution focused exclusively on the private sector in developing countries (IFC, 2016, www.ifc.org). The International Finance Corporation, IFC, has a series of screening steps and procedures to guide investments throughout the life of the project in order to ensure environmental and social due diligence. The IFC follows a series of steps outlined as follows:

A) Review and Agree on Next Steps

The client receives copies of: IFC’s Performance Standards, relevant World Bank Group Environmental, Health and Safety (EHS) Guidelines, and Other supporting documents. The IFC Environmental and Social (E&S) team then: Asks the client to provide key information regarding assets and management of E&S risks and impacts. They then assess the project against the Performance Standards and EHS Guidelines. They May meet with company, government, and local stakeholders to discuss E&S aspects of the project. They then

generate an E&S Review Summary (ESRS) and an E&S Action Plan (ESAP). The ESRS and ESAP are reviewed and approved by the client.

B) Publicly disclose the project and consult with local community

IFC discloses its ESRS along with relevant sponsor E&S documentation on the IFC website. The client discloses project E&S assessment information locally. Projects will engage and consult with Affected Communities to ensure their awareness of the project and provide for an ongoing constructive relationship. For projects with potential significant adverse impacts on Affected Communities and projects involving Indigenous Peoples, IFC will make a determination of the level of community support for the project.

C) Finalize the investment agreement.

Once the World Bank Group Board of Directors approves the project, the investment agreement is mutually agreed and finalized. The final agreement reflects the terms of the ESAP plus any other E&S commitments. Funds are disbursed once the client meets disbursement conditions.

D) Ongoing monitoring and Disclosure.

Monitoring occurs on two levels: Site visits from IFC staff and submission of the client's Annual Monitoring Report on progress in meeting the E&S terms of the investment agreement. Engagement between the client and Affected Communities should be ongoing. IFC will disclose the client's progress against the ESAP. During monitoring, IFC and the client may identify opportunity for project enhancement through IFC Advisory Services. IFC's Compliance Advisor/ Ombudsman (CAO) may also provide additional oversight. The CAO is an independent office that impartially responds to E&S concerns of Affected Communities and aims to enhance IFC accountability and outcomes. The IFC has a series of performance standards on environmental and social accountability. These are summarized in the table below.

Table 3.3: IFC Performance Standards on Environmental and Social Sustainability.

Performance Standards on Environmental and Social Sustainability.	
Performance Standard 1: ASSESSMENT AND MANAGEMENT OF ENVIRONMENTAL AND SOCIAL RISKS AND IMPACTS Underscores the importance of identifying E&S risks and impacts and managing E&S performance throughout the life of a project.	Performance Standard 5: LAND ACQUISITION AND INVOLUNTARY RESETTLEMENT Applies to physical or economic displacement resulting from land transactions such as expropriation or negotiated settlements.
Performance Standard 2: LABOR AND WORKING CONDITIONS Recognizes that the pursuit of economic growth through employment creation and income generation should be balanced with protection of basic rights for workers.	Performance Standard 6: BIODIVERSITY CONSERVATION AND SUSTAINABLE MANAGEMENT OF LIVING NATURAL RESOURCES Promotes the protection of biodiversity and the sustainable management and use of natural resources.
Performance Standard 3: RESOURCE EFFICIENCY AND POLLUTION	Performance Standard 7: INDIGENOUS PEOPLES Aims to ensure that the

PREVENTION Recognizes that increased industrial activity and urbanization often generate higher levels of air, water and land pollution, and that there are efficiency opportunities.	development process fosters full respect for Indigenous Peoples.
<i>Performance Standard 4: COMMUNITY HEALTH, SAFETY AND SECURITY</i> Recognizes that projects can bring benefits to communities but can also increase potential exposure to risks and impacts from incidents, structural failures, and hazardous materials.	<i>Performance Standard 8: CULTURAL HERITAGE</i> Aims to protect cultural heritage from adverse impacts of project activities and support its preservation.

Benefits of performance Standards.

The IFC lists several benefits of implementing the Performance Standards, which helps companies identify and guard against interruptions in project execution, legal claims, brand protection, and accessing international markets. The following are listed of benefits of these standards:

- 1) **IMPROVE FINANCIAL AND OPERATIONAL PERFORMANCE.** IFC believes that meeting the Performance Standards helps clients improve their bottom line. Implementation of the Standards can help optimize the management of inputs such as water and energy, and minimize emissions, effluents, and waste, leading to a more efficient and cost-effective operation.
- 2) **SOCIAL LICENSE TO OPERATE.** In addition, the Standards help clients find ways to maximize local development benefits and encourage the practice of good corporate citizenship. This often results in greater acceptance of the project by local communities and governments, allowing companies to acquire a social license to operate. Enhanced brand value and reputation may also be attractive to new investors or financiers.
- 3) **GAIN AN INTERNATIONAL STAMP OF APPROVAL.** According to IFC, the “Equator Principles,” which have been adopted by more than 70 of the world’s leading investment banks in developed and developing countries are based on IFC’s Performance Standards. These principles are estimated to cover nearly 90% of project financing in emerging markets.

Environmental, Social and Corporate Governance

The IFC has a specific department called IFC’s Environment, Social and Governance Department (CES) that oversees the integration of environment, social and corporate governance and activities supporting investment. The CES is supported by the Investment Support Group of CES that is responsible for the E&S due diligence and supervision of IFC’s investment projects. The support group is led by senior staff and senior environmental and social expert.

Categories of Projects

IFC has three main categories for designation of environmental requirements. The environmental and social category serves as an indication of the nature and extent of potential E&S impacts that the project is expected to have and indicates the IFC institutional disclosure requirements. The categories are defined as follows;

Categorization assigning category A, B, or C to mainstream or FI-1, FI-2 or FI-3 to FI investment projects.

Category A Projects with potential significant adverse social or environmental impacts that are diverse, irreversible, or unprecedented.

Category B Projects with potential limited adverse social or environmental impacts that are few in number, site-specific, largely reversible, and readily addressed through mitigation measures.

Category C Projects with minimal or no adverse social or environmental impacts. Environmental and Social assessments are then prepared using the Environmental Health and Safety Guidelines. These guidelines are technical reference documents with general and industry-specific examples of Good International Industry Practice, defined in PS 3 on Pollution Prevention and Abatement. The general EHS Guidelines contain information on cross-cutting EHS issues potentially. There is also an Environmental and Social Action Plan (ESAP) that is one of the outcomes of the assessment.

The ESAP will also include a comprehensive The Environmental and Social Management System. This is the documented or implemented assessment and management elements that enable the client to meet the requirements of the IFC PS, including policy and procedure, E&S assessments and implementation, organization structure, E&S management program, technical and management capacity, training, community relationships, financial resources, E&S monitoring, and reporting.

Part of the compliance monitoring is done through the Environmental and Social Review Document (ESRD) that covers analysis, and decision-making from due diligence through supervision until the project is closed. The ESRD will include E&S ratings of the Performance Standards and tracking of project attributes; a subset of this will be incorporated in the DOTS.

The Lead Environmental or Social Specialist (LESS) is responsible for leading and managing the E&S review of a proposed investment in collaboration with the Support E&S Specialist (SESS) and as needed other E&S environmental specialist(s) on the project team. For category A and B projects, the LESS should prepare a draft ESRS summarizing IFC's E&S appraisal findings. No ESRS is required for category C projects. The ESRS should present a succinct summary of the review and assessment of the E&S impacts associated with the project and how they are or will be mitigated by the project.

Consultation

In addition to one on one consultation and public consultation meetings, IFC requires that an Environmental and Social Review Summary is prepared. This is the document through which IFC publicly discloses how the E&S aspects of a project were reviewed and the rationale for categorization. It includes a description of the main E&S risks and impacts of the project, and the key measures identified to mitigate those risks and impacts, specifying any actions needed to undertake the project in a manner consistent with the PS and that will be included in the client's Action Plan. The ESRS is written for a general public audience.

Financial Intermediary Investments: Early Review and Appraisal

This procedure specifies the environmental and social (E&S) review process for financial intermediary (FI) investments leading up to the Investment Review Meeting (IRM). ESRP 8 covers the remaining appraisal related steps from disclosure to commitment.

Procedure: Nomination of Responsible Sector Lead (SL) and Lead Environmental and Social Specialist (LESS): The CES SL is determined based on the Industry Department leading the transaction. The Regional Team Leader (RTL) and SL will determine the LESS. Where the FI investment involves multiple Industry Departments, the Financial Institutions Group (FIG) SL will discuss with the SL serving the other Industry Department the assignment of the LESS.

Categorization: Once the appraisal is completed, the LESS will categorize the investment as FI-1 (high), FI-2 (medium) or FI-3 (low). The categorization will be commensurate with the E&S risk profile of the existing and/or proposed portfolio and will take into account the tenor, type, size and sector exposure of the portfolio, and be guided by the Tip Sheet Compendium³ and IFC's Policy on Environmental and Social Sustainability, as follows:

- Category FI-1: when an FI's existing or proposed portfolio includes, or is expected to include, substantial financial exposure to business activities with potentially significant adverse environmental or social risks or impacts that are diverse, irreversible, or unprecedented.
- Category FI-2: when an FI's existing or proposed portfolio comprises, or is expected to comprise of, business activities that have potentially limited adverse environmental and social risks or impacts that are few in number, generally site-specific, largely reversible, and readily addressed through mitigation measures; or includes a very limited number of business activities with potentially significant adverse environmental or social risks or impacts that are diverse, irreversible, or unprecedented.
- Category FI-3: when an FI exists or proposed portfolio includes financial exposure to business activities that predominantly have minimal or no adverse environmental or social impacts.

3.3.4 The Caribbean Development Bank

The Caribbean Development Bank, CDB, was formed by member countries in 1970. According to the CDB's "Agreement to Establish the Caribbean Development Bank as Amended" dated August 2007 (Reprint August 2007), the purpose of the Bank shall be to contribute to the

harmonious economic growth and development of the member countries in the Caribbean (hereinafter called the "region") and to promote economic co-operation and integration among them, having special and urgent regard to the needs of the less developed members of the region. Among other things, the bank will promote public and private investment in development projects by, among other means, aiding financial institutions in the region and supporting the establishment of consortia.

CDB Belize Country Strategy

The CDB has developed a Belize Country Strategy for the period 2016 to 2020 (Caribbean Development Bank Staff Report Country Strategy Paper 2016-2020). Within this framework strategy, the Bank's policy includes the support for renewable energy projects. According to this report, relatively high energy intensity is a characteristic of the country of Belize when compared to some other countries in the Americas and the Caribbean Region, and is among the top third in the world for fuel consumption per capita (Energy intensity is defined as energy consumption per unit of GDP). It also states that The Belize National Sustainable Energy Strategy 2012-2033, established a framework to transition the energy sector and the economy toward low-carbon development. It further states that "given the country's abundance of indigenous energy resources, there is scope for the proportion of RE in the energy mix to be increased."

CDB Environmental and Social Review Procedures

The Environmental and Social Review Procedures (ESRP), (CDB, 2014), outlines how the social and environmental and social risks within the CDB mandate are managed. The ESRP includes eight environment and social performance standards that reflect the principles, core policies, standards and best practice approaches adopted and used in the treatment of sensitive environmental and social issues by the multilateral financial and development community. The objectives of the performance requirements (PR) are to:

- a) optimize decision making with respect to environment and social impacts, and risks to anticipate, avoid, mitigate, and/or compensate for adverse project impacts on the environment and affected people and communities;
- b) Assist BMCs to build capacity and strengthen their institutions and governance systems to effectively manage environmental and social risks; and,
- c) Provide staff, BMCs and other development partners with a clear understanding of the CDB's requirements, and procedures, accountabilities for managing environment and social risks in its operations.

The Environmental Sustainability Unit (ESU) of the Projects Department has responsibility for the updating and revision of the ESRP, for the development of other environment and social operational policies/procedures, guidance in the training of staff in their use, as well as for providing general guidance on these issues.

Environment and Social Performance Requirements ESRP

To achieve the objectives of the ESRP, the Bank has adopted eight *Performance Requirements* (PR) that define the principles and objectives for addressing the treatment and management of environment and social issues. The PR are mainly based on the “Good Practice Note - A Common Framework for Environmental Assessment (2005)”, prepared by the Multilateral Financial Institutions Technical Environment Working Group. The Development Assistance Committee of the Organization for Economic Cooperation and Development, has endorsed the document as the basis for convergence of environmental and social requirements with respect to institutional requirements, processes, and practices for development projects, have endorsed this document.

The ESRP and associated PR apply to all CDB financing and non-financing operations and to both the public and private sector operations. Environmental and social appraisal is integrated in CDB’s wider due diligence and project appraisal process with the scope of the appraisal determined by initial screening and categorization on a “case by case” basis. The objectives, principles, and scope of the PR listed below:

- a) Pollution Prevention, Control and Management.
- b) Toxic and Hazardous Substances Control and Management.
- c) Physical Cultural Property.
- d) Natural Habitats and Biodiversity Conservation.
- e) Directly Affected Communities.
- f) Vulnerable Groups.
- g) Land Acquisition and Resettlement.
- h) Community, Worker Health and Safety.

CDB will not finance projects that do not meet its environment and social PR as defined in this ESRP. At a minimum, all projects financed with CDB’s resources must meet the applicable national environment and social legislation. However, CDB’s requirements may exceed that required under a specific BMC’s legislation.

All new projects must be structured and designed to meet applicable PR, throughout all phases of the project cycle. In the financing of projects, which are already operational and which do not meet the PR, CDB will work with the Borrower to develop an action plan or work programme to achieve compliance for a defined outcome that is satisfactory to the Bank.

CDB is committed to work with other development partners and BMCs to promote the principles and enable the effective implementation of international law governing environment and social PR as set out in the multilateral environment and social agreements, and will cooperate and collaborate with its development partners through co-financed programmes and projects or other collaborative arrangements designed to promote sustainable development. CDB will not finance projects that contravene BMCs obligations under international environment or social agreements.

Monitoring and Reporting

The Borrower is responsible for preparing and implementing programmes and projects financed by the Bank. The borrower is also responsible for meeting the environment and social PR as set

out in legal agreements between the Bank and the Borrower. CDB will work with Borrowers to assist them to meet these responsibilities. Where there are deficiencies in a Borrower's capacity that could hinder their ability to satisfy these requirements, the Bank will provide direct technical assistance (TA) or cooperate and collaborate with third parties such as other development partners, other financiers, technical institutions or non-government organizations (NGOs) to ensure the successful outcomes of programmes or projects. Borrowers are required to monitor and report to the Bank on their compliance with the ESRP requirements. CDB will also monitor Borrower's compliance through site visits, or through independent monitoring arrangements. Persistent non-compliance with ESRP obligations by the Borrower could have financial and legal consequences based on the provisions of the loan agreement.

Stakeholder Participation

The Bank recognizes the value a well-informed and engaged public can bring to the development process and contribute to the attainment of the BMC's sustainable development objectives. CDB is therefore committed to the principle of corporate transparency, accountability and stakeholder engagement, and BMCs are encouraged to adopt and promote these principles. CDB will report on its performance in the application of the ESRP and other activities related to the environment and social dimensions of its operations in its Annual Report.

The Bank will work to promote meaningful dialogue and participation on environment and social issues through its policy dialogue with BMCs as well as in its financing operations. The ESRP requires that Borrowers initiate early engagement, participation, consultations and disclosure of information to parties likely to be affected by significant negative impacts from the investments projects it finances. The level and nature of stakeholder engagement and participation will vary depending on the project, and Bank staff will work with Borrowers to determine the level of consultation and disclosure of information necessary to meet the Bank's requirements.

3.4 International and Regional Legislation and Policies

3.4.1 World Health Organization

WHO, works worldwide to promote health, keep the world safe, and serve the vulnerable populations. Its goal is to ensure that a billion more people have universal health coverage, to protect a billion more people from health emergencies, and provide a further billion people with better health and well-being.

For universal health coverage, it:

- focus on primary health care to improve access to quality essential services
- work towards sustainable financing and financial protection
- improve access to essential medicines and health products

- train the health workforce and advise on labor policies
- support people's participation in national health policies
- improve monitoring, data and information.

For health emergencies, it:

- prepare for emergencies by identifying, mitigating and managing risks
- prevent emergencies and support development of tools necessary during outbreaks
- detect and respond to acute health emergencies
- support delivery of essential health services in fragile settings.

For health and well-being, it:

- address social determinants
- promote intersectoral approaches for health
- prioritize health in all policies and healthy settings.

Through our work, it addresses:

- human capital across the life-course
- non-communicable diseases prevention
- mental health promotion
- climate change in small island developing states
- antimicrobial resistance
- elimination and eradication of high-impact communicable diseases.

Country Accountability Framework

A tool for assessing and planning implementation of the country accountability framework for health with a focus on women's and children's health

- Monitor
- Review
- Review

Purpose

1. To provide an overview of the current status of the different components of a country accountability framework, with a focus on MNCH
2. To lay the foundation for the development of a roadmap with specific activities to implement the country accountability framework
3. To serve as a general monitoring tool to track progress towards implementing the priority activities and accountability framework implementation

Opportunities will be equally distributed between male and female in the workforce. Women are an integral part of the agricultural sector and benefit sharing is expected to be equality distributed as the project will be a viable employer. Young people within the legal working age limit will be encouraged to work on the project.

3.4.2 Nationally Determined Contributions and Sustainable Development Goals

The Nationally Determined Contributions (NDC) for Belize is consistent with the Growth and Sustainable Development Strategy (GSDS) which outlines poverty alleviation and medium-term and longer-term economic sustainable development. Belize will use existing policies, projects and activities resulting in mitigation and adaptation. A low carbon development strategy has been developed which will still achieve the national development targets. The strategy will focus on building technical capacity and human resources, strengthening institutions and policy formulation, facilitate public-private partnerships and engaging stakeholders to adopt sustainable practices which should lead to national resilience to the impacts of climate change. The Sustainable Energy Strategy and Action Plan activities that would apply to the project are:

- to improve energy efficiency and conservation in order to transform to a low carbon economy by 2033. The plan envisions a reduction in energy intensity per capita at least by 30% by 2033 and to reduce fuels imports dependency by 50% by 2020 using renewable energy;
- Have 85% renewable energy by 2030 by implementing hydropower, solar, wind and biomass, and reduction of transmission and distribution losses; and
- Have cumulative reduction in emissions from bagasse would be 947 Gg CO₂ by 2030.

3.4.SDGs and H2030

Belize's medium-term comprehensive Sustainable Development Goals national plan is aligned with the country's vision of Horizon 2030 (H2030). Horizon 2030 embodies the vision for Belize in the year 2030 and the core values that will guide citizen behaviour and inform strategies to achieve a common vision. Under Strategies to Achieve Environment and Sustainable Development Goals it calls for the provision of incentives to promote energy saving and investment in production and use of renewable energy in the areas of wind, solar, biomass, and hydroelectricity, including energy purchase arrangements for those who have excess to sell to the main grid. SDGs and H2030 were developed after extensive stakeholder consultation. One of H2030's four main pillars is responsible environmental stewardship which involves integrating environmental sustainability into development planning and promoting sustainable energy to fix Belize's emission profile.

3.5 Public/Civic Participation and Consultation

The ESIA will be officially lodged with the 5 Cs and with the Department of the Environment so that it can go through the approval process. The Department may direct the developer to modify the draft and/or approve the draft as per EIA Regulations, sections 15-17. There is the need for public consultations which may be undertaken within sixty days. Approval of the environmental impact assessment may be subject to conditions which are

reasonably required for environmental purposes (Environmental Protection Act, sec. 20 (7). Conditions may include signing an Environmental Compliance Plan (ECP) that contains the conditions specified by the Department of the Environment. EIA (Amendment) Regulations, section 13.

Key stakeholders have been identified and engaged through the consultation process from the initial stages of project planning, and followed through the process of studies being conducted as well as through formal and informal consultation meetings. The community has also been engaged through consultations and through consultation meetings. The support and interest in the project has been well documented, and concerns are being addressed as part of the ESMP mitigation of activities and compensation process.

3.6 Stakeholders

The stakeholders have been identified and consulted to conduct activities to deliver the envisioned benefits of the project. The CCCCC apart from being part of the project proponents will also play an advisory role and will work closely with the regulators and the beneficiaries. BEL, BELCOGEN, ASR/BSI will implement the project under close supervision of the PUC, BAHA, NCCO, DOE and the Forest Department. SIRDI and BAHA will support with research on *Arundo donax*. The Ministry of Agriculture, Fisheries, Forestry, Environment, Sustainable Development and Immigration will assist with policy formulation and direction. The workforce (farmers, cane farmer's associations and community workers) will also be beneficiaries.

Literature Cited

Land and Surveys Department Information Handbook. Ministry of Natural Resources and the Environment, 2004. Belmopan, 2004.

Government of Belize, Attorney General's Ministry. *The Substantive Laws of Belize Revised Edition 2000*. Belmopan, 2000. <http://www.belize-law.org>.

Government of Belize. Environmental Protection Act Chapter 328 Revised Edition 2003 of the Substantive Laws of Belize, "Chapter 238 Pollution Regulations". <http://www.doe.bz.gov>.

Government of Belize. *Environmental Protection Effluent (Limitations) (Amendment) Regulations, 2009*. <http://www.doe.bz.gov>.

4.0 TASK 3: ASSESSMENT OF THE ENVIRONMENTAL AND SOCIAL IMPACTS OF THE PROJECT/INVESTMENT

Purpose

The basic objective of the impact assessment is to provide a means to integrate environmental factors that would enhance project planning and execution. The assessment will measure the environmental impacts through criteria-based factors and with a view of preventing adverse environmental impacts while promoting the beneficial effects of the project. The assessment also intends to identify those impacts which are likely to be generated by the implementation and operation of the project and to evaluate, as far as possible, the causes and effects of these impacts and their consequences on the environmental and social structure. It also sets a benchmark for those parameters that would be impacted so that their subsequent monitoring would identify indicators on their status, whether there is a decline in quality or there are no changes. Standards, guidelines and other regulatory policies and framework are also identified with the objective of fulfilling the requirements towards mitigation and avoidance of impacts following such standards, guidelines and regulatory framework.

The impact assessment will follow the standards of the GFC, AE and ESS as stipulated in Task 3 of the TOR. These standards have been set to assess the project's impact on the construction, operation and maintenance activities. The standard format is to rank and prioritize all potential impacts and their associated hazards and associated risks. The key components to impact assessment include:

- Supply chain to keep the project on going;
- Development of an Assessment Criteria to be used as a ranking scheme for the activities and their related impacts; and
- Identification of all the impacts related to land- clearing, biodiversity, water resources, and socio-cultural changes, community and employee health and safety.

The likely impacts of undertaking the project

Any development irrespective of the nature of the undertaking would generate impacts. There can thus be either direct or indirect impacts both qualitatively and in terms of quantity on the physical aspects of the environment, namely land use, soil and geology, flora, fauna, air quality, water quality, noise and the landscape. The impacts could also be reversible or avoidable or a combination of both (**Table 1**), depending on the nature and complexity of the project. Apart from the impact on the physical environment this undertaking will have a positive significant impact in the energy sector as well as the socio-economic aspect which include employment, reduction of carbon emission among others. An assessment of the likely impact of the project on these environmental components has been carried and elaborated in the following sections.

Chapter 4.O is an assessment of the environmental and social impacts of the project and investment and evaluates the level that the A. *donax* Project complies with the interim GCF

Environmental and Social Performance Standards. These measures, as they comply with the GCF Performance Standards (PS), will be included in summary matrix in the ESMP.

Table 4.1 below contains the criteria for rating the impacts of the project.

DURATION	<ul style="list-style-type: none"> • Short Term (ST) • Long Term (LT) 	Short term refers to impacts that last less than 3 years, meaning species recover to pre-impact levels, or natural communities recover to no noticeable impacts. Long term refers to more than 3 years.
NATURE	<ul style="list-style-type: none"> • Direct (D) • Indirect (ID) 	Direct impacts on the environment are those which are as a result of the project. The indirect impacts are those which are not direct and are also known as secondary or even third level impacts.
REVERSIBILITY	<ul style="list-style-type: none"> • Reversibility (R) • Irreversibility (IR) 	Reversible implies that the impacted species or natural community will recover. Irreversible impacts mean that the species or natural community is lost to the project site, and impact should be mitigated.
AVOIDABILITY	<ul style="list-style-type: none"> • Avoidable (A) • Unavoidable (UA) 	Avoidable impacts are those that can be avoided. Unavoidable impacts are those that are not able to be avoided, prevented, or ignored; inevitable.
EXTENT	<ul style="list-style-type: none"> • Wide (W) • Local (L) 	Extent offers a localized setting whether it can be contained within (local) or spread across a medium (wide).
MAGNITUDE	<ul style="list-style-type: none"> • Major (MA) • Minor (MI) 	Depicts the scale and intensity to generate changes in relation to its duration.

4.1 PS1: Assessment and management of environmental and social risks and impacts

Objectives

The objectives of the GCF PS 1 are to:

- Identify funding proposal's environmental and social risks and impacts;
- Adopt mitigation hierarchy: anticipate, avoid, minimize, compensate or offset;
- Improve performance through an environmental and social management system;
- Engagement with affected communities or other stakeholders throughout the funding proposal cycle. This includes communications and grievance mechanisms.

According to the IFC Guidelines (IFC, 2012) PS 1 *underscores the importance of managing environmental and social performance throughout the life of a project. An effective Environmental and Social Management System (ESMS) is a dynamic and continuous process initiated and supported by management, and involves engagement between the client, its workers, local communities directly affected by the project (the Affected Communities) and, where appropriate, other stakeholders.*

The following paragraphs summarize the extent of project compliance with the requirements of PS1, and identifies gaps, and measures that will need to be applied.

4.1.1 Identification of Environmental and Social Risks and Impacts

The potential impact assessment (Chapter 4 of ESIA and at the end of each environmental and social diagnostic) has identified the areas where detailed impact assessment is required. The detailed impacts will be assessed in the sections devoted to each PS; and outlined in tables.

4.1.2 Mitigation Hierarchy

The GCF requires that as described in the ESS “Mitigation Hierarchy” standards, *there are prioritized steps for limiting adverse impacts through avoidance, minimization, restoration and compensation as well as opportunities for culturally appropriate and sustainable development benefits*. The mitigation hierarchy aims to:

- (i) Anticipate and avoid adverse risks and impacts on people and the environment;
- (ii) Where avoidance is not possible, adverse risks and impacts are minimized through abatement measures;
- (iii) Mitigate any residual risks and impacts; and
- (iv) Where avoidance, minimization or mitigation measures are not available or enough, provide remedy and restoration before adequate and equitable compensation of any residual risks and impacts; (GCF, Environmental and Social Policy 2018).

An example of the mitigation hierarchy was implemented during the site selection process, whereby sites with vulnerability such as flooding and accessibility challenge was eliminated, thus using the avoidance technique. The reduction of proliferation of the species being cultivated is to be minimized through various management regimes to be tested as a separate project which will serve to ensure community trust in that the species will not become a nuisance to nearby agro-productive lands.

4.1.3 Assessment of Alternatives

Land acquisition, location and cultivation species selection

Within a national and regional context, the use of the 400-acre area for production will therefore have minimal impact (**Table 2**) on biodiversity for several reasons. It is not located near a Key Biodiversity Area or Protected Area; it utilizes marginal land that would otherwise not be utilized as it is not suitable for agriculture; it consists of an ecosystem that is abundantly available in Belize, and is identified as an area of limited biodiversity value. While the biodiversity impacts are small, the proposed *Biomass Pilot* will lead to a positive impact in addressing climate change as it will contribute to the process of carbon sequestration and possibly the reduction of Greenhouse Gases since the biomass can burn cleaner than bagasse itself.

Table 4.2 Land Clearing Impacts.

Land Clearing	Location		Duration		Reversibility		Avoidable		Significance
	D	ID	ST	LT	R	IR	A	UA	
Removal of topsoil	√		√			√		√	Moderate
Increased Erosion	√		√		√			√	Moderate
Changes to surface water flow	√			√		√	√		Moderate
Biodiversity Loss	√		√		√			√	Low
Removal of wildlife		√		√	√		√		Low

With respect to project planning and choice of cultivation species are fundamental decisions that undergo planning alternative considerations in order to increase the possibility of project success. Other socio-economic considerations during project planning included haul distance of the crop and the use of existing access roads including the avoidance of roads that are visibly more populated.

Integration of Ecosystem

Overall, the project's planning includes the various ecosystem components through integrated land management of its physical resources, biological resources, community setting and its biological components. Alternative crop cultivation was considered but eliminated as a result of the technical capacity of the incineration of *A. donax* as the cleaner crop from those considered supplementing bagasse.

Transportation Alternatives

Alternative transportation routes to be used were considered within the existing community settings, with the objective of using the least populated route thus reducing the impact of transportation to and from the project site. These routes were also pre-determined by the location of the BELCOGEN power generating plant at Tower Hill.

4.1.4 Environmental and Social Management System

The project aims to contribute to the reduction in vulnerability to climate change through the contribution to carbon sequestration, and the reduction of burning of bagasse that does not burn as clean as the *A. donax* plant. In this respect, even at the community level, the reduction of particulate matter and other noxious substances will be realized since the combustion of *A. donax* would lead to a cumulative reduction of substances emitted into the atmosphere.

While the biodiversity impacts are small, the proposed *Biomass Pilot* will lead to a positive impact in addressing climate change as it will contribute to the process of carbon sequestration and possibly the reduction of Greenhouse Gases since the biomass can burn cleaner than bagasse itself.

Since the project will be beneficial in terms of contribution to carbon sequestration, it will create technology transfer, employment and other positive economic outcomes; the community will share net benefits while the project management will be able to apply the Environmental, Health, and Safety Management Systems (OHSP). This includes a comprehensive OHSP that is incorporated in greater detail in the ESMP.

4.1.5 Emergency Response

The *Arundo donax* project has incorporated various emergency response mechanisms including: 1) Emergency Medical Evacuation, 2) Natural Disaster Management Plans, (including a hurricane plan, fire plan, and flood contingency plan), 3) Emergency Evacuation Plan of the Premises, and 4) Collection, Storage, and Transportation and Disposal of Substances including fuel and oils. These management systems are prepared in draft format, so that project management can update, which follows local regulatory framework including guidelines and standards.

4.1.6 Stakeholder Engagement and Grievance Mechanism

Although the project is being planned within an existing agro-productive ecosystem setting, it does consider stakeholder engagement and a grievance mechanism. Stakeholder engagement has involved other stakeholders in the energy sector (e.g. BEL), which are assisting financially to facilitate trial plots to complement the project, and the technical preparation of such trial plots is also being done through regional institutions such as CARDI and SIRDI.

At the community level, a small committee is being formed that includes a representative of the *A. donax* project, village council members of the three nearest villages, a representative of the agriculture high school in the village nearest to the project, and representatives of the Ministry of Agriculture. This advisory committee is being structured to facilitate community communication, participation, and will also serve as the **redress committee** through which any grievances and compensations will be addressed. This group will also serve to supervise pilot projects in solid waste management (including separation at source, recycling and re-use, and transportation to the designated transfer station), which is also being planned through the Solid Waste Management Authority.

Further community participation will be identified and led by this advisory group.

Summary of Stakeholder Engagement Activity

This engagement commenced at project planning through the preparation of stakeholder Management and Engagement Plan, and Stakeholder Gender Analysis and Action Plan.

Stakeholders identified through this process were contacted; and the stakeholder group was expanded and updated as the consultation process progressed. Primary stakeholders such as those from the energy and co-generation sectors, the research institutions, government policy makers and other organizations with technical expertise were kept informed and updated of the advancement of the various stages of the project and of the ESIA. One on one consultation meetings were carried out with this sector, as well as with community leaders of villages nearest to the project. Community engagement also included schools and local regulatory institutions.

Consultation meeting

A consultation meeting was held at the “Belize High School of Agriculture”. Staff from this institution is keenly interested in the project and a representative will be a member of the technical advisory group discussed above. The representative was involved in communicating with the local communities with respect to the details of the consultation meeting.

The consultation meeting was well attended with over eighty (80) participants from nearby communities and other stakeholders. Most of the concerns were at a technical level, and their local knowledge of the site has contributed to the advancement of the research teams.

4.1.7 Social Impacts of Project

There are various positive and potential negative social impacts (**Table 4.3**) that were identified during preliminary investigations and during the ESIA preparations, which were elaborated and summarized herein. Positive impacts from the project such as carbon sequestration, economic benefits from direct or indirect energy benefits, technology transfer etc., were not elaborated in this section.

Table 4.3 Social impacts.

Socio Cultural Changes	Location		Duration		Reversibility		Avoidable		Classification
	D	ID	ST	LT	R	IR	A	UA	
Increased demand for services	√			√	√		√		Low
Increase in vehicular incidents	√		√		√		√		Low
Increased demand for housing	√			√		√		√	Low

During the scoping exercise several key issues were identified based on literature review and validated through the consultation process. These were primarily described in the Gender Analysis and Action Plan as well as the Stakeholder Management and Engagement Plan and the risk analysis. Some issues identified were the focus during the ESMP elaboration:

A) Agriculture and Food Security

From the perspective of the stakeholders the main concerns were as follows:

- 1) The potential for the conversion of land currently under cultivation for food crop to be used to produce *A. donax*. In this regard the Ministry of Agriculture has indicated that it could not be supportive of an industry that would see large-scale land conversion as it would undermine food security.
- 2) There was the perceived need to understand and guard against potential negative impacts of having *A. donax* cultivation in proximity with sugar cane crop where there is a possibility that pests that are harmful to sugarcane, which being effectively controlled, will find safe haven among the *A. donax* plants, thereby undermining control measures.
- 3) Whether there is a possibility of cross-pollination.

These potential impacts are being addressed through the engagement of the Ministry of Agriculture, as the lead policy making body for the agriculture sector in Belize, along with the Ministry of Natural Resources that is responsible for land resources allocation. Through piloting research projects, and community engagement and communication and reporting, the techniques relating to prevention of the proliferation of the *A. donax* crop as well as means of integrated pest management shall be elaborated.

B) Resource and Risk Management

Once again, the issues raised by the sector with respect to resource and risk management highlights the importance of the focus on an ecosystem approach is the aim of project implementation and management.

The most critical resource use issues that arose relate to land and to potential ecological impact of *A. donax*, as described below.

b) *Land Use*

- 4) To utilize only marginal lands for *A. donax* plant propagation;
- 5) Interest in the location and tenure status of the plot; and
- 6) Definition of marginal lands.

b) *Environmental and Ecosystem Health*

Stakeholders are acutely aware of the need for careful management of the *A. donax* crop to avoid unintentional propagation. Some specific issues and recommendations related to risk management are set out below:

- 1) Respondents from the Ministry of Agriculture, the Forest Department, SIRDI, cane farmers association and the community focus group meetings have all flagged a need for

a clear exit strategy, should the *A. donax* cultivation not prove viable. Based on the various questions and recommendations in these discussions, the strategy should clearly outline the measure to be taken to remove all *A. donax* completely from the project site;

- 2) The view that although the plant is hardy, the fact that it tends to propagate in riparian and low-lying areas may be an indicator that its water consumption may be high;
- 3) Use of harvesting technique that would involve burning as this would result in emissions; and
- 4) Question of measures to be taken to ensure the protection of sugarcane crop, as they have experienced that the root system threatens the survival of the sugarcane.

The mitigative actions for the land use as well as ecosystem management is expected to be led through a series of pilot test plots that will focus on plant propagation techniques with the aim at identifying resource conservation (water, soil, fertilizer etc), crop management, integrated pest management and control as well as methods of extermination of the plant if and when the life of the project comes to an end. This will be an on-going research, which is being partly funded by the Belize Electricity Limited, and which is considered complementary to the project but should not depend on potential budgetary allocations from GCF. Nonetheless, due to issues raised, these complementary research activities are considered critical in the support of community confidence, community involvement and participation and stakeholder participation and ownership buy in of the project.

C) Gender and Resource Control

Assigned gender roles within the communities of the North are transitioning but majority control of resources continues to reflect the traditional arrangements. The following are identified key components of the gender roles and relationships that have bearing on the economic life of the communities:

- 4) There are virtually no women on the board of the cane farmers associations despite the data on registered cane farmers drawn from the Sugar Industry Management Information System (SIMIS) shows female cane farmers make up 40% of the total members registered;
- 5) Where women are actively engaged in managing or working their own farms, they are recognized as being highly effective, mainly because they are disciplined about following good agricultural practices and are good financial managers; and
- 6) Women are heavily involved in managing the finances of the cane farming businesses and are observed as being the main ones who do banking for the families' farming business.

While the project itself may be too small in terms of its economic and job creation potential, gender equality will be a standard policy during the selection process for employment and during the community and stakeholder participation of the project. Indirect activities that may arise from project implementation and management will also consider the issue of gender equality and should also be the focus of training and participatory activities associated directly or indirectly from the project.

D) Youth and Aging

It has been found that no persons under 25 years of age hold any position on the boards of any of the three cane farmers' associations, and neither do they form part of the village councils in the Yo Creek and San Lazaro communities, the two communities nearest to the project. SIMIS data shows less than 5% of cane farmers under the age of 25, and those between 25 and 30 years of age account for less than an additional 3% of the total members. Cane farmers aged 50 years and more make up 62.5% of the total number of registered farmers, indicating a labour aging industry with no clear succession planning.

Low involvement of youth in cane farming is because as soon as they obtain higher education they move away from the cane industry and the prevention from becoming members of the cane farmers association; this was challenged by the association and now new cane producing farmers can join the association. There is the preference of youths to find office jobs; the lack of technology in the sugar industry is also non-attractive for young people.

4.2 PS2: Labor and working conditions

According to the IFC (IFC, 2012) PS 2 among other things, *recognizes that the pursuit of economic growth through employment creation and income generation should be accompanied by protection of the fundamental rights of workers.*

Objectives of PS 2

- a. To promote the fair treatment, non-discrimination, and equal opportunity of workers;
- b. To establish, maintain, and improve the worker-management relationship;
- c. To promote compliance with national employment and labor laws;
- d. To protect workers, including vulnerable categories of workers such as children, migrant workers, workers engaged by third parties, and workers in the client's supply chain;
- e. To promote safe and healthy working conditions, and the health of workers; and
- f. To avoid the use of forced labor.

Based on the findings, the following key issues as it pertains to labor and working conditions in relation to the proposed *Arundo donax* project are as follows:

- The working environment and the need to support equal opportunity.
- Occupational Health and Safety (OHS) risks and impacts of construction works.

4.2.1 The Working Environment

Occupational risk and impacts associated with the project will be dependent on all phases of the production process. This includes the land clearing activities, planting, harvesting and processing, storage and delivery. In all phases, safety will be of fundamental importance in protecting the employees from the associated risks and as such the necessary engineering controls coupled with the safety tailgate meetings will be instituted. Personal protective equipment and other safety means will be portrayed to the employees via a sensitization and education campaign.

Potential Impacts

The potential impacts associated with human health and safety could include:

- Exposure to increase levels of noise;
- Effects from application of and exposure to agrochemicals;
- Increase dust and particulate matter; and
- Exposure to high levels of fuel vapours.

4.2.2 Occupational Health and Safety Risks

These issues require both planning, documentation, training and on-going rehearsals and further training. During the day to day operations, the occupational health and safety guidelines with training is required for employees. Other main activities presenting hazard risks identified include (**Table 4.4**):

Chemical Application

Chemical application will include fertilizers and liming only since no pesticide will be used on site. Application will be done with a sprayer in the case of the fertilizers. When these activities are occurring, all other employees will be restricted from entering the affected area for the required period. Employees doing the application will be required to wear the appropriate personal protective equipment which includes rubber gloves, dust mask and goggles to name a few.

Shredding Process

The shredding of the dried biomass material will expose the employees to suspended particulate matter or dust created from the shredding process. This will be an ongoing activity and therefore the employees will be required to use dust mask to avoid inhaling the dust particles. If the

situation needs further corrective measures, then vacuums will be installed to remove this dust from the workplace.

Fuel Dispensing

It is anticipated that the project will have small fuel storage containers onsite due to the project location which may call for the use of generators from time to time. Therefore, the dispensing area will be in an open area so to avoid vapour build-up, spill cleaning and easy access.

Noise

Impacts associated with noise emissions on the health of employees are unlikely to occur given the small number of vehicles and equipment being used. Occurrences will be extremely localized and will have minor consequences. If required (such as during harvesting) then ear protection devised will be required to be used.

Intense Labour

Agriculture production often requires strenuous labour that includes physical activity under hot and humid conditions. Workers' health becomes a priority during strenuous activity and during the peak of hot and humid days.

In addition to ensuring safe working conditions, the Occupational Health and Safety Plan (OHSP) has been drafted as a guide for which the project will continue ensuring that adequate health and safety takes place and that health risks are reduced on the work site and off the work site.

Table 4.4 Residual health and safety impacts.

Health and Safety Impacts	Location		Duration		Magnitude		Extent		Significance
	D	ID	ST	LT	Major	Minor	W	L	H, M, L
Disturbance to employees	√		√			√		√	Low
Exposure to chemicals	√		√			√		√	Low
Exposure to high level of particulate matter	√		√			√		√	Low
Exposure to high levels of fuel vapour	√		√			√		√	Low
Bio security Measures	√		√			√		√	Low
Sanitation measures	√		√			√		√	Low

4.3 PS3: Resource efficiency and pollution prevention

According to the GCF and IFC, PS 3 *recognizes that increased economic activity and urbanization often generate increased levels of pollution to air, water, and land, and consume finite resources in a manner that may threaten people and the environment at the local, regional, and global levels.* It also recognizes the growing global trend *that the current and projected atmospheric concentration of greenhouse gases (GHG) threatens the public health and welfare of current and future generations (IFC, 20112).*

The objectives of PS 3 ARE:

- a) To avoid or minimize adverse impacts on human health and the environment by avoiding or minimizing pollution from project activities;
- b) To promote more sustainable use of resources, including energy and water; and
- c) To reduce project related GHG emissions.

4.3.1 Avoid Minimize or Reduce Project Related Pollution

Waste Impacts

This type of potential impacts will include both the generation of **wastewater** as well as the generation of **solid waste** due to human occupancy at the project site.

The generation of solid waste on site can include discarded food waste, general garbage and refuse, equipment waste, and cleaning waste. These can attract wildlife animals to the area and cause a shift in the ecological balance in a way not induced by nature. The waste can also become a habitat for mosquitoes and other insect pests as well as become unsightly. This is especially so in the case of discarded used tires, containers and other waste materials.

Wastewater generation can cause nutrient enrichment from the injection of macro nutrients into the environment. This is as a result of the untreated wastewater stimulating plant growth on the land. If the untreated wastewater reaches a body of water, then the cumulative impacts could include increased BOD and nutrients in the water. This may also include the subsequent decrease dissolved oxygen in the Blue Creek. Therefore, there is a possibility of the wastewater entering the water body via the intended drainage network. Another wastewater source will be from the washing of the transportation equipment as a preventative measure. The trucks, equipment, harvesters will be washed prior to use thereby generating wastewater.

Potential impacts of waste impacts associated with the cultivation and harvesting project include:

- Pollution of water bodies

- Soil Pollution

Water Pollution

Water pollution can be derived from the generation of wastewater from the sanitary facilities as well as from the maintenance of the equipments. Wastewater generation can cause nutrient enrichment within a body of water making it unsuitable for recreation or domestic use.

The project will call for proper sanitary facilities to be constructed for the workers and administrative staff.

Soil Contamination and Health Risks

Soil contamination will be derived from the generation of solid waste materials as a result of human activities. These include food waste, wrappings, paper, boxes, etc. Collectively these are classified as domestic garbage. The unwanted accumulation and mismanagement of solid waste is what can lead to the soil contamination aspect in the form of hazardous leachates. Furthermore, vector diseases such as malaria can be propagated from discarded waste such as used tires and containers that can hold water.

Air Quality

Air quality impacts will range from the cultivation of the biomass material, its processing (drying and shredding) and transportation to the BELCOGEN facility as well as the actual burning of the biomass material to generate energy (**Table 4.5**). Suspended particulate matter or dust pollution will be generated as a part of the cultivation, processing and transportation of the biomass material. Added to this will be generation of vehicular emissions in transporting the material. The suspended particulate matter will become more problematic as the shredding process occurs in the storage area. Fine particulate matter can cause respiratory illnesses as this process takes place.

One positive outcome is that the burning of the biomass material will result in cumulative cleaner emissions than the combustion of bagasse alone that is the current practice. Notwithstanding, the burning of the biomass material to produce energy will generate CO₂, NO₂ and some SO₃ as part of the combustion process in addition to particulate matter such as ash.

Potential Impacts

Impacts associated with the air quality include the following:

- Suspended Particulate Matter or Dust
- Wildfires and Waste Burning
- Exhaust Emissions

- Combustion Emissions

Suspended Particulate Matter

This issue has been covered before and includes dust particles generated during the land clearing activities as well as the harvesting of the biomass material. Fine dust particles are generated when the harvester is cutting the biomass material and dumping it into the trailer. Similarly, during the shredding of the biomass material after it has been dried. Dust is also generated during vehicular movement in and around the area because of road conditions.

Exhaust Emissions

Emissions will be produced from the movement of heavy equipment, transportation of personnel and of the biomass material. Uncontrolled vehicular exhaust and potential fugitive emissions will impact the localized air quality. The quality of fuel and the condition of the equipment all play a key role in the generation of exhaust emissions.

Wildfires and Waste Burning

Wildfires and the inadvertent burning of the solid waste materials will generate air pollution that can impact the air quality. This will most likely be in the form of smoke. Furthermore, there is the potential for respiratory illnesses if exposed too much of the smoke. Wildfires are a natural occurrence; however, it will be contained within the buffer zone by the fire pass barrier.

Increase Emission due to burning of the Biomass Material

Contamination and the uneven drying of the biomass material can impact the combustion process resulting in an increased ash and slag content. Contamination can result from the over fertilization and liming process thereby increasing the mineral composition of the biomass material resulting in higher ash contents (Si, K, Ca, N). Contamination can also result from the handling of the biomass material. A higher water content due to uneven drying will impact the combustion process.

Table 4.5 Residual air quality impacts.

Air Quality Impacts	Location		Duration		Magnitude		Extent		Significance
	D	ID	ST	LT	Major	Minor	W	L	
Suspended Particulate Matter	√			√		√	√		Moderate
Wildfires and waste burning	√		√			√		√	Low
Exhaust emissions	√		√			√		√	Low
Combustion emissions	√			√	√		√		Moderate

4.3.2 Sustainable use of Resources, Including Energy and Water

The project layout does not call for the use of extensive energy demanding appliances. Energy is needed primarily in the form of electricity for lighting the compound and for powering small appliances. Small amounts of energy are also required from liquid petroleum gas for cooking and lighting of warm beverages mostly to be needed for the comfort of on-site personnel. Electricity generation produces emissions that albeit in small demands do contribute cumulatively to the national emissions of greenhouse gases. Some of Belize's electricity demand is produced by diesel powered generators, considered to be among the highest pollutants. Although the project's demands for electricity will be small as explained earlier, cumulative impacts can be reduced through energy efficiency that includes the design of the worker's quarters and drying buildings, and the use of solar powered electricity for the compounds. The drying sheds should be constructed with energy efficient open areas that allow drying to be facilitated by winds as much as possible, and possibly using sunlight to reduce electricity demands of drying by using large fans.

Most of the energy will be required from fossil fuels that will power vehicles and large equipment. Using energy efficient equipment will be important, but also the limit of the use of these types of equipment will be important in reducing greenhouse gases and the emission of noxious substances into the atmosphere.

4.3.3 Reduction of Project Related GHGs

As outlined above, the project does not call for significant processes that result in important increase of GHGs. However, the use of equipment that uses non-renewable carbon emitting fuels and oils will be inevitable but should include management practices reducing the time of equipment use and the use of efficient and functioning equipment.

One such equipment that will be needed will a stand - by generator which uses petroleum – based fuels and oils. This generator will only be used during power failure and if energy is needed. Other equipment that will use this type of energy are small weed eaters, land mowers or riding mowers. Compressors and domestic appliances due use electricity or LPG. LPG power generated equipment are preferential over those that use carbon emitting fuel sources.

Water Resources Impacts

The 400-acre project site designated for cultivation is not adjacent to a fresh water source for irrigation without prior collection, transportation and storage. The water that will be utilized for cultivating the crop will be natural rainwater that will be retained within the project area and prevented from drainage outside the construction of a buffer zone road access barrier. No water will be utilized from the nearby Blue Creek, nor will any water from the project be drained into the creek. This creek has characteristics of salinity intrusion, which although the *A. donax* crop is somewhat salt tolerant, other native species are not. However, drainage will be constructed to adequately distribute water and clear used water from washing machinery and equipment. The water will drain and remain within the 400-acre project area contained by the buffer zone. The Buffer Zone will also serve to minimize potential flooding of the fields during the rainy season

and as a fire break to prevent any external wildfires to impact the project area. The project will dig a single small well for supplying water for washing machinery and equipment as well as other uses. A water storage tank will also be installed to capture rainwater, and to minimize the use of well water for washing the machinery and equipment and for the use of project personnel. Should the tank or the well run out of water during the dry season, water will be transported from the nearest village, San Lazaro, about 7 miles away.

All transportation equipment will be washed before moving off site. Washing will be done within the premises of the project area at the smaller plot at the designated central work location, which will be supplied with water from a well/tank on the premises. The used wash water will drain but will be contained due to the elevated buffer zone and drainage design.

Potential Impacts to Water Resources

Surface Water

The Rio Hondo is the biggest water body closest to the project site. The Blue Creek is the nearest creek that is about 830 meters away from the project as previously mentioned, but which borders part of the property towards the northern end. Water runoffs from the project will be controlled however, the potential surface water impacts due to project related activities are limited to the following (**Table 4.6**):

Sedimentation of retention ponds and drainage areas

The project will construct a buffer zone to minimize potential flooding of the fields. This same buffer zone will serve to prevent outside drainage. Pollution through increased sedimentation of the natural flow and drainage paths in the vicinity of the project area could result in the lack of fresh water available for native fauna. Without appropriate control measures, sedimentation from erosion caused by surface water run-off from project- related infrastructure may occur (prepared soil and roads).

There is also the possibility of processed water percolating through to the groundwater body. A retaining system of ponds will be installed to reduce this risk, and a leach field with a constructed wetland will be installed for re-use of domestic grey water. One area that slopes towards the creek becomes partially inundated during the peak of the rainy season, but most of the property is not prone to flooding. The area, including the access road is not within the flood risk zone of this part of Orange Walk.

Contamination of water bodies and drainage paths

Chemical contamination from project-related activities to existing surface water bodies and drainage paths by the project can result in contamination of freshwater stocks available for native fauna. Contamination could occur from fuels and hydrocarbons stored and dispensed onsite necessary for land preparation, harvesting, and transportation. Runoff from fertilizer and pesticide application can also contaminate these surface waters.

- *Sedimentation of buffer zone (barrier) and drainage paths*

There will be a constructed buffer zone within the project area. The buffer zone will be sited to collect all surface runoff from the property. This water will then be used for irrigation purposes.

- *Contamination of retention ponds and drainage paths*

The use of agrochemicals can lead to the accumulation of residues in surface water. The project intends on applying natural fertilizers as a means of compensating for the poor agricultural soil quality. The project will use lime to balance the soil acidity. Soil fertilization will be applied as required and needed by the project. There will be no pesticide application.

Table 4.6 Surface water impacts.

Water Resources - Surface Water Quality	Location		Duration		Reversibility		Avoidable		Significance
	D	ID	ST	LT	R	IR	A	UA	
Sedimentation of buffer zone and drainage paths	√		√		√		√		Low
Contamination of water bodies and drainage paths	√		√		√		√		Low

Potential Impacts to Groundwater

The primary objective is to ensure there is no impact on existing users due to a reduction in access to or quality of groundwater resources as a result of the proposed operation. Potential environmental impacts as a result of groundwater abstraction could include (**Table 7**):

- Contamination of groundwater from fuel leaks and spills or contaminated surface water run-off from Project infrastructure or wash down areas.
- Contamination of groundwater from the vertical seepage of irrigation water containing agrochemical residues.

Reduction of available groundwater quality and quantity

There are no active groundwater supply wells within project area itself. Within the project area, therefore, there are no ground water users that will be affected. However, within the village boundaries, the use of well water is an important source for domestic use, primarily for washing. While the project site slopes away from populated areas, care must be taken to monitor the risk of introducing contaminants into the aquifer and not to impact its quantity beyond sustainable levels.

Contamination of groundwater from fuel spills/leaks and contaminated surface water run-off

Potential oil leaks/spills may travel vertically through the soil. The well will be sealed and protected. However, if contaminants do enter the local aquifer, they would be of a small quantity and any environmental effects due to this contamination would be insignificant, it must be monitored.

Contamination of Groundwater from processed water

Contamination of groundwater by washing water has low possibility but requires monitoring.

Table 4.7 Ground water impacts.

Water Resources – Ground water Quality	Location		Duration		Reversibility		Avoidable		Significance
	D	ID	ST	LT	R	IR	A	UA	H, M, L
Reduction of available groundwater quality and quantity to existing users		√	√		√		√		Low
Contamination of groundwater from fuel spills and contaminated surface water runoff		√	√		√		√		Low
Contamination of groundwater from irrigation water		√	√		√		√		Low

Waste Management

Waste management can have impacts (**Figure 4.8**) on the project site.

Liquid Waste Management

Wastewater management will be done by a septic system with a leach field and a constructed wetland. This system will treat domestic sources of wastewater and will also treat the grey water from washing of floors and equipment.

Solid Waste Management

Solid waste management will include a written management protocol that will include the separation at source of solid wastes, temporary storage and transportation to the transfer station.

This solid waste management system will eventually become part of the solid waste pilot project that will be overseen as a community initiative at the local high school. It will serve both to increase waste management and increase separation of waste destined for recycling from non-recycling waste, and will serve to promote behavioural changes in the community aimed at the promoting of environmentally friendly practices that will lead to net benefits including the reduction of greenhouse gases from inadequate waste disposal. Similarly, a compost pilot project will also be initiated at the adjacent high school which will also aim to reduce biologically degradable waste volumes from entering the waste stream; thereby also contributing to a reduction in the production of greenhouse gases by introducing compost systems that are proven to more efficient in the emission of such ozone depleting gases.

Table 4.8 Waste impacts.

Waste Impacts	Location		Duration		Magnitude		Extent		Significance
	D	ID	ST	LT	Major	Minor	W	L	
Water Pollution	√		√			√		√	Low
Soil contamination	√		√			√		√	Low

4.4 PS 4 Community Health, Safety and Security

The GCF/IFC Performance Standard 4 *recognizes that project activities, equipment, and infrastructure can increase community exposure to risks and impacts.*

Objectives:

- a) To anticipate and avoid adverse impacts on the health and safety of the adjacent community during the project life from both routine and non-routine circumstances; and
- b) To ensure that the safeguarding of personnel and property is carried out in accordance with relevant human rights principles and in a manner that avoids or minimizes risks to the adjacent communities.

Potential project impacts to the health and safety of the communities were identified as two main concerns:

- 1) The possibility of escape of the *A. donax* species being cultivated and as a result for it to threaten crops and degrade lands;
- 2) The risk of pest infestation (including weeds) from the propagation area;
- 3) The possible fire hazards that may result from uncontrolled or accidental fires during harvesting or other operations; and
- 4) The risk of spills from the transportation of substances, materials and equipment during project implementation.

Introduction of Pests and New Weed Species

Vegetation clearing, land disturbance and vehicle movement has the potential to increase weed populations or create conditions that are favourable for the establishment of weed species within the project area. Vehicle and equipment movement also has the potential to introduce weed species, usually those that are resistant strains that get accustomed to dust conditions and often line the roadways. There is also the possibility that the cultivation zone may form habitats for pests that may cause nuisances to the communities.

Risk of fire hazards

Uncontrolled burning of weeds or excess plants may result in fire escapes. These may impact properties owned by members of the community or may also pose other health risks from smoke inhalation, and even physical harm from fires (**Table 4.9**).

Table 4.9 Residual health and safety impacts.

Health and Safety	Location		Duration		Magnitude		Extent		Significance
	D	ID	ST	LT	Major	Minor	W	L	H, M, L
Disturbance to employees	√		√			√		√	Low
Exposure to chemicals	√		√			√		√	Low
Exposure to high level of particulate matter	√		√			√		√	Low
Exposure to high levels of fuel vapor	√		√			√		√	Low

Transportation Impacts

The transportation can be described in two stages and includes the transportation of the *Arundo donax* from the fields to the storage area and from the storage area to the BELCOGEN Plant for processing. It also includes the movement of vehicles to and from the worksite including heavy equipment. The impacts include the unwanted proliferation of the biomass material due to spillage along the transportation routes, traffic accidents, dust proliferation and potential for wildlife road kills (**Table 10**). The first stage considers open end tractor trailers that are subjected to unpaved roads and the potential for pieces of the material to fall on the ground.

There is also a potential impact for the chipped and shredded biomass material to spill on the road when heading to the Plant. The project calls for locked containers and the impact can be forgetting to lock the container, purchasing faulty locks and faulty container doors. Other minor

generalized impacts associated with transportation include dust proliferation, noise generation and potential air pollution. Improperly planned routes can also pose a problem, especially when transporting in sensitive areas such as creeks or streams.

- **Traffic**

Potential environmental impacts as a result of traffic and transport could include:

- Traffic accidents
- Accelerated degradation of road surfaces
- Increase in native fauna deaths

Traffic Accidents

Appropriate signs will be placed around the access site. Additionally, the access road will be constructed so that there is visibility to traffic from both sides.

Accelerated Degradation of Road Surfaces and dust proliferation

The access roads will almost certainly suffer from wear and tear; however, this is a natural consequence of its use and the project will implement a road maintenance plan. Wear and tear is expected to cause minor damage to roads and tracks which will be easily remediated with appropriate road maintenance procedures.

Risk of collision with domestic or other animals

Increased vehicular movement always increases the risk of collision with animals, either domestic or other. This may pose hazards to drivers and motorists but may also result in the loss of pets or agriculture value animals. This situation can best be addressed through controlled worker health and safety practices, and in unavoidable situations, through the redress mechanism.

PS 5 Land Acquisitions and Involuntary Resettlement

This PS *recognizes that that project-related land acquisition and restrictions on land use can have adverse impacts on communities and persons that use this land.*

The objectives are as follows:

- a) To avoid, and when avoidance is not possible, minimize displacement by exploring alternative project designs;

- b) To avoid forced eviction;
- c) To anticipate and avoid, or where avoidance is not possible, minimize adverse social and economic impacts from land acquisition or restrictions on land use by (i) providing compensation for loss of assets at replacement cost and (ii) ensuring that resettlement activities are implemented with appropriate disclosure of information, consultation, and the informed participation of those affected;
- d) To improve, or restore, the livelihoods and standards of living of displaced persons; and
- e) To improve living conditions among physically displaced persons through the provision of adequate housing with security of tenure at resettlement sites.

This PS has been fully addressed during project planning. Land acquisition concerns have been raised but have been addressed as follows:

- 1) The land is not considered productive agriculture lands but is being classified as marginal and requiring significant investment for crop success. In this respect it fulfills the Government's policy of not using productive agriculture lands for the propagation of *A. donax* species since this can threaten food security.
- 2) The land was previously held by the Government of Belize, which assisted in identifying its location based on characteristics not only suitable for *A. donax* cultivation but also that was free of any citizen ownership, and which had only marginal use since trees with timber value had long been harvested through the informal market.
- 3) No citizen was residing nor using the lands for any purpose other than hunting and the occasional harvesting of firewood.
- 4) The land does not have any immediate residential homes within any of its boundaries, and the nearest residences at adjacent farms are several kilometers away, and such the communities are several kilometers away.

Therefore, there was no need for compensation, or relocation of any citizen, and the development of the project will enhance the community well-being by increased economic activity, technology transfer, and waste management practices, and community involvement and participation in pilot projects. Nonetheless, this PS was still approached from the need to establish and maintain good working relations with the community and in building partnership in sustainable development initiatives within the zone of influence of the project.

Table 4.10 Transportation impacts.

Transportation – Traffic	Location		Duration		Reversibility		Avoidable		Significance
	D	ID	ST	LT	R	IR	A	UA	
Traffic Accidents	√			√	√		√		Moderate
Accelerated degradation of road surface		√		√	√		√		Low
Increase in native fauna deaths	√		√			√	√		Low

4.5 PS 6 Biodiversity Conservation and Sustainable Management of Living Natural Resources

The GCF guidelines state that *Performance Standard 6 recognizes that protecting and conserving biodiversity, maintaining ecosystem services, and sustainably managing living natural resources are fundamental to sustainable development. The requirements set out in this Performance Standard have been guided by the Convention on Biological Diversity.* It also considers the value of the ecosystem in providing services and sustaining livelihoods.

Objectives of PS 6

- To protect and conserve biodiversity;
- To maintain the benefits from ecosystem services; and
- To promote the sustainable management of living natural resources through the adoption of practices that integrates conservation needs and development priorities.

Potential Impacts to Flora and Fauna

Potential biodiversity impact related to flora and fauna are described below and are based on the description of the vegetation types present including those proposed quantities to be cleared.

Impacts to Threatened Species

Vegetation clearing may reduce the abundance of threatened flora species with consequent impacts to populations of threatened species at the local level. The fauna will leave the area.

Reduced Species Abundance

Clearing vegetation will be necessary during implementation of the Project. The clearing process will remove plants from the broader species populations in and around the area which may have adverse effects on plant species abundance on a local level.

Reduced Conditions Favorable for Plant Growth

Vegetation clearing, vehicle movements and day-to-day operational activities will generate dust. This has the potential to reduce conditions favourable for plant growth (e.g., reduction in photosynthesis and transpiration due to an accumulation of dust on plant surfaces or damage to plants from reactive dust particles) with subsequent reduced plant health.

Introduction of New Weed Species and Weed Infestations

Vegetation clearing, land disturbance and vehicle movement has the potential to increase weed populations or create conditions that are conducive to the establishment of weed species within the Project area. Vehicle and equipment movement also has the potential to introduce weed species, usually these are resistant strains that get accustomed to dust conditions and often line the roadways.

Residual Impact Assessment - Flora and Fauna

Residual impacts to flora and fauna as a result of the project related activities are as follows (**Table 4.11**):

Impacts to Threatened Species

No species that are listed as threatened were found during the flora survey. This may be because an area has been previously cleared coupled with the remaining marginal land does not contain any significant threatened species. Since these species are not present the probability of the project impacting on these species is insignificant.

Reduced Species Abundance due to clearing

Approximately 400 acres of vegetation will be cleared or impacted by the project that will be used for cultivating and harvesting. It is almost certain that species abundance due to clearing will be reduced. However, the consequence of reduced non-threatened species abundance is insignificant given their widespread occurrence in the region. The area is described as lowland broadleaf swamp and lowland savannah.

Introduction of new weeds species and increased weed density reduced Species Abundance due to clearing

New weeds will be suppressed by regular land preparation which will destroy these weeds. Where they are a problem during the growing season they will be removed by disking or by spraying with an herbicide. There should not be an increased weed infestation given the active planting taking place.

Reduced Conditions Favorable to Plant Growth Due to Dust

Given the nature of activities proposed, it is almost certain that some damage to flora could occur as a result of dust. This damage will be localized and temporary and generally having an impact on the grass buffers beside roads and drains. Therefore, the impacts of reduced conditions favourable to plant growth as a result of dust are likely to be minor. It is expected that vegetation affected by dust will recover quickly either from a rainfall episode or during irrigation.

Other potential biodiversity impact - related to fauna is described below and is based on the wildlife surveys conducted as part of the investigations. Potential impacts are mostly to non-threatened native fauna species or communities as well as the potential for increase to introduced fauna species density and distribution within the project area. Only one species of conservation significance was identified within the project site, and this species is not considered threatened or endangered.

Reduced Fauna Species Abundance on Site

There is potential for species abundance to be reduced as a result of:

- Native fauna habitat destruction during clearance activities;
- Death of animals during construction activities;
- “Road kill” deaths as a result of collision with project vehicles;
- Noise and traffic movement disturbing resident populations of native fauna (birds) within the Project area; and
- Death of animals due to contaminated surface water.

Impacts to Threatened Species

During the site transects no species listed under the Critically Endangered List were reported in the project area.

Increased Abundance of Introduced Species

Project related activities have the potential to create conditions that may result in introduced species. This is unlikely to happen with the cultivation and harvesting of the *Arundo donax* as it is widely documented that these types of grass are inhabited by few animals including birds.

Impacts to Threatened Species

The likelihood for significant impacts to threatened or endangered species is unlikely, due to their absence in the project area. However, on a larger scale, the consequence of a reduction in numbers of threatened species in the region is unknown but could be potentially of some risk to the species and may result in changes to the known distribution of species on a local level.

Reduced Species Abundance due to clearing

It is almost certain that faunal species abundance due to clearing, traffic movements and land preparation work may be impacted since they are dependent upon the vegetation groups to be

cleared for food or shelter. The consequence of reduced species abundance through loss of habitat is insignificant, however, given the high probability that fauna will be able to relocate to adjacent areas with suitable habitat as an avoidance measure, thereby being largely unaffected by operations.

Reduced Species Abundance due to contaminated surface water

Surface runoff will be contained within the project buffer areas as much as possible. However, there will be a drainage system to alleviate any flooding. Given the small amount of water to be used by local fauna it is unlikely that this will cause any adverse effect.

Increased abundance of introduced species.

There will be no species introduced as a result of this project. Opportunistic pioneers who may find an adequate habitat may multiply rapidly. However, this would be short lived as these habitats would be regularly destroyed during harvesting.

Potential Impacts of Land Clearing

Potential impacts of land clearing on the current and future land uses without appropriate control measures include:

Removal of Topsoil

Land clearing activities will lead to the removal of over 80% of the vegetation. The land will be cleared using heavy duty equipment and the cleared vegetation will be shredded and returned to the land. If left too long, this topsoil can be blown away by the wind.

Increased Erosion

Removal of vegetation during the rainy season can result in an increase in erosion which can impact surface water within the project area.

Changes to surface water flow

Land clearing may result in changes to water flow as well as stream morphology due to stream alteration from changes in topography.

Land Clearing Impact due to soil erosion

Impacts to land clearing caused by soil erosion are likely. When impacts occur, they will be localized and able to be remediated through re-forestation techniques to be determined based on monitoring.

Table 4.11 Potential impacts to biodiversity.

Impact to Biodiversity	Species	Location		Duration		Reversibility		Avoidable		Significance
		D	ID	ST	LT	R	IR	A	U A	
Impacts to threatened species due to land clearing	Flora	√			√	√			√	Low
	Fauna	√			√	√			√	Low
Reduced species abundance	Flora	√			√	√			√	Moderate
	Fauna	√			√	√			√	High
Introduction of new weeds species and density		√			√	√			√	Moderate
Reduced conditions favourable to plant growth (dust)		√			√	√			√	Moderate
Reduced species abundance due to contaminated surface water	Flora	√		√		√		√		Low
	Fauna	√			√	√		√		Low
Increased abundance of introduced species	Fauna	√		√		√			√	Low

4.6 PS 7 Indigenous Peoples

The GCF/ IFC description of Performance Standard 7 states *that Indigenous Peoples, as social groups with identities that are distinct from mainstream groups in national societies, are often among the most marginalized and vulnerable segments of the population.*

In the country of Belize, particularly in this region, the communities may or may not fit the technical definition of indigenous groups. Although these communities have co-existed for generations in the area, they are integrated into the mainstream society and are not considered marginalized and are not displaced from their traditional lands. These communities form part of Belize's land holding citizens who trade lands and property on the free market as opposed to other indigenous communities elsewhere. Therefore, PS 7 has been described briefly as undertaking measures to prevent the exclusion of the communities from the project participation and plans seek to involve the communities indirectly through pilot projects, communication participation, and redress mechanisms.

4.7 PS 8 Cultural Heritage

As per the GCF/IFC description of Performance Standard 8; *it recognizes the importance of cultural heritage for current and future generations. Consistent with the Convention Concerning the Protection of the World Cultural and Natural Heritage, this Performance Standard aims to ensure that clients protect cultural heritage in the course of their project activities. In addition, the requirements of this Performance Standard on a project's use of cultural heritage are based in part on standards set by the Convention on Biological Diversity.*

Objectives

- a) To protect cultural heritage from the adverse impacts of project activities and support its preservation; and
- b) To promote the equitable sharing of benefits from the use of cultural heritage.

A preliminary archaeological and cultural assessment of a portion of the project site has been done which did not uncover any findings of archaeological or cultural significance. Nonetheless, prior to land preparation and as part of land preparation, it is recommended that a rapid archaeological survey be conducted to ensure that there are no resources of archaeological or cultural significance.

Table 4.12 Summary of Mitigation Measures.

Activities	Degree of Impact	Mitigation Measure
1. Biodiversity and Wildlife	<ul style="list-style-type: none"> Impacts to Threatened Species Reduced Species Abundance Reduced Conditions for Favorable Plant Growth 	<p>The surveys conducted for the area shows that the area has already been severely disturbed from an ecological standpoint. Natural disasters, such as hurricanes and bush fires, as well as human activities, such as illegal logging and slash and burn agriculture, has impacted the project site. Therefore, the mitigation measures to be employed include:</p> <ul style="list-style-type: none"> Limit the unavoidable impact by maintaining the vegetation buffer zone. Confine the biomass project to the designated area. Keep the rhizomes from spreading laterally into agricultural land resulting in the replacement of native species of vegetation. Exposed areas should be replanted and landscaped as soon as possible to reduce soil erosion, sediment, and organic runoff. The remaining vegetation stands will be maintained in their original form. Illegal removal of forest products from the site will not be allowed Vehicles will be routinely washed before they access the planting site. Only approved seeds will be used. Regular land preparation will restrict the growth of these weeds. Limit the time for land preparation to reduce time of exposure. Implementation of appropriate solid waste disposal and management will be carried out in accordance with a solid waste management plan.
2.Land Clearing	<ul style="list-style-type: none"> Removal of Top soil Increased Erosion 	<p>Land clearing activities will involve the removal of all the vegetation and exposing the top soil.</p> <ul style="list-style-type: none"> The cleared vegetation will be shredded and returned to the land as smaller pieces of biomass – some of which will be incorporated into the soil. The burning of the waste vegetation will not be allowed. The remaining vegetation stands will be maintained in their original form. Land clearing will be carried out during the dry season. This will minimize the creation of ruts that can eventually lead to increased erosion. Land clearing will be done in phases so as to reduce the impacts. A buffer zone will be left intact around the property. All major roads will have a grass buffer to minimize erosion.
3.Water Resources	<ul style="list-style-type: none"> Sedimentation of drainage areas Contamination of water bodies 	<ul style="list-style-type: none"> The water that will be utilized for cultivating the crop will be natural rain water that will be retained within the project area and prevented from drainage outside by the Buffer Zone/Access Road barrier. No water will be utilized for the Biomass cultivation from the nearby Blue Creek, nor will any water from the project be drained into the creek.

	<ul style="list-style-type: none"> Contamination of ground water 	<ul style="list-style-type: none"> The drainage will be constructed within the cultivate area to adequately distribute water and also clear used water from washing machinery and equipment. The water will drain and remain within the 400-acre project area contained by the Buffer Zone. The project will dig a single small well for supplying water for washing machinery and equipment as well as another project uses. As a means of preventing water run-off. The buffer zones, which are elevated to 12 to 18 inches above the plantation area, will also contain water utilized for cultivating the <i>Arundo donax</i> during the cultivation. Should the tank or the well run out of water during the dry season, water will be transported from the nearest village, San Lazaro, about 7 miles away from the project area. In addition, the biomass project will contain water within the buffer zone and will not release any water to the nearby waterways including the Blue Creek. The water used to wash equipment will run into the drains that are located between the inner sides of the access road/buffer zone. Only approved agrochemicals will be used at the project site. Best management practices for the construction and siting of access roads will be selected during road construction and clearance of associated sites at all times.
4. Bio security Impacts – unintended propagation	<ul style="list-style-type: none"> Unintended propagation due to improper field cultivation and handling Washing and cleaning of all equipment to prevent unwanted propagation. 	<ul style="list-style-type: none"> The rhizomes, which may grow in <i>Arundo donax</i>, will not be extracted, and will remain in the ground. The <i>Arundo donax</i> stalks, which will be utilized for biomass energy use, will be cropped, chipped, dried and shredded in a manner such that it will be converted to a fibrous material similar to bagasse; which is also not capable of propagation in such a form. The design of the harvesting approach is such that the extracted and processed material is incapable of further propagation. At no time will harvesting within the project area result in the rhizome of the plant being extracted from the soil.
5. Health and Safety	<ul style="list-style-type: none"> Increase ambient noise levels Chemical applications Increase 	<ul style="list-style-type: none"> Reduce equipment noise by installing and maintaining sound proofing or noise abatement devices. Ensure PPE are being worn where applicable Install dust traps at storage site to minimize the amount of particulate matter. Ensure refueling or dispensing is carried out in an open area. The additional staffing includes an assistant project manager who responsibility will be

	<ul style="list-style-type: none"> particulate matter Vapor emission 	<p>primarily to ensure the risk management practices are successfully implemented. Also added to the human resources are security and safety personnel who will be responsible for the Project site as well as monitoring transfers of any <i>Arundo donax</i> plant material from the area.</p> <ul style="list-style-type: none"> Security and safety personnel will be retained via contracts
6. Processing Impacts	<ul style="list-style-type: none"> Increased contamination of biomass material related to improper storage. Reduced drainage and drying. 	<ul style="list-style-type: none"> A properly constructed storage area will be erected to temporarily store the <i>Arundo donax</i> after being harvested. The chipped and dried biomass material will be stored at the custom constructed storage area with hardened concrete flooring until it is ready to be transported as demanded. The storage area, which will be located within the 400-acre area designated for the project. The concrete floored storage area's principal function is to prevent the biomass material from contact with the ground in order to have it as clean fuel, but also represent another measure in reducing the prospects for further propagation in the highly unlikely event that a fully intact rhizome eluded the harvesting, and initial processing of the biomass material. The North Carolina Best Management Practices suggest that the storage of viable biomass material should be covered; this is because it is plant material that is being stored instead of inert biomass that is no longer viable.
7. Transportation	<ul style="list-style-type: none"> Traffic Accidents Accelerated degradation of road surfaces increase in native fauna deaths Accidental spillage of materials 	<ul style="list-style-type: none"> Speed signs will be placed within the project site as well as during the transportation of vehicles and personnel. New roads will be constructed to ensure proper visibility and sloped so as to minimize ground disturbances and erosion potential. Access roads within the property will be made to the minimum width possible without threatening driver safety. Best management practices for farm roads to be implemented at all times. Each load will be locked for transportation in order to ensure that no spillage occurs between the collection site and the planting (<i>Biomass Pilot</i> project) site. The vehicle will be inspected including tires by project personnel prior to transportation to ensure that there is no crop material outside the container truck. The chipped material of approximately half inch sized pieces will be discharged directly into tractor drawn trailers for transportation to the on-site storage area. Communication between management of the BELCOGEN facility will determine the volume and timing for the transportation of the biofuel to the existing power plant facilities.
8. Waste Generation	<ul style="list-style-type: none"> Water Pollution Soil Pollution 	<ul style="list-style-type: none"> Waste generation must be mitigated and as such as waste management plan will be developed to address this important concern. Pilot projects for waste reduction and recycling are being planned.

		<ul style="list-style-type: none"> • For solid waste, the garbage bins should be strategically placed within the worksite and operation construction site. • The bins should be adequately designed and covered to prevent waste from becoming airborne, accessed by vermin and to minimize odor. • The bins should be emptied regularly, and all material scheduled for disposal and properly bagged. • Provide portable sanitary conveniences for the workers for control of sewage waste. A ratio of approximately 20 workers per toilet should be used. • All toilets should be serviced regularly. • All waste from the portable toilets should be placed in sealed containers for final disposal on mainland at a site approved by DOE. • Grey water from kitchen and shower stalls will be discharged to an elevated leach field.
9. Air Quality	<ul style="list-style-type: none"> • Suspended particulate matter • Wildfires and waste burning • Exhaust emissions • Combustion Emissions 	<ul style="list-style-type: none"> • Ensure proper construction of roads to reduce suspended particulate matter. Wet road where possible. • Ensure that the biomass material is as dry as possible for it to combust properly. A dry biomass produces a clean fuel • Similarly, keep the biomass material as clean as possible during drying. • Wildfires produce smoke and as such the project will prevent this by having a buffer area. • There is very little possibility that a ground fire could make it across the buffer zone even in the presence of very high winds and dried biomass fuel on the ground. • Ignition of the harvested biomass can only be achieved at high temperature. If ignition does occur while drying, then the smoke alarms would alert the workers.
10. Cultural Changes	<ul style="list-style-type: none"> • Increase in demand for services due to population increase • Increase in vehicular incidents • Increase demand for housing 	<ul style="list-style-type: none"> • Provisions will be made for communications and electricity, especially given the remote location. • Sanitation facilities will also be made available to address that human need. Likewise, wash area and restrooms will be constructed. • New roads that will be constructed will comply with national standards. • Erection of appropriate signage will be done to address safety. • There is the possibility for the construction of worker housing employees and security personnel.

Environmental Monitoring

The monitoring of the project investment will be from the planting of the biomass material to the harvesting and processing. The project will, therefore, be monitored throughout all the phases. Monitoring will also include not only potential negative environmental impact but also observations of any unforeseen social impact that might arise.

Monitoring will be carried out:

- To observe the production (rate of growth, annual yields, nutrient uptake, water balance, and fertilizer quality) of the *Arundo donax* in the field.
- To ensure good practice to address any concerns regarding aspects such as noise, dust pollution, excessive traffic, and water pollution that the community may have.
- To take actions specific to the Environmental Monitoring Plan, including regular field inspections for excessive plant material, human encroachment, for potential rhizome escape, inspections of container trucks before they leave the premises, inspection of the transportation route following each trip by container truck, and, inspection of all machinery and equipment before it is returned to rental agencies.

The monitoring and inspection related to potential unintended promulgates will be compiled on a quarterly basis and reported to the relevant authorities. This includes potential rhizome escapes, spills of shredded (unviable) crop during transportation, inspection of equipment and transportation vehicles prior to departing area, and if there is any human encroachment from non-project personnel. The report will summarize the date and nature of any documented issues, the remedial actions taken, and any additional information that confirms closure on the matter. The source information will be from the daily logs that are maintained for documenting the monitoring for promulgates as well as other safety features.

Table 4.13: Monitoring program for the Project.

Activity	Frequency	Parameters	Designated to
Spill of <i>Arundo donax</i> (shredded)	After every trip of the container truck transporting material	Residential areas, feeder roads, and highways	Management
Water pollution	Monthly for the first two years, then at quarterly intervals.	Blue Creek and the Rio Hondo by extension. During flooding and heavy rains.	DOE and Management
Excess plant material	Regularly after every harvested crop	plantation preparation, eradication	Management
Pollution (noise and dust)	Regularly, especially during harvesting and transportation	Cleaning equipment, traffic, shredding	Management of Belcogen
Inspection of Container Trucks	Regularly	Before and after loading	Management
Potential rhizome escape	Research plots, and biomass plots, Buffer Zone	Weekly during cultivation	Management - Field Inspection
Human encroachment	Daily	Visual inspection	Security
Inspection of equipment	Regularly during the start of each day or prior to using the equipment	Following washing and before leaving site to return to owners	Management
Air Quality Monitoring - energy production	Daily as per Compliance Plan	Combustion parameters to include CO _x , NO _x and SO _x	DOE
Solid Waste	Regularly as per compliance plan	Collection and disposal of solid waste to follow management plan	SWMA and Management
Wastewater	Regularly as per compliance plan	Operation and maintenance of treatment system	DOE and Management

5.0 Assessment of Alternatives

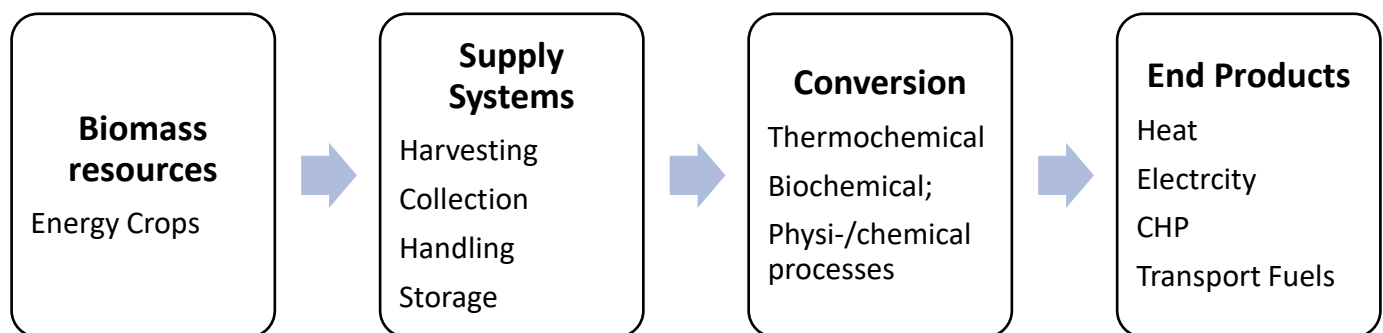
5.1 Introduction

The Government of Belize, through its accredited entity the Caribbean Community Climate Change Centre (CCCCC), is leading the development and implementation of a fully scalable and bankable bio-mass energy production project in Belize, utilizing the fast growing, widely available C3 perennial rhizomatous grass, *Arundo donax*.

The objective of these project preparation assessments is to demonstrate, using an innovative and impactful approach, the long-term feasibility of a viable and environmental and social implications of renewable energy programme based on the utilization of the widely available *Arundo donax*.

In order to foster the development of sustainable biomass-based energy technologies, different fields of research must be integrated (European Biomass Industry Association, www.eubia.org). As such different end products can play a role in providing economic sustainability options for the A Donax project. A diversified biomass energy project, can also aid in modernizing the agricultural economy and creating significant job opportunities.

The following chart shows how an integrated approach can be conducted across the value chain.



Source: Adapted from R&D orientations to bio energy-European Biomass Industry Association'

Sustainable end uses have been identified as bioheat, bioelectricity, transport biofuels, upgraded solid biofuels (pellets) and new bio-products (such as bio-lubricants).

An integrated approach is also consistent with the Belize Country Strategy for the period 2016 to 2020 as developed by the Caribbean Development Bank. This approach represents a first step toward expanded cultivation for the crop that could help Belize address its energy security challenges and meet its national goals. As indicated in the ESIA, the Nationally Determined Contributions (NDC) for Belize is consistent with the Growth and Sustainable Development Strategy (GSDS) which outlines poverty alleviation and medium-term and longer-term economic sustainable development.

The Belize Growth and Sustainable Development Strategy is the guiding development plan for the period 2016–2019. It adopts an integrated, systemic approach and encompasses medium-

term economic development, poverty reduction and longer-term sustainable development issues. This planning document also provides detailed guidance on priorities and on specific actions to be taken during the planning period, including actions that contribute to longer term development objectives beyond 2019.

In addition, the Belize National Sustainable Energy Strategy 2012-2033, established a framework to transition the energy sector and the economy toward low-carbon development. It further states that “given the country’s abundance of indigenous energy resources, there is scope for the proportion of RE in the energy mix to be increased”.

Bioenergy from Perennial Crops

The majority of the studies in our literature review had a focus on bioenergy. The biomass gained from *Arundo donax* cultivation can be utilized mainly for three types of bio energy: bio ethanol, bio-methane and solid bio fuels (for combustion purposes, in shredded or briquetted and pelleted forms) and the objective is to supply supplemental biomass for the cogeneration plant at BSI/ASR.

5.2 Methodology for Evaluation of Alternatives

Given that currently the Biomass Project has identified the *Arundo donax* option the discussion will center on other alternatives that exists whether taken into consideration or not.

The analysis of alternatives for any project can be based on key factors that were investigated and analyzed during the ESIA process. These are the Technical merits of the project, the Economic and Financial Feasibility of the Project and the Social and Environmental Impacts. A project must be technically and economically feasible in order to be acceptable. Technical feasibility must include economical and financial viability and should be implementable and administratively viable as well as sustainable. In combination with the least impacting social and environmental option, then alternatives to the current option might be looked at if the pilot project proves to be not adequate or portions can be enhanced taking into consideration the alternatives as well as do some testing of the alternatives during the pilot phase.

The evaluation of alternatives discussed evaluated four options: “*Arundo donax*” option (Option A); “Using native grass species” Option (Option B), and “Sweet Sorghum” Option (Option C) and “No Action” or non-development (Option D).

5.2.1 Technical and Economic Analysis

A. Biomass Production using *Arundo donax* (Option A)

It appears that the selection of *Arundo donax* as the bio energy crop was based on mostly literature review. There is a significant amount of existing literature regarding this plant in temperate conditions and it remains to see if it will perform similarly under our local conditions.

Many studies with a global outlook have identified *Arundo donax* as one of the most promising candidates for biomass production (see Table 1). Among crops produced in European agricultural systems, in the category of perennial crops, *Arundo donax* had the best

characteristics. However, *Miscanthus giganteus* must also be taken into consideration. *Arundo*, as a perennial energy crop for bio fuel production, is widely used in the United States in high quantity, together with switch grass, *Miscanthus*, canary grass and alfalfa (Gupta et al., 2014, p. 23-47). Permanent grasslands as venues of producing biomass for combusting purposes were highlighted in the review of Prochnow et al (2009). According to the studies they investigated, *Arundo* is among the most promising grass species. In terms of sustainability, extensive grassland management and *a low level of mineral fertilization are required and using conventional farm machinery contributes* to the best economic performances. For combusting purposes, pelletizing or briquetting might also be required.

Table 5.1 Summary of studies on biomass potential of *Arundo donax*.

Study	Topic	Country	Method	Results
Venturi- (2003)	Raw fibre biomass production in Europe	Europe	Review of literature	Among crops produced in European agricultural systems, <i>Arundo donax</i> had the best characteristics among perennial crops, followed by <i>Miscanthus giganteus</i>
Gupta et al. (2014)	Bio energy potentials	Global	Review of literature	The most often used perennial energy crops are <i>Arundo</i> , switch grass, <i>Miscanthus</i> , canary grass and alfalfa
Prochnow et al. (2009)	Permanent grasslands as sites to produce biomass for combusting purposes	Global	Review of literature	1. <i>Arundo</i> is among the most promising grass species 2. For sustainable production extensive management, low level of inputs and using conventional machineries are required
Nackley et al. (2015)	Bioenergy production from invasive species	Global	Review of literature	1. <i>Miscanthus giganteus</i> and <i>Arundo donax</i> are the most promising biomass crop 2. <i>Arundo donax</i> can be considered sustainable in terms of economics and social development, however because of the invasiveness the environmental aspects should considered
Soldatos (2015)	<i>Arundo</i> vs. <i>Miscanthus</i> and switch grass	Mediterranean countries	Mixed	1. In case of all the selected plants fertilization, irrigation, harvesting and transport are the dominant cost items. 2. The cost per dry tonne of <i>Arundo</i> is the lowest. 3. Propagation with rhizomes makes <i>Arundo</i> and <i>Miscanthus</i> plant establishment more costly.

Others narrow the candidates to two potential crops: *M. giganteus* and *Arundo donax* as the most ideal bio energy crops. However, the latter is often critically looked at because of its invasive characteristics. *Arundo* is deemed to be sustainable in terms of economics (biomass supply and revenue generating) and social development (neutral or negative CO₂ emissions and avoiding food-crop competition), however in terms of environmental protection it has deficiencies, mainly

in reducing freshwater resources and having negative biodiversity impacts (Nackley, et al., 2015).

From a purely economic aspect, investing in perennial plants for biomass production purposes consists of high establishment costs that are paid only in the first year but after the initial years the maintenance cost of the plants reduces only for basic fertilization in every 3–4 years. On the other hand, revenues can be expected only from these condors third year, while the average life cycle of such plants can be 15–20 years (Soldatos, 2015). The cost of establishment is much higher for *Arundo* and *Miscanthus*, because in these cases rhizomes are required with expensive plantation. It was also found that using marginal land reduces the yields; therefore; from an economical point-of-view makes it less attractive for a farmer.

B. Biomass production using locally available C4 grass species (Option B)

There are a number of plant species that generate high yields of biomass with minimal inputs; many of these are C4 grasses. Grass species with C4 photosynthesis, such as Aleman grass (*Echinochloa polystachya*), Elephant grass (*Pennisetum purpureum*), fox tail millet (*Setaria italica*), miscanthus (*Miscanthus giganteus*), sweet sorghum (*Sorghum bicolor*), sugarcane (*Saccharum* sp.) and switchgrass (*Panicum virgatum*), are ideal energy crops because they possess the following traits: high conversion efficiency of light into biomass energy, high water use efficiency and high leaf level nitrogen use efficiency, capacity to grow in marginal land areas, and a relatively high tolerance to soil constraints such as salinity and water logging (Taylor et al., 2010).

Grasses with C4 photosynthesis possess an additional CO₂ concentrating mechanism that enables them to outperform C3 species, particularly under high temperature and light conditions and are, therefore, capable of generating larger quantities biomass, even in resource limited environments. Plants with C3 photosynthesis such as poplar (*Populus*) and willow (*Salix*) also generate high yields of biomass, but take longer to grow and have higher contents of lignin, making the polysaccharides less accessible, thus the biomass quality is lower.

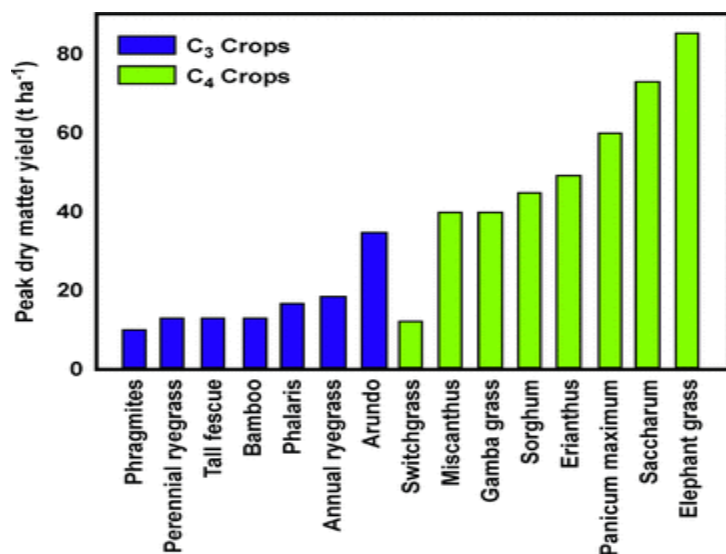
Plant species with C4 photosynthesis may have further advantage over C3 species in some of the types of climate scenarios that have been projected for the future as a result of global warming. In many areas a greater incidence of drought and higher temperatures are expected (Sheffield J & Wood EF, 2008). Grass species with C4 photosynthesis are well suited to those areas where the average temperature will increase and where the incidence of drought is expected to increase. C4 plants are among the most productive plants on the planet, both as agricultural crops and the worlds' worst weeds (Hatch, 1987).

Belize has many native and introduced perennial C4 grasses growing all over the country. Some species have been identified (not exhaustive) as being present in Belize such as:

 <p>Aleman grass (<i>Echinochloa polystachya</i>)</p>	 <p>Elephant grass (<i>Pennisetum purpureum</i>)</p>	 <p>Miscanthus (<i>Miscanthus giganteus</i>)</p>
 <p>Switchgrass (<i>Panicum virgatum</i>)</p>	 <p>Guinea grass (<i>Panicum maximum</i>)</p>	 <p>Dumb cane (<i>Tripsacum</i> sp.)</p>
 <p><i>Phragmites australis</i></p>	 <p><i>Gynerium sagittatum</i></p>	 <p>sweet sorghum (<i>Sorghum bicolor</i>)</p>

A study, by Fedenko et al., was conducted to quantify dry biomass yield and the carbohydrate and lignin composition of six potential biofuel grasses (elephant grass, energy cane, sweet cane, wild cane (*Arundo*), giant miscanthus, and sugarcane) across three sites in Florida for plant (2009) and first ratoon (2010) crops. Dry biomass yields ranged from about 30 to 50 Mg ha⁻¹ and were generally greatest for elephant grass, energy cane, sweet cane, and sugarcane. Accordingly, total plant carbohydrate yields (20 to 25 Mg ha⁻¹) were comparable among sugarcane, energy cane, sweet cane, and elephant grass, **but were generally less for *Arundo*** (see Figure 1) and even less for giant miscanthus.

Figure 5.1: Comparison of peak dry matter yields of field grown.



The harvest of wild population in the entire district would be easily done by setting up a collection centre and offer a reasonable price. It would generate income and employment for many unemployed persons in the district. Additionally, it would provide the opportunity to keep many areas along the road to be cleaned as these grasses grow freely along the many rural roads, yards, and communal lands, as well as on farms. Once the collection centre is established the grasses can be dried and chopped. This would require minimal investments.

Singh et al. (2015) in an USA Field experiment based on Wild cane (*Arundo*) vs. sugarcane, sweet cane, energy cane and elephant grass where the results in terms of dry biomass yield, several plants can exceed *Arundo* under specific conditions.

Additionally, this could be a good use of the excess sargassum arriving on Belize's coast. It should be collected and dried and then transported to be used as biomass feed for the cogeneration plant.

C. Biomass production using Sweet Sorghum (Option C)

Discussion of what types of C₄ plants may be used as bioenergy crops has been limited. Miscanthus, *Arundo* and switchgrass have been the focus for considerable research and development activities in Europe and the USA. However, many promising energy crops appear

to have been overlooked, in particular, variants of sugarcane and sweet sorghum. The genetic complexity and narrow genetic base of sugarcane presents considerable challenges (Nair et al., 1999, p.73-79). These issues are not pertinent to the diploid sorghum. Most of the literature about sorghum focuses on grain sorghum varieties, but the difference in potential energy yields between grain and sweet sorghum varieties is significant. There is enormous genetic diversity within *Sorghum bicolor* varieties, and some sweet sorghum varieties have been reported that produce similar yields to sugarcane (Ratnavathi et al. 2010). Sweet sorghum also competes well with miscanthus and switchgrass in regards to biomass yields (Propheter et al. 2010). Some sorghum varieties and species also ratoon and some are rhizomatous (Pritchard, 1964). Extensive trials comparing the top varieties of candidate energy crops are needed to compare the energy yields and resources required.

Crop duration also impacts final potential yields. In warmer climates it is possible to harvest two crops per year from sweet sorghum. The second sorghum crop need not require a second planting, as sorghum produces what is called a ratoon crop. After sorghum stems are chopped off, the base of the plant will grow a second set of shoots from which similar sugar yields may be harvested. Sweet sorghum may also prove to be cost effective relative to sugar production because sweet sorghum has a lower fertilizer requirement than sugarcane and pest and disease management is less complex for sweet sorghum (Almodares & Hadi, 2009, p. 772-780).

The chemical energy contained within biomass may be harvested by conversion to bioethanol or by conversion to alternate fuels, by direct combustion or by pyrolysis. In the context of bioethanol production, high quality biomass refers to a composition that can be easily and cheaply converted to liquid transport fuels. That is, the maximum accessible yield of firstly, monosaccharides and disaccharides, and secondly, easily extracted polysaccharides. Large quantities of polysaccharides, such as cellulose, contribute to biomass quantity but biomass quality is also important. Cellulose may be bound within lignin, and thus, inaccessible to processing. Lignin content, composition, and also the type of bonds between lignin, hemicellulose and cellulose are factors that influence biomass quality.

Sweet sorghum plants grown in soil salinity of 3.2 dS/m and limited (210 mm) irrigation water yielded 27.1-33.5 t/ha biomass, 2.6-3.86 T/ha total sugar and 4926-7620 L/ha theoretical ethanol yields (Vasilakoglou I, et al., 2010). Thus, this crop may yield sufficient sugar for ethanol production in areas that are not ideal for food production such as arid environments where soil and water may be moderately saline.

There is a new variety known as super sorghum which has high biomass yields. Please see attached pamphlet.

D. No action Biomass production (option D)

This option would pose no technical or economic problems and would result in the status quo. The disadvantages of the “No Action” Alternative are economical mainly from the loss of net social and economic benefits. Loss of benefits would include the loss of income from this new activity, the loss of foreign exchange savings as BEL will continue to import electricity, the loss of revenue-generation for the country, the loss of employment and the loss of future economic and scientific benefits. The emphasis alone on poverty reduction through direct and indirect

employment is perhaps the single most positive economic benefit; however, the lowering of the cost of electricity would impact the overall Belizean population. The employment of over 500 persons with a secure long-term employment and satisfactory salary can only be described as positive in the present economic context of a struggling economy. Indirectly another 10,000 families would benefit as well as the overall public as electricity rates are lowered.

5.2.2 Results of the Analyses

Much more information is needed and research to do a thorough analysis. However, it would be interesting to carry out some research and comparison during the pilot phase to be able to compare viability and feasibility of the different options.

Use of Resources

The most sustainable systems for growing energy are those that maximize the production of photo assimilate and minimize the requirement for valuable inputs such as nitrogen, phosphorus and water. Furthermore, an ideal energy cropping system would be one which increases soil organic carbon over time, by sequestering carbon and minimizing the greenhouse gas emissions. Boosting soil organic carbon over time would have the additional benefit of improving the soil structure and nutrient availability.

Perennial sorghum has been developed by crossing *Sorghum bicolor* with *Sorghum halepense*, a species of *Sorghum* which is rhizomatous (DeHaan et al., 2005). *Sorghum alnum* and *S. halepense* are also rhizomatous (Pritchard AJ, 1964). Continuous cultivation of sorghum increases soil organic carbon; thus, *Sorghum sp.* may be useful for carbon sequestration purposes (Wang et al., 2010).

Photosynthetic phosphorus (P) use efficiency in C4 species increases as P becomes more limiting, to a greater extent than in C3 species (Ghannoum O, Conroy JP, 2007). Thus, in P limiting environments C4 species may be better able to sustain photosynthesis, and thus, production of photo assimilates, than C3 species.

Water Use

Evapotranspiration causes water loss; water loss can be reduced by lowering stomatal conductance, but this compromises CO₂ capture. It should be noted that C4 plants tend to have higher water use efficiency because of the ability of C4 plants to fix CO₂ with less open stomata by virtue of the high affinity of PEP carboxylase for bicarbonate (Furbank et al., 2009); thus, enabling C4 plants to maintain a lower intercellular CO₂ concentration and, therefore, a greater diffusion gradient (Long SP & Ort DR, 2010). The water use efficiency of C3 plants is 2-3 g dry mass/kg H₂O (Kramer PJ & Boyer JS, 1995), which is one third to one half of the efficiency of C4 plants, many of which may achieve 4-6 g dry mass/kg H₂O.

Future climate scenarios predict that higher atmospheric carbon dioxide levels will lead to more days with higher temperatures and more erratic rainfall leading to an increase in the incidence of drought. Generally, C4 grasses have the capacity to generate more biomass than C3 grasses in

conditions where the maximum daily temperature is higher (Rubio et al. 2010). Conditions of elevated temperature and CO₂ improve yields of sugar and biomass in sugar cane and sorghum, respectively (Funct. Plant Biol.). The water use efficiency of sweet sorghum increases, exceeding that of maize and grain sorghum, under water stress conditions (Conley et al 2001). The normalized leaf level transpiration efficiency of sorghum was 10.5 µmol/mmol kPa, whereas C3 crops averaged around 4.8 µmol/mmol kPa (Steduto P & Albrizio R, 2005).

5.2.3 Environmental Analysis

Analysis conducted for the environmental and social parameters of the alternatives included the social, and environmental impacts (see table 5.2).

Table 5.2: Comparison of Technical, Economic and Environmental Parameters for Alternatives.

Parameters	Alternative A <i>Arundo donax</i> (development)	Alternative B Local C4 grass	Alternative C Sweet Sorghum	Alternative D Status quo
Economic & Environmental Parameters	Employment opportunities Foreign exchange savings Cheaper electricity rates Energy security Use of marginal lands Alternative activity for farmers	Employment opportunities Income generation Foreign exchange savings Involve youth and other marginalized groups	employment opportunities Income generation Foreign exchange savings Cheaper electricity rates Energy security Alternative activity for farmers Can replace land abandoned due to sugar prices	No employment opportunities No foreign exchange savings No diversification of productive sector No poverty reduction
Ecological	Ecological impact can be in waterways and due to invasive characteristics. Mitigation plan in place.	No ecological impact as it would only use harvested plants from wild populations.	Ecological impacts are maintained as low impact. Mitigation measures will ensure low/no impact to resources.	Non - development would lead to least ecological impacts.
Hydrology & Water Resources	Medium/Medium Term/Local Impacts(Reversible) This plant is a hydrophyte	No impact as will not be cultivated plants.	Small local impact	Small/Short Term/Local Impacts

Parameters	Alternative A <i>Arundo donax</i> (development)	Alternative B Local C4 grass	Alternative C Sweet Sorghum	Alternative D Status quo
Construction & Equipment Use	Small/Short Term/Local & Reversible impacts from vegetation removal & impacts to birds.	No impact to minimal	Small impact, might build bird populations	No impacts
Vegetation & Soils	Mostly long term and some reversible impacts as on marginal lands	No impact to positive impact	Medium to small impacts to positive impacts	No impact
Terrestrial Fauna	Negative impacts to some faunal species	Little impact	Medium/Medium Term/Local	No impact
Aquatic Fauna	Medium impact but risk can be mitigated	No impact	Low impact but mitigation can be in place	No impact
Land Use	Use marginal lands so might be positive	No impact	Low land use changes and impacts	No impact
Historical/Cultural	None	None	Low	None
Human Environment & Health	Risk to human health if wrong practices utilized Adequate Facilities to be made available	minimal	Potential risk if adequate practices not followed	None

Parameters	Alternative A <i>Arundo donax</i> (development)	Alternative B Local C4 grass	Alternative C Sweet Sorghum	Alternative D Status quo
Technical & Administrative	With adequate staffing, supervision & monitoring, environmental compliance can be assured	minimal	Technical skills and technology are not complex	none
Economic	Economic returns expected	Economic returns assured	Economic returns are expected	No economic returns
Social	Ensures opportunities for employment etc.	Opportunities for employment and income generation	Employment opportunities and income generation for farmers	Lack of opportunities
Health Risks	To the communities downstream if activities not monitored	None or minimal	Some health risks to downstream users of watersheds, reduced health risk to employees	none

5.3 Alternatives for Sustainable Opportunities (end products)

The majority of the studies in the literature reviewed had a focus on bioenergy, the three types of bioenergy: bioethanol, bio-methane and solid biofuels can be considered, by looking at industry best practices as it relates to current advances.

Many cited studies are typically conducted in agricultural soils with residual soil N and moderate organic matter levels. As such any decision to start using options A through C should possibly be preceded by a demonstration agro-park type programme.

These alternatives are discussed herein, along with a brief description of the physical processes of each of the options, followed by a summary of the potential impacts and mitigation of each process.

5.3.1 Potential Use as Upgraded Solid Biofuels (Pellets)

The biomass gained from *Arundo donax* cultivation can be utilized mainly for three types of bioenergy: bioethanol, bio-methane and solid biofuels (for combustion purposes, in shredded or briquetted and pelleted forms).

With regards to the use of solid pelleted biofuels, these are a number of combustion and gasification processes which currently exist. In many cases however, traditional solid biofuels require pre-treatment in order to meet requirements of these conversion processes. These traditional methods typically operate at low efficiencies with biomass feedstocks which can result in inefficiencies when competing with power production from fossil fuels or efficient renewables such as solar. Modern technologies and pre-treatment can result in upgraded solid biofuels suitable for highly sophisticated conversion processes.

Renewable energy companies, such as Arterran Renewables of Canada, utilize any organic material with a suitable amount of cellulose content and can convert it into a next generation solid biofuel. In the case of Arterran, the resulting characteristics have been shown to be superior to common wood pellets and can replace fossil fuels used for the production of heat and electricity.

As an example, pellets are created by taking raw hardwood or softwood chips with 35% to 50% moisture content can be dried to 10% to 14%. This densified wood now has an energy range of 7,250+- Btu per pound for softwood and up to 8,500 Btu per pound for hardwood with moisture content of 5% to 8%.

Advances biofuel processes such as the Arterran model, start with the same 35% to 50% moisture content wood but they dry the wood by processing it with a catalyst, and end up with a solid biofuel that has a significantly higher energy density of 10,933 to 12,200 Btu per pound with a moisture content of only 2% to 4%. This will lead to significant reductions in ash, Sulphur and heavy metals in the final products.

In terms of high temperature corrosion within the bio-mass energy applications however, heavy metals can cause variable levels of corrosion due to various processes. As such there are

operational benefits, in addition to reduction of GHG and other gasses.

Table 5.3: A comparison of the Arterran pellets highlighting the differences.

Comparison of fuel	Coal	Wood Pellets	Arterran
Energy (GJ/tonne)	18-30	16-19	24-28
Energy (Btu/lb)	7700-13000	7250-8500	10500-12200
Moisture Content%	6-15	5-10	2-4
Ash%	6-15	0.3-0.7	0.3-0.5
Heavy metals	Yes	No	No
Sulphur	Yes	No	No
Tar and Creosol	Yes	Yes	No
Hydrophobic	Yes	No	Yes
Grindability			
Energy to Grind (kwe/MWth)	3	12-25	1
Grindability Index (higher is better)	>50	<30	>50
Other feedstocks			
Municipal Waste	--	No	Yes
Animal manure	--	No	Yes
Agricultural waste	--	No	Yes
Carbon credits	No	Yes	Yes
Off gassing	Yes	Yes	No
Special storage	No	Yes	No
Plant Portability	No	No	Yes

The use of traditional unprocessed biomass tends to decline in the next decades, while the consumption of bioenergy tends to increase worldwide, regarding the high global primary energy demand (IEA, 2019). In this scenario, besides other biofuels, fuel pellets play an important role in the bioenergy market.

Currently, the main consumers of pellets are Western Europe and North America. The European Union and Japan are however, projected to be the largest pellets importers in the near future (IEA, 2012). Fuel pellets have some advantages in comparison with unprocessed biomass.

Among the advantages are:

- the higher energy density,
- implying lower storage and
- transportation costs (researchgate.net publication)

On the other hand, there are some disadvantages. For instance, the high level of ash content at high pyrolysis temperatures could present problems in a gasifier. In addition, sugarcane bagasse

presents high level of moisture content, demanding higher energy consumption during the drying process (researchgate.net publication).

Sugar Cane Bagasse Pellets

Sugarcane bagasse pellets have similar characteristics (e.g. NO, CO and SO₂ emissions) and conversion efficiency in comparison to wood pellets (researchgate.net publication).

Pellets properties are essentials in the study of performance in thermochemical processes, such as combustion, gasification and pyrolysis. These properties can affect aspects related with transport, storage, handling, fuel conversion and environmental emissions. Pelletizing process of sugarcane bagasse is a great alternative to commercialize such biomass worldwide (researchgate.net publication).

Quality standards are fundamental in order to meet the following requirements: guarantee a common national or international quality of fuel pellets; ensure legal compliance and security among the actors by defining responsibilities and duties; establish limit values and quality indicators, for use, transport and storage; define technical characteristics for heating equipment; inform the final consumers about quality characteristics; ensure customer satisfaction and disseminate biomass fuel, be environmentally friendly.

The current state of the art in wood pellet market is focused on certification system, including requirements for pellet production and quality assurance, labelling, logistics and intermediate storage as well as delivery to costumers (EN plus, 2013).

Pellets properties from international standards are presented in Table 1. ISO 17225-2 is a standard for wood pellets (International Organization for Standardization [ISO], 2014a) (<https://www.iso.org/obp/ui/#iso:std:iso:17225:-2:dis:ed-2:v1:en>), while ISO 17225-6 is a standard for non-wood pellets (International Organization for Standardization [ISO], 2014b). The European Pellets Standard EN 14961-1 is a general requirement for solid biofuels (European Committee for Standardization [CEN], 2010). The North American PFI standard establishes requirements for wood pellets (PFI, 2011).

Table 5.4: Standard for Wood Pellets.

Specification	ISO 17225-2	ISO 17225-6	EM 14961-1	USA PFI
Diameter (mm)	6,8,12 ± 1	6 - 10	6,8,10 ± 1	5.84-7.25
Length (mm)	3.15-40	3.15-40	3.15-40	≤ 42
Bulk density (kg m-3)	≥ 600	≥ 600	≥ 600	608.7-746.9
Durability (%)	≥ 97.5 - ≤ 99	≥ 97.5	≥ 96.5	≥ 95.0
Moisture (%)	≤ 10	≤ 12	≤ 10	≤ 10
Heating value (MJ kg-1)	≥ 16.5	≥ 14.5	≥ 16.5	-
Heating value (kcal kg-1)	> 3941	> 3463	> 3941	-
Ash content (%)	≤ 0.7	≤ 6	≤ 1.0	≤ 2.0
Fines (5)	≤ 1	≤ 2	≤ 1.0	≤ 1.0
Nitrogen, N (%)	≤ 0.3	≤ 1.5	≤ 0.5%	-
Sulphur, S (%)	≤ 0.04	≤ 0.2	≤ 0.05%	-
Chlorine, Cl (%)	≤ 0.02	≤ 0.1	≤ 0.3%	< 300ppm

Arundo Donax Pellets

Biomass from annual and perennial crops, grown specifically for energy production, which consist of plants that persist for several years also known as short-rotation crops. According to Jungers et al, these bioenergy sources raw materials (woody species and short-rotation crops) have a number of environmental benefits such as carbon sequestration and a reduction of pollution (Zeldon and others, 2015).

A field study was conducted in Costa Rico to determine the short-rotational crops biomass and bioenergy potential. The trial consists of 3 agricultural forage species (*Arundo donax*, *Pennisetum purpureum* and *Pennisetum purpureum* × *Pennisetum glaucum*).

The Costa Rico tests showed that *Pennisetum purpureum* propagated by plant, had the lowest ash percentage with 13.33%; *Arundo donax* had the lowest moisture content with 52.28% and *Pennisetum purpureum* × *Pennisetum glaucum* obtained the highest calorific value with 20218 kJ/kg. As for energy produced, all had variations; however, *Pennisetum purpureum* propagated in both rhizome and plant, obtained the highest value (approx.470 GJ/ha) after 6 months of being planted.

The results of the present study confirmed that *Pennisetum* species and *Arundo donax* are a promising feedstock for biomass production with adequate energy properties at six months old (first rotation) and could play an important role as a bioenergy crops.

When biomass is extruded into a pellet for fuel, it must be carefully stored and transported without any exposure to water until it is burned in a boiler or it will fall apart and become useless.

Pellet Manufacturing Processes

To overcome the water-solubility issue over the past 20 years, several companies have developed various approaches to manufacture a water- repellent biomass pellet (<https://arterran.com/wp-content/uploads/2020/02/Water-Resistant-Pellet-Manufacturing-Processes-15-Feb-2020.pdf>).

Two of most common are:

Torre faction - This process has been proven technically by several companies in Europe and the US over the past 25+ years. Biomass is ground to a small micro-chip size, then ‘slow-roasted’ in a low oxygen environment at temperatures typically between 200°C and 320 °C. Pyrolysis is similar to roasting or baking where the biomass constituents are “cooked off” and the remaining biomass becomes denser. The finished material is then ground and densified in a pellet press just like a white pellet. The final form of torrefied pellet is hydrophobic and with a higher energy content than a white pellet.

Steam Explosion - This method of biomass processing is a pre-treatment that opens up the fibres and makes the biomass polymers more accessible for subsequent processes or densification processes. Typically, wood chips are heated to ~280°C at a pressure of 3.5 MPa (500 psi). The pressure is then raised to 7.0 MPa (1,000 psi) for a few seconds and the biomass is discharged through restricted ports where it “explodes” and opens up the fibre. Pellets from steam explosion processes are dark brown in color, and stiffer than conventional wood pellets. They are less abrasive and are distinctly hydrophobic. The bulk density of steam exploded pellets is relatively high in comparison to conventional wood pellets, but the finished product typically does not have energy content much greater than a white pellet fuel. Hence the commercial case for selling a steam exploded pellet is that it is waterproof and is accepted as a proven manufacturing method.

A third method, known as Thermo-Catalytic Conversion (TCC) is process developed and third-party validated by a Canadian company-Arterran Renewables. The TCC technology homogenizes lignocellulosic biomass at much lower process temperature and pressure than that required for torrefaction or steam explosion. The blend of biomass at normal moisture content with proprietary catalysts inside a commercial reactor vessel, results in slurry, which is then mechanically separated. The solid portion then immediately densified into a pellet fuel which is both water resistant and has an energy density equal to bituminous coal (<https://arterran.com/wp>).

Table 5.5 Comparison of Currently Available Water-Resistant Biomass Fuels.

	Coal	Torrefied Pellets	Steam Exploded	Wood Pellets	Arterrnan Advanced Fuel
Energy Density GJ/t	17-30	20-20	20-22	16-20	24-29
Moisture wt. %	10 to 15	1 to 5	2 to 5	16 to 20	2 to 4
Ash %	3 - 50	1 to 2	1.3 to 2	.5-2.0	1.5 to 2
Fixed Carbon %	50-55	28-35	28-36	20-25	45-46
Volatiles %	15-30	55-65	55-66	70-75	50-51
Bulk Density Volumetric kg/m ³	800-850	700-850	700-850	550-750	775-850
Hydrophobicity	Yes	Yes	Yes	No	Yes
Biological Degradation	No	No	No	Yes	No
Self-Heating	No	No	No	Yes	No
Oxygen Depletion	High	No	No	Extreme	No

Potential Impacts to Environment from Pelletization and Mitigation and Control Measures

The project's activities may lead to the following potential impacts:

- Increased air and dust particulate matter can result from the cutting and mechanical process of pelletization. This can be hazardous to human health (employees and communities).
- Pelletization can result in noise pollution derived from the physical process as well as from the maintenance of the equipments.
- Wastewater generation from the cooling process can cause nutrient enrichment within a body of water making it unsuitable for recreation or domestic use.
- Chemical contamination from pelletization-related activities to existing surface water bodies and drainage paths by the project could result in contamination of freshwater stocks available for native fauna.

Table 5.6 Summary of Activities Degree of Impacts and Mitigation and Control Measures for Pelletization Activities.

Activities	Degree of Impact	Mitigation Measure
Pelletization	<ul style="list-style-type: none"> • Air and particle matter due to physical processes • Contamination of water bodies • Contamination of ground water 	<p>Use dust suppression methods which include:</p> <ul style="list-style-type: none"> • Properly enclosed building structure where pelletization process will occur. • Minimize air and dust particles from escaping into the environment by using a vacuum system to perform clean ups. • Workers must wear respiratory protection in order to reduce exposure to airborne particulates. • Prevent attrition of pellets and store in properly marked bins that will ease transportation to the plant. • Wastewater generated by the steam explosion process will be sent to a holding pond until the desired ambient temperature is achieved before recirculation or disposal. • No water will be utilized for the Biomass cultivation from the nearby Blue Creek, nor will any water from the project be drained into the creek. • The drainage will be constructed within the cultivate area to adequately distribute water and also clear used water from washing machinery and equipment. • The water will drain and remain within the 400-acre project area contained by the Buffer Zone. • In addition, the biomass project will contain water within the buffer zone and will not release any water to the nearby waterways including the Blue Creek. • The water used to wash equipment will run into the drains that are located between the inner sides of the access road/buffer zone. • Best management practices adopted in site selection and in the construction and of access roads during road construction and clearance of associated sites at all times.

5.3.2 Bio-methane options

Research shows that bio propane can be produced without major modifications to current petroleum refining processes and practices. Although capital costs for plants could be high initially, uncovering ways to produce bio propane advances the propane industry closer to diversifying its supply chain with a renewable fuel (Propane Education and Research Council).

With regards to bio methane, its production is straightforward. The facilities and systems are commercialized and off the shelf from several vendors, and the economics and productivity are well understood. Bio methane can be delivered in both compressed and liquid forms and as such has commercial applications in both the power generation and transportation sectors.

Biomethane use in the transportation sector can sometimes be overlooked, but in order to reduce GHG emissions, it can provide a viable option. When biogas is purified or upgraded to natural gas quality (then mostly referred to as “biomethane”), it can be used in the same manner as fossil gas for natural gas vehicles (NGV) or so-called dual fuel vehicles.

NGV use is steadily increasing internationally based on the very strong advantages of NGV operation: relatively low emissions compared to diesel and gasoline, typically lower fuel costs, and similar ease of driving.

Argentina, Brazil, China, Colombia, Germany, India, Iran, Italy, Pakistan, Sweden and Switzerland have relatively well-developed NGV infrastructures.

In addition to bio-methane however, the Country can also conduct R&D programmes into the use of Bio-propane.

There have been several advances recently, with a few companies that are now producing bio-propane on a commercial scale. These include:

- Global Bio-energies- producing Bio-butylene
- Eni producing Bio-propane
- Neste Oil producing Bio-propane
- Total Oil Company- nearing production

BioLPG has made significant progress. In the past four years, production volumes have grown some 50% to around 200 thousand tonnes annually, and sales of branded BioLPG have begun in Europe and the USA. Although this is less than 1% of the market for fossil LPG, it is a robust start.

In the short term, the biggest potential for further expansion is co-processing, i.e. making BioLPG in conventional refineries using conventional hydrotreaters. This is attractive, because it uses existing processing units that already connect to the LPG distribution network.

Bio-propane can be easily integrated into the current propane industry in Belize, and can complement the growing transport-LPG markets. This will further improve energy security programmes, as it has the potential to reduce fossil fuel imports and enhance the local energy economy.

General Research Process

- Develop, evaluate, and refine methods for producing bio propane, synthetic propane, and DME from biomass (wood, corn, grass, and more), biocrude (oil extracted from crops such as soybeans and rapeseed), coal, and other sources.
- Assess the economic viability and potential market for each production method and capture results in reports.
- Develop a path to commercial production of bio propane, including the identification of appropriate industry and government partners.

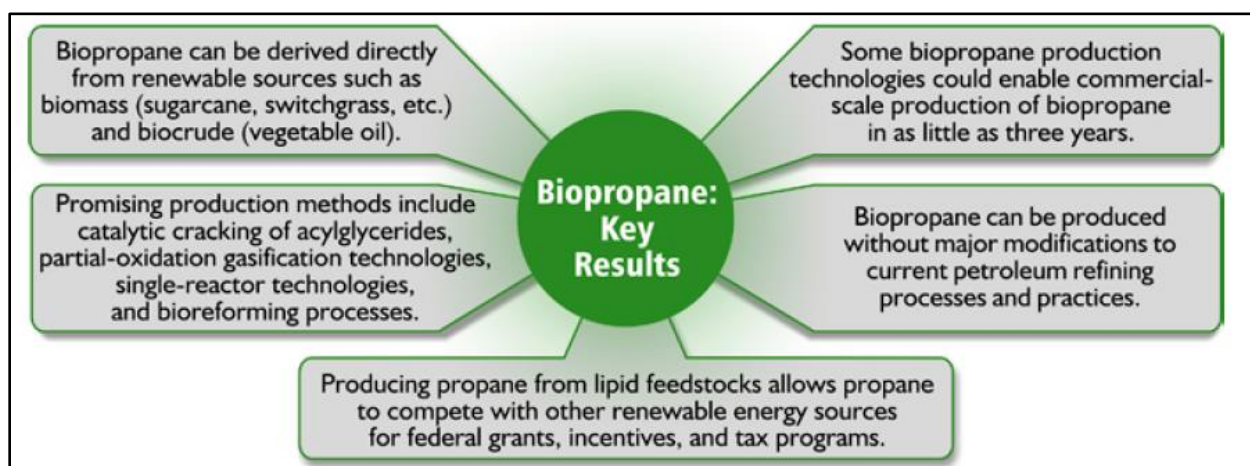


Figure 5.2: Bio propane: key Results

Source: Bio propane Production Methods; Propane Education and Research Council.

Research Project Reports

- Expert Analysis of the Concept of Synthetic and/or Bio propane (Gas Technology Institute) evaluates synthetic propane and bio propane production methods and determines the economic viability of bio propane and DME production technologies.
- The report includes a strategy for the full-scale commercial production of bio propane and synthetic propane; an evaluation of the major risks and uncertainties for the relevant technologies; and an analysis of related government programs.
- Bio propane from Syngas and Acyl glycerides (Source: E. Johnson, 2019, after Mississippi State University), examines the reaction products for the heterogeneous catalytic cracking of acyl glycerides into gasoline, diesel-range organics, and light gases such as propane. The report proposes using the existing wastewater treatment infrastructure to grow specialized microorganisms needed to produce biocrude, which can be catalytically cracked into bio propane.
- Biomass Conversion over Acidic Solids and Supported Metals Catalysts (E. Johnson, 2019) includes a preliminary economic analysis and a model compound study for the

conversion of oxygenates over acidic solids. The report determines that these compounds can be efficiently converted to propane and other hydrocarbons.

Bio propane can be produced as a by-product of various gasification technologies, which involve the conversion of biomass into a synthetic gas (syngas) before being further processed into different products, including methanol, DME, gasoline and diesel. The product yields depend on the makeup of the syngas, the type of process, the process temperature and the catalyst used.

A number of companies and organisations around the world are conducting research into advanced biofuels production processes, some of which involve the production of bio propane or bio-DME as a co-product or as the principal output. These technologies can be categorised according to the type of feedstock – vegetable oil, wood and other starchy material and sugar. The maturity of these technologies varies considerably.

Bio propane Commercialization

Principal process technologies that can produce bio propane are shown in Figure 5.3 below.

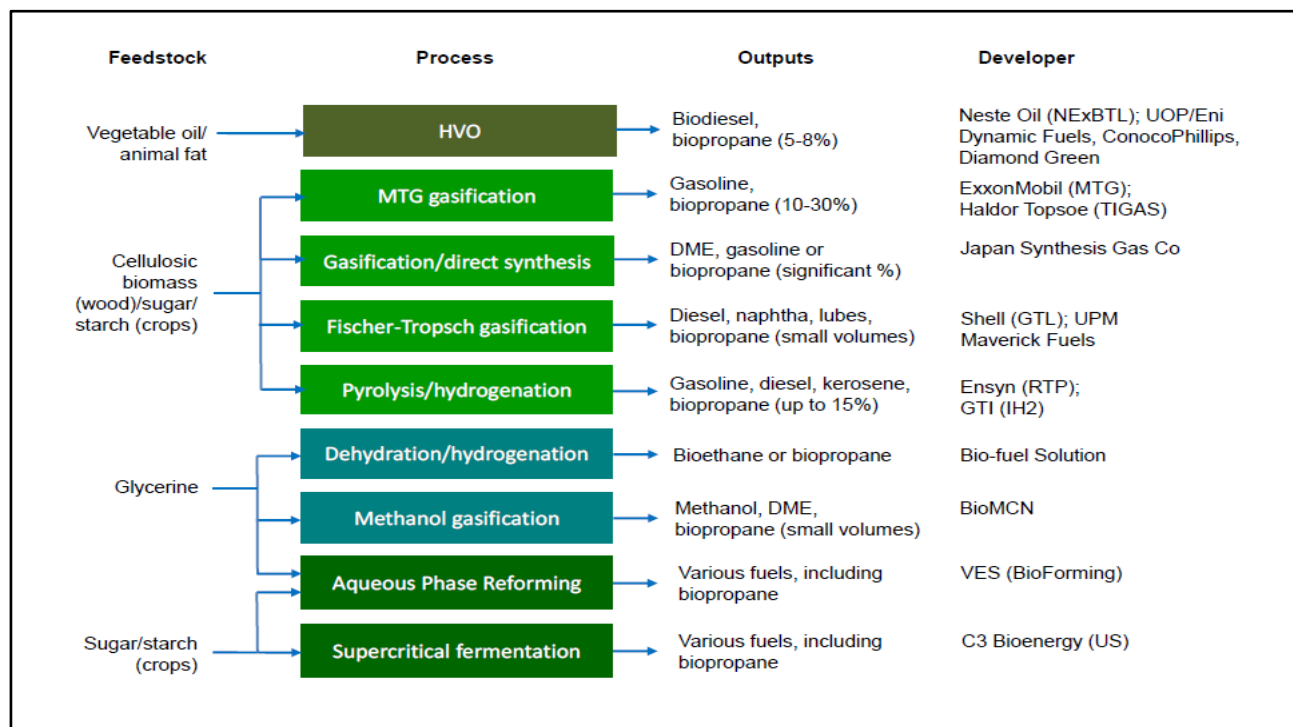


Figure 5.3: Principal Process Technologies in Bio propane Production.

Potential Impacts to Environment from Bio propane and Mitigation and Control Measures.

The project's activities may lead to the following potential impacts:

- Indirect impacts of deforestation due to farming practices which include pest control, watering and erosion.
- Water use impacts include disruption of local water sources, nutrient runoffs and water stress impacts during the dry season.
- Reduce dependence on fossil fuel and reduce GHG. However, harmful air emissions can be generated and released into the atmosphere as the bio propane is combusted. The burning produces carbon dioxide and small quantities of carbon monoxide and other particulates just as fossil fuel do.
- Safety hazards associated with the production of bio propane can lead to increased employee risk especially in the gasification stage when converting the methane to bio propane.

Table 5.7 Summary of Activities Degree of Impacts and Mitigation and Control Measures for bio propane Activities.

Activities	Degree of Impact	Mitigation Measure
Production of bio propane	<ul style="list-style-type: none"> • Land clearing activities • Water availability • Ambient air quality • Safety 	<ul style="list-style-type: none"> • Area of land(s) considered for cultivation and production has little to no agricultural value other than the intended propagation of the said grass. • Land clearing activities will follow best management practices to reduce the overall environmental impact. • No water will be utilized for the Biomass cultivation from the nearby Blue Creek, nor will any water from the project be drained into the creek. • The drainage will be constructed within the cultivate area to adequately distribute water and also clear used water from washing machinery and equipment. • The water will drain and remain within the 400-acre project area contained by the Buffer Zone. • The project will dig a single small well for supplying water for washing machinery and equipment as well as another project uses. • As a means of preventing water run-off. The buffer zones, which are elevated to 12 to 18 inches above the plantation area, will also contain water utilized for cultivating the <i>Arundo donax</i> during the cultivation. • Should the tank or the well run out of water during the dry season, water will be transported from the nearest village, San Lazaro, about 7 miles away from the project area. • In addition, the biomass project will contain water

		<p>within the buffer zone and will not release any water to the nearby waterways including the Blue Creek.</p> <ul style="list-style-type: none"> • The water used to wash equipment will run into the drains that are located between the inner sides of the access road/buffer zone. • Only approved agrochemicals will be used at the project site. • Best management practices for the site location as well as construction of access roads will be done during road construction and clearance of associated sites at all times. • GHG and air pollution will be reduced by sustainable harvesting of the biomass. • Reduction of GHG emissions that contribute to global climate change although to a small scale. • The amount of waste will be reduced since all the cultivated biomass will be used and thus there will be no need for waste management. • Use of proper technology, engineering controls as well as training and educating the employees on the process will assist in reducing the overall risk • Issuance of PPE, implementation of safety plans and others will greatly reduce the risks.
--	--	---

5.3.3 Bioethanol Options

Ethanol can be used as a transport fuel either when blended with conventional petrol to power vehicles, or used alone. It can be blended with petrol up to 10 percent (E10) without the need for engine modification. Its energy content and combustion efficiency are similar to those of conventional gasoline, and thus has approximately equivalent economic value.

The literature also shows that ethanol is an excellent oxygenate (reduces carbon monoxide (CO) emissions) and raises the octane number (acts as an anti-knocking agent) of fuel, and can substitute for the petrochemical fuel additive MTBE (methyl tertiary-butyl ether) which has been shown to pollute groundwater.

With regards to *Arundo donax*, studies published by the National Center for Biotechnology Information suggest that the grass can be used in the production of biofuels/bioenergy not only by biological fermentation, but also by direct biomass combustion. Both its industrial uses and the extraction of chemical compounds are largely proved, so that *Arundo donax* can be proposed as the feedstock to develop a bio-refinery (<https://www.ncbi.nlm.nih.gov/pubmed/25457226>).

However, some processes currently used are very inefficient, producing a very dilute mixture, and refining is highly energy intensive. In the continuing development of this technology, consideration must also be given to the role of decomposing organic matter in soil fertility and the potential impacts of removing these residues, such as greater use of nitrate fertilizers, water pollution, and topsoil erosion (Preliminary Assessment of Bioenergy Production in the Caribbean-UNDP).

Bioethanol Feasibility

The feasibility of a new energy crop depends largely on:

- production costs,
- cost of converting the biomass to usable energy, and;
- cost of competing fuels.

The ideal biomass for ethanol production via sugar pre-treatment, hydrolysis, and fermentation would contain a high concentration of cellulose and hemicellulose, and have minimal recalcitrance to assure high sugar yields and negligible inhibitor formation.

Arundo donax presents possibilities for new sources of biomass for energy and biofuels production. A study completed by Bura, Ewanick and Gustafson (Bura and others, April 2012) examined the feasibility of using *Arundo Donax* for production of ethanol via three-stage processing: steam explosion pre-treatment, hydrolysis, and fermentation.

The results of the study, completed in 2012, suggested that simultaneous saccharification and fermentation (SSF) of the combined water insoluble and water soluble fractions from steam pre-treated giant reed at severity condition of 190°C, 5 minutes and 3% SO², provided the highest ethanol yield – 79% of the theoretical maximum, which corresponds to 0.179 L ethanol/kg of raw material, which equals 179 litres/tonne.

The study also noted that this number applies to an experiment carried out in a laboratory. Field tests in a pilot can provide further data for commercialization.

Commercial Applications

Advanced biofuels are conceived as first step towards the deployment of integrated bio-refineries for the production of (advanced) biofuels and bio-chemicals able to replace conventional fossil-based chemicals, hence contributing further to reduce the use of fossil resources.

PROESA™ is a unique technology platform using lingo-cellulosic (non-food) sources. Sugars obtained through PROESA™ can be used to produce a wide variety of “bio” products, such as biofuels (e.g. bioethanol) and other biochemical products.

Based on a 2012 strategic partnership between Novozymes – a world leader in the enzymes industry – and Beta Renewables -a joint venture between Biochemtex and the U.S. fund TPG (Texas Pacific Group), which owns the PROESA™ technology, the world’s first commercial scale cellulosic ethanol facility was built up and put in operation in Italy (Crescentino) in 2013. The Crescentino plant, uses the PROESA™ technology, and is the first plant in the world to be designed and built to produce bioethanol from agricultural residues and energy crops at commercial scale using enzymatic conversion. It has a capacity of 50 million liters/year.

The Crescentino facility is a multi-feedstock cellulosic facility and can handle agricultural residues from a broad variety of crops including wheat and rice straw. Furthermore, the plant uses energy crops like *Arundo donax* (also known as giant cane) as feedstock.

The processing method of bioethanol production of giant reed as a potential second generation lignocellulosic plants, is more complex and diverse from first generation bioethanol plants (cereals). In comparison to other bioethanol plants (cereals, sugar cane, miscanthus, sorghum etc.), giant reed produces generally 20%, or even 50% higher bioethanol per hectare (11 000-15 000 liters), because of high biomass production and chemical components (Williams et al., 2008; Corno et al., 2014).

Thanks to the developed Proesatechnology, can be made efficiently the cellulose digestion and solved the utilization of lignin as electric energy (13 MW). Based on their economic profitability, annual total cost of bioethanol production from giant reed or agricultural residues(wheat straw) is less than 500 euro, which is cheaper than production from sorghum (600 euro) in case of capacity of 100 000 tons material processing per year (G. Antal, 2018).

It should be noted however that in Brazil, the Prosea technology was adopted by GranBio, but subsequently abandoned. GranBio is a subsidiary of the Brazilian finance company GranInvestimentos, supported by the Brazilian development bank BNDES, which holds a 15% stake in the company. In September 2014, it officially opened the second refinery in the world equipped with BetaRenewables’ PROSEA technology. Initially, GranBio claimed success, stating that 3 million liters of cellulosic ethanol had been produced by August 2015.

Yet in June 2017, 21 months after the plant was opened, the company admitted that it had still not succeeded in operating the plant successfully, due to “challenges with the pre-treatment technology”, i.e. Beta Renewables’ technology.

It has since transpired that the PROSEA technology involved a two-stage process, including steam explosion (high temperature and pressure followed by sudden decompression), during which severe corrosion occurred.

Furthermore, the pre-treated bagasse formed a thick slush which became difficult to transport or drain and which clogged up the equipment, as well as corroding it. A court case between GranBio and Mossi & Ghisolfi group is pending although the latter is embroiled in bankruptcy proceedings. GranBio has now installed a new pre-treatment system and has reportedly started producing and exporting ethanol from bagasse, albeit still well below the plant’s capacity. It will therefore be necessary to adapt the processes involved, based on appropriate technology and international best practices.

Potential Impacts to Environment from Bioethanol and Mitigation and Control Measures.

The project’s activities may lead to the following potential impacts:

- Wastewater generation from the treatment processes required to convert the *Arundo donax* to biofuel.
- Chemical contamination from the activities to existing surface water bodies and drainage paths by the project could result in contamination of freshwater stocks available for native fauna.
- Land clearing impacts associated with the planting and harvesting of the *Arundo donax*.
- Water use impacts include disruption of local water sources, nutrient runoffs and water stress impacts during the dry season.
- Reduce dependence on fossil fuel and reduce GHG.
- Safety hazards associated with the production of biofuel can lead to increased employee risk.

Table 5.8 Summary of Activities Degree of Impacts and Mitigation and Control Measures for bioethanol Activities.

Activities	Degree of Impact	Mitigation Measure
Production of bioethanol	<ul style="list-style-type: none"> • Contamination of water bodies and water sources • Pollution due to solid waste • Land clearing activities • Water availability • Safety 	<ul style="list-style-type: none"> • The wastewater generated by the pre-treatment and the other processes will be properly treated by settlement ponds prior to being discharged. • Solid waste bi-products produced by the process will be mixed with soil and serve as natural fertilizers for the next crop. • Land clearing activities will be conducted in an environmentally safe and sound manner to prevent unwanted impacts associated with planting and harvesting. • All production drainage will be directed towards the oxidation ponds. • The water used to wash equipment will run into the drains that are located between the inner sides of the access road/buffer zone. • As a means of preventing water run-off. The buffer zones, which are elevated to 12 to 18 inches above the plantation area, will also contain water utilized for cultivating the <i>Arundo donax</i> during the cultivation. • In addition, the biomass project will contain water within the buffer zone and will not release any water to the nearby waterways including the Blue Creek. • Only approved agrochemicals will be used at the project site. • GHG and air pollution will be reduced by sustainable harvesting of the biomass. • Reduction of GHG emissions that contribute to global climate change although to a local scale. • Use of proper technology, engineering controls as well as training and educating the employees on the process will assist in reducing the overall risk • Issuance of PPE, implementation of safety plans and others will greatly reduce the risks.

5.4 Selection of Alternative Cultivation Sites

Alternative sites were evaluated by the experts from the 5 Cs by visiting sites that had existing *Arundo donax* vegetation growing naturally. This was followed by the use of geographic information systems provided by the Land Information Center (LIC) of Belize and from the Cathalac Research Institution based in Panama. Several sites in the Stann Creek District were identified, but the feasibility of transportation of the biomass to the Belcogen plant was obviously prohibitive; thus, eliminating these sites. Further planning allowed the team to select sites within the Orange Walk District in a close proximity to the Belcogen facility, but avoiding the risks for flooding and similar disasters. Below is a summary of the site selection process methodology.

5.4.1 Avoidance of Incompatible Sites

There were two stages of site selection using the avoidance method. During this process, other lands that are suitable and have *Arundo donax* vegetation were identified but later eliminated using these criteria. In order to accomplish this, it was necessary to identify available property suitable for *Arundo donax* cultivation and to eliminate all sites that are at risk to flooding and excessive inundation; and those that would conflict with other land uses. This was done by the preparation of a map showing the location of *Arundo donax* and other areas in the Orange Walk District. A series of criteria were then used to eliminate potential sites to avoid: (1) protected areas, (2) flood hazard risk (including storm surge), (3) fire hazard, (4) national waters, (5) agriculture farms (banana and sugar cane), (6) soil types; and (7) Transportation access. This process ensured that potential sites avoided from the onset all the above risk factors. Therefore, the avoidance of flood prone areas, for example, is in itself an avoidance technique that is also mitigation against flood risks.

During project planning, in addition to these criteria, the criteria of physical location in terms of proximity to the BELCOGEN Plant, transportation availability in terms of roads and other infrastructure, as well as the elimination of parcels that are subject to total inundation and that are vulnerable to flooding were selected. Therefore, the avoidance of high-risk sites was done via this process, resulting in the selection of the existing sites.

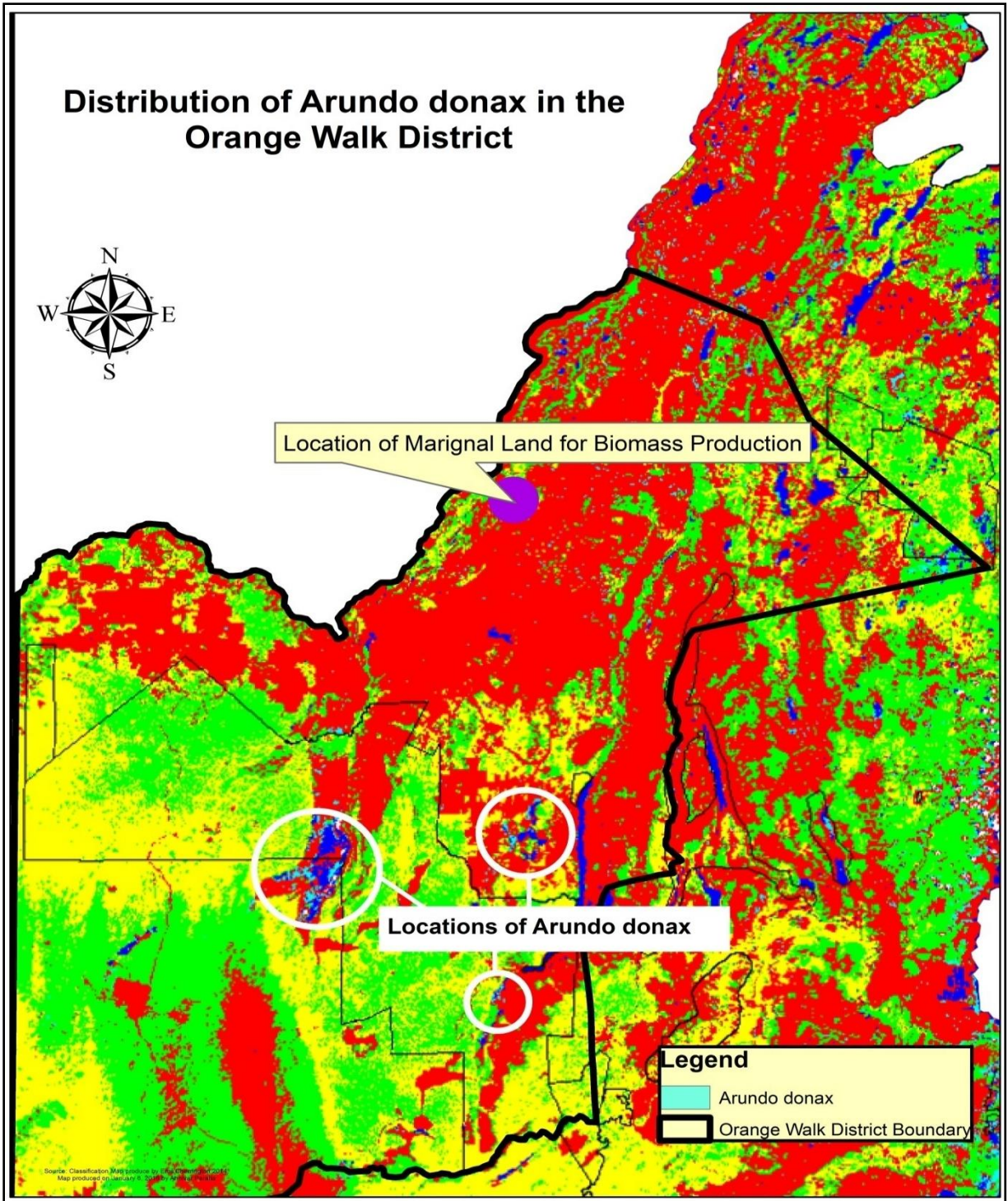


Figure 5.4: Map Showing Distribution of Arundo donax Vegetation within Orange Walk.

5.4.2 Mitigation Planning

Based on the site selection criteria for suitability due to proximity to the Belcogen plant, accessibility, as well as the availability of land etc, there is then the need for the mitigation against possible natural disaster. While the potential sites do not fall within an area of high risk for disasters, there is a low risk for flooding in some parts of the property. There is also a need to plan for such unavoidable phenomenon, primarily hurricanes and storms. As a result, the site disaster planning will focus primarily on the development of a hurricane preparation and evacuation plan for the employees operating within the project sites. Furthermore, as part of the Disaster Management Plan, a fire management plan had been drafted. The draft documents detailing the hurricane plan and fire plan are expected to be updated and completed prior to or before full project implementation. The reader is advised to see the Annexes to the ESIA/ESMP, for the draft disaster management plans that have been drafted.

5.5 Conclusions and Recommendations

The Environmental and Social Assessment (ESIA) and Environmental and Social Management Plan (ESMP), also seeks to identify appropriate institutional/organizational and social participation for this renewable energy initiative on a sustainable basis. This includes the management of mitigation measures, the management of activities towards these mitigation actions and the means of verification of the management actions (see ESMP).

In doing so, the project will (amongst other things) offer the potential for the development of a new industry both at the community and company levels as well as increase the country's contribution to the reduction of GHG emissions.

The site selected for the biomass pilot project is adequate given that it is on marginal lands and near the cogeneration plant to make it feasible. The concerns would be:

1. That the *Arundo* planted do not escape the site to become a problem in the nearby waterways and nearby cane plantations. This can be mitigated having a control plan in place and constant monitoring.
2. Since *Arundo* is a hydrophyte, will there be irrigation in place to alleviate water stress in the situation where there is an extended drought as is currently happening in northern Belize so as not to lose all the investments made.
3. It would be recommended that other C4 species be planted on the test plots to see how they perform against *Arundo*.

Recommendations:

It would be reasonable to include some of the alternative options during the pilot phase. The sorghum would be a very viable alternative as well as the other of just collecting wild populations of C4 grass species.

Discussions should be initiated with BSI/ASR in the interest of venturing into bioethanol production and inquire if the authorities would promote an E10 mix for the use of transportation in the Country to offset the investments. Additionally, this would allow the uptake of any excess production of sugarcane. It would also support a programme for the production of sweet sorghum.

Encourage the use of waste separation in nearby communities and to incorporate the organic waste as biomass supply.

Literature Cited:

- Almodares and Hadi 2009. *Production of bioethanol from sweet sorghum: A review*. *Afr. J.*
- Antal, Gabriela. *Giant reed (Arundo donax L.) from ornamental plant to dedicated bioenergy species: review of economic prospects of biomass production and utilization*. International Journal of Horticultural Science 2018, 24 (1-2): 39-46. University of Debrecen, Printed in Hungary, 2018. *Bio*.13, 241–248.
- Bura, Renata., Ewanick, Shannon., and Gustafson Rick. *Assessment of Arundo donax (Giant reed) as feedstock for conversion to ethanol*. TAPPI Journal 11(13): 59-66. April 2012.
- Carvalho, L., Lundgren, J., And Wopienka, E. . Challenges In Small-Scale Combustion Of Agricultural Biomass Fuels. Austrian Bioenergy Centre, Rottenhauserstrasse, 1, 3250 Wieselburg, Austria 2 Division of Energy Engineering, Luleå University of Technology, 97184, Luleå, Sweden.
- Conley et al 2001, CO₂ enrichment increases water-use efficiency in sorghum. *New Phytol.* **151**,
- Corno, Luca., Pilu, Roberto., and Adani, Fabrizio. *Arundo donax L.: a non-food crop for bioenergy and bio-compound production*. Biotechnology Advances, 32 (8): 1535-1549. Copyright © 2014 Elsevier Inc.
- DeHaan et al (2005). Perennial grain crops: A synthesis of ecology and plant breeding. *Renew. Renew. Agr. Food Syst.* **20**(1), 5–14.
- Elrich, Catharina., Ohman, Marcus., Bjornbom, Emilia., and, Fransson, Thorsten, H. Thermochemical characteristics of sugar cane bagasse pellets. Elsevier, Volume 84, Issue5.
- Enhancement in leaf photosynthesis and upregulation of Rubisco in the C₄ sorghum plant at fertilizer at two dates in the spring. *Grass and Forage Science* **65**, 102–109.
- Furbank et al (2009). *C₄ rice: a challenge for plant phenomics*. *Funct. Plant Biol.* 36, 845–856. Gas and Technology institute. <https://www.gti.energy/>
- Ernsting, Almuth., and, Smolker, Rachel. *Dead End Road: The false promises of cellulosic biofuels*. Biofuelwatch, September 2018 Authors: Almuth Ernsting & Rachel Smolker Design: Oliver Munnio. *Dead End Road: The false promises of cellulosic biofuels*. Biofuelwatch, September 2018. <https://www.biofuelwatch.org.uk/wp-content/uploads/Cellulosic-biofuels-report-2.pdf>.

- Fedenko, J.R., Erickson, J.E., Woodard, K.R. et al. *Bioenerg. Res.* (2013) 6: 1082.
- Ferreira. Leonardo P de Almeida, Sola, Vanderley Herrero, and, Ramirez Behaine, Jhon Jairo. Universidad Tecnológica Federal de Parana, Brazil. Oct-Dec 2017.
- Ghannoum O, Conroy JP (2007) Phosphorus deficiency inhibits growth in parallel with
- Gupta et al Chapter2—BioenergyResearch: An Overview on Technological Developments and Bioresources. *Bioenergy Res. Adv. Appl.* 2014, 23–47.
- Hatch 1987. *C4 photosynthesis, a unique blend of modified biochemistry, anatomy and ultrastructure. Biochim. Biophys. Acta.* **895**, 81–106.
- <http://www.eubia.org/cms/wiki-biomass/r-d-orientations/>
- <http://www.ppmc-transport.org/proesa-technology-advanced-biorefinery-platform-in-italy/>
- <https://arterran.com/wp-content/uploads/2020/02/Water-Resistant-Pellet-Manufacturing-Processes-15-Feb-2020.pdf>
- https://www.irena.org/-media/Files/IRENA/Agency/Publication/2017/Mar/IRENA_Biogas_for_Road_Vehicles_2017.pdf
- <https://www.ncbi.nlm.nih.gov/pubmed/25457226>
- https://www.researchgate.net/publication/320089357_Sugarcane_bagasse_pellets_Characterization_and_comparative_analysis
- <https://www.undp.org/content/dam/barbados/docs/projectdocs/energy/publications/Preliminary%20Assessment%20of%20Bioenergy%20Production%20in%20the%20Cbean.pdf>
- <https://www.wlpga.org/wp-content/uploads/2018/10/BioLPG-The-Renewable-Future-2018.pdf>
- International Energy Agency [IEA], 2018. <https://www.iea.org/fuels-and-technologies/bioenergy>
- Johnson, Eric. *Review Process Technologies and Projects for Bio LPG*. Atlantic Consulting, 8136 Gattikon, Switzerland; ejohnson@ecosite.co.uk; Tel.: +41-44-772-1079 Received: 8 December 2018; Accepted: 9 January 2019; Published: 15 January 2019. *Energies* 2019.
- Ratnavathi et al. 2010. Study on genotypic variation for ethanol production from sweet sorghum juice. *Biomass Bioenerg.* **34**, 947-952.
- Kramer PJ, Boyer JS (1995). *Water relations of plants and soils*. Academic Press, Inc.

Soldatos, P. *Economic Aspects of Bioenergy Production from Perennial Grasses in Marginal Lands of South Europe*. Bioenergy Res. 2015, 8, 1562–1573.

Long SP, Ort DR (2010). *More than taking the heat: crops and global change*. *Curr. Opin. Plant Bio.* **13**, 241–248.

Menecon Consulting in association with Atlantic Consulting. *RHI Evidence Report: Bio propane for Grid Injection Assessment of the Market, Renewable Heat Potential, Cost, Performance and Characteristics of Bio propane for Gas Grid Injection*. © Crown copyright 2014.

Nackley, et al. *Good Intentions vs Good Ideas: Evaluating Bioenergy Projects that Utilize Invasive Plant Feedstocks*; Cabi Publishing: Wallingford, UK, 2015; Volume 5, pp. 134–153.

Nair et al. 1999 Analysis of genetic diversity and phylogeny in *Saccharum* and related genera photosynthesis in a C3 (*Panicum laxum*) but not two C4 (*P. coloratum* and *Cenchrus ciliaris*) grasses. *Funct. Plant Biol.* **34**, 72–81.

Preliminary Assessment of Bioenergy Production in the Caribbean-UNDP.

Pritchard AJ (1964). *Comparative trials with Sorghum alnum and other forage sorghums in south-east Queensland*. *Aust. J. Exp. Agric. Anim. Husbandry* **4**, 6–14.

Prochnow et al Bioenergy from permanent grassland—A review: 2. Combustion. *Bioresour. Technol.* 2009, 100, 4945–4954.

Propheter et al. 2010. *Performance of annual and perennial biofuel crops: Nutrient removal Queensland*. *Aust. J. Exp. Agric. Anim. Husbandry* **4**:6-14.

Rubio et al. 2010. *Responses of C3 and C4 grasses to application of nitrogen and phosphorus fertilizer at two dates in the spring*. *Grass and Forage Science* **65**, 102–109.

Salazar – Zeledon, Estephania., Moya, Roger., and, Valaert, Jorre. Biomass and Bioenergy Production of *Arundo donax* L., *Pennisetum purpureum* Schum. and *Pennisetum purpureum* Schumack. × *Pennisetum glaucum* L. in Short Rotation Cropping System in Costa Rica, 2015. *Journal of Biobased Materials and Bioenergy*, December 2015.

Steduto P, Albrizio R (2005). *Resource use efficiency of field-grown sunflower, sorghum, wheat and chickpea II. Water use efficiency and comparison with radiation use efficiency*. *Agricultural and Forest Meteorology* **130**, 269–281.

Vasilakoglou I, et al (2010) Sweet sorghum productivity for biofuels under increased soil salinity and reduced irrigation.

Field Crop. Res. asilakoglou I, Dhima K, Karagiannidis N, Gatsis T (2010) Sweet sorghum productivity for biofuels under increased soil salinity and reduced irrigation. *Field Crop. Res* screening experiment. *New Phytol.* **185**(3), 780–791.
sequestration: A phytotron study. *J. Environ. Protect.* **1**, 73–84.

Sheffield J, Wood EF (2008). *Projected changes in drought occurrence under future global warming from multi-model, multi-scenario, IPCC AR4 simulations. Climate Dynamics* **31**, 79–105.

Soldatos, P. Economic Aspects of Bioenergy Production from Perennial Grasses in Marginal south-east Queensland. *Aust. J. Exp. Agric. Anim. Husbandry* **4**, 6–14.

Steduto P, Albrizio R (2005). *Resource use efficiency of field-grown sunflower, sorghum, wheat and chickpea II. Water use efficiency and comparison with radiation use efficiency. Agricultural and Forest Meteorology* **130**, 269–281.

Taylor et al. 2010 Eco physiological traits in C3 and C4 grasses: a phylogenetically controlled ultrastructure. *Biochim. Biophys. Acta.* **895**, 81–106.
using RAPD markers. *Genet. Resour. Crop, Eval.* **46**, 73–79.

Venturi, P.; Venturi, G. *Analysis of energy comparison for crops in European agricultural systems. Biomass Bioenergy* 2003, **25**, 235–255.

Wang et al (2010). *Growing cover crops to improve biomass accumulation and carbon warming from multi-model, multi-scenario, IPCC AR4 simulations. Climate Dynamics* **31**, 79–105.

Williams, Chris and Biswas, Tapias With the Support of Fibre Cell Australia Pty Ltd. *Commercial Potential of Giant Reed for Pulp, Paper and Biofuel Production.* RIRDC Publication No. 10/215. December 2010 RIRDC Publication No. 10/215 RIRDC Project No. PRJ-000070, Australia.

6.0 Disaster Risk Assessment and Disaster Risk Management Plan

Description of Plans

The disaster risk assessment and disaster risk management plan is prepared in two sections, with the first part discusses the disaster risks associated with the project and the second part comprising a summary of the phytosanitary crop risk assessment prepared by the 5 Cs as part of the Environmental Risk Management Plan.

The ESIA and ESMP are prepared as separate documents. The Disaster Risk Management Plan is presented in Section six of the ESMP. This includes the emergency management plan, hurricane plan, the occupational health and accidental and emergency plans as well as monitoring parameters are outlined in the ESIA.

This section summarizes and updates the Environment and Risk Management Plan prepared by the 5 Cs in February 2016 (Environmental Risk Management Plan, for Piloting the Cultivation of *Arundo donax* in Northern Belize, CCCCC 2016). The plan looks at the risk within the context of investment, the investment background (climate risks, phytosanitary risks), as well as management risks associated with the proposed cultivation and processing of the *Arundo donax* species.

6.1 Disaster Risk Assessment and Disaster Risk Management Plan

6.1.1 Overview of Regional Disaster Risks

There are two main types of disaster risks that can be associated with the *Arundo donax* biomass to energy project. These are man-made risks and risks from natural disasters.

Man-made hazards include risk of chemical exposure and spills, risk of spills of hazardous materials, accidents and risk of fires from dwellings and structures.

Natural hazards can come as a result of seismic activities and the movement of faults, sink holes, flooding, hurricanes, and excessive rainfall due to climate anomalies. However, at the time of writing, the pandemic as a result of the COVID 19 virus was a clear indication that natural hazards should include health emergencies, including those stemming from diseases, whether local or originating elsewhere.

Disaster Risk management aims to assess the exposure to hazards and growing risks of natural disasters. As a result of growing population risk and exposures to hazards, financial institutions such as the IFC, World Bank, IDB, and other financial institutions, are ensuring that projects are now screened for *climate and disaster risk to ensure that they build the resilience of people on the ground* (World Bank, 2019).

It is reported that disasters hurt the poor and vulnerable population the most. *From 1998 through 2018, 91% of storm-related fatalities were in low- and middle-income countries, even though these countries experienced just 32% of storms (World Bank, 2019).*

At the global stage, disasters are always impacting communities that are vulnerable; and at the regional stage, being the Caribbean and Central American Regions, disasters have impacted countries significantly over the past decade. Examples of regional disasters are the recent hurricanes that devastated the Caribbean Islands of Puerto Rico, Cuba, Haiti and the Dominican Republic, as well as several CARICOM countries including Dominica, St. Kitts Nevis, and the most recent country that was severely impacted is the Bahamas. In 2019, the Atlantic Hurricane season reported a total of 18 named storms; of which six (6) were hurricanes and three (3) of these were intense hurricanes.

The Central American and Caribbean Regions are also vulnerable to earthquakes, with the Caribbean Plate bordering several plates, and the boundaries of these plates are tectonically active. The Caribbean Plate is a mostly oceanic tectonic plate underlying Central America and the Caribbean Sea off the north coast of South America.

Roughly 3.2 million square kilometres (1.2 million square miles) in area, the Caribbean Plate borders the North American Plate, the South American Plate, the Nazca Plate and the Cocos Plate. These borders are regions of intense seismic activity, including frequent earthquakes, occasional tsunamis, and volcanic eruptions.

6.1.2 Overview of Natural Disaster Risks

Unlike disasters common to Caribbean and Central American regions, Belize is poised in a less vulnerable position to risks of earthquakes and volcano eruptions due to its geographic and geologic setting. However, it is in a high risk area for tropical storms, and hurricanes, as well as extreme weather events, such as extreme rainfall and drought. During the last few years, there has been growing evidence that the climate change phenomenon can be attributed to the increasing drought in Belize and changing weather pattern that the country is presently experiencing. The drought has resulted in significant impact to crops and the changing weather patterns has resulted in a significant degree of uncertainty in terms of crop yields, the timing of such yields, as well as on the economic projection in terms of investment and return of investments. The climate change phenomenon now plays a major role in influencing agriculture productivity in Belize (e.g. sugar, and rice).

The World Bank's report *Shock Waves: Managing the Impacts of Climate Change on Poverty* (2016) (Hallegatte and others), concludes that natural disasters contributes to global poverty and that disasters also contribute to poverty by reducing economic growth. The same report states that drought and floods have "significant impact on the global poverty headcount", (Hallegatte and others, 2016).

Another World Bank Report, *Shock Waves: Managing the Impacts of Climate Change on Poverty* (2016) by Stephane Hallegatte, and others; states that climate resilience measures will be

needed to help provide “safety nets” for the poor. It also states that climate change threatens to push an additional 100 million people into extreme poverty by 2030.

Population growth and rapid urbanization are driving the increase in disaster risks. The United Nations estimates that 68% of the world’s population will live in cities by 2050 (<https://www.un.org/development/desa/en/news/population/2018-revision-of-world-urbanization-prospects.html>).

According to the Bank’s *Investing in Urban Resilience* report (World Bank 2015); by the year 2030, without significant investment into making cities more resilient, natural disasters may cost cities worldwide \$314 billion each year. The report further states that investing in more resilient infrastructure can provide a net benefit in low- and middle-income countries. Such investments can improve the quality and resilience of essential services – such as transport, or water and electricity supply – and thereby contribute to more resilient and prosperous societies.

6.1.3 Natural Disaster Risks in Belize

Belize is considered a country that is highly vulnerable to natural disasters such as hurricanes, tropical storms, floods, drought, fires, and pests and diseases. These natural disasters, especially hurricanes, tropical storms, drought, floods and fires or even diseases may or may not be influenced by the climate change phenomenon; but what has been recently documented is that the drought due to climate change does increase pest infestations.

This section looks at a number of natural disasters that are increasingly becoming high risk to the country. With respect to the Arundo donax project, it is likely that these risks may or may not pose a threat to long-term crop viability, and will require mitigation and resilience measures to be considered.

Climate Change Vulnerability

Climate Change and climate variability will impact agriculture systems and practices such as soil fertility and land preparation; pest and disease control; and water requirements (excess and deficits). Higher temperatures will cause increased stress on current livestock breeds, and crop types and varieties. Climate Change and climate variability will very likely result in less rainfall overall, but the most detrimental effect is likely to come from the variation in the seasonal distribution of rainfall, leading to more periodic droughts and extensive floods. The project zone in the Western area of the Orange Walk district is vulnerable to these projected climate extremes.

The results of analysis on climatic trends and future climate model projections for the western Caribbean region, including Belize, have shown that over the past 50 years temperatures have been rising steadily and are projected to continue along this trend. Rainfall variability has increased, and will likely become more pronounced in the future. Increases in seasonal evapotranspiration rates have been noted over the recent past, while significant decrease in wet season moisture surpluses is foreseen. Global sea levels have risen over the past 130 years and are forecast to continue rising during the 21st century (CCCC/BEST, 2015).

Analysis of Climate Change projections suggested that, under the A2 scenario (worst case) Belize will experience temperature increases of near 2 °C by the 2050s and almost 4 °C by the 2080s, relative to the baseline period 1961-1990. The Regional Climate Models (RCM) projections for 2050 show percent change in rainfall in the order of -20 % to – 30 % from the reference period 1961-1990 under the A2 scenario, and around -50 % to -60 % change from normal by 2080.

In a recent climate modeling study, Cherrington *et al.* (2014), examined 13 latest-generation downscaled global climate models (GCMs) to see the effects of climate change, land use change and runoff for watersheds in Belize for the year 2050. The study showed that the potential change in rainfall patterns will range from -24.9% below the historical norm to 23.7% above the historical norm, with an average of 7.6% below the historical norm. Additionally, for 2050, the land use change scenarios indicate potential declines in forest cover across the entire geographic domain of 1.3% in a best-case scenario, to 22.6% in a worst-case scenario – relative to 2010 forest cover. Intersecting land use change scenarios with select climate change scenarios (5 of the 19), the results indicate that for the Belize River – the most populated watershed – with increased deforestation, runoff could potentially increase by 85.2% (under a slightly wetter climate) or, conversely, decrease by 12.1% (under a drier climate), whereas with decreased deforestation, runoff could potentially decrease by 40.4% (under a drier climate), or increase by 37.1% (under a slightly wetter climate).

These projections into the future highlight the possible effects Global Warming will have on the environment, exacerbated by anthropogenic activities. The effects of increased climate variability and extreme climatic conditions will put additional stress on rain-fed agriculture cropping systems in the near, medium and long term. Figure 1.20 is a summary of the regional climate model projection for Belize.

- ❑ **Temperature:** 2-4°C increase in temperature projected for 2050 to 2080
- ❑ **Precipitation:** -20 to -30% by 2050 & -50 to -60% by 2080 – Increased in spatial and temporal variability.
- ❑ Heat waves; longer and intense droughts.
- ❑ **Sea Level Rise:** 0.32 to 0.63 m by 2080
- ❑ **Storm surge: 2040 – 2065**
 - Category 2 hurricane 2.47 m
 - Category 5 hurricane 5.87 m
- ❑ **Storm surge: 2081 – 2100:**
 - Category 2 hurricane 2.91 m
 - Category 5 hurricane 6.31 m
- ❑ Increased frequency of major hurricanes (Cat 3 or stronger).

Figure 6.1: Summary of the Regional Climate Model Projection for Belize.

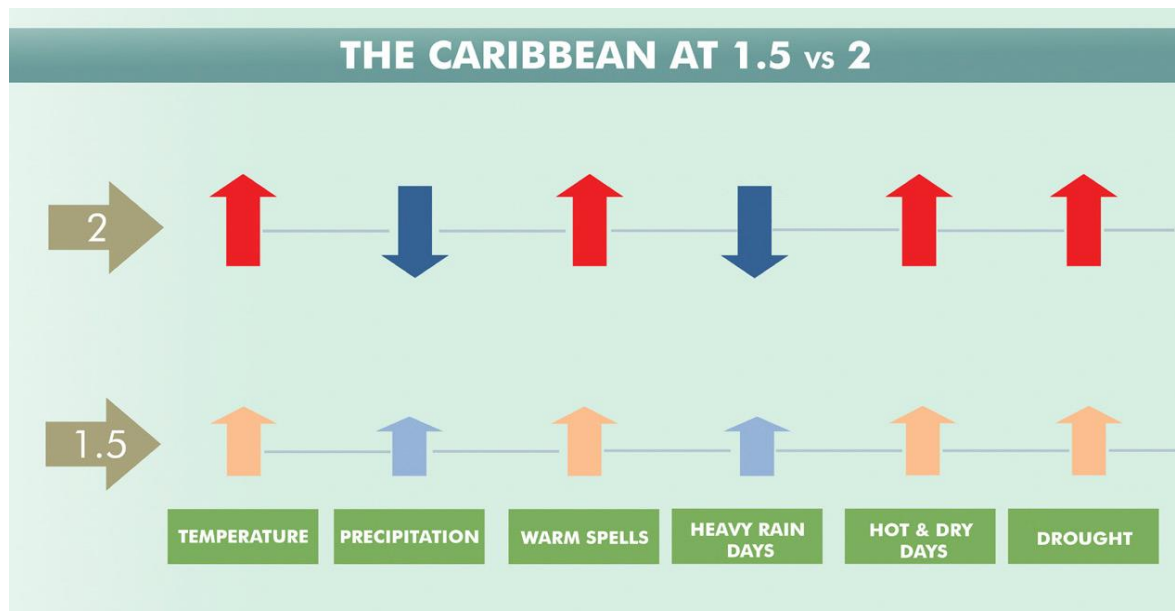


Figure 6.2: Some relative changes in Caribbean Climate for Global Warming

*Up/down arrows indicates increase/decrease relative to a 1971-2000 baseline. Size/Shading indicates magnitude/intensity of projected change. (Source: CCCCC, 2016).

6.1.4 Natural and Man-Made Hazards

Natural hazards include tropical storms, hurricanes, extreme weather (primarily extreme rainfall events such as tropical waves); drought, and drought – related phenomenon such as forest fires.

Man-made hazards include the risk of fires due to anthropogenic activities, accidents, and spills due to operation of equipment.

6.1.5 Hazards from Natural Disasters

Belize is located in the Tropical to Sub-tropical zone; for which it has a fairly high vulnerability to natural disasters stemming from weather- and weather-related phenomena such as tropical storms, hurricanes and floods. At the same time, the increased global temperature anomaly will also increase the risk of forest fires, another natural disaster.

This section summarizes the project's vulnerability to natural disasters. As part of the Environmental and Social Management Plan (ESMP), an Emergency Evacuation Plan, an Emergency Management Plan and an Occupational Health and Safety Plan have been drafted. These are detailed in Annex A to the ESMP Report.

6.1.6 Risks and Vulnerability to Hurricanes and Tropical Storms

Due to its geographic location, and low-lying topographic characteristics, the Caribbean Region, including Belize (primarily its coastal zone) is at risk to the effects of climate change. According to Usher, (Usher 2000), the changes in the hydrological cycle in Belize as a result of climate change, would be characterized by changes in sea levels, the intensity of hurricanes and its accompanying storm surge, and changes in rainfall patterns and temperature. These changes may result in the following impacts:

- Exacerbated erosion of the coastline and accompanying beach loss;
- Coral bleaching as a result of temperature rise;
- Potential negative impacts to coastal regions, including depletion of sea grass beds from resulting fresh water runoff (including siltation etc.);
- Alteration or destruction of agro-productive communities due to changes in precipitation and seasonality, resulting in the alteration of the productivity of agro-productive ecosystems;
- Increased inundation as a result of sea level rise, with consequences such as the expansion of salt-water intrusion zones;
- Inundation and salinity intrusion of agriculture lands, resulting in net decrease in productivity;
- Vulnerability to flooding and soil erosion of low-lying communities;
- Loss in net tourism economic activities as a result of the combined effects of climate change (damage to coral reef etc.);
- Impact on human health as well as plant health due to the change in patterns of infectious diseases;
- Extreme dry conditions in northern ecosystems.

These impacts are not confined to a specific site and are in fact of a regional and national scale, and the results of these potential impacts can be described as cumulative impacts of climate change, rather than resulting from individual project development.

Planning for disaster management and climate change adaptation for an investment such as the *Arundo donax* project should focus along two primary planning actions: (1) Avoidance of disaster-prone areas; and (2) Disaster Planning (Mitigation).

In recent years Belize has been affected either directly or indirectly by several tropical systems (including a tropical depression) with some making landfall in neighbouring countries, which

resulted in flooding, storm surge and some wind damage. These tropical systems included Fourteen (14) storms over a period of eighteen (18) years; as follows:

- Hurricane Mitch, October 1998, making landfall in Honduras as a major hurricane;
- Hurricane Keith, October 2000, making landfall in Ambergris Caye as a major hurricane;
- Tropical storm Chantal in August 2001, made landfall near the Belize/Mexico border, causing moderate wind damage, wave action and high rains;
- Hurricane Iris in October 2001, made landfall near Placencia, Belize as a major hurricane;
- Hurricane Dean in 2007, made landfall as a major hurricane approximately 25 miles from the Belize/Mexico border;
- Tropical Storm Arthur in late May 2008, made landfall in Northern Belize.
- Tropical Depression 16, formed off the coast of southern Belize, causing historic flooding (October 2008);
- Hurricane Alex, in June 2010, made landfall in Northern Belize as a tropical storm, later forming into a hurricane in the Gulf of Mexico,
- Hurricane Karl, 2010, made landfall north of Chetumal Mexico, as a tropical storm;
- Tropical Storm Matthew, in September 2010 made landfall near the Honduras/Nicaragua border but caused flooding and rainfall damage in Stann Creek and Toledo;
- Hurricane Richard, in October 2010, made landfall in the Belize District as a category one hurricane, but maintained its tropical force winds well inland, causing damage in the Belize and Cayo Districts;
- Tropical Storm Harvey, made landfall in Belize as a tropical storm in August 2011;
- Hurricane Ernesto made landfall in Mexico, about 45 miles north of the Belize/Mexico border, only causing rainfall in Belize;
- Hurricane Earl made landfall in Belize on August 4th 2016 as a category I hurricane.

The period 1998 to 2012, included the passing of Hurricane Iris, one of the most destructive storms in terms of wind damage. Iris made a direct hit to the Stann Creek and Toledo Districts. Even Hurricanes Richard (2010), and Hurricane Earl (2016) being moderate category one hurricane impacted the Belize and Cayo Districts in 2010, resulting in significant damage to property and agriculture. Hurricane Iris caused widespread devastation from wind damage, while Hurricane Keith impacted directly the island of Ambergris Caye with resulting wind and

rain damage to property. Arthur impacted the Stann Creek District with floods resulting in devastation to bridges and private property, including crops, homes, and even taking several human lives. Hurricane Mitch and Tropical Storm Chantal resulted in flood damages to northern Belize. Tropical Depression 16 was a rainfall and flood event, completely inundating numerous villages in both Orange Walk and Stann Creek for weeks.

Floods resulting from Arthur, and TD 16 (2008) caused historic floods from intense rainfall all over Belize; with human casualties in the Stann Creek District.

As in most parts of coastal Belize, a direct hurricane landfall in or near coastal population centers makes these communities highly vulnerable to the effects of wind, storm surge and flooding, as has been demonstrated in recent history.

Similarly, the Caribbean Disaster Mitigation Project (CDMP) has determined that due to Belize's shallow offshore shelf, the low-lying areas are at high risk of destructive storm surges. The 1995 CDMP report has also determined that *Because of the geographic location of Belize in the Atlantic Basin, and the geometry of the Gulf of Honduras and Central America, there is a strong north/south gradient to the occurrences of storms. The northern coast of Belize is exposed to more frequent and more intense storms than the southern part. For example, tropical storm events are expected to occur in Punta Gorda on average every 6 years, while in Ambergris Cay they typically occur twice as often, every 3 years (CDMP, OAS, 1995).*

6.1.7 Flood Risks

Belize's low lying areas, including those along or near the flood plain of major rivers and also coastal areas are highly susceptible to flooding during extreme events such as tropical depressions, storms and hurricanes. Flooding was experienced in many areas as a result of the passing storms and hurricanes listed above.

In 2008 Tropical Depression 16 (TD 16) resulted in significant flood damages especially in the Stann Creek Districts where it resulted in the loss of infrastructure (bridges and roads), crops and even several lives lost due to flash floods.

The year 2013 was an unusual year in terms of rainfall patterns. Most of the months for that year resulted in rainfall way above normal, resulting in widespread flooding throughout the country. Flooding, therefore, is an ever-present risk that requires resilience and mitigation planning.

6.1.8 Forest Fire Risks

Forest fires, as well as other vegetation or "bush" fires, while not uncommon during the dry season in Belize; tend to have higher proliferation during extended dry periods, and pose significant risk to property. Fire hazards are greater in shrub lands, and in areas with pine and pine savannah vegetation. The *Arundo donax* site is not only located in an area of less rainfall

and drier conditions, but the vegetation presents higher risk of fires. Furthermore, the natural characteristics of the *A. donax* plant increases the risks of fires, primarily during the dry season and droughts.

6.1.9 Risk of Seismicity and Seismic Hazard

Based on regional seismic activity, most of Belize is not known to be a tectonically active country. However, the location of several active plates with fault zones in countries neighbouring Belize does result in local tectonic activity. In 2009, for example, an earthquake caused by the movement of the North American and Caribbean Plate; which runs from the Caribbean Sea and past an area near the boundary with Belize and Guatemala, resulted in a magnitude 7.3 quake offshore. This quake resulted in some damage to structures in Belize, with a magnitude felt ranging from 4.0 to 6.5 in some parts of the country.

Quake of May 2009

According to the United States Geological Survey (USGS, 2009), several people were killed, many injured and more than 130 buildings were damaged or destroyed in northern Honduras as a result of the May 28 2009 earthquake offshore Honduras. At least 5 buildings destroyed and 25 damaged in Belize. This earthquake was felt in much of Belize, El Salvador, Guatemala and Honduras. Also felt in the Bahamas, Cayman Islands and Virgin Islands and in parts of Colombia, Costa Rica, Cuba, Jamaica, Mexico, Nicaragua and Panama. Seiches were reported in swimming pools at La Ceiba and Roatan and ground cracks and possible liquefaction was observed at Monkey River, Belize (USGS, 2009).

According to the USGS, the location and focal mechanism of the Honduras earthquake of May 28, 2009, imply that the shock occurred as the result of “left-lateral strike-slip faulting on the Swan Islands Transform Fault, a segment of the boundary between the North America and Caribbean plates” (USGS, 2009).

Previous strong earthquakes along the North America/Caribbean plate boundary include the destructive Guatemala earthquake of February 4, 1976, M 7.5, which produced more than 23,000 fatalities. The 1976 earthquake occurred on the Motagua fault, a segment of the plate boundary that lies in southern Guatemala, several hundred kilometres southwest of the plate boundary that ruptured in the May 28, 2009 shock (USGS, 2009).

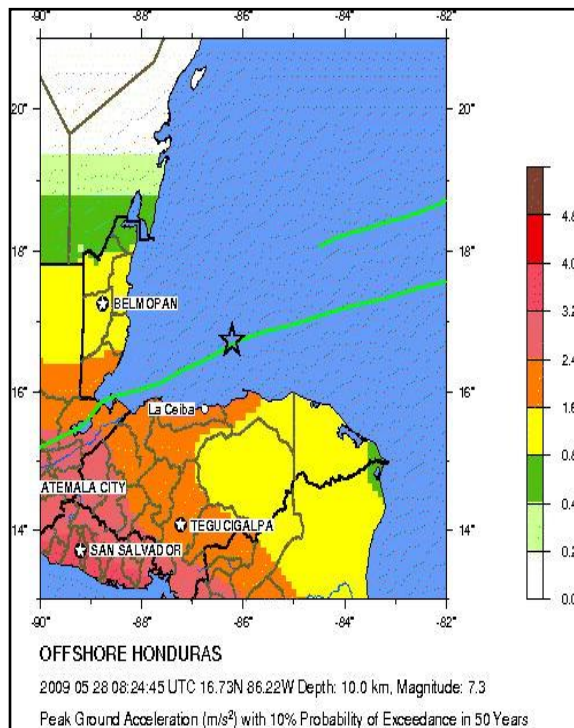


Figure 6.3: Peak Ground Acceleration (m/s²) of May 2009 Earthquake

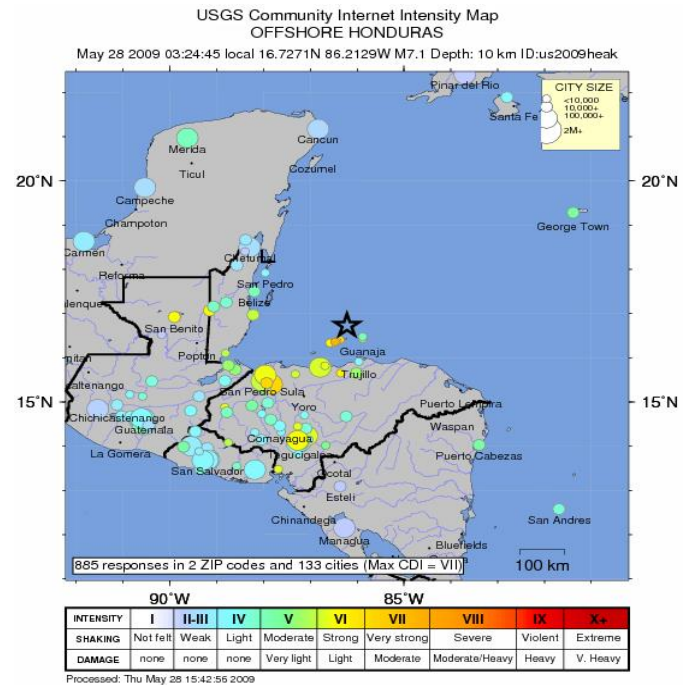


Figure 6.4: USGS Intensity Map of May 2009 Earthquake offshore Honduras

Mitigation measures against seismic activity poses challenges to planners due to the unpredictability of seismic activity; its intensity and its location. At the *Arundo donax* site, low seismicity has historically been the case. Support structures such as buildings will be single story structures; thus reducing the risk for failure as a result of seismic activity.

6.10 Risk of Diseases and Pandemics

At the time of completion of the ESIA AND ESMP reports, the global pandemic caused by the SARS-Cove-2 virus was well established. This disease was previously unforeseen, and its rapid development led to countries taking previously unthinkable measures such as the locking down of entire cities, and even countries as part of quarantine measures in an attempt to contain the spread of the disease. The disease was previously unknown in terms of its epidemiological characteristics and thus most policies, practices and measures taken for its containment were fairly new. The country of Belize established quarantine guidelines and health measures based on the advice of the medical and scientific community. As a result, businesses, companies, in fact, communities throughout the entire country adopted these guidelines and measures in an attempt to contain the disease, and thus protect the population from this unpredictable phenomenon. Therefore, natural disasters do need to consider the proliferation of diseases and

pandemics in the preparation of project management schemes. Management and mitigation measures to safe guard against diseases should be adopted in the health and safety measures that the project has drafted. The occupational health and safety guidelines should be modified to include the official government guidelines as diseases emerge.

6.2 Man Made Disaster Risks

Man - made disaster risks include risks such as fires, chemical spills and motorized accidents.

In Belize the risk of fires are increased during the dry season, especially during the peak, which is from March to May. During this period, conditions are dry, with practically little or no rainfall, especially in the north. The soil is dry, and the windy conditions increase during the months of March and April. During this time, fires are considered high risk and can be ignited due to electrical inadequacy, careless use of home and fires in the open, and from accidental spill and ignition of fuels and any source of ignition. Fires may also be caused due to abandoned garbage that may be heated from the sun's light, and from fires that were not adequately put out.

Fires during this period may be difficult to control, and in most cases “bush” fires run freely until the source of fuel finishes, or becomes low. Forest fires are an annual problem in Belize, since these run uncontrollably into the natural vegetation. Agriculture fires, for example, often escape, causing damage to natural vegetation and to nearby properties.

The Arundo donax project is proposing the use of extensive buffer zones as one technological mitigation measure for the control of fires and for other purposes.

6.2.1 Risk of Chemical Spills

The project being conceptualized is not considered a highly dependent on chemicals and substances other than fuel and oils, and limited chemicals for biological control. In other words, quantities should be limited to a few gallons, with the except for fuel that may exceed that quantity for the use of generators.

Chemicals and chemical movement are controlled substances in terms of storage, handling and movement and use or application. There use follows approved practices by manufacturers. Due to the relatively small volumes of a few gallons, chemical spills during and after transportation will be low. There spill can be initiated, however, as a result of mechanical failure of transportation equipment, and as a result of negligence.

A chemical spill contingency plan has been put in place as part of the ESMP.

6.2.2 Risk for Accidents

Accidents and accident related incidences have a fairly medium level of risk considering the project's small scale nature. However, accidents are not always controlled by the trained project employees, but also by other drivers and operators within the community.

6.2.3 Phytosanitary Risks including Crop Management

While the project is expected to manage risks; there is always the risk of crop failure. This has been addressed via the preparation of crop risk assessment that looked at the possibility of the crop being affected by invasive species, and cultivation techniques. This risk, while existent, is considered low, but with major consequences should this happen.

6.3 Ranking of Risks and Severity of Consequences.

A practical approach in risk assessments and impact assessments can be done using matrices. While the use of these matrices can be highly subjective, they are nonetheless useful guides. Based on the risk assessment, these natural and man - made risks have been classified using a numerical and colour code for the use of the ranking of the degree of these risks, with low risk (1) being green, medium risk (2), being yellow and high risk (3), being red. Similarly, the severity of the risk, are Minor (green), Moderate (yellow) and Major (red). Therefore, a quick look can determine degree of the risk and its severity as shown in Table *. The reader should note that the risks identified and ranked are based on both the national risk assessed, and how this relates to the existing project location and conditions. For example, while the country as a whole has a high risk for storms and flooding, given the local context of the project setting, the risk for floods is fairly low.

Table 6.1: Matrix using colour coding.

Degree of RISK		
1	2	3
LOW	MEDIUM	HIGH
Severity of RISK		
MINOR	MODERATE	MAJOR

Risk: The degree or probability of loss or peril to human health or the environment that an activity, action, or program, (on-going or with potential of taking place) may have.

Severity or consequence of risk: The significance of the potential negative impact to the human health and environment resulting from the consequences of the risk occurring or continues to occur without the recommended or corrective actions taken.

Table 6.2: Ranking of Risks and Severity of the Consequences.

RISK	LOW(1)	MEDIUM (2)	HIGH (3)	SEVERITY
				Minor,
				Moderate
				Major
Hurricanes			√	Major
Tropical Storms		√		Major
Floods			√	Moderate
Fires		√		Moderate
Earthquakes	√			Low
Crop Diseases		√		Low
Diseases/Pandemics		√		Major
Chemical Spills		√		Low
Accidents		√		Moderate
Crop Failure	√			Major

6.4 Phytosanitary and other Crop Management Risk Assessment

6.4.1 Preface

Belize is a contracting party to the International Plant Protection Convention (IPPC), and is a member of the World Trade Organization (WTO). The IPPC is formally named in the WTO Sanitary and Phytosanitary (SPS) Agreement as the international standard setting organization for phytosanitary measures. The IPPC is an international treaty to secure action to prevent the spread and introduction of pests of plants and plant products (including plants as pests), and to promote appropriate measures for their control. The Belize Agricultural Health Authority (BAHA) is recognized under the IPPC as Belize's official National Plant Protection Organization, and as such is responsible for conducting pest risk analyses to support decisions about the management of phytosanitary risk.

Pest risk analysis (PRA) involves three processes: risk assessment, risk management and risk communication. *Pest risk assessment* provides the scientific basis for the overall management of risk. It involves identifying hazards and characterizing the risks associated with those hazards by estimating their probability of introduction and establishment as well as the severity of their economic impact. *Pest risk management* is the process of identifying and evaluating potential mitigation measures which may be applied to reduce the identified pest risk to acceptable levels and selecting appropriate measures. *Pest risk communication* is an additional component of PRA that is common to all stages of the PRA process.

International Agreements/Conventions Context

Belize is party to several international and regional conventions that make specific mention of environmental protection and/or biodiversity conservation.

Belize signed the Convention on Biological Diversity on June 13 1992 in Rio de Janeiro, Brazil and ratified it in December 1993. Belize is also party to the Convention on International Trade of Endangered Species of Wild Fauna and Flora (CITES) since 1981; the Convention on Wetlands of International (Ramsar Convention) in 1989.

Other important conventions that Belize has signed or ratified related to biodiversity protection and conservation are: The Convention on the Inter-Regional Organization for Plant and Animal Health (OIRSA); the International Plant Protection Convention acceded May 14, 1987.

Invasive species

There is considered to be adequate (but by no means complete) information in Belize on invasive species (Belize Fifth National Report to the Convention on Biological Diversity), and for those species causing significant impacts to the economy, pathways have been identified and where feasible, management regimes have been put in place. There aren't, however, the human resources to address every invasive species, and a number have become well established. Where they are a serious cause of concern to human health, agricultural production, or the fisheries industry however, measures have been put into place to control the impacts, where feasible.

BAHA is mandated to regulate the import of fruit, vegetables and vegetable material to Belize, to ensure that crop pests do not enter the country. BAHA also has the authority to prevent the transport of plant material and/or animals within Belize to stop the spread of infection through introduction of invasive vectors.

Background

As is often the case of the introduction, development or evolution of any new industry, in this case a new biomass energy project, there will be lessons learnt in the process that would contribute to the minimization of risk in the commercialization phase.

Risks are not necessarily avoided when cellulosic biofuels are produced from energy crops, grown for their high cellulosic biomass yield. Growing land-based energy crops on land currently used for the production of other crops will generally lead to indirect land use change and pressure on existing food and feed markets. Converting natural forest and grassland to biomass crops will generally cause environmental damage.

Energy crops could be grown sustainably and with minimal or no indirect impacts. That could mean using land that can be converted with minimal environmental costs, or even with environmental benefits (land that is unused or underutilized and has low productivity, low carbon stocks, and low biodiversity). There is reason to believe that energy crops could potentially deliver environmental benefits when grown on previously disturbed, abandoned agricultural land. While literature studies comparing biodiversity and carbon stocks in energy crop plantations to marginal land are scant, it is clear that in many cases perennial energy crops can improve agricultural land previously used for annual row crops and may offer similar environmental benefits to existing unmanaged grassland. The literature suggests that growing perennial energy crops may rehabilitate agricultural land faster than simple abandonment. *Data on annual energy crops such as biomass sorghum is scarcer, but they may be sustainably cultivable in many areas.*

Arundo donax is considered to be sustainable in terms of economics (biomass supply and revenue generating) and social development (neutral or negative CO₂ emissions and avoiding food-crop competition); however in terms of environmental protection it has deficiencies, mainly in reducing freshwater resources and having negative biodiversity impacts. However, a certain section of the literature, mainly based on US experience, shows that *Arundo* should be produced with care due to its invasiveness hazard.

Purpose

The purpose of this Environment and Risk Mitigation and Management Plan is to provide a framework to guide mitigation and management of potential risks that may arise from the proposed biomass pilot project to confirm the feasibility of managed/controlled cultivation of *Arundo donax* for utilization as an energy crop in Belize.

Such risk reduction areas would include the whole supply chain (see Fig 6.1):

✓ **Production related issues**

- ✓ Reduction in environmental impact of agronomic management
- ✓ Harvesting and storage related issues
- ✓ transportation-related issues
- ✓ End use related issues

ARUNDO: BIOMASS TO ENERGY SOLUTIONS

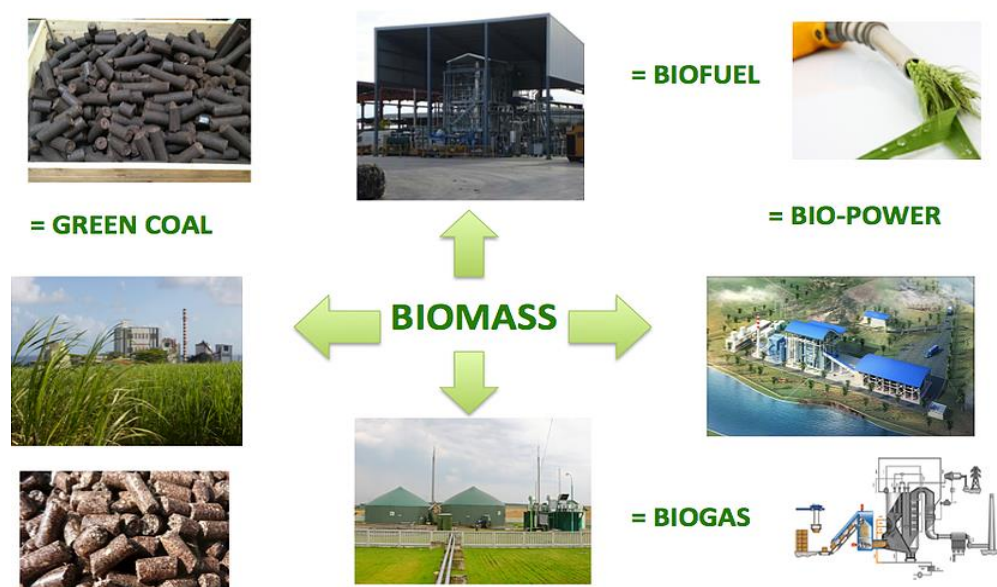


Figure 6.5: Arundo Supply and utilization chain

Description

Name: *Arundo donax* L. (Poaceae)

Common names: *wild cane*, giant reed, bamboo reed, giant cane, Spanish reed.

Description of plant: *Arundo donax* is a perennial grass with strong, fleshy rhizomes, deeply-penetrating fibrous roots and tall stems (2-10 m). It is the tallest and largest ornamental grass species after bamboo. Individual stems (culms) are erect, 1-3.5 cm thick, and have glabrous nodes and hollow internodes. The outer stem tissue is hard, brittle and glossy. Leaves are blue-green, 30-100 cm long and arranged alternately in two vertical rows on opposite sides of the stalk. Flowers are plume-like panicles, 30-65 cm long, found at the upper tips of stems. The flower is a spikelet 10-15 mm long with 2-4 florets. Seeds are light brown, oblong caryopses 3-4 mm long.

Variegated strains have originated from bud variations that have been isolated and further propagated. Selection has led to a number of variegated forms that, with the exception of variegated leaves, do not differ significantly from the green form (Rojas et al., 2014). 'Nile Fiber'

is a patented cultivar of *Arundo donax* grown for landscape and biomass production (Carroll & Volotin, 2014). This cultivar may be distinguished from standard ecotypes in having a purple band below each node section and in lacking serrated leaf margins. It is also characterized by increased growth, greater wall thickness, higher germination rates of propagules, extreme vigor and superior fibre for pulp and paper. Plant height can reach as much as 15 m in 2-3 years.

The Bio-G clone is an improved ecotype of *Arundo donax*, also developed for biomass production (Galiltec, 2014). It is uniformly produced through tissue culture technology and is described as a resilient and high-yielding energy crop that "augments the positive qualities of *Arundo*". This clone is being promoted for biomass production in Honduras and other countries.

Arundo donax has been cultivated for a variety of purposes, including biofuel, pulp and paper, light construction material, animal fodder, reed and pipe making, windbreaks, erosion control, and medicinal and ornamental use. However, *Arundo donax* has become highly invasive in riparian and wetland areas of some countries outside of its native range, including the United States and Mexico. It is recognized by some scientists as one of the World's Top 100 plant invaders (Lowe et al., 2000).

The plant tolerates diverse ecological and soil conditions and is resistant to most pests, which makes its production attractive. *Arundo* has the risk of invasiveness in flooded areas. In general, *Arundo donax* has great biomass potential requiring lower input level while a wide range of climatic conditions and soil types (even polluted) is suitable for its production.

6.4.2 Status in Belize

Arundo donax is reported to occur in natural ecosystems in Belize, commonly referred to as wild cane, is a plant that has been documented at least since 1883 (Morris) as part of the Belize ecosystem/landscape (See table 6.1). Collaborative work between the 5Cs, the Land Information Centre of the Belize Ministry of Natural Resources and Agriculture, and CATHALAC of Panama, enabled the development of baseline data about the distribution of *Arundo* in Belize. The spectrum analysis exercise undertaken by CATHALAC, Emil Cherrington in 2012, using satellite imaging estimated that, some 354 km² of land is under *Arundo* on a national scale, which converts to about 1.5% of the country's territory.

The area within the country where *Arundo* is in existence includes the Orange Walk District in Northern Belize where the proposed Biomass Pilot will be established (see Fig 6.2). Some locations of the naturally growing *Arundo* within the Orange Walk District are circled in white on the map. Riparian areas are particularly sensitive. However, as the spectrum analysis from the 2012 satellite imaging confirms that there is already considerable growth of *Arundo* along the banks of the Monkey and Sittee Rivers in the south of the country, as well as in the Orange Walk District in the north of the country where the proposed Biomass Pilot is located. For *Arundo* to propagate, it requires either a rhizome or a stalk that is planted manually or mechanically and covered with soil.

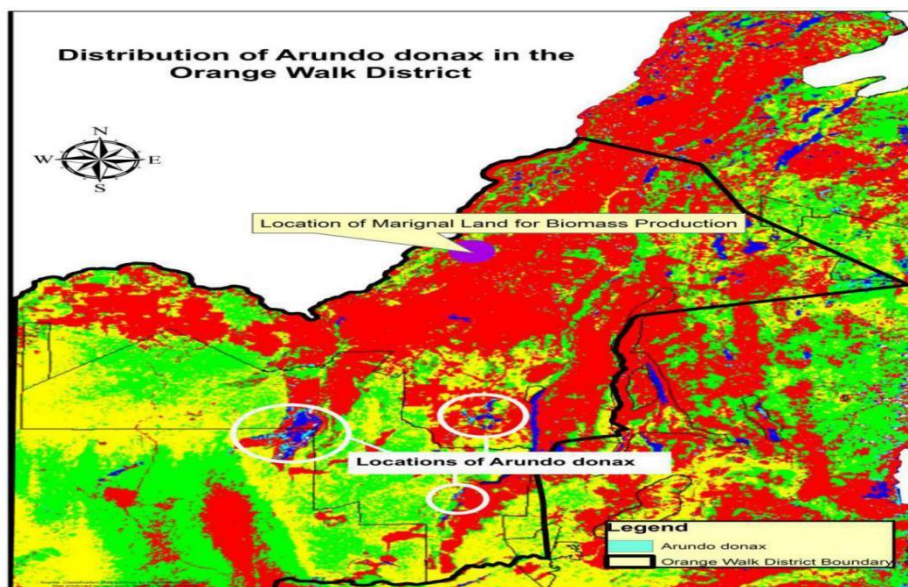


Figure 6.6: Distribution of Arundo in Orange Walk District

Table 6.3: Country Report of presence of Arundo Donax in Belize.

Country	Distribution	Origin	First Reported	Invasive	Planted	Reference
Belize	Present	Introduced	1883	Yes?	No	Clayton et al., 2014

History of Introduction and Spread

It is believed that *Arundo donax* was introduced from Asia via the Middle East to the entire Mediterranean basin in prehistory. It was only later exported from the Mediterranean by early French and Spanish colonialists, and widely dispersed, largely by man into all the subtropical and warm temperate areas of the world. In many areas it has become well established.

Arundo donax has also been widely dispersed in the New World, from the USA to South America, and occurs in most of the West Indies. It was first introduced into the United States at Los Angeles, California in the early 1800's, and it escaped from cultivation as far north as Virginia and Missouri. In the West Indies, *Arundo donax* was first reported in 1864 for Jamaica and Antigua (Grisebach, 1864) and in 1883 in Puerto Rico (Bello, 1883) and Belize.

6.4.3 Habitat

Arundo donax is a hydrophyte but can grow in a wide range of conditions, from moist well-drained soils to those with a water table at or near the surface. Soil preferences are also broad, occurring on coarse sands, gravelly soils, heavy clays and river sediments from freshwater to semi-saline soils on brackish estuaries or in ditches, and along the banks of streams, rivers and lakes. It is almost certain that invasive populations are the result of escapes and displacement of plants from commercial plantations and horticultural propagation. It is particularly prominent in the coastal river basins in southern California where it sometimes occupies entire river channels from bank to bank and is thought to have invaded following large storms in the late 1960s (Jackson et al., 1994).

Hosts/Species Affected

Arundo donax is not usually a weed of crops, rather tending to out-compete and displace native vegetation in riparian habitats. However, it has been reported as invasive in pasture/cropland in South Africa, Tanzania, Egypt, Argentina, Uruguay, Chile, Puerto Rico, and the Dominican Republic (Perdue, 1958).

6.4.4 Biology and Ecology

Genetics

The base chromosome is $x=12$, but with numerous ploidy levels reported, with $2n=60$, $2n=72$, $2n=110$ and $2n=112$. A chromosome number of $2n=40$ has been recorded for *Arundo donax* var. *macrophylla*. There are generally low levels of genetic variation in introduced populations as they tend to reproduce only vegetative.

Physiology and Phenology

New shoots arise from rhizomes in nearly any season. Growth also occurs in any season, but is highly sensitive to temperature and moisture. Under favorable conditions (warm and wet months), *Arundo donax* grows very rapidly. Growth rates of up to 0.7 m/week have been recorded, putting it among the fastest growing terrestrial plants. Young culms develop at the full diameter of older canes and further growth involves thickening of the walls. The new growth is soft, very high in moisture and has little wind resistance (Perdue, 1958). Age of individual culms is certainly more than one year and branching seems to represent stem growth in later years, whereas rhizomes show indeterminate growth. Branches can also form when a stem is cut or laid over. Die-back is infrequently observed but culms fade or become partially brown in winter, becoming dormant under cold conditions.

Reproductive Biology

Very little information is available in the literature regarding the biology of *Arundo donax*. Although plants have been grown in scattered locations from seed collected in Asia, it is reported

that *Arundo donax* does not produce viable seeds in most areas where it is apparently well-adapted. The importance of sexual reproduction to the species, as well as seed viability, dormancy, germination and seedling establishment have yet to be well studied. Population expansion occurs almost exclusively through vegetative reproduction in most reported cases, either from underground rhizome extension of a colony or from plant fragments carried downstream, to become rooted and form new clones (Else, 1996). Root formation can also occur where an attached clump has fallen over and is in contact with the substrate, and layering has now been proposed as a more common means of reproduction in invasive stands in the USA than either via rhizome extension or plant fragments (Boland, 2006). Much of the cultivation of *Arundo donax* is therefore initiated by planting rhizomes that root and sprout readily. Wild stands in the USA have reportedly yielded over 20 t of oven-dry biomass per ha (Perdue, 1958).

Environmental Requirements

Arundo donax is extremely tolerant to different climates and can survive and grow at almost any time under a wide variety of environmental conditions. However, it does not appear to tolerate high elevations over much of its native and introduced ranges, nor does it like continental environments where regular freezing occurs. In Egypt, it was found to tolerate both higher and lower water table levels than. Often found on sand dunes near seashores. It tends to favor low gradients <2% grade over steeper and smaller channels, but scattered colonies can be found in moist sites or springs on steeper slopes. It is reported to tolerate annual precipitation of 300-4000 mm, annual temperatures of 9-29°C and a soil pH of 5.0-8.7 (Duke, 1975).

Natural enemies

Based on the literature review the following table has been compiled, however, it is not limited to the list in Table 6.2. During the Biomass pilot phase data will also be collected on any pests and diseases found on *Arundo*.

Table 6.4: Natural enemies of *Arundo donax*

Natural enemy	Type	Life stages
<i>Longiunguis donacis</i>	Herbivore	Leaves
<i>Microsphaeropsis arundinis</i>	Pathogen	Leaves/Stems
<i>Puccinia arundinis-donaeis</i>	Pathogen	Leaves
<i>Puccinia torosa</i>	Pathogen	Leaves

Natural enemy	Type	Life stages
<i>Tetramesa romana</i>	Herbivore	Stems

Notes on Natural Enemies

Armillaria mellea, *Leptostromadonacis*, *Papulariasphaerosperma*, *Puccinia coronata* and *Selenophomadonacis* have been identified as affecting *Arundo donax* (Bell, 1997). The effects and specificity of *Phomaglomerata* and *Alveophomaarundinis* attacking the leaves and stems have yet to be ascertained. The leaves of *Arundo donax* contain a number of toxic and unpalatable natural minerals and chemicals, such as silica, cardiac glycosides, hydroxamic acids, and alkaloids that protect the plant from native insects. Due to the presence of these toxic chemicals and minerals that protect the plant from native insects that might attempt to feed or reproduce upon it, such species become scarce with the invasion of *Arundo donax*. Unfortunately, little is known about predators in its invasive range that can damage or kill *Arundo donax*. A number of invertebrates are known to feed on the grass in Eurasia and Africa (El-Enany, 1985; Hoshovsky, 1987). Caterpillars of *Phothedesdulcis* have been reported feeding on *Arundo donax* in France (Dufay, 1979); *Zyginidiaguyumi* in Pakistan (Ahmed et al., 1977) and the moth borer, *Diatraeasaccharalis* in Barbados (Tucker, 1940) have also been reported.

Natural Dispersal (Non-Biotic)

In its native range, wind dispersal of seeds is facilitated by having a dense seed head on the end of a tall, flexible stem, presumably sending the seeds some distance. Established plants may expand by rhizome extension roughly 0.5 m per year. More research is needed to determine the importance of sexual reproduction and whether viable seeds are in fact produced in this species. In its introduced range, vegetative propagation is key to its establishment in new locations, and is essentially a downstream phenomenon with rhizome fragments dispersing along watercourses, particularly post flooding. It may be spread locally by agricultural machinery and as a contaminant in soil and crop seeds.

Intentional Introduction

Arundo donax has been purposefully introduced by man and cultivated into many of the subtropical and warm temperate areas of the world for a number of uses. It is planted as an ornamental and cultivated for a variety of uses including erosion control along ditches and drainage canals. It is available via the nursery trade and spreads as a garden escapee and through the disposal of garden waste.

Table 6.5: Plant Trade

Plant parts liable to carry the pest in trade/transport	Pest stages
Bulbs/Tubers/Corms/Rhizomes	
Flowers/Inflorescences/Cones/Calyx	seeds
Fruits (Inc. pods)	seeds
Growing medium accompanying plants	
Roots	
Stems (above ground)/Shoots/Trunks/Branches	stems
True seeds (Inc. grain)	seeds
Plant parts not known to carry the pest in trade/transport	
Bark	
Leaves	
Seedlings/Micro propagated plants	
Wood	

6.4.5 Impact Summary

Category	Impact
Animal/plant collections	None
Animal/plant products	None
Biodiversity (generally)	Negative
Crop production	None
Cultural/amenity	Positive
Economic/livelihood	Positive
Environment (generally)	Positive and Negative
Fisheries / aquaculture	Negative
Forestry production	None
Human health	None
Livestock production	None
Native fauna	Negative
Native flora	Negative
Rare/protected species	None
Tourism	None

Category	Impact
Trade/international relations	Negative
Transport/travel	None

6.4.6 Economic Impact and Environmental Impact

Economic Impact

When flooding occurs in areas heavily populated by *Arundo donax*, it forces flood waters out of the primary channels and into critical banks, bridges and other physical structures. In addition, its stems and rhizomes break off in the flood currents and flow with the flood. These rhizomes and stems deposit themselves in drainage systems, along small agricultural ditches, under bridges and in other flood control systems where it can quickly re-establish itself in these new locations. This leads to costly clean-up operations to un-block obstructed waterways, and quite possibly structural damage and hazards when trapped behind bridges and other structures. This can put an economic strain on areas inundated with *Arundo donax*. Costs of removal vary but can be in excess of BZ\$10,000/acre, and areas are rapidly re-infested if sustained control efforts are not maintained over many years. *Arundo donax* stands collect sediments from stream flow. As the sediment surface under the *Arundo donax* stands rise, it can force the stream water into new paths which then interact with other infestations downstream or across the stream. The result is accelerated erosion of stream banks, lost property, and expensive repairs to the property.

Environmental Impact

Arundo donax is an aggressive species with an ability to reproduce quickly, allowing it to out-compete native plant species. It displaces native plants and wildlife as a consequence of the massive stands it forms but the exact mechanism of competition is not yet known. Unlike native riparian plants, *Arundo donax* provides little shading to the in-stream habitat, leading to increased water temperatures, lower oxygen and reduced habitat quality for aquatic wildlife (Hoshovsky, 1987; Team Arundo del Norte, 2002). *Arundo donax* is also known to interfere with the management of flood defences and wildlife habitat management. *Arundo donax* is also thought to alter hydrological regimes and reduce groundwater availability by transpiring large amounts of water from semi-arid aquifers and layers of permeable rock consuming three times

more water than native plants (Iverson, 1994). It also causes substantial alterations to water flow during storm events leading to increased erosion.

Arundo donax infestations are threatening native riparian vegetation in California. In the Santa Ana River of Southern California, for example, it is estimated that 68% of the riparian vegetation is comprised of *Arundo donax* (Dudley, 2000). *Arundo donax* has displaced native vegetation which provides nesting sites for native species such as the Least Bell's Vireo (*Vireo bellipusillas*), a federally endangered species, the Willow Flycatcher (*Empidonax trailliieximos*), a federally threatened species, and the Yellow Cuckoo (Bell, 1993). *Arundo donax* is also known to be a habitat for the invasive Norway rat (*Rattus norvegicus*) which has caused/contributed to the extinction/range reduction of native mammals, birds, reptiles and invertebrates through predation and competition. *Arundo donax* displaces native riparian vegetation, forming huge monocultures which can cover hundreds of hectares and provide poor habitats for terrestrial insects and wildlife. It crowds out native plants that shade streams, resulting in warmer water that harms aquatic life. Unpalatability of *Arundo donax* to native fauna could then impact on wildlife which depends on insects normally supported by the native vegetation. With the invasion of *Arundo donax*, what was once a complex food web becomes simplified, leaving fewer species that can survive in its presence.

Table 6.6: Threatened Species example.

Threatened Species	Conservation Status	Where Threatened	Mechanism	References
Catostomus santaanae (Santa Ana sucker)	EN (IUCN red list: Endangered) EN (IUCN red list: Endangered); USA ESA listing as threatened species USA ESA listing as threatened species	California	Ecosystem change habitat alteration	US Fish and Wildlife Service, 2011

6.4.7 Social Impact

Arundo donax is an ***extremely flammable plant*** even when green. The thick stands ignite quickly and easily, and through their extensive placement, can double the available fuel for wildfires which can spread rapidly through entire riparian systems, often near urbanized areas. Post-fire regeneration of even greater quantities of *Arundo donax* can then occur (Scott, 1994).

Table 6.7: Risk and Impact Factors

Invasiveness	Impact outcomes	Impact mechanisms	Likelihood of entry/control
Proved invasive outside its native range	Ecosystem change/ habitat alteration	Allelopathic	Highly likely to be transported internationally deliberately
Has a broad native range	Modification of fire regime	Competition - monopolizing resources	Difficult/costly to control
Abundant in its native range	Modification of hydrology	Competition - smothering	
Tolerates, or benefits from, cultivation, browsing pressure, mutilation, fire etc	Modification of nutrient regime	Rapid growth	
Pioneering in disturbed areas	Modification of successional patterns	Rooting	
Highly mobile locally	Monoculture formation		
Long lived	Negatively impacts agriculture		
Fast growing	Negatively impacts cultural/traditional practices		
Has high reproductive potential	Negatively impacts aquaculture/fisheries		
Reproduces asexually	Reduced native biodiversity		
	Threat to/ loss of native species		

Similarities to Other Species/Conditions

A. donax can be confused with the closely related common reed (*Phragmites australis* or *Phragmites communis*) and pampas grass (*Cortaderia* spp.), with cultivated bamboos, and in its earlier growth stages with some large-stature grasses such as *Elymus* spp.

6.4.8 Prevention and Control

Cultural control

Prescribed burning has been used to control *Arundo donax*, with a flame thrower being used as a cheap, alternative spot treatment to heat-girdle the stems at the base of the plant. Larger, mature, infestations can be burnt by broadcast burning with or without a prior pre-spray of herbicides to kill and desiccate the plants. This is generally not recommended as it does not kill the underground rhizomes and probably encourages *Arundo donax* germination over native riparian species. Burning presents containment risks and the possibility of damage to beneficial species, resulting from soil disturbances which may result from firebreak construction as well as from difficulties of promoting fire through patchily distributed stands. Cut material is often burnt on site because of the difficulties associated with collection and removal of all the chipping material.

Prescribed grazing is a managerial control method sometimes employed to control *Arundo donax*. Although *Arundo donax* is not very palatable to cattle, during the drier seasons they do browse young shoots, followed by upper parts of more mature plants (Wynd et al., 1948). In parts of California, goats have been used quite effectively to control *Arundo Donax* (Daar, 1983) although they tend to be less selective than sheep and the latter have been shown in feeding experiments to survive for extended periods on a diet of *Arundo donax* alone (Fratteggiani-Bianchi, 1963). Although sheep may prove a more practical alternative to mowing in some cases, it is important to manage this so as to avoid soil compaction problems in overly damp areas. It has also been suggested that wild geese breeds might contribute to *Arundo donax* control efforts given their capacity to consume weed grasses and sedges.

Since *Arundo donax* in its invasive range appears to be unable to regenerate much, if at all, from wind or water-carried seeds or small propagules, its invasiveness could be controlled by not planting within the floodplain, and placing barrier screen systems along irrigation canals.

Mechanical control

Smaller infestations can be eradicated by manual methods, especially where there is a risk of damage to sensitive native plants and wildlife by other methods. This is successful with young plants less than 2m in height, but care must be taken to remove all the rhizome material, and as such may be more effective in loose soils and after periods of rain when the substrate is more workable. Plants can also be removed using hand tools such as pick-axes and shovels,

particularly in combination with the cutting of stems near the base with pruning shears or a chainsaw. Stems and roots should be removed or burned on site to avoid re-rooting and a chipper can be used to reduce the volume of cut material. For larger infestations on accessible terrain, heavier tools such as rotary brush-cutters, chainsaws and tractor mounted mowers may facilitate biomass reduction and should be followed either by rhizome removal or chemical treatment. These methods may be of limited use on inaccessible or sloping terrain, and may interfere with the re-establishment of native plants and animals (Hoshovsky, 1987). Mechanical control tends to be very difficult as even rhizomes buried 1-3 m deep readily resprout and removal of all such material is not practical, especially in sensitive sites where soil disturbance is disruptive or where soils are susceptible to compaction or erosion or when they are saturated.

Chemical control

In many situations, this may be necessary and is usually carried out in combination with mechanical control. Glyphosate is most commonly used against *Arundo donax*, which is approved for use in wetlands. As a broad-spectrum herbicide, care should be taken to avoid application or drift onto desirable vegetation. This can be achieved by treating the culms directly, also reducing herbicide costs, with fair results being achieved year-round with best kill in autumn (Else, 1996). Concentrated glyphosate solution is applied to the stems, cut at a height of 5-10 cm, by painting with a sponge or spraying with a mister. The solution must be applied immediately after cutting, as translocation ceases within minutes of cutting. As new growth is sensitive to herbicides, a common alternative is to cut or mow a patch and allow regeneration, returning 3 weeks to 3 months later to treat the new growth. With all chemical methods, follow-up treatment and assessment are necessary. The optimal application period is post-flowering, usually in late July to early October when plants are translocating nutrients into roots and rhizomes. Foliar uptake and kill are best achieved by spraying during the active growing periods and small patches can be treated from the ground using backpack or towed sprayers, and major infestations have been aerially sprayed using helicopters in the USA (Zemba & Hoffman, 2000).

Biological control

Pest surveys and assessments have been initiated for the biological control of *Arundo donax*, but no biological control agents have yet been released. A number of invertebrates are known to feed on the grass in Eurasia and Africa (El-Enany, 1985; Hoshovsky, 1987). Caterpillars of *Phoebastria dulcis* have been reported feeding on *Arundo donax* in France (Dufay, 1979); *Zyginidia guyana* in Pakistan (Ahmed et al., 1977) and the moth borer, *Diatraea saccharalis* in Barbados (Tucker, 1940) have also been reported. A review of the CABI Bioscience herbarium suggests that there are obligate biotrophic fungi associated with *Arundo donax* in China, but not India or Pakistan, lending weight to the theory that China may in fact be a true centre of origin for the species. As with invertebrates, a number of pathogens are also associated with *Arundo donax* in its naturalized range. Given the commercial value of *Arundo donax*, the use of insects and/or pathogens would undoubtedly engender conflicts of interest. Biological control is thought to offer one of the best long-term options, affordable and environmentally friendly management of *Arundo donax*. The ARS European Biological Control Laboratory (Montpellier, France) in cooperation with a USDA-ARS laboratory initiated a foreign exploration programme in 1999

which has already located potential agents in the Mediterranean Basin, India and Sri Lanka (Kirk et al., 2003). *Arundo donax* stems and leaves contain a wide array of noxious chemicals, including silica (Jackson & Nunez, 1964), tri-terpines and sterols (Chandhuri & Ghosal, 1970), cardiac glycosides, curare-mimicking indoles (Ghosal et al., 1972), hydroxamic acid, and numerous other alkaloids which, however, probably protect it from most native insects and other grazers (Zuniga et al., 1983; Miles et al. 1993).

Integrated Control

A suite of methods is needed to control *Arundo donax* depending upon the presence or absence of native plants, the size of the stand, the amount of biomass which must be dealt with, the terrain and the season. Several technical approaches can be successful, with the best one for a particular site dependent on available labour resources, the size of the infestation, degree of intermixing with desirable native riparian vegetation, site accessibility and other factors. Follow-up treatments are usually necessary for one to five years after the initial control. Often the lower, frequently flooded stream banks will re-vegetate spontaneously, and upper, drier banks may need re-planting with native species. Where *Arundo donax* is the only vegetation on stream banks, post-eradication revegetation efforts may be critical for bank stabilization. Groups dedicated to tackling this problem weed, have produced brochure for the general public, handbooks for landowners interested in *Arundo donax* removal, a guide for *Arundo donax* removal programme, and public-education video.

Biodiversity Impact

Belize Department of Environment had no objection to the Biomass Pilot utilizing *Arundo donax*; however, clearance should be obtained from BAHA. *Arundo* is classified differently in various jurisdictions. For example, while the US Environmental Protection Agency (EPA) approved *Arundo* as a biofuel, and it is presently being cultivated in the states of North Carolina and Oregon, while it is banned in California.

In the specific case of the proposed Biomass Pilot in Belize, the biodiversity impact of *Arundo donax* spreading to replace native species and vegetation is considered minimal. This is primarily because the project will only utilize the relatively abundant land in Belize that is classified as “marginal” and not suitable for agriculture. The land classification in Belize is separated into five categories for land potential and agricultural value, as illustrated in Table 6.6 below. The classification, conventionally categorized, is based on agricultural potential and soil attributes, including fertility and drainage. The 2003 National Food and Agriculture Policy, based on the results of a number of studies, declared that 64% of all land in Belize is unsuitable for agriculture. Of the land that is unsuitable for agriculture in Belize, a sizable 4,600 square kilometers (over 20% of total land area) are marginal (Land Value category 4).

Table 6.8: Summary of Land Potential (Agricultural Value)

Agricultural Value	Area (km ²)	%	Characteristics	Economic Potential
1	990	4.3	Includes floodplain soils, generally acid but respond well to fertilizers.	High to very high-income potential. Suitable for most crops.
2	2,790	12.1	Includes the undulating to flat well drained limestone land. Generally high fertility, but citrus should be avoided because of risk of lime chlorosis and droughtiness.	Good chance of financial success. Suitable for arable, pasture and sugar-cane.
3	4,480	19.5	On limestone but imperfectly drained, although some may suffer from moisture deficiency. Some soils are compacted or shallow.	Moderate chance of financial success with good management, unlikely to provide economic return under poor management.
4	4,670	20.3	These soils are really poorly drained, shallow, and drought prone.	Marginal, even with skilled management and high inputs.
5	10,040	43.7	Mostly steep slopes of the Maya mountains and limestone karst.	Extremely small chance of financial success.

SOURCE: King, R.B., Pratt, J.H., Warner, M.P. and Zisman, S.A. (1993). Agricultural Development Prospects in Belize (NRI Bulletin 48)

The 500 acre that was approved by the Ministry of Natural Resources and Agriculture including the 400 acres area designated for the Biomass Pilot (including the larger surrounding 1,800 acre area identified by the 5Cs) has been confirmed as being “marginal” by the Department of Environment of the Ministry of Forestry, Fisheries, and Sustainable Development following an inspection by its officials prior to the agency providing a no-objection to 5Cs to proceed with the Biomass Pilot. It is recommended that a no objection also be obtained from the Department of Agriculture as they would be the competent authority to ensure the designation of the marginal lands. These lands have low quality soil and poor drainage, making them unsuitable for agriculture even with skilled management and the use of high value chemical inputs (fertilizers). Despite the poor agricultural potential for conventional crop production, the 5Cs analysis suggests that these lands, which would otherwise be unutilized, can be well suited for growing a resilient biomass crop such as *Arundo*, given its characteristics.

Literature Cited

- Acevedo-Rodríguez P, Strong MT, 2012. Catalogue of the Seed Plants of the West Indies. Smithsonian Contributions to Botany, 98:1192 pp. Washington DC, USA: Smithsonian Institution. <http://botany.si.edu/Antilles/WestIndies/catalog.htm>
- Ahmed M, Jabbar A, Samad K, 1977. Ecology and behavior of *Zyginidiaquyumi* (Typhlocybinae: Cicadellidae) in Pakistan. Pakistan Journal of Zoology, 9(1):79-85
- Arianoutsou M, Bazos I, Delipetrou P, Kokkoris Y, 2010. The alien flora of Greece: taxonomy, life traits and habitat preferences. Biological Invasions, 12(10):3525-3549. <http://www.springerlink.com/content/64p8761783323136/>
- Balogh L, Dancza I, Kiraly G, 2004. Actual list of neophytes in Hungary and their classification according to their success. In: Biological invasions in Hungary - Invasive plants [ed. by Mihaly, B. \Botta-Dukat, Z.]. 61-92.
- Bell GP, 1993. Biology and Growth Habits of Giant Reed (*Arundo donax*). In: Jackson NE, Frandsen P, Douthit S, eds. *Arundo donax* workshop proceedings, Ontario, Canada, 1-6. http://www.ceres.ca.gov/tadn/TA_proceedings.html.
- Bell GP, 1977. Ecology and management of *Arundo donax*, and approaches to riparian habitat restoration in Southern California. In: Wade JH, Pysek P, Green D, eds. *Plant Invasions: Studies from North America and Europe*. Leiden, Netherlands: Blackhuys Publishers, 103-113.
- Bello D, 1883. [English title not available]. (Apuntes para la flora de Puerto Rico. Segunda parte. Monoclamideas.) *Anales de la Sociedad Espanola de Historia Natural*, 12:103-130.
- BioNET-EAFRINET, 2014. East African Network for Taxonomy. Online Key and Fact Sheets for Invasive plants. <http://keys.lucidcentral.org/keys/v3/eafrinet/weeds/key/weeds/Media/Html/index.htm>
- Biswas SR, Choudhury JK, Ainun Nishat, Rahman MM, 2007. Do invasive plants threaten the Sundarbans mangrove forest of Bangladesh? *Forest Ecology and Management*, 245(1/3):1-9. <http://www.sciencedirect.com/science/journal/03781127>
- Boland JM, 2006. The importance of layering in the rapid spread of *Arundo donax* (giant reed). *Madrano*, 53(4):303-312.
- Environmental Risk Management Plan, for Piloting the Cultivation of *Arundo donax* in Northern Belize, Caribbean Community Climate Change Centre, February 2016).
- Caribbean Disaster Mitigation Project (CDMP). CDMP, *Atlas of Probable Storm Effects in the Caribbean Sea*, <http://www.oas.org/cdmp/document/reglstrm/index.htm>.

- Celesti-Grapow L, Alessandrini A, Arrigoni PV, Banfi E, Bernardo L, Bovio M, Brundu G, Cagiotti MR, Camarda I, Carli E, Conti F, Fascetti S, Galasso G, Gubellini L, Valva Vla, Lucchese F, Marchiori S, Mazzola P, Peccenini S, Poldini L, Pretto F, Prosser F, Siniscalco C, Villani MC, Viegi L, Wilhalm T(et al), 2009. Inventory of the non-native flora of Italy. *Plant Biosystems*, 143(2):386-430.
- Chandhuri RK, Ghosal S, 1970. Triterpines and sterols from the leaves of *Arundo donax*. *Phytochemistry*, 9:1895-1896.
- Chong KY, Tan HTW, Corlett RT, 2009. A checklist of the total vascular plant flora of Singapore: native, naturalised and cultivated species. Singapore: Raffles Museum of Biodiversity Research, National University of Singapore, 273 pp. http://lkenhm.nus.edu.sg/nus/pdf/PUBLICATION/LKCNH%20Museum%20Books/LKC NHM%20Books/flora_of_singapore_tc.pdf
- Christou M, Mardikis M, Alexopoulou E, 2001. Research on the effect of irrigation and nitrogen upon growth and yields of *Arundo donax* L. in Greece. *Biomass and Energy Crops II*. AAB: Warwick.
- Clayton WD, Govaerts R, Harman KT, Williamson H, Vorontsova M, 2014. World Checklist of Poaceae. Richmond, UK: Royal Botanic Gardens, Kew. <http://apps.kew.org/wcsp/>
- Daar S, 1983. Using goats for brush control. *The IPM Practitioner*, 5(4):4-6.
- DAISIE, 2014. Delivering Alien Invasive Species Inventories for Europe. European Invasive Alien Species Gateway. www.europe-aliens.org/default.do
- Dudley T, 2000. *Arundo donax*. In: Bossard CC, Randall JM, Hoshovsky MC, ed. *Invasive Plants of California's Wildlands*. Berkeley, USA: University of California Press, 53-58.
- Dufay C, 1979. *Phothedesdulcis*, new record for the French fauna (Lepidoptera: Noctuidae). *Alexanor*, 11(2):82-84.
- Duke JA, 1975. Ethnobotanical observations on the Cuna Indians. *Economic Botany*, 29:278-293.
- Duke JA, 1983. *Arundo donax*. *Handbook of Energy Crops*. http://newcrop.hort.purdue.edu/newcrop/duke_engery/Arundo_donax.html.
- Duke JA, Wain KK, 1981. *Medicinal Plants of the World*. Computer Index. www.newcrop.hort.purdue.edu.
- Morris, then Director of Public Gardens and Plantations, Jamaica, recorded *Arundo* in current

- E. Belize's Sittie River area in his book, *The Colony of British Honduras, Its Resources and Prospects; with Particular Reference to Its Indigenous Plants and Economic Production* (Harrison and Sons, London, 1883), 30
- Emil Cherrington, *The Water Center for the Humid Tropics of Latin America and the Caribbean* (CATHALAC in Spanish - Centro del Agua del Trópico Húmedo para America Latina y el Caribe)
- Edgar E, Connor HE, 2000. *Flora of New Zealand. Volume V: Grasses*. Lincoln, New Zealand: Manaaki Whenua Press, 650 pp.
- Evaluating Bioenergy Projects that Utilize Invasive Plant Feedstocks; Cabi Publishing-C a B Int: Wallingford, UK, 2015; Volume 5, pp. 134–153.
- El-Enany MAM, 1985. Life history studies of *Aponychussolimani* Zaher with first description of adult male and immature stages (Acari: Tetranychidae). *Zool. Soc. Egypt Bull.*, 35:86-91.
- Else JA, 1996. Post-flood establishment of native woody species and an exotic, *Arundo donax*, in a southern California riparian system. MSc Thesis, San Diego State University, USA.
- Filgueiras TS, 2014. *Arundo* in Lista de Espécies da Flora do Brasil (*Arundo* in the list of species of the flora of Brazil). Rio de Janeiro, Brazil: JardimBotânico do Rio de Janeiro.
- Flora of China Editorial Committee, 2014. *Flora of China*. St. Louis, Missouri and Cambridge, Massachusetts, USA: Missouri Botanical Garden and Harvard University Herbaria. http://www.efloras.org/flora_page.aspx?flora_id=2
- Florence J, Chevillotte H, Ollier C, Meyer J-Y, 2013. Base de donnéesbotaniquesNadeaud de l'Herbier de la PolynésieFrançaise (PAP) (Botanical database of the Nadeaud Herbarium of French Polynesia). <http://www.herbier-tahiti.pf>
- Fosberg FR, Sachet M-H, Oliver R, 1987. A geographical checklist of the Micronesian monocotyledonae. *Micronesia* 20: 1-2, 19-129.
- Foxcroft LC, Richardson DM, Wilson JR, 2007. Ornamental plants as invasive aliens: problems and solutions in Kruger National Park, South Africa. *Environmental Management*, 41(1):32-51.
- Fratteggiani-Bianchi R, 1963. Possibilities of using the leaves of the common cane (*Arundo donax*) in animal feeding. *Riv. Zootec.*, Milano, 36(6):343-353.
- Ghosal S, Chandhuri RK, Cutta K. Bhattachaupa SK, 1972. Occurrence of curarimimetic indoles in the flowers of *Arundo donax*. *Planta Medica* 21:22-28.

- Graveson R, 2012. The Plants of Saint Lucia (in the Lesser Antilles of the Caribbean). The Plants of Saint Lucia (in the Lesser Antilles of the Caribbean). <http://www.saintlucianplants.com>
- Grisebach AHR, 1864. Flora of the British West Indian Islands. London, UK: Lovell Reeve & Co., 806 pp.
- Guézou A, Trueman M, Buddenhagen E, Chamorro S, Guerrero AM, Pozo P, Atkinson R, 2010. An extensive Alien Plant Inventory from the Inhabited Areas of Galapagos. Plos One, 5(4): e10276.
- Hallegatte, Stephane., Vogt-Schilb., Adrien, Bangalore, Mook., and Rozenberg, Julie. *Unbreakable: Building the Resilience of the Poor in the Face of Natural Disasters* (2017).© 2017 International Bank for Reconstruction and Development / The World Bank.
- Hallegatte, Stephane., Bangalore, Mook., Bonzanigo, Laura., Fay, Marianne., Kane, Tamaro., Narloch, Ulf., Rozenberg, Julie., Treguer, David., and Vogt-Schilb, Adrien. *Shock Waves: Managing the Impacts of Climate Change on Poverty* (2016). © 2017 International Bank for Reconstruction and Development / The World Bank.
- Hafliger E, Scholz H, 1981. Grass weeds 2. Grass weeds 2. Ciba-Geigy Ltd. Basle Switzerland, xx + 137 + 23 pp.
- Herrera K, Lorence DH, Flynn T, Balick MJ, 2010. Checklist of the vascular plants of Pohnpei with local names and uses. Allertonia:146 pp.
- Hickman JC, 1993. The Jepson manual: higher plants of California. Berkeley, CA, USA: University of California Press, 1400 pp.
- Hoddle MS, Goolsby J, 2010. Giant Reed, *Arundo donax* (Poaceae)., USA: Center for Invasive Species Research, University of California Riverside. https://cissr.ucr.edu/giant_reed_arundo.html
- Hoshovsky M, 1987. *Arundo donax*. Element stewardship abstract. San Francisco, USA: The Nature Conservancy.
- Hussey BMJ, Keighery GJ, Cousens RD, Dodd J, Lloyd SG, 1997. Western Weeds: A Guide to the Weeds of Western Australia. Perth, Australia: The Plant Protection Society of Western Australia Inc.
- I3N-Argentina, 2014. Invasivealienspeciesdatabase, I3N Argentina. Bahía Blanca, Argentina: I3N Argentina - Universidad Nacional del Sur. www.inbiar.org.ar
- I3N-Brasil, 2014. Base de dados nacional de espécies exóticas invasora

- (National database of exotic invasive species). Florianópolis - SC, Brazil: I3N Brasil, Instituto Hórus de Desenvolvimento e Conservação Ambiental. <http://i3n.institutohorus.org.br>
- I3N-Chile, 2014. Red de Información sobre especies invasoras ([English title not available]). Santiago, Chile: Universidad de Santiago de Chile, Facultad de Química y Biología. <http://i3n.usach.cl/index.asp>
- I3N-Colombia, 2014. Invasive species—alien plants. Especies Focales - Instituto Humboldt. <http://www.humboldt.org.co>
- ISSG, 2003. Global Invasive Species Database. Invasive Species Specialist Group, IUCN. Auckland, New Zealand: University of Auckland. www.issg.org.
- ISSG, 2007. Global Invasive Species Database (GISD). Invasive Species Specialist Group of the IUCN Species Survival Commission. <http://www.issg.org/database>
- Iverson ME, 1994. The impact of *Arundo donax* on water resources. In: Jackson NE, Frandsen P, Douthit S, eds. Proceedings of the *Arundo donax* Workshop, Ontario, Canada, 19-25.
- Jackson GC, Frandsen P, Douthit S, 1994. In: *Arundo Donax* Workshop Proceedings, University of California.
- Jackson GC, Nunez JR, 1964. Identification of silica present in the giant reed (*Arundo donax* L.). J. Agric. Univ. (Puerto Rico), 48:60-62.
- Jørgensen PM, León-Yáñez S, 1999. Catalogue of the vascular plants of Ecuador. Monogr. Syst. Bot. Missouri Bot. Gard, 75. i-viii, 1-1182.
- Kairo M, Ali B, Cheesman O, Haysom K, Murphy S, 2003. Invasive species threats in the Caribbean region. Report to the Nature Conservancy. Curepe, Trinidad and Tobago: CAB International, 132 pp. http://www.issg.org/database/species/reference_files/Kairo%20et%20al,%202003.pdf
- Khuroo AA, Irfan Rashid, Zafar Reshi, Dar GH, Wafai BA, 2007. The alien flora of Kashmir Himalaya. Biological Invasions, 9(3):269-292. <http://www.springerlink.com/content/p47k291348887h31/?p=3f7396e4601240f4a981389077081fd3&pi=3>
- Kirk AA, Widmer T, Campobasso G, Carruthers R, Dudley T, 2003. California Invasive Plant Council's Symposium. The potential contribution of natural enemies from Mediterranean Europe to the management of the invasive weed *Arundo donax* (Graminae; Arundinae) in the US. USDA-ARS, European Biological Control Laboratory. USDA-ARS, Western Regional Research Center, Exotic and Invasive Weed Research Unit.

- Krauss U, 2012. 161 Invasive Alien Species present in Saint Lucia and their current status. Caribbean Alien Invasive Species Network (CIASNET), 12 pp. <http://www.ciasnet.org/wp-content/uploads/2010/08/IAS-present-in-SLU-May-2012-revision.pdf>
- Low T, Booth C, 2007. The Weedy Truth about Biofuels. Melbourne, Australia: Invasive Species Council, 46 pp. http://www.invasives.org.au/downloads/isc_weedybiofuels_oct07.pdf
- Meyer JY, 2000. Preliminary review of the invasive plants in the Pacific Islands (SPREP member countries). In: Invasive species in the Pacific: A technical review and draft regional strategy [ed. by Sherley G]. Samoa: South Pacific Regional Environment Programme, 190 pp.
- Meyer JY, 2000. Preliminary review of the invasive plants in the Pacific islands (SPREP Member Countries). In: Sherley G, tech. ed. Invasive species in the Pacific: a technical review and draft regional strategy. South Pacific Regional Environment Programme, Samoa.
- Meyer JY, 2007. Rapport de mission sur l'Ile d'Uvea (Wallis & Futuna) du 6 au 17 Novembre 2007: Inventaire préliminaire de la flore vasculaire secondaire ([English title not available]). Papeete, Tahiti: Ministère de l'Education, l'Enseignement Supérieur et la Recherche, 39 pp. http://www.li-an.fr/jyves/Meyer_2007_Rapport_Plantes_Introduites_Wallis.pdf
- Meyer JY, 2008. Report of the expert mission to Rapa Nui, 2-11 June 2008. Strategic action plan to control invasive alien plants on Rapa Nui (Easter Island) (Rapport de mission d'expertise à Rapa Nui du 02 au 11 Juin 2008: Plan d'action stratégique pour lutter contre les plantes introduites envahissantes sur Rapa Nui (Île de pâques)). Papeete, Tahiti: Délégation à la Recherche, Ministère de l'Education, l'Enseignement Supérieur et la Recherche, 62 pp. http://www.li-an.fr/jyves/Meyer_2008_Rapport_Expertise_Rapa_Nui.pdf
- Miles DH, Tunasuwan K, Chittawong V, Kokpol U, Choudhary MI, Clardy J, 1993. Boll weevil antifeedants from *Arundo donax*. *Phytochemistry*, 34(5):1277-1279; 9 ref.
- Missouri Botanical Garden, 2003. VAScular Tropicos database. St. Louis, USA: Missouri Botanical Garden. <http://mobot.mobot.org/W3T/Search/vast.html>.
- Missouri Botanical Garden, 2007. Tropicos database. St Louis, USA: Missouri Botanical Garden. <http://www.tropicos.org/>
- Munz PA, 1959. A California flora. Berkeley, USA: University of California Press.
- Nackley, L.L.; Quinn, L.D.; Matlaga, D.P.; Barney, J.N. Good Intentions vs Good Ideas:
- Orchard AE, 1994. Flora of Australia. Vol. 49, Oceanic islands 1. Canberra, Australia:

Australian Government Publishing Service.

- Oviedo Prieto R, Herrera Oliver P, Caluff MG, et al., 2012. National list of invasive and potentially invasive plants in the Republic of Cuba - 2011. (Lista nacional de especies de plantas invasoras y potencialmente invasoras en la República de Cuba - 2011). Bissea: Boletín sobre Conservación de Plantas del Jardín Botánico Nacional de Cuba, 6(Special Issue 1):22-96.
- Perdue RE, 1958. Arundo donax – source of musical reeds and industrial cellulose. Economic Botany 12:368-404.
- PIER, 2007. Pacific Islands Ecosystems at Risk. USA: Institute of Pacific Islands Forestry. <http://www.hear.org/pier/index.html>
- PROTA, 2014. PROTA4U web data base. Grubben GJH, Denton OA, eds. Wageningen, Netherlands: Plant Resources of Tropical Africa. <http://www.prota4u.org/search.asp>
- Queensland Department of Primary Industries and Fisheries, 2011. Special edition of Environmental Weeds of Australia for Biosecurity Queensland., Australia: The University of Queensland and Department of Primary Industries and Fisheries. <http://keyserver.lucidcentral.org/weeds/data/03030800-0b07-490a-8d04-0605030c0f01/media/Html/Index.htm>
- Raghu S, Anderson RC, Daehler CC, Davis AS, Wiedenmann RN, Simberloff D, Mack RN, 2006. Adding biofuels to the invasive species fire? Science (Washington), 313(5794):1742. <http://www.sciencemag.org>
- Randall RP, 2012. A Global Compendium of Weeds. Perth, Australia: Department of Agriculture and Food Western Australia, 1124 pp. <http://www.cabi.org/isc/FullTextPDF/2013/20133109119.pdf>
- Rossa B, Tueffers AV, 1998. Arundo donax L. (Poaceae): A C3 species with unusually high photosynthetic capacity. Botanica Acta, 111(3):216-221.
- Royal Botanic Garden Edinburgh, 2004. Flora Europaea Database. Royal Botanic Garden Edinburgh, UK. <http://rbg-web2.rbge.org.uk/FE/fe.html>.
- Royal Botanic Garden Edinburgh, 2007. Flora Europaea, Database of European Plants (ESFEDS). Edinburgh, UK: Royal Botanic Garden Edinburgh. <http://rbg-web2.rbge.org.uk/FE/fe.html>
- Royal Botanic Gardens Sydney, 2003. Australia's Virtual Herbarium. Sydney, Australia: Royal Botanic Gardens. <http://plantnet.rbgsyd.gov.au/cgi-bin/avh/avh.cgi>.
- Sanz-Elorza M, Dana E, Sobrino E, 2001. Checklist of invasive alien plants in Spain (Iberian

- Peninsula and Balearic Islands). *Lazaroa*, 22:121-131; many ref.
- Scott GD, 1994. Fire threat from *Arundo donax*. In: Jackson NE, Frandsen P, Douthit S, eds. *Arundo Donax Workshop Proceedings*, November 1993. Berkeley, USA: University of California Press, Berkeley, 17-18.
- Shukla U, 1996. *The Grasses of North-Eastern India*. Jodhpur, India: Scientific Publishers, 325 pp.
- Smith AC, 1979. *Flora vitiensis nova. A new flora of Fiji*. Hawaii, Pacific Tropical Botanical Garden, 1:495.
- Smithsonian National Museum of Natural History, 2003. *Arundodonax*.
<http://ripley.si.edu:8765/search/query.html?qt=Arundo+donax>.
- Space JC, Flynn T, 2001. Report to the Kingdom of Tonga on invasive plant species of environmental concern. Hawaii, USA: USDA Forest Service, Institute of Pacific Islands Forestry, 79 pp.
- Space JC, Flynn T, 2002. Report to the Government of Samoa on invasive plant species of environmental concern. Honolulu, Hawaii, USA: USDA Forest Service.
- Space JC, Flynn T, 2002. Report to the Government of the Cook Islands on invasive plant species of environmental concern. Honolulu, USA: USDA Forest Service, 146 pp.
- Space JC, Waterhouse BM, Miles JE, Tiobech J, Rengulbai K, 2003. Report to the Republic of Palau on invasive plant species of environmental concern. Honolulu, USA: USDA Forest Service.
- Stone BC, 1970. *The Flora of Guam*. *Micronesica*, 6:1-659.
- Swarbrick JT, 1997. Environmental weeds and exotic plants on Christmas Island, Indian Ocean. Report to Parks Australia. J.T. Swarbrick, Weed Science Consultancy, 131 pp.
- Szabo P, Varhegyi G, 1996. Thermogravimetric/mass spectrometric characterization of two energy crops, *Arundo donax* and *Miscanthus sinensis*. *Journal of Analytical and Applied Pyrolysis*, 36(2):179-190.
- Team *Arundo del Norte*, 2002. *TeamArundo del Norte*. <http://teamarundo.org>.
- Thaman RR, Fosberg FR, Manner HI, Hassall DC, 1994. The flora of Nauru. *Atoll Research Bulletin*, 392:1-223.
- Thomas S, 2010. Horizon-scanning for invasive non-native plants in Great Britain. [Natural England Commissioned Reports, Number 053.]
- Tucker RWE, 1940. An account of *Dicraea saccharalis* with special reference to its occurrence

- in Barbados. *Trop. Agric., Trinidad*, 17:133-138.
- The World Bank Group. *Investing in Urban Resilience Promoting and Protecting Development in a Changing World*. 2015. www.worldbank.org.
- US Fish and Wildlife Service, 2011. In: Santa Ana sucker (*Catostomus santaanae*). 5-Year Review: Summary and Evaluation. US Fish and Wildlife Service, 74 pp.. http://ecos.fws.gov/docs/five_year_review/doc3616.pdf
- USDA, NRCS, 2007. The PLANTS Database. Baton Rouge, USA: National Plant Data Center. <http://plants.usda.gov/>
- USDA-ARS, 2003. Germplasm Resources Information Network (GRIN). Online Database. Beltsville, Maryland, USA: National Germplasm Resources Laboratory. <https://npgsweb.ars-grin.gov/gringlobal/taxon/taxonomysearch.aspx>
- USDA-ARS, 2007. Germplasm Resources Information Network (GRIN). Online Database. Beltsville, Maryland, USA: National Germplasm Resources Laboratory. <https://npgsweb.ars-grin.gov/gringlobal/taxon/taxonomysearch.aspx>
- USDA-ARS, 2014. Germplasm Resources Information Network (GRIN). Online Database. Beltsville, Maryland, USA: National Germplasm Resources Laboratory. <https://npgsweb.ars-grin.gov/gringlobal/taxon/taxonomysearch.aspx>
- USDA-NRCS, 2002. The PLANTS Database, Version 3.5. National Plant Data Center, Baton Rouge, USA. <http://plants.usda.gov>.
- USDA-NRCS, 2014. The PLANTS Database. Baton Rouge, USA: National Plant Data Center. <http://plants.usda.gov/>
- Verloove F, 2006. Catalogue of neophytes in Belgium (1800-2005). *ScriptaBotanicaBelgica*, 39: 89 pp. http://alienplantsbelgium.be/sites/alienplantsbelgium.be/files/tabel_2.pdf
- Villaseñor JL, Espinosa-Garcia FJ, 2004. The alien flowering plants of Mexico. *Diversity and Distributions*, 10(2):113-123.
- Wagner WI, Herbst DR, Sohmer SH, 1999. Manual of the Flowering Plants of Hawaii, revised edition. Honolulu, Hawaii, USA: University of Hawaii Press.
- Wagner WL, Herbst DR, Sohmer SH, 1999. Manual of the flowering plants of Hawaii. Revised edition. Honolulu, Hawaii, USA: University of Hawaii Press/Bishop Museum Press, 1919 pp.
- Wittenberg R, 2005. An inventory of alien species and their threat to biodiversity and economy

in Switzerland. CABI Bioscience Switzerland Centre report to the Swiss Agency for Environment, Forests and Landscape. The environment in practice 0629. Bern, : Federal Office for the Environment, 155.

Wynd FL, Steinbauer GP, Diaz NR, 1948. *Arundo donax* as a forage grass in sandy soils. *Lloydia*, 11(3):181-184.

Yuncker TG, 1959. Plants of Tonga. B.P. Bishop Museum Bull., 220:165.

Zemba R, Hoffman S, 2000. Environmental Assessment of the Santa Ana Watershed Program. Fountain Valley, California.

Zohary M, 1962. Plant Life of Palestine. New York, USA: The Ronald Press Co.

Zuñiga GE, Argandoña VH, Niemeyer HM, Corcuera LJ, 1983. Hydroxamic acid content in wild and cultivated Graminae. *Phytochemistry*, 22:2665-2668.

<https://earthquake.usgs.gov/data/shakemap/>

<https://www.worldbank.org/en/topic/disasterriskmanagement/overview#2>