



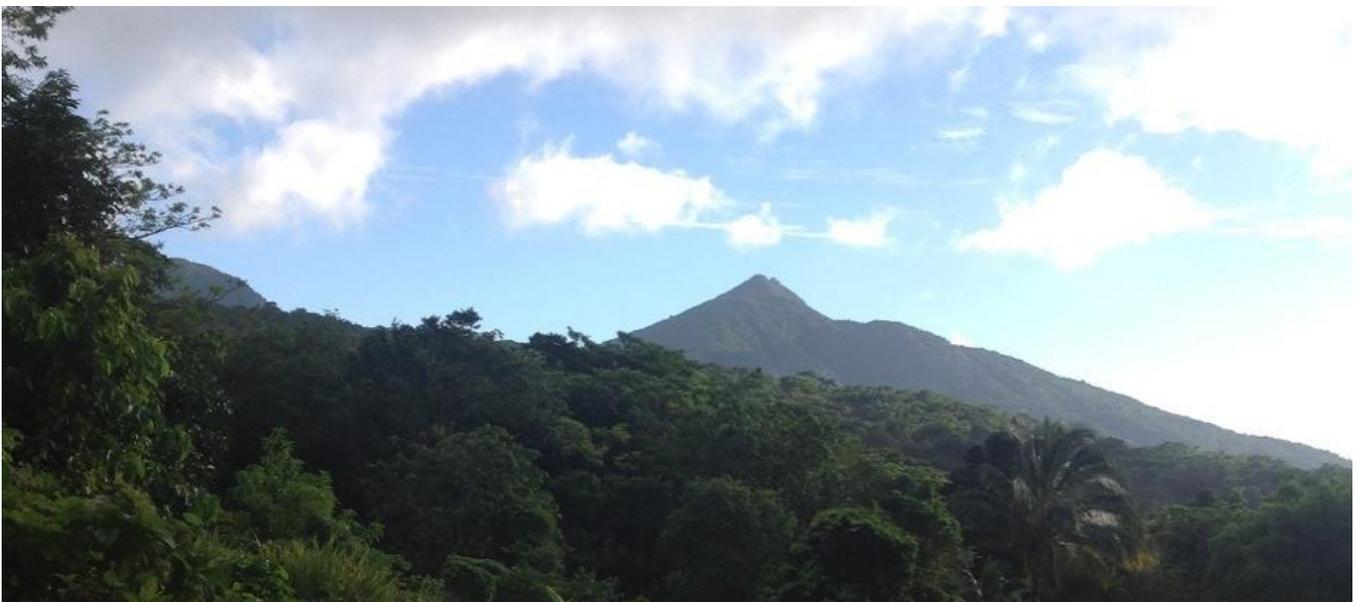
Dominica Geothermal Development – Environmental and Social Impact Assessment

NZ Ministry of Foreign Affairs & Trade

ESIA Volume 5: Technical Appendices

RZ020300-0002-NP-RPT-0008 | V2

July 2018



Dominica Geothermal Development – Environmental and Social Impact Assessment

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Revision	Date	Description	By	Review	Approved
A	April 2017	Draft Issue to MFAT for Review	A Kubale	Pete Gabriel	Bruce Clarke
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Introduction

ESIA Volume 5 provides Technical Appendices relevant to this ESIA and as referenced within ESIA Volume 1: Introduction, ESIA Volume 2: EIA, ESIA Volume 3: SIA and ESIA Volume 4: ESMP, Framework ESMS and Assessment Against WBG Standards. Table 1.1 below provides an overview of the Technical Appendices provided in this Volume and indicates which Volume (one to four) they predominantly are associated with. It should be noted that Appendices may be associated with other Volumes and this will be noted within the respective Volume text.

Table 1.1 : ESIA Technical Appendices

ESIA Volume	Technical Appendix	Document Title
ESIA Volume 1: Introduction	Appendix A	WB Performance Standards
	Appendix B	Technical Report – Detailed Process Description
	Appendix C	ESIA Terms of Reference
	Appendix D	Biodiversity Survey Terms of Reference
ESIA Volume 2: EIA	Appendix E	Technical Report – Air Quality Impact Assessment
	Appendix F	Technical Report – Noise Impact Assessment
	Appendix G	Technical Report – Morne Trois Pitons National Park Impact Assessment
	Appendix H	Technical Report – Terrestrial Ecology Impact Assessment
	Appendix I	Occupational Health and Safety & Working Conditions
ESIA Volume 3: SIA	Appendix J	Stakeholder Engagement – Meeting Minutes
	Appendix K	Stakeholder Engagement Plan including Community Grievance Mechanism
N/A – Applies to all ESIA Volumes	Appendix L	*Caraïbes Environnement Développement & Coll 2015 – Final Summary Report

*Due to file size only the Final Summary Report has been provided. If required the full report can be disclosed separately.

Appendix A. WB Performance Standards

Performance Standard	Objectives
1 Assessment and Management of Environmental and Social Risks and Impacts	<ul style="list-style-type: none"> To identify and evaluate environmental and social risks and impacts of the project. To adopt a mitigation hierarchy to anticipate and avoid, or where avoidance is not possible, minimize, and where residual impacts remain, compensate/ offset for risks and impacts to workers, Affected Communities, and the environment. To promote improved environmental and social performance of clients through the effective use of management systems. To ensure that grievances from Affected Communities and external communications from other stakeholders are responded to and managed appropriately. To promote and provide means for adequate engagement with Affected Communities throughout the project cycle on issues that could potentially affect them and to ensure that relevant environmental and social information is disclosed and disseminated.
2 Labour and Working Conditions	<ul style="list-style-type: none"> To promote the fair treatment, non-discrimination, and equal opportunity of workers. To establish, maintain, and improve the worker-management relationship. To promote compliance with national employment and labour laws. 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. To promote safe and healthy working conditions, and the health of workers. To avoid the use of forced labour.
3 Resource Efficiency and Pollution Abatement	<ul style="list-style-type: none"> To avoid or minimize adverse impacts on human health and the environment by avoiding or minimizing pollution from project activities. To promote more sustainable use of resources, including energy and water. To reduce project-related GHG emissions.
4 Community Health, Safety and Security	<ul style="list-style-type: none"> To anticipate and avoid adverse impacts on the health and safety of the Affected Community during the project life from both routine and non-routine circumstances. 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 Affected Communities.
5 Land Acquisition and Involuntary Resettlement	<ul style="list-style-type: none"> To avoid, and when avoidance is not possible, minimize displacement by exploring alternative project designs. To avoid forced eviction. 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 cost⁴ and (ii) ensuring that resettlement activities are implemented with appropriate disclosure of information, consultation, and the informed participation of those affected. To improve, or restore, the livelihoods and standards of living of displaced persons. To improve living conditions among physically displaced persons through the provision of adequate housing with security of tenure at resettlement sites
6 Biodiversity Conservation and Sustainable Management of Living Natural Resources	<ul style="list-style-type: none"> To protect and conserve biodiversity. To maintain the benefits from ecosystem services. To promote the sustainable management of living natural resources through the adoption of practices that integrates conservation needs and development priorities

Performance Standard	Objectives
7 Indigenous Peoples	<ul style="list-style-type: none"> • To ensure that the development process fosters full respect for the human rights, dignity, aspirations, culture, and natural resource-based livelihoods of Indigenous Peoples. • To anticipate and avoid adverse impacts of projects on communities of Indigenous Peoples, or when avoidance is not possible, to minimize and/or compensate for such impacts. • To promote sustainable development benefits and opportunities for Indigenous Peoples in a culturally appropriate manner. • To establish and maintain an ongoing relationship based on Informed Consultation and Participation (ICP) with the Indigenous Peoples affected by a project throughout the project's life-cycle. • To ensure the Free, Prior, and Informed Consent (FPIC) of the Affected Communities of Indigenous Peoples when the circumstances described in this Performance Standard are present. • To respect and preserve the culture, knowledge, and practices of Indigenous Peoples.
8 Cultural Heritage	<ul style="list-style-type: none"> • To protect cultural heritage from the adverse impacts of project activities and support its preservation. • To promote the equitable sharing of benefits from the use of cultural heritage.

Appendix B. Technical Report – Detailed Process Description



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Dominica Geothermal Power Project – Environmental and Social Impact Assessment

NZ Ministry of Foreign Affairs & Trade

Process Description

RZ020300-0009-KH-RPT-0001 | V2

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Dominica Geothermal Development – Environmental and Social Impact Assessment

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C	09/03/2018	Updated Revised Final	Sam Pearce		Alastair Brookes
V1	08/06/2018	FINAL ISSUE	Sam Pearce	Alastair Brookes	Alastair Brookes
V2	27/07/2018	Revised Final Issue for Disclosure	B Clarke	Alastair Brookes	Alastair Brookes

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Important note about your report

The sole purpose of this report and the associated services performed by Jacobs New Zealand Limited (“Jacobs”) is to describe the Environmental and Social Impact Assessment (ESIA) for the Dominica Geothermal Power Project in accordance with the scope of services set out in the contract between Jacobs and the New Zealand Ministry of Foreign Affairs and Trade (the Client). That scope of services, as described in this report, was developed with the Client, the Government of the Commonwealth of Dominica (GoCD) and the Developer (Dominica Geothermal Development Company (DGDC) established and owned by the GoCD).

Jacobs has been contracted by the Client to undertake the conceptual design and overall project definition through their engineering team. In preparing this ESIA report, Jacobs has relied upon, and presumed accurate, any information (or confirmation of the absence thereof) provided. Except as otherwise stated in the ESIA report, Jacobs has not attempted to verify the accuracy or completeness of any such information. If the information is subsequently determined to be false, inaccurate or incomplete then it is possible that our observations and conclusions as expressed in this report may change.

Jacobs derived the data in this report from information sourced as noted in the ESIA volumes and/or available in the public domain at the time or times outlined in this report. The passage of time, manifestation of latent conditions or impacts of future events may require further examination of the project and subsequent data analysis, and re-evaluation of the data, findings, observations and conclusions expressed in this report. Jacobs has prepared this report in accordance with the usual care and thoroughness of the consulting profession, for the sole purpose described above and by reference to applicable standards, guidelines, procedures and practices at the date of issue of this report. For the reasons outlined above, however, no other warranty or guarantee, whether expressed or implied, is made as to the data, observations and findings expressed in this report, to the extent permitted by law.

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Glossary

Term	Description
Baseload power plant	Electricity-generating units that are operated to meet the minimum load on the electricity supply system.
Binary-cycle plant	A geothermal electricity generating plant employing a closed-loop heat exchange system in which the heat of the geothermal fluid (the "primary fluid") is transferred to a lower-boiling-point fluid (the "secondary" or "working" fluid), which is thereby vaporised and used to drive a turbine/generator set.
Brine	A geothermal solution containing appreciable amounts of sodium chloride and/or other salts.
Commercial Operation Date (COD)	The date after which all testing and commissioning has been completed and the developer can start producing electricity for sale.
Condensate	Liquid water formed by condensation of steam.
Condenser	Equipment that condenses turbine exhaust steam into condensate.
Cooling tower	A structure in which heat is removed from hot condensate through heat exchange with air.
Drilling	Boring into the Earth to access geothermal resources, usually with oil and gas drilling equipment that has been modified to meet geothermal requirements.
Dry steam	Superheated steam without a water phase.
Efficiency	The ratio of the useful energy output of a machine or other energy-converting plant to the energy input. Technology with a higher efficiency will require less energy to do the same amount of work.
Emission	The release or discharge of a substance into the environment; generally refers to the release of gases or particulates into the air.
Enthalpy	A measurement of energy in a thermodynamic system. It is the thermodynamic quantity equivalent to the total heat content of a system. It is equal to the internal energy of the system plus the product of pressure and volume.
Fault	A fracture or fracture zone in the Earth's crust along which slippage of adjacent rocks has occurred.
Flash plant	Pressure vessels designed to effectively separate flash steam from the liquid phase.
Flash steam / Flashing	Steam produced when the pressure on a geothermal liquid is reduced. Also called flashing.
Geothermal energy	The Earth's interior heat made available by extraction of geothermal fluids.
Geothermal power plant	A facility which uses geothermal steam or heat to drive turbine-generators to produce electricity. Three different types make use of the various temperature ranges of geothermal resources: dry steam, flash and binary.
Geothermal reserves	Energy from a geothermal resource that is commercially recoverable now
Geothermal reservoir	A large volume of underground hot water and steam in porous and fractured hot rock. The hot water in geothermal reservoirs occupies only 2 to 5% of the volume of rock, but if the reservoir is large enough and hot enough, it can be a powerful source of energy. Geothermal reservoirs are sometimes overlain by a layer of impermeable rock. While geothermal reservoirs usually have surface manifestations such as hot springs or fumaroles, some do not.
Geothermal resources	A resource of geothermal nature which requires further work to be classified as a geothermal reserve.
Geothermal well	Geothermal production and injection wells are constructed of pipes layered inside one another and cemented into the earth and to each other. This protects any shallow drinking water aquifers from mixing with deeper geothermal water.

Term	Description
Injection	The process of returning spent geothermal fluids to the subsurface; also referred to as reinjection.
Injection well	A well through which geothermal water is returned to an underground reservoir after use.
Kilowatt (kW)	One thousand watts of electricity (power).
Kilowatt hour (kWh)	One thousand watthours (energy).
Megawatt (MW)	A unit of power, equal to a thousand kilowatts (kW) or one million watts(W). The watt is a unit of power (energy/time), the rate energy is consumed or converted to electricity. Assessment of the energy in geothermal systems is commonly in terms of equivalent electrical power or MWe, which takes into account the efficiency of conversion.
Megawatts under wellhead	A technical measure of the supply of geothermal fluids available at the well head valve, presented in megawatts of electrical energy as proven through testing.
Morne Trois Pitons National Park (MTPNP) World Heritage Site	A World Heritage Site is a natural or man-made site or structure recognised as being of outstanding international importance by the United Nations Educational, Scientific and Cultural Organisation (UNESCO) and therefore designated as a site deserving of protection under international treaties.
Operations and maintenance (O&M) cost	Operating expenses are associated with operating a facility (e.g. engineering costs). Maintenance expenses are that portion of expenses consisting of labour, materials, and other direct and indirect expenses incurred for preserving the operating efficiency or physical condition of utility plants that are used for power production, transmission, and distribution of energy.
Permeability	The capacity of a substance (such as rock) to transmit a fluid. The degree of permeability depends on the number, size, and shape of the pores and/or fractures in the rock and their interconnections. It is measured by the time it takes a fluid of standard viscosity to move a given distance.
Production well	A well through which geothermal water is extracted from an underground reservoir to use in the generation of electricity.
Proven geothermal reserves	Defined as the electricity that can be generated and sold with reasonable certainty over the project life. Commonly used units are Mega Watt-hour.
Separator	A pressure vessel used to separate water and steam, normally by centrifugal action.
Slim hole	A geothermal exploration well which is drilled at a smaller diameter than a standard production well
Steam	The vapour form of water that develops when water boils.
Subsidence	A sinking of an area of the Earth's crust due to fluid withdrawal and pressure decline.
Surface Exploration	Scientific activities to investigate the geothermal reservoir using non-invasive techniques. Typically surface exploration will include geology, geochemistry, geophysics and aerial surveys.
Transmission line	Structures and conductors that carry bulk supplies of electrical energy from power-generating units.
Turbine	A machine for generating rotary mechanical power from the energy of a stream of fluid (such as water, steam, or hot gas). Turbines convert the kinetic energy of fluids to mechanical energy through the principles of impulse and reaction, or a mixture of the two.
Well logging	Assessing the geologic, engineering, and physical properties and characteristics of geothermal reservoirs with instruments placed in the wellbore.
Wellhead pressure	A measure of the pressure of geothermal fluids being produced by the geothermal reservoir as measured at the valve opening from the wellhead.

1. Introduction

1.1 Document Purpose

The purpose of this document is to describe the process of constructing, operating and decommissioning a 7 MW_e Geothermal Power Plant on the island of Dominica (the Project) in order to inform the environmental and social impact assessment (ESIA) to be undertaken prior to construction of the Project. This is required in accordance with local legislation and international lending institution safeguards.

1.2 Structure

The structure of this document is set out as follows:

- **Project Background** – a brief overview of the project history
- **Reservoir information** – the known conditions of the geothermal reservoir
- **Project Overview** – description of the proposed Dominica geothermal development, covering:
 - Power plant technology – an overview of the Organic Rankine Cycle and Steam Flash power plant technology options for converting the energy in the geothermal steam and/or brine to electrical energy.
 - Geothermal steamfield equipment – the layout and equipment of the preferred steamfield design.
 - Supporting infrastructure – water, roads and other infrastructure necessary to facilitate the Project development.
 - Electrical equipment and interconnection – overview of the indoor switch room and associated equipment, and the proposed interconnection to the DOMLEC grid.
 - Hazardous substances – overview of hazardous substances found on a typical geothermal plant and the method and location of disposal.
- **Construction** – activities required for the engineering design, procurement, and construction of facilities to support the geothermal project. The project will use the wells which have already been drilled and tested. As such this document assumes no drilling of new wells in advance of operation.
- **Operation** – activities required to operate and maintain the facility with the goals of maximising plant availability and providing reliable supply to DOMLEC. Monitoring and management of the geothermal reservoir is a component of this phase, and environmental emissions mostly occur as a result of plant operation.
- **Decommissioning** - activities required to decommission the above ground facilities and remediate the site to an agreed level. This may include plugging and abandoning geothermal wells.
- **Potential Environmental Issues from Activities** – review of issues as a result of construction, operation and decommissioning.

2. Project Background

The Commonwealth of Dominica is a small island developing state in the Caribbean Sea with a population of approximately 72,000 people and a land area of approximately 750 km². About 60% of the land is classified as a World Heritage site by UNESCO, due to its rich biodiversity. It is located near the centre of a string of islands known as the Lesser Antilles, between the neighbouring French territories of Martinique and Guadeloupe. The capital Roseau is located to the south-west of the island and has a population of around 15,000 people.



Figure 2-1 : Map of Dominica and Caribbean islands¹

As with many other island nations, Dominica's primary source of electricity production is from diesel generation, which exposes the country's economy to uncertainty in regard to the cost and supply of diesel imports. Changing the power generation mix and reducing the cost and volatility of electricity prices have become development priorities for Dominica. Being a relatively young volcanic island, Dominica has significant geothermal resource potential. Therefore, since 2006 the Government of the Commonwealth of Dominica (GoCD) has pursued an exploration programme to evaluate the viability of geothermal resource in the Roseau Valley (Figure 2-2).

Geothermal power projects typically connect production wells through a steamfield facility to a power plant which, in turn, is connected to an electricity grid. Geothermal energy extracted from below the ground may take the form of steam, hot water (brine) or a combination of both, and often a quantity of non-condensable gases (mostly carbon dioxide, but also some hydrogen sulphide). Used geothermal fluids produced by the project are returned to the geothermal reservoir via injection wells, which may be located some distance away (i.e. over 1 km) from the production wells.

¹ <http://www.locationcaribbean.com/caribbean-map>

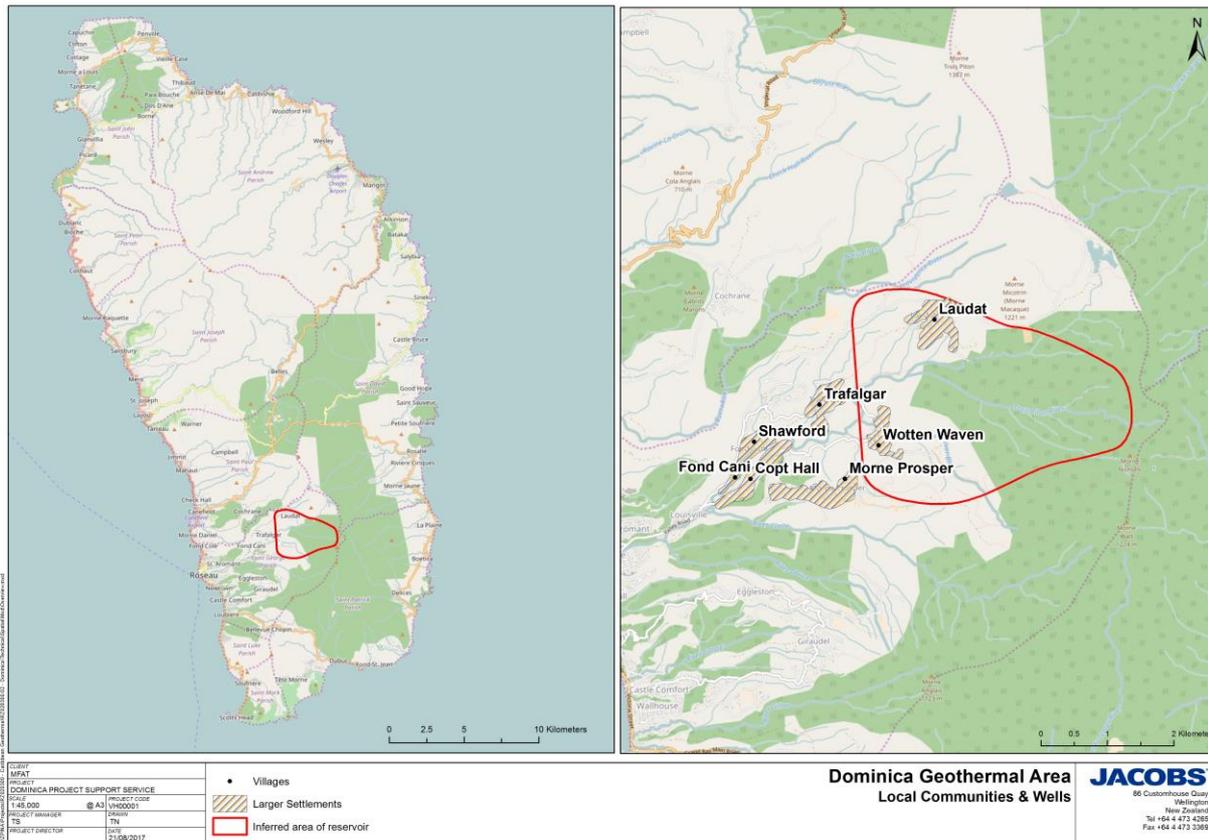


Figure 2-2 : Location of Roseau Valley (Site of proposed Geothermal Power Plant in Laudat)

The Dominica geothermal resource was extensively investigated by the GoCD between 2008 and 2013, with the support of the European Development Fund and the French Development Agency. Three exploratory wells were drilled from December 2011 to June 2012, characterising the reservoir as follows:

- A shallow depth with the top expected to occur at an approximate elevation of 0 m above sea level.
- Medium to high permeability and measured temperatures in the liquid dominated section in the range of 220 – 246°C.
- The lateral extent was conservatively estimated at a minimum surface area of about 9 km² and thickness assumed to be around 1,000m.

The resource estimate undertaken by ELC² in 2013 indicated a 50% probability of a gross plant capacity of 91 MW_e, with a 90% probability of at least 57 MW_e for the inferred area of the reservoir. This gave confidence that the field could be developed to serve the electrical power needs of the island, and potentially electricity could be exported to neighbouring islands via sub-sea cables. Two further wells were drilled in 2013 – 14 and provided evidence of an exploitable geothermal resource at the wellhead.

Having successfully carried out exploration, the Government now wishes to complete the Project through the recently established Dominica Geothermal Development Company Ltd, who will develop a 7 MW_e geothermal power plant and sell electricity to DOMLEC. The project company is 100%-owned by GoCD, being established as a private company under the laws of the Commonwealth of Dominica. Electricity will be sold to DOMLEC, under the regulatory framework established through the Electricity Supply Act 2006. The project will be financed using grant monies from international agencies and bilateral partners, the World Bank and with the Government’s own resources.

² Electroconsult S.p.A. “Wotten Waven Geothermal Field – Commonwealth of Dominica, West Indies – Feasibility Study Small Geothermal Power Plant”, Final Draft, September 2013.

3. Reservoir Information

3.1 Wotten Waven Geothermal System

The Wotten Waven geothermal system is described in the ELC Preliminary Resource Assessment (ELC, 2012) and the Feasibility Study – Small Geothermal Report (ELC, 2013), together with gap analysis and commentary by World Bank experts (World Bank, 2013).

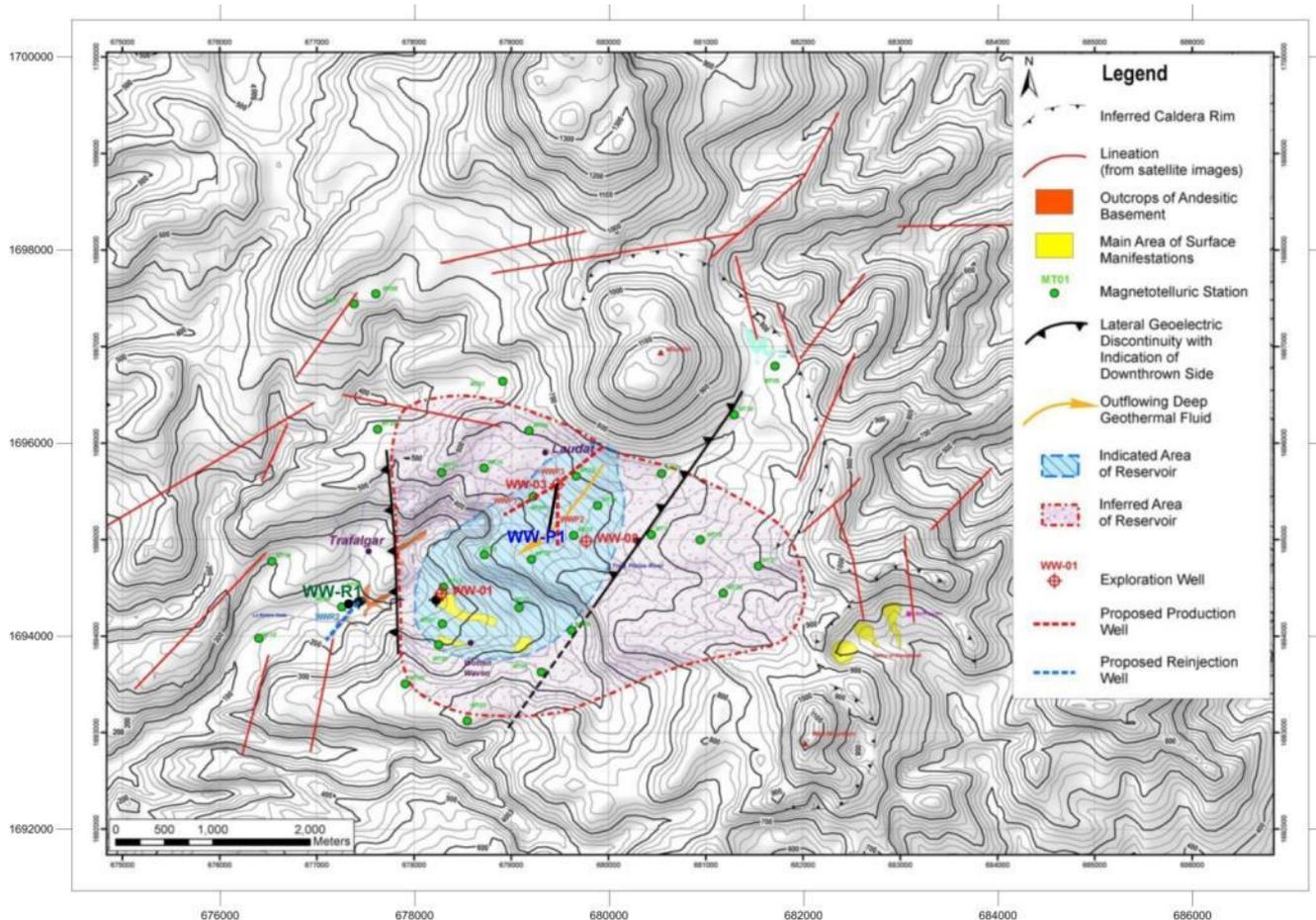


Figure 3-1: Wotten Waven geothermal field, with locations of recent wells WW-P1 and WW-R1 (ELC, 2013)

The conceptual model of the field presented by ELC assumes the main resource upflow is to the north under Mount Micotrin, with a flow to the south-west shown by the orange arrow in Figure 3-1. An alternative possibility is that the main upflow is indicated by fumaroles and thermal activity associated with the Acid Lake and Valley of Desolation. This was suggested by the World Bank and Jacobs considers this location more likely.

The well temperature, pressure and chemistry data and the existing MT data are not sufficient to clarify the location of the upflow. The World Bank has raised a concern that the eastern extension of the field may contain acidic fluids, but Jacobs does not consider this is likely to affect future operation of the existing wells. It should be investigated if a larger development is considered in future.

The reservoir temperatures and pressures measured in the existing in-field wells (excluding WW-R1) are nearly uniform and the deep permeability in these wells is generally good. As a result, the indicated (measured) reservoir area shown in Figure 3-1 corresponding to an area of 3 km² is considered to be sufficiently proven to be used as a basis for a small development using existing wells.

As shown in Table 3-1, ELC estimated that there is a 90% probability that the indicated resource is at least 25 MW_e, and a 50% probability of supporting 41 MW_e. These estimates provide sufficient confidence for a small scale development using existing wells to be sustainable for 30 years, although there is a low risk that recharge by low temperature or acidic fluids could prematurely reduce the output of the wells.

Table 3-1: Inferred Geothermal Resource at Wotten Waven (ELC, 2013)

Wotten Waven Geothermal, Dominica			
Electrical Energy Potential (MW_e) for 30 Years			
	P90	P50 (Median)	P10
Inferred + Indicated Area	57.0	91.5	123.0
Indicated Area	25.5	41.0	60.5
Input Estimates and Assumptions			
	Lower Limit	Most Likely	Upper Limit
Inferred + Indicated Reservoir Area (km²)	9.0	10.0	13.0
Indicated Area Reservoir Area (km²)	3.0	4.0	5.0
Reservoir Temperature (°C)	235	240	255
Reservoir Thickness (m)	800	1,000	1,200

3.2 Geothermal Wells

Five wells have been drilled to date, 3 slimhole exploration / production wells, one standard diameter production well and one standard diameter injection well, with details shown in Table 3-2.

Table 3-2: Well physical parameters

Parameter	WW-01	WW-02	WW-03	WW-P1	WW-R1
Wellhead, Easting (m)	678,302	679,822	n/a	679,461	677,321
Wellhead, Northing (m)	1,694,864	1,695,029	n/a	1,695,567	1,694,334
Wellhead elevation (masl)	235	580	543	552	187
Total depth (mRKB)	1200	1469	1613	1505	1914
Azimuth (°)	-	-	-	190	-
Throw (m)	-	-	-	465	-
Casing size (in)	7	7	7	9-5/8	9-5/8
Casing shoe depth (m)	303	427.5	590.6	726	607
Liner size (in)	4-1/2	4-1/2	4-1/2	7	Open hole
Liner depth (m)	269-1200	281-1337	569-1612	700-1505	1914

3.2.1 Production Well Tests

Flow tests were undertaken on well WW-P1 by Geothermal Resource Group (GRG) for 5.4 days from 10 June 2014. During the tests, total mass flow ranged from 20 kg/s to a maximum of about 80 kg/s (288 ton/hr) at an enthalpy of between 1150 and 1190 kJ/kg and flowing wellhead pressure of 13.5 bara. Maximum flow rates could only be sustained for a few hours, on several occasions, due to limited sump capacity and injection equipment limitations.

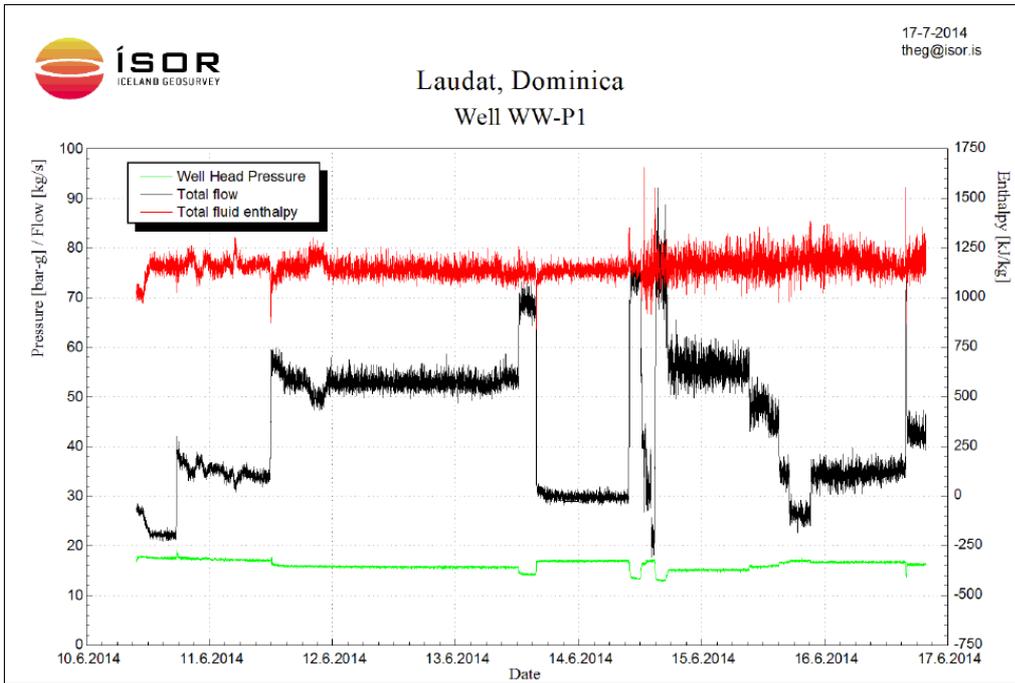


Figure 3-2: Wellhead pressure and calculated total flow and total enthalpy during production test of Well WW-P1 (Jun 2014)

As shown in Figure 3-3 below, the calculated steam flow at 7 bara separation pressure varied between 5.0 kg/s and 17.0 kg/s depending on the throttling of the well. During a stable flow period from June 12th and 13th at WHP of ~16 bar, ÍSOR calculated the steam flow at 7 bara separation pressure of 11.1 kg/s and liquid flow 41.8 kg/s – giving a steam fraction of 21%, corresponding to an enthalpy of 1130 kJ/kg. (ÍSOR, 2014)

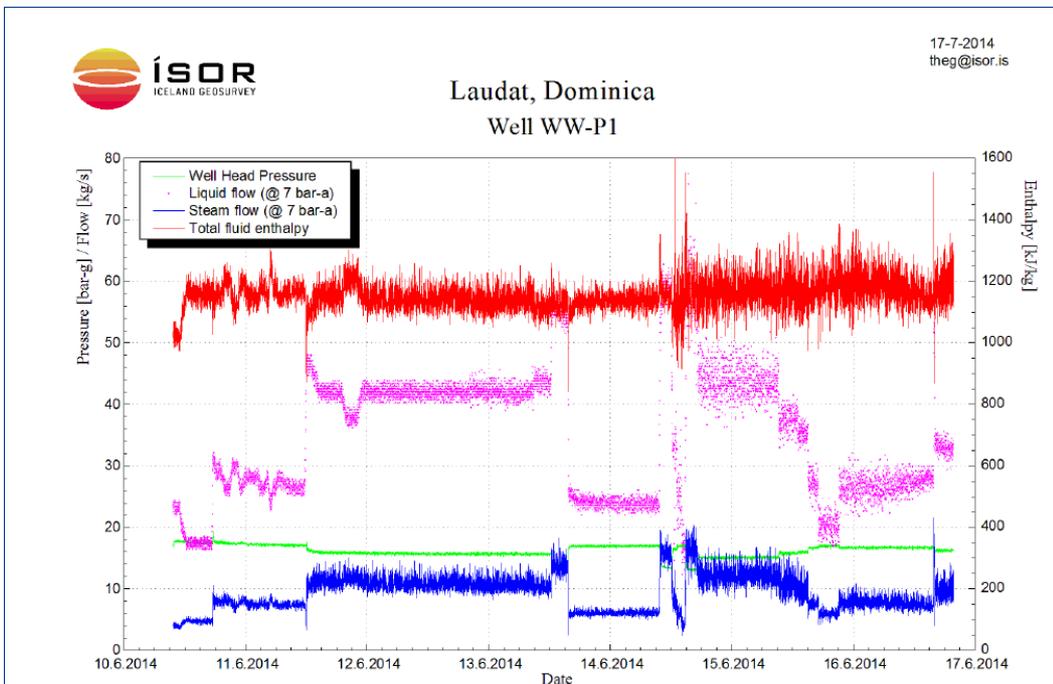


Figure 3-3: Calculated liquid and steam flow at 7 bara separation pressure, together with well head pressure and the total fluid enthalpy for well WW-P1 (Jun 2014)

Based on the results of step tests and previous observations, ÍSOR calculated the discharge at a Well Head Pressure of between 13.0 and 17.0 bara, as shown in Table 3-3 below. At atmospheric separation pressure and

a WHP of 13.0 bara the estimated steam flow is 22 kg/s. At 7 bara separation pressure the steam flow is calculated to be ~14-18 kg/s. Depending on the type of power plant to be installed at the site, the expected power output of WW-P1 at a separation pressure of 7 bara is between 7 and 9 MW_e assuming a usage of ~2 kg/s of steam for each MW_e. (ISOR, 2014)

Table 3-3: Liquid flow, steam flow, total flow and calculated discharge enthalpy at atmospheric separation pressure for different WHP

WHP (barg)	Total flow (kg/s)	Liquid flow (kg/s)	Steam flow (kg/s)	Enthalpy (kJ/kg)
13.0	75.1	53.0	22.1	1140
15.1	54.7	37.0	17.7	1160
15.7	48.3	31.2	17.1	1170
16.0	44.5	28.9	15.6	1160
16.4	34.5	22.5	12.0	1170
16.9	26.0	16.1	9.9	1180

3.3 Geothermal Fluid Chemistry

During the flow tests on WW-P1 undertaken by GRG in June 2014, samples of the two-phase fluid were collected. Six complete samples of vapour and liquid were collected during the test and three additional samples of steam were also collected during a step test on 15 June for gas / steam ratio measurements. Liquid samples were also collected regularly from the weir box throughout the test for conductivity and pH measurements.

3.3.1 Chemical Analyses of Vapour Phase

The vapour phase samples were collected to evacuated double-port gas bottles containing a 10 M NaOH solution. The gases in the head-space of the bottles (Ar, H₂, N₂, CH₄ and O₂) were analysed using a gas chromatograph and CO₂ and H₂S levels were determined by titration of the caustic solution. The liquid phase samples were collected in several sampling containers and subjected to various ion chromatography (IC), colorimetry, gravimetry, and mass spectrometry (MS) chemical tests (ISOR, 2014). The results are shown in Table 3-4 below.

Table 3-4: Results from chemical analyses of the liquid and vapour phases of samples collected during the well test (ISOR)

Sample		20140816	20140808	20140809	20140810	20140811	20140812
Date		10.6.2014	11.6.2014	12.6.2014	13.6.2014	14.6.2014	15.6.2014
Temperature	(°C)	205.4	205.2	203.4	198.3	203.5	201.9
Pressure	(barg)	16.8-17.1	16.4-16.8	14.9-15.1	13.5	15.8-16.0	15.0-15.9
Liquid phase							
pH/°C		6.03/24.0°C	6.19/25.4°C	6.37/25.5°C	6.44/26.0°C	6.39/26.2°C	6.23/26.2°C
Conductivity	(µS/cm/°C)	7300/25.0°C	7730/25°C	7870/25°C	8000/25°C	7920/25°C	7940/25°C
CO ₂	(mg/L)	154.6	133.7	113.4	106	108.6	116.2
H ₂ S	(mg/L)	19.65	11.05	7.21	7.2	5.25	8.56
SiO ₂	(mg/L)	489.6	497.2	507.2	506	514.2	501.6
Cl	(mg/L)	2660	2830	2900	2950	2910	2940
B	(mg/L)	33.3	37.7	38.9	38.1	37.6	37.2

Sample		20140816	20140808	20140809	20140810	20140811	20140812
Br	(mg/L)	11.3	12.1	12.4	12.5	12.4	12.6
F	(mg/L)	1.36	1.36	1.2	1.23	1.25	1.3
Ca	(mg/L)	56.5	55.7	55.6	56.7	55.2	56.4
Na	(mg/L)	1520	1620	1660	1670	1670	1680
K	(mg/L)	234	246	249	250	252	252
Mg	(mg/L)	0.22	0.2	0.25	0.29	0.26	0.28
NH ₃	(mg/L)	0.55	0.59	0.62	0.62	0.65	0.67
SO ₄	(mg/L)	22.4	21.5	21.8	21.1	21.1	20.4
Fe	(mg/L)	1.03	0.217	0.0511	0.147	0.0606	0.0338
Al	(µg/L)	195	189	178	196	190	181
As	(µg/L)	42.3	144	118	48.4	87.2	71.3
Ba	(µg/L)	448	481	479	498	509	506
Cd	(µg/L)	0.00922	0.0242	0.0148	0.01	0.00991	0.011
Co	(µg/L)	0.0858	0.00985	<0.005	0.00937	0.00559	<0.005
Cr	(µg/L)	22	9.38	2.22	6.6	3.03	1.28
Cu	(µg/L)	0.205	0.143	0.19	0.254	0.149	0.156
Hg	(µg/L)	0.00438	0.00865	0.00417	0.00945	0.0055	<0.002
Li	(µg/L)	3650	3950	4040	4010	4050	4100
Mn	(µg/L)	274	151	127	184	171	176
Mo	(µg/L)	5.61	8.54	14.9	2.94	10.4	7.16
Ni	(µg/L)	13.6	2	1.33	3.05	1.84	1.52
P	(µg/L)	4.22	1.66	2.3	<1	1.38	1.45
Pb	(µg/L)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Sr	(µg/L)	880	935	948	956	971	969
V	(µg/L)	0.115	0.128	0.223	0.141	0.152	0.137
Zn	(µg/L)	2.23	0.989	0.578	0.581	0.394	0.41
TDS	(mg/L)	4936	5076	5112	5228	5200	5200
Vapour phase							
CO ₂	(mg/kg)*	63200	39200	31600	26600	29900	28140
H ₂ S	(mg/kg)*	2580	1770	1420	1220	1430	1300
Ar	(mg/kg)*	7.8	4.7	3.3	2.7	3.2	3.4
N ₂	(mg/kg)*	586	302	224	194	201	208
CH ₄	(mg/kg)*	7.8	5.6	4.3	3.8	3.9	3.8
O ₂	(mg/kg)*	<0.01	<0.01	<0.01	1.4	<0.01	<0.01
H ₂	(mg/kg)*	9.9	6.1	4.6	4.3	3.8	3.3
B	(mg/kg)*	0.88	0.89	0.83	0.73	0.67	0.82
NH ₃	(mg/kg)*	3.11	1.5	3.01	2.68	3.48	3.2
Na	(mg/kg)*	0.86	3.15	0.37	0.4	0.42	0.33

* mg/kg condensate

3.3.2 Chemical Composition of Reservoir

Based on the above results, a chemical speciation programme WATCH was used to calculate the composition of the reservoir fluid. These are shown in Table 3-5 below, based on sample 20140810 and assuming a reservoir temperature of 246°C.

Table 3-5: Calculated composition of reservoir liquid assuming reservoir temperature of 246°C (ÍSOR, 2014)

Sample	20140816	20140810	20140812
pH	5.32	5.62	5.59
CO ₂ (mg/L)	6042	3195	3080
H ₂ S (mg/L)	258	149	145
SiO ₂ (mg/L)	443	447	449
Cl (mg/L)	2412	2606	2629
F (mg/L)	1.2	1.1	1.2
Ca (mg/L)	51	50	50
Na (mg/L)	1378	1475	1502
K (mg/L)	212	220	225
Mg (mg/L)	0.2	0.26	0.25
NH ₃ (mg/L)		0.55	
N ₂ (mg/L)	55.6	22.6	21.3
SO ₄ (mg/L)	20.3	18.6	18.2

3.3.3 Conductivity and pH

Samples for pH and conductivity measurements were also collected from the weir box throughout the test. The conductivity and the pH increased rapidly during the first few hours of the test (Figure 3-4). The conductivity levelled off within the first 24 hours of the test, but continued to rise slightly throughout the remainder of the test.

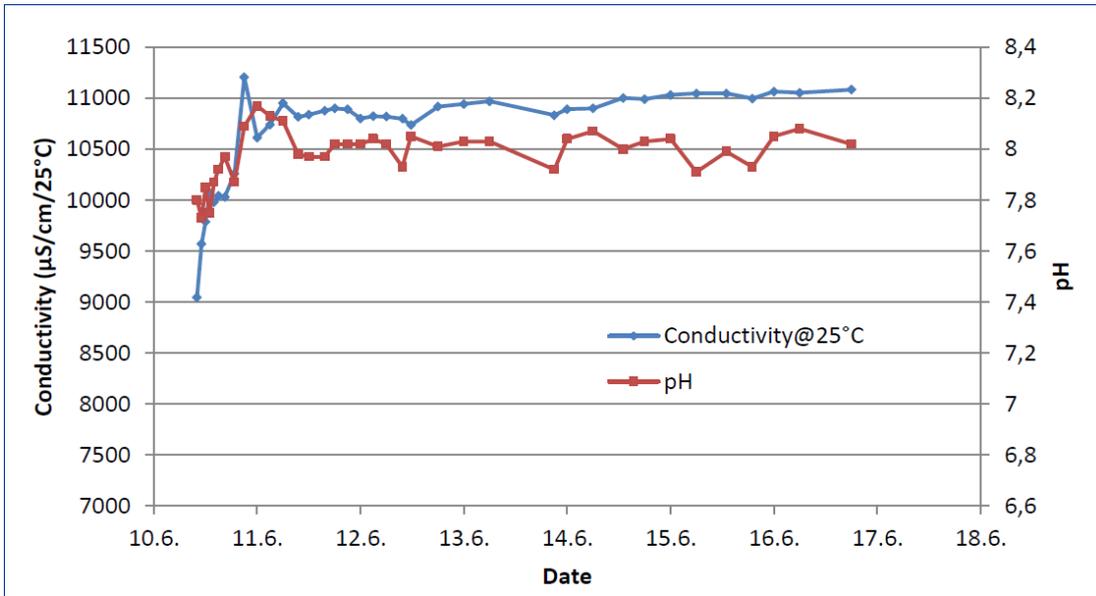


Figure 3-4: Conductivity at 25°C and pH in samples collected from the weir box during the flow test (ÍSOR)

3.3.4 Non Condensable Gas Content

ÍSOR also measured the non-condensable gas content of the discharge utilising three methods (with Giggenbach bottles, a gas flow meter and an inflatable plastic tube). These gave average gas/steam ratios of 16.5 L gas/kg condensate at a separation pressure of 15.5 bara (calculated at standard temperature and pressure (STP) conditions). As shown in Figure 3-5 below the gas concentration in the vapour phase decreases with increasing flow rate (which is inversely proportional to the well head pressure which controls the boiling and steam fraction).

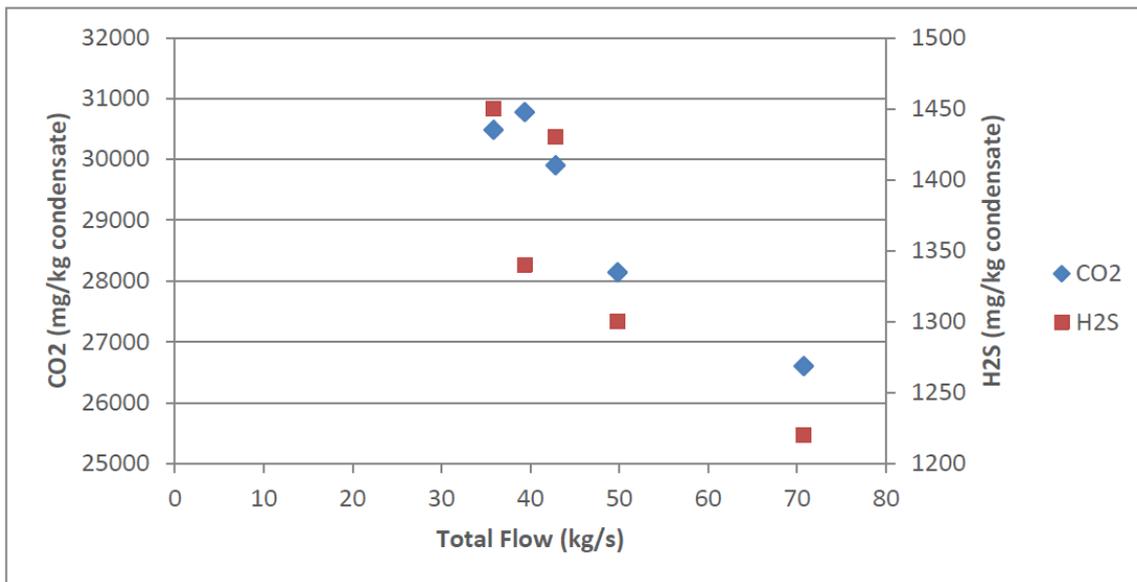


Figure 3-5: Vapour phase concentration of CO₂ and H₂S versus total flow from the well (ÍSOR) [assumed 15.5bara]

3.3.5 Conclusions

Based on the chemical tests ÍSOR concluded that:

- Due to limited changes in the conductivity of the liquid phase throughout the test, the similar chemical composition of the samples collected during the test and the good agreement between geothermometers and logged reservoir temperature indicates that the discharge is representative for the reservoir fluid.
- The deep liquid (reservoir liquid) is relatively dilute with Cl and Na concentrations close to 2600 mg/L and 1500 mg/L respectively.
- Boiling due to depressurisation within the well is expected to cause calcite scaling at or slightly above the boiling level.
- The overall gas content of the steam at 150°C (4.8 bara) based on calculations from samples 20140810 and 20140812 was 1.6 wt% (at 4.8 bara) or approximately 8 L gas/kg condensate.

4. Project Overview

The Project comprises the development of a two-unit geothermal power plant with a gross capacity of 7 MW_e in the Roseau Valley, Dominica. This covers the following stages: construction, completion, testing, commissioning, ownership, operation and decommissioning, including the steamfield, required electrical connections and integration with associated infrastructure. The preliminary design for the Project is ongoing, with detailed design to be completed following a formal tender process for an Engineer, Procure and Construct contractor(s) in 2018.

The Project will be developed by the Dominica Geothermal Development Company (DGDC), which was established mid-2017. The DGDC will operate under guidance from commercial, financial and technical advisors. The company will appoint an EPC contractor for the development and a separate Operations & Maintenance contractor.

The key components of the proposed 7 MW_e power plant include:

- Power plant comprising 2 x 3.5 MW_e units (either single flash steam condensing cycle or organic Rankine cycle units (binary turbine), which will be adjacent to wells WW-P1 and WW-03. The binary power plants may use wet cooling or dry cooling;
- Production well WW-P1 – The existing geothermal production well at Laudat is indicated to have potential to generate 6 to 9 MW_e and will be the sole production well for the project;
- Reinjection wells WW-R1 (located in Trafalgar) and WW-01 (located in Wotten Waven) – The used geothermal fluid (brine and possibly some steam condensate) produced from production well WW-P1 would be disposed of into reinjection wells WW-R1 and WW-01;
- Cross-country brine reinjection piping – The 250 to 300 mm diameter reinjection pipeline will be carrying used geothermal fluid from Laudat to Trafalgar with approximate piping length of 3.5 km;
- Steamfield infrastructure including two phase piping, steam piping, steam separator, atmospheric flash tank, brine collection and disposal system, condensate collection and disposal system, pressure relief system, storage sump and rock muffler;
- Supporting infrastructure including existing well pads, turbine building, primary and ancillary equipment, cooling system, and water supply; and
- 3 x 11 kV underground cable interconnection to the DOMLEC electricity grid at the power plant site.

The Government has ownership of the existing well pads (WW-01, WW-02 and WW-03), whose locations are presented in Figure 4-1, along with the preferred injection line route. This route alignment will be finalised in close co-ordination with process engineering, mechanical, geotechnical and civil engineering design disciplines, along with the Government, Land and Survey Division and environmental and social scientists.

The conceptual power plant layout is displayed in Figure 4-2 and land will have to be acquired to site the power plant and other associated infrastructure. Land requirements are discussed in detail in Section 4.5.

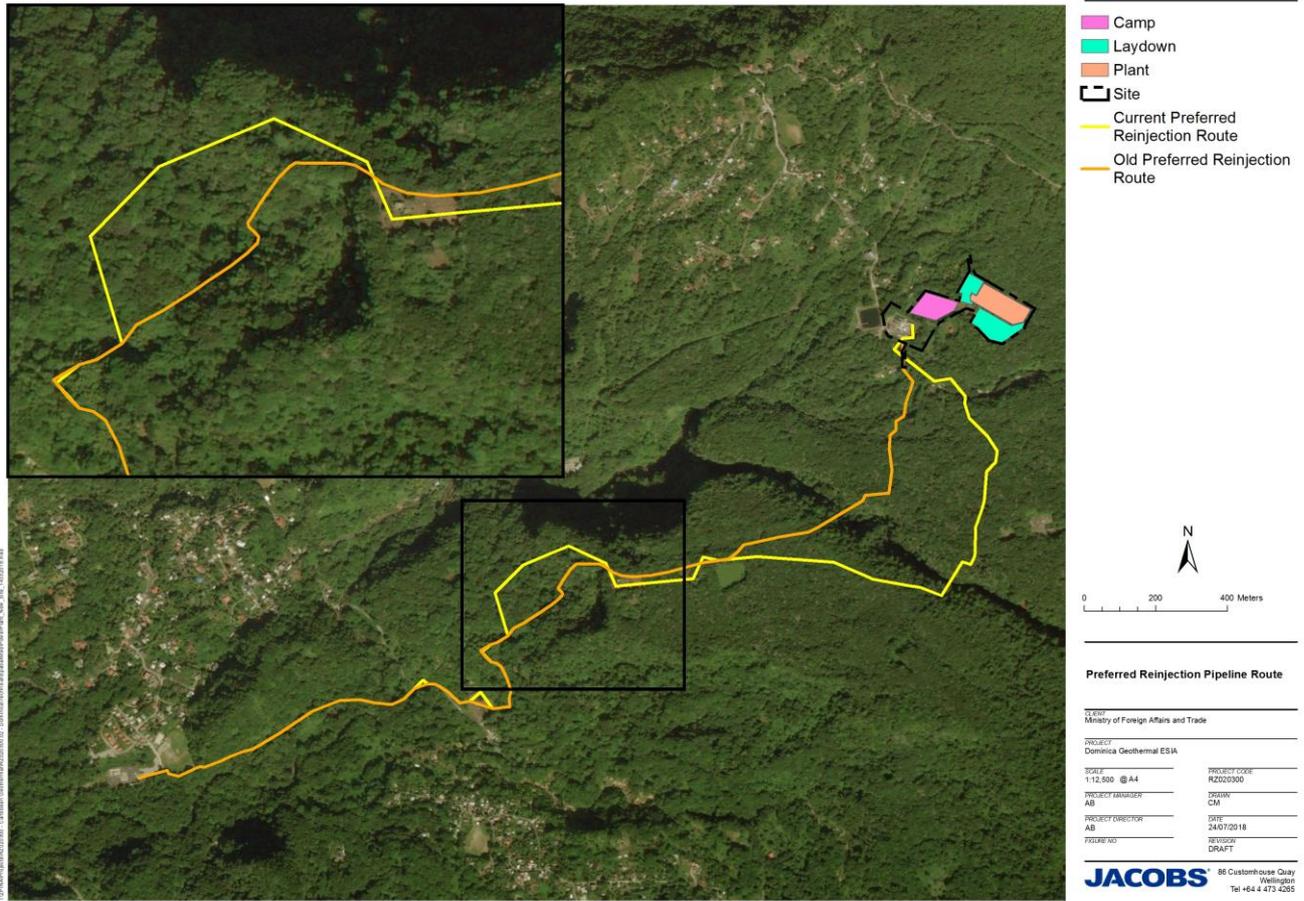


Figure 4-1: Preferred injection pipeline route from WW-P1 to WW-01 and WW-R1

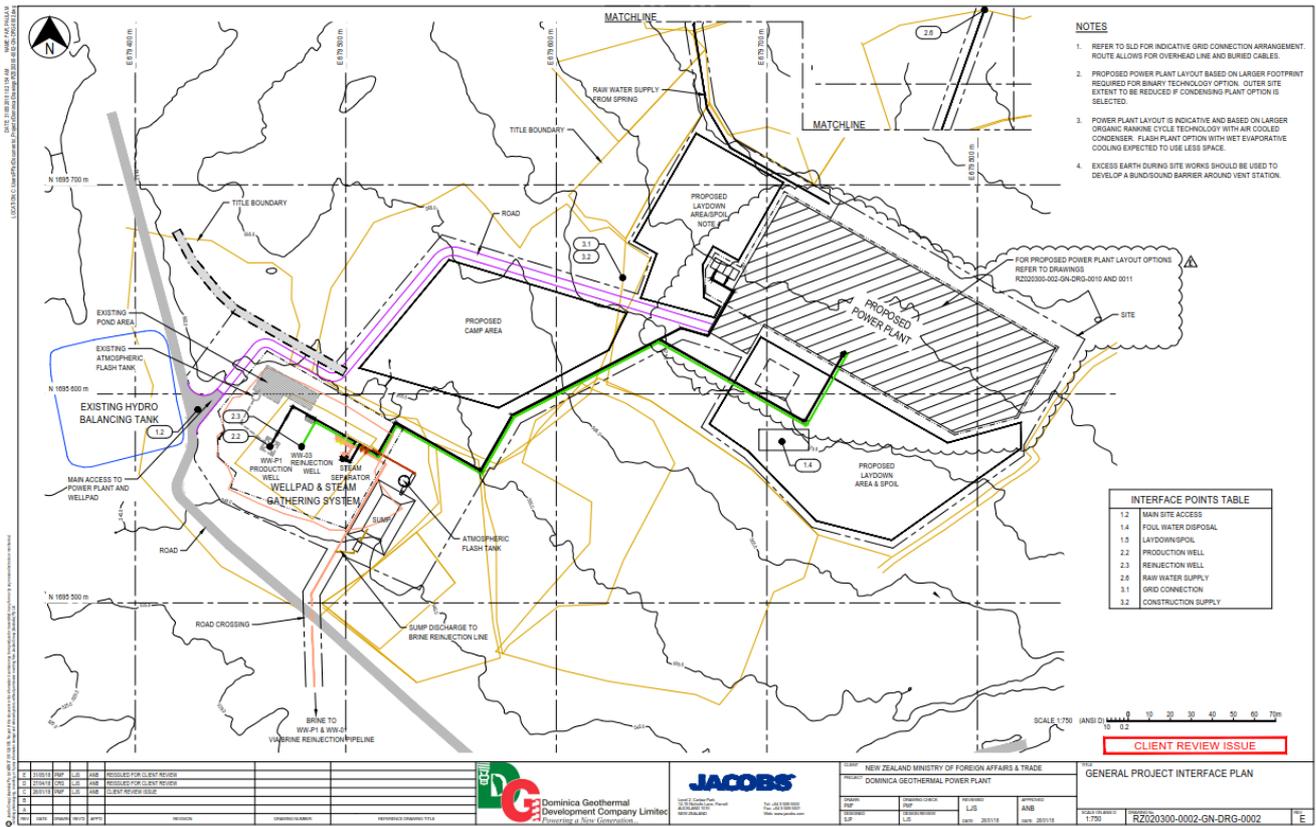


Figure 4-2: Proposed Power Plant Site and Production Steamfield Layout

4.1 Power Plant Technology Options

Various methods of electricity generation from geothermal wells are available, the selection of which is primarily driven by the nature of the geothermal resource. Energy is typically extracted from steam, or a mixture of brine and steam. There is much more energy in steam than in hot water and even though the ratio of brine to steam produced by WW-P1 is about 5:1, most energy still lies in the steam phase. As such it is proposed that steam will be used as the primary driver.

During project feasibility analysis various options were discounted including backpressure unit, dual flash cycle, geothermal combined cycle, triple flash cycle and Kalina cycle. As such there are two appropriate main power plant technology options:

- i. Single flash steam condensing cycle; and
- ii. Organic Rankine cycle (ORC)

It is proposed that suppliers will be invited to offer power plants based on a clear set of technical specifications for the project. This section discusses the likely options for electricity generation to allow various impacts for each of the two suitable technologies to be established and assessed in the ESIA.

4.1.1 Single flash steam condensing cycle

Geothermal steam from the separator is used directly in a steam turbine connected to a generator. After the steam passes through the steam turbine it is condensed for injection. Figure 4-3 presents the single flash plant process. The key features of this plant design are:

- Single steam admission pressure;

- Direct contact condenser and mechanical induced draft wet cooling tower;
- Hybrid non-condensable gas (NCG) removal system.

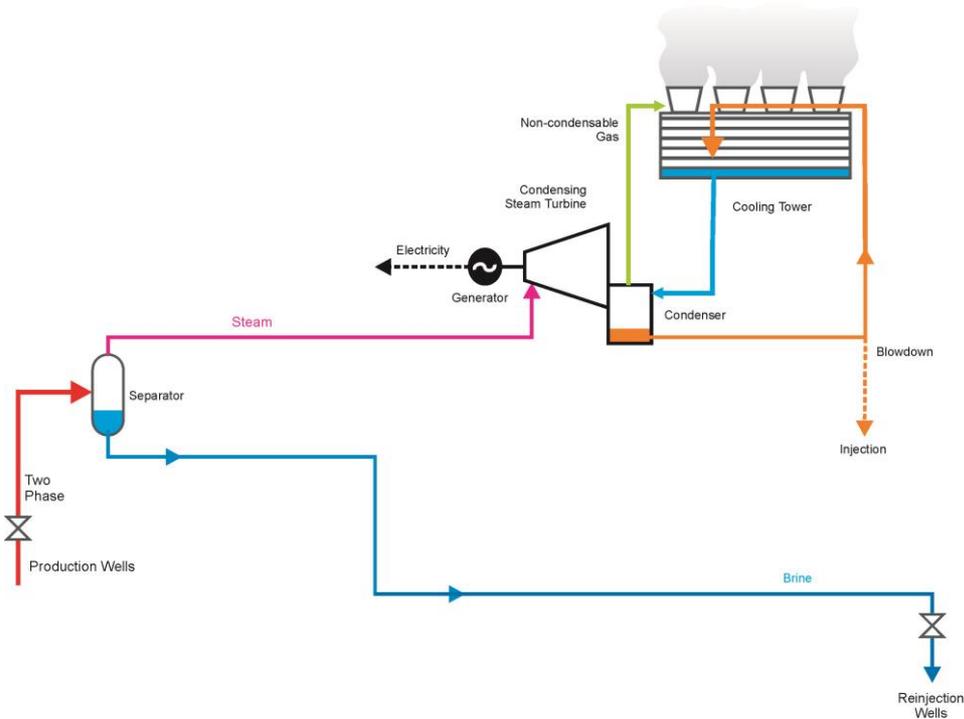


Figure 4-3: Typical geothermal single flash steam condensing cycle³

4.1.1.1 Condensing Steam Turbine

Steam enters the turbine from the steamfield and the flow rate is modulated by a control valve called a governor valve. Excess steam is vented through an upstream steam vent system consisting of a pressure control valve and rock muffler (which is part of the “steamfield”). Immediately upstream of the governor valve is a main stop valve that shuts if the turbine trips.

The geothermal steam is passed through the turbine providing motive force to rotate the turbine and generator. The steam then exhausts into a condenser at a pressure of about 0.1 bara (i.e. under high vacuum). Figure 4-4 provides an indication of the size of plant envisaged for the Dominica project.

³ <http://theearthproject.com/everything-geothermal-energy/>



Figure 4-4: Condensing Steam Turbine (Source: GDA - <http://www.gdareno.com>)

4.1.1.2 Condenser

The purpose of the condenser is to condense the steam, creating a vacuum and thereby generate more power due to the higher pressure differential and higher heat drop across the turbine. Normally “direct contact condensers” are used in the geothermal industry. They rely on cool water (which comes from previously condensed steam that has passed through the turbine) being directly sprayed into the steam to condense it.

4.1.1.3 Gas Extraction Equipment

In order to maintain the vacuum in the condenser, the non-condensable gases (NCGs) must be continuously removed. This is accomplished by use of a gas extraction system, steam-driven ejector or steam ejector / ring pump (hybrid). The type of system is determined during the bidding for the plant, and can be influenced by the value attached to steam used in the ejectors.

Whatever the approach, the NCGs extracted from the condenser are piped to the cooling tower where they are discharged to the atmosphere in the warm plume of moist air and dispersed to the environment.

4.1.1.4 Oil System

A lubricating oil system is required for the turbine generator units. The system includes:

- Oil pumps;
- Oil coolers;
- Oil Tank.
- Filters and Purifiers

As mitigation for leakage or spills, oil containment bunds / trays are normally specified around or under all lube oil equipment to contain at least 110% of the total oil system capacity.

4.1.2 Organic Rankine Cycle

This technology requires geothermal fluids pass heat to an organic working fluid which boils and the organic vapour then drives a turbine connected to a generator. These are often also called 'Binary Cycle' plants because they use two fluids (the original steam and the organic secondary fluid).

Figure 4-5 shows a typical binary plant which separates the steam and brine. There are different combinations for using geothermal fluids in a binary cycle plant, the simplest being to use the geothermal fluid directly without any separation of the steam and brine phases.

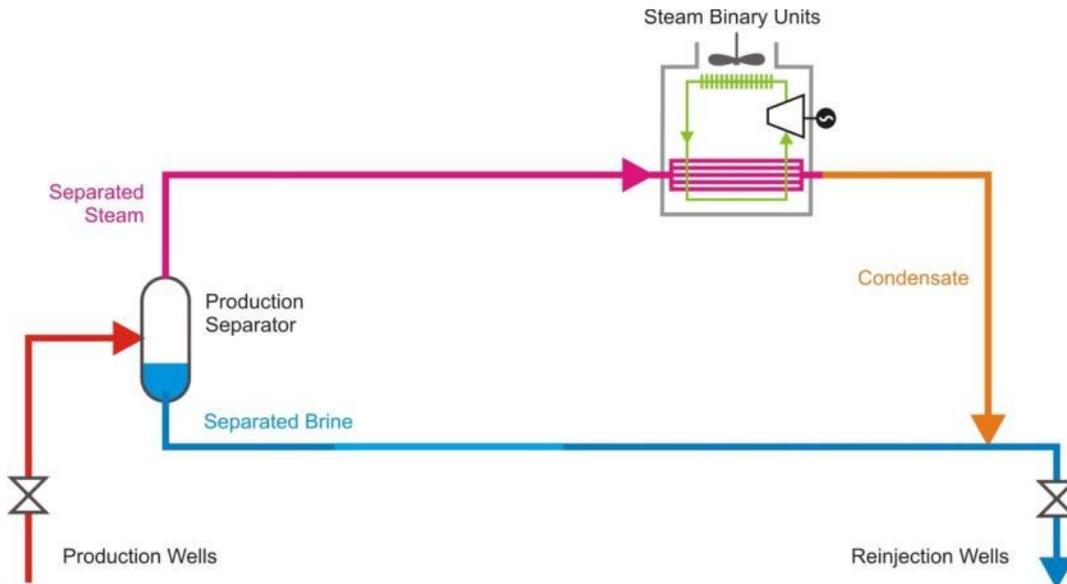


Figure 4-5: Typical geothermal Organic Rankine cycle

4.1.2.1 Working Fluid and Heat Exchangers

Most working fluids employed for power generation with binary processes are flammable. Isopentane, N-Pentane and Isobutane are typical working fluids. N-pentane is recommended based on boiling point, use in New Zealand and safety. Being flammable necessitates requirements for safe design, construction, operation and maintenance. The working fluid must be topped-up on an ongoing basis which means that the fluid must be imported and stored safely over the life of the project.

The heat exchangers in a binary plant transfer the energy of the geothermal fluids to the working fluid. They are usually shell and tube type. In a typical plant a pre-heater and a vaporiser will be utilised. Typically, the brine will pass through the pre-heater and heat the working fluid to its boiling point. The steam condensing in the vaporiser will then vaporise the working fluid after which it is delivered to the turbine or expander. The number of heat exchangers will be at the discretion of the EPC contractor. A recuperator, upstream of the preheater, may also be used to transfer waste heat in the turbine exhaust to the working fluid.



Figure 4-6: Binary plant heat exchangers (large plant example)

4.1.2.2 Working Fluid Pumps

The working fluid is circulated in a closed system at elevated pressures in order to extract the maximum amount of power for a given resource condition. Pumps are used to circulate the working fluid around the cycle. The pumps will be supplied by the power plant contractor.

4.1.3 Power Plant Cooling Options

A cooling system is required to reject heat which cannot be converted to electric power. In the case of the condensing steam turbine plant this is always an evaporative water cooling system because cooled water for subsequent heat rejection by evaporation is freely available from the steam which is previously condensed in the process.

In the case of the binary plant the cooling system is almost always air cooling. This is because the binary fluid leaves the binary turbine as a vapour which must then be condensed without direct contact with another fluid because it is reused again in the process. The condensation can be achieved either by air (dry) cooling or water (evaporative) cooling. The cooling process will be confirmed by the EPC contractor during bidding.

The main differences between the evaporative (wet) cooling option and the air (dry) cooling options are: the land area required for the cooling towers; the visual impact of the equipment; overall efficiency; visual emissions or plumes, the injection load and the total installed cost. The trade-off between different options is best evaluated against specific offers.

- Wet cooling towers are typically used with condensing steam Rankine cycle plants. Water cooling towers have a visible plume of water vapour when the relative humidity of the atmosphere is high and are particularly visible on cool mornings – this is because the air flow leaving the tower is 100% humid. Towers can be configured so that there is some sensible heating of the air flow leaving the tower which reduces the humidity below 100% and alleviates the visible plume as it leaves the tower. As a large part of the steam condensate is evaporated, the total amount of liquid to be reinjected is less than for air cooling.
- Air coolers have a larger land footprint than water coolers. Air coolers do not have a visible plume of water vapour, but may exhibit a heat haze.

It is proposed that both wet and dry cooling options are considered in the competitive bidding process unless the visual impact or land requirements preclude one or the other options determined through the ESIA. The

cooling system will typically be closely integrated with the power plant and supplied as part of the overall EPC power plant package.



Figure 4-7: Air cooling for 9MW_e binary plant (left). Evaporative cooling tower for 5MW_e plant (right)

4.1.4 Building for Main Power Plant Equipment

As the dominant power source for the island, bidding documents will specify that the main components of the power plant that are sensitive to a wet, tropical, corrosive geothermal environment be housed in appropriate enclosures designed to withstand heavy rainfall and hurricane conditions as per relevant building standards adjusted for a geothermal environment. The power plant will be constructed on a number of concrete foundations designed to withstand the weight and movement of large pieces of mechanical equipment and the associated building / structures. It is proposed that the power plant manufacturer / EPC contractor will take responsibility for preparing the foundations.

In the case of a single flash steam power plant it is typical to house the steam turbine generator and its associated equipment in a turbine hall or shelter in order to protect the machinery from both the tropical elements and the corrosive geothermal environment and provide for easier maintenance and operation. Some elements of the balance of plant equipment, including circulating water cooling systems and gas extraction systems are likely to be located outside this building but with adequate protection from the elements.

In the case of a binary power plant this equipment is usually housed outdoors, but with a substantial shelter over the equipment.

The control room and electrical control and monitoring equipment for both plant options will need to be housed in environmentally-controlled spaces, which may be connected to or separate from the turbine-generator building.

4.1.5 Fire Detection and Protection

Both plant options will require substantial fire detection and protection to prevent damage to components and buildings such as the cooling towers and oil containing equipment including the turbine-generators.

For both options, this would likely comprise a fire ring main and spray system that covers the physical plant, and an inert gas (CO₂, “inergen”, or similar) discharge system for the control room and building annex. A fire-fighting water tank will be required and sized in accordance with NFPA 850 (Recommended Practice for Fire Protection for Electric Generating Plants and High Voltage Direct Current Converter Stations). Monitoring systems associated with the fire protection system will be spaced around the site as required by the relevant fire service standards. The single flash option would also include monitors (spray cannons) covering the cooling tower.

Due to the flammable nature of the likely working fluid for the organic Rankine system, this plant option will require a full firefighting system comprising water storage tank in accordance with NFPA 850, fire water pump and jockey pump, fire-water mains, and hydrant/monitors. There will also need to be a fire detection system, plus hydrocarbon gas detectors that would identify any potential leakage.

4.1.6 Comparisons

Table 4-1 : Main differences between Single Flash and Organic Rankine Cycle

Items / main difference	Single Flash	Organic Ranking Cycle
Typical Size	~ 60 x 90 m inc. laydown	~60 x 175 inc. laydown
Cooling system	Typically evaporative cooling; Possible visible water vapour plume during certain ambient conditions	Typically air cooled condenser No visible water vapour plume
Motive fluid	Geothermal steam driven turbine	Hydrocarbon used as motive fluid to drive turbine, heat absorbed into motive fluid from geothermal steam via heat exchangers
Steamfield	Same components and operation	

4.2 Geothermal Steamfield Equipment

The steamfield will be designed, procured and constructed for the entire capacity of the 7 MW_e power plant. The two-phase fluid will be sent to a separator where it is divided into steam and brine phases. Steam will be directed to the power plant, and brine to the injection pipeline. The steamfield plays several important roles in the safe and reliable operation of a geothermal plant, being:

- 1) Handling variable multi-phase steam, brine and non-condensable gas flows while ensuring that neither production wells nor injection wells are adversely affected by its operation;
- 2) Matching the supply of steam to the power plant as it changes in response to fluctuations in electricity demand;
- 3) Provide clean steam to the steam turbine or the organic Rankine cycle heat exchangers;
- 4) Disposing of spent fluids into injection wells.

The steamfield will be identical for either option of power plant technology selected.

4.2.1 Steamfield Arrangement

The steamfield comprises the Steam Gathering System (SGS) and brine injection pipeline, made of the following systems:

- Two phase collection and separation;
- Steam gathering;
- Brine collection and disposal (including brine pumping if required);
- Condensate collection and disposal (if required);
- Pressure relief;
- Atmospheric Flash Tanks;
- Steam venting and pressure control;
- Storage sumps;
- Access tracks for construction and maintenance.

The preferred steamfield arrangement for the Project is shown in Figure 4-1 and Figure 4-2 of Section 4. The individual systems and infrastructure are described in the following sections.

4.2.2 Two Phase Collection and Separation System

This system consists of:

- The production well WW-P1;
- Two phase piping from production well to separator;
- Steam separator;
- Atmospheric flash tank (AFT).

The proposed total power plant capacity of 7 MW_e is dictated by the well output and allows a reserve factor to accommodate some decline in well flow without reducing power generation. The flowrate from the well is controlled by a manual wellhead control valve. The piping system at Dominica will only have one production well and this will feed two-phase fluid directly to the separator, the preferred design of which is a vertically oriented Weber type. If another well is drilled in the future, the two wells will feed a common collection header, which in turn will feed the separator.

Low point drains (LPDs) will be located at the local low points on the two-phase line and be used on start-up and shutdown to drain down the condensate that forms from condensing steam. These will usually discharge to ground but can be piped to a storage sump for disposal. High point vents (HPVs) are located at high points to vent air and non-condensable gases (NCGs) on start-up and shutdown.

The separator is a key piece of equipment and should be designed to operate at variable flows and pressures aligned with power plant turn down ratios and rapid response to load changes imposed by the electrical grid system operator. For the Project, the separator will be installed on the WW-P1 well pad or potentially nearby at the adjacent power plant site.

A typical large vertical cyclone separator is shown in Figure 4-8.



Figure 4-8: Typical geothermal separator

For Dominica, this vessel will be between 7.5-10m high and approximately 1.8m in diameter. This will likely be a prominent visual impact depending on surrounding terrain and foliage.

Other key pieces of equipment to be housed on this pad will depend on the final technology selected, but will include an atmospheric flash tank (AFT) (which will also double as a two-phase or brine receiving vessel during well testing and during start-up of the brine line), steam venting and pressure control system, brine pumping units (if required) and a storage sump.

The AFT will be between 1 m and 3 m in diameter and it is also used to receive any discharges due to operational upsets. Should the level of brine in the separator brine drum rise beyond a high level, emergency dump valves (EDVs) will open and discharge brine to an AFT. The brine will flash inside the vessel and the steam component will discharge to atmosphere. The brine is sent to the local sump where it can then be pumped away to an injection well for disposal. An AFT is shown in Figure 4-9.



Figure 4-9: Atmospheric Flash Tank (AFT / Silencer)

4.2.3 Steam System

On exit from the separator the steam is gathered in a steam header and transported to the power plant. Condensate drain pots (CDPs) are located at low points in the system to collect condensate that has generated in the pipelines. Vents are located at the high points to vent air and non-condensable gases on start-up and shut down of the system. The piping is typically wrapped in calcium silicate and / or fibre-glass insulation material and an aluminium cladding.

Upstream of the power plant, a steam scrubber is utilised as a final condensate removal stage to ensure that the moisture content of steam is as low as possible prior to admission to the turbine. The geothermal condensate removed from the steam will be sent to a storage sump and pumped away for injection.

4.2.3.1 Steam Pressure Relief System

Pressure relief is required on the steam gathering system on exit from the separator. The piping network will typically not be designed to withstand the pressure generated by a well that is shut in (i.e. not flowing). The difference between operating pressure and shut in pressure can be up to 40 bar or higher. Usually just the individual well branch line will be rated for full shut in pressure. It is therefore necessary to protect the rest of the system from over pressure.

Typical events that will cause an over pressure in the system include turbine trips which will cause the main turbine control valve (or governor valve) to close and lock in the system. Bursting discs will be used on the Project to release pressure in the event of an emergency build-up of pressure in the system. This equipment will

either discharge to atmosphere or pipe to the AFT. The preferred method will be confirmed by the contractor. This event is not part of normal operation of the plant.

4.2.3.2 Steam Venting and Pressure Control System

The steam venting and pressure control system is used for the following purposes:

- “Trim” system pressure by venting steam to maintain the desired interface pressure on entry to the turbine;
- Vent steam in the event of system upsets (i.e. turbine trips).

A series of vent valves upstream of the power plant will vent steam as necessary. Steam is vented to a rock muffler which controls the release of pressurised steam and attenuates noise associated with this. The rock muffler consists of a pipe with numerous small holes (known as a sparger) buried in rocks with noise attenuating properties, typically scoria.

During normal operation there will be a small flowrate of steam through the vent system to maintain steam pressure on entry to the turbine. Upon turbine trip, the full steam load can be vented so as not to over-pressurise the system. Venting steam in this manner allows the rest of the system to operate as normal i.e. separators will continue to separate steam and brine at the desired pressure until the power plant can be brought back online. This avoids having to shut down the entire system. A typical vent system, vent valves and rock muffler from a large steamfield is shown in Figure 4-10.



Figure 4-10: Vent system

4.2.3.3 Storage Sumps

For this project, storage sumps will be required at the production and brine injection well pads. This will store brine or condensate that is discharged due to operational upsets. A typical sump is shown in Figure 4-11 (sized to approximately 20m x 40m and 3m deep). The preferred option for emptying the sump at the production well pad WW-P1 is via gravity to the brine injection wells WW-R1 and WW-01.



Figure 4-11: Storage sump

4.2.4 Condensate Collection and Disposal System

Condensate is produced in two locations in a typical geothermal power project:

- As a result of temperature difference across the walls of the steam pipes and the surrounding atmosphere, despite the use of insulation;
- Discharge of excess condensate from the cooling tower basin (on condensing cycle options only, see explanation below).

Condensate produced in steam pipelines is generally collected via a condensate collection drain pot (CDP), found at local low points on the route and then disposed to ground via a steam trap. A typical CDP is shown in Figure 4-12.



Figure 4-12: Condensate collection drain pot (CDP)

This condensate will be discharged to a piped network and disposed of at downhill storage sumps. The condensate can then be pumped to an injection well for disposal.

If a steam condensing turbine option is selected, condensate will also be produced as a result of steam exhaust from the turbines, condensing inside the condenser (or heat exchanger). While some of this condensate is re-used inside the cooling tower to make up for losses due to evaporation and drift, the balance must be disposed of via an injection well. The volume of condensate produced is low compared with brine produced and it is envisaged that condensate be injected into well WW-03, located on pad WW-P1. It is not expected that the small flow of condensate will affect the performance of WW-P1. If it does, this condensate may be disposed of in WW-02. Disposal pumps may also be required but these are much smaller than those required for brine disposal and constitute a small amount of the over-all parasitic load for the plant.

Condensate disposal is normally done via a dedicated pipeline to a different well than that used for brine injection because condensate has different chemistry to the separated brine. However, this is not necessarily the case and in some instances (particularly binary options) there can be advantages in combining the flows to prevent silica deposition, depending on chemistry. Bidders will be asked to present their preferred approach, with the requirement to inject condensate to a dedicated well being optional.

4.2.5 Brine Collection and Injection System

The brine from the separators passes through a brine collection drum into a network of pipes that will feed the brine injection wells. The current preferred disposal option is via gravity. The injectivity index of wells WW-01 and WW-R1 indicate that both are required to dispose of the expected volume of brine produced from WW-P1 at full output. However, there is a degree of uncertainty around the injection capacities of the two wells and the volume of brine produced. In the unlikely event that the injection capacity does not meet the requirement or if significant wellhead pressures are required to force the brine into the reservoir, two possible solutions can be implemented.

Firstly, a pump station could be installed at WW-R1 prior to operation in order to increase the brine pressure into WW-R1 and increase the combined injection capacity of WW-R1. The quantity of pumps required is a decision made later in the project design, but is likely to be 2 x 100% (i.e. a duty and a standby, if pumps are required). The second option is stimulation of well WW-R1 by pumping cold water from the Roseau River to increase well injection capacity. This would require 51,840 m³ of water to be pumped into WW-R1 at a rate of 20 kg/s over a 1-month period.

Connection to both wells would be undertaken during construction and installation of the brine injection pipeline. The injection pipeline will be insulated to reduce heat loss, which is necessary to avoid deposition of silica and to protect people and wildlife from burns. It will be clad in aluminium or other appropriate material and may be coloured or camouflaged to reduce visual impacts. The injection pipeline must operate at high temperature and pressure and needs to be carefully designed with suitable supports and guides which safely allow for thermal expansion of the pipe between its hot and cold states. This will require vertical or horizontal u-bends every ~100m.

The pipeline will also have drains at any low points for draining down the line on shutdown in order to prevent silica polymerising in the lines due to stagnant conditions. These drain points will be connected to the sumps at the injection well pads for subsequent disposal into the injection wells.

4.3 Supporting Infrastructure

4.3.1 Well Pads

Three well pads will be used for the development: WW-P1, WW-01 and WW-R1. All sites require remedial works to bring them up to standard.

- Site WW-P1: Site improvement, slope stabilization, drainage works, fencing, security lighting.
- Site WW-01: Site fencing, slope stabilization.
- Site WW-R1: Site fencing, security lighting, disposal of material/ general cleanup.

4.3.2 Water

The main requirements for water are:

- Potable;
- Supply for fire fighting;
- Maintenance and plant cleaning.

4.3.2.1 Potable Water Supply

A potable water supply will be required for the geothermal development for drinking water, showers, toilets and kitchen facilities. The quantities of water required will be small as only a small work force (2 or 3 staff) would be required. Options for water sources include taking water from local streams or rivers, rain water or deliveries of bottled water. Water taken from local streams will require filtration and biological treatment. The most likely solution is:

- Drinking water delivered;
- Rainwater collection for showers (if permitted) and cleaning;

4.3.2.2 Sewage treatment

Sewage treatment requirements are specified in the bidding documents to comply with the requirements for maximum levels of residual contaminants as defined in the IFC Performance Standards and EHS Guidelines and the Environmental and Social Management Plan shall be complied with for all fluids discharged from the Plant.

4.3.2.3 Supply for fire water

As discussed in Section 4.1.5, water for fire-fighting will require a tank located at the site which will be sized in accordance with NFPA 850 (Recommended Practice for Fire Protection for Electric Generating Plants and High Voltage Direct Current Converter Stations). Water requirements for fire protection will be aligned with the power plant technology choice and specified in bidding documentation.

4.3.2.4 Maintenance and cleaning

Unit maintenance would be undertaken to meet manufacturers, inspection agency and unit specific requirements.

Major steamfield maintenance and inspections will be undertaken during power plant unit shutdowns to take advantage of the reduced steam demand. Sections of the steamfield will be taken out of service during which the separators, scrubbers and flash tanks will be inspected, cleaned and Non-Destructive Testing (NDT) would be carried out. Brine pumps and motors, valves and actuators will be inspected, overhauled and tested.

Other major maintenance work is associated with the steam production and injection wells, which require periodic workovers to remove any scale deposition. Portable water sources are thought to be the most pragmatic solution to facilities beyond WW-P1 and out of reach of available tank water.

4.3.2.5 Stormwater Management

Stormwater management will be required throughout construction and operation of the project infrastructure, taking account of well pads, steamfield equipment and power plant location. A stormwater management plan will be required before the construction phase and will include stormwater management during operation. The typical objectives of which are as follows:

- to minimise any potential adverse environmental effects on water quality and aquatic ecosystems from the proposed stormwater discharge from the operation of the development;

- to protect and enhance the natural character and amenity of watercourses from the proposed stormwater discharge from the operation of the steamfield and plant;
- to minimise any potential adverse environmental effects from flooding or erosion (inclusive of land or watercourses) from the stormwater discharge from the operation of the steamfield and plant.

Stormwater run-off from buildings and yards will be collected and discharged to local watercourse. Contaminated stormwater (e.g. oily water, hazardous substances) will go to a 3 stage interceptor before discharge to watercourse. It is not considered feasible to use the injection line for any contaminated stormwater.

4.3.3 Road Network

The road and track network for the Project existed prior to the geothermal drilling campaigns, although works were required to allow passage of the drilling rig. Road access to the well pads and power plant site has previously been established by the Government. Some remedial works will be required for the existing road network, but no new roads are needed. Some access tracks may be required around the preferred injection route.

4.4 Electrical Equipment and Interconnection

For each technology option, the layout and design of the electrical equipment will be similar but subject to constraints imposed by the technology chosen. This section discusses the electrical equipment involved in generating electricity and interconnecting to the DOMLEC electricity grid.

4.4.1 Connection to DOMLEC Grid

The new geothermal power plant will evacuate power at 11 kV through new three underground cables that will connect to the existing 11 kV switchgear at Laudat Hydro Station. These three new underground cables will run through land to be acquired for the power plant and through land owned by DOMLEC. They will be run under or directly alongside the proposed access road into the Project site. The length of this route is approximately 440 m. The proposed connection arrangement is provided in Figure 4-13.

For installation, trenches will be dug in which the cables will be laid and the trench backfilled. There is the potential to create sediment containing run-off when the trenches are open. This run-off will be handled as part of the mitigation measures proposed for civil construction works in general. Once installed, there will be no visual impact, nor impact on the use of the roads or amenities as they are underground. Therefore, no mitigation specific measures are required.

In addition to the 11 kV underground cable connection to the Laudat Hydro Station, DOMLEC are to also carry out ancillary works on the network. This includes the rebuild of the existing transmission line from Trafalgar Hydro Station to Fond Cole Power Station, which was destroyed by Hurricane Maria. As it represents an opportunity to build back better, DOMLEC have opted to upgrade the line to be capable of operating at 33 kV as part of this rebuild. That entails fitting slightly longer insulators which suspend the transmission wires from the poles. Also, they will extend the line from Trafalgar Hydro Station to Laudat Hydro Station to provide a 2nd circuit using the existing poles. These measures are to improve DOMLEC's network capacity, capability and flexibility and will be carried out even if the geothermal power plant is not developed and as such are not considered to be an associated facility as defined under Performance Standard 1. The construction method to be used for the rebuild will be determined by DOMLEC.



Figure 4-13 : Proposed connection with DOMLEC Grid

4.4.2 Generator

The energy contained within geothermal steam is converted to electrical energy using a turbine that is mechanically coupled to a generator. Figure 4-14 illustrates a typical generator (painted grey colour). The size of the generator required is dependent on the amount of power to be converted.

The electrical power from the generator will be transmitted from the power plant using insulated cables, at 11kV, allowing connection to the existing DOMLEC 11kV network without adding a step-up transformer.



Figure 4-14: 5.8 MW_e generator (Ngawha Power Station, New Zealand)

4.4.3 Switchroom

In order to safely operate and transmit electrical power from one location to another an indoor switchroom will be built. This facility will house equipment required to de-energise and protect incoming / outgoing lines / cables etc. Typical switchroom equipment includes circuit breakers, surge arrestors, current transformers and voltage transformers.

4.5 Land Requirements

4.5.1 Power Plant

The land required for the power plant, and hence civil works required to prepare the site, will depend on the power plant technology selected and design by the EPC contractor. Figure 4-15 provides nominal land area requirements for 2 x 3.5 MW_e power plants, with binary plant requiring an area of approximately 115m x 60m (~60 m x 175 m including laydown area) and steam condensing plant requiring approximately 50 m x 60 m (60 m x 90 m including laydown area). This gives estimated minimum land requirements (including laydown) of:

- Steam Condensing Plant: 5,400m²
- Binary Plant: 10,500m²

However, taking into consideration local site factors and specific plant requirements (terrain characteristics, operations facilities, maintenance facilities etc.), the proposed plant layout as presented in Figure 4-2 has a land requirement estimate of 20,000 m², for the largest case binary plant option – including laydown / spoil areas. Approximately 10% of the power plant site will be concreted and the rest covered with gravel.

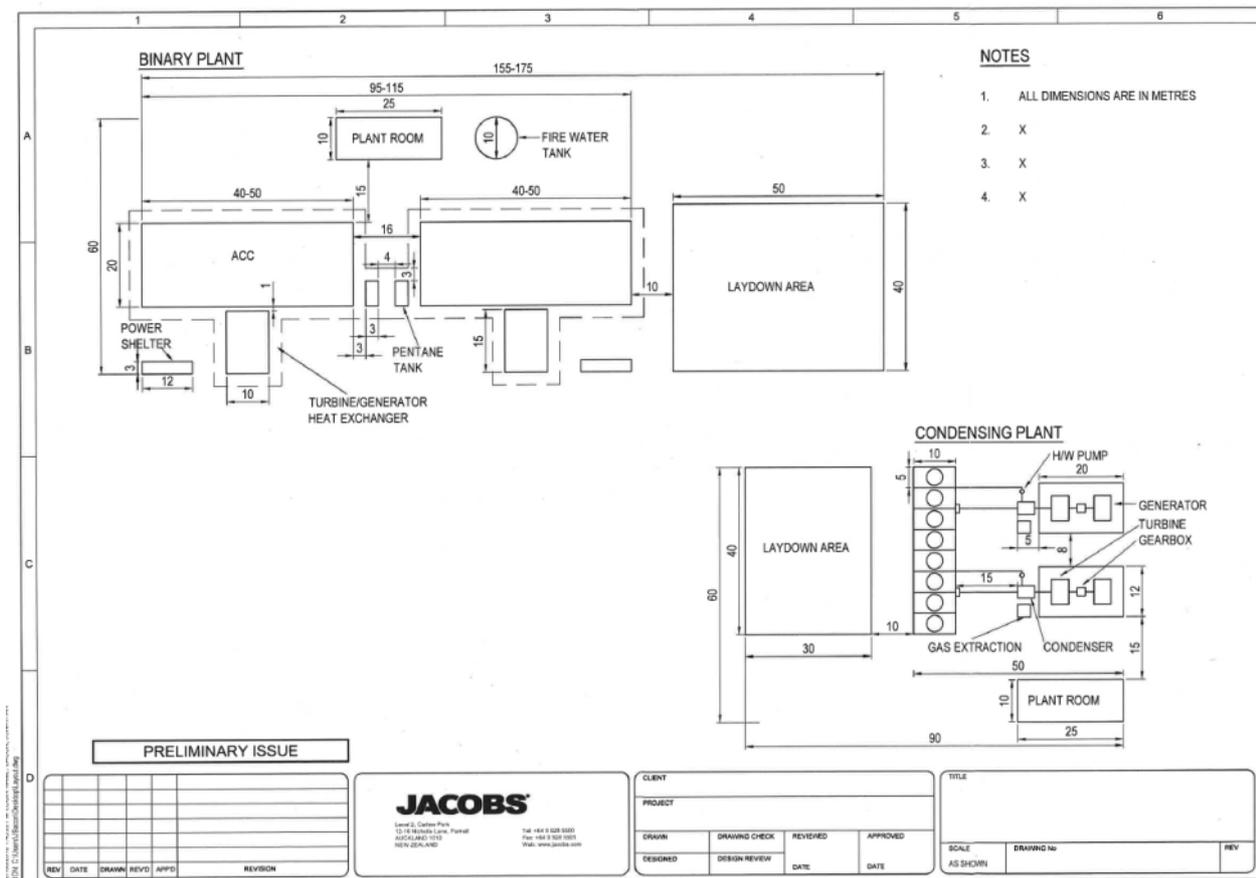


Figure 4-15: Nominal land area required for 2 x 3.5 MW_e binary and steam condensing technologies

4.5.2 Steamfield

The felling of trees and other shrubs will be necessary in constructing an injection pipe corridor. Given the relatively small size of the project the brine transmission pipes will likely be limited to a diameter of DN 250-300mm (12” inches). A corridor of 3-5 metres wide will be required to enable access during construction. Expansion loops are required every ~100 m to account for expansion of the steel on contact with the hot brine. A number of trees will need to be felled to allow for space and construction access. A typical expansion loop is shown in Figure 4-16.



Figure 4-16: Typical pipe expansion loop (large steam line, under construction)

The estimated land requirements for the steamfield and associated equipment, such as the sumps, separator and atmospheric flash tanks, and wellpads are:

- Preferred 3.25km Injection Line: 13,000m²
- Steamfield Equipment (includes pipes at PP): 1,700m²
- Sump at Power Plant: 600m²
- Wellpad WW-R1 & associated equipment: 2,000m²
- Wellpad WW-01 & associated equipment: 2,000m²

4.5.3 Switchroom & Transmission Line

The Project includes an indoor switchroom that will be located at the power plant site. This will connect to the transmission line that will connect to Laudat hydro power station to the north. The estimated land requirements are:

- Switchroom: 250 m²
- 300m Transmission Line: 300 m²

4.6 Hazardous Substances and Disposal

4.6.1 Geothermal Fluids

Uncontrolled discharges of geothermal fluids (brine and condensate) can be harmful to the environment. Brine can contain dangerous metals (such as arsenic) as well as other harmful substances (such as boron). These substances can leach into soils and accumulate if not remediated. Brine is also hot and could damage or kill flora and fauna in the vicinity of any discharge.

While geothermal condensate will contain far fewer quantities of hazardous materials, it can be rich in boron which will tend to accumulate in the cooling tower sludge. As noted in Section 3.3.3, the pH of this fluid is between 6.0 and 8.5.

All geothermal fluid should be captured and sent to injection wells. This is standard practice at most geothermal developments.

4.6.2 Working Fluid Storage

In a power plant utilising an ORC cycle the working fluid will require storage. The storage tank may require pressurisation depending on the volatility of the fluid selected.

Leakage of hydrocarbon working fluids and ancillary plant fluids such as oil presents a fire risk and a fire fighting system is normally integrated into the design.



Figure 4-17: Working Fluid Storage Tank with bunding and fire protection system (red piping)

4.6.3 Acid Storage

Depending on the nature of the geothermal fluids produced, acid dosing may be required as a pH modification step. This is required to adjust the pH of brine to ensure that Silica Saturation Index (SSI) limits are maintained within appropriate levels. The acid selected is normally concentrated sulphuric acid, though it may also be possible to use acetic acid. Based on the data obtained for WW-P1, it is not expected that there will be an issue with SSI for the envisaged steam separation pressures.

4.6.4 Antiscalant

Antiscalant dosing for prevention of calcite formation in the production well is likely to be required. This will be a poly-acrylate or poly maleic acid (PMA). Solutions will need to be securely contained and stored appropriately on site, with volumes and any controlled mixing undertaken dependent on scale accumulation in well and piping infrastructure.

4.6.5 Caustic Soda Storage

Caustic dosing from a skid mounted unit may be required to ensure the pH of the cooling water circuit is kept within appropriate limits. A system using pre-mixed sodium hydroxide is typical, although this may not be available in Dominica and it may be necessary to pre-mix the solution on site using bagged caustic soda.

4.6.6 Biocide Storage

For wet cooling towers biocide dosing is required to prevent build-up of biologic growth such as algae. Sodium Hypochlorite (NaOCl) is typical but must be shock dosed as otherwise the algae may become resistant to it. In this case other chemicals can be employed.

The biocide is stored in a tank to prevent degradation of biocide material (poly ethylene (HDPE) is common).

4.6.7 Dispersant

Cooling tower water dispersant(s) are chemicals that inhibit or prevent scale formation in the tower. As with caustic soda and biocide a bunded storage area is typical for all chemical storage tanks or containers. Bunding is usually specified to contain at least 110% of the volume of the largest tank and piping inside the bunded area.

Sumps would be provided to allow removal of hazardous chemicals with permanently located submersible pump(s) discharging into the cooling tower basin.

4.6.8 Turbine Lube Oil

Lubricating oil can cause adverse environmental impacts if leakage occurs. Plant areas will need to be bunded and have oily water separators to ensure any leaked or spilled fluids do not contaminate the site.

4.6.9 Disposal

These hazardous substances will be in use during the life of the plant and stored as described above. Disposal of the substances during the plants operation would only be required in the event of a spillage. In the event of a spillage, the bunding will contain most substances and it can then be collected to either be reused within the plant or injected into the injection well if appropriate. For other cases, specialist waste disposal contractors are employed. For the binary plant option, a spillage of the working fluid is a fire risk. In this case, the plant should be cleared and made safe and specialist waste disposal contractors brought in to collect and absorb the spillage.

5. Construction Activities

This section describes the construction activities typical for a condensing flash plant development. A binary plant development would not be significantly different.

5.1 Construction Overview

The construction activity will be concentrated on the main power plant, switchyard and separator station sites, but other work is required at the individual well-sites and in the piping corridors linking the wells to the power plant. Construction lay-down areas will be required for storage of equipment required for construction.

The plant for the construction works will include small drilling rigs, excavators, trucks, rollers, compactors, cranes, portable welders and generators and other items that are normal for such construction activities. It is not envisaged that a concrete batching plant will be required as concrete will be supplied by local plants. This requirement will be at the discretion of the EPC contractor.

The construction of the project is anticipated to last 18 months to two years, following the indicative schedule below.

	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Off-site preparatory work	■							
Site preparation		■	■					
Foundations for equipment and pipelines			■	■				
Powerhouse & permanent buildings				■	■			
Major equipment installation					■	■		
Interconnecting piping, wiring and instrumentation						■	■	
Switchyard and transmission line								■

5.1.1 Separation Plant, Power Plant and Switchyard Construction

In the early stages most activity would occur off-site, including detailed engineering design, placing of construction contracts, and factory manufacturing and testing. Initial on-site work will be limited to final surveying and geotechnical investigations.

Once engineering is sufficiently advanced, site preparation would commence. This work involves bulk earthworks, roading, and preparation of the construction site including establishing temporary construction facilities, security fencing, drainage controls and access control. Construction facilities include lay-down space for storage of equipment and materials awaiting installation, amenities (washrooms, lunchrooms, car-parking) for construction workforce, and construction management offices. Prior to the commencement of construction, sediment and erosion control measures will be constructed in accordance with the sediment and erosion control plan and any local regulatory requirements. The objective of these measures is to:

- Avoid, or minimise, any potential adverse environmental effects on water quality and aquatic ecosystems from soil disturbance activities required during the construction;
- Avoid, or minimise, any potential adverse environmental effects on water quality and aquatic ecosystems from any watercourse crossings required during the construction;
- Avoid, or minimise, any potential adverse effects on land instability both within the site and on neighbouring properties during the soil disturbance activities required during the construction.

Thereafter, site construction work progressively involves:

- construction of foundations for major structures, equipment and pipelines;
- construction of the powerhouse and permanent ancillary and amenity buildings;

- erection of major and ancillary equipment such as steam-turbine generators, cooling towers, pumps;
- interconnecting piping, electrical wiring and instrument installation;
- switchyard and transmission line construction and connection to the grid.

Concrete foundations for the separator station will be constructed, followed by the set up and welding of steel pipes to transport steam and fluids such as brine, condensate, two-phase fluid to and from the power plant. Separator station plant and equipment will also be installed. At the separator station the excavation of a holding pond (lined) for geothermal fluid discharges will be required.

Specific disposal areas for washing out empty concrete trucks would be set up, with a hose and bunded area for discharge of washwater. The contractor will regularly remove accumulated concrete washings and these will be disposed of to landfill, while the water will percolate through the base of the bunded area to the ground.

During the site construction phase the site work-force reaches its maximum, in this instance some 10's of persons. Co-ordination on the timing of electrical interconnection works, responsibilities for completion and mutual agreement on the technical aspects must be fulfilled with DOMLEC.

As the power plant installation nears completion, commissioning commences, testing initially without, and then with, geothermal fluid. An important facet of commissioning involves cleaning of steam piping by steam blowing. Once the entire plant has been brought into operation a range of performance and reliability tests are undertaken. Having completed and passed performance and reliability tests the plant is handed over for commercial operation.

5.1.2 Injection Pipeline Construction

The construction contractor will form walking tracks within the injection pipe corridor and install infrastructure services between the track and pipeline route. Concrete foundations for the pipeline will be constructed, followed by the set up and welding of steel pipes to transport the separated brine. The volume of water required for these foundations is minimal and will be sourced from local watercourses. Pipe bridges will need to be constructed over the intermittent watercourses within the site as appropriate, and dependent on final steamfield configuration.

Local ponds (lined) to drain accumulated geothermal fluid during the shutdown of the injection pipeline will be excavated at low points in the pipeline.

The plant required for the injection pipeline construction works will include small drilling rigs for creating foundations, mobile cranes, trucks to transport materials and equipment, generators for pipe welding as well as excavators and trucks for foundation excavations. The preferred option includes the construction of a 160 m suspension pipe bridge over Breakfast River gorge. This will require manual cartage or potentially use of a helicopter to transport materials into some of the more remote areas, to be decided by the contractor.

5.2 Port to Site Access

All equipment will be required to be transported by sea to the island. Dominica's main port is at Woodbridge Bay, about 2km north of Roseau. The berth at Woodbridge Bay is used by both cargo and cruise vessels. The port has two shore cranes with capacities of 27 tons and 46 tons respectively. The port is capable of handling breakbulk, containers, bagged cargo and pallets⁴.

⁴ <http://vertraco.nl/dominica/>



Figure 5-1: Woodbridge Bay Port

A preliminary transportation and logistics assessment indicates cargo handling capabilities at the port are sufficient. The existing road network is currently undergoing repair after the recent storms in 2015 and 2016. Following the completion of these works, the road will be suitable for the transport of equipment to the project site. The photos below show the road network when it was used to transport the drilling rig and equipment and traffic baseline monitoring has been undertaken on this route.



Figure 5-2: Access road to injection site (WW-R1) and football pitch (Caraïbes Environnement Developpement 2013)



Figure 5-3: Production site (WW-P1 right) from the southern access road (Caraïbes Environnement Developpement 2013)

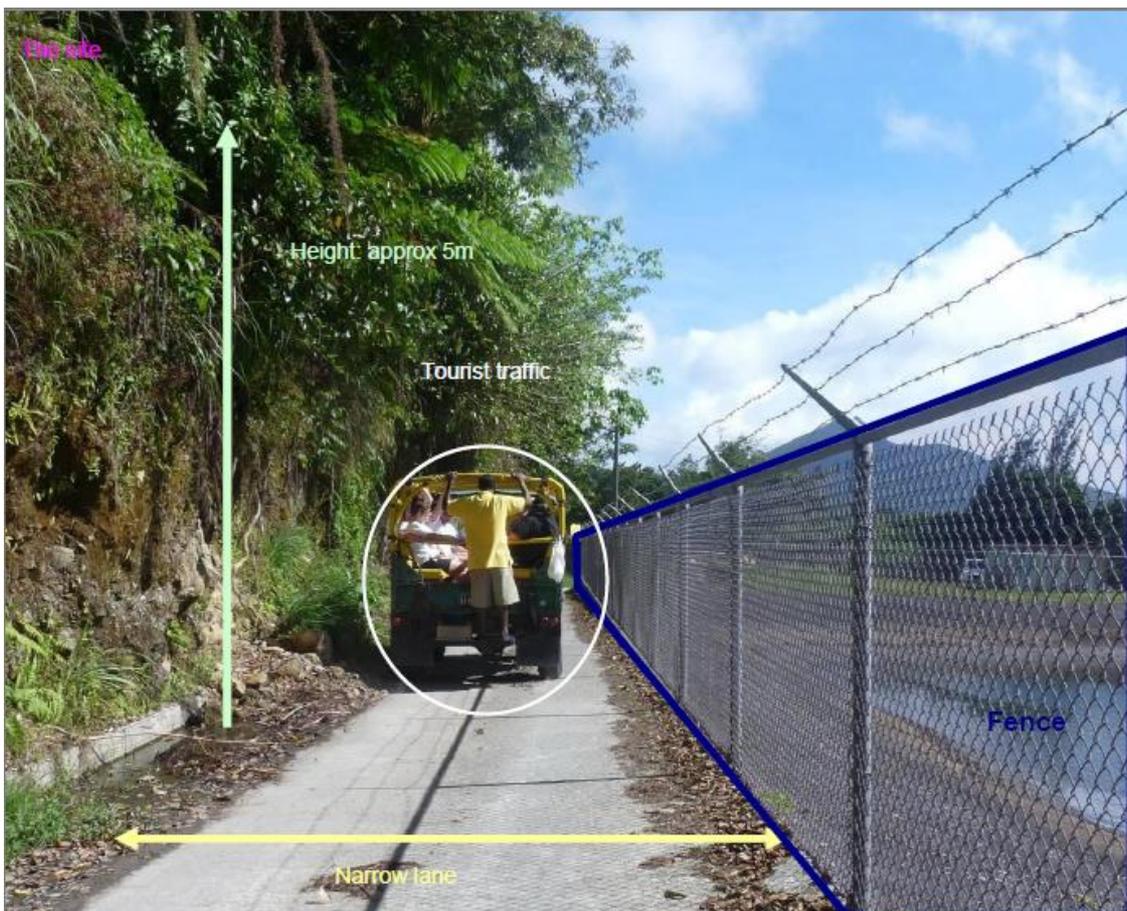


Figure 5-4: Access road west of the site – 2011 photo (Caraïbes Environnement Developpement 2013)

5.3 Local Site Access

The Laudat platform (containing WW-P1 and WW-03) is located close to the DOMLEC hydro balancing tank and is an open space cleared of vegetation, closed off with a gate (albeit in need of repair). The plots of land adjacent to the project are either open pasture, regenerating forest or planted with various types of fruit trees,

similar to the project site's original state. The area is not exclusively agricultural, with houses and a bar / restaurant situated close by to the north of the site. A paved road runs along the project site and enables access to the forest from the village of Laudat, as well as being the access road for two tourist sites (Titou Gorge and walking track to the Boiling Lake).⁵



Figure 5-5: Panoramic view from east of the Laudat (WW-P1) Platform Site (Caraïbes Environnement Développement 2013)

The injection site (WW-01) near Wotten Waven is located directly next to the road and in close proximity to several vendors and tourism attractions (hot pools). To the north is forested area with a few people undertaking small scale farming. Injection site WW-R1 is near the village of Trafalgar and is located in a wetland area characterised by low vegetation. It lies in a small valley that is closed off to the north and south by tree-covered foothills and peaks. The vegetation is natural and wooded on the hillsides, with little human activity due to the difficult access. As shown in Figure 5-6 below, the injection well site is in an inhabited and developed zone with natural and somewhat inaccessible surroundings on all sides.



Figure 5-6: Site WW-01 (left). View over Trafalgar (WW-R1) injection site (Caraïbes Environnement Développement 2013)

It is possible that construction activities relating to the power plant and steamfield may interfere with farming and subsistence activities on site. In addition to the local access roads there are existing tracks and routes for both private and public use near the Laudat site and on proposed injection line routes. Farm access will need to be maintained as far as practical during construction. The construction contractor and project owner will need to liaise with land owners to ensure construction works are co-ordinated with farming operations. This will be addressed further during the ESIA.

⁵ Caraïbes Environnement Développement, 2013

5.4 Temporary Facilities

5.4.1 Construction Laydown Areas

One main construction laydown area is required adjacent to the power plant and separation plant site for the storage of power plant construction materials. The final location of this area is still being discussed. Other laydown areas may be required depending on contractor preferences, such as alongside the main pipe corridor for storage of injection pipeline construction materials.

Each laydown area will be fenced with security and access control. The power plant laydown area will be a base location and include site construction offices, worker amenities, lighting, stores & warehouse containers and similar facilities. The other laydown areas will be used predominantly for the storage of piping and equipment for the injection pipeline.

5.4.2 Staff Amenities

Amenities and ablutions for the construction workforce will include:

- potable water supply from either a tanker-supplied storage tank, or a dedicated treatment plant;
- lunchroom with hot water facilities;
- ablutions as required for the workforce with either on-site (packaged septic treatment plant) or off-site disposal (i.e. portable latrines);
- showers (as required) and an effluent soakage system.

5.4.3 Utility Services

Temporary telecommunications and electric power will be required during construction. A connection to the existing telecom network will be required.

A dedicated construction power supply will also be required at the power plant site. It was noted in the Caraïbes 2013 EIA report that Roseau Valley is covered by drinking water and wastewater systems, electric power grids and a telephone network and that both WW-P1 and WW-R1 sites were close to electricity networks. The adequacy of these connections will need to be determined in conjunction with DOMLEC, and they may need to be supplemented by portable diesel generators during construction.

5.4.4 Water and Wastewater Systems

Raw water will be required during construction and ongoing operation and maintenance of the plant. Water abstraction for the Project will require an authorisation application to the “Minister for Housing Lands Settlement and Water Resource Management” (Caraïbes Environnement Développement 2013).

Raw water for construction and permanent works shall be drawn from a naturally occurring spring located at higher elevation above the site.

The Employer shall be responsible for obtaining the permit to use the water for construction and permanent works. The Contractor shall be responsible for the design, execution and completion of the raw water intake structure and piping required to transfer to Site.

Table 5-1: Proposed raw water supply information

Item	Natural Spring	Unit
1. Raw Water Source Location		
1.1 Latitude	15°19'58.20"	N
1.2 Easting	61°19'34.22"	W
1.3 Elevation	623	mASL
2. Water take limits		
2.1 Daily	10,000	Litres
2.2 Monthly	200,000	Litres
2.4 Maximum instant	5	Litres/s

Domestic wastewater from amenities at the power plant site will need be collected and treated in packaged plant to meet discharge requirements. The contractor will also have to have plant in place for the worker's camp.

The construction contractor may elect to construct and service a suitably sized on-site sewage treatment system to meet the requirements of construction staff at the site. If so, the contractor will need to maintain the treatment plant and associated effluent disposal system to meet any required discharge criteria and to prevent odour or other nuisance to the community during the period of construction. The contractor will typically be responsible for decommissioning and removing the unit at the end of the construction period.

5.5 Commissioning Activities

5.5.1 Steamfield Commissioning

5.5.1.1 Production Wellhead

The production well will be commissioned first before being put on-line with the two phase pipes. On start-up, it is possible for the wells to discharge debris such as stones and drilling residues as well as two phase fluid. The start-up method would be decided by the characteristics of the wells and the geothermal resource. It would be prudent to have an initial clearing discharge to the local silencer (rock muffler). The well will then be discharged to the local flash tank and brine will be captured in the wellpad sump.

5.5.1.2 Two Phase Pipeline from WW-P1 to Separator

The production well WW-P1 will be brought on-line and used to flush the two phase lines up to the separator.

During commissioning, brine disposal is initially to the wellpad sump, therefore, the duration of steam blowing or other tests may be limited by the available sump capacity. If necessary, activity may need to be suspended to allow the sump to be emptied, typically pumped to an injection well. Noise levels at locations where steam is discharged to atmosphere is expected to be similar to well testing noise levels but short lived.

5.5.1.3 Description of Steam Blow

Steam turbines are precision machines vulnerable to damage from any solid particles entrained in the steam. The manufacture and fabrication of piping results in solid matter being present inside the piping, and it is important to remove such contamination before finally connecting the pipework to the steam turbine. Removal of these solid particles from the pipe interior is accomplished by steam blowing wherein hot steam is passed through the piping at high velocity for a sustained period. Repeated exposure to the combination of thermal expansion / contraction and high fluid velocity is able to dislodge and remove the solid contaminants from the bore of the pipework. The source of steam for pipeline cleaning is the geothermal field itself, meaning that steam blowing occurs in the early stages of commissioning. The rock muffler may be used to discharge the

steam blowing vent to reduce noise emission. As the steam line is quite short it may also be possible to manually clean the line before commissioning.

An auxiliary steam blow will take place to clean power plant piping associated with systems such as steam ejectors. This will be done as per the procedure for the main steam line and may be carried out simultaneously. The remaining steam piping in the power plant from the governor valves to the turbine is then manually cleaned after the steam blows.

Pressure control valves (PCVs) provide steam pressure control. The PCVs will be removed and replaced by temporary spool pieces to allow steam blowing of the steam piping through to just upstream of the rock muffler. A temporary spool piece will also be installed on the end of the line to vent the steam above and away from ground level. Steam blow of the PCV lines can be done in conjunction with the main steam line.

5.5.1.4 Injection Pipeline

The cross-country injection pipeline will be flushed after construction and as part of a hydro-test. Location of a suitable discharge point will depend on the site piping layout and geometry, but is expected to be into one of the sumps at the injection wellpads.

5.5.2 Power Plant

5.5.2.1 General

Commissioning of the power plant involves a variety of activities. This is the first time that most of the equipment within the power plant will be tested. Listed below are some of the major aspects of the power plant commissioning phase.

5.5.2.2 Turbine Oil Systems

The turbine oil systems will be circulated and flushed through temporary filters in the lines. The only waste generated will be the temporary filters used during the process.

5.5.2.3 Cooling Water Pipes

Cooling water pipes will be flushed and the water will be circulated. Water used during the cleaning will be obtained from the site raw water supply and is usually discharged to the stormwater system. This water is then typically discharged to ground, pending environmental approval. No chemicals will be added during this process. Strainers will collect the minimal (handfuls) amount of debris expected to be generated and the debris will be taken to landfill.

5.5.2.4 Wet Cooling Towers (if provided)

The cooling towers will have their first basin fill during commissioning. This will come from the site raw water supply. It is expected the fill would be completed over a 24 hour period.

5.5.2.5 Biocide and Caustic Systems (if provided, for wet cooling tower chemical control)

These systems will receive first fill during commissioning. They will be located in separate areas that will be banded so any potential spillage would be a localised, rare event, and would be cleaned up by an approved disposal contractor.

5.5.2.6 Electrical Systems

The power plant and switchroom electrical systems will be energised under defined and controlled conditions according to contractor and grid operator guidelines.

6. Operation Activities

6.1 Typical Steamfield and Power Plant Operation Activities

The operation of the steamfield and power plant covers three phases:

- start-up;
- operation, and;
- shut-down.

6.1.1 Start-up

The start-up operation involves the start-up of the production well and the introduction of steam into the piping systems. Process drain valves are generally left open to remove condensate from the pipes and vessels, draining to storage sumps. Brine from the separator and AFT are discharged to the storage sumps at the power plant and separator station locations. Steam is vented to atmosphere through the steam vent valves located at high point vents as well as at the rock muffler located at the power plant.

6.1.2 Operation

During normal operation minimal steam venting occurs, the production steam is sent to the power plant and brine is sent to the power plant or directly to injection wells depending on the power plant technology. When all power plant systems are in operation, the power plant generates electricity which is exported to the grid.

6.1.3 Shut-down

Shut-down may be planned or due to unscheduled maintenance / outage or in some instances may involve a major transmission line outage. During shut-down the unit(s) stops generating electricity for export. The power plant vent valves will emit steam until the production wells are trimmed back to match the required remaining station demand. For a complete station shut the steamfield will be closed down and the steamfield piping systems will be drained to sumps at the wellpads as well as to the power plant sump. The production well will be either shut in or placed on bleed.

6.1.4 Emergency Shut down

If conditions arise that requires the power plant to immediately shut down, the plant systems will trip the power plant and steam will be directed away to the vent station. If during the emergency shutdown, the pressure continues to rise in the steamfield due to major equipment failure, the bursting discs may activate to release steam vertically to atmosphere. Under this situation the steam venting from the bursting disc will create a significant noise until the wells are shut in and geothermal fluids stop flowing.

This event is considered an emergency and is unlikely.

6.1.5 Maintenance

Unit maintenance would be undertaken to meet manufacturers, inspection agency and unit specific requirements. An inspection twelve months after commissioning is an anticipated requirement. Unit specific maintenance cycles will then be developed on the basis of the needs of the turbine generator sets. These are anticipated to be on a two to five yearly cycle, with early years of operation requiring more frequent maintenance. Given the expected power output of the plant and the quantity of electricity it will produce relative to the current grid demand, it is likely that outages would be scheduled during periods of low demand.

It is envisaged that a unit maintenance shut-down will occur annually. These annual shut-downs would be of about seven days in duration. Some specialised equipment (e.g. cranes) would be brought onto site for this work. The four yearly interval unit works takes about two to four weeks to perform (for a typical flash plant) and

an increased work force would be required. Additional labour resources would be engaged from local contractors and specialist providers.

Major steamfield maintenance and inspections will be undertaken during power plant unit shutdowns. The steamfield will be taken out of service during which time the separators, scrubbers and flash tanks will be inspected, cleaned and Non-Destructive Testing (NDT) would be carried out. Brine pumps and motors, valves and actuators will be inspected, overhauled and tested.

Other major maintenance work is associated with the steam production and injection wells, which require periodic workovers to remove any scale deposition.

6.2 Drilling Related Activities during Operation

The wells proposed for this project have been drilled and tested previously. Drilling activities related to new wells are not anticipated at the start of this project but at some point in the future it is likely that make up wells will be required to maintain operational requirements. An assessment of the impact of drilling new wells is considered outside the scope of this document and relevant ESIA, due to the uncertainty around all aspects of make-up wells required. A separate ESIA will be undertaken when make-up well requirements are well defined, at some point during the operation of the plant. Activities related to the maintenance of the already drilled wells, such as workovers, will occur during normal operation of the plant.

6.2.1 Cleanouts

In the course of the productive life of the wells, operational problems such as deposition of scale, silica, or calcite may develop in the wells affecting their operation. When this occurs, cleanouts using a drilling rig are sometimes required to restore the well's productivity or injectivity. Workover operations are of a relatively short duration (3 days to 15 days) and much of the ancillary equipment required to drill a new well is not required. A basic rig, substructure, BOP, pump and tank are generally sufficient. Water is used as the drilling fluid to avoid damaging permeable formations with drilling mud

6.2.2 Workover

A drilling workover generally entails some form of well repair which may require removing scale in the wellbore, removing the production liner, repairing the casing, deepening or side tracking the original bore, or plugging and abandoning all or part of the well.

The scale of a drilling workover operation falls somewhere between a new well and a clean out. Most of the ancillary equipment, i.e. cementing and mud handling equipment, and drilling consumables are often required.

Rather than scheduling periodic workovers or cleanouts, downhole antiscalant equipment may be fitted to wells. This will require regular site visits, both by operations staff and inhibitor delivering trucks. They will also require a garden shed sized hut on the wellpad to store the antiscalant.

6.2.3 Master Valve Change

Master valve changes can generally be undertaken without a drilling rig. The well is quenched by injecting cold water down the well in a controlled manner to prevent thermal stressing of the casing. Once the well is off-pressure the valve can be changed using a small crane. An alternative method used to change the master valve is installing a retrievable packer in the casing to isolate the well bore and so enabling the valve to be removed. The latter method requires a small drilling rig or other specialist packer installation equipment.

6.2.4 Make-up Wells

During the life of the station, declining output from the well supplying the plant will mean that it will be necessary to drill additional make-up wells to maintain the output from the plant.

The drilling operation required to drill new wells will depend on the total depth of the well, the types and sizes of casing to be used and the geological objectives / targets of the well. It can take between 30 and 60 days to drill a new well. New drilling pads may be required to accommodate the drilling rig, ancillary equipment and drilling waste disposal system. As well as the basic rig, up to four 30 m³ mud storage tanks, mud pumps, mud cooling towers, solids handling equipment, cementing equipment, air drilling equipment and various storage and accommodation huts are located on or nearby the wellpad. Quantities of consumables, casing, cement and drilling mud additives are used during the drilling of a new well.

Multiple wells may be drilled from a single wellpad and it is envisaged WW-P1 pad would be utilised in the first instance for any additional make-up well.

7. Decommissioning Activities

For the Dominica geothermal development, it is assumed that design practices will allow for the full decommissioning of the power plant and steamfield, should that be required at the end of the plants design life or before if unforeseen conditions make the development uneconomic.

7.1 Overview

Following decommissioning, the site would be restored or reclaimed to its approximate original condition or to some standard that results in stable environmental conditions. Typical activities during the decommissioning / reclamation phase include:

- closure of all facilities and wells;
- removal of aboveground components and gravel from well pads;
- access roads (if not maintained for other uses);
- other ancillary facility sites;
- re-contouring the surface, and;
- re-vegetation.

The site activities associated with decommissioning are similar to those required for construction. Impacts would be similar to those addressed for the construction phase; however, many of these impacts would be reduced by implementing good industry practices. Restoration during this phase would also ensure that impacts beyond the life of the geothermal development are avoided or minimized.

It is likely that for plant decommissioning on this scale, a specialist contractor would be engaged to oversee the entire plant and steamfield decommissioning for a lump sum. Disposal of waste products such as concrete may be an issue. Disposal at local landfills may overwhelm the existing facilities on Dominica and landfill waste may need to be transported offsite to some other facility.

7.2 Infrastructure Components

7.2.1 Wells

Wells that are no longer required for production can be plugged and abandoned. This will require a drilling rig and associated equipment. The well is first quenched to eliminate its productivity. The quantity of water required and time to quench the well is dependent on porosity of the structure below the well but will be similar on a day to day basis as drilling (up to 8,000 m³ / day). Cement is then pumped into the well bore to fully seal off the well. The cellar and the casing can then be removed if required but it is not good practice to locate permanent structures over abandoned wells. The steel components of the cellar can be sold for scrap but the concrete will have to be disposed at a landfill.

7.2.2 Steamfield Piping and Vessels

Equipment that is likely to be salvageable within the steamfield includes:

- Pipelines;
- Vessels;
- Valves (for steel);
- Pumps (depending on condition);
- Electrical components (for copper).

Pipeline supports are either

- pile type (i.e. buried in the ground to a given depth, surrounded by a concrete support) or;
- pad type (i.e. a large concrete pad to keep the support in place).

Pile type supports can either be removed from the ground completely or the support can be cut to a certain depth and the remaining steel and concrete buried over with topsoil. The support structure will be removed with a jackhammer and be disposed of to landfill.

The pad type support will be primarily all concrete except for the join between the pipe and the pad, which will contain metal. The pad will need to be removed and disposed of to landfill.

The pipe itself, provided it is good condition with minimal corrosion and minimal scaling on the pipe internals, can be recycled with an appropriate smelter if it is economic to do so. With the remote location of Dominica, removing the second hand pipe to an appropriate location may not be economically feasible.

The vessels, such as separation vessels, could be sold as second hand items or be sold to an appropriate recycling smelter. The foundations would need to be removed, as described previously.

Pumps and valves can either be sold as second hand equipment, depending on their condition, or sold as scrap items to be recycled or disposed of as required.

The copper in the electrical components, such as cables, will have recycling value and can be sold to an appropriate recycler. Other items which can't be salvaged will be sent to landfill.

7.2.3 Power Plant Equipment

If equipment items within the power plant are still in good working order, they can generally be sold second hand. Typical items would include:

- Flash Power Plants;
 - Turbine
 - Gas extraction equipment (steam ejectors, liquid ring vacuum pumps)
 - Condenser
 - Pumps (depending on condition)
- Binary Power Plants;
 - Turbine
 - Heat exchangers
 - Pumps (depending on condition).

Other items such as storage tanks can be sold for scrap so long as they are in a reasonable condition and if the cost of removal is equal or greater than the salvage value. Electrical equipment can be salvaged for its copper and other materials and sold to appropriate recycling entities.

The support structures for this equipment (foundations, support columns etc) will be disposed of to landfill. The structures will be required to be broken down to smaller components, likely by jackhammering, to allow for more manageable transport offsite to landfill.

7.2.4 Electrical Equipment

The electrical equipment, particularly the generator, will contain large quantities of copper which can be salvaged and sold.

The foundations will have to be removed as described previously.

7.2.5 Buildings

Modern building design and construction methods consider the whole life cycle of a building. These methods allow for the building to be removed after it has reached the end of its life without the need for total demolition and landfilling of all the components.

The building structure will typically be designed to be taken apart and if the structural members are in good condition they can be sold to an appropriate recycling smelter. The internals of the building will also be composed of large quantities of steel, access platforms for example, and can be disposed of with the structural members.

The structural concrete will need to be broken down into smaller, more manageable components and disposed of in the manner described in previous sections.

Electrical equipment within the building is likely to be too small scale to salvage (e.g. computers, lighting fixtures) and if they cannot be reused or recycled will likely be sent to landfill.

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Appendix C. ESIA Terms of Reference



Dominica Geothermal Development – Environmental and Social Impact Assessment

Ministry of Foreign Affairs and Trade

Terms of Reference (ToR)

RZ020300-0000-NP-RPT-0001 | Version 7

July 2018



Dominica Geothermal Development – Environmental and Social Impact Assessment

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Document history and status

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2	23 Nov 2016	Changes following requests by World Bank	P Gabriel / Dorney Burgdorf	B Clarke	A Brookes
3	10 January 2017	Changes following further clarifications by World Bank	P Gabriel / Dorney Burgdorf	B Clarke	A Brookes
4	10 April 2017	Changes following further clarifications by World Bank	P Gabriel / Dorney Burgdorf	B Clarke	A Brookes
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Important note about your report

The sole purpose of this report and the associated services performed by Jacobs New Zealand Limited (Jacobs) is to provide a Terms of Reference for the Dominica Geothermal Power Plant Environmental and Social Impact Assessment in accordance with the scope of services set out in the contract between Jacobs and the Client (New Zealand Ministry of Foreign Affairs and Trade). That scope of services, as described in this report, was developed with the Client.

In preparing this report, Jacobs has relied upon, and presumed accurate, any information (or confirmation of the absence thereof) provided by the Client and/or from other sources. Except as otherwise stated in the report, Jacobs has not attempted to verify the accuracy or completeness of any such information. If the information is subsequently determined to be false, inaccurate or incomplete then it is possible that our observations and conclusions as expressed in this report may change.

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The report is based on information supplied by Jacobs' Client and from information held by Jacobs for the Environmental and Social Impact Assessment project.

The report is based on information supplied by Jacobs' Client and from information held by Jacobs for the ESIA. This report has been prepared on behalf of, and for the exclusive use of, Jacobs' Client, and is subject to, and issued in accordance with, the provisions of the contract between Jacobs and the Client. Jacobs accepts no liability or responsibility whatsoever for, or in respect of, any use of, or reliance upon, this report by any third party.

Glossary

ASL	Above Sea Level
DOMLEC	Dominica Electricity Services Limited
DOWASCO	Dominica Water and Sewerage Company Limited
EIA	Environmental Impact Assessment
EHS	Environmental Health and Safety
EP	Equator Principles III (2013)
EPC	Engineer, Procure and Construct
GoCD	Government of the Commonwealth of Dominica
ESMS	Environmental and Social Management System
EPFI	Equator Principle Financial Institutions
ESMP	Environmental and Social Management Plan
ESIA	Environmental and Social Impact Assessment
IFC	International Finance Corporation
IUCN	International Union for Conservation of Nature
kV	Kilovolt
kW	Kilowatt
MW	Mega Watt
MWe	Mega Watt Electric
NO _x	Oxides of Nitrogen
NO ₂	Nitrogen Dioxide
ORC	Organic Rankine Cycle
OUV	Outstanding Universal Value
O ₃	Ozone
PM _{2.5}	Ultra-fine Particulate Matter
PM ₁₀	Fine Particulate Matter
PS	Performance Standard
SEP	Stakeholder Engagement Plan
SO ₂	Sulphur Dioxide
ToR	Terms of Reference

1. Introduction

1.1 Background

The Commonwealth of Dominica is a small island developing state in the Caribbean Sea with a population of approximately 72,000 people and a land area of approximately 750 km². About 60% of the land is classified as a World Heritage site by UNESCO, due to its rich biodiversity. It is located near the centre of a string of islands known as the Lesser Antilles, between the neighbouring French territories of Martinique and Guadeloupe. The capital Roseau is located to the south-west of the island and has a population of around 15,000 people.

Dominica’s power system relies heavily on diesel imports to generate electricity. Changing the power generation mix and reducing the cost and volatility of electricity prices have become development priorities for Dominica. To this end the Government of the Commonwealth of Dominica (GoCD) has pursued an exploration programme to evaluate the viability of geothermal resource in the Roseau Valley (Figure 1-1).

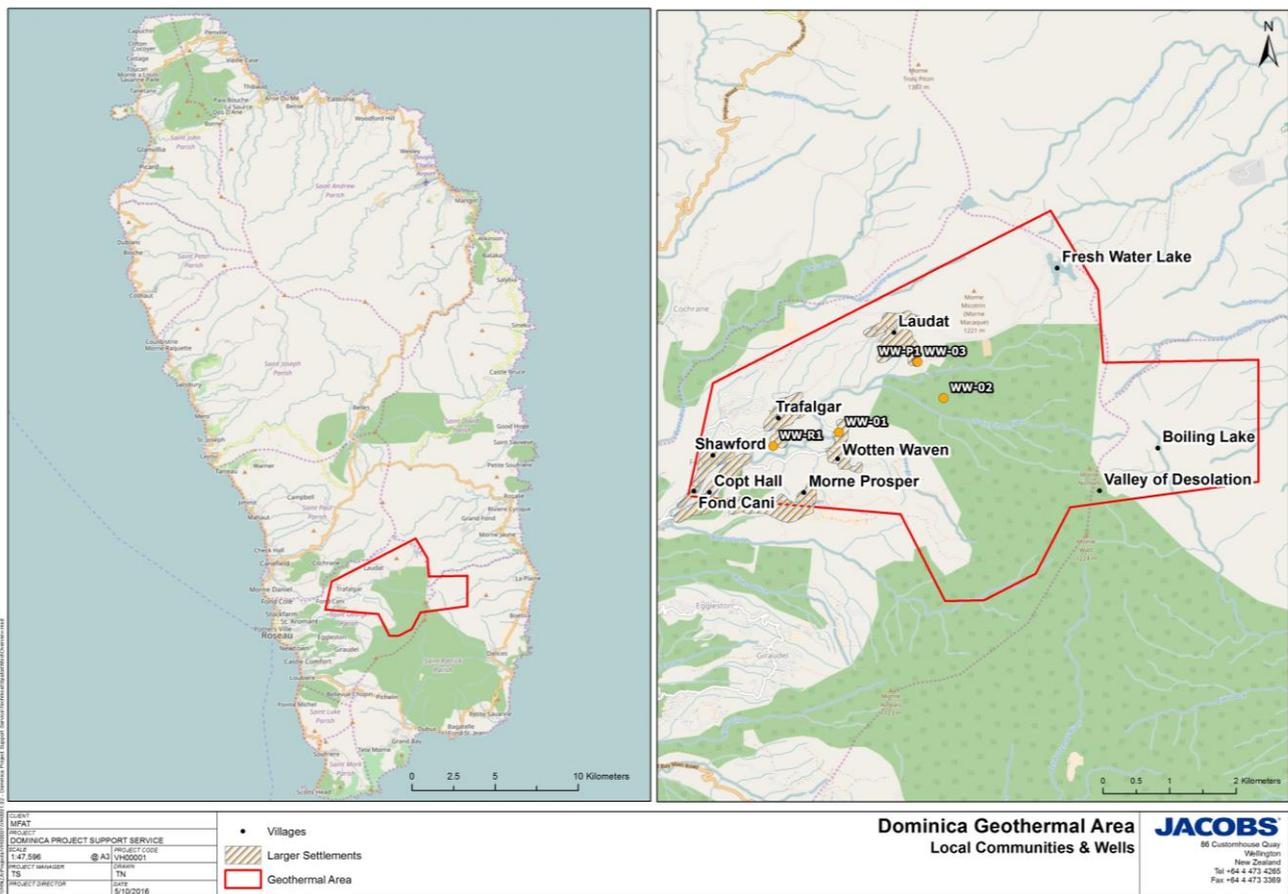


Figure 1-1: Location of Roseau Valley (Site of proposed Geothermal Power Plant)

The exploration programme has been conducted in a phased manner over the course of approximately 10 years:

No.	Phase Name	Activities
1	Preparation	Project establishment, geoscientific investigations
2	Exploration	Exploration drilling of 3 slim hole wells and resource assessment
3	Production	Production drilling of one full size well and one reinjection well
4	Construction	Present phase comprising power plant construction and start-up

The GoCD has previously taken the leadership to complete the successful drilling of exploration, production and injection wells in order to enable a geothermal power project in Dominica. The exploration campaign, which has been focussed in the Laudat-Wotten Waven-Trafalgar geothermal field, has proven the existence of a geothermal resource suitable for power generation.

The Government now wishes to complete the project by establishing the Dominica Geothermal Development Company Ltd (DGDC) to develop a 7 MW geothermal power plant and sell electricity to DOMLEC. The project company will be 100%-owned by GoCD, being established as a private company under the laws of the Commonwealth of Dominica. Electricity will be sold to DOMLEC, under the regulatory framework established through the Electricity Supply Act 2006. The project will be financed using grant monies from international agencies and bilateral partners, the World Bank and with the Government's own resources.

Prior to the construction and commissioning of the Geothermal Power Plant an assessment of the potential environmental and social impacts of construction and operation of the power plant and associated infrastructure is required in accordance with local legislation and international lending institution safeguards.

1.2 Purpose of the Terms of Reference

The Terms of Reference (ToR) describe the scope of the Environmental and Social Impact Assessment (ESIA) that will be carried out to evaluate the potential positive and negative impacts of construction and operation of the project in accordance with the requirements identified in Section 2. In addition it describes the process of identifying and implementing appropriate controls to avoid, mitigate and/or offset potential environmental and social impacts.

1.3 Structure of Terms of Reference

The structure of the ToR is set out as follows:

- Section 1 – Introduction
- Section 2 – Legislative Requirements
- Section 3 – Project Description
- Section 4 – ESIA Scope of Works

2. Legislative Requirements

It is important that a geothermal development meets internationally accepted environmental and social safeguard standards in order to ensure that benefits to project affected people are maximised and that potential adverse environmental and social impacts are minimised.

2.1 Local Legislation

With sole responsibility for physical development of land in Dominica, the GoCD manages physical development through the Commonwealth of Dominica Physical Planning Act 2002. In accordance with this Act, development permission is required before the construction of the project may commence. Clause 17 of the Act states:

'No person shall carry out any development of land except under and in accordance with the terms of a development permission granted in that behalf prior to the commencement of such development...'

Applications for development permission must be submitted to the Physical Planning Department within the Ministry of Agriculture and Environmental Protection along with an Environmental Impact Assessment (Clause 20(1)(b)). As defined in the Act an Environmental Impact Assessment (EIA) means:

- *'The environmental appraisal which will identify positive and negative impacts on the site, the immediate communities as well as on the wider regional context.'*
- *The environmental assessment includes the direct impact of each project component as well as on the physical, socio-economic and socio-cultural features of the site, the immediate communities as well as the wider regional context.'*

Before carrying out an EIA a Terms of Reference should be submitted to the Ministry for review in order to confirm the scope of the EIA.

In accordance with Clause 22(1) the Chief Physical Planner may require the applicant to:

- a) *Publish details of his application at such times, in such places and in such manner as may be specified in the notice;*
- b) *Give details of his application to such persons or authorities as may be specified in the notice.*

Further, as specified in Clause 22(3), where an EIA is required, the Authority shall:

- a) *publish a notice in at least one daily newspaper and affix a notice on the land to which the application relates that an application to develop land has been received and will be determined on a date specified in the notice; and*
- b) *invite comments and representations either in writing or orally on such application.*

The Chief Physical Planner may also *'consult in writing any public officer or other person who appears to him to be able to provide information relevant to an application for development permission to enable the Chief Physical Planner to advise the Minister or the Authority, as appropriate, with regard to the application'* (Clause 24 (1)).

The ESIA will be approved by the Physical Planning Department of the GoCD in consultation with relevant Departments (i.e. the Environmental Coordinating Unit, Lands and Surveys Department, Environmental Health and Safety Department). Monitoring of the implementation of Environmental and Social Management Systems will be conducted by the Environmental Health and Safety Department.

2.2 International Standards

As the World Bank has indicated its intention to provide funding to the development, the project is also required to demonstrate compliance with the World Bank Performance Standards for Private Sector Activities, OP 4.03,

(WBG, 2013) and the WBG Environmental, Health, and Safety Guidelines (hereafter referred to as the 'EHS Guidelines').

2.2.1 Categorising the Project

In accordance with the World Bank's Operational Policy, the World Bank undertakes environmental screening of each proposed project to determine the appropriate extent and type of Environmental Assessment (EA) needed. The Bank classifies the proposed project into one of three key categories, depending on the type, location, sensitivity, and scale of the project, as well as the nature and magnitude of its potential environmental impacts.

- **Category A:** A Category A project is likely to have significant adverse environmental impacts that are sensitive, diverse, or unprecedented. These impacts may affect an area broader than the sites or facilities subject to physical works. The EA for a Category A project examines the project's potential negative and positive environmental impacts, compares them with those of feasible alternatives (including the "without project" scenario), and recommends any measures needed to prevent, minimise, mitigate, or compensate for adverse impacts and improve environmental performance. For a Category A project, the borrower is responsible for preparing a report, normally an Environmental Impact Assessment (or a suitably comprehensive regional or sectoral EA).
- **Category B:** A Category B project has potential adverse environmental impacts on human populations or environmentally important areas - including wetlands, forests, grasslands, and other natural habitats - which are less adverse than those of Category A projects. These impacts are site-specific; few if any of them are irreversible; and in most cases mitigatory measures can be designed more readily than for Category A projects. The scope of EA for a Category B project may vary from project to project, but it is narrower than that of Category A assessment. Like Category A, a Category B environmental assessment examines the project's potential negative and positive environmental impacts and recommends any measures needed to prevent, minimize, mitigate, or compensate for adverse impacts and improve environmental performance. The findings and results of EA for Category B projects are described in the project documentation (Project Appraisal Document and Project Information Document).
- **Category C:** A Category C project is likely to have minimal or no adverse environmental impacts. Beyond screening, no further EA action is required.

All Category A and Category B Projects require an assessment process to address the relevant environmental and social risks and impacts of the proposed project in accordance with the applicable standards (i.e. WBG IFC Performance Standards and/or the WBG Environmental and Social Framework and the WBG EHS Guidelines). The assessment documentation should propose measures to minimise, mitigate, and offset adverse impacts in a manner relevant and appropriate to the nature and scale of the proposed project. For Category A, and as appropriate, Category B Projects, the assessment documentation includes an Environmental and Social Impact Assessment (ESIA), Environmental and Social Management Plan (ESMP) and Environmental and Social Management System (ESMS).

The assessment process should, in the first instance, address compliance with relevant host country (Dominica) laws, regulations and permits that pertain to environmental and social issues and with the IFC Performance Standards and EHS Guidelines.

Based on a description of the project (Section 3), a review of previous studies, summarised in Section 4.2 and a preliminary risk assessment (Section 4.4) carried out by Jacobs New Zealand Limited (Jacobs) it is considered the project should be given a preliminary classification of **Category A**. This is for the following reasons:

- Based on the initial preliminary risk assessment, most of the potential social and environmental impacts have been determined to be of low risk (i.e. to be managed by routine procedures) and would therefore not require any additional design mitigation.
- The route injection line Option C (Figure 3-4) passes close to the residential area of Laudat and therefore there may be adverse impacts due to:
 - Potential physical relocation or infringement of land use for residents of Laudat. Such displacement is undesirable and also not expected to occur, but cannot be completely ruled out at this stage.

- Potential disturbance of habitat (i.e. through vegetation removal) that has been classified as 'high' sensitivity by Caraibes Environment Development (2015a/b). High sensitivity areas were classified as those that contained the following:
 - A high number of protected species inside (IUCN, French and Dominican legislation);
 - An area with very few anthropic influences; or
 - A high number of endemic species (Dominican and Caribbean).
- Three of the potential power plant sites (Option 1A, 1 and 3 – see Figure 3-3)) fall within habitat that has been classified as 'high' sensitivity by Caraibes Environment Development (2015a/b).

It should be noted that the habitat classification carried out by Caraibes Environment Development in 2015 was done at a high level when the potential reinjection line routes and power plant sites were not known. Assigning the project as Category A is a precautionary approach at this stage based on the current level of uncertainty with site locations of reinjection lines and the power plant. This categorisation will be confirmed following site visits in December 2016 and by further studies through the ESIA process.

2.2.2 World Bank Performance Standards for Private Sector Activities May 2013

As the project is considered a private sector led economic development project, the following World Bank Performance Standards would apply to the project (note that these standards are equivalent to the IFC Performance Standards – Appendix A (IFC, 2012):

- Performance Standard 1: Assessment and Management of Environmental and Social Risks and Impacts;
- Performance Standard 2: Labor and Working Conditions;
- Performance Standard 3: Resource Efficiency and Pollution Prevention;
- Performance Standard 4: Community Health, Safety, and Security
- Performance Standard 5: Land Acquisition and Involuntary Resettlement;
- Performance Standard 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources;
- Performance Standard 7: Indigenous Peoples; and
- Performance Standard 8: Cultural Heritage.

2.2.3 General and Industry Specific EHS Guidelines

In addition to the performance standards, the WBG has developed Environmental, Health and Safety (EHS) Guidelines covering both general and industry specific issues. The EHS Guidelines contain the performance levels and measures that are normally acceptable to WBG and are generally considered to be achievable in new facilities at reasonable costs by existing technology. The environmental assessment process may recommend alternative (higher or lower) levels or measures, which, if acceptable to the financiers, become project or site-specific requirements.

In general, when host country regulations differ from the levels and measures presented in the EHS Guidelines, projects are expected to achieve whichever is more stringent. If less stringent levels or measures are appropriate in view of specific project circumstances, a full and detailed justification for any proposed alternatives is needed as part of the site-specific environmental assessment. This justification should demonstrate that the choice for any alternate performance levels is protective of human health and the environment.

The General EHS Guidelines became available for use in April 2007 and will be used in the preparation of the ESIA Report and supporting technical analysis. The industry specific guidelines are as follows:

- Geothermal Power Generation, and
- Electric Power Transmission and Distribution.

2.2.3.1 Environmental, Health and Safety General Guidelines (April, 2007)

The EHS Guidelines cover the following key areas:

Environmental

The general environmental guidelines are:

- Air Emissions and Ambient Air Quality
- Energy Conservation
- Wastewater and Ambient Water Quality
- Water Conservation
- Hazardous Materials Management
- Waste Management
- Noise

Occupational Health and Safety Guidelines

The general occupational health and safety guidelines are:

- General Facility and Design and Operation
- Communication and Training
- Physical Hazards
- Chemical Hazards
- Biological Hazards
- Radiological Hazards
- Personal Protective Equipment
- Special Hazard Environments
- Monitoring

Community Health and Safety Guidelines

The general community health and safety guidelines are:

- Water Quality and Availability
- Structural Safety of Project Infrastructure
- Life and Fire Safety
- Traffic Safety
- Transport of Hazardous Materials
- Disease Prevention
- Emergency Preparedness and Response

Construction and Demolition Guidelines

The general construction and demolition guidelines are:

- Environment
- Occupational Health and Safety
- Community Health and Safety

2.2.3.2 Environmental, Health and Safety Guidelines for Geothermal Power Plants (April, 2007)

These guidelines provide a summary of EHS issues associated with geothermal power generation and recommendations for their management. These include:

Environmental

Environmental issues that may occur during geothermal power generation projects, include the following:

- Effluents
- Air emissions
- Solid waste
- Well blowouts and pipeline failures
- Water consumption and extraction

Occupational Health and Safety

Occupational health and safety issues during the construction and decommissioning of geothermal power generation projects are common to those of other industrial facilities and their prevention and control are discussed in the General EHS Guidelines. Specific health and safety issues in geothermal power projects include the potential for exposure to:

- Geothermal gases
- Confined spaces
- Heat
- Noise

Community Health and Safety

Community health and safety issues during the construction and decommissioning of geothermal power generation plants are common to those of most large industrial facilities, and are discussed in the General EHS Guidelines. Community health and safety issues during the operation of geothermal power generation plants include:

- Exposure to hydrogen sulphide gas
- Infrastructure safety
- Impacts on water resources

Performance indicators and monitoring for each of the issues listed above follows the advice provided in the General EHS Guidelines.

2.2.3.3 Environmental, Health, and Safety Guidelines for Electric Power Transmission and Distribution

The EHS Guidelines for Electric Power Transmission and Distribution sets out relevant information that needs to be considered in the environmental and social impact assessment of transmission lines between a generation facility and a substation located within an electricity grid. Key issues covered include:

- construction and maintenance of Right of Way and impacts on terrestrial habitats;
- electric and magnetic fields (EMF);
- hazardous materials; and
- occupational health and safety.

2.2.4 Other Relevant Treaties and Legislation

International treaties that Dominica is signatory to and any local Dominican legislation will be listed and a summary of key requirements will be included in the Policy, Legal and Administrative Framework section of the ESIA.

The project is located approximately 400 m from the Morne Trois Piton National Park UNESCO World Heritage Site and as such the assessment of potential impacts will be completed in line with International Union for the Conservation of Nature (IUCN) World Heritage Advice Note on Environmental Assessment.

3. Project Description

3.1 Overview

The project comprises the construction, completion, testing, commissioning, ownership and operation of geothermal wells, steam gathering and reinjection system, power plant with nameplate capacity of 7MW and connection to electrical grid and associated infrastructure in the Roseau Valley, Dominica.

The preliminary design for the project is ongoing with detailed design to be completed following a formal tender process for an Engineer, Procure and Construct contractor(s). Therefore some of the descriptions provided in this Section are high level and typical of a geothermal development in this setting.

Geothermal projects connect production wells through a steamfield facility to a power plant which is connected to an electricity grid. Geothermal fluids consist of steam, hot water (brine) and a small quantity of non-condensable gases (mostly carbon dioxide, but also some hydrogen sulphide). Used geothermal fluids produced by the project (separated brine and steam condensate) are returned to the geothermal reservoir via reinjection wells, which may be located some distance away (i.e. over 1 km) from the production wells to avoid short-circuiting or premature cooling of the production wells.

The key components of the proposed 7 MW power plant include:

- Power plant comprising 2 x 3.5 MW units or a single 7 MW unit (either Steam Rankine Cycle or Organic Rankine Cycle units).
- Production well at WW-P1 - The existing geothermal production well, WW-P1 at Laudat, is indicated to have potential to generate 6 to 9 MWe of geothermal electricity and will be the sole production well for the project. In the event that there is a decline in production well output to a level that will no longer sustain the full operation of the power plant, a workover of WW-P1 may be required or it might be necessary to drill an additional make-up well which would also be located on pad WW-P1
- Reinjection to wells WW-R1 and WW-01 - The used geothermal fluid (brine and possibly some steam condensate) produced from production well WW-P1 would be disposed of into reinjection wells WW-R1 and WW-01 in Trafalgar and Wotten Waven respectively via a 30 cm diameter pipeline of up to 4 km in length. WW-R1 will require injection of cold water for a period of up to three months to improve reinjection capacity prior to commissioning.
- Steamfield infrastructure including two phase piping, steam separators, atmospheric flash tank, steam gathering system, brine collection and disposal system, condensate collection and disposal system, pressure relief system and storage sump.
- Supporting Infrastructure including well pads, turbine building, primary and ancillary equipment, cooling system, road network and water/waste water supply.
- Substation and interconnection to the DOMLEC electricity grid via a transmission line to Laudat Power Plant.

Further description of the proposed technology and land requirements is provided below.

3.2 Power Conversion Technologies

Energy can be extracted from both brine and steam, or a mixture thereof, and turned into electric power. There is much more energy in steam than in hot water and even though the ratio of brine to steam produced by WW-P1 is about 5:1, most energy still lies in the steam phase. There are two main power plant technology options, steam Rankine cycle or organic Rankine cycle, either of which is suitable:

1) Steam Rankine Cycle

Geothermal steam is used directly in a steam turbine connected to a generator. After the steam passes through the steam turbine it can either be condensed or discharged directly to atmosphere. The atmospheric discharge option (sometimes called a back pressure turbine) is not recommended for the initial project development as

this can create a significant visual plume, it would only achieve ~3.5 MW output and there would be substantial work required to retrofit and convert the turbine to a condensing option.

2) Organic Rankine Cycle (ORC)

The geothermal fluids pass heat to an organic working fluid which boils and the organic vapour then drives a turbine connected to a generator. These are often also called 'Binary Cycle' plants because they use two fluids (the original steam and the organic secondary fluid). Organic Rankine Cycle plants may use brine, steam or two-phase fluids produced from the wells, with any of the options potentially providing a suitable solution.

3.3 Cooling System

A cooling system is required to reject heat which cannot be converted to electric power. This can either be air (dry) cooling or water (evaporative) cooling. The main differences between the two are: the land area required for the cooling towers; the visual impact of the equipment; overall efficiency; visual emissions, the reinjection load and the total installed cost.

- Organic Rankine Cycle plants are usually configured with air coolers, but they can be specified to use water cooling. Air coolers do not have a visible plume of water vapour, but may exhibit a heat haze and typically have a larger land footprint than water coolers.
- Wet cooling towers are typically used with condensing Steam Rankine Cycle plants. They have the advantage that part of the steam condensate is evaporated, so the total amount of liquid to be injected is less than for air cooling. However, water cooling towers may have a visible plume of water vapour when the relative humidity of the atmosphere is high.

A hybrid cooling option (which includes a small amount of dry cooling) can provide an alternative which removes the visual plumes of water vapour from water cooling towers, but comes at a slightly increased cost. The cooling system will typically be closely integrated with the power plant and supplied as part of the overall power plant package.



Figure 3-1: Turbine Hall and Evaporative Cooling Tower (left). Air cooling for 20MW plant (right)

3.4 Steamfield

The steamfield will comprise of the following:

- 1) A single production well on WW-P1 located in Laudat. Separation of steam and brine will take place on the production pad, with steam being transferred via a pipeline to the power plant, which would be located adjacent to the production well pad. River water was utilised for drilling and it is expected that existing infrastructure may be used for the provision of water for the power plant.
- 2) Approximately 3 km of cross-country pipelines to take hot brine for reinjection into two wells, WW-R1 and WW-01. The specific route for the brine line has not yet been confirmed (refer Section 3.7.2).

- 3) Well WW-03 located adjacent to WWP1 or WW-02 may be used for condensate injection, although this requirement will depend on the technology selected.

The steamfield equipment plays several important roles in the safe and reliable operation of a geothermal plant:

- Handling variable multi-phase steam, brine and non-condensable gas flows while ensuring that neither production wells nor reinjection wells are adversely affected by its operation.
- Matching the supply of steam to the power plant with the demand for steam from power plant as it changes in response to fluctuations in electricity demand.
- Providing clean steam (or brine) to the steam turbine or the Organic Rankine Cycle heat exchangers.
- Disposing of spent fluids into reinjection wells.

The steamfield will take production of two-phase fluid from WW-P1. Although in the current project only one production well is envisaged, the addition of future wells will be considered in the layout and design of pad WW-P1. The two-phase fluid will be sent to a separator where it will be divided into steam and brine phases, before flowing to the power plant (depending on technology) or reinjection pipeline. It may be necessary to install two separators if a two-phase development approach is chosen.

Separators may be vertical or horizontal, with major differences being the space required, tolerance to changes in geothermal fluids and overall efficiency. The separator is best located close to the production well and so is likely to be installed on the WW-P1 well pad. Other key pieces of equipment to be housed on this pad will depend on the final technology selected, but may include an atmospheric flash tank, steam venting and pressure control system, and storage sumps.

If a steam condensing turbine option is selected there is a requirement to inject the condensate produced. This is normally done via a dedicated pipeline to a different well than that used for brine injection because condensate has different chemistry to that of the separated brine. However, this is not necessarily the case and in some instances there can be advantages in combining the flows to prevent silica deposition, depending on the chemistry. This will be addressed during the detailed design process. The volume of condensate produced is low compared with brine produced and, if required, it is recommended that condensate be injected into well WW-03, located on pad WW-P1 or to WW-02. Organic Rankine Cycle technology enables condensate to be recombined and reinjected with the brine.

The steamfield takes the used geothermal fluids to reinjection wells WW-R1 and WW-01. The steamfield pipeline will be insulated to reduce heat loss, which is necessary to avoid deposition of silica. It will be clad in aluminium or other appropriate material and may be coloured or camouflaged to reduce visual impacts. The reinjection pipeline must operate at high temperature and pressure and needs to be carefully designed with suitable supports and guides which safely allow for thermal expansion of the pipe between its hot and cold states. This will require vertical or horizontal u-bends.

3.5 Civil Works

Three existing well pads will be used for the development WW-P1, WW-01 and WW-R1. All sites will require remedial works to bring them up to standard, with an initial indication of the work required as follows:

- Site WW-P1: Site improvement, slope stabilization, drainage works, fencing, security lighting.
- Site WW-01: Site fencing, slope stabilization, improve road access.
- Site WW-R1: Site fencing, security lighting, disposal of material/ general clean-up.

WW-P1 will contain the majority of fluid production and separation equipment, with power generation equipment to be located on a newly created pad adjacent to WW-P1. The Government currently owns the well pads. However, additional land will be required for the power plant site and for the injection line piping system. The land required for the power plant, and hence civil works required to prepare the site, will depend on the power plant technology selected. Figure 3-2 provides nominal land area required for 2 x 3.5 MW power plants, with binary plant requiring an area of approximately 115 m x 60 m (plus laydown area) and steam condensing plant

requiring approximately 50 m x 40 m (plus laydown area). A larger scale version of this Figure is provided in Appendix B.

Land requirements are discussed in more detail in Section 3.7.

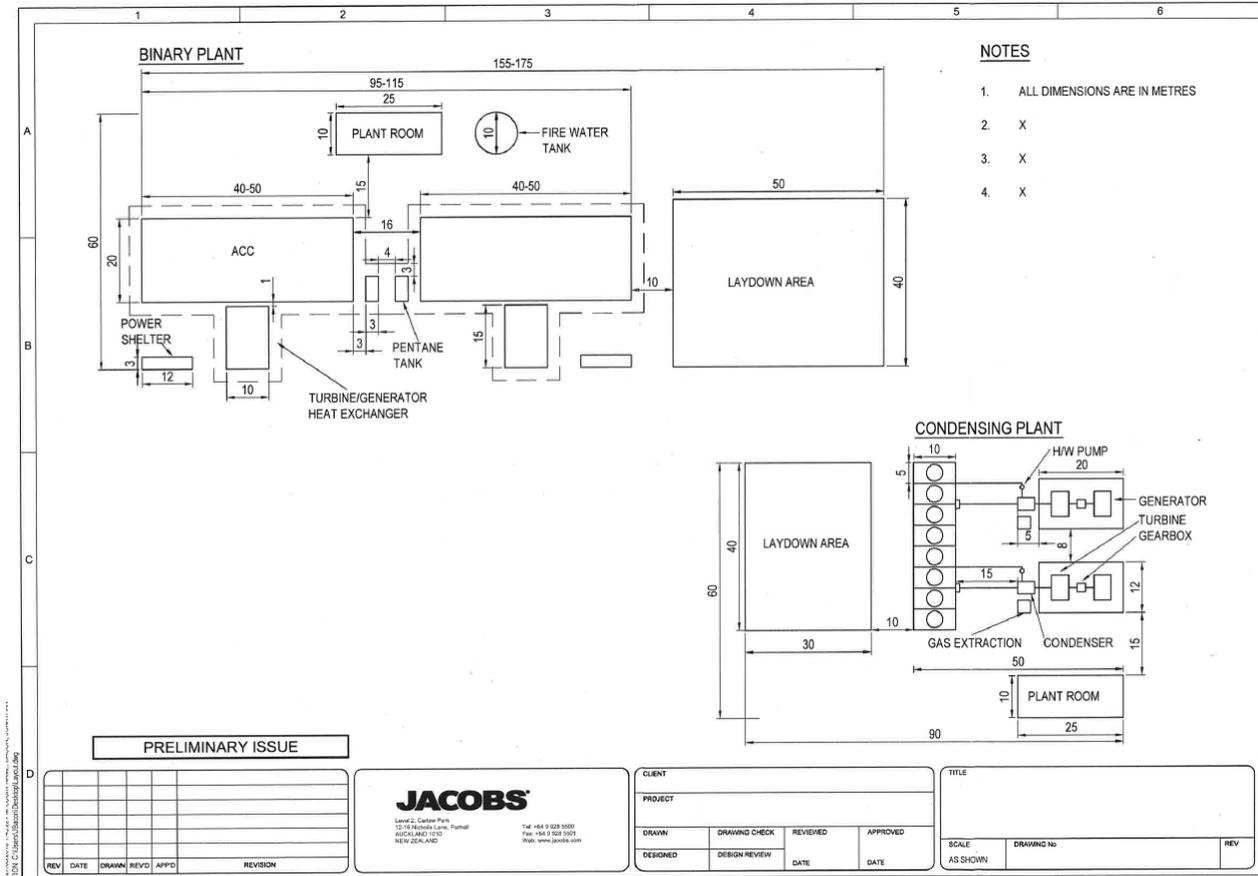


Figure 3-2: Nominal land area required for 2 x 3.5 MW binary and steam condensing technologies

The power plant will be constructed on a concrete pad designed to withstand the weight and movement of large pieces of mechanical equipment.

As the dominant power source for the island, it is recommended that the main components of the power plant be housed in a fully enclosed building designed to withstand heavy rainfall and hurricane conditions. This should be constructed to accommodate 2 x 3.5 MW turbines. Some elements of the balance of plant equipment, including circulating water cooling systems and gas extraction systems may be outside but under appropriate cover.

Access to the well pads is the responsibility of the Government and an evaluation of the roads and public infrastructure is required to ensure that the power plant can be safely delivered.

3.6 Land Requirements

In line with International Standards, the project will seek to avoid involuntary resettlement, economic displacement and minimise compulsory land acquisition. The Roseau Valley is relatively sparsely populated and the Government has already carried out numerous consultations and outreach with local landowners. As part of the ESIA process any additional land acquisition, including potential resettlement or economic displacement, will be completed in accordance with WB Performance Standard 5. The process will consist of the following steps:

- 1) An Audit of the land acquisition completed to date (known as Completion Audit) to ensure compliance with World Bank PS 5 and the IFC Guidance Note on PS 5, Annex B, 'Completion Audit -Table of Contents'.
- 2) For known new sites required for the project, where land acquisition will result in physical or economic displacement, a Resettlement Action Plan (RAP) and/or Livelihood Restoration Plan (LRP) will be completed prior to project construction. The contents of the Resettlement and/or Livelihood Framework, and/or any Resettlement Action Plans and Livelihood Plans will follow the principles and requirements as outlined in the World Bank PS 5, and further elaborated in the IFC Guidance Note on PS 5 with special attention to Annex A, Outline of a Resettlement Action Plan.
- 3) For any additional sites not known prior to appraisal but which might be required during project implementation that could result in physical or economic displacement, a Resettlement and/or Livelihood Restoration Framework will be prepared.

3.6.1 Land Acquisition

The Government has acquired the land for the existing well pads. Of the three sites which were purchased (WW-P1, WW-01, WW-R1), two were purchased through negotiated agreement and WW-P1 was purchased by Compulsory Acquisition under the Land Acquisition Act 1946, as the owner of the land is deceased. An audit of the land acquisition completed to date will be carried out and measures taken to mitigate any identified gaps.

Construction and operation of the plant may require the acquisition of up to three or more adjacent properties currently in private ownership, which may total approximately 6.5 acres. The final reinjection route is still being determined and will require a land corridor approximately 15 - 30 foot wide. An estimated 4 acres of lands will be required to establish the right of way for the reinjection pipeline and associated infrastructure. Future land acquisition will be completed in accordance with the requirements of WB Performance Standard 5 including the completion of compensation payments, along with involuntary resettlement and economic displacement requirements described below.

3.6.2 Involuntary Resettlement

As the Roseau Valley is relatively sparsely populated, it is considered unlikely that involuntary resettlement will be required. However, until the final requirements and locations have been finalised it cannot be ruled out. The Government has carried out numerous consultations and outreach with local landowners over the past six years as is documented in the previous two EIAs (2009 and 2011), a Gap Analysis (2013) and the ESIA Baseline Study (2015). For the areas where project related civil works will be undertaken and people are physically displaced, a Resettlement Action Plan will be prepared and implemented prior to project construction.

3.6.3 Economic Displacement and Livelihood Impacts

There are a number of farmers and potential small businesses that could be displaced by development of the project. For the areas where project related civil works will be undertaken in locations where economic displacement could result, a Livelihood Restoration Plan will be prepared and implemented prior to project construction.

3.6.4 Power Plant

Sites around WW-P1 were examined for suitability for expansion of the geothermal project and power plant siting. It is proposed that the new separation plant be located on the western end of the existing wellpad. The remaining space on the wellpad should be conserved for future production drilling. Three sites have been identified which are suitable for the development, with relatively modest slope and located in close proximity to existing wellpad.

- 1) Option 1 immediately North of WW-P1 is large enough to accommodate a condensing plant, with provision to include the Option 1A site for ancillary requirements such as offices and maintenance facilities. Much of this site is in the ownership of the government as a 3.8 acre parcel of land was acquired for WW-P1.
- 2) Option 2 is to the east of WW-P1 and on approximately the same elevation. Ready access could be formed from WW-P1. The site would be suitable for a condensing plant, but also has a potential use as an

extended wellpad for future drilling programs (i.e. export plant). A local preference was expressed by the Community Liaison Officer that this area be used for future drilling.

- 3) Option 3 is a larger site suitable for a binary plant. It is located some 100m north-east of WW-P1 and has a 12° slope to the north which could be readily levelled to form a platform. It is currently used for small scale agriculture.



Figure 3-3: Power plant site options

Option 1 and 1A are the preferred sites as they are largely in the ownership of the Government. They are best suited to a steam Rankine condensing plant. If a binary plant is selected Option 3 is the preferred site, although it may be possible to place a binary plant with wet cooling onto Option 1 and 1A. Option 2 should be retained for future drilling and production expansion.

3.6.5 Steamfield

Options for steam/brine separation, steam pressure control, steam scrubbing, and start-up, normal and emergency shutdown operations need to be considered and the land required to achieve these operations needs to be determined through a preliminary steamfield design exercise. These will be practically the same for all power plant technology options.

The land requirements for the steamfield piping system are dominated by the brine reinjection pipeline, which will run from WW-P1 to WW-01 and/or WW-R1. The diameter of the pipeline would be approximately DN 250 to 300 mm (10 to 12 inches).

Site visits by mechanical and geotechnical disciplines identified eight possible pipeline routes. The routes were evaluated on the basis of the constructability, topography, geohazard exposure (i.e. landslides, rock falls, etc), estimated capital costs, operational considerations and social and environmental constraints. The following route options are preferred and shown in Figure 3-4:

- Option A, D and F
- Option C, D and F
- Option H and F

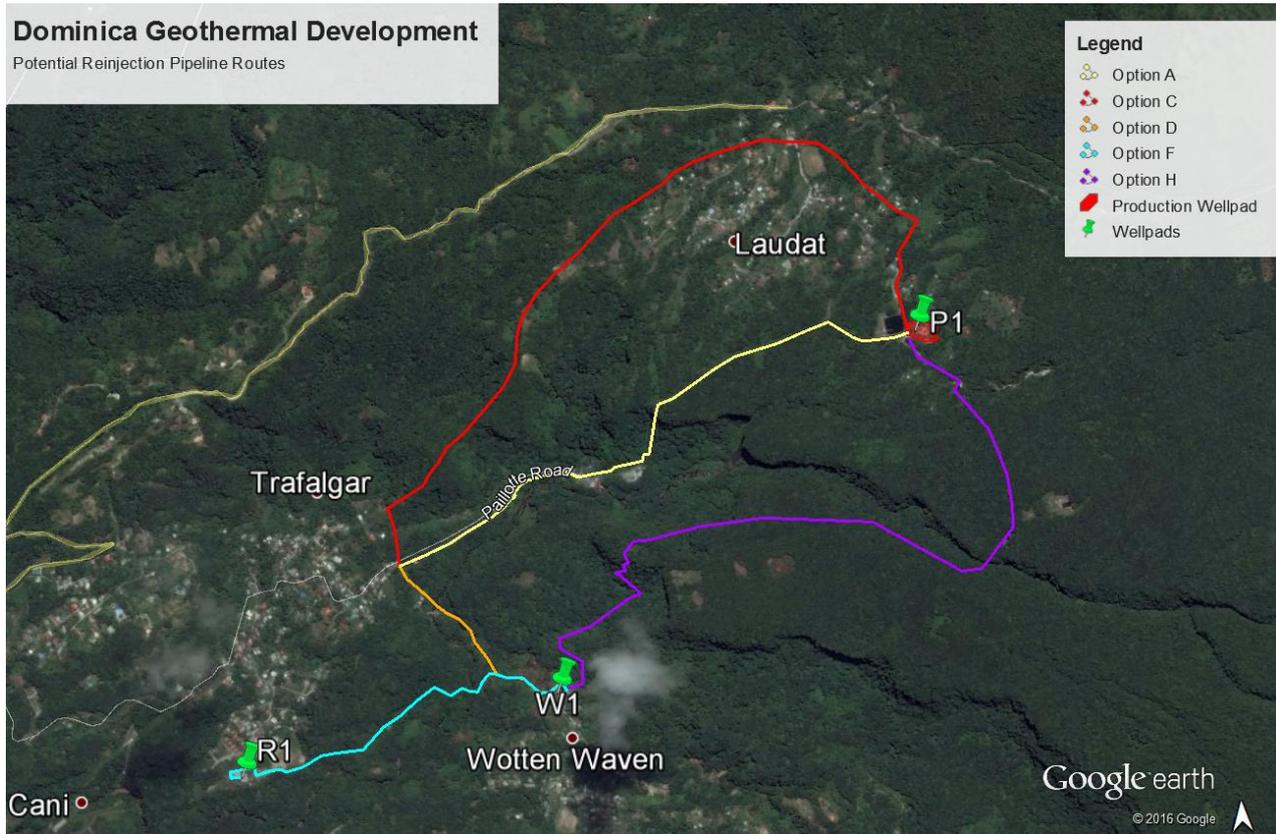


Figure 3-4: Proposed reinjection pipeline routes from WW-P1 to WW-R1 and WW-01

Final route selection will be carried out in close co-ordination between the process engineering, mechanical, geotechnical and civil engineering design disciplines, along with the Government, Land and Survey Division and environmental and social scientists.

Option A - Follows DOMLEC's hydropower pipelines across easily navigated topography and would need to utilise DOMLECs existing bridge which currently carries the penstock. Construction would be simpler in this section and there is adequate space for expansion loops. The pipeline would then need to descend the 60 – 80m vertical cliff, alongside the existing hydro pipeline (Figure 3-5). Once the cliff has been descended, the route runs alongside the river and road.

Option C – This is the longest route and would require pumping of brine (~80kW – 100kW load) from WW-P1 at 554m asl to 615m asl. The route would follow the existing penstock route, before traversing to the north and west of Laudat to avoid the village itself and associated road/accessway crossings. The pipeline would descend down a steep and narrow ridge line on which the Waitukubuli National Trail presently runs.

Option D – From the point where the Trail meets the road, the pipeline would cross the river, supported on the new Bailey bridge, before following the road to Wotten Waven and pad WW-01.

Option F – This section of pipeline would go from WW-01 to WW-R1. The pipeline would follow the river, crossing the gorge with a pipe bridge near the river junction. The last 200m before the football field would follow a narrow track with minimal space for expansion loops. The track has steep slopes and would require rockfall protection. Space for construction in this part of the trail is limited.

Option H - This route would traverse cross country from WW-P1 to near the old aerial tram station. From there the pipe would cross the Breakfast River Gorge using a suspension bridge of 50 – 70 m. The pipeline would then cross relatively flat terrain before descending down a short section of narrow pathway, which broadens and eventually comes out by WW-01.

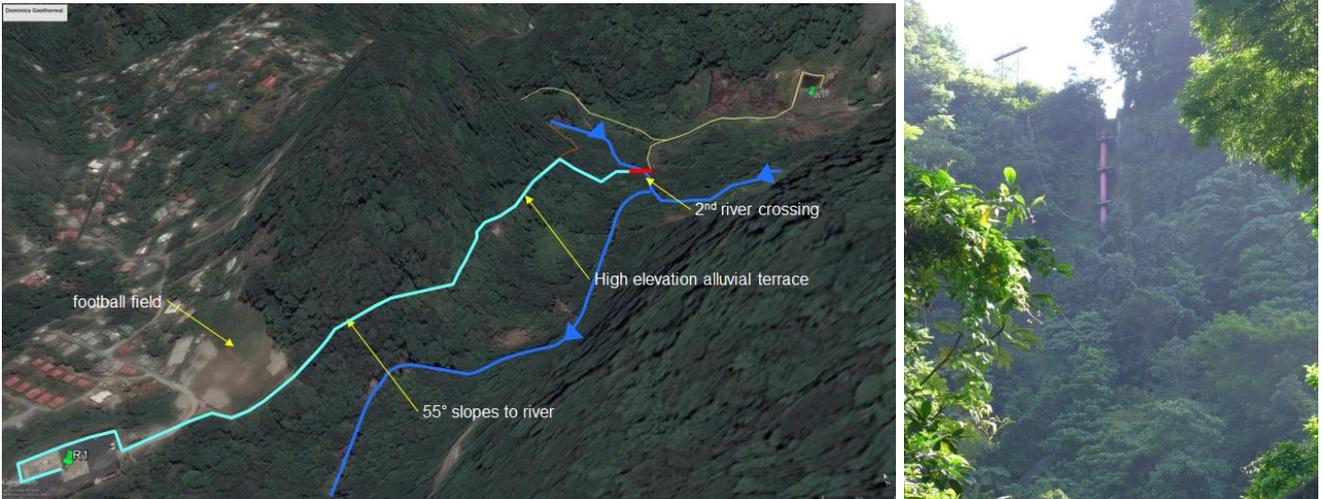


Figure 3-5: Recommended reinjection pipeline route from WW-01 to WW-R1

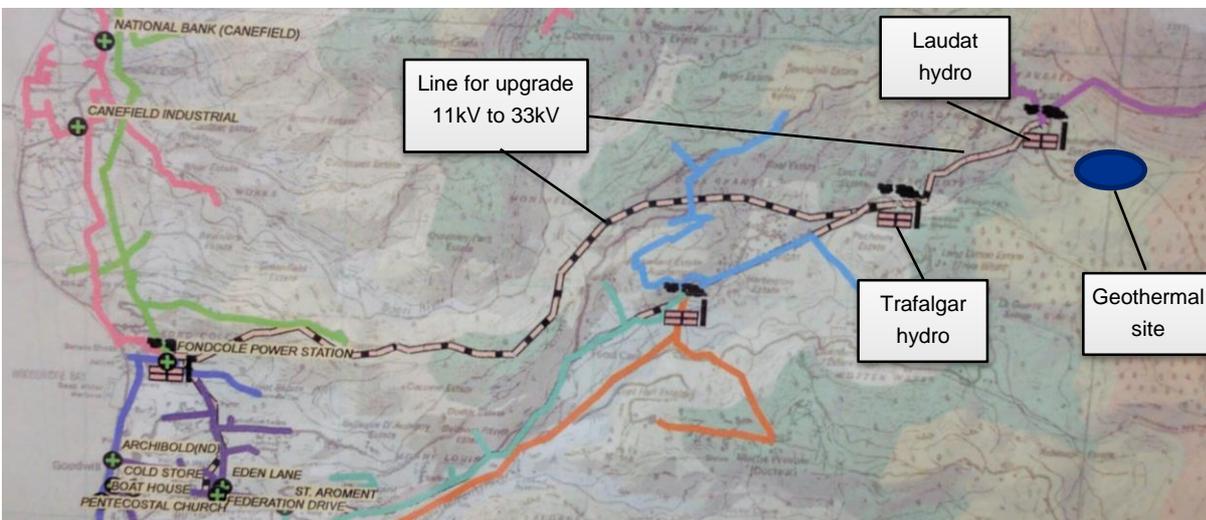
3.7 Electricity Transmission Infrastructure

There is still some discussion on the optimum transmission infrastructure to support grid interconnection of the power plant, which is presently the subject of a power systems analysis. The following interconnection approach is therefore subject to refinement based on the outputs of technical work. As associated infrastructure, these works will be considered in the ESIA as they are directly related to the project.

The geothermal plant will (likely) connect to the DOMLEC grid at the project site and have a direct 33 kV connection to Fond Cole. The geothermal plant would have a step-up 11kV:33 kV transformer located at the power plant site. A new 11 kV line would be constructed from Laudat hydro power station to the 11kV busbar at the geothermal power plant. The poles would also carry the 33 kV line from the geothermal power plant, which would not connect Laudat hydro station to the 33 kV system, before interconnecting with the existing line between Laudat and Trafalgar.

The power lines from Laudat to Fond Cole will be upgraded from 11 kV to 33 kV by reinsulating the existing lines. The existing route and wires will remain unchanged. Minor works will be required to disconnect the existing dedicated 11 kV line from the Trafalgar power station such that a direct line for the geothermal plant is provided.

Figure 3.1 : Location of existing power lines in relation to geothermal project site



4. Scope of Work

4.1 Objective of the Study

The goal of the ESIA is to evaluate the temporary and permanent impacts of the construction, commissioning, operation and decommissioning of the power plant, steamfield and transmission infrastructure, on the natural and human environment. The study will make recommendations to mitigate or minimize the foreseeable negative impacts, which will be captured in the Environmental and Social Management Plan (ESMP). An Environmental and Social Management System (ESMS) will also need to be established to ensure implementation of relevant environmental and social controls.

The ESIA will build upon the existing safeguards work carried out for exploration and production drilling, baseline survey work carried out through the INTERREG IIIB Programme and recommendations provided in the 'Situational analysis for the preparation of the Wotten Waven-Trafalgar-Laudat field in the Roseau Valley'.

Any drilling of further wells at existing well pads will be covered in the ESIA, but any future delineation wells for a new development (which may be 10 years way or more) will not be included.

4.2 Baseline Environmental and Social Data

The Roseau Valley lies inland from the coast, bordering the capital city of Roseau. The valley is heavily wooded with rich vegetation and various communities exist in the area (Trafalgar, Laudat, Fond Cani and Wotten Waven). There also exist some very popular tourist attractions, such as the hot springs at Wotten Waven, Trafalgar Falls, the Boiling Lake, Titou Gorge, Valley of Desolation, and the Freshwater Lake.

Existing physical, biological and socio-economic conditions will be described in the ESIA to form the basis for an assessment of potential impacts from the construction and operation of the Project. This will include:

- Air quality, climate, meteorological and acoustic data
- Water quality and hydrology
- Land use, land cover and visual amenity
- Terrestrial and aquatic ecology, with an emphasis on rare, endangered and endemic species, critical habitats and ecosystems services
- Natural hazards, such as hurricanes, landslips and flooding
- Socioeconomic environment, including public health, settlements (demographic profile, gender profile and land ownership), social infrastructure, economic profile (i.e. level of employment) and economic activities (reference should be made to Section 4.2.2.8 for more details)
- Culture and heritage
- Transport infrastructure and traffic movements.

These will be established through the review of literature and findings of earlier studies and completion of supplementary baseline data collection activities to address any perceived gaps in information.

4.2.1 Studies Completed to Date

To date the following environmental and social studies have been completed:

- Caribes Environment Development (2009) Regulatory Impact Assessment on the Initial Environment - Environmental Feasibility Study.
- Caribes Environment Development (2011). Stage 1: Exploration Drilling Process – Environmental Impact Assessment.
- Caribes Environment Development (2013) Stage 2: Preliminary Environmental Impact Assessment of Geothermal Production and Re-Injection Drilling Wells in Dominica – Environmental Impact Assessment.

- To support the preparation of an ESIA for the Project, baseline surveys of the social, physical and biological environment within the Roseau Valley were completed between October 2013 and April 2015. These were summarised in the following reports (collectively referred to as the ‘Baseline Study’):
 - Caraibes Environment Development (2015a). Initial environmental status of the Roseau Valley in Dominica, planned for development of geothermal electricity production. Final report, May 2015. Section 3 Biodiversity / Terrestrial Flora and Fauna.
 - Caraibes Environment Development (2015b). Initial environmental status of the Roseau Valley in Dominica, planned for development of geothermal electricity production. Final summary report.

4.2.2 Gap Analysis

A review of these studies has been carried out. The findings of this review are presented below along with any further baseline data collection proposed. In addition a review of the situational analysis prepared by the World Bank has been carried out, with relevant findings incorporated into the scope of work described below.

4.2.2.1 Air Quality

Caraibes Environment Development conducted baseline survey of air quality in 30 locations in 2014 (Caraibes Environment Development, 2015a/b). The survey monitored concentrations of sulphur dioxide (SO₂); hydrogen sulphide (H₂S); oxides of nitrogen (NO_x) – nitrogen dioxide (NO₂); fine particulate (PM₁₀) and ultra-fine particulate (PM_{2.5}); and ozone (O₃) on two occasions, once during the dry season (23 April to 6 May 2014) and once in the wet season (20 November to 11 December 2014). The study also selected the location for the installation of a reference weather station, which enabled measurement of the principal weather features over the course of a year. This data will be used to establish the air quality baseline in the ESIA.

4.2.2.2 Noise

During baseline sampling, noise measurements were taken in the principal residential zones, the main tourist sites and valley hotels (Caraibes Environment Development, 2015a/b). Two noise measurement campaigns were carried out in the tourist high season (December 2013) and low season (April 2014). Five residential zones studied: Laudat, Fond Cani North / Fond Cani West & South, Trafalgar, Wotten Waven, Morne Prosper with 54 acoustic measurement points analysed over a 24 hour period. The results attributed ambient noise levels to local fauna, human activity, vegetation and running water (rivers and waterfalls, etc.). Ambient noise levels were generally higher at night and there were higher ambient noise levels closer to tourist sites and hotels. This data will be used to establish the baseline in the ESIA.

The data recorded as part of the baseline study has been deemed sufficient to use in the ESIA to satisfy the requirements of the local and international legislation and guidelines.

4.2.2.3 Hydrology and Hydrogeology

No information on hydrology (flows) or hydrogeology is presented in previous EIAs for drilling or the baseline report prepared by Caraibes Environment. However, gauging of surface water flows has been carried out at the following locations by DOWASCO:

Location	Coordinates	
River Claire	- N15d17'51.89"	W61d19'44.32"
River Douce	- N15d18'11.82"	W61d22'06.21"
Titou Gorge	- N15d19'44.66"	W61d19'30.11"
Trafalgar River	- N15d19'24.98"	W61d20'33.46"
River Blanc	- N15d18'41.39"	W61d19'29.96"
Tributary	- N15d18'37.83"	W61d19'21.78"

In addition, it is understood that DOMLEC carries out continuous monitoring of flows entering the hydroelectric power plant at Laudat. Therefore it is proposed to request information from DOMLEC regarding abstraction of water from Titou Gorge, which is the most likely source of water abstraction for development of the geothermal power plant, due to its proximity to the site. This will supplement the information already obtained by DOWASCO.

Detailed information on hydrogeology is not considered necessary for the ESIA as there is not proposed to be abstraction of groundwater for construction or operation of the project.

4.2.2.4 Aquatic Ecology and Water Quality

The baseline studies in 2015 recorded the current condition of the aquatic habitats, water quality and biological values of the waterways in the study area (Caraibes Environment Development, 2015a/b). The baseline data is considered comprehensive in the documentation of current water quality and the condition of the biota present, including all relevant biological groups (diatoms, macroinvertebrates, microcrustaceans and fish). It is noted that systems for classifying the health of aquatic communities in the study region were limited, however, appropriate attempts were made to develop relevant biological indices that can be used as the basis for assessment of potential impacts associated with the proposed development. Species vulnerability to disturbance was assessed using the International Union for Conservation of Nature (IUCN) Red Lists.

There were three sampling trips undertaken to establish baseline conditions, and this information will be sufficient for preparation of the ESIA. However, it is recommended that further sampling be undertaken prior to construction of the project in order to establish the magnitude of any natural variability in the system. This will provide a robust basis for comparison with ongoing monitoring during the construction and operations stages.

4.2.2.5 Landscape, Visual and Heritage

The baseline study for visual amenity captured the location of view points over the valley from high points as well as the view up the valley from Roseau, providing descriptions of landscape and architectural characteristics of the territory. The baseline data also included discussions with historians, botanists and residents from Laudat and documentary research. Landscape types were established, as well as key infrastructure and buildings in the locality. This data will be used to establish the baseline in the ESIA.

Further information may be collected on site visits by Jacobs and through ongoing consultation with the local communities, related to the temporary visual impact of vertical steam discharges.

4.2.2.6 Terrestrial Flora and Fauna

An initial baseline survey for flora and fauna and subsequent analysis was carried out in 2008 with the aim to provide an introduction to the biodiversity of the Roseau Valley, and also the legal context related to forest clearing and protected natural spaces. Three areas were initially selected in 2011 for detailed flora and fauna assessment and then a fourth added in 2015 (Caraibes Environment Development, 2015a/b). At each area the dominant habitat and flora and fauna species were described and matched to vegetation type descriptions. The general description of the biodiversity and flora and fauna in the Roseau Valley was informative and based on expert knowledge of the island biodiversity (using the International Union for Conservation of Nature (IUCN) Red Lists). There was also a high level classification of the sensitivity of the habitat carried out, which the geothermal resource areas into the following:

- 1) High sensitivity areas containing:
 - A high number of protected species inside (IUCN, French and Dominican legislation);
 - An area with very few anthropic influences;
 - A high number of endemic species (Dominican and Caribbean); or
 - The presence of species poorly represented elsewhere.
- 2) Medium sensitivity areas containing:
 - Lower number of protected species than high sensitivity areas;

- Higher level of anthropogenic disturbance than high sensitivity areas; and
 - Less endemic species (Dominican and Caribbean)
- 3) Low sensitivity areas containing:
- Higher level of anthropogenic disturbance than medium sensitivity areas; and
 - Fewer endemic and protected species than medium sensitivity areas.

The description of fauna species and habitats was based on opportunistic observations during the vegetation / flora survey and the methods and results of targeted surveys were not discussed. To address this limitation, the authors noted that up to 176 bird species were reported in the literature for the island, including three species of threatened status listed under the IUCN and two species protected in Dominica.

The bird species of the island of Dominica were listed and described in the baseline studies. However, these species were not identified in the reports or potential habitats mapped within the Project area. Similarly, it is not possible to determine from the reports whether threatened vertebrate species are present within the Project area. Therefore, further ground-based surveys will be required as part of the terrestrial ecological assessment in the footprint of the proposed power plant site and reinjection line route.

4.2.2.7 Natural Hazards (including Flood Risk)

Bibliographical data was collected in the Roseau Valley during baseline sampling activities (Caraibes Environment Development, 2015a/b). For flooding, the measurement and monitoring of water flow rates in the valley was recorded and for earthquakes and land movements, historical document describing previous seismic activities were assessed as well as analysis of precise geological maps of the valley. This desk-based survey was complemented by field data that allowed the determination of:

- The hydrological characteristics of the valley (water tables, flooding zones, population survey).
- Natural phenomenon index (lithology, slope, geomorphology).
- Correlation with hazards observed on neighbouring islands.

Analysis of this data allowed for flood modelling and hazard mapping for the valley, identifying areas along the potential reinjection routes which may be prone to landslips.

The data recorded as part of the baseline study has been deemed sufficient to use in the ESIA to satisfy the requirements of the local and international legislation and guidelines. This data will be used to establish the baseline in the ESIA.

4.2.2.8 Socio-economic

The project's socioeconomic baseline has benefited from previous EIAs (2009 and 2011); a Gap Analysis carried out by the World Bank in early 2013; and a subsequent ESIA social, physical and biological baseline survey (ESIA Baseline Study) carried out between 2013 and 2015. Current baseline information collected by Caraibes Environment Development in 2015 is based upon desktop study and data collection including 25-30 interviews conducted with local stakeholders. In addition, the report indicates that three public meetings were held on 11, 12 and 13 December 2013 in Laudat, Trafalgar and Wotten-Waven respectively. Additional meetings were also noted in November of 2013 and January of 2014 per memos from the Ministry of Public Works and Ports Geothermal Project Management Unit. Further details of the meetings completed to date will be provided to the extent feasible in the ESIA and Stakeholder Engagement Plan (SEP). A Stakeholder Engagement Plan (SEP), including a grievance mechanism, is to be prepared. The project socio-economic area of influence is not specifically defined but consultation is focused around the three communities of Laudat, Trafalgar and Wotten-Waven.

About 1,800 people live in the Roseau Valley, of which nearly 1000 in Trafalgar and Shawford, and the remaining in the hamlets of Wotten Waven/Casseau, Copthall, and Laudat. Many livelihoods in the Valley depend on tourism, as this is one of the main tourist sites in the country, primarily for hot springs and nature

activities; on small-scale agriculture; as well as jobs in the capital. The 2013 consultations documented community concerns for the potential risks associated with a geothermal plant; potential impacts (which can be both positive and negative) on ecotourism; and potential for job creation, among others.

The baseline includes demographic information on the Roseau Valley from Dominica's Central Statistical Office supplemented by information from field surveys and the Caribbean Development Bank on quality of life, education, housing, infrastructure governance and the economy. There is very little information on community health and safety.

The ESIA to be conducted for the proposed project will build upon previous studies and complete any remaining gaps, primarily concerning community engagement; community health risks; land acquisition and potential involuntary resettlement; livelihood issues; and cultural heritage. An Environmental and Social Management Plan (ESMP) will be prepared and include action plans as needed, and the ESMS developed. Further work is required in the following areas:

- Community engagement - Further engagement including approximately 10 town hall meetings, approximately 4-6 focus groups meetings in each affected community, and 2-4 community workshops will be carried out to broaden community understanding of the project and understand the communities concerns in greater detail. Informal meetings with local schools and members of the affected community will also be conducted on a quarterly basis. Additional details of the planned community engagement process during the ESIA preparation phase and during project implementation are outlined in the SEP being developed for the project.
- Community health - As part of the consultation conducted to date, health has been identified as a significant community concern. Therefore, it is important to establish baseline conditions for health in the Roseau Valley prior to construction of the project to understand any changes in local health following development of the project. Further data should include basic health statistics on disease, life expectancy, and illness.
- Livelihood –Socio-economic census data should be collected for the households and farmers that will be directly affected by the project to determine if a livelihood restoration process is required. 4-6 focus groups will also be conducted to better understand eco-tourism impacts and impacts on farmers.

There are no indigenous communities located in the immediate vicinity of the project geothermal area, with the nearest community being an estimated 15 km north-east (the Carib Territory). Therefore, impacts upon indigenous communities are not considered relevant and have been screened out of the ESIA.

It is possible that the project will provide community development opportunities through the provision of new jobs for local residents, indirect economic development impacts, collaboration and public involvement opportunities such as trips to other power facilities, and potential opportunities for education and industry diversification. As part of the Assessment, community development initiatives and benefit sharing options will be explored and considered. A community development program which sets out these initiatives may also be developed as appropriate.

4.2.3 Cultural Heritage

Current baseline information collected by Caraibes Environment Development in 2015 identified several cultural heritage elements in the Roseau Valley, including those related to agricultural heritage and architectural heritage. The complex and ancient history of human occupation of the island has led to numerous influences on current and past architecture in the Roseau Valley. One example from Wotten Waven includes a water mill dating from the 18th century.

The ESIA will have a cultural baseline to assess whether any of the project activities are located in areas with cultural or architectural significance (tangible features). It will also include a consultation process with local people so that the potential impact on unique natural features or intangible forms of culture are identified and understood. The ESMP includes a chance finds procedure, and depending on the findings of the baseline assessment, more project specific mitigation measures in impacted areas may be necessary. UNESCO will be consulted to ensure that there is no potential impact to the designation of the nearby World Heritage Site (the

Mornes Trois Pitons National Park), nor inconsistency with any existing or planned management plans for the core area and surroundings.

4.2.4 Traffic

No baseline traffic data has been identified for the Roseau Valley. Although it is believed that traffic levels are not high, there is potential for existing road users to be affected by construction traffic. Therefore it is proposed to conduct traffic counts within the potentially affected communities of Laudat, Trafalgar and Wotten Waven to establish baseline conditions, and consider the influence of cruise ships. In addition, a site visit will be conducted to review the existing road infrastructure and take photographs to document its current condition.

4.3 Stakeholder Engagement

Building on stakeholder engagement that has already been completed, a process of identifying relevant stakeholders that may be directly or indirectly affected by the project will be completed. A Stakeholder Engagement Plan (SEP) is being prepared for the project which will guide engagement activities which are to be conducted in order to address the information gaps identified in Section 4.2.1.8. The objectives of this SEP are to:

- Identify the local legal framework of consultation activities and disclosure requirements, particularly in respect of those public consultation activities that are directly required under the local permitting process;
- Identify potential stakeholders in the area of influence, as well as relevant interested parties such as government agencies and other key stakeholders;
- Record all consultation activities, including those prior to the commencement of the environmental and social impact assessment (ESIA) process;
- Describe how concerns or grievances will be handled;
- Provide an action plan for further consultation including at least 2 meetings bi-annually in each affected community during preparation, construction and operational phases of the project, including details on appropriate formats for effective and culturally meaningful interaction with the community and relevant stakeholders; and
- Provide a disclosure plan, including the identification of any locations where relevant project documentation will be available locally and elsewhere as well as languages to be used.

The SEP will be revised and updated periodically including upon completion of the ESIA to assist with ongoing engagement throughout the Geothermal Programme.

4.4 Impact Assessment

The assessment of all environmental and social impacts will encompass both potential impacts and uncertain risks. The level of investigation of potential impacts or particular risks will be proportionate to the severity of potential consequences and likelihood of such an event occurring.

To guide the ESIA and ensure sufficient focus on key issues/risks a preliminary risk assessment has been conducted by Jacobs. The key issues/risks identified through this process are highlighted in Table 4-1 below:

Table 4-1: Key Issues/Risks to be addressed in ESIA

Aspect	Potential Impact
Air Quality	<ul style="list-style-type: none"> • Emission of gases such as hydrogen sulphide (the primary indicator gas for odour) from the power plant during operation. • Generation of dust and combustion gas emission through earth moving and construction activities. • Odour from hydrogen sulphide emissions.

Aspect	Potential Impact
Greenhouse Gas	<ul style="list-style-type: none"> Greenhouse gas emissions from construction machinery and the power plant during operation.
Natural Hazards	<ul style="list-style-type: none"> Risks related from natural hazards, such as seismic activity, landslides, hurricanes, volcanic activity and flood inundation.
Geothermal Features	<ul style="list-style-type: none"> Potential impact on surface geothermal features as a result of abstraction of steam and reinjection of brine/condensate
Community Health	<ul style="list-style-type: none"> Potential impacts on community health, such as potential for seismic activity, emissions of hydrogen sulphide and generation of dust, noise, subsidence and from major accident hazards if organic Rankine plant is installed. Fire risk is also a consideration in particular with binary plant. During the commissioning stage of the project, when various parts of the power plant are first started-up, discharges of non-condensable gases (NCGs) may occur outside of the normal disposal points.
Cultural Heritage	<ul style="list-style-type: none"> Potential impacts on cultural heritage features (architecturally significant buildings and agricultural areas).
Social (including land acquisition)	<ul style="list-style-type: none"> Positive impacts upon the local community through the generation of employment opportunities. Any economic displacement of members of the community as a result of land acquisition for the development of the power plant and steamfield. There is also the potential for temporary effects upon communities and tourism if works (including construction traffic) inhibit access to schools, communities and tourist attractions. Appropriate consideration will be given to livelihood restoration for any parties that are economically displaced by the project. Further engagement including town hall meetings, focus groups meetings in each affected community, and community workshops will be carried out to broaden community understanding of the project and understand the communities concerns in greater detail. Informal meetings with local schools and members of the affected community will also be conducted on a quarterly basis. It is important to establish baseline conditions for health in the Roseau Valley prior to construction of the project to understand any changes in local health following development of the project. Further data should include basic health statistics on disease, life expectancy, and illness. Socio-economic census data should be collected for the households and farmers that will be directly affected by the project to determine if a livelihood restoration process is required. Focus groups will also be conducted to better understand eco-tourism impacts and impacts on farmers.
Working Conditions	<ul style="list-style-type: none"> The ESIA will provide a more detailed description of the proposed civil works, the operation of power plant and of the steamfield, as well as the related labour requirements and working conditions. The potential for labour influx has been reviewed, will be further examined, but is not expected to be an issue for the project. There will be consideration of the working conditions of employees/contractors engaged in construction and operation. Human Resources (HR) Policies and Procedures. DGDC will need to draft and implement human resources regulations following Dominica's Labour legislation and the requirements of PS2, specifically articulating the workers' rights to form and join workers' organizations, and procedures for workers to express their grievances and protect their rights without retaliation or discrimination. Occupational Health and Safety. A comprehensive set of plans, standards, procedures and work instructions should be prepared and adopted by DGDC to cover all aspects of occupational health and safety. Risks to the occupational health and welfare of personnel involved in the project implementation should be assessed and mitigated following a risk management process in accordance with DGDC's adopted requirements. Contractors will be required to comply with the occupational health and safety procedures. A Security Management Plan will be developed to safeguard project, workers and property and to ensure that safeguarding activities are carried out in a legitimate manner that avoids or minimizes risks to the community's safety and security, as per PS2 and PS4.
Noise	<ul style="list-style-type: none"> Construction and operation of the power plant will generate noise (i.e. from steam discharges) which

Aspect	Potential Impact
	may impact upon the surrounding communities and wildlife.
Pest Species	<ul style="list-style-type: none"> • Importation of machinery/equipment for use in construction and operation can lead to introduction of pest species.
Soil and Groundwater	<ul style="list-style-type: none"> • Spillage of hazardous substances stored/used in construction and operation of the power plant. • Generation and disposal of construction and domestic waste. • Creation of solid wastes, sludge and slurries. • Contamination of shallow aquifers.
Terrestrial Flora and Fauna	<ul style="list-style-type: none"> • Removal of vegetation and earthworks to enable construction of the re-injection pipeline, which could result in impacts on biodiversity with particular reference to critical habitat for endangered species, associated with the nearby Morne Trois National Park World Heritage Site. Special reference will be made to any rare or threatened species as well as endemic species of both animals and plants. Impacts on the Outstanding Universal Value (OUV) of the Morne Trois National Park World Heritage Site in relation to biodiversity will be considered. • Noise and air quality impacts on the Morne Trois National Park World Heritage Site and the OUV of the site.
Visual Amenity	<ul style="list-style-type: none"> • Construction of new infrastructure will alter the visual landscape. • Vertical steam discharges could create temporary visual impacts. • Impacts on the OUV of the Morne Trois National Park World Heritage Site in relation to visual impacts.
Water Quality and Freshwater Ecology	<ul style="list-style-type: none"> • Reinjection of brine and condensate. • Sedimentation of water courses during construction as result of run-off from earthworks. • Spillage of hazardous substances used during construction and operation of the power plant. • Discharge of stormwater containing contaminants from the power plant to local water courses. .
Water Resources	<ul style="list-style-type: none"> • Abstraction of water for domestic purposes and fire suppression system within power plant.

An assessment of these issues/risks and all other potential environmental and social impacts of the proposed works described in Section 3 will be carried out, including any potential cumulative impacts. The ESIA will state the criteria adopted in assessing the proposed project and its impacts, such as compliance with relevant legislation, policies, standards, community acceptance and maximisation of environmental and social benefits and minimisation of risks.

To support the impact assessment, air dispersion modelling and acoustic modelling will be carried out to estimate potential impacts on the local population and wildlife.

4.4.1 Air Quality Modelling

For the air dispersion modelling assessment it is proposed to use the CALPUFF dispersion model to assess the effects of hydrogen sulphide releases from releases of geothermal fluids during the well testing and operational phases of the project. Meteorological data for the model will be developed using the diagnostic meteorological model WRF, and formatted for use with CALPUFF using the CALMET meteorological model. Locally collected meteorological data will be assessed to determine its quality, and if practicable will be integrated into the meteorological dataset for use with the dispersion model.

The modelling will be dependent upon assumptions made in regard to H₂S discharge rates and the nature of the discharges themselves. These will be informed by analysis of the geothermal fluid made previously, and by process descriptions which should provide details of the well locations, geothermal fluid discharge rates, and parameterisation of the discharges in terms of heights, velocities, and temperatures.

The resulting ground level concentrations of H₂S in the surrounding area will be compared to IFC Performance Standards 2012 and World Bank Environmental Health and Safety General Guidelines 2007 (listed above in Section 2) to assess the environmental impact and identify areas where potentially adverse health or nuisance

effects may result. Locations of potentially sensitive receptors will also be identified using aerial imagery, and by information gathered during site visits.

ALOHA consequence modelling of major credible accident scenarios pertaining to use and storage of iso-pentane should the organic Rankine cycle plant option be selected to determine extent of an accident event such as vapour cloud release, vapour cloud explosion.

4.4.2 Acoustic Modelling

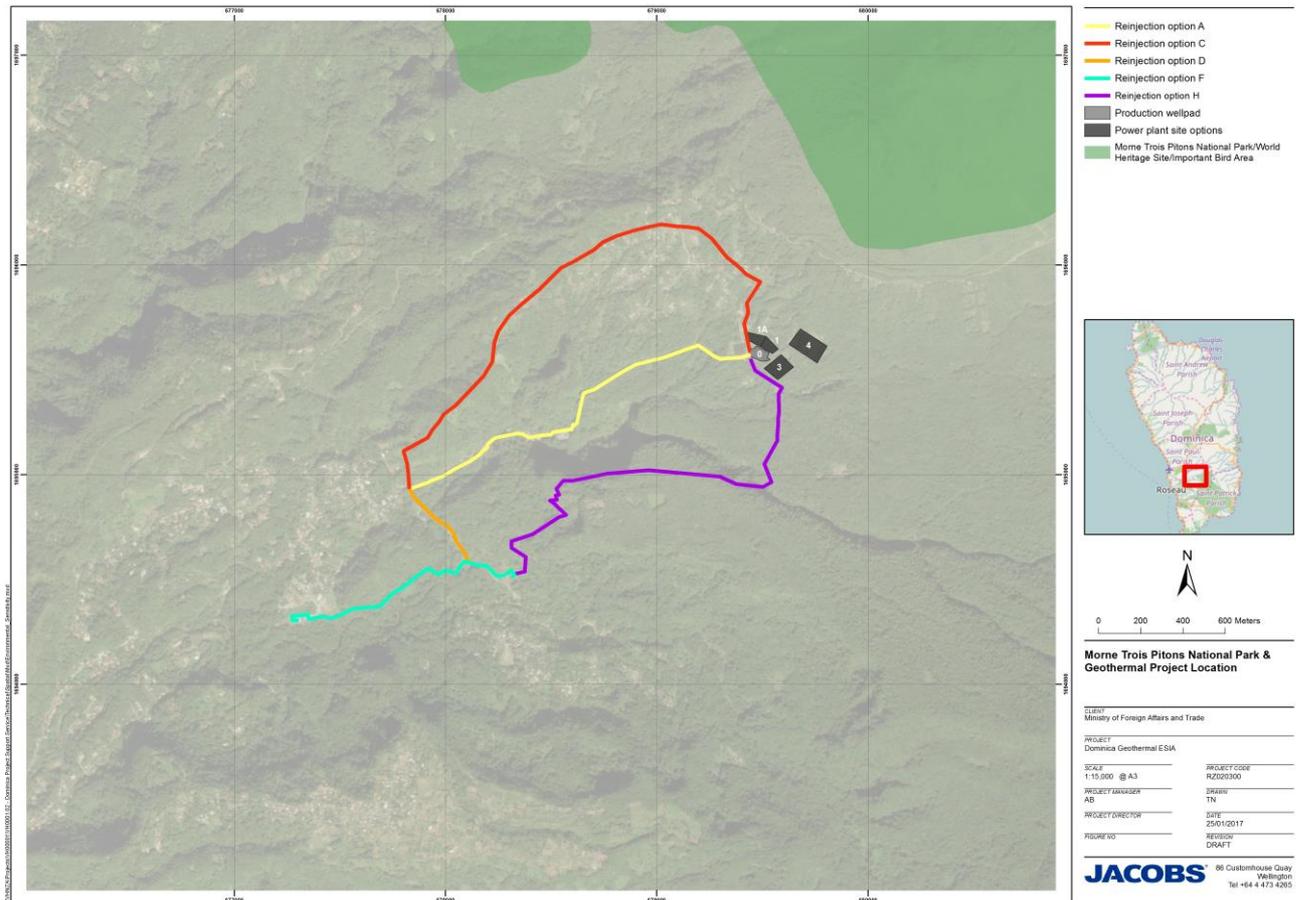
Monitored background noise levels will determine noise criteria in accordance with IFC Performance Standards 2012 and World Bank Environmental Health and Safety General Guidelines 2007 (refer to Section 2). Local guidelines will also be reviewed to determine if any are relevant to noise. Aerial imagery will be reviewed alongside the Caraibes Environment Development (2015a/b) baseline study report to determine nearby potentially affected receivers.

Based on the provided inputs and design, an equipment inventory will be prepared for the operational noise model. Noise levels will be modelled using the ISO9613-1 standard within SoundPlan 7.4 modelling software. Broad management measures for operational noise mitigation will be provided and re-modelled if required. Potential construction noise impacts will also be modelled using ISO9613. Basic construction noise management measures will be provided.

4.4.3 Morne Trois National Park World Heritage Site

The project is estimated to fall around 400m from the boundary of the Morne Trois National Park UNESCO World Heritage Site at its nearest point. Therefore, the ESIA will provide an assessment of potential impacts of the project on the Outstanding Universal Value (OUV) of the Morne Trois National Park World Heritage Site, in line with IUCN's World Heritage Advice Note on Environmental Assessment. For reference, the location of the project in relation to Morne Trois National Park World Heritage Site is shown on Figure 4.1 below.

Figure 4.1 : Location of the Morne Trois National Park World Heritage Site



4.5 Management and Monitoring

The ESIA will propose measures for the mitigation, avoidance and/or offsetting of potential adverse impacts to ensure adverse impacts are as low as reasonable possible. In addition it will include monitoring (including the performance measures that will be used) to be conducted to ensure control measures are effective and impacts are minimised.

4.6 Reporting

4.6.1 Environmental and Social Impact Assessment

The ESIA will provide stakeholders with sufficient information to understand the type and nature of the project, the potential environmental and social impacts, and the measures proposed to mitigate all adverse impacts. All phases of the project will be described including pre-construction, construction and operation. Direct, indirect and cumulative impacts will be identified and assessed with respect to environmental and social values and potential extent of impacts.

The ESIA report will include the following:

- A Non-Technical Summary of the potential environmental and social impacts of the project.
- A description of the project's objectives and rationale, as well as its relationships to strategic policies and plans.
- Description of the proposed construction works and operation of the power plant and steamfield.

- A description of feasible alternatives capable of substantially meeting the proposal's objectives.
- An outline of the relevant legislation and approvals required for the project to proceed.
- Descriptions of the existing environment, particularly where this is relevant to the assessment of impacts.
- An assessment of the risks of adverse and beneficial environmental and social impacts arising from the project.
- Measures for avoiding, minimising, managing and monitoring adverse impacts.
- A description of stakeholder consultation undertaken.
- Responses to issues raised during public and stakeholder consultation.

The ESIA will be supported by appendices containing relevant data, technical reports and any other sources of the ESIA analysis.

4.6.2 Environmental and Social Management Plan

An Environmental and Social Management Plan will be prepared, which identifies the potential environmental and social impacts, the proposed means of mitigation/avoidance and monitoring (including the performance measures that will be used) to be conducted to ensure control measures are effective and adverse impacts are minimised. The plans should also set out reporting requirements and corrective actions.

4.6.3 Environmental and Social Management System

An Environmental and Social Management System (ESMS) will be established to enable implementation of environmental and social controls for the project. The ESMS documentation will describe:

- **Policy** – overarching policy defining environmental and social objectives and principles guiding the project
- **Identification of risks and impacts** – Process for identifying environmental and social risks and impacts of the project
- **Management programs** – a suite of programs, including management plans and procedures that describe mitigation and performance improvement measures that address potential environmental and social risks and impacts associated with the project
- **Organisation capacity and competency** - identification of roles, responsibilities and authority for implementation of the ESMS
- **Emergency preparedness and response** – establish and maintain a system in collaboration with appropriate third parties to ensure preparedness for response to accidental and emergency situations associated with the project
- **Monitoring and review** – procedures for monitoring and measuring effectiveness of the management programmes, including compliance with legal/contractual and regulatory requirements
- **Stakeholder engagement** – process and mechanisms for ongoing engagement with stakeholders
- **External communications and grievance mechanisms** – procedures for addressing communications from external stakeholders, including recording receipt, screening of enquiries, evaluation of issues raised and response. Furthermore a grievance mechanism should be established to facilitate resolution of concerns raised by members of the effected communities
- **Ongoing reporting to affected communities** – periodic reporting i.e. of progress, to affected communities.

4.6.4 Stakeholder Engagement Plan

A comprehensive and inclusive program of consultation with stakeholders throughout the geothermal programme is required. To facilitate this, a Stakeholder Engagement Plan (SEP) will be prepared, which describes:

- The purpose, aims, objectives and protocols for community and stakeholder consultation.
- Issues or risks for community and stakeholder consultation (i.e. what will cause the consultation to succeed/ fail).
- Proposed consultation approach.
- Stakeholders to be consulted.
- Consultation activities to be undertaken for the ESIA.
- Undertaking stakeholder analysis and mapping, including identification of development stakeholders, residents of local communities, government agencies, etc.) and their likely areas of interest, assessment of potential stakeholder risks and establishment of a stakeholder register for the ESIA.
- Development of an implementation plan, including timeline/ key dates for key stakeholder consultation activities.
- Development of community and stakeholder consultation protocols, in consultation with the project team.
- Development of a grievance mechanism, which outlines a process for handling and responding to complaints and grievances raised by the community in respect of the proposed development.

In addition it is expected that a Livelihood Restoration Plan will be required addressing engagement with members of the community that will be economically displaced as a result of the project. If required a Resettlement Policy Framework and Resettlement Action Plan will be developed as described in Section 3.6, The Completion Audit will be consistent with World Bank PS 5 and the IFC Guidance Note on PS 5, Annex B, Completion Audit -Table of Contents.

4.7 Project Team

The team will comprise of personnel with expertise in the following fields:

- Project Management of ESIA to meet requirements of World Bank Group Standards
- Terrestrial Ecology
- Water quality and aquatic ecology
- Air quality and air dispersion modelling
- Acoustic modelling
- Stakeholder engagement and social impact assessment
- Economics
- Hydrology
- Hydrogeology
- Geographical Information Services
- Greenhouse Gas
- Visual impact
- Natural hazards (geology, geotechnical , geothermal features)
- Risk assessment of major credible accidents
- Waste, hazardous substances and occupational health and safety
- Management systems.

4.8 Schedule

The ESIA is proposed to be completed by September 2017.

5. References

Caraibes Environment Development (2009). Regulatory Impact Assessment on the Initial Environment - Environmental Feasibility Study.

Caraibes Environment Development (2011). Stage 1: Exploration Drilling Process – Environmental Impact Assessment.

Caraibes Environment Development (2013). Stage 2: Preliminary Environmental Impact Assessment of Geothermal Production and Re-Injection Drilling Wells in Dominica – Environmental Impact Assessment.

Caraibes Environment Development (2015a). Initial environmental status of the Roseau Valley in Dominica, planned for development of geothermal electricity production. Final report, May 2015. Section 3 Biodiversity / Terrestrial Flora and Fauna.

Caraibes Environment Development (2015b). Initial environmental status of the Roseau Valley in Dominica, planned for development of geothermal electricity production. Final summary report.

IUCN (2013). World Heritage Advice Note Environmental Assessment & World Heritage.

World Bank. Power Development in Dominica – A Situational Analysis for the Preparation of the Wotten Waven-Trafalgar-Laudat field in the Roseau Valley.

Appendix A. WBG IFC Performance Standards

Performance Standard	Objectives
Social and Environmental Assessment and Management Systems	<ul style="list-style-type: none"> • To identify and evaluate environmental and social risks and impacts of the project. • To adopt a mitigation hierarchy to anticipate and avoid, or where avoidance is not possible, minimize, and where residual impacts remain, compensate/ offset for risks and impacts to workers, Affected Communities, and the environment. • To promote improved environmental and social performance of clients through the effective use of management systems. • To ensure that grievances from Affected Communities and external communications from other stakeholders are responded to and managed appropriately. • To promote and provide means for adequate engagement with Affected Communities throughout the project cycle on issues that could potentially affect them and to ensure that relevant environmental and social information is disclosed and disseminated.
Labour and Working Conditions	<ul style="list-style-type: none"> • To promote the fair treatment, non-discrimination, and equal opportunity of workers. • To establish, maintain, and improve the worker-management relationship. • To promote compliance with national employment and labour laws. • 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. • To promote safe and healthy working conditions, and the health of workers. • To avoid the use of forced labour.
Pollution Prevention and Abatement	<ul style="list-style-type: none"> • To avoid or minimize adverse impacts on human health and the environment by avoiding or minimizing pollution from project activities. • To promote more sustainable use of resources, including energy and water. • To reduce project-related GHG emissions.
Community Health, Safety and Security	<ul style="list-style-type: none"> • To anticipate and avoid adverse impacts on the health and safety of the Affected Community during the project life from both routine and non-routine circumstances. • 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 Affected Communities.
Land Acquisition and Involuntary Resettlement	<ul style="list-style-type: none"> • To avoid, and when avoidance is not possible, minimize displacement by exploring alternative project designs. • To avoid forced eviction. • To anticipate and avoid, or where avoidance is not possible, minimize adverse social and economic impacts from land

Performance Standard	Objectives
	<p>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.</p> <ul style="list-style-type: none"> • To improve, or restore, the livelihoods and standards of living of displaced persons. • To improve living conditions among physically displaced persons through the provision of adequate housing with security of tenure at resettlement sites.
<p>Biological Conservation and Sustainable Natural Resource Management</p>	<ul style="list-style-type: none"> • To protect and conserve biodiversity. • To maintain the benefits from ecosystem services. • To promote the sustainable management of living natural resources through the adoption of practices that integrate conservation needs and development priorities.
<p>Indigenous Peoples</p>	<ul style="list-style-type: none"> • To ensure that the development process fosters full respect for the human rights, dignity, aspirations, culture, and natural resource-based livelihoods of Indigenous Peoples. • To anticipate and avoid adverse impacts of projects on communities of Indigenous Peoples, or when avoidance is not possible, to minimize and/or compensate for such impacts. • To promote sustainable development benefits and opportunities for Indigenous Peoples in a culturally appropriate manner. • To establish and maintain an ongoing relationship based on Informed Consultation and Participation (ICP) with the Indigenous Peoples affected by a project throughout the project’s life-cycle. • To ensure the Free, Prior, and Informed Consent (FPIC) of the Affected Communities of Indigenous Peoples when the circumstances described in this Performance Standard are present • To respect and preserve the culture, knowledge, and practices of Indigenous Peoples.
<p>Cultural Heritage</p>	<ul style="list-style-type: none"> • To protect cultural heritage from the adverse impacts of project activities and support its preservation. • To promote the equitable sharing of benefits from the use of cultural heritage.

Appendix C. Project Schedule

A high level summary of the project schedule is presented below:

Task Name	Duration	Start	Finish
Dominica Geothermal Project Establishment	280 days	Thu 19/05/16	Wed 14/06/17
Technical	484 days?	Thu 19/05/16	Tue 27/03/18
Geothermal Plant & Steamfield	338 days	Mon 20/06/16	Wed 4/10/17
Grid connection & power system	330 days	Thu 19/05/16	Wed 23/08/17
DOMLEC transmission work	181 days?	Tue 18/07/17	Tue 27/03/18
Public infrastructure & civil works	473 days	Mon 30/05/16	Wed 21/03/18
Procurement	387 days	Tue 1/11/16	Wed 25/04/18
Commercial	296 days	Mon 2/01/17	Mon 19/02/18
Environmental & Social	445 days	Thu 19/05/16	Wed 31/01/18
Undertake ESIA	360 days	Thu 19/05/16	Wed 4/10/17
Project kick-off and RFI	1 wk	Sat 20/08/16	Thu 25/08/16
Gap Analysis of baseline studies	2.2 wks	Wed 24/08/16	Wed 7/09/16
Process Description	20 wks	Thu 19/05/16	Wed 5/10/16
Preparation of Baseline ToRs	6 wks	Mon 12/09/16	Fri 21/10/16
Submission of draft ESIA TOR	6 wks	Thu 20/10/16	Wed 30/11/16
Final ESIA TOR approved by GoCD	4 wks	Thu 15/12/16	Wed 11/01/17
Preparation for site visit	2 wks	Thu 1/12/16	Wed 14/12/16
Scoping/Baseline site visit	2 wks	Thu 15/12/16	Wed 28/12/16
Stakeholder engagement	30 wks	Thu 15/12/16	Wed 12/07/17
Biodiversity Assessment	12 wks	Thu 25/05/17	Thu 10/08/17
Modelling	10 wks	Thu 18/05/17	Wed 26/07/17
Preparation of Technical Reports	4 wks	Thu 27/07/17	Wed 23/08/17
Preparation of ESIA, ESMP, ESMS	4 wks	Thu 24/08/17	Wed 20/09/17
Submission of draft ESIA to MFAT and DGDC		Fri 8/09/17	Fri 8/09/17
<i>Project on hold following Hurricane Maria</i>	<i>24 wks</i>	<i>Tue 18/09/17</i>	<i>Fri 2/03/17</i>
Conduct Land Acquisition Census Survey	3 wks	Mon 20/03/18	Fri 6/04/18
Preparation of Revised ESIA and ESMP	8 wks	Mon 12/03/18	Wed 9/05/18
Preparation of ARAP	4 wks	Mon 9/04/18	Wed 9/05/18
Submission of Draft ESIA and ESMP to WB		Wed 9/05/18	Wed 9/05/18
WB Review	3 wks	Wed 9/05/18	Wed 30/05/18
Revise ESIA based on WB Comments	2.5 wks	Wed 30/05/18	Fri 15/06/18
Submission of Final Draft ESIA and ESMP to WB		Fri 15/06/18	Fri 15/06/18
WB SGS Review	2 wks	Mon 18/06/18	Mon 3/07/18
Disclosure of ESIA NTS to communities	1 wk	Mon 2/02/18	Fri 6/07/18
Preparation of Final ESIA and ESMP to WB for Disclosure	2 wks	Mon 3/07/18	Fri 13/07/18
Submit Final ESIA and ESMP to WB for Disclosure		Fri 13/07/18	Fri 13/07/18
Submit ESIA & ESMP to GoCD	1 wk	Fri 13/07/18	Fri 20/07/18
WB ESIA disclosure period	17 wks	Mon 16/07/18	Wed 9/11/18

Government Activities & Decision Making	154 days	Fri 20/07/2018	Mon 20/12/18
WB Financial Approval		Wed 1/02/17	Mon 20/12/18

Appendix D. Biodiversity Survey Terms of Reference



Dominica Geothermal Development – Environmental and Social Impact Assessment

Ministry of Foreign Affairs and Trade

Biodiversity Assessment Terms of Reference

RZ020300-0000-NP-RPT-0002 | V1

June 2017



Dominica Geothermal Development - Environmental & Social Impact Assessment

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 Project Manager: Alastair Brookes
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Document history and status

Revision	Date	Description	By	Review	Approved
V0	April 2017	First Draft	C Thomson	P Gabriel	A Brookes
V1	May 2017	World Bank comments added.	C Thomson	P Gabriel	A Brookes
V2	5 June 2017	Reviewed following World Bank Regional Safeguard Advisor (RSA)	C Thomson	P Gabriel	A Brookes

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1. Terms of Reference for Biodiversity Assessment

1.1 Purpose of the Terms of Reference

This Biodiversity Terms of Reference (ToR) describes the scope of the field surveys for the biodiversity assessment for the Environmental and Social Impact Assessment (ESIA) that will be carried out to evaluate the potential positive and negative impacts of construction and operation of the project in accordance with laws of the Commonwealth of Dominica (GoCD) and international standards (World Bank Performance Standards for Private Sector Activities., May 2013). This relates specifically to Performance Standard 6 (PS6) Biodiversity Conservation and Sustainable Management of Living Natural Resources (IFC 2012). This document should be read in conjunction with the ToR for the ESIA (issued to the GoCD in January 2017).

The biodiversity assessment will aim to assess potential impacts on biodiversity throughout all phases of the Project. The data collected by the sub-consultant will be used to address the following objectives:

- Describe the characteristics and ecological condition of the vegetation communities and habitats within the study area. Characterise the key ecosystems within the Project area and adjacent habitats including ecosystems that could be specifically linked to geothermal resources (thermal pools and vents).
- To obtain an understanding of the main biodiversity values of the Project area and its surrounding area, including, but not limited to, the biodiversity values as described in para. 16 of PS6.
- To evaluate whether the Project is located within Critical Habitat (CH) as defined by the IFC's PS6.
- To assess the potential impacts on biodiversity in the Project area as a result of the proposal including direct and indirect impacts of the Project on biodiversity values.
- To develop management and mitigation measures in line with the mitigation hierarchy described in PS6 that specifically focus on avoiding and minimising impacts to those values during Project activities.

1.2 Background

1.2.1 Provision of Background Information

The biodiversity assessment will need to provide detail on the predicted impacts of the Project on biodiversity through all phases of the Project. This would include a literature review of the potential impacts of geothermal projects on biodiversity by members of the ESIA team. The literature review would serve to provide the reader with some context to relevance of the information presented in the biodiversity assessment and the potential impacts on the project on biodiversity. The ESIA will provide a review of relevant literature that includes current knowledge and background on other similar geothermal projects, to synthesis what the typical and potential impacts of the proposed action on terrestrial biodiversity may be and this should include potential direct and indirect impacts.

1.2.2 Previous Biodiversity Assessments

An initial flora and fauna analysis was carried out in 2008 by an ecologist and field assistant which appear to be experienced with the local flora and fauna. The goal of this work was to provide an introduction to the biodiversity of the Roseau Valley, and also the legal context related to forest clearing and protected natural spaces. Three areas were initially selected in 2011 and then a fourth added in 2015 for more detailed flora and fauna assessment. At each area the dominant habitat and flora and fauna species is described and matched to vegetation type descriptions.

1.2.3 Need for Further Field Study

A more targeted approach is now required in the ESIA that address the extent and distribution of vegetation and habitat types along the preferred re-injection line route and other sites selected for the plant infrastructure. This could be targeted within the area of potential impact only to limit survey effort and based on stratified sampling effort where feasible. The proposed locations for further survey are outlined in Figure 1-1.

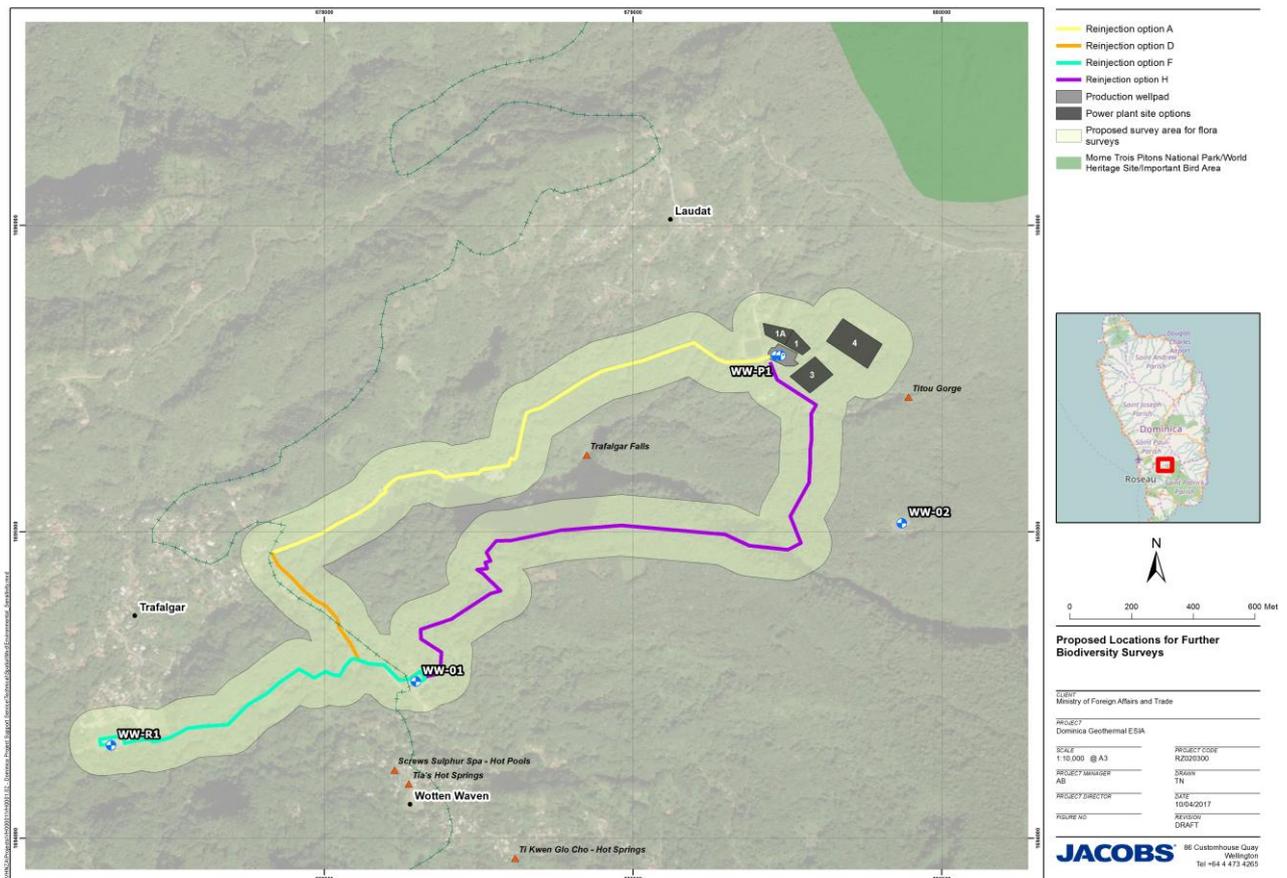


Figure 1-1: Proposed Locations for Further Biodiversity Surveys

The ESIA Team will undertake a preliminary land-use/habitat classification of the study area shall be prepared in GIS by interpretation of satellite imagery and/or aerial photography. This information shall be used to stratify the vegetation and habitat types for further detailed field survey. Stratification is necessary to ensure that the full range of potential habitats and vegetation types are systematically sampled. Stratification shall consider land-use and elevation. Ecologists will then need to ground-truth vegetation types using a rapid assessment approach.

1.3 Key Issues

Significant biodiversity issues of concern include the following:

- The options proposed for the reinjection lines traverse potential habitat for three globally threatened bird species- two endemic species of the Amazona parrots, *Amazona arausiaca* (vulnerable), and *Amazona imperialis* (endangered) and the Forest thrush, *Cichlherminia herminieri* (vulnerable) all on the IUCN red list.
- The project would traverse land that contains the middle reaches of a number of major streams and rivers that provide potable water.
- Fumarolic vegetation- One of the rarest formations on Dominica. The occurrence of and potential impact to rare or endemic species of fumaroles associated vegetation should be considered when evaluating geothermal infrastructure.
- A UNESCO-designated World Heritage Site (Morn Trios Pitons National Park) adjoins the study area to the north and east, upstream of the site.

1.4 Scope of Work – Field Surveys

1.4.1 Introduction

A targeted survey of the terrestrial ecology shall be conducted to provide a baseline assessment of the existing terrestrial ecosystems and species on the Project site, in a manner that allows an assessment, by others, of the future actual and potential impacts on the ecosystems and species from the development of the Project. This includes the route of the preferred injection pipeline and any sites for future plant infrastructure

The purpose of the survey is to identify the ecological values that may be affected by the Project in terms of:

- Flora and fauna diversity, including habitats of rare and threatened species,
- Threatened, rare, vulnerable, and endangered species.

The surveys carried out will focus on the following groups / species:

- Vegetation / Flora;
- Bird / Avifauna, in particular the three globally threatened species mentioned above ;
- Herpetofauna (Amphibians and Reptiles);
- Mammals; and

Survey methodologies must be replicable and scientifically robust. Sampling techniques shall be adequate to provide a detailed list of species and habitats using primarily visual and aural methods. Trapping and handling of species is not expected as part of this study.

1.4.2 Vegetation, Terrestrial Habitat and Flora Survey

A rapid plot based assessment is to be used to identify the vegetation communities and their boundaries. Data can be input into GIS for mapping vegetation types across the study area.

A combination of transects and plot-based surveys shall be used to provide information on vegetation boundaries, floristic diversity and the possible presence of rare and threatened plants. The transect data shall be used to develop a digital map of vegetation types and their approximate boundaries with a focus on the areas subject to disturbance from the Project. This would include up to 100 metres from the reinjection line and along any proposed access roads and ancillary sites required for machinery, stockpiling of pipes and workers facilities.

Plot-based surveys shall be carried out using 20 x 20 m (400 m²) plots established at each stratification unit at the priority sites identified.

The plot based survey shall aim to record all plant species in the plot and their relative cover (abundance) within the plot using an appropriate scale. Particular attention shall be paid to the dominant, rare, endemic, threatened, protected, invasive species, and the species that are of importance to local communities. Locations of rare or threatened plant species shall be identified using a GPS and data on the size and distribution of the population shall be recorded.

The following general data shall be recorded at each floristic plot:

- Unique identifier (Plot number);
- Location using exact GPS coordinate;
- Photographs showing habitat structure and any notable plant species;
- Altitude and slope characteristic; and
- Habitat types and structure.

Additional habitat condition data shall be recorded at each plot, including the level of modification or disturbance of habitat found within the plot and this shall be assessed according to the following grading:

- Relatively stable or undisturbed communities (e.g. old growth, unlogged forest);
- Late successional or lightly disturbed communities (e.g. old growth forest that was selectively logged in recent years);
- Mid-successional or moderately to heavily disturbed communities (e.g. young to mature secondary forest); and
- Early successional or severely disturbed communities.

1.4.3 Birds / Avifauna

The survey shall focus on sampling bird species' richness and abundance located within the range of different habitat strata present. The impenetrable density of the forest habitats are likely to preclude the use of line transects surveys and therefore point count methods are proposed. Surveys shall be conducted over wet and dry seasons and the survey date and weather conditions shall be recorded. A full-season bird survey campaign will be conducted, whose timeline will span beyond the preparation/completion of the ESIA. This will consider wet and dry seasons as well as migratory species of avifauna that might be present in the temperate winter months. When planning the bird survey campaign, the potential for identification of migratory species will be considered.

Point count surveys involve a 20 minute time-based survey and each point to record all birds seen or heard within a 50m radius of the census point. Bird surveys shall be conducted within 4 hours of sunrise to sample peak activity time and surveys shall avoid adverse weather (e.g. high wind or rain). Geographic coordinates shall be recorded at each survey point.

Observations on birds shall be done primarily through visual observation and call identification. Nests and important food source/trees for any protected and rare species described previously shall be recorded and captured with GPS positions noted.

1.4.4 Amphibians

Surveys shall involve a combination of diurnal and nocturnal census and will have the greatest chance of detecting most species if undertaken at night, in wet weather.

Systematic daytime searches for adult frogs shall be conducted with a survey effort of at least one hour within the relevant habitat of each stratification unit (this refers to off-stream wetlands and minor tributaries and the fringes of the major stream habitat). Nocturnal surveys shall involve a combination of listening for frog calls, spotlighting, searching within habitat and call recording. All aspects of the watercourse and adjacent areas must be searched, including under logs and rocks, under bark and in litter.

Surveys along the stream channels that are crossed by the pipeline shall involve a nocturnal fixed time search involving two person hours of searching per 200m section of the stream. Sites shall be selected to sample different terrestrial habitat types present along the river or stream.

1.4.5 Reptiles

Timed, diurnal active searches shall be undertaken, which involve a 30 minute search effort per stratification unit up to 100 hectares in size.

Particular attention shall be paid to rocky landscapes, where the reptiles can typically gather. Searches shall focus on rocky outcrops, logs, and leaf litter. The thirty minute active search per stratification unit shall be repeated at night to survey for nocturnal reptiles.

The type and number of species shall be recorded during the survey. Areas of high concentration shall be captured with GPS. Study area and observations of significance shall be photographed.

1.4.6 Mammals

Surveys shall aim to sample all stratification units in the Project area and aim to survey from vantage points above the canopy or walking inside the forest along available trails.

Line-transect sampling shall be used, as this is the most established technique for many mammals. Survey methodology shall include recording signs (faecal pellets, tracks, feeding signs, breeding sites or nests) and mammal sounds by walking inside the forest along available trails. The length of transect shall aim to be a minimum 1000m, but this may vary where access is not possible or very difficult. Surveys shall be repeated during the day and at night. The survey shall be completed between 6am to 10am and repeated between 6pm and 10pm using spotlight method to record both diurnal and nocturnal species. All individuals detected on and to each side of the transect line shall be recorded. The location and length of each transect shall be recorded and mapped.

The identification of the species shall include their scientific name. In case scientific name determination is impossible or uncertain, at least the genus shall be clearly indicated followed by the term sp.

For cryptic mammal species motion-detection camera traps shall be used at a density of 1 trap / 20 hectares. Camera traps shall be set along the search transects and shall be set (unbaited) and at approximately 40cm – 50cm above the ground to accommodate the height of the target species. Mammal species can be active day or night, and therefore camera traps shall be programmed to take pictures 24 hours per day. In locations with low traffic, camera traps shall be typically checked only once every 14– 30 days, whereas they shall be checked every 5-10 days at sites with high traffic, in order to avoid running out battery and filling up memory cards. Cameras shall be placed on existing tracks where mammal signs are observed.

The likely occurrence of mammals' species of conservation importance shall be also recorded based on the availability of suitable habitat. Local people shall be interviewed regarding the mammals species, number, breeding and hunting in the study area. A list with protected and threatened animal species along with photographs shall be prepared before the survey. A number of local markets shall be visited to collect similar information.

1.4.7 Locations

Each site/plot/transect shall be captured with GPS so that exact locations can be repeated as part of monitoring exercises as necessary.

1.4.8 Timing

Terrestrial ecology surveys shall be conducted at a suitable time of year if possible, with any limitations in seasonality noted in the results.

1.5 Survey Reporting

Reporting on the terrestrial ecology surveys shall include clear information on the location of survey sites (maps and GPS coordinates), methods used, survey dates, and any other important information. The data shall be presented in summary tables, with the protected, threatened, vulnerable, rare, or endemic species tabulated and mapped.

A description of each vegetation type is required, including the vegetation classification, and name of dominant plants species in each strata. The information should be sufficient to allow development of a detailed vegetation type map over the study area showing the distribution and type of each vegetation community and important habitat for rare or threatened species.

The report should include a list of species recorded and the following information to allow readers to assess whether the scope and methods of the studies were adequate to provide baseline data for the Project and to detect species of conservation interest within the Project area:

- Specific dates of surveys at each sampling site for each taxon;
- Specific locations of surveys and sampling points;
- Number of sampling points;
- Length of sampling (# days, hours, etc.);
- Detailed field methods - how were samples or records taken, what equipment was used, etc. (e.g. # and length of transects, etc.);
- Names of field workers carrying out the surveys and their qualifications;
- Names of people who identified the species;
- Description of biodiversity values for the Project area with respect to para. 16 of Performance Standard 6. Provide comment on any other biodiversity values of importance in the project area, such as Critically Endangered or Endangered species, CITES species, endemic species, etc.;
- Identification of any data gaps; and
- Recommendations for follow-up studies and/or surveys.

1.6 Use of the Biodiversity Survey Data by the ESIA Team

Using the data provided by the biodiversity surveyors, the proximity of the Project to any environmentally sensitive areas shall be shown on a map of suitable scale. Areas shall be regarded as sensitive if identified as important habitat for protected, threatened, vulnerable or rare species of flora and fauna.

Results from the surveys shall be analysed and interpreted with respect to literature from the study area. The indication of the species shall include scientific name. In any case where the exact scientific name cannot be determined the genus shall be clearly indicated followed by the term sp.

1.6.1 Impact Assessment

The ESIA team will use the sub-consultants survey data to assess the impacts of the Project on the biodiversity values identified by the survey and to determine appropriate mitigation measures. Potential impacts on biodiversity should be assessed in regards to all aspects of the Project including:

- Overlay of the Project area with established or proposed protected areas, Key Biodiversity Areas (KBAs), Important Bird Areas (IBAs), Alliance for Zero Extinction (AZE) Sites or Habitat of Endangered, Vulnerable or Near Threatened species.
- Comment on broad habitat types with respect to the modified and natural habitat definition as defined in Performance Standard 6, including comment on the type and extent of anthropogenic activities.
- Critical Habitat Assessment (as per PS6).
- Loss of habitat through land occupied for construction and operation of the Project and its facilities.
- Possible barrier effect of roads and associated vegetation clearance, and consequent impacts on landscape and animal population connectivity.
- Hydrological impacts.
- Air pollutants and dust.
- Noise and vibration.
- Light and other disturbance, including disturbance from the presence of humans.
- Mortality and injury to animals from vehicle collisions and from machinery.
- Habitat fragmentation and edge effects.
- Induced access and in-migration (and resulting pressures on biodiversity and natural resources).
- Hunting, bushmeat and wildlife trade.

- Invasive species and pathogens.
- Calculate how much forest will be cleared for the Project and evaluate the indirect impacts that the Project may bring (including from roads, construction, transport, etc).
- Evaluate significance of the impacts on each biodiversity value including the biodiversity values recognised in the nearby World Heritage Area.

1.6.2 Mitigation and offsets

The ESIA team will use the sub-consultants survey data and the assessment of impacts of the Project on the biodiversity values to determine appropriate mitigation measures. Mitigation options would consider:

- Application of the mitigation hierarchy as described in PS6 to avoid, minimise or remedy the impacts from Project activities on the key biodiversity values identified and sensitive biodiversity areas, focusing on avoidance as a first step (location of access roads, proposed infrastructure, etc). If avoidance is not possible then minimising and mitigating any impacts on-site (restoration, changing operations to have less impact, etc.).
- Develop a set of mitigation measures that can be incorporated into the Project Standard Operating Procedures (SOPs).
- After mitigation is taken into account, determine the residual impact and its significance. Identify impacts that cannot be avoided or mitigated and thus will need to be offset.

1.6.3 Consultation

The ESIA team will use the data collected by the sub-consultant to consult with relevant specialists as necessary to understand the importance of the biodiversity values identified from the field surveys. Internationally-based scientists, specialists, or NGOs may be consulted regarding habitats or species relevant to the assessment.

1.7 Summary

Further survey effort is required to identify flora and fauna, in particular rare and conservation significant species, and link these to vegetation / habitat map(s) to determine the extent of potential impacts on important species. Data should be presented and delivered in a clear and manageable format for analysis by ecologists, allowing them to complete the ESIA.

Appendix E. Technical Report – Air Quality Impact Assessment



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Dominica Geothermal Power Plant – Environmental and Social Impact Assessment

NZ Ministry of Foreign Affairs and Trade

Technical Report – Air Quality Impact Assessment

RZ020300-0002-NP-RPT-0010 | V2

July 2018



Dominica Geothermal Development

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 Document No.: RZ020300-0002-NP-RPT-0010
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A	25 July 2017	Draft for internal review	CB	B Clarke	B Clarke
B	1 August 2017	Post peer review edits	CB	B Clarke	B Clarke
C	15 August 2017	Updated draft for final review	CB	B Clarke	B Clarke
D	16 August 2017	Final draft	CB	B Clarke	B Clarke
E	7 September 2017	Final draft (minor edits)	CB	B Clarke	B Clarke
F	February 2018	Assessment at new location	CB	B Clarke	B Clarke
V1	June 2018	FINAL FOR ISSUE	CB	B Clarke	B Clarke
V2	July 2018	FINAL FOR ISSUE	CB	B Clarke	B Clarke

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Appendix A. Dust Assessment Criteria

- A.1 Dust Emission Magnitude
- A.2 Area Sensitivity
- A.3 Risk of Dust Impacts

Appendix B. CALPUFF Model Input File

Important note about your report

The sole purpose of this report and the associated services performed by Jacobs New Zealand Limited (“Jacobs”) is to describe the Environmental and Social Impact Assessment (ESIA) for the Dominica Geothermal Power Project in accordance with the scope of services set out in the contract between Jacobs and the New Zealand Ministry of Foreign Affairs and Trade (the Client). That scope of services, as described in this report, was developed with the Client, the Government of the Commonwealth of Dominica (GoCD) and the Developer (Dominica Geothermal Development Company (DGDC) established and owned by the GoCD).

Jacobs has been contracted by the Client to undertake the conceptual design and overall project definition through their engineering team. In preparing this ESIA report, Jacobs has relied upon, and presumed accurate, any information (or confirmation of the absence thereof) provided. Except as otherwise stated in the ESIA report, Jacobs has not attempted to verify the accuracy or completeness of any such information. If the information is subsequently determined to be false, inaccurate or incomplete then it is possible that our observations and conclusions as expressed in this report may change.

Jacobs derived the data in this report from information sourced as noted in the ESIA volumes and/or available in the public domain at the time or times outlined in this report. The passage of time, manifestation of latent conditions or impacts of future events may require further examination of the project and subsequent data analysis, and re-evaluation of the data, findings, observations and conclusions expressed in this report. Jacobs has prepared this report in accordance with the usual care and thoroughness of the consulting profession, for the sole purpose described above and by reference to applicable standards, guidelines, procedures and practices at the date of issue of this report. For the reasons outlined above, however, no other warranty or guarantee, whether expressed or implied, is made as to the data, observations and findings expressed in this report, to the extent permitted by law.

This report should be read in full and no excerpts are to be taken as representative of the findings. No responsibility is accepted by Jacobs for use of any part of this report in any other context.

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1. Introduction

1.1 Overview

This Technical Report is part of an Environmental and Social Impact Assessment (ESIA) for the construction and operation of the Dominica Geothermal Power Project (hereafter referred to as 'the Project'). The Project comprises the construction, completion, testing, commissioning, and operation of geothermal wells, steam gathering and reinjection system, power plant with a capacity of 7 MW and connection to electrical grid and associated infrastructure in the Roseau Valley, Dominica. The design for the Project is ongoing, with detailed design to be completed following a formal tender process for an Engineer, Procure and Construct (EPC) Contractor(s) in 2017.

1.2 Project Description

The key components of the proposed 7 MW power plant include:

- Power plant comprising 2 x 3.5 MW units (either single flash steam condensing cycle or organic Rankine cycle units (binary turbine), which will be adjacent to wells WW-P1 and WW-03. The binary power plants may use wet cooling or dry cooling;
- Production well WW-P1 – The existing geothermal production well at Laudat is indicated to have potential to generate 6 to 9 MW and will be the sole production well for the project;
- Reinjection wells WW-R1 (located in Trafalgar) and WW-01 (located in Wotten Waven) – The used geothermal fluid (brine and possibly some steam condensate) produced from production well WW-P1 would be disposed of into reinjection wells WW-R1 and WW-01 via a 250 to 300 mm diameter reinjection pipeline of up to 3.25 km in length;
- Steamfield infrastructure including two phase piping, steam separator, atmospheric flash tank, brine collection and disposal system, condensate collection and disposal system, pressure relief system, storage sump and rock muffler;
- Supporting infrastructure including existing well pads, turbine building, primary and ancillary equipment, cooling system, and water supply; and
- 11 kV interconnection to the DOMLEC electricity grid at the power plant site.

Figure 1.1 provides the locations of the well pads (WW-P1, WW-03, WW-R1 and WW-01) and reinjection lines.

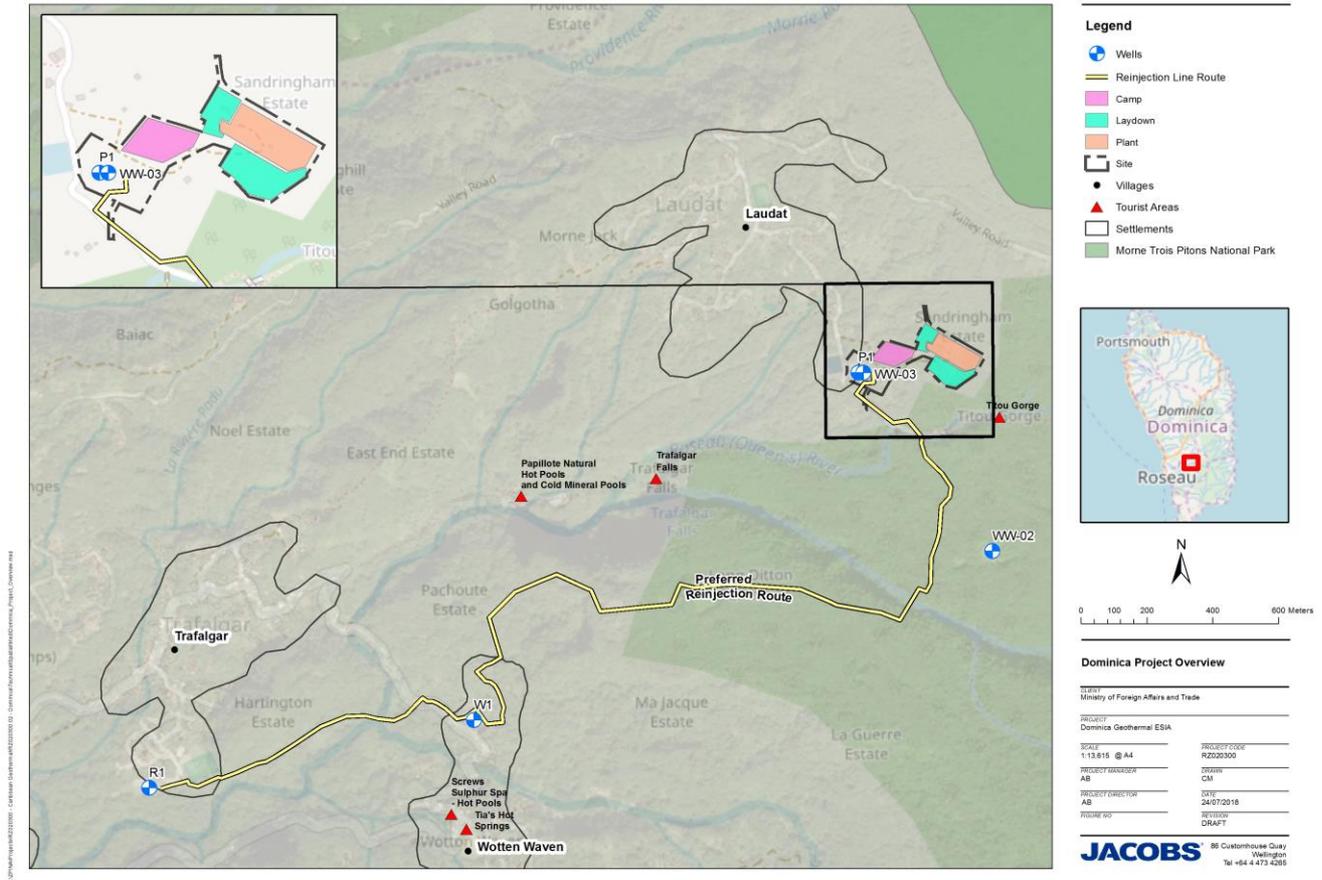


Figure 1.1 : Project Overview Purpose

This report assesses the potential impacts associated with the construction and operations of the Project on air quality, and provides an assessment of potential air quality impacts at nearby residential locations, including:

- Release of non-condensable gases (NCGs), specifically hydrogen sulphide gas (H₂S); and
- Nuisance dust.

The report is one of several technical reports prepared as a supporting documentation for an Environmental and Social Impacts Assessment (ESIA). It is based on a feasibility study preliminary design and the information given in this document is expected to be updated as the design progresses.

1.3 Limitations and assumptions

Limitations to the modelling and prediction of contaminant concentrations in ambient air are heavily dependent on the accuracy of the emissions and meteorological data used in the model. During the initial stages of the Project, specific configuration of the power plant and related air discharges are not available. Consequently, air discharges from similar existing geothermal power plants have been adapted for the purpose of this assessment. The emissions data assumed for the dispersion modelling assessment has been taken from Jacobs' assumptions of plant layout and early characterisation of the chemical composition of the geothermal resource. The emissions of NCGs and dust from the power plant and overall site may vary from those predicted in this report depending on the final type and layout of the power plant and on the composition of the geothermal fluids.

2. Site Description

The Commonwealth of Dominica is a small island developing state in the Caribbean Sea with a population of approximately 72,000 people and a land area of approximately 750 km². About 60% of the land is classified as a World Heritage site by UNESCO, due to its rich biodiversity. It is located near the centre of a string of islands known as the Lesser Antilles, between the neighbouring French territories of Martinique and Guadeloupe. The capital Roseau is located to the south-west of the island and has a population of around 15,000 people.



Figure 2.1 : Map of Dominica and Caribbean islands

2.1.1 Terrain and Land Use

Dominica consists of steep terrain which is largely covered by tropical rain forest. The island is the most mountainous of the Lesser Antilles group of islands, with the highest peak being Morne Diablotins at an elevation of 1447 metres above sea level.

2.1.2 Climate and Meteorology

Dominica has a tropical climate moderated by northeast trade winds and heavy rainfall. Average daytime temperatures vary from 26°C to 32°C, with diurnal variations of usually no greater than 3°C. The island receives approximately 2,600 mm of precipitation per year on average.

2.1.3 Existing Air Quality

The existing air quality is expected to be generally good, given the relatively low population, absence of heavy industry, and the relatively small size of the island. Anthropogenic emissions are primarily limited to diesel-fired power generators, traffic, and solid fuel combustion for cooking, etc.

As Dominica is a volcanic island there are natural sources of atmospheric emissions, including steam, carbon dioxide, and hydrogen sulphide, from natural geothermal features such as vents and fumaroles and in some areas the smell of hydrogen sulphide is noticeable¹.

Baseline monitoring has been undertaken previously to determine the existing levels of air contaminants, including H₂S but also NO₂, SO₂, ozone, and particulate matter as PM₁₀ and PM_{2.5}. The monitoring was undertaken at 30 locations for two 15-day periods (one during the wet season and one during the dry season). Monitoring of gaseous contaminants (i.e. H₂S, NO₂, SO₂, and ozone) was done using passive samplers, which provide an integrated concentration for the course of the monitoring period. PM₁₀ and PM_{2.5} were continuously measured during the monitoring period using continuous (active) particulate monitors. A summary of the results are provided in Table 2.1 below.

The monitoring sites used to conduct the baseline ambient air monitoring represent a variety of environments across the island of Dominica, including the capital (Roseau), villages in the vicinity of the Project (Laudat, Trafalgar, Fond Cani, Wotten Waven), and the Project area itself (near Laudat).

Key conclusions resulting from the baseline monitoring campaign include:

- Minor differences were observed between the wet and dry season measurements.
- NO₂ levels were low, and not significantly affected by anthropogenic emissions.
- Ozone concentrations were similarly low and did not appear to be significantly affected by anthropogenic emissions.
- SO₂ concentrations were variable, with some locations, particularly in the Wotten Waven and Morne Prosper sites having the highest measurements. Given the absence of SO₂ discharges in the area however, it is likely that these readings are a result of the analysis method used for SO₂ for the passive samples where H₂S was also presented resulting in false positives levels.
- H₂S concentrations were above the odour threshold limit of 0.3 µg/m³ at all sites, and at many sites in the Project area exceeded the nuisance threshold value of 7 µg/m³. The highest concentration of H₂S measured was 19.1 µg/m³ as a 15-day average. Using a conversion factor to estimate concentrations from longer averaging periods to 1-hour averages, this equates to around 62 µg/m³ as a 1-hour average for comparison with the odour threshold of 7 µg/m³. However, the measured concentrations are not considered unusual for active geothermal areas.
- Particulate matter (as PM₁₀ and PM_{2.5}) monitoring results indicated some influence from anthropogenic emissions, principally from burning activities.

¹ Recorded in field notes from Jacobs site visit

Table 2.1 : Baseline Ambient Monitoring Results (average of wet and dry season monitoring results)

Site ID	Site Location	Average Contaminant Concentrations, µg/m ³			
		NO ₂	SO ₂	H ₂ S	Ozone
LD1	Fresh lake	0.2	0.2	0.7	71.5
LD2	Laudat	2.3	1.5	1.0	51.9
LD3	Laudat	5.7	6.3	1.4	-
LD4	Laudat	2.6	7.0	6.1	48.1
LD5	Laudat	0.6	0.8	6.8	36.8
LD6	Laudat	0.5	8.1	1.6	54.1
TR7	Trafalgar	1.5	5.3	2.7	25.6
TR8	Trafalgar	1.8	5.6	2.5	29.9
TR9	Trafalgar	3.1	15.2	5.8	-
TR10	Trafalgar	0.9	16.7	9.7	22.7
TR11	Trafalgar	5.0	6.3	2.3	-
TR12	Trafalgar	4.4	13.3	3.9	-
WW19	Wotten Waven	0.9	18.5	11.5	35.4
WW20	Wotten Waven	0.9	28.1	18.6	42.3
WW21	Wotten Waven	6.1	39.6	11.4	34.8
WW22	Wotten Waven	0.9	34.0	19.1	43.0
WW23	Wotten Waven	0.4	58.4	18.4	-
WW24	Wotten Waven	0.8	3.7	5.1	22.1
WW25	Wotten Waven	3.1	21.8	11.9	-
WW26	Wotten Waven	2.4	11.5	6.2	-
MP27	Morne Prosper	5.8	41.4	9.4	46.5
MP28	Morne Prosper	0.7	23.5	4.7	-
MP29	Morne Prosper	2.6	17.1	5.6	-
FC13	Fond Cani	2.7	7.7	3.5	-
FC14	Fond Cani	1.5	16.7	5.9	17.9
FC15	Fond Cani	6.7	7.8	9.3	30.4
FC16	Fond Cani	10.7	9.0	5.8	-
FC17	Fond Cani	5.5	29.1	6.9	-
FC18	Fond Cani	4.4	9.6	7.4	-
CT30	Roseau	13.9	11.8	6.2	-
Maximum		13.9	58.4	19.1	71.5

2.1.4 Sensitive Receptors to Power Plant Emissions

Sensitive receptors in regard to air quality impacts from the Project include private residences, schools, hospitals, or other areas where people may be potentially exposed to discharges from the site. For the purpose of this assessment representative locations at nearby villages have been selected to predict the level of potential impacts of the discharges. These receptor locations are provided in Table 2.2 below, and on the map in Figure 2.2.

Table 2.2 : Sensitive Receptor Locations

Receptor ID	Description	UTM X (m)	UTM Y (m)
1	Boiling Lake	683085	1694272
2	Copt Hall	676788	1694159
3	Fond Cani (north)	677187	1695410
4	Fond Cani (south)	676115	1693622
5	Fresh Water Lake	681576	1696995
6	Laudat North	679049	1696166
7	Laudat South	679297	1695814
8	Laudat West	678639	1695967
9	Morne Prosper	677876	1693710
10	Shawford	676403	1694163
11	Trafalgar East	677774	1694913
12	Trafalgar South	677406	1694405
13	Trafalgar West	677173	1694965
14	Valley of Desolation	682213	1693626
15	Wotten Waven	678308	1694252

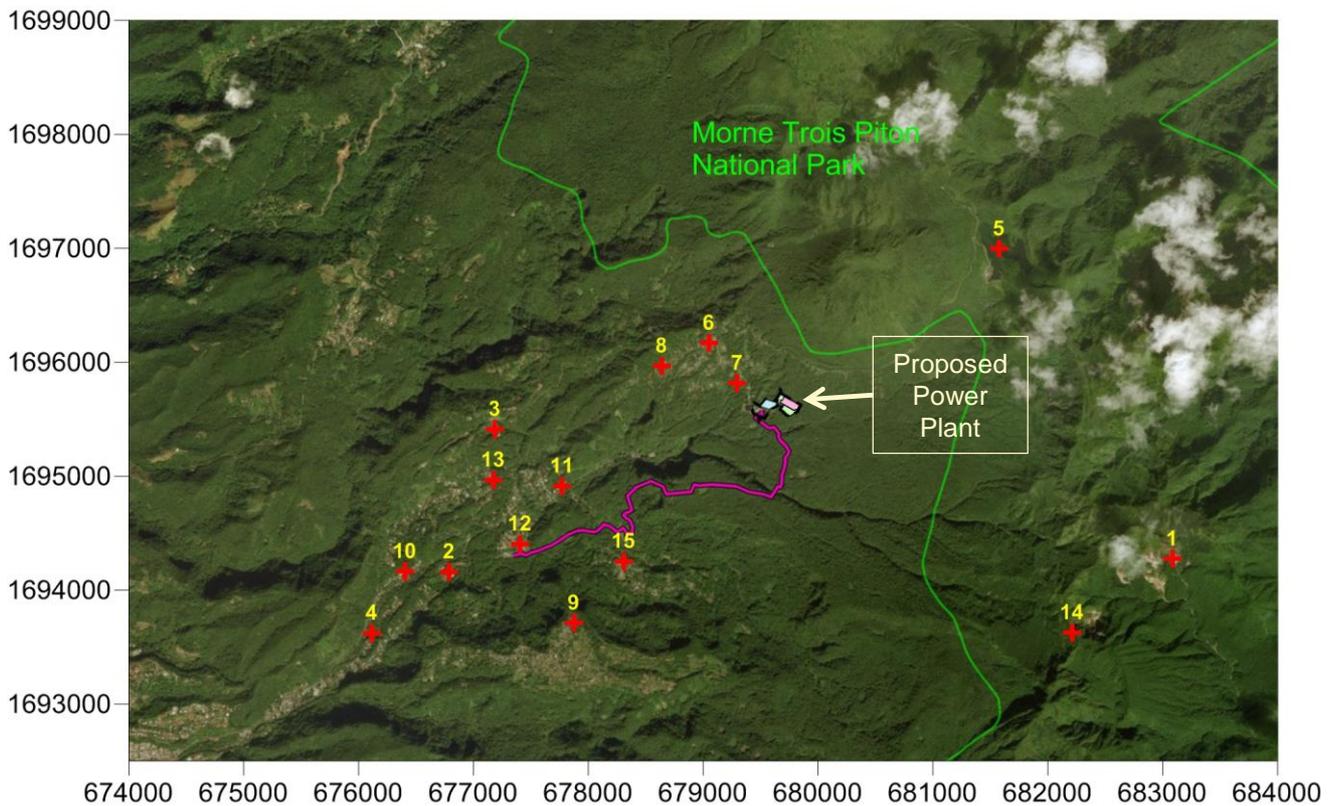


Figure 2.2 : Sensitive Receptor Locations

3. Air Emissions

3.1 Nature of Emissions

3.1.1 Non-Condensable Gases

Emission of NCGs is likely to be around four per cent of the total combined steam. The NCGs released will include hydrogen sulphide (H₂S) carbon dioxide (CO₂), and minor pollutants such as mercury (Hg), arsenic (As), ammonia (NH₃), fluoride (F⁻). The IFC EHS Guidelines for Geothermal Power Generation (2007b) state: *“Hydrogen sulfide and mercury are the main potential air pollutants [from geothermal power plants]. The presence and concentration of potential air pollutants may vary depending on the characteristics of the geothermal resource”*. For this assessment only H₂S and mercury have been considered, as the other pollutants are expected to be present in very minor concentrations and have limited potential to cause adverse impacts.

The IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation (2011) notes that; *“H₂S is toxic, but rarely of sufficient concentration [from geothermal power plants] to be harmful after venting to the atmosphere and dispersal”*.

3.1.2 Dust and Combustion Gas Emissions

Combustion gas emissions from the exhausts of transport vehicles, construction machinery, and electricity generators using diesel fuel will be associated with construction activities, and to a lesser extent operation and maintenance of the Project. Potential pollutants from diesel combustion include nitrogen oxides (NO_x), which comprises of nitrogen dioxide (NO₂) and nitrogen oxide (NO), sulphur dioxide (SO₂), carbon monoxide (CO), and carbon dioxide (CO₂), and particulate matter smaller than 10 and 2.5 microns (PM₁₀ and PM_{2.5}, respectively).

There will be minor discharges of particulate matter associated with wet cooling towers. Because wet cooling towers provide direct contact between the cooling water and the air passing through the tower, some of the liquid water may be entrained in the air stream and be carried out of the tower as drift droplets.

Construction activities also have the potential to result in fugitive dust discharges that could have nuisance effects on the surrounding environment.

3.2 Potential Discharges during Project Phases

3.2.1 Air Discharges during Construction

The construction activities with potential to create nuisance dust include:

- Minor reshaping works of the production and reinjection well pad, earthworks for the formation of power plant, and switchyard site and site access roads;
- Excavations for foundations and construction of power plant and steamlines infrastructure; and,
- Clearance and earthworks of the condensate reinjection pipeline route approximately 4 m wide and 4 km long.

Following commissioning of the well, the two phase pipelines and steam lines will be commissioned via a “steam blow” where hot steam (from the geothermal resource) will be passed through the piping at high velocity for a sustained period. This will remove any solid particles present in the piping interior which may damage the steam turbines. As with production well testing steam and NCGs will be discharged to atmosphere, although for a much shorter time.

Although very unlikely, there is also the potential for a well blowout to occur during drilling, which will result in the unplanned release of geothermal fluids including NCGs.

During construction activities there will also be a number of sources of combustion gas emissions from the exhausts of drilling rig, transport vehicles, construction machinery, and electricity generators using diesel fuel. Potential pollutants from diesel combustion include nitrogen oxides (NO_x), sulphur dioxide (SO₂), carbon monoxide (CO), carbon dioxide (CO₂), and particulate matter smaller than 10 and 2.5 microns (PM₁₀ and PM_{2.5}, respectively).

3.2.2 Air Discharges during Operation

The Process Description for the ESIA describes two types of technologies (Rankine steam condensing and organic Rankine binary) for generating electrical energy from this geothermal resource. At this stage it is too early to confirm which technology option would be used for the Project. Regardless of the option selected, emissions from the Project will include the release of NCGs from sources such as steam vents and from a point source situated in the cooling tower arrangement. Although these can be considered 'natural' in the sense that they are already emitted from numerous existing fumaroles and vents on Dominica, the power plant will emit these in larger quantities than might be experienced naturally. Hydrogen sulphide is the primary NCGs of concern with potential to have adverse impacts on the surrounding environment, with nuisance odour impacts occurring at relatively low concentrations.

Additionally, unplanned or intermittent releases of steam and NCGs could result from:

- Pipeline failures due to damage or corrosion;
- Power plant shutdowns in which steam from the steam separator is vented to air via a rock muffler; and,
- Overpressure release of steam through flash tanks.

If the Project uses wet cooling towers there will be minor amounts of particulate matter discharged from the cooling towers as water droplets. These droplets may contain trace amounts of dissolved solids that would remain airborne as the droplets evaporate. These discharges are typically mitigated by drift eliminators, and are not expected to have a significant impact on the surrounding environment.

Combustion gas emissions during operation will be limited to emergency generators, firewater pumps, and service vehicles required for transporting maintenance equipment and materials.

3.2.3 Drilling for Additional Production Wells

As discussed in Section 1 the exploration phase of the Project has been completed, and the preferred production well site has been drilled and tested to confirm adequate conditions for power generation. Additional wells may need to be drilled at a later date to supplement the decline of wells over time.

If additional production wells are required, once the drilling is completed, the wells will be discharged for a period (up to 14 days) to determine well productivity, and estimate likely well run-down over time. A short initial discharge will be made to clear the well of debris, and then the well will be discharged into a portable well test silencer that will enable measurements of flow and enthalpy. This test is run until stable conditions are obtained and could release between 10 and 50 tonnes per hour of geothermal fluid (including brine, steam and non-condensable gases (NCGs)). Once the well has stabilized, samples of the discharge brine and any separated steam will be collected for chemical analysis.

Emission of NCGs is likely to be around four to five per cent of the total combined steam and NCGs released, and will include hydrogen sulphide (H₂S) carbon dioxide (CO₂), and minor pollutants; mercury (Hg), arsenic (As), ammonia (NH₃), fluoride (F⁻). The IFC EHS Guidelines for Geothermal Power Generation (2007b) state: *"Hydrogen sulfide and mercury are the main potential air pollutants [from geothermal power plants]. The presence and concentration of potential air pollutants may vary depending on the characteristics of the geothermal resource"*. The discharges will be similar to what are emitted during the operational phase of the Project, which have been assessed in this report.

Although very unlikely, there is also the potential for a well blowout to occur during drilling, which would result in the unplanned release of geothermal fluids including NCGs.

During additional drilling activities there will also be a number of sources of combustion gas emissions from the exhausts of drilling rig, transport vehicles, construction machinery, and electricity generators using diesel fuel. Potential pollutants from diesel combustion include nitrogen oxides (NO_x), which comprises of nitrogen dioxide (NO₂) and nitrogen oxide (NO), sulphur dioxide (SO₂), carbon monoxide (CO), and carbon dioxide (CO₂), and particulate matter smaller than 10 and 2.5 microns (PM₁₀ and PM_{2.5}, respectively).

3.2.4 Air Discharges during Decommissioning

Decommissioning whole geothermal developments is a rare operation as generally, if the resource conditions are still favourable, equipment can be refurbished or replaced. Power plants can undergo refurbishment at the end of their design life to upgrade and repair equipment to enable operation and generation to continue.

For the Dominica geothermal power project, it is assumed that design practices will allow for the full decommissioning of the power plant and steam field should that be required at the end of the plants design life, or before if unforeseen conditions make the development uneconomic.

Emissions generated by activities during the decommissioning and reclamation phase will include dust emissions from land clearing, structure removal, backfilling, dumping, and reclamation of disturbed areas (grading, seeding, planting).

4. Guidelines and Standards

4.1 Introduction

The Commonwealth of Dominica has no regulations or standards with specific regard to ambient air quality. For this assessment recommendations from the World Health Organisation (WHO) and the New Zealand Ambient Air Quality Guidelines 2002 (AAQG) (MfE, 2002) have been considered.

Regarding the general requirement for assessing the impacts to air quality, this report has been prepared to meet the requirements of the WB Performance Standards, which provide guidance for managing environmental and social risk in project financing.

4.2 International Standards

As the World Bank has indicated its intention to provide funding to the development, the project is also required to demonstrate compliance with the World Bank Performance Standards for Private Sector Activities, OP 4.03, (WBG, 2013) and the WBG Environmental, Health, and Safety Guidelines (hereafter referred to as the 'EHS Guidelines').

4.3 Performance Standards

The WB Performance Standards, which are equivalent to the IFC Performance Standards on Social and Environmental Sustainability (IFC, 2012), are made up of eight performance standards which establish the standards the project should meet over the life of the investment.

Performance Standard 3 on Resource Efficiency and Pollution Prevention outlines the requirements for clients regarding GHG emissions. The objectives of Performance Standard 3 are:

- *'To avoid or minimize adverse impacts on human health and the environment by avoiding or minimizing pollution from project activities;*
- *To promote more sustainable use of resources, including energy and water; and*
- *To reduce project-related GHG emissions.'*

The General Requirements of Performance Standard 3 require that projects apply resource efficiency and pollution prevention principles and techniques which are technically and financially feasible and meet with good international industry practice (GIIP), regardless of the project's location.

Requirement 10 of Performance Standard 3 deals with pollution prevention including emissions to air:

‘The client will avoid the release of pollutants or, when avoidance is not feasible, minimize and/or control the intensity and mass flow of their release. This applies to the release of pollutants to air, water, and land due to routine, non-routine, and accidental circumstances with the potential for local, regional, and transboundary impacts. Where historical pollution such as land or ground water contamination exists, the client will seek to determine whether it is responsible for mitigation measures. If it is determined that the client is legally responsible, then these liabilities will be resolved in accordance with national law, or where this is silent, with GIIP [Good International Industry Practice].’

4.4 Environmental, Health and Safety Guidelines

The Environmental, Health, and Safety (EHS) Guidelines are technical reference documents with general and industry-specific examples of Good International Industry Practice (GIIP). When one or more members of the World Bank Group are involved in a project, these EHS Guidelines are applied as required by their respective policies and standards. The General EHS Guidelines are designed to be used together with the relevant Industry Sector EHS Guidelines which provide guidance to users on EHS issues in specific industry sectors.

The applicable EHS Guidelines comprise:

- Environmental, Health and Safety (EHS) General Guidelines (IFC, 2007a); and
- EHS Guidelines for Geothermal Power Generation (IFC, 2007b).

If the Project is seeking funding from the World Bank and it will be necessary to demonstrate use of these guidelines.

The EHS General Guidelines require that projects are assessed against the national ambient air quality guidelines or standards for the country in which they will operate, or in their absence, the WHO Ambient Air Quality Guidelines. It also provides general guidance on assessment, mitigation, and monitoring of specific air pollutants.

Specific to air quality the EHS Guidelines for Geothermal Power Generation provide recommendations for management of air quality emissions. These include:

- Considering technological options that include total or partial re-injection of gases with geothermal fluids within the context of potential environmental impacts from alternative generating technologies together with other primary factors, such as the fit of the technology to the geologic resource and economic considerations (e.g. capital and operation / maintenance costs);
- When total re-injection is not feasible, venting of hydrogen sulphide and non-condensable volatile mercury if, based on an assessment of potential impact to ambient concentrations, pollutant levels will not exceed applicable safety and health standards; and
- If necessary, use of abatement systems to remove hydrogen sulphide and mercury emissions from non-condensable gases. Examples of hydrogen sulphide controls can include wet or dry scrubber systems or a liquid phase reduction / oxidation system, while mercury emissions controls may include gas stream condensation with further separation or adsorption methods.

4.5 Air Quality Criteria Used in this Assessment

The primary pollutants of concern for the Project will be dust generated during construction activities, and emissions of NCGs from well testing and power plant operation. Of most relevance is likely to be hydrogen sulphide (H₂S) as other contaminants are usually present in very minor concentrations. Discharges of other contaminants (e.g. fugitive dust and products of diesel combustion) will be for a limited period during the construction phase. The assessment criteria used for these potential sources, across all phases, are presented in the following sections.

4.5.1 General

The final assessment of the significance of the impact, taking into account the impact specific assessment criteria, and mitigation measures, has been categorised using the definitions presented in Table 4.1.

Table 4.1 : Significance of Impacts

Significance	Impacts
Positive	An enhancement of some ecosystems or population parameter
Negligible	Incidental on-site effect. No ecological consequences.
Minor	Minor release immediately contained. Reduction in abundance / biomass of flora fauna in affected area. No changes to biodiversity. Minor environmental nuisance.
Moderate	Off-site release contained with outside assistance. Reduction in biomass in local area without significant loss of pre-impact ecological functioning. Significant sustained environmental nuisance.
Major	Off-site release with significant impact to biodiversity and ecological functioning with eventual recovery (maybe not to pre-impact conditions).
Severe	Toxic release with off-site detrimental effect. Irreversible changes to abundance of biomass in affected environment. Loss of ecological functioning with little prospect of full recovery.

4.5.2 Hydrogen Sulphide

As discussed in Section 4.1, there are no national ambient air quality guidelines or standards for Dominica. In the absence of national guidelines and standards the IFC EHS General Guidelines recommend using the WHO Ambient Air Quality Guidelines (WHO AAQG) (2005). The WHO AAQG recommends a guideline value which is based on the lowest-observed-adverse-effect level (LOAEL) of 15,000 µg/m³, the level at which eye irritation is caused. A safety factor of 100 is applied to the LOAEL in order to obtain the WHO AAQG for H₂S of 150 µg/m³ as a 24-hour average.

The New Zealand Ministry for the Environment (MfE) Ambient Air Quality Guidelines (NZ AAQG) (2002), provides a guideline value of 7 µg·m⁻³ (1-hour average) for H₂S, which is based on odour threshold rather than health effects, and in addition, notes that it may be unsuitable for use in geothermal areas due to decreased sensitivity through continuous exposure.

A summary of the potential health effects of H₂S, summarised from the NZ AAQG, is presented in Table 4.2.

Table 4.2 : Health effects of H₂S

Concentration (µg/m ³)	Effect
0.2-2.0	Odour threshold - detectable by 50% of people. Considered to have a smell of “rotten eggs” at 3 to 4 times this concentration.
7.0	Nuisance odour level (not considered applicable to geothermal areas)
15,000*	Eye irritation (LOEAL)
70,000	Permanent eye damage
225,000	Paralysis of olfactory perception (odour can no longer be detected)
400,000	Risk of pulmonary oedema
750,000	Over-stimulates the central nervous system, causing rapid breathing, cessation of breathing, convulsions, and unconsciousness.
1,400,000	Lethal

* The WHO Concise Chemical Assessment Document notes this concentration as the lowest observed adverse effect level (LOAEL) (WHO, 2003)

As shown in Table 4.2, the level at which health effects of H₂S become a concern are well above the level at which it is considered to be a nuisance odour. In general, emissions from most geothermal power plants are at a level which could produce nuisance odour effects, but are well below levels for adverse health effects.

The NZ MfE Good Practice Guide for Assessing and Managing Odour in New Zealand suggests the use of “FIDOL” for assessing the impact of odours. This method was developed for assessing actual odour events, however can be applied to predicted impacts if reasonable assumptions on the FIDOL parameters can be determined. FIDOL incorporates an assessment of:

- Frequency - how often an individual is exposed to odour;
- Intensity - the strength of the odour;
- Duration - the length of a particular odour event;
- Offensiveness - the ‘hedonic tone’ of the odour; and
- Location - the type of land use and nature of human activities in the vicinity of an odour source.

4.5.3 Mercury (Hg)

The effects of chronic exposure to elemental mercury include central nervous system effects (such as erethism, irritability, insomnia), severe salivation, gingivitis and tremor, kidney effects (including proteinuria) and acrodynia in children. The WHO ambient air guideline for inorganic mercury is 1 µg/m³ as an annual average, and is based on protecting against potential health impacts on the central nervous system. This limit is proposed for the Project.

4.5.4 Nuisance Dust

The production of dust from construction works such as the formation of roads and preparation of lay-down and drill zones will be inevitable. Modelling for dust is generally not considered appropriate for assessing construction impacts, as emission rates vary depending on a combination of the construction activity and meteorological conditions, which cannot be reliably predicted. For this assessment *Guidance on the Assessment of Dust from Demolition and Construction, Version 1.1* developed by the Institute of Air Quality Management (IAQM) (2014) has been used.

Activities on Site have been divided into four types to reflect their different potential effects. These are:

- Demolition;
- Earthworks;
- Construction; and
- Trackout.

Of these four types of activities, only earthworks and construction are relevant to the Project as no demolition and minimal materials transport is required.

The IAQM method uses a five step process for assessing dust impacts from construction activities:

Step 1. Screening based on distance to nearest receptor. No further assessment is required if there are no receptors within a certain distance of the works;

Step 2. Assess risk of dust effects from activities by:

- the scale and nature of the works, which determines the risk of dust arising; and
- the sensitivity of the area.

Step 3. Determine site specific mitigation for remaining activities with greater than negligible effects.

Step 4. Assess significance of remaining activities after mitigation has been considered.

Step 5. Reporting.

The Step 1 screening criteria provided by the IAQM guidance suggests screening out assessment of impacts from activities where sensitive 'human receptors' will be more than 350 m from the boundary of the site, 50metres of the route used by construction vehicles, or up to 500 metres from the Site entrance. Sensitive 'ecological receptors' can be screened out if they are greater than 50 metres from the boundary of the site, 50 metres of the route used by construction vehicles, or 500 metres from the site entrance.

The Step 2 assessment determines the Dust Emission Magnitude for each of four dust generating activities; demolition, earthworks, construction, and track out. The classes are; Large, Medium, or Small, with suggested definitions for each category. The lists of suggested definitions for earthworks and construction activities are presented in Appendix A.

The class of activity is then considered in relation to the distance of the nearest receptor and a risk category determined through an assessment matrix for each of three categories:

- Sensitivity to dust soiling effects;
- Sensitivity of people to health effects from PM₁₀; and,
- Sensitivity of Ecological effects.

A copy of each matrix for earthworks and construction is presented in Appendix A.

5. Emissions Estimation

5.1 Non-Condensable Gases (NCGs)

Emissions of NCGs from the plant’s operation have been estimated based on assumptions of plant design for both options of geothermal plant (i.e. steam condensing and binary/ORC). The composition of NCGs in the geothermal fluid is based on tests undertaken during the exploration phase of the project. These assumptions are described below:

- Approximately 2.3 kg/s of steam flow per MW of power generation (16.1 kg/s total for a 7 MW power development).
- Steam from the well will consist of around 1.6% NCGs by weight for a total of 0.26 kg/s.
- NCGs consist of 4.3% H₂S by weight for a discharge rate of 11.08 g/s H₂S.
- Mercury is present in varying concentrations in geothermal resources, with typical concentrations being around 20 ppb in the steam, but may be up to 500 ppb (Arnorsson, 2004). We have assumed the upper limit for a mass discharge rate of 0.0081 g/s.
- NCGs will be discharged into the cooling tower plumes in order to enhance dispersion of the gases via thermal buoyancy and mechanical draft provided by the cooling towers.

5.2 Discharge Parameters

Two types of power plant are currently being considered for the Project, a standard steam condensing plant, and an Organic Rankine Cycle (ORC) plant. For the purpose of assessing NCGs dispersion, the nature of the discharges will be similar, with the main differences being the configuration of the cooling fans/towers. Table 5.1 provides the emission parameters for two options for the Project, the steam condensing option and the ORC option. The discharge parameters have been based on preliminary site design drawings and referenced to similar projects. Both options have been assessed as buoyant line sources, under the assumption that the discharges will be vented through the cooling towers in order to enhance buoyancy. The most important parameter is the contaminant discharge rate for H₂S of 11.08 g/s, whereas the other parameters would be expected to have less of an influence on the model predictions.

Table 5.1 : Estimated Discharge Parameters and Emission Rates for Operation of Power Plant

Parameter	Steam Condensing Option	ORC Option
Line source length (m)	40	100
Line source height(m)	18	7
Building Height	18	7
Building Width (m)	20	20
Temperature (C)	35	35
Buoyancy Parameter (m ⁴ /s ³)	419	1900
H ₂ S (g/s)	11.08	11.08
Hg (g/s)	0.0081	0.0081

6. Dispersion Modelling Assessment

6.1 Modelling Methodology

Emissions of non-condensable gases from the Project have been modelled using the CALPUFF modelling system, which consists principally of a meteorological model CALMET, and a transport and dispersion model CALPUFF.

The CALMET meteorological model is used to provide meteorological data over the study area which is necessary as an input into the CALPUFF dispersion model. The CALMET model is initialised with terrain and land use data describing the region of interest as well as meteorological data from various sources. In the absence of high quality meteorological data in this area, the WRF meteorological model was used to generate a 50 x 50 kilometre wind field. CALMET used this data to generate a dataset for input into CALPUFF.

CALPUFF is a non-steady-state Gaussian puff dispersion model capable of simulating the effects of time and space-varying meteorological conditions on pollutant transport, transformation, and removal (Scire et al. 2000a). This model requires time-variant two and three-dimensional meteorological data output from a model such as CALMET, as well as information regarding the relative location and nature of the sources to be modelled for the application. Output from the CALPUFF model includes ground-level concentrations of the species considered, as well as dry and wet depositional fluxes.

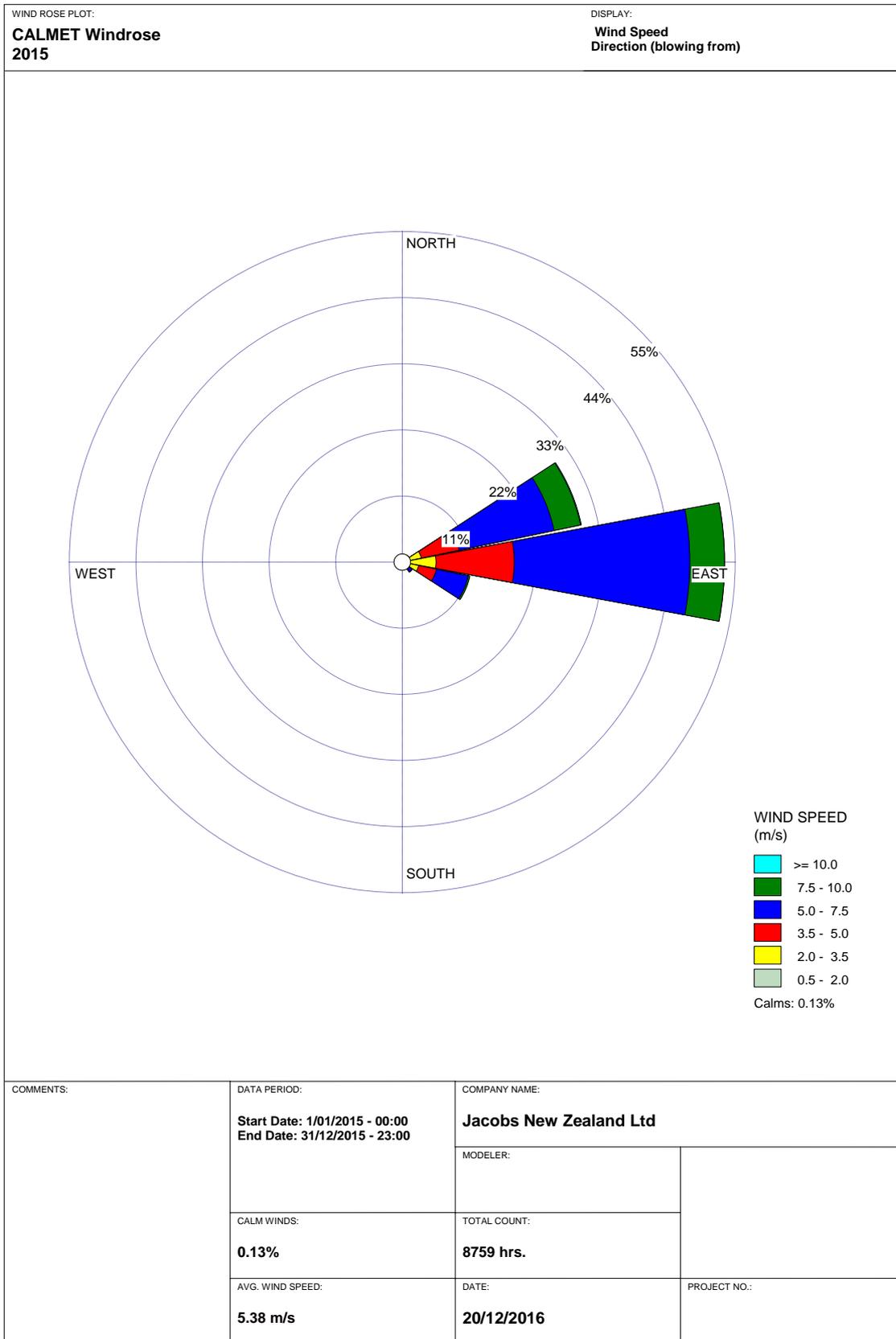
6.1.1 CALMET Settings

The CALMET diagnostic meteorological model was used to develop three-dimensional wind fields, temperature, and atmospheric stability or use with the CALPUFF dispersion model. The settings include:

- A 50 by 50 grid of 0.2 km intervals over the region, with 10 vertical levels;
- Local terrain data was obtained from NASA Shuttle Radar data for the island of Dominica;
- Land use categories were obtained from information provided by the United States Geographical Survey (USGS);
- CALMET default geophysical parameters were used based on local land use categories contained in the topographical maps; and
- Surface and upper air wind and temperature profiles and estimates of the surface humidity and pressure were commissioned from Lakes Environmental Software, who used the Weather Research Forecast (WRF) model, to develop the dataset.

The CALMET modelling domain area adopted for this assessment extends over a 20 x 20 km area, and encompasses the entire island of Dominica. A horizontal grid spacing of 200 metres was selected for the CALMET simulation. With this grid spacing, it was possible to maximize run time and file size efficiencies while still capturing large-scale terrain feature influences on wind flow patterns. To properly simulate pollution transport and dispersion, it is also important to simulate the typical vertical profiles of wind direction, wind speed, temperature, and turbulence intensity within the atmospheric boundary layer (i.e., the layer within about 2000 metres above the Earth's surface). To capture this vertical structure, ten vertical layers were selected for the extent of the modelling domain area. CALMET defines a vertical layer as the midpoint between two faces (i.e., 12 faces corresponds to 11 layers, with the lowest layer always being ground level or 10 m). The vertical faces used in this study are: 0, 20, 40, 80, 160, 320, 640, 1000, 1500, 2000, 2500 and 3000 metres.

The resultant meteorological file from CALMET covered the period 1/1/2015 to 1/1/2016 consisted of 365 days. A windrose of meteorological data extracted at a location near the Project area is provided as Figure 6.1, and shows the majority of winds are from the east, with average wind speeds of 5.4 m/s and calm winds (winds less than 0.5 m/s) occurring 0.1% of the time.



WRPLOT View - Lakes Environmental Software

Figure 6.1 : CALMET Windrose for Project Location

6.1.2 CALPUFF Settings

The CALPUFF dispersion model (Version 7.2.1) was used for this assessment. The model contains the PRIME algorithms, which are considered more reliable than earlier algorithms for assessing building wake effects caused by winds blowing over and around those buildings located near the stacks. However, downwash potential in the lee of structures was not included for modelling of stack discharges, given that the dimensions of the buildings relative to the stack height are not sufficiently high or wide to result in downwash effects in the model.

CALPUFF was set up as follows:

- The discharges were modelled as buoyant line sources;
- Dispersion estimated using the micro-meteorological dispersion algorithms. These are recommended by Scire (2003) as being theoretically more sound than using dispersion curves;
- Dispersion rates were calculated using turbulence computed from micrometeorology;
- Transitional plume rise was switched on;
- No chemical transformation was included;
- The model was run to predict one-hour, 24-hour, and annual averages; and
- The default model settings for CALPUFF were used except as otherwise specified.

A copy of the CALPUFF model input file is provided as Appendix B.

6.2 Modelling Results

The highest ground level concentrations (GLCs) as 99.9th percentile 1-hour average for H₂S predicted by the modelling at the sensitive receptors are presented in Table 6.1 below. Isopleth diagrams of the model prediction are presented as Figure 6.2 (for condensing plant option) and Figure 6.3 (for ORC option) below. The isopleth diagrams indicate the main area of impacts from the discharges is predicted to be the west and northwest of the Project site, downwind due to the predominant easterlies. South-easterly winds, while not frequently observed, appear to result in elevated concentrations to the northwest of the Project. These winds are likely to be relatively light, resulting in poorer dispersion of the plume.

The highest predicted GLC of H₂S as a 99.9th percentile 1-hour average was 1,100 µg/m³ for the steam condensing option and 8,210 µg/m³ for the ORC option, and occurs adjacent to the cooling towers, to the northwest of the laydown area. The difference between the two scenarios is due to the nature of the sources, with the ORC source having a lower discharge height as well as a lower buoyancy which results in higher concentrations near the point of discharge compared to the steam-condensing option. Both scenarios are predicted to result in concentrations that are well below the WHO lowest observable adverse effect level (LOAEL) for H₂S of 15,000 µg/m³, although they are significantly above the NZ Ministry for the Environment Odour-based guideline of 7 µg/m³ (It should be noted that this odour guideline should not be applied to areas with active natural geothermal features such as the Project area).

However, the maximum predicted concentrations decrease rapidly with distance from the power plant, and in the main residential areas are below the nuisance odour threshold of 7 µg/m³. The model predictions for the ORC option are significantly lower than for the steam condenser option at the sensitive receptors, despite the ORC predictions being higher near the power plant itself. This is presumably due to differences in release height and estimated buoyancy of the discharges which result in higher concentrations near the power plant, but greater dispersion at further distances.

Predicted 1-hour concentrations of H₂S within the Morne Trois Piton National Park are highest directly north northwest of the power plant, with highest concentrations being around 85 µg/m³ for the steam condensing option and 28 µg/m³ for the ORC option. The highest concentrations are well below the LOAEL for H₂S, and are not likely to result in adverse ecosystem impacts.

It is possible that the operation of the power plant could result in a discernible increase in odour from H₂S discharges at residences nearest to the Project area. However, given the active geothermal nature of the area and the existing baseline levels of H₂S in this area, it is unlikely that these would reach nuisance levels.

Table 6.1 : Predicted 99.9th Percentile GLCs of 1-hour average H₂S (µg/m³) from 7 MW Geothermal Plant Operation

Receptor ID	Description	Predicted 1-hour average (99.9 th percentile) H ₂ S Concentrations (µm ³)	
		Steam Condensing Option	Binary/ORC Option
1	Boiling Lake	0.0003	0.006
2	Copt Hall	1.5	0.3
3	Fond Cani (north)	8.0	2.3
4	Fond Cani (south)	0.9	0.3
5	Fresh Water Lake	0.008	0.003
6	Laudat_North	8.8	1.1
7	Laudat South	5.6	5.1
8	Laudat West	14.9	2.9
9	Morne Prosper	1.2	0.1
10	Shawford	1.7	0.5
11	Trafalgar East	2.7	0.5
12	Trafalgar South	1.2	0.2
13	Trafalgar West	3.5	0.9
14	Valley of Desolation	0.008	0.007
15	Wotten Waven	0.3	0.02
Highest at Morne Trois National Park		85	28
Highest within modelling domain		1110	8210

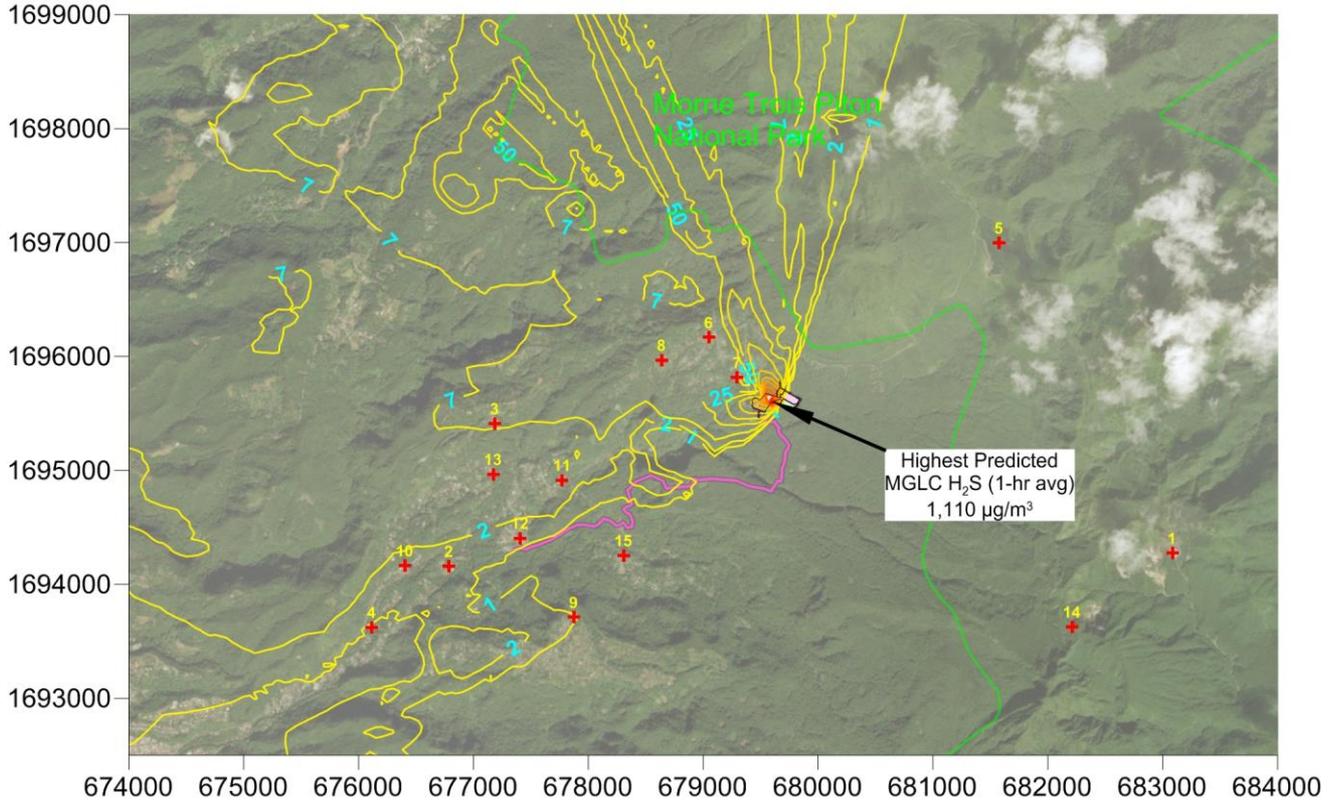


Figure 6.2 : Predicted GLCs as a 99.9th %ile 1-hour average of H₂S (µg/m³) from 7 MW Geothermal Plant Operation (Steam Condensing Option)

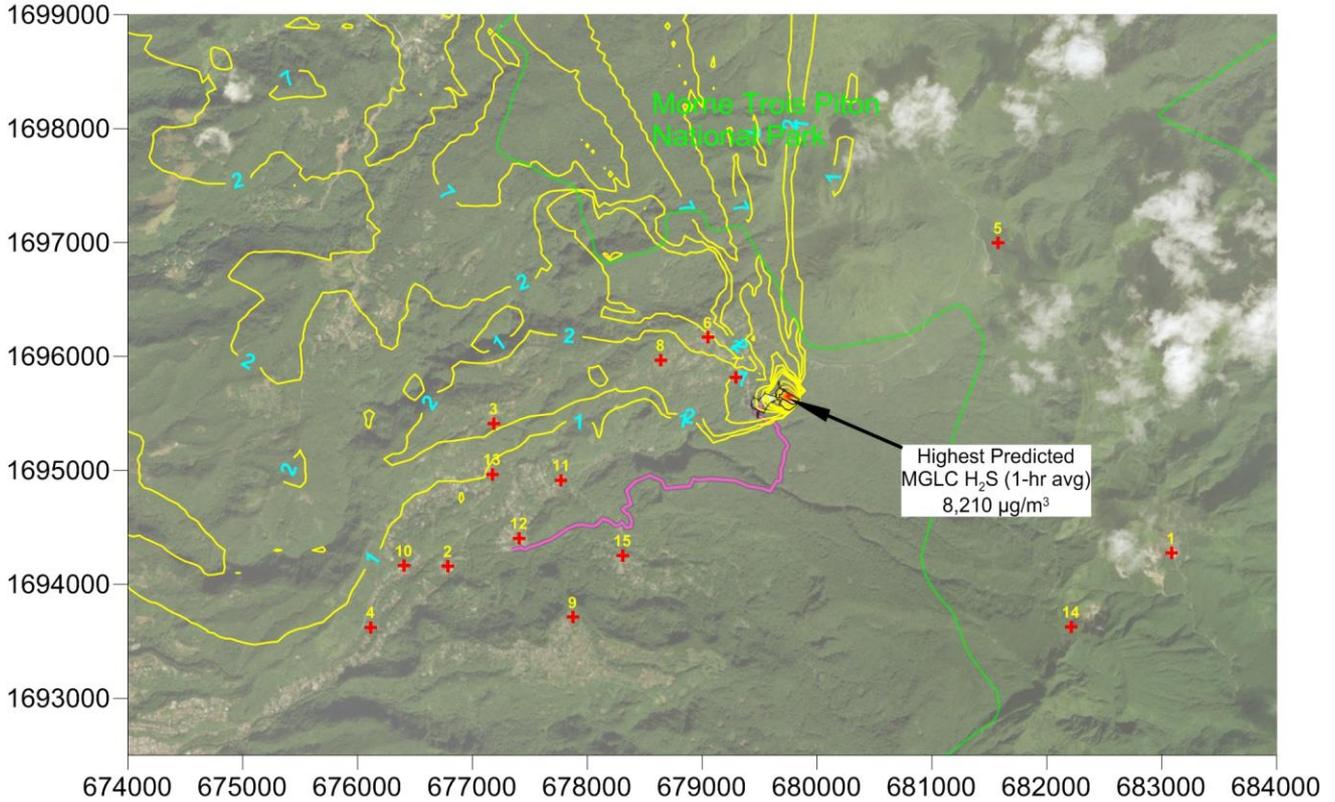


Figure 6.3 : Predicted GLCs as a 99.9th %ile 1-hour average of H₂S (µg/m³) from 7 MW Geothermal Plant Operation (ORC Option)

Predictions of H₂S as 24-hour averages are provided in Table 6.2 below, and similarly indicate concentrations of H₂S are below the WHO guideline for H₂S of 150 µg/m³ at all sensitive receptors. Concentrations near the power plant are predicted to exceed this guideline value, with the 150 µg/m³ limit exceeded just beyond the boundary in a very limited area, but not where there are residences.

Highest predicted 24-hour average concentrations of H₂S at the Morne Trois National Park occur at the boundary to the north northwest of the power plant, with the maximum concentrations being 7 µg/m³ for the ORC option and 23 µg/m³ for the steam condensing option. This indicates the likelihood of some minor odour impacts at this location from the plant, but health and ecosystem impacts will be low.

Table 6.2 : Predicted MGLCs of 24-hour average H₂S (µg/m³) from 7 MW Geothermal Plant Operation

Receptor ID	Description	Predicted 24-hour average H ₂ S Concentrations (µm ³)	
		Steam Condensing Option	Binary/ORC Option
1	Boiling Lake	0.03	0.14
2	Copt Hall	0.21	0.04
3	Fond Cani (north)	2.48	0.34
4	Fond Cani (south)	0.18	0.03
5	Fresh Water Lake	0.05	0.05
6	Laudat_North	3.62	0.30
7	Laudat South	0.98	1.01

Receptor ID	Description	Predicted 24-hour average H ₂ S Concentrations (µm ³)	
		Steam Condensing Option	Binary/ORC Option
8	Laudat West	2.72	0.50
9	Morne Prosper	0.55	0.15
10	Shawford	0.49	0.07
11	Trafalgar East	0.84	0.07
12	Trafalgar South	0.19	0.04
13	Trafalgar West	1.46	0.15
14	Valley of Desolation	0.02	0.04
15	Wotten Waven	0.18	0.03
Highest at Morne Trois National Park		23	7
Highest within modelling domain		720	4110

The highest measured background concentration of H₂S measured as part of the baseline assessment (provided in Table) is 19 µg/m³, which if added to the model predictions results in concentrations that remain well below the LOAEL of 15,000 µg/m³ and the 24-hour average guideline of 150 µg/m³ at all receptors. The highest maximum ground level concentration (MGLC) as a 24-hour average occurring at nearby receptors is 3.62 µg/m³ which occurs at Laudat North with 23 µg/m³ predicted to occur at the boundary of the Morne Trois Piton National Park for the steam condensing option.

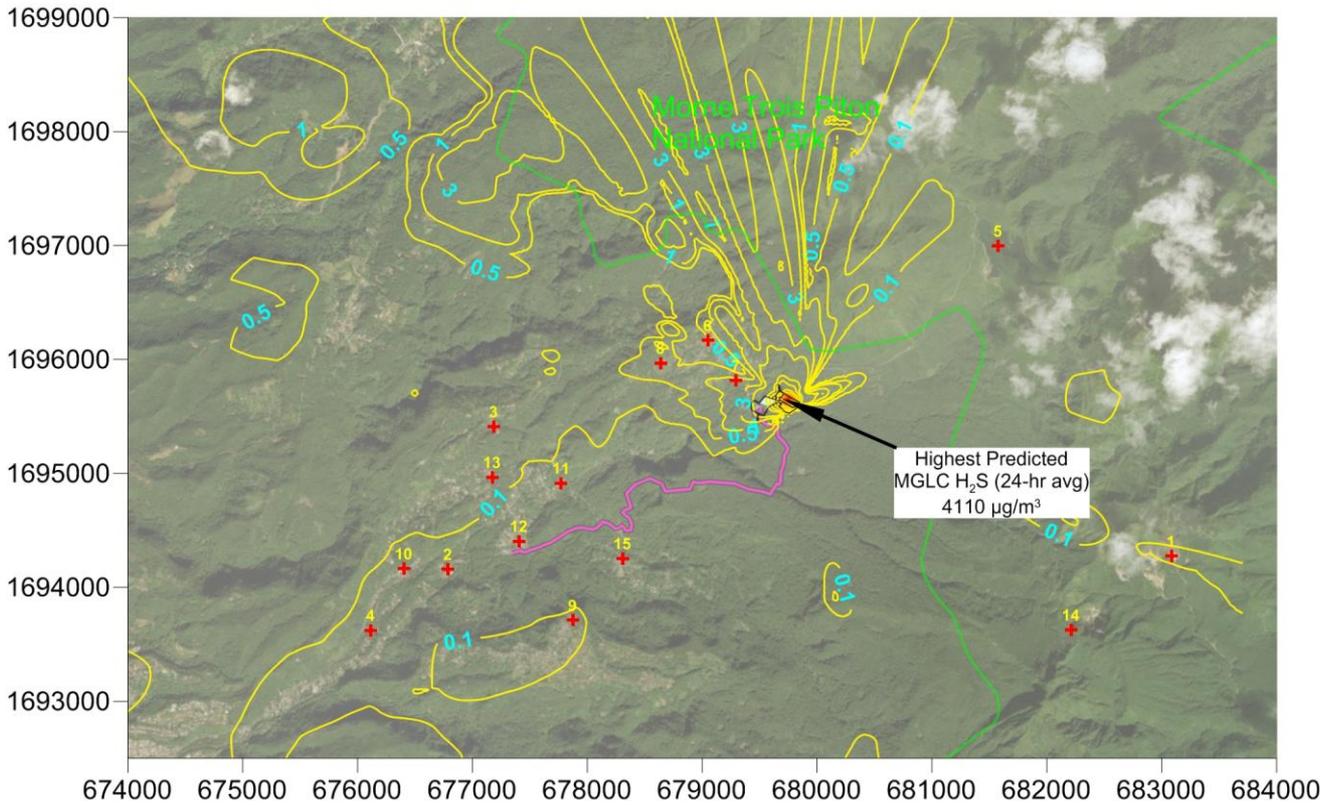


Figure 6.5 : Predicted MGLCs of 24-hour average H₂S (µg/m³) from 7 MW Geothermal Plant Operation (ORC Option)

The annual average mercury concentrations predicted by the modelling at the sensitive receptors during operation of the power plant are provided in Table 6.3 below. The highest annual average ground level concentration of mercury was predicted to be 0.53 µg/m³, and occurs near the Project boundary. This is below the WHO ambient air guideline for inorganic mercury of 1 µg/m³. Concentrations are much lower at the sensitive receptors, and beyond the park boundary, with the highest predicted concentration at sensitive receptors being 0.003 µg/m³. Given the low concentrations of mercury predicted, which are likely to be significantly lower as the mercury concentrations in the steam is expected to be well below the upper range found in geothermal resources, mercury discharges from the Project have a minor level of impact on the surrounding environment.

Table 6.3 : Predicted MGLCs of Annual Average Mercury (µg/m³) from 7 MW Geothermal Plant Operation

Receptor ID	Description	Predicted Annual Average Mercury Concentration (µm ³)	
		Steam Condensing Option	Binary/ORC Option
1	Boiling Lake	9.7E-08	2.4E-05
2	Copt Hall	4.5E-06	1.5E-04
3	Fond Cani (north)	4.5E-04	1.8E-03
4	Fond Cani (south)	2.9E-06	1.3E-04
5	Fresh Water Lake	1.3E-07	3.5E-05
6	Laudat North	3.0E-05	2.6E-03
7	Laudat South	2.2E-05	7.2E-04
8	Laudat West	1.6E-04	2.0E-03

Receptor ID	Description	Predicted Annual Average Mercury Concentration (μm^3)	
		Steam Condensing Option	Binary/ORC Option
9	Morne Prosper	3.1E-06	4.1E-04
10	Shawford	9.2E-06	3.6E-04
11	Trafalgar East	2.3E-05	6.1E-04
12	Trafalgar South	3.8E-06	1.4E-04
13	Trafalgar West	6.6E-05	1.1E-03
14	Valley of Desolation	7.7E-08	1.5E-05
15	Wotten Waven	7.6E-07	1.3E-04
Highest at Morne Trois National Park (at park boundary)		1.9E-04	4.4E-05
Highest within modelling domain		3.4E-01	5.3E-01

7. Air Quality Impact Assessment

7.1 Construction

7.1.1 Health

Health impacts from H₂S during construction activities will be short term during the well commissioning, and unlikely to reach levels which would result in an adverse impact on health.

Safety monitoring systems with warning alarms for high emissions of potentially hazardous gases will be incorporated as part of the drilling set-up.

7.1.2 Odour

The FIDOL assessment for odour impacts during exploration undertaken above, will equally apply to the construction phase, as there are likely to be H₂S levels above the nuisance odour limit identified in the NZ AAQG, but that the emissions will be for short duration during well testing and will be less noticeable as a result of desensitisation from continuous exposure to elevated background concentrations from natural sources.

7.1.3 Dust

Most construction activities can be screened out due to the distance from receptors, which appear from aerial imagery to be generally greater than 350 metres from the Project, although there are some residences (<20) within 200-350 metres of the Project. Additional works on tracks and the laydown area would be no greater than the exploration activities already undertaken. It is possible that sections of the reinjection line will be located nearer to receptors.

A general assessment of the dust emission magnitude of earthworks activities which may be associated with the Project would class them as “small” following the IAQM assessment definition in Appendix A:

‘Total site area <2,500 m², soil type with large grain size (e.g. sand), <5 heavy earth moving vehicles active at any one time, formation of bunds <4 m in height, total material moved <10,000 tonne, earthworks during wetter months.’

Similarly, an assessment of the dust emission magnitude of construction activities associated with the Project would class them as “small” following the IAQM assessment definition:

‘Total building volume <25,000 m³, construction material with low potential for dust release (e.g. metal cladding or timber).’

Table 7.1 : Dust Emission Magnitude

Activity	Dust Emission Magnitude
Earthworks	Small
Construction	Small

The majority of the construction activities associated with the Project will not be closer than 100 m of the nearest residences, giving the Project a ‘Low’ sensitivity classification in regard to dust soiling effects.

Similarly, human health impacts are classified as ‘Low’ given the absence of residences within 200 metres of the Project, and with few residences (estimated at well below 100 residential properties from examining aerial imagery) within 100 metres of the Project.

Ecological effects are classified as “Negligible”, as the Project area is more than 50 metres from a sensitive ecological area (e.g. the Morne Trois Pitons National Park).

These sensitivity classifications are summarised in Table 7.2 below.

Table 7.2 : Outcome of Defining the Sensitivity of the Area to Dust Effects

Potential Impact	Earthworks	Construction
Dust Soiling	Low	Low
Human Health	Low	Low
Ecological	Negligible	Negligible

The dust emission magnitude for the earthworks and construction activities in **Table 7.1** should be combined with the sensitivity of the area as described in **Table 7.2** to determine the risk of impacts with no mitigation applied. The risk matrices in Appendix A are then applied to assign a level of risk for each activity. The resulting dust risk for earthworks and construction activities are shown in **Table 7.3** below. As the dust emission magnitude for all activities is classified as ‘Small’, and the sensitivity of the area is classified as ‘Low’ for all activities, the resulting risk is therefore classified as ‘Negligible’ for dust soiling, human health and ecological effects. For those cases where the risk category is ‘Negligible’, no mitigation measures beyond those required by legislation will be required, although good practice dust management methods are recommended in any case.

Table 7.3 : Dust Risk Table to Define Site-Specific Mitigation

Source	Dust Soiling	Human Health	Ecology
Earthworks	Negligible	Negligible	Negligible
Construction	Negligible	Negligible	Negligible

When taken in combination with the relatively short duration of the construction, it is considered that there will be no significant impact from generated dust emissions at these sites.

7.1.4 Combustion Gases

Ambient air monitoring undertaken during the baseline monitoring described in Section 2.1.3 indicate that overall air quality is good with respect to combustion gases, although there is the potential for cumulative impacts of SO₂ and particulate matter. However, combustion emissions associated with construction activities will be more than 350 metres from the main residential areas and emissions from the main source will occur over a relatively short duration. As such, it is considered that the potential impact on people living and working in the surrounding area combustion gas emissions will be **Negligible**.

7.2 Operation

The results of the CALPUFF modelling are presented as a plot of H₂S concentration versus downwind distance in Figure 6.2. The predicted highest one-hour maximum ground level H₂S concentration as a 99.9 %ile was 8,210 µg·m⁻³ and this occurs within 50 metres downwind from the source. This value is well below the WHO lowest observable adverse effect level (LOAEL), of 15,000 µg·m⁻³.

The results of the CALPUFF modelling suggest it is possible that there will be H₂S odour concentrations downwind from the Project that will be smelt by local residents and has the potential under certain meteorological conditions to be regarded as a nuisance (offensive or objectionable). However, the NZ AAQG note that continuous exposure to H₂S will reduce a receptor’s sensitivity to it, this is likely to be the case in Dominica where there are already natural levels of H₂S present as a result of the natural geothermal activity on the Island.

A FIDOL assessment of the nuisance odour impact is considered below, based on the results of the CALPUFF modelling:

Frequency

- The discharges of odour will be more or less continuous from operation of the Project, although meteorological conditions resulting in the highest concentrations are likely to be intermittent.

Intensity

- The odour intensity is considered to be high as H₂S has a very low odour threshold and a very recognisable odour, although Dominican residents may have a reduced sensitivity to it as a result of continuous exposure from natural emission sources.

Duration

- The duration of the discharges will be more or less continuous. However, for individual receptors, the odour would only be apparent when downwind of the Project.

Offensiveness

- H₂S is described as having the odour of “rotten eggs”, although, as with intensity, Dominican residents may have a reduced sensitivity to it as a result of continuous exposure from natural emission sources.

Location

- On the basis of the modelling it is possible that nuisance odour will be detectable within the local villages to the west of the Project location (downwind of the predominant easterlies) and could potentially impact residences in their day to day activities.

Overall, it is considered that there would be a minor impact on receptors with regard to odour, due to the relatively concentrations predicted at the main residential areas and a likely desensitised local population.

There will be no nuisance dust impacts during the operation of the power plant.

Combustion emissions from the operation of the Project will be restricted to occasional use equipment such as emergency generators, firewater pumps, and maintenance vehicles. As such, it is considered that the potential impact on people living and working in the surrounding area from combustion emissions will be **Negligible**.

8. Mitigation and Monitoring

8.1 Mitigation

Although the unmitigated impacts of nuisance dust are not considered to be significant in the wider context of the Project, there could be individual residences within closer proximity to construction sites, as well as local use of near-by walking tracks and farming areas. The Project will apply good working practices to minimise potential impacts through mitigation techniques such as water suppression, covering or enclosed storage of aggregates (including topsoil and sand) where practical, and limiting dust generation activities in high winds or specific wind directions, if required.

Routine maintenance checks will be undertaken on wellheads and blowout prevention equipment to check it is in operable condition.

If a wet cooling tower system is to be used for the Project, drift eliminators will be incorporated into the final design to minimise particulate emissions.

Impacts from the operational station will be dependent on the geothermal fluid chemistry and the plant design. Given the predicted level of effects is predicted to be at an acceptable level, additional measures such as total or partial re-injection of gases with geothermal fluids; and abatement systems to remove hydrogen sulphide emissions from NCGs (e.g. wet/dry scrubbers), are not required.

8.2 Monitoring

Safety monitoring systems with warning alarms for high emissions of potentially hazardous gases, including H₂S, incorporated at the well sites, the power plant and reinjection sites, as well as providing direct safety measures in the event of a blowout, will highlight potential H₂S emissions issues which could arise during well commissioning and operation. All personnel and local residents will be made aware of the procedure should an alarm be activated.

As part of good working practice the construction manager will complete routine checks on dust generation from construction activities, and confirm that dust suppression and appropriate storage is being used where required. In addition, a mechanism for complaints regarding dust will be available to locals, and due regard given to any issues raised.

Ambient monitoring for H₂S can be easily undertaken at sensitive locations (e.g. nearby residential areas) using low-level ambient H₂S monitors such as Odialog², which can be deployed at multiple locations for up to two months at a time.

For the Organic Rankine Cycle option, there will be infrared heat detectors and pentane vapour monitors installed at the power plant site around the working fluid condenser/equipment and cooling tower, for early detection of any leaks of pentane or heat sources.

² <http://www.odalog.com/data-logging-products/low-range/>

9. Conclusion

There are a number of potential pathways for effects on air quality to occur during the various phases of the Dominica geothermal development.

Emissions associated with the combustion of diesel fuel for; drilling rig, transport vehicles, construction machinery, and electricity generators during exploration and construction, and; emergency generators, firewater pumps, and service vehicles during operation have been considered to represent a **Negligible** impact on air quality due to their relatively short duration and distance from receptors.

The potential impacts which have been identified as having minor impacts are:

- Dust generation from construction activities related to the preparation of tracks, drill sites, and laydown areas during the construction stage and the additional preparation for the well pads, power plant, steam lines, and transmission equipment associated with the power plant operation. The impacts of these activities will be reduced by using good working practices to minimise the generation of dust.
- Release of NCGs from well testing activities, with H₂S being the most relevant. Only nuisance impacts associated with increased ambient concentration of H₂S are anticipated to be of concern, as health impacts only occur with exposure to very high concentrations, which are not expected to occur as a result of this project.
- The potential for H₂S health impacts and nuisance odour during the operation of the plant. Dispersion modelling of potential discharges from plant operation indicates that the health impacts will be **Negligible** at all areas, including at nearby sensitive receptors. Nuisance odour impacts will likely be observable in the immediate vicinity of the plant, though at the nearest sensitive receptors these will be typical of active geothermal regions and would likely be indistinguishable from existing background levels.

With appropriate mitigation and monitoring in place it is considered that the potential impacts on air quality of the surrounding area will be acceptable.

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Appendix A. Dust Assessment Criteria

The assessment criteria below have been summarised from the *Guidance on the Assessment of Dust from Demolition and Construction* developed by the Institute of Air Quality Management (IAQM) (2014).

A.1 Dust Emission Magnitude

Earthworks

Earthworks will primarily involve excavating material, haulage, tipping and stockpiling. This may also involve levelling the site and landscaping. Every site is different in terms of timing (seasonality), geology, topography and duration and therefore professional judgement must be applied when classifying the earthworks' activities.

The following are examples of the potential dust emission classes (note that not all the criteria need to be met for a particular class); other criteria may be used if justified in the assessment:

- Large: Total site area >10,000 m², potentially dusty soil type (e.g. clay, which will be prone to suspension when dry to due small particle size), >10 heavy earth moving vehicles active at any one time, formation of bunds >8m in height, total material moved >100,000 tonne;
- Medium: Total site area 2,500m² – 10,000 m², moderately dusty soil type (e.g. silt), 5-10 heavy earth moving vehicles active at any one time, formation of bunds 4 m – 8 m in height, total material moved 20,000 tonne – 100,000 tonne; and
- Small: Total site area <2,500 m², soil type with large grain size (e.g. sand), <5 heavy earth moving vehicles active at any one time, formation of bunds <4 m in height, total material moved <10,000 tonne, earthworks during wetter months.

Construction

The key issues when determining the potential dust emission class during the construction phase include the size of the building(s)/infrastructure, method of construction, construction materials, and duration of build. Every site is different in terms of timing (seasonality), building type, duration, scale (volume and height) and therefore professional judgement must be applied when classifying the construction activities into one of the 3 magnitude classes.

The following are examples of the potential dust emission classes (note that not all the criteria need to be met for a particular class); other criteria may be used if justified in the assessment:

Large: Total building volume >100,000m³, piling, on site concrete batching; sandblasting

Medium: Total building volume 25,000m³ – 100,000m³, potentially dusty construction material (e.g. concrete), piling, on site concrete batching; and

Small: Total building volume <25,000m³, construction material with low potential for dust release (e.g. metal cladding or timber).

A.2 Area Sensitivity

The dust emission magnitudes for both earthworks and construction activities should then be used in the matrix in Table A1 to determine the earthworks risk category for dust soiling effects with no mitigation applied.

Similarly, the dust emission classes should be used in the matrix provided in Table A2 to assess risk to human health, and Table A3 for assessing ecological risk.

Table A1 Sensitivity of the area to Dust Soiling Effects on People and Property

Receptor Sensitivity	Number of Receptors	Distance from Source (m)			
		<20	<50	<100	<350
High	>100	High	High	Medium	Low
	10-100	High	Medium	Low	Low
	1-10	Medium	Low	Low	Low
Medium	>1	Low	Low	Low	Low
Low	>1	Low	Low	Low	Low

Table A2 : Sensitivity of the area to Human Health Impacts

Receptor Sensitivity	Annual Mean PM ₁₀ Concentration	Number of Receptors	Distance from Source (m)				
			<20	<50	<100	<200	<350
High	>32 µg/m ³	>100	High	High	High	Medium	Low
		10-100	High	High	Medium	Low	Low
		1-10	High	Medium	Low	Low	Low
	28-32 µg/m ³	>100	High	High	Low	Low	Low
		10-100	High	Medium	Low	Low	Low
		1-10	High	Medium	Low	Low	Low
	24-28 µg/m ³	>100	High	Medium	Low	Low	Low
		10-100	High	Medium	Low	Low	Low
		1-10	Medium	Low	Low	Low	Low
	<24µg/m ³	>100	Medium	Low	Low	Low	Low
		10-100	Low	Low	Low	Low	Low
		1-10	Low	Low	Low	Low	Low
Medium	>32 µg/m ³	>100	High	Medium	Low	Low	Low
		10-100	Medium	Low	Low	Low	Low
		1-10	Medium	Low	Low	Low	Low
	28-32 µg/m ³	>100	Low	Low	Low	Low	Low
		10-100	Low	Low	Low	Low	Low
		1-10	Low	Low	Low	Low	Low
	24-28 µg/m ³	>100	Low	Low	Low	Low	Low
		10-100	Low	Low	Low	Low	Low
		1-10	Low	Low	Low	Low	Low
	<24µg/m ³	>100	Low	Low	Low	Low	Low
		10-100	Low	Low	Low	Low	Low
		1-10	Low	Low	Low	Low	Low
Low	-	>1	Low	Low	Low	Low	Low

Table A3 : Sensitivity of the area to Ecological Impacts

Receptor Sensitivity	Number of Receptors	Distance from Source (m)	
		<20	<50
High	>100	High	Medium
	10-100	Medium	Low
	1-10	Low	Low
Medium	>1	Low	Low
Low	>1	Low	Low

A.3 Risk of Dust Impacts

The dust emission magnitude determined for construction and earthworks activities (i.e. small, medium or large) should be combined with the sensitivity of the area determined by the matrices in Tables A1, A2 and A3) to determine the risk of impacts with no mitigation applied. The matrix in Table A4 provides a method of assigning the level of risk for each activity. This should be used to determining the level of mitigation that must be applied. For those cases where the risk category is ‘Negligible’, no mitigation measures beyond those required by legislation will be required.

Table A4 : Risk of Dust Impacts

Sensitivity of Area	Dust Emission Magnitude		
	Large	Medium	Small
High	High Risk	Medium Risk	Low Risk
Medium	Medium Risk	Medium Risk	Low Risk
Low	Low Risk	Low Risk	Negligible

Appendix B. CALPUFF Model Input File

CALPUFF.INP 2.0 File version record

----- Run title (3 lines) -----
 CALPUFF MODEL CONTROL FILE

INPUT GROUP: 0 -- Input and Output File Names

 Default Name Type File Name

 CALMET.DAT input ! METDAT = F:\Modeling\Dominica\CALMET\calmet_2015.dat !
 or
 ISCMET.DAT input * ISCDAT = *
 or
 PLMMET.DAT input * PLMDAT = *
 or
 PROFILE.DAT input * PRFDAT = *
 SURFACE.DAT input * SFCDAT = *
 RESTARTB.DAT input * RSTARTB= *

 CALPUFF.LST output ! PUFLST = CALPUFF3b.lst !
 CONC.DAT output ! CONDAT = CALPUFF3b.con !
 DFLX.DAT output ! DFDAT = CALPUFF3b.dry !
 WFLX.DAT output ! WFDAT = CALPUFF3b.wet !

VISB.DAT output ! VISDAT = CALPUFF3b.vis !
 TK2D.DAT output * T2DDAT = *
 RHO2D.DAT output * RHODAT = *
 RESTARTE.DAT output * RSTARTE= *

 Emission Files

 PTEMARB.DAT input * PTDAT = *
 VOLEMARB.DAT input * VOLDAT = *
 BAEMARB.DAT input * ARDAT = *
 LNEMARB.DAT input * LNDAT = *

 Other Files

 OZONE.DAT input * OZDAT = *
 VD.DAT input * VDDAT = *
 CHEM.DAT input * CHEMDAT= *
 AUX input * AUXEXT = *
 (Extension added to METDAT filename(s) for files
 with auxiliary 2D and 3D data)
 H2O2.DAT input * H2O2DAT= *
 NH3Z.DAT input * NH3ZDAT= *
 HILL.DAT input * HILDAT= *
 HILLRCT.DAT input * RCTDAT= *
 COASTLN.DAT input * CSTDAT= *
 FLUXBDY.DAT input * BDYDAT= *
 BCON.DAT input * BCNDAT= *

```

DEBUG.DAT  output * DEBUG =      *
MASSFLX.DAT output * FLXDAT=     *
MASSBAL.DAT output * BALDAT=     *
FOG.DAT   output * FOGDAT=      *
RISE.DAT  output * RISDAT=      *
    
```

 All file names will be converted to lower case if LCFILES = T
 Otherwise, if LCFILES = F, file names will be converted to UPPER CASE
 T = lower case ! LCFILES = T !
 F = UPPER CASE
 NOTE: (1) file/path names can be up to 132 characters in length

Provision for multiple input files

```

Number of Modeling Domains (NMETDOM)
      Default: 1   ! NMETDOM = 1 !

Number of CALMET.DAT files for run (NMETDAT)
      Default: 1   ! NMETDAT = 1 !

Number of PTEMARB.DAT files for run (NPTDAT)
      Default: 0   ! NPTDAT = 0 !

Number of BAEMARB.DAT files for run (NARDAT)
      Default: 0   ! NARDAT = 0 !

Number of VOLEMARB.DAT files for run (NVOLDAT)
      Default: 0   ! NVOLDAT = 0 !
    
```

!END!

 Subgroup (0a)

Provide a name for each CALMET domain if NMETDOM > 1
 Enter NMETDOM lines.

```

          a,b
Default Name    Domain Name
-----
none           * DOMAIN=   * *END*
    
```

The following CALMET.DAT filenames are processed in sequence
 if NMETDAT > 1

Enter NMETDAT lines, 1 line for each file name.

```

          a,c,d
Default Name Type    File Name
-----
none    input * METDAT= * *END*
-----
a
    
```

The name for each CALMET domain and each CALMET.DAT file is treated as a separate input subgroup and therefore must end with an input group(terminator).

b

Use DOMAIN1= to assign the name for the outermost CALMET domain.
 Use DOMAIN2= to assign the name for the next inner CALMET domain.
 Use DOMAIN3= to assign the name for the next inner CALMET domain, etc.

```

    -----
    | When inner domains with equal resolution (grid-cell size) |
    | overlap, the data from the FIRST such domain in the list will |
    | be used if all other criteria for choosing the controlling |
    | grid domain are inconclusive. |
    -----
    
```

c

Use METDAT1= to assign the file names for the outermost CALMET domain.
 Use METDAT2= to assign the file names for the next inner CALMET domain.
 Use METDAT3= to assign the file names for the next inner CALMET domain, etc.

d

The filenames for each domain must be provided in sequential order

 Subgroup (0b)

The following PTEMARB.DAT filenames are processed if NPTDAT>0
 (Each file contains a subset of the sources, for the entire simulation)

Default Name	Type	File Name
none	input	* PTDAT= * *END*

 Subgroup (0c)

The following BAEMARB.DAT filenames are processed if NARDAT>0
 (Each file contains a subset of the sources, for the entire simulation)

Default Name	Type	File Name
none	input	* ARDAT= * *END*

 Subgroup (0d)

The following VOLEMARB.DAT filenames are processed if NVOLDAT>0
 (Each file contains a subset of the sources, for the entire simulation)

Default Name	Type	File Name
none	input	* VOLDAT= * *END*

 INPUT GROUP: 1 -- General run control parameters

Option to run all periods found
 in the met. file (METRUN) Default: 0 ! METRUN = 1 !

METRUN = 0 - Run period explicitly defined below
 METRUN = 1 - Run all periods in met. file

Starting date: Year (IBYR) -- No default ! IBYR = 2011 !
 Month (IBMO) -- No default ! IBMO = 1 !
 Day (IBDY) -- No default ! IBDY = 1 !
 Starting time: Hour (IBHR) -- No default ! IBHR = 0 !
 Minute (IBMIN) -- No default ! IBMIN = 0 !
 Second (IBSEC) -- No default ! IBSEC = 0 !

Ending date: Year (IEYR) -- No default ! IEYR = 2012 !
 Month (IEMO) -- No default ! IEMO = 1 !
 Day (IEDY) -- No default ! IEDY = 1 !
 Ending time: Hour (IEHR) -- No default ! IEHR = 0 !
 Minute (IEMIN) -- No default ! IEMIN = 0 !
 Second (IESEC) -- No default ! IESEC = 0 !

(These are only used if METRUN = 0)

Base time zone: (ABTZ) -- No default ! ABTZ = UTC-0400 !
 (character*8)

The modeling domain may span multiple time zones. ABTZ defines the
 base time zone used for the entire simulation. This must match the
 base time zone of the meteorological data.

Examples:

Los Angeles, USA = UTC-0800
 New York, USA = UTC-0500
 Santiago, Chile = UTC-0400
 Greenwich Mean Time (GMT) = UTC+0000
 Rome, Italy = UTC+0100
 Cape Town, S.Africa = UTC+0200
 Sydney, Australia = UTC+1000

Length of modeling time-step (seconds)

Equal to update period in the primary
 meteorological data files, or an
 integer fraction of it (1/2, 1/3 ...)

Must be no larger than 1 hour
 (NSECDT) Default:3600 ! NSECDT = 3600 !
 Units: seconds

Number of chemical species (NSPEC)

Default: 5 ! NSPEC = 1 !

Number of chemical species

to be emitted (NSE) Default: 3 ! NSE = 1 !

Flag to stop run after

SETUP phase (ITEST) Default: 2 ! ITEST = 2 !
 (Used to allow checking
 of the model inputs, files, etc.)
 ITEST = 1 - STOPS program after SETUP phase
 ITEST = 2 - Continues with execution of program
 after SETUP

Restart Configuration:

Control flag (MRESTART) Default: 0 ! MRESTART = 0 !

 0 = Do not read or write a restart file
 1 = Read a restart file at the beginning of
 the run
 2 = Write a restart file during run
 3 = Read a restart file at beginning of run
 and write a restart file during run

Number of periods in Restart
 output cycle (NRESPD) Default: 0 ! NRESPD = 0 !

 0 = File written only at last period
 >0 = File updated every NRESPD periods

Meteorological Data Format (METFM)
 Default: 1 ! METFM = 1 !

METFM = 1 - CALMET binary file (CALMET.MET)
 METFM = 2 - ISC ASCII file (ISCMET.MET)
 METFM = 3 - AUSPLUME ASCII file (PLMMET.MET)
 METFM = 4 - CTDM plus tower file (PROFILE.DAT) and
 surface parameters file (SURFACE.DAT)
 METFM = 5 - AERMET tower file (PROFILE.DAT) and
 surface parameters file (SURFACE.DAT)

Meteorological Profile Data Format (MPRFFM)
 (used only for METFM = 1, 2, 3)
 Default: 1 ! MPRFFM = 1 !

MPRFFM = 1 - CTDM plus tower file (PROFILE.DAT)
 MPRFFM = 2 - AERMET tower file (PROFILE.DAT)

PG sigma-y is adjusted by the factor (AVET/PGTIME)**0.2
 Averaging Time (minutes) (AVET)
 Default: 60.0 ! AVET = 60. !
 PG Averaging Time (minutes) (PGTIME)
 Default: 60.0 ! PGTIME = 60. !

Output units for binary concentration and flux files
 written in Dataset v2.2 or later formats
 (IOUTU) Default: 1 ! IOUTU = 1 !
 1 = mass - g/m3 (conc) or g/m2/s (dep)
 2 = odour - odour_units (conc)
 3 = radiation - Bq/m3 (conc) or Bq/m2/s (dep)

Output Dataset format for binary concentration
and flux files (e.g., CONC.DAT)

(IOVERS) Default: 2 ! IOVERS = 2 !
 1 = Dataset Version 2.1
 2 = Dataset Version 2.2

!END!

INPUT GROUP: 2 -- Technical options

Vertical distribution used in the
near field (MGAUSS) Default: 1 ! MGAUSS = 1 !
 0 = uniform
 1 = Gaussian

Terrain adjustment method
(MCTADJ) Default: 3 ! MCTADJ = 3 !
 0 = no adjustment
 1 = ISC-type of terrain adjustment
 2 = simple, CALPUFF-type of terrain
 adjustment
 3 = partial plume path adjustment

Subgrid-scale complex terrain
flag (MCTSG) Default: 0 ! MCTSG = 0 !
 0 = not modeled
 1 = modeled

Near-field puffs modeled as
elongated slugs? (MSLUG) Default: 0 ! MSLUG = 0 !
 0 = no
 1 = yes (slug model used)

Transitional plume rise modeled?
(MTRANS) Default: 1 ! MTRANS = 1 !
 0 = no (i.e., final rise only)
 1 = yes (i.e., transitional rise computed)

Stack tip downwash? (MTIP) Default: 1 ! MTIP = 1 !
 0 = no (i.e., no stack tip downwash)
 1 = yes (i.e., use stack tip downwash)

Method used to compute plume rise for
point sources not subject to building
downwash? (MRISE) Default: 1 ! MRISE = 1 !
 1 = Briggs plume rise
 2 = Numerical plume rise

Method used to simulate building

downwash? (MBDW) Default: 1 ! MBDW = 1 !

- 1 = ISC method
- 2 = PRIME method

Vertical wind shear modeled above
stack top (modified Briggs plume rise)?

(MSHEAR) Default: 0 ! MSHEAR = 0 !

- 0 = no (i.e., vertical wind shear not modeled)
- 1 = yes (i.e., vertical wind shear modeled)

Puff splitting allowed? (MSPLIT) Default: 0 ! MSPLIT = 0 !

- 0 = no (i.e., puffs not split)
- 1 = yes (i.e., puffs are split)

Chemical mechanism flag (MCHEM) Default: 1 ! MCHEM = 0 !

- 0 = chemical transformation not modeled
- 1 = transformation rates computed internally (MESOPUFF II scheme)
- 2 = user-specified transformation rates used
- 3 = transformation rates computed internally (RIVAD/ARM3 scheme)
- 4 = secondary organic aerosol formation computed (MESOPUFF II scheme for OH)
- 5 = user-specified half-life with or without transfer to child species
- 6 = transformation rates computed internally (Updated RIVAD scheme with ISORROPIA equilibrium)
- 7 = transformation rates computed internally (Updated RIVAD scheme with ISORROPIA equilibrium and CalTech SOA)

Aqueous phase transformation flag (MAQCHEM)

(Used only if MCHEM = 6, or 7) Default: 0 ! MAQCHEM = 0 !

- 0 = aqueous phase transformation not modeled
- 1 = transformation rates and wet scavenging coefficients adjusted for in-cloud aqueous phase reactions (adapted from RADM cloud model implementation in CMAQ/SCICHEM)

Liquid Water Content flag (MLWC)

(Used only if MAQCHEM = 1) Default: 1 ! MLWC = 1 !

- 0 = water content estimated from cloud cover and presence of precipitation
- 1 = gridded cloud water data read from CALMET water content output files (filenames are the CALMET.DAT names PLUS the extension AUXEXT provided in Input Group 0)

Wet removal modeled ? (MWT) Default: 1 ! MWT = 1 !

- 0 = no
- 1 = yes

Dry deposition modeled ? (MDRY) Default: 1 ! MDRY = 1 !
 0 = no
 1 = yes
 (dry deposition method specified
 for each species in Input Group 3)

Gravitational settling (plume tilt)
 modeled ? (MTILT) Default: 0 ! MTILT = 0 !
 0 = no
 1 = yes
 (puff center falls at the gravitational
 settling velocity for 1 particle species)

Restrictions:
 - MDRY = 1
 - NSPEC = 1 (must be particle species as well)
 - sg = 0 GEOMETRIC STANDARD DEVIATION in Group 8 is
 set to zero for a single particle diameter

Method used to compute dispersion
 coefficients (MDISP) Default: 3 ! MDISP = 3 !

- 1 = dispersion coefficients computed from measured values
 of turbulence, sigma v, sigma w
- 2 = dispersion coefficients from internally calculated
 sigma v, sigma w using micrometeorological variables
 (u*, w*, L, etc.)
- 3 = PG dispersion coefficients for RURAL areas (computed using
 the ISCST multi-segment approximation) and MP coefficients in
 urban areas
- 4 = same as 3 except PG coefficients computed using
 the MESOPUFF II eqns.
- 5 = CTDM sigmas used for stable and neutral conditions.
 For unstable conditions, sigmas are computed as in
 MDISP = 3, described above. MDISP = 5 assumes that
 measured values are read

Sigma-v/sigma-theta, sigma-w measurements used? (MTURBVW)
 (Used only if MDISP = 1 or 5) Default: 3 ! MTURBVW = 3 !

- 1 = use sigma-v or sigma-theta measurements
 from PROFILE.DAT to compute sigma-y
 (valid for METFM = 1, 2, 3, 4, 5)
- 2 = use sigma-w measurements
 from PROFILE.DAT to compute sigma-z
 (valid for METFM = 1, 2, 3, 4, 5)
- 3 = use both sigma-(v/theta) and sigma-w
 from PROFILE.DAT to compute sigma-y and sigma-z
 (valid for METFM = 1, 2, 3, 4, 5)
- 4 = use sigma-theta measurements
 from PLMMET.DAT to compute sigma-y
 (valid only if METFM = 3)

Back-up method used to compute dispersion
 when measured turbulence data are

missing (MDISP2) Default: 3 ! MDISP2 = 3 !
 (used only if MDISP = 1 or 5)
 2 = dispersion coefficients from internally calculated
 sigma v, sigma w using micrometeorological variables
 (u*, w*, L, etc.)
 3 = PG dispersion coefficients for RURAL areas (computed using
 the ISCST multi-segment approximation) and MP coefficients in
 urban areas
 4 = same as 3 except PG coefficients computed using
 the MESOPUFF II eqns.

[DIAGNOSTIC FEATURE]
 Method used for Lagrangian timescale for Sigma-y
 (used only if MDISP=1,2 or MDISP2=1,2)
 (MTAULY) Default: 0 ! MTAULY = 0 !
 0 = Draxler default 617.284 (s)
 1 = Computed as Lag. Length / (.75 q) -- after SCIPUFF
 10 < Direct user input (s) -- e.g., 306.9

[DIAGNOSTIC FEATURE]
 Method used for Advective-Decay timescale for Turbulence
 (used only if MDISP=2 or MDISP2=2)
 (MTAUADV) Default: 0 ! MTAUADV = 0 !
 0 = No turbulence advection
 1 = Computed (OPTION NOT IMPLEMENTED)
 10 < Direct user input (s) -- e.g., 800

Method used to compute turbulence sigma-v &
 sigma-w using micrometeorological variables
 (Used only if MDISP = 2 or MDISP2 = 2)
 (MCTURB) Default: 1 ! MCTURB = 1 !
 1 = Standard CALPUFF subroutines
 2 = AERMOD subroutines

PG sigma-y,z adj. for roughness? Default: 0 ! MROUGH = 0 !
 (MROUGH)
 0 = no
 1 = yes

Partial plume penetration of Default: 1 ! MPARTL = 1 !
 elevated inversion modeled for
 point sources?
 (MPARTL)
 0 = no
 1 = yes

Partial plume penetration of Default: 1 ! MPARTLBA = 1 !
 elevated inversion modeled for
 buoyant area sources?
 (MPARTLBA)
 0 = no
 1 = yes

Strength of temperature inversion Default: 0 ! MTINV = 0 !

provided in PROFILE.DAT extended records?

(MTINV)

- 0 = no (computed from measured/default gradients)
- 1 = yes

PDF used for dispersion under convective conditions?

Default: 0 ! MPDF = 0 !

(MPDF)

- 0 = no
- 1 = yes

Sub-Grid TIBL module used for shore line?

Default: 0 ! MSGTIBL = 0 !

(MSGTIBL)

- 0 = no
- 1 = yes

Boundary conditions (concentration) modeled?

Default: 0 ! MBCON = 0 !

(MBCON)

- 0 = no
- 1 = yes, using formatted BCON.DAT file
- 2 = yes, using unformatted CONC.DAT file

Note: MBCON > 0 requires that the last species modeled be 'BCON'. Mass is placed in species BCON when generating boundary condition puffs so that clean air entering the modeling domain can be simulated in the same way as polluted air. Specify zero emission of species BCON for all regular sources.

Individual source contributions saved?

Default: 0 ! MSOURCE = 0 !

(MSOURCE)

- 0 = no
- 1 = yes

Analyses of fogging and icing impacts due to emissions from arrays of mechanically-forced cooling towers can be performed using CALPUFF in conjunction with a cooling tower emissions processor (CTEMISS) and its associated postprocessors. Hourly emissions of water vapor and temperature from each cooling tower cell are computed for the current cell configuration and ambient conditions by CTEMISS. CALPUFF models the dispersion of these emissions and provides cloud information in a specialized format for further analysis. Output to FOG.DAT is provided in either 'plume mode' or 'receptor mode' format.

Configure for FOG Model output?

Default: 0 ! MFOG = 0 !

(MFOG)

- 0 = no
- 1 = yes - report results in PLUME Mode format
- 2 = yes - report results in RECEPTOR Mode format

Test options specified to see if they conform to regulatory values? (MREG) Default: 1 ! MREG = 0 !

- 0 = NO checks are made
- 1 = Technical options must conform to USEPA Long Range Transport (LRT) guidance
 - METFM 1 or 2
 - AVET 60. (min)
 - PGTIME 60. (min)
 - MGAUSS 1
 - MCTADJ 3
 - MTRANS 1
 - MTIP 1
 - MRISE 1
 - MCHEM 1 or 3 (if modeling SOx, NOx)
 - MWT 1
 - MDRY 1
 - MDISP 2 or 3
 - MPDF 0 if MDISP=3
1 if MDISP=2
 - MROUGH 0
 - MPARTL 1
 - MPARTLBA 0
 - SYTDEP 550. (m)
 - MHFTSZ 0
 - SVMIN 0.5 (m/s)

!END!

INPUT GROUP: 3a, 3b -- Species list

Subgroup (3a)

The following species are modeled:
! CSPEC = H2S ! !END!

SPECIES NAME (Limit: 12 Characters in length)	MODELED (0=NO, 1=YES)	Dry		NUMBER (0=NONE, 1=1st CGRUP, 2=2nd CGRUP, 3= etc.)
		EMITTED (0=NO, 1=YES)	OUTPUT GROUP DEPOSITED (0=NO, 1=COMPUTED-GAS 2=COMPUTED-PARTICLE 3=USER-SPECIFIED)	
! H2S=	1,	1,	1,	0 !

!END!

Note: The last species in (3a) must be 'BCON' when using the

boundary condition option (MBCON > 0). Species BCON should typically be modeled as inert (no chem transformation or removal).

 Subgroup (3b)

The following names are used for Species-Groups in which results for certain species are combined (added) prior to output. The CGRUP name will be used as the species name in output files. Use this feature to model specific particle-size distributions by treating each size-range as a separate species. Order must be consistent with 3(a) above.

 INPUT GROUP: 4 -- Map Projection and Grid control parameters

Projection for all (X,Y):

Map projection
 (PMAP) Default: UTM ! PMAP = UTM !

- UTM : Universal Transverse Mercator
- TTM : Tangential Transverse Mercator
- LCC : Lambert Conformal Conic
- PS : Polar Stereographic
- EM : Equatorial Mercator
- LAZA : Lambert Azimuthal Equal Area

False Easting and Northing (km) at the projection origin
 (Used only if PMAP= TTM, LCC, or LAZA)
 (FEAST) Default=0.0 ! FEAST = 0.000 !
 (FNORTH) Default=0.0 ! FNORTH = 0.000 !

UTM zone (1 to 60)
 (Used only if PMAP=UTM)
 (IUTMZN) No Default ! IUTMZN = 20 !

Hemisphere for UTM projection?
 (Used only if PMAP=UTM)
 (UTMHEM) Default: N ! UTMHEM = N !
 N : Northern hemisphere projection
 S : Southern hemisphere projection

Latitude and Longitude (decimal degrees) of projection origin
 (Used only if PMAP= TTM, LCC, PS, EM, or LAZA)
 (RLAT0) No Default ! RLAT0 = 0N !
 (RLON0) No Default ! RLON0 = 0E !

TTM : RLON0 identifies central (true N/S) meridian of projection
 RLAT0 selected for convenience
 LCC : RLON0 identifies central (true N/S) meridian of projection
 RLAT0 selected for convenience
 PS : RLON0 identifies central (grid N/S) meridian of projection
 RLAT0 selected for convenience
 EM : RLON0 identifies central meridian of projection
 RLAT0 is REPLACED by 0.0N (Equator)
 LAZA: RLON0 identifies longitude of tangent-point of mapping plane
 RLAT0 identifies latitude of tangent-point of mapping plane

Matching parallel(s) of latitude (decimal degrees) for projection
 (Used only if PMAP= LCC or PS)

(XLAT1) No Default ! XLAT1 = 0N !
 (XLAT2) No Default ! XLAT2 = 0N !

LCC : Projection cone slices through Earth's surface at XLAT1 and XLAT2
 PS : Projection plane slices through Earth at XLAT1
 (XLAT2 is not used)

 Note: Latitudes and longitudes should be positive, and include a
 letter N,S,E, or W indicating north or south latitude, and
 east or west longitude. For example,
 35.9 N Latitude = 35.9N
 118.7 E Longitude = 118.7E

Datum-region

The Datum-Region for the coordinates is identified by a character
 string. Many mapping products currently available use the model of the
 Earth known as the World Geodetic System 1984 (WGS-84). Other local
 models may be in use, and their selection in CALMET will make its output
 consistent with local mapping products. The list of Datum-Regions with
 official transformation parameters is provided by the National Imagery and
 Mapping Agency (NIMA).

NIMA Datum - Regions(Examples)

WGS-84 WGS-84 Reference Ellipsoid and Geoid, Global coverage (WGS84)
 NAS-C NORTH AMERICAN 1927 Clarke 1866 Spheroid, MEAN FOR CONUS (NAD27)
 NAR-C NORTH AMERICAN 1983 GRS 80 Spheroid, MEAN FOR CONUS (NAD83)
 NWS-84 NWS 6370KM Radius, Sphere
 ESR-S ESRI REFERENCE 6371KM Radius, Sphere

Datum-region for output coordinates
 (DATUM) Default: WGS-84 ! DATUM = WGS-84 !

METEOROLOGICAL Grid:

Rectangular grid defined for projection PMAP,
 with X the Easting and Y the Northing coordinate

X index of LL corner (IBSAMP) No default ! IBSAMP = 10 !
(IBCOMP <= IBSAMP <= IECOMP)

Y index of LL corner (JBSAMP) No default ! JBSAMP = 25 !
(JBCOMP <= JBSAMP <= JECOMP)

X index of UR corner (IESAMP) No default ! IESAMP = 60 !
(IBCOMP <= IESAMP <= IECOMP)

Y index of UR corner (JESAMP) No default ! JESAMP = 75 !
(JBCOMP <= JESAMP <= JECOMP)

Nesting factor of the sampling
grid (MESHDN) Default: 1 ! MESHDN = 4 !
(MESHDN is an integer >= 1)

!END!

INPUT GROUP: 5 -- Output Options

FILE	DEFAULT VALUE	VALUE THIS RUN
Concentrations (ICON)	1	! ICON = 1 !
Dry Fluxes (IDRY)	1	! IDRY = 1 !
Wet Fluxes (IWET)	1	! IWET = 1 !
2D Temperature (IT2D)	0	! IT2D = 0 !
2D Density (IRHO)	0	! IRHO = 0 !
Relative Humidity (IVIS) (relative humidity file is required for visibility analysis)	1	! IVIS = 1 !
Use data compression option in output file? (LCOMPRES)	Default: T	! LCOMPRES = T !

*

0 = Do not create file, 1 = create file

QA PLOT FILE OUTPUT OPTION:

Create a standard series of output files (e.g.
locations of sources, receptors, grids ...)
suitable for plotting?
(IQAPLOT) Default: 1 ! IQAPLOT = 1 !
0 = no
1 = yes

DIAGNOSTIC PUFF-TRACKING OUTPUT OPTION:

Puff locations and properties reported to
PFTRAK.DAT file for postprocessing?
(IPFTRAK) Default: 0 ! IPFTRAK = 0 !
0 = no
1 = yes, update puff output at end of each timestep
2 = yes, update puff output at end of each sampling step

DIAGNOSTIC MASS FLUX OUTPUT OPTIONS:

Mass flux across specified boundaries
for selected species reported?
(IMFLX) Default: 0 ! IMFLX = 0 !
0 = no
1 = yes (FLUXBDY.DAT and MASSFLX.DAT filenames
are specified in Input Group 0)

Mass balance for each species
reported?
(IMBAL) Default: 0 ! IMBAL = 0 !
0 = no
1 = yes (MASSBAL.DAT filename is
specified in Input Group 0)

NUMERICAL RISE OUTPUT OPTION:

Create a file with plume properties for each rise
increment, for each model timestep?
This applies to sources modeled with numerical rise
and is limited to ONE source in the run.
(INRISE) Default: 0 ! INRISE = 0 !
0 = no
1 = yes (RISE.DAT filename is
specified in Input Group 0)

LINE PRINTER OUTPUT OPTIONS:

Print concentrations (ICPRT) Default: 0 ! ICPRT = 1 !
Print dry fluxes (IDPRT) Default: 0 ! IDPRT = 0 !
Print wet fluxes (IWPRT) Default: 0 ! IWPRT = 0 !
(0 = Do not print, 1 = Print)

Concentration print interval
(ICFRQ) in timesteps Default: 1 ! ICFRQ = 1 !
Dry flux print interval
(IDFRQ) in timesteps Default: 1 ! IDFRQ = 1 !
Wet flux print interval
(IWFRQ) in timesteps Default: 1 ! IWFRQ = 1 !

Units for Line Printer Output
(IPRTU) Default: 1 ! IPRTU = 3 !
for for
Concentration Deposition

- 1 = g/m**3 g/m**2/s
- 2 = mg/m**3 mg/m**2/s
- 3 = ug/m**3 ug/m**2/s
- 4 = ng/m**3 ng/m**2/s
- 5 = Odour Units

Messages tracking progress of run
written to the screen ?

(IMESG) Default: 2 ! IMESG = 2 !

0 = no

1 = yes (advection step, puff ID)

2 = yes (YYYYJJHH, # old puffs, # emitted puffs)

SPECIES (or GROUP for combined species) LIST FOR OUTPUT OPTIONS

---- CONCENTRATIONS ---- ----- DRY FLUXES ----- ----- WET FLUXES ----- -- MASS FLUX --

SPECIES

/GROUP PRINTED? SAVED ON DISK? PRINTED? SAVED ON DISK? PRINTED? SAVED ON
DISK? SAVED ON DISK?

! H2S= 0, 1, 0, 1, 0, 1, 0 !

Note: Species BCON (for MBCON > 0) does not need to be saved on disk.

OPTIONS FOR PRINTING "DEBUG" QUANTITIES (much output)

Logical for debug output
(LDEBUG)

Default: F ! LDEBUG = F !

First puff to track
(IPFDEB)

Default: 1 ! IPFDEB = 1 !

Number of puffs to track
(NPFDEB)

Default: 1 ! NPFDEB = 1 !

Met. period to start output
(NN1)

Default: 1 ! NN1 = 1 !

Met. period to end output
(NN2)

Default: 10 ! NN2 = 10 !

!END!

INPUT GROUP: 6a, 6b, & 6c -- Subgrid scale complex terrain inputs

Subgroup (6a)

Number of terrain features (NHILL) Default: 0 ! NHILL = 0 !

Number of special complex terrain receptors (NCTREC) Default: 0 ! NCTREC = 0 !

Terrain and CTSG Receptor data for CTSG hills input in CTDM format ? (MHILL) No Default ! MHILL = 2 !

1 = Hill and Receptor data created by CTDM processors & read from HILL.DAT and HILLRCT.DAT files

2 = Hill data created by OPTHILL & input below in Subgroup (6b); Receptor data in Subgroup (6c)

Factor to convert horizontal dimensions to meters (MHILL=1) Default: 1.0 ! XHILL2M = 1.0 !

Factor to convert vertical dimensions to meters (MHILL=1) Default: 1.0 ! ZHILL2M = 1.0 !

X-origin of CTDM system relative to CALPUFF coordinate system, in Kilometers (MHILL=1) No Default ! XCTDMKM = 0 !

Y-origin of CTDM system relative to CALPUFF coordinate system, in Kilometers (MHILL=1) No Default ! YCTDMKM = 0 !

! END !

Subgroup (6b)

1 **
HILL information

HILL NO.	XC (km)	YC (km)	THETAH (deg.)	ZGRID (m)	RELIEF (m)	EXPO 1 (m)	EXPO 2 (m)	SCALE 1 (m)	SCALE 2 (m)	AMAX1	AMAX2
----	----	----	-----	-----	-----	-----	-----	-----	-----	-----	-----

Subgroup (6c)

COMPLEX TERRAIN RECEPTOR INFORMATION

XRCT (km)	YRCT (km)	ZRCT (m)	XHH
-----	-----	-----	----

1
Description of Complex Terrain Variables:
XC, YC = Coordinates of center of hill
THETAH = Orientation of major axis of hill (clockwise from

North)
 ZGRID = Height of the 0 of the grid above mean sea level
 RELIEF = Height of the crest of the hill above the grid elevation
 EXPO 1 = Hill-shape exponent for the major axis
 EXPO 2 = Hill-shape exponent for the major axis
 SCALE 1 = Horizontal length scale along the major axis
 SCALE 2 = Horizontal length scale along the minor axis
 AMAX = Maximum allowed axis length for the major axis
 BMAX = Maximum allowed axis length for the major axis

XRCT, YRCT = Coordinates of the complex terrain receptors
 ZRCT = Height of the ground (MSL) at the complex terrain Receptor
 XHH = Hill number associated with each complex terrain receptor
 (NOTE: MUST BE ENTERED AS A REAL NUMBER)

**

NOTE: DATA for each hill and CTSG receptor are treated as a separate input subgroup and therefore must end with an input group terminator.

INPUT GROUP: 7 -- Chemical parameters for dry deposition of gases

SPECIES LAW COEFFICIENT NAME	DIFFUSIVITY (cm**2/s)	ALPHA	STAR	REACTIVITY (s/cm)	MESOPHYLL RESISTANCE (dimensionless)	HENRY'S
-----	-----	-----	-----	-----	-----	-----

! H2S = 0.1656, 1, 8, 5, 3.5 !

!END!

INPUT GROUP: 8 -- Size parameters for dry deposition of particles

For SINGLE SPECIES, the mean and standard deviation are used to compute a deposition velocity for NINT (see group 9) size-ranges, and these are then averaged to obtain a mean deposition velocity.

For GROUPED SPECIES, the size distribution should be explicitly specified (by the 'species' in the group), and the standard deviation for each should be entered as 0. The model will then use the deposition velocity for the stated mean diameter.

SPECIES NAME	GEOMETRIC MASS MEAN DIAMETER (microns)	GEOMETRIC STANDARD DEVIATION (microns)
-----	-----	-----

!END!

INPUT GROUP: 9 -- Miscellaneous dry deposition parameters

Reference cuticle resistance (s/cm)
(RCUTR) Default: 30 ! RCUTR = 30.0 !
Reference ground resistance (s/cm)
(RGR) Default: 10 ! RGR = 10.0 !
Reference pollutant reactivity
(REACTR) Default: 8 ! REACTR = 8.0 !

Number of particle-size intervals used to
evaluate effective particle deposition velocity
(NINT) Default: 9 ! NINT = 9 !

Vegetation state in unirrigated areas
(IVEG) Default: 1 ! IVEG = 1 !
IVEG=1 for active and unstressed vegetation
IVEG=2 for active and stressed vegetation
IVEG=3 for inactive vegetation

!END!

INPUT GROUP: 10 -- Wet Deposition Parameters

Scavenging Coefficient -- Units: (sec)**(-1)

Pollutant	Liquid Precip.	Frozen Precip.
-----	-----	-----

! H2S = 0, 0 !

!END!

INPUT GROUP: 11a, 11b -- Chemistry Parameters

This rate is used only at night for MCHEM=1
 and is added to the computed rate both day
 and night for MCHEM=6,7 (heterogeneous reactions)
 Default: 0.2 ! RNITE1 = .2 !

Nighttime NOx loss rate in %/hour (RNITE2)
 (Used only if MCHEM = 1)
 Default: 2.0 ! RNITE2 = 2.0 !

Nighttime HNO3 formation rate in %/hour (RNITE3)
 (Used only if MCHEM = 1)
 Default: 2.0 ! RNITE3 = 2.0 !

H2O2 data input option (MH2O2) Default: 1 ! MH2O2 = 1 !
 (Used only if MCHEM = 6 or 7, and MAQCHEM = 1)
 0 = use a monthly background H2O2 value
 1 = read hourly H2O2 concentrations from
 the H2O2.DAT data file

Monthly H2O2 concentrations in ppb (BCKH2O2)
 (Used only if MQACHEM = 1 and either
 MH2O2 = 0 or
 MH2O2 = 1 and all hourly H2O2 data missing)
 Default: 12*1.
 ! BCKH2O2 = 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00 !

--- Data for SECONDARY ORGANIC AEROSOL (SOA) Options
 (used only if MCHEM = 4 or 7)

The MCHEM = 4 SOA module uses monthly values of:
 Fine particulate concentration in ug/m³ (BCKPMF)
 Organic fraction of fine particulate (OFRAC)
 VOC / NOX ratio (after reaction) (VCNX)

The MCHEM = 7 SOA module uses monthly values of:
 Fine particulate concentration in ug/m³ (BCKPMF)
 Organic fraction of fine particulate (OFRAC)

These characterize the air mass when computing
 the formation of SOA from VOC emissions.
 Typical values for several distinct air mass types are:

Month	1	2	3	4	5	6	7	8	9	10	11	12
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

Clean Continental

BCKPMF	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
OFRAC	.15	.15	.20	.20	.20	.20	.20	.20	.20	.20	.20	.15
VCNX	50.	50.	50.	50.	50.	50.	50.	50.	50.	50.	50.	50.

Clean Marine (surface)

BCKPMF	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5
OFRAC	.25	.25	.30	.30	.30	.30	.30	.30	.30	.30	.30	.25
VCNX	50.	50.	50.	50.	50.	50.	50.	50.	50.	50.	50.	50.

Urban - low biogenic (controls present)

BCKPMF 30. 30. 30. 30. 30. 30. 30. 30. 30. 30. 30. 30. 30.
 OFRAC .20 .20 .25 .25 .25 .25 .25 .25 .20 .20 .20 .20
 VCNX 4. 4. 4. 4. 4. 4. 4. 4. 4. 4. 4. 4.

Urban - high biogenic (controls present)

BCKPMF 60. 60. 60. 60. 60. 60. 60. 60. 60. 60. 60. 60.
 OFRAC .25 .25 .30 .30 .30 .55 .55 .55 .35 .35 .35 .25
 VCNX 15. 15. 15. 15. 15. 15. 15. 15. 15. 15. 15. 15.

Regional Plume

BCKPMF 20. 20. 20. 20. 20. 20. 20. 20. 20. 20. 20. 20.
 OFRAC .20 .20 .25 .35 .25 .40 .40 .40 .30 .30 .30 .20
 VCNX 15. 15. 15. 15. 15. 15. 15. 15. 15. 15. 15. 15.

Urban - no controls present

BCKPMF 100. 100. 100. 100. 100. 100. 100. 100. 100. 100. 100. 100.
 OFRAC .30 .30 .35 .35 .35 .55 .55 .55 .35 .35 .35 .30
 VCNX 2. 2. 2. 2. 2. 2. 2. 2. 2. 2. 2. 2.

Default: Clean Continental

! BCKPMF = 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00 !
 ! OFRAC = 0.15, 0.15, 0.20, 0.20, 0.20, 0.20, 0.20, 0.20, 0.20, 0.20, 0.20, 0.15 !
 ! VCNX = 50.00, 50.00, 50.00, 50.00, 50.00, 50.00, 50.00, 50.00, 50.00, 50.00, 50.00, 50.00 !

--- End Data for SECONDARY ORGANIC AEROSOL (SOA) Option

Number of half-life decay specification blocks provided in Subgroup 11b

(Used only if MCHEM = 5)

(NDECAY) Default: 0 ! NDECAY = 0 !

!END!

 Subgroup (11b)

Each species modeled may be assigned a decay half-life (sec), and the associated mass lost may be assigned to one or more other modeled species using a mass yield factor. This information is used only for MCHEM=5.

Provide NDECAY blocks assigning the half-life for a parent species and mass yield factors for each child species (if any) produced by the decay.
 Set HALF_LIFE=0.0 for NO decay (infinite half-life).

SPECIES	a	b
NAME	Half-Life (sec)	Mass Yield Factor

```
* SPEC1 = 3600., -1.0 * (Parent)
* SPEC2 = -1.0, 0.0 * (Child)
*END*
```


(ILANDUIN) Default: 20 ! ILANDUIN = 20 !

Roughness length (m) for modeling domain
(Z0IN) Default: 0.25 ! Z0IN = .25 !

Leaf area index for modeling domain
(XLAIIN) Default: 3.0 ! XLAIIN = 3.0 !

Elevation above sea level (m)
(ELEVIN) Default: 0.0 ! ELEVIN = .0 !

Latitude (degrees) for met location
(XLATIN) Default: -999. ! XLATIN = -999. !

Longitude (degrees) for met location
(XLONIN) Default: -999. ! XLONIN = -999. !

Specialized information for interpreting single-point Met data files -----

Anemometer height (m) (Used only if METFM = 2,3)
(ANEMHT) Default: 10. ! ANEMHT = 10.0 !

Form of lateral turbulence data in PROFILE.DAT file
(Used only if METFM = 4,5 or MTURBVW = 1 or 3)
(ISIGMAV) Default: 1 ! ISIGMAV = 1 !
0 = read sigma-theta
1 = read sigma-v

Choice of mixing heights (Used only if METFM = 4)
(IMIXCTDM) Default: 0 ! IMIXCTDM = 0 !
0 = read PREDICTED mixing heights
1 = read OBSERVED mixing heights

Maximum length of a slug (met. grid units)
(XMXLEN) Default: 1.0 ! XMXLEN = 1.0 !

Maximum travel distance of a puff/slug (in
grid units) during one sampling step
(XSAMLEN) Default: 1.0 ! XSAMLEN = 1.0 !

Maximum Number of slugs/puffs release from
one source during one time step
(MXNEW) Default: 99 ! MXNEW = 99 !

Maximum Number of sampling steps for
one puff/slug during one time step
(MXSAM) Default: 99 ! MXSAM = 99 !

Number of iterations used when computing
the transport wind for a sampling step
that includes gradual rise (for CALMET
and PROFILE winds)
(NCOUNT) Default: 2 ! NCOUNT = 2 !

Minimum sigma y for a new puff/slug (m)
(SYM IN) Default: 1.0 ! SYMIN = 1.0 !

Minimum sigma z for a new puff/slug (m)
 (SZMIN) Default: 1.0 ! SZMIN = 1.0 !

Maximum sigma z (m) allowed to avoid numerical problem in calculating virtual time or distance. Cap should be large enough to have no influence on normal events. Enter a negative cap to disable.
 (SZCAP_M) Default: 5.0e06 ! SZCAP_M = 5.0E06 !

Default minimum turbulence velocities sigma-v and sigma-w for each stability class over land and over water (m/s)
 (SVMIN(12) and SWMIN(12))

	----- LAND -----						----- WATER -----					
Stab Class :	A	B	C	D	E	F	A	B	C	D	E	F
Default SVMIN :	.50	.50	.50	.50	.50	.50	.37	.37	.37	.37	.37	.37
Default SWMIN :	.20	.12	.08	.06	.03	.016	.20	.12	.08	.06	.03	.016

! SVMIN = 0.500, 0.500, 0.500, 0.500, 0.500, 0.500, 0.370, 0.370, 0.370, 0.370, 0.370, 0.370!
 ! SWMIN = 0.200, 0.120, 0.080, 0.060, 0.030, 0.016, 0.200, 0.120, 0.080, 0.060, 0.030, 0.016!

Divergence criterion for dw/dz across puff used to initiate adjustment for horizontal convergence (1/s)
 Partial adjustment starts at CDIV(1), and full adjustment is reached at CDIV(2)
 (CDIV(2)) Default: 0.0,0.0 ! CDIV = .0, .0 !

Search radius (number of cells) for nearest land and water cells used in the subgrid TIBL module
 (NLUTIBL) Default: 4 ! NLUTIBL = 4 !

Minimum wind speed (m/s) allowed for non-calm conditions. Also used as minimum speed returned when using power-law extrapolation toward surface
 (WSCALM) Default: 0.5 ! WSCALM = .5 !

Maximum mixing height (m)
 (XMAXZI) Default: 3000. ! XMAXZI = 3000.0 !

Minimum mixing height (m)
 (XMINZI) Default: 50. ! XMINZI = 20.0 !

Default wind speed classes --
 5 upper bounds (m/s) are entered;
 the 6th class has no upper limit
 (WSCAT(5)) Default :
 ISC RURAL : 1.54, 3.09, 5.14, 8.23, 10.8 (10.8+)

Wind Speed Class :	1	2	3	4	5
	---	---	---	---	---

(ROLDMAX) Default: 0.25 ! ROLDMAX = 0.25 !

HORIZONTAL SPLIT

Number of puffs that result every time a puff is split - nsplith=5 means that 1 puff splits into 5

(NSPLITH) Default: 5 ! NSPLITH = 5 !

Minimum sigma-y (Grid Cells Units) of puff before it may be split

(SYSPLITH) Default: 1.0 ! SYSPLITH = 1.0 !

Minimum puff elongation rate (SYSPLITH/hr) due to wind shear, before it may be split

(SHSPLITH) Default: 2. ! SHSPLITH = 2.0 !

Minimum concentration (g/m³) of each species in puff before it may be split
Enter array of NSPEC values; if a single value is entered, it will be used for ALL species

(CNSPLITH) Default: 1.0E-07 ! CNSPLITH = 1.0E-07 !

Integration control variables -----

Fractional convergence criterion for numerical SLUG sampling integration

(EPSSLUG) Default: 1.0e-04 ! EPSSLUG = 1.0E-04 !

Fractional convergence criterion for numerical AREA source integration

(EPSAREA) Default: 1.0e-06 ! EPSAREA = 1.0E-06 !

Trajectory step-length (m) used for numerical rise integration

(DSRISE) Default: 1.0 ! DSRISE = 1.0 !

Boundary Condition (BC) Puff control variables -----

Minimum height (m) to which BC puffs are mixed as they are emitted (MBCON=2 ONLY). Actual height is reset to the current mixing height at the release point if greater than this minimum.

(HTMINBC) Default: 500. ! HTMINBC = 500.0 !

Search radius (km) about a receptor for sampling nearest BC puff. BC puffs are typically emitted with a spacing of one grid cell length, so the search radius should be greater than DGRIDKM.

(RSAMPBC) Default: 10. ! RSAMPBC = 10.0 !

Near-Surface depletion adjustment to concentration profile used when sampling BC puffs?

(MDEPBC) Default: 1 ! MDEPBC = 1 !

0 = Concentration is NOT adjusted for depletion

1 = Adjust Concentration for depletion

!END!

 INPUT GROUPS: 13a, 13b, 13c, 13d -- Point source parameters

 Subgroup (13a)

Number of point sources with
 parameters provided below (NPT1) No default ! NPT1 = 0 !

Units used for point source
 emissions below (IPTU) Default: 1 ! IPTU = 1 !

- 1 = g/s
- 2 = kg/hr
- 3 = lb/hr
- 4 = tons/yr
- 5 = Odour Unit * m³/s (vol. flux of odour compound)
- 6 = Odour Unit * m³/min
- 7 = metric tons/yr
- 8 = Bq/s (Bq = becquerel = disintegrations/s)
- 9 = GBq/yr

Number of source-species
 combinations with variable
 emissions scaling factors
 provided below in (13d) (NSPT1) Default: 0 ! NSPT1 = 0 !

Number of point sources with
 variable emission parameters
 provided in external file (NPT2) No default ! NPT2 = 0 !

(If NPT2 > 0, these point
 source emissions are read from
 the file: PTEMARB.DAT)

!END!

 Subgroup (13b)

a
 POINT SOURCE: CONSTANT DATA

Source No.	X Coordinate (km)	Y Coordinate (km)	Stack Base (m)	Base Height (m)	Stack Elevation (m)	b Exit Diameter (m/s)	c Exit Temp. (deg. K)	Bldg. Dwash	Emission Rates

a

Data for each source are treated as a separate input subgroup and therefore must end with an input group terminator.

SRCNAM is a 12-character name for a source
(No default)

X is an array holding the source data listed by the column headings
(No default)

SIGYZI is an array holding the initial sigma-y and sigma-z (m)
(Default: 0.,0.)

FMFAC is a vertical momentum flux factor (0. or 1.0) used to represent the effect of rain-caps or other physical configurations that reduce momentum rise associated with the actual exit velocity.
(Default: 1.0 -- full momentum used)

ZPLTFM is the platform height (m) for sources influenced by an isolated structure that has a significant open area between the surface and the bulk of the structure, such as an offshore oil platform. The Base Elevation is that of the surface (ground or ocean), and the Stack Height is the release height above the Base (not above the platform). Building heights entered in Subgroup 13c must be those of the buildings on the platform, measured from the platform deck. ZPLTFM is used only with MBDW=1 (ISC downwash method) for sources with building downwash.
(Default: 0.0)

b

0. = No building downwash modeled

1. = Downwash modeled for buildings resting on the surface

2. = Downwash modeled for buildings raised above the surface (ZPLTFM > 0.)

NOTE: must be entered as a REAL number (i.e., with decimal point)

c

An emission rate must be entered for every pollutant modeled.

Enter emission rate of zero for secondary pollutants that are modeled, but not emitted. Units are specified by IPTU

(e.g. 1 for g/s).

Subgroup (13c)

Subgroup (13c)

BUILDING DIMENSION DATA FOR SOURCES SUBJECT TO DOWNWASH

Source(a)

No. Effective building height, width, length and X/Y offset (in meters) every 10 degrees. LENGTH, XBADJ, and YBADJ are only needed for MBDW=2 (PRIME downwash option)

a

Building height, width, length, and X/Y offset from the source are treated as a separate input subgroup for each source and therefore must end with an input group terminator. The X/Y offset is the position, relative to the stack, of the center of the upwind face of the projected building, with the x-axis pointing along the flow direction.

 Subgroup (13d)

a
 POINT SOURCE: VARIABLE EMISSIONS DATA

Use this subgroup to describe temporal variations in the emission rates given in 13b. Factors entered multiply the rates in 13b. Skip sources here that have constant emissions. For more elaborate variation in source parameters, use PTEMARB.DAT and NPT2 > 0.

IVARY determines the type of variation, and is source-specific:
 (IVARY) Default: 0

- 0 = Constant
- 1 = Diurnal cycle (24 scaling factors: hours 1-24)
- 2 = Monthly cycle (12 scaling factors: months 1-12)
- 3 = Hour & Season (4 groups of 24 hourly scaling factors, where first group is DEC-JAN-FEB)
- 4 = Speed & Stab. (6 groups of 6 scaling factors, where first group is Stability Class A, and the speed classes have upper bounds (m/s) defined in Group 12)
- 5 = Temperature (12 scaling factors, where temperature classes have upper bounds (C) of: 0, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 50+)

 a
 Data for each species are treated as a separate input subgroup and therefore must end with an input group terminator.

 INPUT GROUPS: 14a, 14b, 14c, 14d -- Area source parameters

 Subgroup (14a)

Number of polygon area sources with parameters specified below (NAR1) No default ! NAR1 = 0 !

Units used for area source

a

Data for each source are treated as a separate input subgroup and therefore must end with an input group terminator.

Subgroup (14d)

a
AREA SOURCE: VARIABLE EMISSIONS DATA

Use this subgroup to describe temporal variations in the emission rates given in 14b. Factors entered multiply the rates in 14b. Skip sources here that have constant emissions. For more elaborate variation in source parameters, use BAEMARB.DAT and NAR2 > 0.

IVARY determines the type of variation, and is source-specific:
(IVARY) Default: 0

- 0 = Constant
- 1 = Diurnal cycle (24 scaling factors: hours 1-24)
- 2 = Monthly cycle (12 scaling factors: months 1-12)
- 3 = Hour & Season (4 groups of 24 hourly scaling factors, where first group is DEC-JAN-FEB)
- 4 = Speed & Stab. (6 groups of 6 scaling factors, where first group is Stability Class A, and the speed classes have upper bounds (m/s) defined in Group 12)
- 5 = Temperature (12 scaling factors, where temperature classes have upper bounds (C) of: 0, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 50+)

a

Data for each species are treated as a separate input subgroup and therefore must end with an input group terminator.

INPUT GROUPS: 15a, 15b, 15c -- Line source parameters

Subgroup (15a)

Number of buoyant line sources with variable location and emission parameters (NLN2) No default ! NLN2 = 0 !

(If NLN2 > 0, ALL parameter data for

these sources are read from the file: LNEARB.DAT)

Number of buoyant line sources (NLINES) No default ! NLINES = 1 !

Units used for line source

emissions below (ILNU) Default: 1 ! ILNU = 1 !

- 1 = g/s
- 2 = kg/hr
- 3 = lb/hr
- 4 = tons/yr
- 5 = Odour Unit * m³/s (vol. flux of odour compound)
- 6 = Odour Unit * m³/min
- 7 = metric tons/yr
- 8 = Bq/s (Bq = becquerel = disintegrations/s)
- 9 = GBq/yr

Number of source-species combinations with variable emissions scaling factors provided below in (15c) (NSLN1) Default: 0 ! NSLN1 = 0 !

Maximum number of segments used to model each line (MXNSEG) Default: 7 ! MXNSEG = 7 !

The following variables are required only if NLINES > 0. They are used in the buoyant line source plume rise calculations.

Number of distances at which transitional rise is computed Default: 6 ! NLRISE = 6 !

Average building length (XL) No default ! XL = 40 !
(in meters)

Average building height (HBL) No default ! HBL = 15 !
(in meters)

Average building width (WBL) No default ! WBL = 5 !
(in meters)

Average line source width (WML) No default ! WML = 5 !
(in meters)

Average separation between buildings (DXL) No default ! DXL = 10 !
(in meters)

Average buoyancy parameter (FPRIMEL) No default ! FPRIMEL = 419 !
(in m⁴/s³)

!END!

Subgroup (15b)

BUOYANT LINE SOURCE: CONSTANT DATA

Source No.	Beg. X Coordinate (km)	Beg. Y Coordinate (km)	End. X Coordinate (km)	End. Y Coordinate (m)	Release Height (m)	Base Elevation	Emission Rates

1	! SRCNAM = SRC 1 !						
1	! X = 679.4625598, 1695.610582, 679.4926323, 1695.60813,				15.1,		566, 11.08 !

!END!

a
Data for each source are treated as a separate input subgroup and therefore must end with an input group terminator.

b
An emission rate must be entered for every pollutant modeled. Enter emission rate of zero for secondary pollutants that are modeled, but not emitted. Units are specified by ILNTU (e.g. 1 for g/s).

Subgroup (15c)

a
BUOYANT LINE SOURCE: VARIABLE EMISSIONS DATA

Use this subgroup to describe temporal variations in the emission rates given in 15b. Factors entered multiply the rates in 15b. Skip sources here that have constant emissions.

IVARY determines the type of variation, and is source-specific:
(IVARY) Default: 0

- 0 = Constant
- 1 = Diurnal cycle (24 scaling factors: hours 1-24)
- 2 = Monthly cycle (12 scaling factors: months 1-12)
- 3 = Hour & Season (4 groups of 24 hourly scaling factors, where first group is DEC-JAN-FEB)
- 4 = Speed & Stab. (6 groups of 6 scaling factors, where first group is Stability Class A, and the speed classes have upper bounds (m/s) defined in Group 12)
- 5 = Temperature (12 scaling factors, where temperature classes have upper bounds (C) of: 0, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 50+)

a
Data for each species are treated as a separate input subgroup

and therefore must end with an input group terminator.

 INPUT GROUPS: 16a, 16b, 16c -- Volume source parameters

 Subgroup (16a)

Number of volume sources with parameters provided in 16b,c (NVL1) No default ! NVL1 = 0 !

Units used for volume source emissions below in 16b (IVLU) Default: 1 ! IVLU = 1 !

- 1 = g/s
- 2 = kg/hr
- 3 = lb/hr
- 4 = tons/yr
- 5 = Odour Unit * m³/s (vol. flux of odour compound)
- 6 = Odour Unit * m³/min
- 7 = metric tons/yr
- 8 = Bq/s (Bq = becquerel = disintegrations/s)
- 9 = GBq/yr

Number of source-species combinations with variable emissions scaling factors provided below in (16c) (NSVL1) Default: 0 ! NSVL1 = 0 !

Number of volume sources with variable location and emission parameters (NVL2) No default ! NVL2 = 0 !

(If NVL2 > 0, ALL parameter data for these sources are read from the VOLEMARB.DAT file(s))

!END!

 Subgroup (16b)

a
 VOLUME SOURCE: CONSTANT DATA

X	Y	Effect.	Base	Initial	Initial	Emission	Rates
Coordinate	Coordinate	Height	Height	Elevation	Sigma y	Sigma z	
(km)	(km)	(m)	(m)	(m)	(m)		
-----	-----	-----	-----	-----	-----	-----	-----

 a

Data for each source are treated as a separate input subgroup and therefore must end with an input group terminator.

b

An emission rate must be entered for every pollutant modeled. Enter emission rate of zero for secondary pollutants that are modeled, but not emitted. Units are specified by IVLU (e.g. 1 for g/s).

Subgroup (16c)

a
VOLUME SOURCE: VARIABLE EMISSIONS DATA

Use this subgroup to describe temporal variations in the emission rates given in 16b. Factors entered multiply the rates in 16b. Skip sources here that have constant emissions. For more elaborate variation in source parameters, use VOLEMARB.DAT and NVL2 > 0.

IVARY determines the type of variation, and is source-specific:
(IVARY) Default: 0

- 0 = Constant
- 1 = Diurnal cycle (24 scaling factors: hours 1-24)
- 2 = Monthly cycle (12 scaling factors: months 1-12)
- 3 = Hour & Season (4 groups of 24 hourly scaling factors, where first group is DEC-JAN-FEB)
- 4 = Speed & Stab. (6 groups of 6 scaling factors, where first group is Stability Class A, and the speed classes have upper bounds (m/s) defined in Group 12)
- 5 = Temperature (12 scaling factors, where temperature classes have upper bounds (C) of: 0, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 50+)

a

Data for each species are treated as a separate input subgroup and therefore must end with an input group terminator.

INPUT GROUPS: 17a & 17b -- Non-gridded (discrete) receptor information

Subgroup (17a)

Number of non-gridded receptors (NREC) No default ! NREC = 15 !

!END!

 Subgroup (17b)

a
 NON-GRIDDED (DISCRETE) RECEPTOR DATA

Receptor No.	X Coordinate (km)	Y Coordinate (km)	Ground Coordinate (m)	Height b Elevation Above Ground (m)
1 ! X =	683.08496,	1694.27175,	788,1.8!	!END!
2 ! X =	676.78769,	1694.15906,	128,1.8!	!END!
3 ! X =	677.18657,	1695.40992,	456,1.8!	!END!
4 ! X =	676.11493,	1693.62233,	96,1.8!	!END!
5 ! X =	681.57628,	1696.99513,	769,1.8!	!END!
6 ! X =	679.04888,	1696.16631,	605,1.8!	!END!
7 ! X =	679.29651,	1695.81445,	561,1.8!	!END!
8 ! X =	678.63944,	1695.96685,	572,1.8!	!END!
9 ! X =	677.87574,	1693.71032,	445,1.8!	!END!
10 ! X =	676.40317,	1694.16261,	132,1.8!	!END!
11 ! X =	677.77411,	1694.91266,	262,1.8!	!END!
12 ! X =	677.40579,	1694.40462,	192,1.8!	!END!
13 ! X =	677.17294,	1694.96527,	280,1.8!	!END!
14 ! X =	682.21249,	1693.62586,	904,1.8!	!END!
15 ! X =	678.30756,	1694.25223,	251,1.8!	!END!

a
 Data for each receptor are treated as a separate input subgroup and therefore must end with an input group terminator.

b
 Receptor height above ground is optional. If no value is entered, the receptor is placed on the ground.

Appendix F. Technical Report – Noise Impact Assessment

Dominica Geothermal Power Plant - Environmental and Social Impact Assessment

NZ Ministry of Foreign Affairs and Trade

Dominica Geothermal Power Plant Technical Report - Noise Impact Assessment

RZ020300-0002-NP-RPT-0011 | Rev 4

July 2018

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Appendix C. Predicted noise contours (Adverse weather condition)

Important note about your report

The sole purpose of this report and the associated services performed by Jacobs New Zealand Limited (“Jacobs”) is to describe the Noise Assessment for the Dominica Geothermal Power Project Environmental and Social Impact Assessment (ESIA) Project in accordance with the scope of services set out in the contract between Jacobs and the Client. That scope of services, as described in this report, was developed with the Client.

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1. Introduction

1.1 Overview

This Technical Report is part of an Environmental and Social Impact Assessment (ESIA) for the construction and operation of the Dominica Geothermal Power Project (hereafter referred to as 'the Project'). The Project comprises the construction, completion, testing, commissioning and operation of geothermal wells, steam gathering and reinjection system, power plant with nameplate capacity of 7 MW and connection to electrical grid and associated infrastructure in the Roseau Valley, Dominica. The design for the Project is ongoing, with further detailed design to be completed following a formal tender process for an Engineer, Procure and Construct contractor(s) in 2017.

1.2 Project Description

The key components of the proposed 7 MW power plant include:

- Power plant comprising 2 x 3.5 MW units or single 1 MW unit (either single flash steam condensing cycle or organic Rankine cycle units)
- Production well WW-P1 - The existing geothermal production well at Laudat has the potential to generate 6 to 9 MWe of electricity and will be the sole production well for the project.
- Reinjection to existing wells WW-03, WW-R1 and WW-01. The used geothermal fluids (brine and some steam condensate) would be disposed of into reinjection wells WW-R1 and WW-01 via a pipeline of up to 4 km in length and condensate to WW-03 which is located near WW-P1.
- Steamfield infrastructure including two phase piping, steam separators, atmospheric flash tank, steam gathering system, brine collection and disposal system, condensate collection and disposal system, pressure relief system and storage sump.
- Supporting infrastructure including well pads, turbine building, primary and ancillary equipment, cooling system, road network and water/waste water supply
- Substation and interconnection to the DOMLEC electricity grid at Laudat Power Plant.

Figure 1.1 provides the locations of the well pads (WW-P1, WW-03, WW-R1 and WW-01) and reinjection lines. Figure 1.2 shows the layout of the power plant.

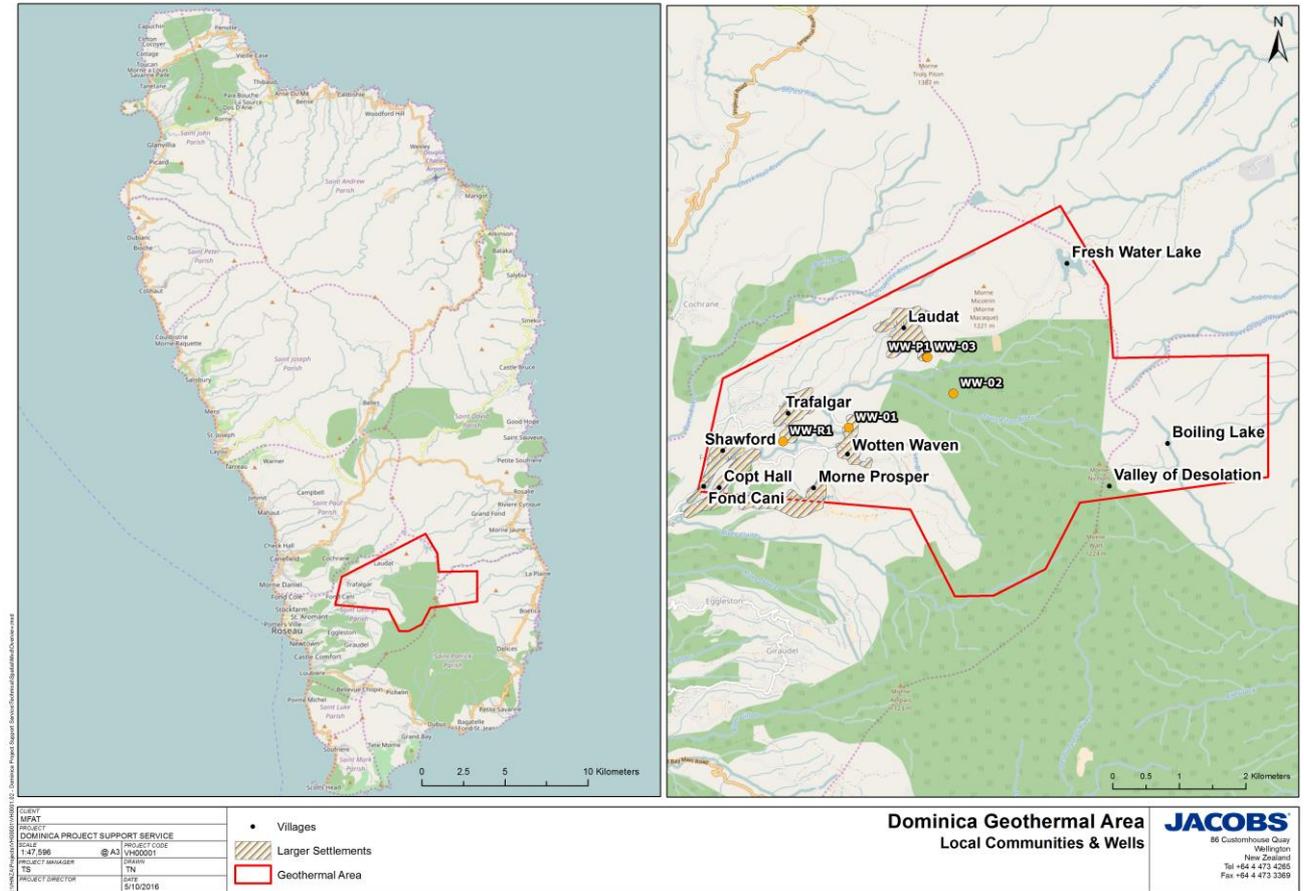


Figure 1.1 : Site layout and nearby residential areas

Dominica Geothermal Power Plant Technical Report - Noise Impact Assessment

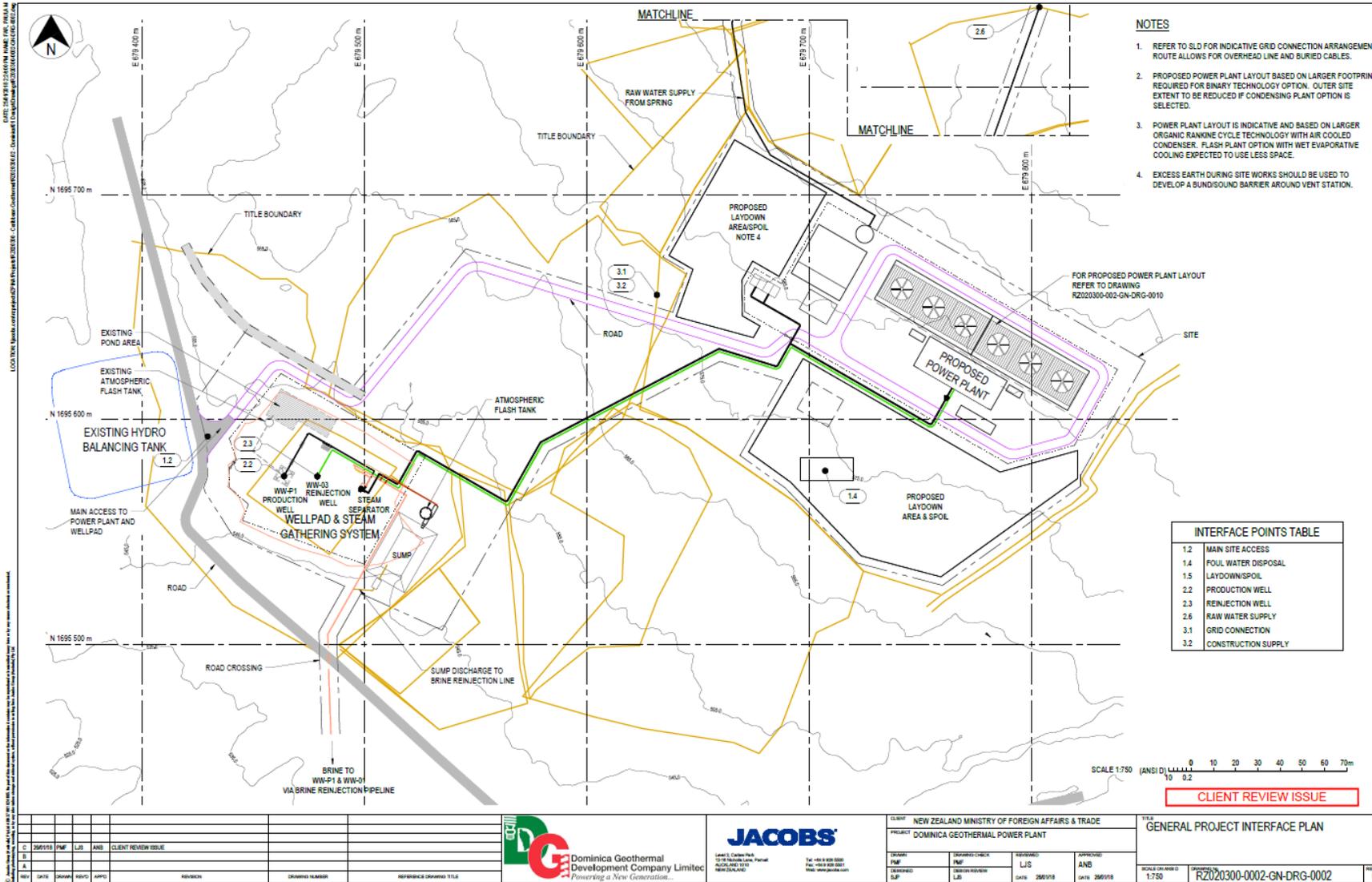


Figure 1.2 : Power Plant Layout

1.3 Purpose

This report identifies noise impacts associated with this type of facility and provides an assessment of potential noise impacts at nearby residential locations. The report is one of several technical reports prepared as a supporting documentation for an Environmental and Social Impacts Assessment (ESIA). It is based on a feasibility study preliminary design and the information given in this document is expected to be updated as the design progresses.

1.4 Limitations and Assumptions

Limitations to the modelling and prediction of environmental noise levels are heavily dependent on the accuracy of the noise data used in the model. During the initial stages of the Project, specific information of equipment manufacturers and models are not available and therefore the acoustic data for similar known equipment has been substituted to enable far field noise levels to be estimated. The acoustic data assumed for the model report has been taken from Jacobs' in house noise database and therefore is generic in nature. The noise emissions from the power plant and overall site may vary from those predicted in this report depending on the specific make and model of the equipment selected and the design of the structures that house it.

It is recommended that at the time of detailed design of the project equipment specification and procurement should be made with the assistance of an acoustic consultant. A full inventory of plant and equipment and associated noise emission data should be developed such that a noise model could be used to confirm the noise level predictions made in this report.

2. Description of the Existing Environment

2.1 Site Characteristics

The Project is located in the Roseau Valley, in central, southern Dominica and is near the villages of Laudat, Trafalgar, Shawford, Wotten Waven and Casseau. Landuse is predominately mature or secondary rainforest, or rural agricultural.

It is understood each of these villages contains a primary school, and three small health centres are located in the villages of Trafalgar, Wotten Waven and Laudat.

The project is located in a mountainous area, with the landform generally falling away to the southwest of the site.

2.2 Existing Noise Environment

The nearest and most representative affected properties in the surrounding villages have been considered in this assessment. These villages and the propose project site have been presented in Figure 1.1 which include:

- Laudat
- Trafalgar
- Copt Hall
- Shawford
- Fond Cani
- Morne Prosper
- Wotten Waven.

Additionally the following natural locations have been considered:

- Boiling Lake
- Valley of Desolation
- Fresh water Lake (2.5km north east of Laudat).

2.3 Noise Monitoring Results

The existing ambient noise environment in areas surrounding the proposed project site was measured during the peak tourist season of December 2013 and repeated during the off season in April 2014.

Noise monitoring was undertaken at representative locations in five villages surrounding the site:

- Laudat
- Fond Cani (north, west and south)
- Trafalgar
- Wotten Waven
- Morne Prosper.

Monitoring locations have been presented in Figure 2.1.

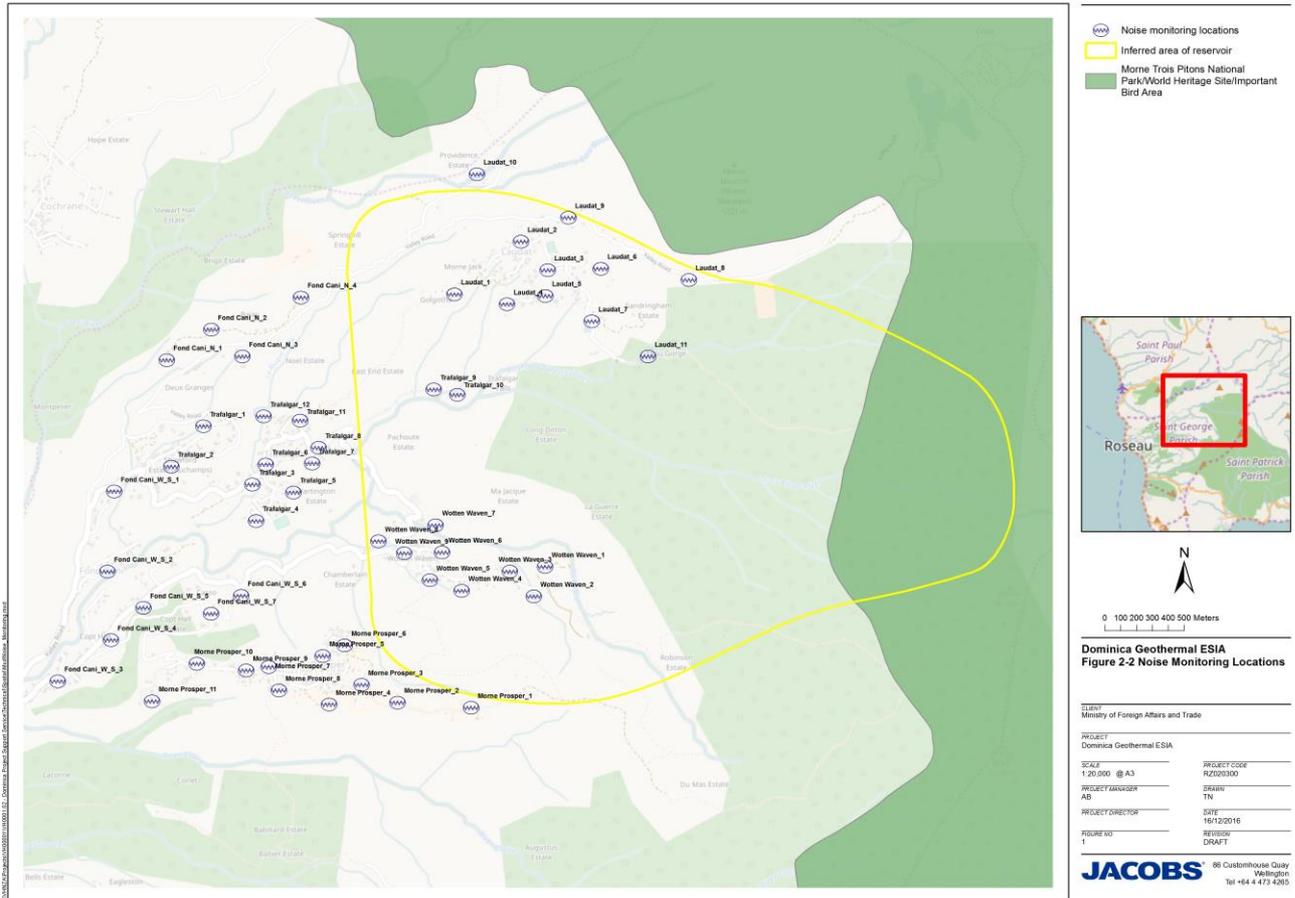


Figure 2.1 : Noise monitoring locations

When measuring noise levels, the use of statistical descriptors is necessary to understand and describe how variations in the noise environment occur over any given period. A list of common descriptors used in this noise assessment as well as their meaning is given below.

- L_{max} maximum noise level measured at a given location over the 15 minute interval.
- L_{A10} – the noise level exceeded for 10% of the 15 minute interval, this is commonly referred to as the average-maximum level.
- L_{Aeq} – the noise level having the same energy as the time varying noise level over the 15 minute interval.
- L_{A90} – the noise level exceeded for 90 percent of the 15 minute interval. This is commonly referred to as the background noise level and represents the quietest 90 seconds in a 15 minute period.

The results of the attend noise measurements have been summarised in Table 2.1 for each of the monitoring locations and detailed results are presented in Appendix A.

Table 2.1 : Attended noise monitoring results

Location	Monitored noise level L_{Aeq} (period) dB(A)			
	Peak tourist season December 2013		Off tourist season April 2014	
	Daytime (7am to 9pm)	Night time (9pm to 7am)	Daytime (7am to 9pm)	Night time (9pm to 7am)
Laudat				
Average L_{Aeq}	44.3	47.1	44.4	46.7
Maximum L_{Aeq}	53.0	53.5	51.0	52.0
Minimum L_{Aeq}	35.5	40.0	38.0	42.0
Fond Cani North				
Average L_{Aeq}	44.0	48.0	39.9	44.1
Maximum L_{Aeq}	49.0	49.0	43.5	49.0
Minimum L_{Aeq}	38.0	46.5	36.0	37.5
Fond Cani West and South				
Average L_{Aeq}	53.2	53.3	52.6	50.4
Maximum L_{Aeq}	59.5	60.0	57.5	57.5
Minimum L_{Aeq}	43.0	46.5	42.0	41.0
Morne Prosper				
Average L_{Aeq}	45.6	48.4	41.3	43.6
Maximum L_{Aeq}	49.5	52.0	46.0	47.0
Minimum L_{Aeq}	38.0	43.5	36.0	35.0
Wotten Waven				
Average L_{Aeq}	46.0	52.8	47.1	49.6
Maximum L_{Aeq}	49.0	57.5	49.5	51.0
Minimum L_{Aeq}	39.5	45.0	41.0	48.0
Trafalgar				
Average L_{Aeq}	52.0	54.4	47.1	47.3
Maximum L_{Aeq}	60.0	62.5	50.5	50.5
Minimum L_{Aeq}	43.5	46.5	44.0	43.5

2.4 Discussion

The detailed noise monitoring data for each site is provided in Appendix A. Further details are contained within the Environmental Baseline Study “*Initial environmental status of the Rodeau Valley in Dominica, planned for development of geothermal electricity production*” (document: REPORT-E3B2-R0206/15/OF/HG-EN, dated May 2015).

The main sources of noise in the area surrounding the project are local fauna, residential noise, low traffic on local roads, wind and water courses. Ambient noise levels are generally louder during night time hours due to local fauna such as insects and nocturnal wildlife. In the vicinity of local traffic generating developments, such as schools, hotels and tourist attractions, noise levels were somewhat higher.

3. Noise Limits

The operations of the Project have the potential to impact on residential and other noise sensitive receiver amenity and therefore must be assessed to determine requirements for noise mitigation where necessary. The use of guidelines to define a level of noise emissions from an industrial facility provides the most affected receivers with noise impacts that are within an acceptable range for day to day wellbeing.

The Project specific noise criteria will be taken to be the most stringent of the noise goals of either the World Bank Group (WBG) Environmental Health and Safety (EHS) Guideline or the Dominican regulations.

3.1 Dominican Regulations – Environmental Standards for Protection against Noise (June 2003)

This document sets the maximum permissible noise levels for noise produced by fixed and mobile sources. This document presents the following maximum noise levels.

Table 3.1 : Dominica Environmental Noise Standards

Receiver category	Maximum permissible external noise level $L_{Aeq}(\text{period})$ dB(A)*	
	Daytime (7am to 9pm)	Night time (9pm to 7am)
Area 1 - Zones of tranquillity		
Hospitals, medical centres, place of worship	55	50
Offices, schools	60	55
Zoos, botanical gardens	60	55
Quiet areas for the preservation of habitat	60	50
Area 2 – Residential Zones		
Residential areas	60	50
Residential areas within commercial and/or industrial areas	65	55
Area 3 – Commercial Zones		
Industrial zones	70	55
Commercial zones	70	55

* As no statistical parameter appears to be presented in this document, it is assumed that these levels are $L_{Aeq}(\text{period})$.

3.2 WBG EHS Guidelines

The WBG recommends noise limits for residential locations in accordance with its EHS Guidelines. These guidelines have been adopted from Guidelines for Community Noise, World Health Organization, 1999 and are values for noise levels measured outside a dwelling. The noise level guidelines from the IFC have been reproduced in Table 3.2 :

Table 3.2 : IFC noise guidelines for noise sensitive locations

Receptor	Day 07:00-22:00	Night-time 22:00-07:00
	$L_{Aeq1\text{ hr}}$	$L_{Aeq1\text{ hr}}$
Residential, Institutional Educational	55 dB(A)	45 dB(A)

Receptor	Day 07:00-22:00	Night-time 22:00-07:00
Industrial, Commercial	70 dB(A)	70 dB(A)

The guidelines state:

“Noise impacts should not exceed the levels presented in Table 3.2 or result in a maximum increase in background levels of 3 dB at the nearest receptor location – off site”

The additional criteria of background plus 3 dB(A) is referred to as a maximum increase in noise levels and is only to be adopted where the guideline levels in the table are already exceeded. For the purposes of these calculations, the minimum monitored L_{Aeq} during the tourist down season for each village will be used.

Table 3.3 : World Bank noise guidelines for power stations

Location (Residential, Institutional Educational receptors)	Initial noise limits dB(A)		Existing dB(A)		Final noise limits dB(A)	
	Daytime 07:00- 22:00	Night-time 22:00- 07:00	Daytime 07:00- 22:00	Night-time 22:00- 07:00	Daytime 07:00- 22:00	Night-time 22:00- 07:00
	$L_{Aeq1\ hr}$	$L_{Aeq1\ hr}$	$L_{Aeq\ period}$	$L_{Aeq\ period}$	$L_{Aeq1\ hr}$	$L_{Aeq1\ hr}$
Laudat	55	45	38.0	42.0	55	45
Fond Cani North			36.0	37.5	55	45
Fond Cani West and South			42.0	41.0	55	45
Morne Prosper			36.0	35.0	55	45
Wotten Waven			41.0	48.0	55	51
Trafalgar			44.0	43.5	55	45

It can be seen that the WBG EHS noise guidelines are generally applicable, however for locations in Wotten Waven, the night time noise level is greater than the guidelines and as such the alternative ‘background plus 3 dB(A)’ criteria may be applied during this period at this location.

3.3 Summary of operational noise criteria

Given the different criteria applicable to this project, the minimum criteria for each location will be used to assess operational noise associated with the project. These have been set out below in Table 3.4.

Table 3.4 : Summary of operational noise criteria (L_{Aeq} 1 hour)

Location	World Bank Base Criteria dB(A)		World Bank ‘Plus 3’ Criteria dB(A)		Dominica Criteria dB(A)		Final noise criteria dB(A)	
	Day	Night	Day	Night	Day	Night	Day	Night
Laudat	55	45	55	45	60	55	55	45
Fond Cani North	55	45	55	45	60	55	55	45
Fond Cani West and South	55	45	55	45	60	55	55	45
Morne Prosper	55	45	55	45	60	55	55	45

Location	World Bank Base Criteria dB(A)		World Bank 'Plus 3' Criteria dB(A)		Dominica Criteria dB(A)		Final noise criteria dB(A)	
Wotten Waven	55	45	55	51	60	55	55	51
Trafalgar	55	45	55	45	60	55	55	45
Recreational areas	55	45	55	45	60	50	55	45

It can be seen that where compliance is shown to meet the World Bank 'Background plus 3' noise criteria, local noise criteria will also be met.

3.4 Construction Noise Limits

The risk of adverse impact of construction noise within a community is determined by the extent of its emergence above the existing background noise level, the duration and scheduling of the event and the characteristics of the noise.

There is no specific construction noise impact criteria identified for the Project, however, an increase of 15 dB(A) above daytime background noise levels and 10 dB(A) above night time noise levels has been used as a guideline to determine if mitigation of construction noise is likely to be required. Again, the minimum monitored L_{Aeq} during the tourist down season for each village has been referenced in these calculations.

Table 3.5 : Construction noise guidelines

Location (Residential, Institutional Educational receptors)	Existing dB(A)		Allowance dB(A)		Construction noise limits dB(A)	
	Day 07:00- 22:00	Night-time 22:00- 07:00	Day 07:00- 22:00	Night-time 22:00- 07:00	Day 07:00- 22:00	Night-time 22:00- 07:00
	$L_{Aeq1\ hr}$	$L_{Aeq1\ hr}$	$L_{Aeq\ period}$	$L_{Aeq\ period}$	$L_{Aeq1\ hr}$	$L_{Aeq1\ hr}$
Laudat	38.0	42.0	15	10	53.0	52.0
Fond Cani North	36.0	37.5			51.0	47.5
Fond Cani West and South	42.0	41.0			57.0	51.0
Morne Prosper	36.0	35.0			51.0	45.0
Wotten Waven	41.0	48.0			56.0	58.0
Trafalgar	44.0	43.5			59.0	53.5

4. Effects of Prevailing Weather Conditions

4.1 Wind

Wind has the potential to increase noise at a receiver when it is light and stable and blows from the direction of the noise source. As the strength of the wind increases the noise produced by the wind will obscure noise from most industrial and transport sources.

Wind effects need to be considered when wind is a feature of the area under consideration. Where the source to receiver wind component at speeds of up to 3 m/s occur for 30% or more of the time in any seasonal period (during the day, evening or night), then wind is considered to be a feature of the area and noise level predictions must be made under these conditions.

In order to determine the prevailing wind conditions for the project, 12 months of wind data collected in 2015 within the project area was development into annual and seasonal wind roses. These are displayed below in Figure 4.1.

Seasonal wind records indicate that prevailing winds are not a feature of the areas since the frequency of occurrence of winds up to 3 m/s is below the 30% threshold for all seasons. Hence, prevailing winds have not been considered as part of this noise assessment.

4.2 Temperature Inversions

Temperature inversions, when they occur, have the ability to increase noise levels by focusing sound waves. Temperature inversions occur predominantly at night during the winter months. For a temperature inversion to be a significant characteristic of the area it needs to occur for approximately 30% of the total night-time during winter, or about two nights per week.

Temperature inversions occur during E, F and G stability categories. These three categories are considered to represent weak, moderate and strong inversions respectively. For noise-assessment purposes, only moderate and strong inversions are considered significant enough to require assessment.

In dispersion modelling, stability class is used to categorise the rate at which a plume will disperse. In the Pasquill-Gifford stability class assignment scheme there are six stability classes, A through to F. Class A relates to unstable conditions, such as might be found on a sunny day with light winds. Class F relates to stable conditions, such as those that occur when the sky is clear, the winds are light and an inversion is present. The intermediate classes B, C, D and E relate to intermediate dispersion conditions. A seventh class, G, has also been defined to accommodate extremely stable conditions such as might be found in arid rural areas.”

An analysis of the occurrence of each stability class has not been conducted. However, to provide for a conservative ‘worst case’ assessment, noise modelling of night-time operations allows for temperature inversion.

With regard to construction noise impacts, as all construction works will be undertaken during the day period (when the likelihood of temperature inversions is significantly reduced), construction noise due to the project has only been modelled under neutral condition.

4.3 Noise Modelling Parameters for Metrological Conditions

The resultant weather conditions used to predict the level of noise for the different modelling scenarios are shown below:

- Construction and operational noise – neutral weather condition, 2 m/s wind from source to receiver and Pasquill Stability Class C; and
- Operational noise – enhanced weather condition, 2 m/s wind from source to receiver and Pasquill Stability Class F.

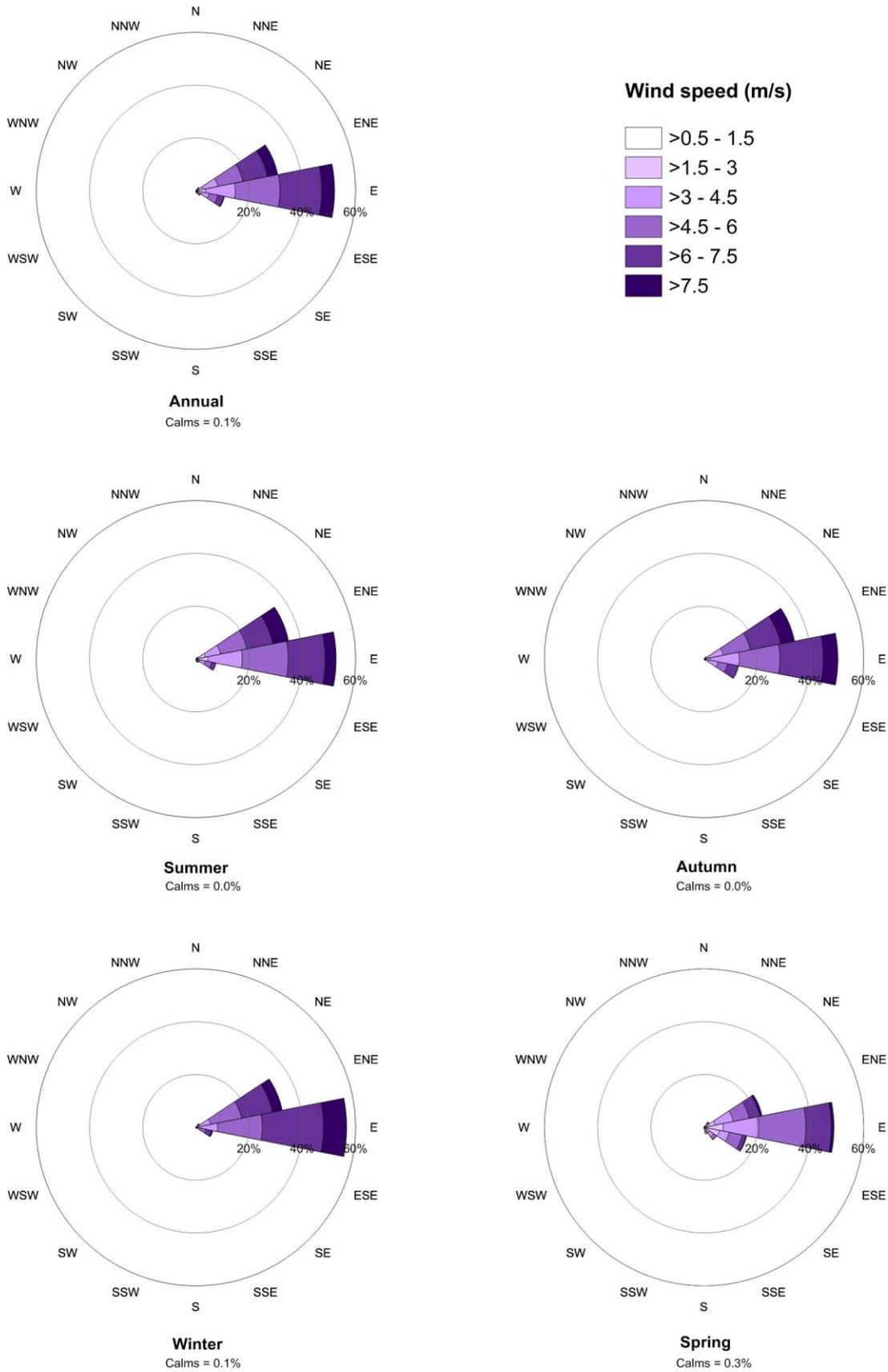


Figure 4.1 : Wind roses for 2015

5. Significance of Noise Impacts

The significance of construction and operational noise impacts can be characterised as the product of the degree of predicted impact (magnitude of impact) and the value of the receiver that is subjected to that impact (sensitivity of receiver). The criteria for the definition of magnitude and sensitivity are presented below.

5.1 Magnitude of Impacts

The definition of the magnitude ratings are explained in Table 5.1 below.

Table 5.1 : Magnitude rating definition

Category	Description
Major	an impact that is significant and mitigation must be considered.
Moderate	an impact that is significant and mitigation should be considered.
Minor	an impact that is significant, but small enough that noise management practices would ensure noise levels are below significance criteria.
Negligible	no need to consider in decision making, no mitigation required.

The magnitude of the noise impact is defined by a series of noise change categories with an associated semantic scale presented in Table 5.2 below.

Table 5.2 : Magnitude of noise impact criteria

Magnitude of impact	Exceedance of operational noise criteria – dB(A)
Major	≥ 5
Moderate	3.0 – 4.9
Minor	0.1 – 2.9
Negligible	0

5.2 Sensitivity of Receivers

The definition of the sensitivities of receivers to noise impacts during construction and operation are based on the maximum permissible daytime noise levels specified in Table 3.1. The sensitivity of receiver definition is presented in Table 5.3 below.

Table 5.3 : Sensitivity of receiver definition

Category	Description
High	Hospitals, medical centres, place of worship
Medium	Offices, schools Zoos, botanical gardens Quiet areas for the preservation of habitat Residential areas
Low	Residential areas within commercial and/or industrial areas
Negligible	Commercial and industrial premises

5.3 Evaluating the Significance of Impacts

The significance of effect is a function of the value or sensitivity of the receptor and the magnitude of the impact. Table 5.4 presents the significance of effect, based on the magnitude of impact in Table 5.2 and the sensitivity of receptors in Table 5.3.

Table 5.4 : Significance of noise impact

Sensitivity of receiver	Magnitude of impact			
	Major	Moderate	Minor	Negligible
High	Major	Major	Moderate	Negligible
Medium	Major	Moderate	Minor	Negligible
Low	Moderate	Minor	Negligible	Negligible
Negligible	Minor	Negligible	Negligible	Negligible

6. Construction Noise Assessment

The construction of the project is expected to last for at least two years during which time the construction and commissioning of the geothermal plant will be completed. This report has considered potential construction impacts from the following project construction phases:

- Power plant
- Reinjection pipelines
- Suspension bridge
- Tramway Carpark.

It should be noted that for the development of the power plant no additional well drilling will be required, however at a later date well drilling for additional production wells and reinjection wells may be required due to well declines over time.

Noise levels typically decrease with increasing separation distance from the site, increasing screening from terrain or structures and are also affected to some extent by meteorological and ground surface conditions.

Potential construction noise impacts were modelled using the CONCAWE algorithm in the SoundPLAN noise modelling software package.

6.1 Construction Activities

The identified construction activities for the Project include several phases that have the potential to generate noise impacts in the far field. Although the equipment types and numbers would vary in practice, the likely activities and typical equipment during construction will include:

Table 6.1 : Representative construction phases and equipment

Construction stage	Noisiest equipment	Sound Power Level dB(A)
Power Plant		
Earthworks	D7 Dozer 30t Excavator 40t Road dump truck 20t Vibratory roller	115
Plant construction	100T Mobile crane Gas cutter x2 Ratchet gun x2	109
Building construction	Concrete truck and pump Concrete drill Welder Nail gun Truck mounted crane	110
Reinjection pipelines		
Earthworks	Bobcat <10t Vibratory roller	111
Footings	Concrete truck and pump	109

Construction stage	Noisiest equipment	Sound Power Level dB(A)
	Concrete drill	
Placement of pipe sections	100T Mobile crane Gas cutter Ratchet gun	107
Production / Reinjection well		
Earthworks	Bobcat <10t Vibratory roller	111
Finishing works	100T Mobile crane Gas cutter Ratchet gun	107
Suspension Bridge		
Earthworks	Bobcat <10t Vibratory roller	111
Footings	Concrete truck and pump Concrete drill	109
Placement of cables and platform	100T Mobile crane Gas cutter Ratchet gun	107
Tramway carpark		
Earthworks	15t Road grader 30t Excavator 40t Road dump truck 2 x 20t Vibratory roller	116
Asphalting	Asphalt paving machine 30T Road dump truck	110

Due to uncertainties around haulage routes, material sites and detailed project design, potential impacts associated with traffic movements have not been considered. It should be noted that for the development of the power plant no additional well drilling will be required, however at a later date well drilling for additional production wells and reinjection wells may be required due to well declines over time.

6.2 Results of Construction Noise Calculations

Noise levels have been predicted for the closest residential properties to each work area. These sites have been shown below in Figure 6.1.



Figure 6.1 : Noise prediction locations

The noise level at the sensitive receiver locations during the construction phase of the plant and associated infrastructure will vary depending on the location of the work within the site, the type and number of equipment operating at any one time, the duration of the activity, and meteorological conditions at the time. In the absence of a complete methodology and to simplify the large number of variables for construction activities around the site, a “typical” construction scenario has been assessed for the Project. The scenario includes all equipment outlined in each phase of Table 6.1, operating for 50% of the time. This is not intended to be a worst case scenario for the construction activities but should serve to provide an indication of the expected levels on a day to day basis. Table 4-2 presents the predicted noise levels for a typical operation scenario noise impact.

The CONCAWE algorithm has been used to predict noise impacts from neutral weather conditions. Meteorological modelling and weather records have shown that temperature inversions are not a feature of the island and as such noise transmission under adverse weather conditions has not been considered.

Construction scenarios are defined using the following abbreviations:

- PPE - Power Plant Earthworks
- PPC - Power Plant Construction
- PPB - Power Plant Building Construction
- RPE - Reinjection Pipeline Earthworks
- RPF - Reinjection Pipeline Footings

- RPP - ReInjection Pipeline Pipe Installation
- WE - Production / ReInjection Well Earthworks
- WF - Production / ReInjection Well Finishing
- SBE - Suspension Bridge Earthworks
- SBF - Suspension Bridge Footings
- SBC - Suspension Bridge Placement of Cables
- TCE - Tramway Carpark Earthworks
- TCA - Tramway Carpark Asphaltting

Table 6-2: Predicted construction noise levels (Neutral meteorological conditions)

Receiver	Daytime Noise criteria dB(A)	Predicted maximum L _{Aeq} during construction stage [dB(A)]												
		PPE	PPC	PPB	RPE	RPF	RPP	WE	WF	SBE	SBF	SBC	TCE	TCA
Laudat (north)	53.0	26	IA	IA	25	IA	IA	IA	IA	IA	IA	IA	28	IA
Laudat (south)	53.0	53	47	48	37	35	33	43	39	IA	IA	IA	33	27
Laudat (west)	53.0	34	28	29	28	26	IA	29	IA	IA	IA	IA	28	IA
Trafalgar (east)	59.0	27	IA	IA	38	36	34	35	31	IA	IA	IA	IA	IA
Trafalgar (south)	59.0	IA	IA	IA	59	57	55	53	49	IA	IA	IA	IA	IA
Trafalgar (west)	59.0	IA	IA	IA	31	29	27	30	26	IA	IA	IA	IA	IA
Copt Hall	57.0	IA	IA	IA	25	IA	IA	IA	IA	IA	IA	IA	IA	IA
Shawford	57.0	IA	IA	IA	29	27	25	29	IA	IA	IA	IA	IA	IA
Fond Cani (north)	51.0	IA	IA	IA	26	IA	IA	26	IA	IA	IA	IA	IA	IA
Fondi Cani (south)	57.0	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA
Morne Prosper	51.0	IA	IA	IA	30	28	26	29	25	IA	IA	IA	IA	IA
Wotten Waven	56.0	IA	IA	IA	46	44	42	47	43	IA	IA	IA	IA	IA
Boiling Lake*	55.0	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA
Valley of Desolation*	55.0	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA
Freshwater lake*	55.0	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA	IA

BOLD indicates a potential exceedance of construction noise criteria / IA = Inaudible [less than 20dB(A)]

■ = Major Significance of Impact; ■ = Moderate Significance of Impact; ■ = Minor Significance of Impact; ■ = Negligible Significance of Impact

6.3 Discussion

6.3.1 Power plant works

Construction works associated with the power plant, i.e. PPE, PPC and PPB, are predicted to comply with the daytime noise limits at all surrounding residential receivers. The predicted maximum noise level of each power plant construction scenario is as follow:

- PPE works is 53 dB(A) at the Laudat (south) residential receiver;
- PPC works is 47 dB(A) at the Laudat (south) residential receiver; and
- PPB works is 48 dB(A) at the Laudat (south) residential receiver.

The power plant construction works have been predicted to be inaudible at most residential receivers, and is considered to have negligible significance noise impact.

6.3.2 Reinjection pipeline works

Works associated with the construction of the reinjection pipeline, i.e. RPE, RPF and RPP, are predicted to comply with the noise limits at all other surrounding residential receivers. The maximum noise level of the reinjection pipeline construction activities are predicted to be as follow:

- RPE works is 59 dB(A) at the Trafalgar (south) residential receiver;
- RPF works is 57 dB(A) at the Trafalgar (south) residential receiver; and
- RPP works is 55 dB(A) at the Trafalgar (south) residential receiver.

Reinjection pipeline works are considered to have negligible significance of impact at all surrounding receivers.

Noise mitigation measures have been recommended in Section 8 of this report to reduce the impacts of reinjection pipeline construction works on surrounding receivers.

6.3.3 Reinjection well works

Works associated with the construction of the reinjection wells, i.e. WE and WF, are predicted to comply with the noise limits at all surrounding residential receivers.

Reinjection well earthworks and finishing works are considered to have negligible significance of impact at all surrounding receivers.

Based on the noise predictions, receivers surrounded will comply with the noise limits where they are least 45 metres from any reinjection wells construction works.

6.3.4 Bridge and carpark works

Construction works associated with the suspension bridge and tramway carpark, i.e. SBE, SBF, SBC, TCE and PPB, are predicted to comply with the daytime noise limits at all surrounding residential receivers.

Bridge and carpark works are considered to have negligible significance of impact at all surrounding receivers.

7. Proposed Operational Activities Assessment

7.1 Assessment Methodology

The noise assessment considers the predicted noise impacts at the most affected receiver locations and compares these to the Project noise criteria. From Section 3 the WBG requirements were identified the limiting condition for noise impact assessment.

The prediction of noise impacts has been undertaken using SoundPLAN noise modelling software, which incorporates specific Project information to predict noise levels at sensitive receiver locations. The assessment of noise impacts from the project has compared the predicted levels at the receiver locations to the noise goals identified in Section 3 to confirm compliance with environmental objectives.

The noise model used the CONCAWE algorithm to predict the $L_{Aeq\ 1\ hour}$ noise level impacts at the nearby residences. Although in practice the noise level from the project may vary depending on demand, these noise impacts are considered to be constant for both daytime and night time periods. The CONCAWE algorithm has been used to predict noise impacts from both adverse and neutral weather conditions.

7.1.1 Modelling Methodology

The assessment of noise impacts at residential locations nearest to the power plant is based on the prediction of noise levels using a noise model. The noise model for this Project was developed from topographic data for the area and identification of receiver locations from available aerial photography. Precise equipment noise levels and site layouts were not determined at the time of the assessment and as such a combination of typical noise levels and project OHS design specifications have been used for modelled noisy equipment.

To predict the noise impact at the nearby receivers and approximation of the individual contribution from each major source is required. Where necessary, estimates of the contribution have been made based on measurements of similar sources from other sites. The major sources of noise emissions associated with each project component are presented below in Table 7.1. This table is not an exhaustive list of noise sources from the project however the main items of noisy plant have been identified for the noise model.

Table 7.1 : Representative operational noise sources

Component	Equipment	Sound Power Level (SWL) dB(A)
Power plant – Flash steam condensing unit	Turbine (including exhaust ducting, inlet valves and pipes)	93
	Evaporative cooling towers	81
	Steam ejectors	90
	Pumps	96
	TOTAL	99
Power Plant – Organic Rankine Cycle unit	Turbine (including exhaust ducting, inlet valves and pipes)	93
	Air cooled condenser (ACC) fans	88
	Working fluid feed pumps	97
	Vapouriser / pre-heater / desuperheater	76
	TOTAL	99
Steam gathering system	Atmospheric flash tank	118

Component	Equipment	Sound Power Level (SWL) dB(A)
	Rock muffler	80
	Steam inlet pipes and valves inc. pressure control valves	76
	TOTAL	118
Reinjection wells	Reinjection pumps	77
Commissioning of both power plant and reinjection wells	Steam pressure releases	118

* Noise levels for these units were unable to be obtained and as such an SWL of 93 has been used in this preliminary assessment, this being the OHS limit of 85dB(A) at a distance of 1m.

The loudest noise events during operation are likely to be associated with either:

- a) the emergency release of steam pressure as a result of a ruptured disk; or
- b) steam vented from rock muffler when plant trips out or shuts down.

These events may be up to 140 dB(A), however will be very short term. Although noise levels from this event may be high, they will not exceed 1hr noise criteria due to their short duration.

The CONCAWE algorithm has been used to predict noise impacts from neutral weather conditions. Meteorological modelling and weather records have shown that temperature inversions are not a feature of the island and as such noise transmission under adverse weather conditions has not been considered.

Modelling of the plant site has assumed all equipment is operating at full capacity at the site boundary. No localised shielding on the project site (for example from buildings or other site equipment) has been included in the model. As such the following noise predictions represent an unlikely 'worst case' forecast of potential noise impacts.

7.1.2 Modelling Predictions

The noise levels were predicted for the nearest residential locations in each village as presented in Figure 6.1.

As emissions from the plant will remain steady, noise has been assessed against the more stringent night time criteria only. Table 7.2 and Table 7.3 present summaries of the noise predictions for the nearest locations against the night time noise goals.

The noise contours for the predicted noise levels for the two preferred power plant options have been overlaid onto the aerial photography and are presented in Appendix B.

Operational scenarios are defined using the following abbreviations:

- PS3 - Power Plant Steam Cycle – Site option 3
- PR3 - Power Plant Rankine cycle – Site Option 3
- SGS - Steam Gathering System
- RIW - Production / Reinjection Wells
- COM - Commissioning

Table 7.2: Predicted operational noise levels (Neutral meteorological conditions)

Receiver	Operational noise criteria	Predicted maximum L _{Aeq} during operation [dB(A)]				
	Night	PS3	PR3	SGS	RIW	COM
Laudat (north)	45	IA	IA	33	IA	33
Laudat (south)	45	40	38	53	IA	53
Laudat (west)	45	25	23	39	IA	39
Trafalgar (east)	45	IA	IA	45	IA	45
Trafalgar (south)	45	IA	IA	63	22	63
Trafalgar (west)	45	IA	IA	40	IA	40
Copt Hall	45	IA	IA	32	IA	32
Shawford	45	IA	IA	39	IA	39
Fond Cani (north)	45	IA	IA	36	IA	36
Fondi Cani (south)	45	IA	IA	IA	IA	IA
Morne Prosper	45	IA	IA	39	IA	39
Wotten Waven	51	IA	IA	57	IA	57
Boiling Lake*	45	IA	IA	IA	IA	IA
Valley of Desolation*	45	IA	IA	IA	IA	21
Freshwater lake*	45	IA	IA	IA	IA	IA

BOLD indicates a potential exceedance of construction noise criteria / IA = Inaudible [less than 20dB(A)]

Red = Major Significance of Impact; **Orange** = Moderate Significance of Impact; **Yellow** = Minor Significance of Impact; **Green** = Negligible Significance of Impact

Table 7.3: Predicted operational noise levels (Enhanced meteorological conditions)

Receiver	Operational noise criteria	Predicted maximum L _{Aeq} during operation [dB(A)]				
	Night	PS3	PR3	SGS	RIW	COM
Laudat (north)	45	22	20	40	IA	40
Laudat (south)	45	44	42	55	IA	55
Laudat (west)	45	29	27	45	IA	45
Trafalgar (east)	45	21	IA	50	IA	50
Trafalgar (south)	45	IA	IA	64	23	64
Trafalgar (west)	45	IA	IA	45	IA	45
Copt Hall	45	IA	IA	36	IA	36
Shawford	45	IA	IA	44	IA	44
Fond Cani (north)	45	IA	IA	42	IA	42
Fondi Cani (south)	45	IA	IA	25	IA	25

Receiver	Operational noise criteria	Predicted maximum L_{Aeq} during operation [dB(A)]				
	Night	PS3	PR3	SGS	RIW	COM
Morne Prosper	45	IA	IA	45	IA	45
Wotten Waven	51	IA	IA	60	IA	60
Boiling Lake*	45	IA	IA	IA	IA	IA
Valley of Desolation*	45	IA	IA	IA	IA	28
Freshwater lake*	45	IA	IA	IA	IA	IA

BOLD indicates a potential exceedance of construction noise criteria / IA = Inaudible [less than 20dB(A)]

■ = Major Significance of Impact; ■ = Moderate Significance of Impact; ■ = Minor Significance of Impact; ■ = Negligible Significance of Impact

7.2 Discussion

The predicted noise levels presented in Table 7.2 and Table 7.3 indicate that the operations of the Steam or Rankine power plant at the preferred site will most likely comply with the noise criteria at all surrounding residential receivers. The predicted noise levels show that operational noise from the Steam or Rankine power plant are inaudible at most surrounding receivers except at Laudat (south), Laudat (west) and Trafalgar (east). Operational noise levels of the Steam power plant are predicted to be up to 40 dB(A) during neutral weather condition and up to 44 dB(A) during enhanced weather condition. While operational noise levels of the Rankine power plant are predicted to be up to 38 dB(A) during neutral weather condition and up to 42 dB(A) during enhanced weather condition. Based on the predicted operational noise levels of the power plant, it can be seen that the Rankine power plant is the quieter option. Operational noise impacts of either Steam or Rankine power plant at the preferred site are considered to have negligible significance of impact at all surrounding receivers.

Operations of the production / reinjection wells are also predicted to comply with the noise criteria at all surrounding residential receivers. The noise modelling results show that production / reinjection wells are inaudible at most receivers except at Laudat (south), Trafalgar (east), Trafalgar (south), Trafalgar (west), Morne Prosper and Wotten Waven. The worst case operational noise impact of production / reinjection wells has been predicted to be 22 dB(A) during neutral weather condition and 23 dB(A) during enhanced weather condition. Both worst case operation noise impacts were predicted at Trafalgar (south). Production / reinjection wells are considered to have negligible significance of impact at all surrounding receivers.

Steam gathering system and commissioning noise impacts during neutral weather condition are predicted to exceed the noise criteria at Laudat (south), Trafalgar (south) and Wotten Waven, but are predicted to comply with the noise criteria at all other surrounding residential receivers. During enhanced weather condition, steam gathering system and commissioning noise impacts are predicted to exceed the noise criteria at Laudat (south), Trafalgar (east), Trafalgar (south) and Wotten Waven, but are predicted to comply with the noise criteria at all other surrounding residential receivers. The predicted noise impacts at Laudat (south), Trafalgar (east), Trafalgar (south) and Wotten Waven have been predicted to exceed the noise criteria by 10 dB(A), 5 dB(A), 19 dB(A) and 9 dB(A) respectively during enhanced weather condition. Steam gathering system and commissioning works will potentially have major significance of impact at Laudat (south), Trafalgar (east), Trafalgar (south) and Wotten Waven, but is considered to have negligible significance of impact at all other surrounding receivers. That said, it is understood that commissioning testing will only occur for a relatively short period and is therefore, not considered to be an adverse impact. The implementation of management measures, such as community consultation, notification, undertaking team gathering system operations and commissioning testing during daytime period only etc. would generally be sufficient in reducing receiver annoyance.

Recommended noise mitigation measures have been provided in Section 8 of this report to ensure that the power plant operates in a noise compliant manner.

8. Recommended Mitigation

8.1 Construction Noise

Worse case construction noise impacts are predicted to comply with the noise limits at all surrounding residential receivers. Notwithstanding this finding, it will be important for the contractor to undertake all reasonable and feasible measures to manage noise levels, minimise noise impacts and liaise with affected landowners and local communities.

During the planning and scheduling of construction works the predicted noise levels should be considered in establishing work site locations, construction techniques and on site practises. The following principles and proactive noise management measures should be considered for implementation:

- A Construction Noise Management Plan (CNMP) should be formulated to provide a framework for addressing construction noise levels. Noise control options including site mitigation and the investigation of low noise plant should be detailed and direction provided for the delivery of best practice noise management on site.
- Construction works should adopt Best Management Practice (BMP) and Best Available Technology Economically Achievable (BATEA) practices. BMP includes factors discussed within this report and encouragement of a project objective to reduce noise emissions. BATEA practices involve incorporating the most advanced and affordable technology to minimise noise emissions.
- Limit construction works to daytime hours where reasonable and feasible.
- Locating haul routes as far as possible from residential receivers
- Using equipment that has been well maintained so that noise emissions are minimised
- Provide localised noise screening where works are to be conducted within 200 metres (the compliance distance) of any sensitive receivers.
- Where possible, static construction plant such as generators should be located adjacent to on-site structures to impede noise propagation.
- Engines shall not be started and on-site activities shall not be undertaken outside of the daytime construction hours. Non noise generating works can be undertaken at staging areas where works are not adjacent to residential receivers.
- Construction activities should be undertaken in accordance with BS 5228, Code of Practice for Noise Control on Construction and Demolition Sites. All equipment used on site would be required to demonstrate compliance with the noise levels recommended within BS 5228.
- Appropriate use of all plant and equipment, with reasonable work practices applied, including no extended periods of 'revving', idling or 'warming up' in proximity to existing residential receivers. Any excessively loud activities should be scheduled during periods of the day when general ambient noise levels are greatest. This would reduce the potential for cumulative noise impacts (relating to worst-case elevated operations) and extended periods of off-site annoyance.
- Minimising reversing alarm noise emissions from mobile plant and transport truck operations should be considered, provided occupational health and safety requirements are satisfied. Where practicable, site entry and exit points should be managed to limit the need for reversing.
- Construction plant source noise levels should be confirmed prior to the commencement of works to verify construction noise impacts and noise management measures.
- Provide a summary of required construction noise management practices to all staff and contractors and be included during site inductions. The summary should include, as a minimum, the permitted hours of construction work, work site locations and site ingress/egress.
- Local residents and land owners are to be notified a minimum of 2 weeks prior to the commencement of construction works. The notification would detail proposed construction works, permitted hours of work and potential noise impacts.

8.2 Operational Noise

Based on the predicted noise levels as presented in Table 7.2, it is shown that the Rankine type power plant is the quieter compared to the Steam type power plant. Based on this assessment, it is recommended that the Rankine power plant be installed.

As the steam gathering system and commissioning phases of the power plant has the potential to adversely impact on surrounding residential receivers, it is recommended that the measures be implemented during these operations of the power plant:

- Steam gathering system operations and commissioning testing should be conducted during daytime periods only.
- Erect temporary localised screening during steam gathering system operations and commissioning testing. Potential noise impact reduction of up to 6 dB(A) is achievable where acoustic screens are located within 5 metres of the construction works, be at least 300 mm above the height of the noise source and provide a solid façade impeding line of sight to nearest receivers – any gaps negate noise reduction performance.
- Notify local residents and landowners prior to any steam gathering system operation and commissioning testing.

9. Conclusion

An assessment of construction and operational noise impacts on residential noise sensitive receivers has been undertaken for the proposed Project in the Roseau Valley, in central, southern Dominica. The assessment considered the operational noise impacts of the proposed Steam cycle and Rankine cycle options at the preferred site.

The construction noise assessment identified that these activities are expected to occur for at least two years. During this time, activities would incorporate a multitude of equipment combinations and locations within the site. The construction noise assessment has identified management levels at surrounding receivers for these impacts and undertaken typical construction scenarios to determine the likelihood of noise impacts at residential locations. The outcome of the construction noise assessment has identified that noise levels are not likely to cause adverse impacts at all surrounding receiver locations during all construction activities.

The operations of the power plant, steam gathering system, production / reinjection wells and commissioning were modelled using predictive noise modelling software. The result of these predictions indicates that power plant operations, production / reinjection wells operations are likely to comply with the noise criteria at all surrounding receivers. Steam gathering system and commissioning operations are likely to comply with the noise criteria at most receivers except at Laudat (south), Trafalgar (east), Trafalgar (south) and Wotten Waven.

To ensure that all construction activities are well within the noise management levels, mitigation measures such as formulating of construction noise management plan, adopting Best Management Practice and Best Available Technology Economically Achievable practices, limiting construction works to daytime hours, appropriate use of all plant and equipment etc. should be implemented.

To ensure steam gathering system and commissioning operational noise do not adversely impact on surrounding receivers, it is recommended that these two operations should be conducted during daytime periods only; temporary localised screening be installed during steam gathering system operation and commissioning testing, and local residents and landowners be notified prior to any of these operation.

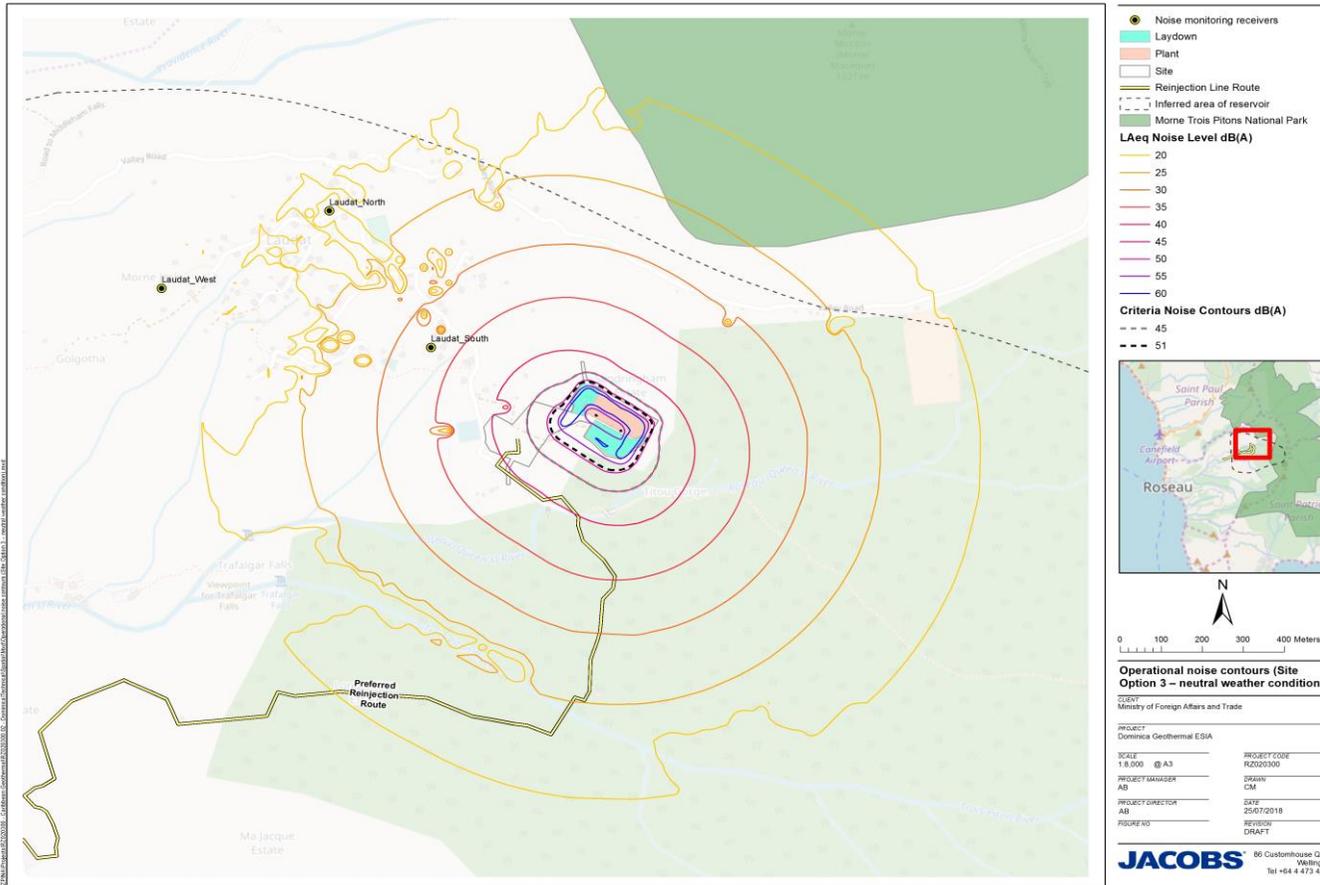
Appendix A. Detailed monitoring results

Location	Monitored noise level $L_{Aeq}(\text{period})$ dB(A)			
	Peak tourist season December 2013		Off tourist season April 2014	
	Daytime (7am to 9pm)	Night time (9pm to 7am)	Daytime (7am to 9pm)	Night time (9pm to 7am)
Laudat				
Location 1	39.5	44.5	42.0	47.0
Location 2	39.5	42.0	42.0	44.0
Location 3	39.5	42.5	43.5	43.5
Location 4	39.0	40.0	42.5	45.0
Location 5	40.0	41.5	43.5	44.5
Location 6	44.5	45.0	43.5	45.5
Location 7	36.5	40.5	42.0	45.0
Location 8	35.5	40.5	38.0	42.0
Location 9	36.5	49.0	41.5	43.5
Location 10	39.0	51.0	44.0	49.5
Location 11	53.0	53.5	51.0	52.0
Average	44.3	47.1	44.4	46.7
Maximum	53.0	53.5	51.0	52.0
Minimum	35.5	40.0	38.0	42.0
Fond Cani North				
Location 1	38.0	47.5	37.0	40.5
Location 2	39.0	46.5	43.5	49.0
Location 3	39.0	48.5	39.0	38.5
Location 4	49.0	49.0	36.0	37.5
Average	44.0	48.0	39.9	44.1
Maximum	49.0	49.0	43.5	49.0
Minimum	38.0	46.5	36.0	37.5
Fond Cani West and South				
Location 1	49.5	46.5	48.5	48.5
Location 2	59.5	60.0	57.5	57.5
Location 3	55.0	49.5	57.0	43.0
Location 4	47.0	47.0	46.5	44.0
Location 5	43.0	50.0	46.0	45.0
Location 6	46.0	50.0	46.5	46.5

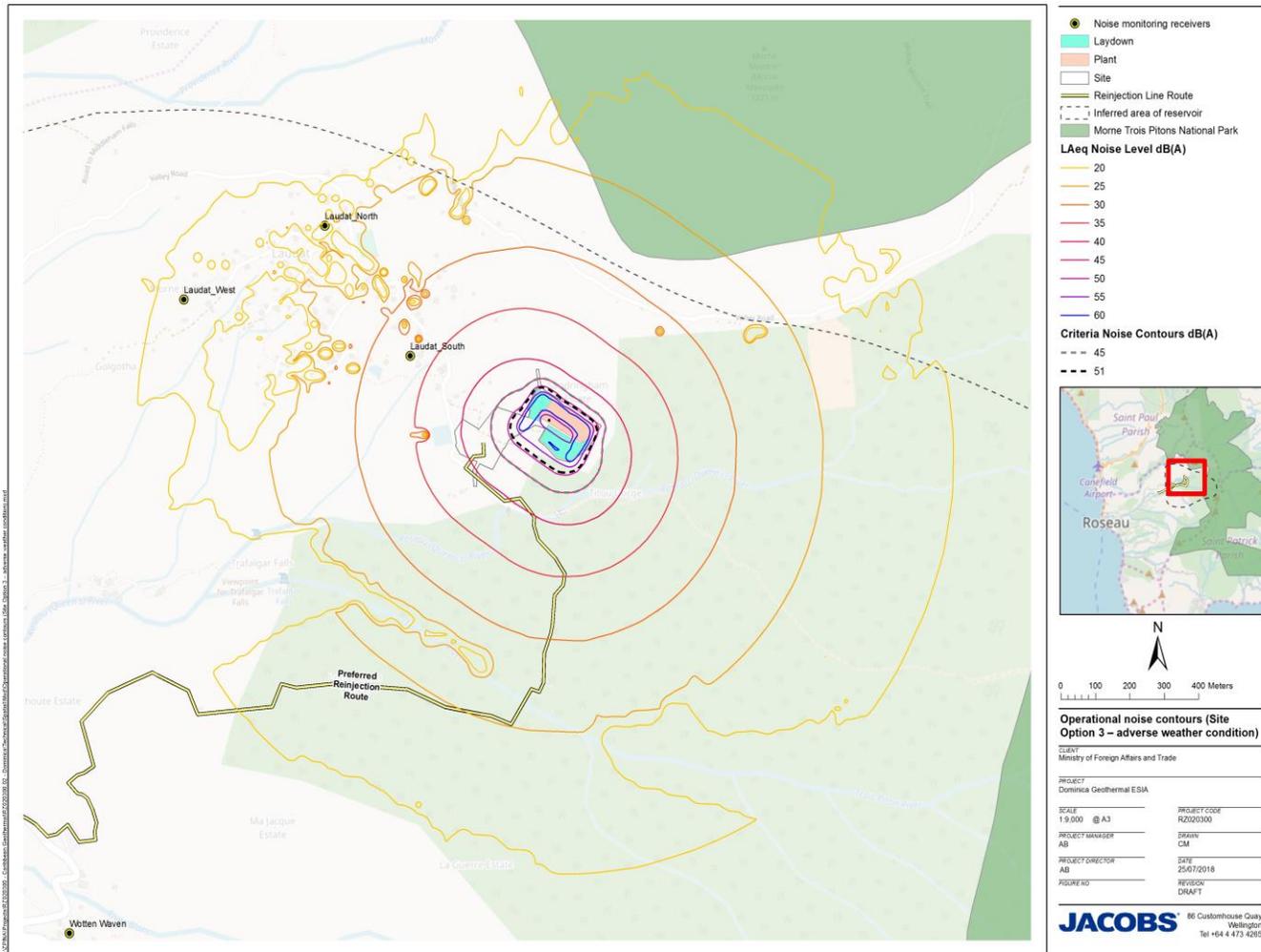
Location	Monitored noise level $L_{Aeq}(\text{period})$ dB(A)			
	Peak tourist season December 2013		Off tourist season April 2014	
	Daytime (7am to 9pm)	Night time (9pm to 7am)	Daytime (7am to 9pm)	Night time (9pm to 7am)
Location 7	46.0	50.0	42.0	41.0
Average	53.2	53.3	52.6	50.4
Maximum	59.5	60.0	57.5	57.5
Minimum	43.0	46.5	42.0	41.0
Morne Prosper				
Location 1	38.0	45.0	38.0	45.0
Location 2	38.0	45.0	39.0	46.0
Location 3	47.0	52.0	-	-
Location 4	42.5	46.0	39.5	35.0
Location 5	49.5	51.0	41.5	45.5
Location 6	47.0	50.0	41.0	38.5
Location 7	43.0	46.5	43.0	47.0
Location 8	41.0	43.5	36.0	35.0
Location 9	48.5	48.0	46.0	44.5
Average	45.6	48.4	41.3	43.6
Maximum	49.5	52.0	46.0	47.0
Minimum	38.0	43.5	36.0	35.0
Wotten Waven				
Location 1	40.0	53.0	45.5	49.0
Location 2	41.0	45.0	47.0	51.0
Location 3	39.5	45.0	41.0	48.0
Location 4	43.0	49.0	46.0	48.0
Location 5	45.5	46.5	49.5	51.0
Location 6	46.0	52.0	45.5	48.0
Location 7	49.0	50.5	49.0	50.0
Location 8	48.5	57.0	46.0	50.5
Location 9	49.0	57.5	49.0	49.5
Average	46.0	52.8	47.1	49.6
Maximum	49.0	57.5	49.5	51.0
Minimum	39.5	45.0	41.0	48.0
Trafalgar				
Location 1	44.0	47.0	44.0	44.5

Location	Monitored noise level $L_{Aeq}(\text{period})$ dB(A)			
	Peak tourist season December 2013		Off tourist season April 2014	
	Daytime (7am to 9pm)	Night time (9pm to 7am)	Daytime (7am to 9pm)	Night time (9pm to 7am)
Location 2	44.0	46.5	45.0	43.5
Location 3	53.5	56.0	47.0	47.0
Location 4	60.0	62.5	44.5	46.5
Location 5	46.0	51.0	45.0	46.0
Location 6	50.0	52.5	49.5	49.0
Location 7	43.5	48.5	45.0	43.5
Location 8	52.0	52.0	-	-
Location 9	50.0	52.5	49.0	50.5
Location 10	51.0	52.0	50.5	50.0
Location 11	45.0	47.5	49.0	47.5
Location 12	48.0	50.5	44.5	48.0
Average	52.0	54.4	47.1	47.3
Maximum	60.0	62.5	50.5	50.5
Minimum	43.5	46.5	44.0	43.5

Appendix B. Predicted noise contours (Neutral weather condition)



Appendix C. Predicted noise contours (Adverse weather condition)



Appendix G. Technical Report – Morne Trois Pitons National Park Impact Assessment



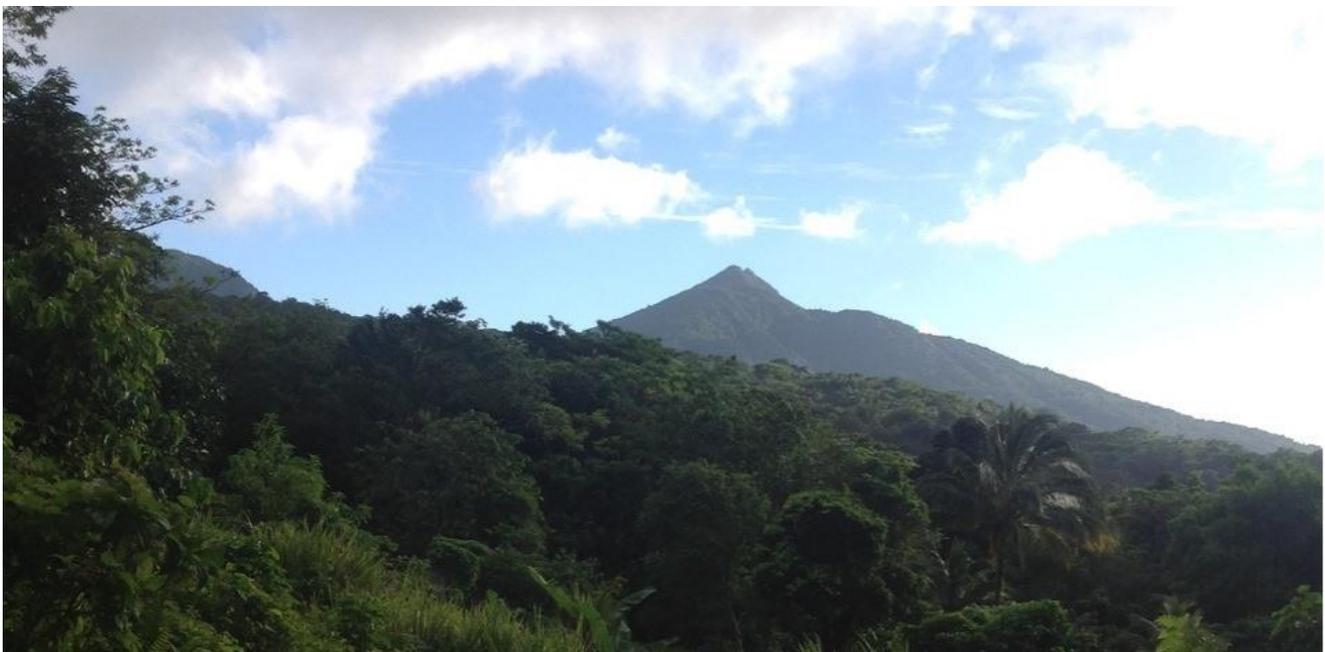
Dominica Geothermal Development Environmental and Social Impact Assessment

Ministry of Foreign Affairs and Trade

Morne Trois Pitons National Park Impact Assessment

RZ020300-0002-NP-RPT-0012 | V2

July 2018



Dominica Geothermal Development – Environmental and Social Impact Assessment

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Appendix A. WHC / IUCN Recommendations		

Glossary

ALOHA	Areal Locations of Hazardous Atmospheres
dB(A)	A-weighted decibels
DOMLEC	Dominica Electricity Services Limited
EIA	Environmental Impact Assessment
ESMP	Environmental and social management plan
ESIA	Environmental and social impact assessment
H ₂ S	Hydrogen sulphide
IFC	International Finance Corporation
IUCN	International Union for the Conservation of Nature
MTPNP	Morne Trois Pitons National Park
MW	Megawatt
OUV	Outstanding Universal Value
PS	Performance Standard
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific Cultural Organisation
WHC	World Heritage Centre
WHS	World Heritage Site

1. Introduction

1.1 Overview

The Commonwealth of Dominica is a small island developing state in the Caribbean Sea. It has a population of approximately 72,000 people and a land area of approximately 750 km². Around 22% of the island is a protected area, of which approximately 9% is designated by the United Nations Educational, Scientific Cultural Organisation (UNESCO) as the Morne Trois Pitons National Park (MTPNP) World Heritage Site (WHS).

This report is one of several technical reports prepared as supporting documentation for an Environmental and Social Impact Assessment (ESIA) of the proposed 7 megawatts (MW) Dominica Geothermal Project (the Project), which is being developed by the Dominica Geothermal Development Company Ltd – a government owned Special Project Vehicle.

The proposed geothermal development is located approximately 460 m from the WHS boundary at the closest point. As such, an assessment of potential impacts on the WHS is required, consistent with the International Union for the Conservation of Nature (IUCN) World Heritage Advice Note on Environmental Assessment (IUCN, 2013).

The location of the Project in relation to the western boundary of Morne Trois Pitons National Park World Heritage Site is shown in Figure 1.1. The Project infrastructure is shown in more detail in Figure 1.1.

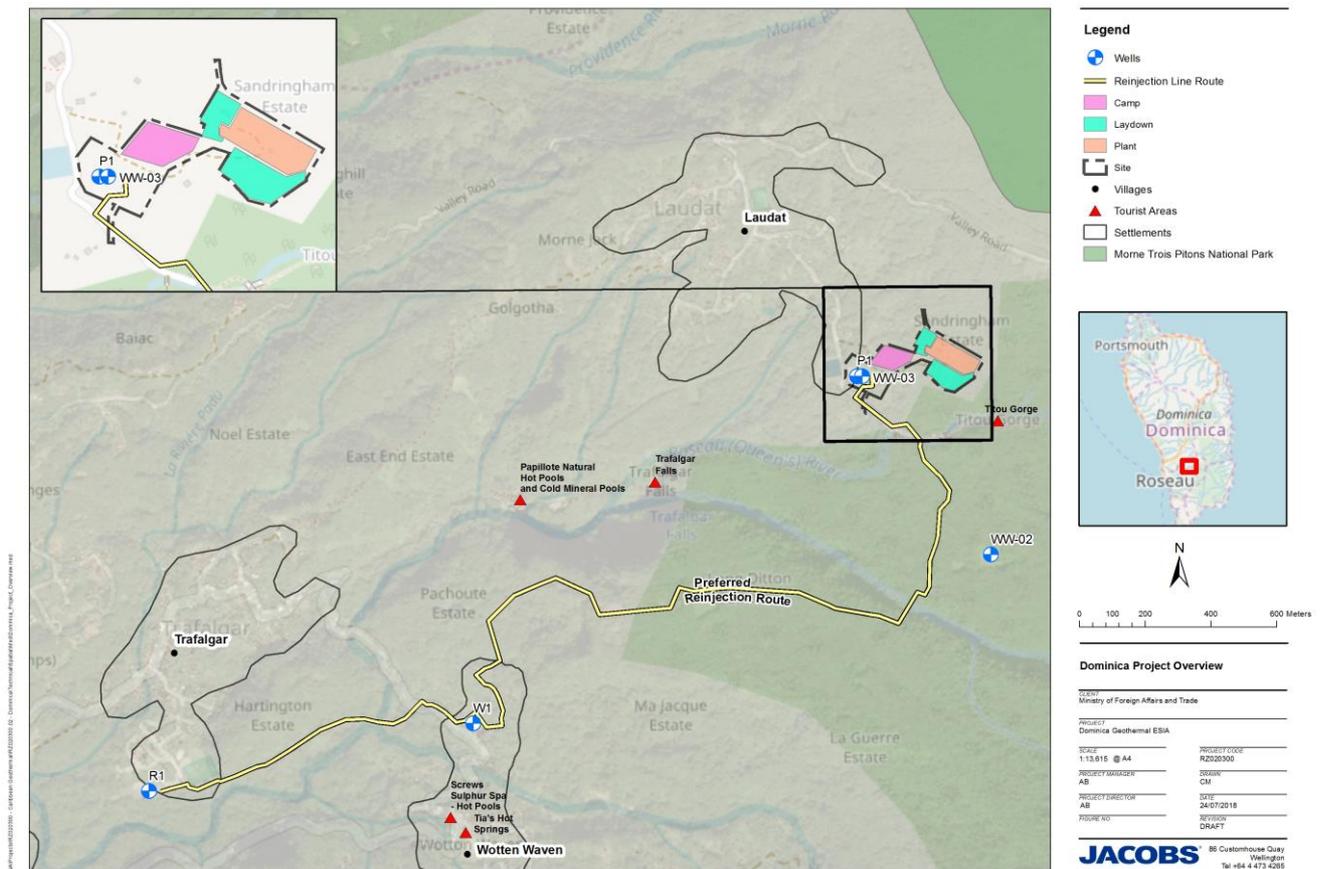


Figure 1.1: Location of power plant and reinjection pipeline (the Project) in the Roseau Valley

1.2 Proposed Development

The Project is proposed as a two-unit geothermal power plant with a gross capacity of 7 MW. Detailed descriptions of the Project infrastructure are provided in the Process Description, and summarised below.

- Power plant comprising 2 x 3.5 MW units (either single flash steam condensing cycle or organic Rankine cycle units (binary turbine), which will be adjacent to wells WW-P1 and WW-03. The binary power plants may use wet cooling or dry cooling;
- Production well WW-P1 – The existing geothermal production well at Laudat is indicated to have potential to generate 6 to 9 MW and will be the sole production well for the project;
- Reinjection wells WW-R1 (located in Trafalgar) and WW-01 (located in Wotten Waven) – The used geothermal fluid (brine and possibly some steam condensate) produced from production well WW-P1 would be disposed of into reinjection wells WW-R1 and WW-01 via a 250 to 300 mm diameter reinjection pipeline of up to 3.25 km in length;
- Steamfield infrastructure including two phase piping, steam separator, atmospheric flash tank, brine collection and disposal system, condensate collection and disposal system, pressure relief system, storage sump and rock muffler;
- Supporting infrastructure including existing well pads, turbine building, primary and ancillary equipment, cooling system, and water supply; and
- 11 kV interconnection to the DOMLEC electricity grid at the power plant site.

Further details of the specific Project elements are provided in ESIA Volume 1: Introduction and ESIA Volume 5: Technical Appendices, Technical Report – Detailed Process Description.

1.3 Activities Proposed

Since the commencement of exploratory drilling in 2011, five wells have been drilled (WW-P1, WW-R1, WW-01, WW-02 and WW-03). The Project will use the wells which have already been drilled and tested. As such this document assumes no drilling of new wells in advance of operation. If additional ‘make-up’ wells are required during the lifespan of the Project, a separate ESIA will be undertaken when the requirements are known. Maintenance of the existing wells is, however, considered within this ESIA. Project-related activities expected to be required are set out in Table 1.1. No part of the infrastructure lies within the boundaries of the WHS. Construction of the Project will take 18 months to two years.

Table 1.1: Indicative activities required during each phase of the Project

Activity
Construction
<ul style="list-style-type: none"> • Vegetation clearance (outside boundaries of WHS) for the power plant site, laydown areas, reinjection route and creation/widening of access roads • Earthworks (outside boundaries of WHS) for the power plant site, laydown areas, reinjection route and creation of access tracks for the reinjection line • Operation of construction plant (outside boundaries of WHS) • Increased presence of vehicles • Increased human presence • Release of run-off or sediments during construction • Accidental spillage of chemical or hydrocarbon loads • Use of water for equipment washdown, workers (potable and sanitary uses), and potentially a reserve for fire-fighting. Water could be abstracted from Titou Gorge Stream (c.150 m south of the plant, and downstream of the WHS).
Operation
<ul style="list-style-type: none"> • Monitoring and maintenance of the geothermal reservoir, including well workovers, as detailed in ESIA Volume 5: Technical Appendices, Technical Report – Detailed Process Description. • Water use - for workers, supply for fire-fighting, and for maintenance and plant cleaning. This would be sourced from surface water

sources and/or brought in from off-site

- Water abstraction – possible requirement to pump cold water from the Roseau River (from a location downstream of the WHS) to increase well injection capacity
- Increased human presence
- Emissions to air of non-condensable gases
- Air coolers, which do not have a visible plume of water vapour but may exhibit a heat haze OR water cooling towers, which have a visible plume of water vapour when the relative humidity of the atmosphere is high
- Other routine maintenance works
- If Organic Rankine Cycle (ORC) technology is selected, the flammable substance n-pentane will be required (c. 30 tonnes), to be stored in the condenser and process lines and in a bunded storage tank at the power plant site, in the condenser and process lines of the power plant.

Decommissioning

- Activities likely to be similar in nature to those during construction, above, but less extensive and intensive
- Plugging and abandoning geothermal wells

1.4 Assessment Methodology

1.4.1 Introduction

World Heritage Sites are those places which have been determined by UNESCO to be of “Outstanding Universal Value”¹ (OUV), fulfilling at least 1 of 10 selection criteria, and meeting conditions relating to site integrity, and protection/management systems. Their designation indicates that they are deemed important to the collective interests of humanity.

In addition to the national legislation and financier’s requirements regarding Environmental Assessments, as set out in the ESIA Volume 1: Introduction, Chapter 2, this assessment also reflects the requirements of the IUCN World Heritage Advice Note on Environmental Assessment (IUCN, 2013). The Advice Note provides guidance on integrating natural² World Heritage Sites, such as the MTPNP, within Environmental Assessments. The guidance is concerned specifically with impacts of the Project on the OUV of the site, rather than all potential impacts.

1.4.2 Outstanding Universal Value

OUV has three components:

- Values;
- Integrity; and
- Protection and management.

All development proposals that could affect the OUV of a WHS are required to be submitted by States Party to the World Heritage Committee before a decision on their funding, permitting or implementation is taken. As such, a copy of this ESIA will be provided to the World Heritage Committee for comment.

1.4.3 World Heritage Impact Assessment Principles

The World Heritage Advice Note sets out eight Impact Assessment Principles with which the assessment is required to comply. The principles are set out within Table 1.2, and references provided to their location for this development.

¹ Defined as “...natural significance which is so exceptional as to transcend national boundaries and to be of common importance for present and future generations of all humanity.”

² World Heritage sites are designated by criteria which categorise them as natural, cultural or mixed.

Table 1.2: World Heritage Impact Assessment Principles

No.	Requirement of Environmental Assessment for proposals affecting natural World Heritage Sites	Details / reference where addressed in report
1	Take place as early as possible in the decision-making process.	Consultation between the GoCD and the World Heritage Committee has been ongoing since the inception of the development proposals (as documented in UNESCO Mission Report (UNESCO, 2017b)).
2	Identify and evaluate reasonable alternatives to the proposal.	Section 3.2
3	Assess the likely environmental and social effects of the development proposal(s) on the Outstanding Universal Value of the site.	Section 3
4	Identify adequate mitigation measures for any residual negative impacts on Outstanding Universal Value that cannot be further reduced.	Section 4
5	Include a separate chapter on World Heritage impacts in the Environmental Assessment report.	This document comprises the WHS assessment.
6	Be publicly disclosed and subject to thorough public consultation.	Details of consultation undertaken for the Project are detailed within Stakeholder Engagement Plan (located in ESIA Volume 5: Technical Appendices), and included consideration of the MTPNP.
7	Propose, implement and independently audit an environmental management plan.	Monitoring and management will be undertaken as detailed in Section 4.
8	Effectively integrate the conclusions of the assessment into the decision-making process.	The conclusions of this document and the ESIA as a whole will be taken into consideration by the deciding authorities, as required by national legislation and international standards.

The guidance requires consideration of all likely effects of the proposal on the OUV of the WHS, including potential direct, indirect and cumulative effects. Potential social issues that could impact on the site’s OUV should also be assessed, and a consideration provided of alternative options, including the ‘no project’ option.

1.4.4 Mitigation and Residual Impacts

Adequate mitigation measures are identified for potential minor residual negative impacts identified on OUV that cannot be avoided or further reduced. The assessment also notes how these measures will be implemented, who will implement them within what timeframe, and what resources are secured for their implementation.

The assessment presents conclusions on the proposal’s potential negative impacts on all relevant aspects of OUV, including on values, integrity and protection and management.

Based on the findings of the assessment and any residual impacts, a preferred development proposal option/scenario is recommended.

2. Existing Environment

2.1 Background

The MTPNP World Heritage site was first proposed as a forest reserve in 1952. In 1975 it was designated a National Park under the National Parks and Protected Areas Act No.16. It was inscribed as a WHS in 1997 and falls within IUCN Management Category II: National Park.

2.2 Site Description

The MTPNP covers nearly 7000 hectares of the volcanic island, comprising a rugged mountain landscape and deep canyons. There are five live volcanic centres within the park, the highest of which reaches 1,342 metres. The landscape is scenically striking and features natural hot springs, bubbling mud ponds, lakes and magnificent waterfalls. Within the park are the sources of the major watercourses of the southern part of the island.

Amongst the park's most notable features are the Boiling Lake, a flooded fumarole which is consistently around 95°C, surrounded by impressive cliffs. The sounds, colours, heavy vapours and strong sulphurous smell make this a highly unusual sight. It is the largest feature of its type in the world and is a particular draw for tourists.

Fuelled by abundant seasonal rainfall (c.7 metres annually), lush vegetation covers much of the landscape of the MTPNP – an exception being the comparatively barren 'Valley of Desolation'. The extreme topography and varied mosaic of vegetation and habitats makes for a highly diverse ecological system supporting a wide variety of species.

The area of the inscribed site is 6,857 hectares. A number of changes to the boundaries have taken place since, and formal publication of the current boundary and buffer zone is understood to be expected in the near future.

2.2.1 Hurricane Maria

Hurricane Maria caused havoc and destruction on the night of Monday 18 September 2017. MTPNP would have been undoubtedly damaged, first hand observations mention forest defoliation of between 80 to 90% ultimately leading to tree deaths (DominicaVibes, 2017) with Dominica's wildlife having been severely hit. Conservation efforts associated with the island's rare bird species (Imperial Parrot and Red-necked parrot) ensured that a number kept in captivity were held safe (American Bird Conservancy, 2018). Populations in the wild have fared less well. Rainforest ecosystems such as those found on Dominica have been through previous hurricane events and vegetation cover and habitat integrity has returned rapidly (within 2 years; DominicaVibes, 2017) reaching semi-maturity or maturity.

The damage caused by the hurricane to MTPNP is not addressed further in this impact assessment. However, further actions have been proposed in the chapter covering Terrestrial Ecology Impact Assessment.

2.3 Designation

2.3.1 Values

In respect of the "Values" component of OUV, the site was inscribed under natural criteria (viii) and (x).

Criterion (viii): earth processes³. The application to this site is summarised as follows:

- The array and intact nature of geomorphologic features;

³ "Outstanding examples representing major stages of earth's history, including the record of life, significant on-going geological processes in the development of landforms, or significant geomorphic or physiographic features"

- The distinctive geology and landforms comprised of three major types of geological formations;
- The spectrum of volcanic activity in the form of streams of various colours, fumaroles, mud ponds and hot springs; and
- The ongoing geomorphological processes of reduction taking place in a largely undisturbed setting, which are of great scenic value and major scientific interest.

Criterion (x): threatened species and their habitats⁴. The application to this site is summarised as follows:

- The site is a very rare example of a largely intact forest areas remaining in the Insular Caribbean;
- Its high levels of endemism (birds, plants and herpetofauna), within a region recognised as a centre of endemism of global importance and with highly threatened biodiversity; and
- The variety of forest types, and associated diverse flora.

2.3.2 Integrity

Integrity is a measure of 'wholeness' and requires assessment of the extent to which the site:

- 1) Includes all elements necessary to express its OUV;
- 2) Is of adequate size to ensure the complete representation of features and processes which convey its significance; and
- 3) Suffers from negative effects of developments and/or neglect.

UNESCO (2017a) details the site's compliance with these criteria. It notes that the MTPNP supports a "microcosm of Dominica's biological diversity and species endemism, and provides intact and protected habitat for a wide diversity of flora and fauna, including a range of endemic species across several taxonomic groups".

2.3.3 Protection and Management

Responsibility for protection and management of the MTPNP falls under the remit of the Division of Forestry, Wildlife and National Parks, which is part of the Ministry of Agriculture and Fisheries. Day-to-day responsibility for the MTPNP lies with the National Parks Unit of the Division.

In March 2017, a joint World Heritage Centre (WHC) and IUCN 'reactive monitoring mission' to the MTPNP took place. The mission reported the site to be in a good state of conservation (UNESCO, 2017a/b). This is in part due to the natural protection afforded by the harsh terrain and the lack of road infrastructure through most of the site. Some agricultural encroachment has been noted in the south of the site. Neither report identified any immediate threat to the park's essential attributes and natural heritage values, provided legal requirements continue to be maintained and enforced. A summary of the mission findings and their implications for the Project is provided in Section 2.7.

2.4 Existing Site Conditions

2.4.1 Introduction

Based on the scale of the proposed development, the activities required, and its distance from the WHS, a high-level baseline is provided, focussed on threatened and protected features.

2.4.2 Flora / Habitats

Five forest types can be distinguished within the MTPNP, including rare elfin or cloud forest at the highest elevations, followed at progressively lower elevations by montane forest, rainforest, seasonal forest, dry scrub

⁴ "Contain the most important and significant natural habitats for in-situ conservation of biological diversity, including those containing threatened species of outstanding universal value from the point of view of science or conservation."

woodland and littoral woodland. The microclimatic variations afforded by the terrain support a wealth of plant species, including endemic vascular plant species (recorded as 21 in 1997).

The site is the largest of the national parks in the Windward Islands and Leeward Islands, has the most varied volcanic features, and is the only one with major forest cover.

Table 2.1: Sensitive feature of the MTPNP – flora/habitats

Component of OUV	Category of feature	Examples
Values	Threatened species and their habitats ⁵	<ul style="list-style-type: none"> • elfin forest • montane forest • rainforest • seasonal forest • dry scrub woodland • littoral woodland • endemic vascular (recorded as 21 in 1997) and non-vascular plants

2.4.3 Fauna

The rich and varied fauna includes endemic reptiles and amphibians, and 80% of the island's bird species, including the Vulnerable⁶ and endemic red-necked parrot (*Amazona arausiaca*). This species lives in forested areas in just a handful of areas on Dominica. In total 17% of the island's population distribution occurs within the MTPNP. Adjacent areas of critical importance are not protected and one of the major threats to the species is habitat loss, mainly caused by clearance for agriculture (UNESCO, 2017b).

Other species recorded in 1997 were 12 species of bat, 12 species of herpetofauna and 30 decapod crustaceans. The park also provides habitat for the Imperial parrot or Sisserou (*Amazona imperialis*), the island's national bird and of symbolic importance due to its inclusion on the national flag.

Table 2.2: Sensitive feature of the MTPNP – fauna

Component of OUV	Category of feature	Examples
Values	Threatened species and their habitats	<p>Globally threatened species (IUCN Red List of Threatened Species):</p> <ul style="list-style-type: none"> • Critically Endangered giant ditch frog (<i>Leptodactylus fallax</i>) • Endangered, endemic and restricted-range imperial parrot; • Endangered and endemic tree frog (<i>Eleutherodactylus amplinympha</i>) • Vulnerable, endemic and restricted-range red-necked parrot; • Vulnerable and restricted-range forest thrush (<i>Turdus lherminieri</i>) <p>15 restricted-range bird species:</p> <ul style="list-style-type: none"> • Lesser Antillean swift (<i>Chaetura martinica</i>) • Green-throated carib (<i>Eulampis holosericeus</i>) • Purple-throated carib (<i>Eulampis jugularis</i>) • Blue-headed hummingbird (<i>Cyanophaea bicolor</i>) • Antillean crested hummingbird (<i>Orthorhynchus cristatus</i>) • Lesser Antillean flycatcher (<i>Myiarchus oberi</i>) • Lesser Antillean pewee (<i>Contopus latirostris</i>) • Scaly-breasted thrasher (<i>Alenia fusca</i>) • Pearly-eyed thrasher (<i>Margarops fuscatus</i>)

⁵ Under the definitions of the International Finance Corporation (IFC) Performance Standard 6 (PS6), habitats of significant importance to Critically Endangered, Endangered, endemic or restricted-range species, are considered Critical.

⁶ IUCN Red List <http://www.iucnredlist.org/details/22686395/0>

Component of OUV	Category of feature	Examples
		<ul style="list-style-type: none"> Brown trembler (<i>Cinlocerthia ruficauda</i>) Rufous-throated solitaire (<i>Myadestes genibarbis</i>) Antillean euphonia (<i>Euphonia musica</i>) Plumbeous warbler (<i>Setophaga plumbea</i>) Lesser Antillean bullfinch (<i>Loxigilla noctis</i>) Lesser Antillean saltator (<i>Saltator albicollis</i>)

2.5 Social Context

28 villages lie within a mile of the MTPNP boundaries, although there are no settlements or major roads within the park itself. There is a small quarry in the northeast of the park, and very limited areas of other activities, but it is otherwise a largely undisturbed environment. Tourism activities are present but limited in extent due to the poor infrastructure. In 1997, 10,000 -15,000 visitors were thought to hike to the Emerald Pool, and 1,500-2,000 to the Boiling Lake; it is possible that these figures have increased in the intervening years. An 'aerial tram' was developed, which took visitors into the park itself, however operation ceased some years ago due to financial reasons. Water and power rights are granted to DOMLEC through the park and have not resulted in any major issues to date.

2.6 Evaluation

The impact assessment in Section 3 considers potential impacts of the development on the three elements of OUV of the WHS. The occurrence of a likely significant effect requires both an impact on a sensitive feature, and an effects pathway. As per the site's inscription, the sensitive features of the MTPNP can be categorised as shown in Table 2.3. The presence or absence of an effects pathway from the proposed development on each of the features is therefore also shown.

Table 2.3: Elements of the OUV of MTPNP

Component of OUV	Category of feature (where applicable) and examples	Effects pathway possible
Values	Earth processes: <ul style="list-style-type: none"> array of geomorphologic features the distinctive geology and landforms the spectrum of volcanic activity including streams, fumaroles, mud ponds and hot springs the ongoing geomorphological processes 	No
	Threatened species and their habitats: <ul style="list-style-type: none"> see Table 3 see Table 4 	Yes
Integrity	<ul style="list-style-type: none"> intact nature of geomorphologic features largely undisturbed setting natural attributes considered to be whole and intact site includes all elements necessary to express its outstanding universal value site is of adequate size to express its outstanding universal value 	Yes
Protection and management	<ul style="list-style-type: none"> adequate systems of protection and management in place to safeguard the future of the site 	No

As shown in Table 2.3, earth processes and geological/geomorphological features are unlikely to be affected by the proposed scheme as no effects pathways have been identified. The assessments of geology, soils and groundwater, and of geothermal resources within the ESIA Volume 2: EIA concluded no significant impacts on geothermal features inside the park. It should be noted that natural variation is observed in the characteristics

of some features of the MTPNP. The Boiling Lake, for example, has been known to vary in water level, and even to disappear periodically; this last occurred in early 2017 and before that, about 12 years ago.

Similarly, to the geomorphology of the MTPNP site, no changes to the protection and management of the site are part of the proposals, and there is considered to be no pathway for impacts on this element of the OUV. Thus no adverse impacts are anticipated on the above, and these features are therefore not discussed further.

2.7 UNESCO Visit

The objectives and corresponding findings of the 2017 WHC/IUCN mission to the MTPNP are summarised below. The resulting recommendations of the report are provided in Section 4, and will sit alongside the mitigation detailed by this assessment.

- i. Consider the impacts of existing and potential future geothermal infrastructure in the Roseau Valley.

It was reiterated to the mission team that no development of geothermal infrastructure would ever be allowed within the MTPNP and proposed buffer zone. No actual or potential threats to the site were identified in relation to the four existing but non-operational wells, however two (at Laudat village and Trafalgar) were considered to require specific and enhanced monitoring to safeguard this.

- ii. Assess progress towards the development of this ESIA.

Draft Terms of Reference for this ESIA were submitted to the World Heritage Centre for review by IUCN shortly after the mission. These incorporated the need to integrate in the study a specific assessment of potential impacts on the site's OUV.

- iii. Identify any other potential threats to the OUV of the site.

Climate change was identified as a primary potential threat in the future, as well as hydropower development and tourism pressure.

- iv. Assess current arrangements in respect of integrity, and of protection and management.

Resources were described as "stretched yet effective", and the legislation was reported to define clearly the site as a no-take area with strictly regulated access. An enhanced management plan in respect of all the protected areas on the island and supported by the United Nations Development Programme (UNDP) is in development. Ongoing studies in relation to a buffer zone and zoning strategy, funded by the World Bank were also reported to be in progress.

3. Assessment of Impacts

3.1 Assessment of Proposed Project Design

The significance of an impact can be considered a product of the magnitude of the impact and the sensitivity of the feature. The term ‘magnitude’ encompasses: duration and spatial extent of the impact; reversibility; likelihood; and compliance with legal standards and established professional criteria. ‘Sensitivity’ is a measure of the feature’s capacity to absorb proposed changes and/or the opportunities for mitigation. For further details of impact assessments methodology, reference should be made ESIA Volume 2: EIA.

Significance is classified in accordance with the impact evaluation matrix in Table 3.1, which considers the magnitude and sensitivity of the impact.

For those sensitive features of the OUV for which there exists an effect pathway, likely effects from direct, indirect and cumulative impacts of the proposal are assessed in Table 3.2. Of the activities set out within Section 1.3, only those activities which have potential to have an impact on the WHS are included. The magnitude, sensitivity and resulting significance are also detailed in Table 3.1.

Table 3.1: Impact evaluation matrix

		Magnitude			
		Major	Moderate	Minor	Negligible
Sensitivity	High	Major	Major	Moderate	Negligible
	Medium	Major	Moderate	Minor	Negligible
	Low	Moderate	Minor	Negligible	Negligible
	Negligible	Minor	Negligible	Negligible	Negligible

Table 3.2: Assessment of significance of impact on WHS in the absence of mitigation

Activity	Potential impact	Effect	Magnitude	Sensitivity	Significance
Construction					
Vegetation clearance	<ul style="list-style-type: none"> • loss of habitat (outside the WHS) • reduction of ecological connectivity 	<p>Habitat loss and resulting fragmentation outside the WHS has a low likelihood of indirectly and/or cumulatively contributing to similar effects within the WHS, including Critical habitat. This is because of the scale of the Project infrastructure and high degree of regeneration post-disturbance.</p> <p>Removal of nests or nesting habitat outside the WHS which would otherwise act as fringe habitat and extend the range of a species, including species which are threatened and/or protected.</p> <p>Reduction of foraging habitat for species which may move in and out of the site.</p>	Minor	Medium	Minor
Construction activities including earthworks, excavations, creation/widening of access roads, and the operation of construction plant	<ul style="list-style-type: none"> • noise 	Construction noise levels have been modelled for three points within the MTPNP: Boiling Lake, Valley of Desolation and Freshwater Lake. Noise levels are predicted to be inaudible (less than 20dB(A)) under all 13 construction scenarios.	Negligible	Medium	Negligible
	<ul style="list-style-type: none"> • harmful air emissions • dust • night-time illumination of platforms 	<p>If of sufficient magnitude, air emissions and dust could result in disturbance to animals within the WHS, and associated stress and reduction in fecundity.</p> <p>Air emissions and dust during construction have been modelled for three points within the MTPNP: Boiling Lake, Valley of Desolation and Freshwater Lake.</p> <p>Maximum predicted concentrations of hydrogen sulphide (H₂S) decrease rapidly with distance from the power plant and adverse impacts are not</p>	Negligible	Low	Negligible

Activity	Potential impact	Effect	Magnitude	Sensitivity	Significance
		<p>expected.</p> <p>Dust emissions from 'small'⁷ earthworks are considered negligible at distances >200m.</p> <p>Works on tracks and the laydown area would be no greater than the exploration activities already undertaken.</p> <p>There is a small potential for cumulative impacts of SO₂ and particulate matter, however the effect at the MTPNP would be negligible.</p> <p>Lighting of platforms is unlikely to be sufficiently disturbing at 600m to result in stress, behavioural changes or reduced breeding success.</p>			
	<ul style="list-style-type: none"> introduction/spread of invasive plant species 	<p>Spread of invasive species into the WHS, which may outcompete native species. However, no air-dispersed plant species are known to be of concern in this area. Construction plant and vehicles will not drive onto the WHS so no impacts will occur.</p>	Minor	Medium	Minor
	<ul style="list-style-type: none"> release of hazardous substances from accidental spillage or major accident 	<p>Uncontrolled discharges of geothermal fluids (brine and condensate) can be harmful to the environment, containing substances such as arsenic and boron. Brine is also very hot.</p> <p>Unless occurring on a major scale, however, release of contaminants is unlikely to result in significant impacts, as the WHS is upstream of the Project site.</p> <p>Uncontrolled discharges of geothermal fluids (brine and condensate</p>	Minor	Medium	Minor
	<ul style="list-style-type: none"> run-off or sedimentation 	<p>Unless occurring on a major scale, contamination of watercourses is unlikely to result in significant impacts, as the WHS is upstream of the Project site.</p>	Minor	Medium	Minor

⁷ As defined in the Institute of Air Quality Management (IAQM) (2011). For details see the ESIA Volume 3: EIA, Chapter 4 - Air Quality.

Activity	Potential impact	Effect	Magnitude	Sensitivity	Significance
Increased presence of vehicles	<ul style="list-style-type: none"> noise and vibration dust emissions to the air collision with animals 	<p>Effects would be as above, but not on a scale that would be noticeable at the MTPNP.</p> <p>Vehicles would not be present on the MTPNP, and encounters with animals outside the park boundaries are considered unlikely.</p>	Minor	Low	Negligible
Increased human presence	<ul style="list-style-type: none"> encroachment increased access to WHS through improved infrastructure 	<p>An influx of workers in search of employment, and associated businesses and services, may result in settlements growing. This may place increased pressure on resources such as land, water, waste disposal procedures. Given the Project site is on a small island this is unlikely to occur on scale that would impact the WHS.</p>	Minor	Low	Negligible
Operation					
Operation of power plant (including turbines, fans, pumps etc.), reinjection wells, and steam pressure releases during commissioning of both power plant and reinjection wells	<ul style="list-style-type: none"> noise 	<p>Operational noise levels have been modelled for three points within the MTPNP: Boiling Lake, Valley of Desolation and Freshwater Lake. Noise levels are predicted to be inaudible (less than 20dB(A)) under all 10 operational scenarios, with one exception, which is 21dB(A) at the Valley of Desolation, during steam pressure releases. Noise level changes of 3dB(A) are imperceptible to human receptors and a change of 1dB(A) is therefore negligible, even for sensitive animals.</p>	Negligible	Medium	Negligible
	<ul style="list-style-type: none"> harmful air emissions 	<p>If of sufficient magnitude, air emissions and dust could result in disturbance to animals within the WHS, and associated stress and reduction in fecundity.</p> <p>Air emissions and dust during construction have been modelled for three points within the MTPNP: Boiling Lake, Valley of Desolation and Freshwater Lake.</p> <p>Maximum predicted concentrations of hydrogen sulphide (H₂S) were found to decrease rapidly with</p>	Negligible	Low	Negligible

Activity	Potential impact	Effect	Magnitude	Sensitivity	Significance
		distance from the power plant and adverse impacts are not expected.			
Maintenance activities including well workovers and cleanouts, which could include small-scale drilling	<ul style="list-style-type: none"> release of toxic gas e.g. hydrogen sulphide noise vibration 	<p>In high concentrations hydrogen sulphide can result in necrosis and mortality.</p> <p>Vibration, noise and lighting may affect fauna, resulting in stress, behavioural changes, reduced breeding success.</p> <p>The above are not expected to be experienced within the WHS boundaries at a magnitude that would be above negligible.</p>	Minor	Low	Negligible
Increased human presence	<ul style="list-style-type: none"> encroachment increased access to WHS through improved infrastructure 	A workforce of only two or three workers is expected during operation; therefore, no impacts are expected.	Minor	Low	Negligible
If ORC technology is selected, storage and use of the flammable substance n-pentane	<ul style="list-style-type: none"> leak or rupture of n-pentane storage tank at the power plant 	<p>Based on the Areal Locations of Hazardous Atmospheres (ALOHA) modelling detailed within ESIA Volume 2: EIA, Chapter 15, the spatial extent and level of consequence of a leak or rupture of an n-pentane storage tank at the power plant was estimated for three scenarios.</p> <p>The effects at the WHS boundary under this scenario were negligible.</p>	Minor	Low	Negligible
	<ul style="list-style-type: none"> leak or rupture of n-pentane storage tank at the power plant resulting in a pool fire in the bund 	Under the modelled scenario, the effects at the WHS boundary were negligible.	Minor	Low	Negligible
	<ul style="list-style-type: none"> boiling liquid expanding vapour explosion (BLEVE)⁸ 	Under the modelled scenario the thermal radiation from this event sufficient to cause pain (to humans) within 60 seconds extends to 462m from the incident location, which is approximately 140m from the WHS	Moderate	Low	Minor

⁸ A BLEVE is an explosion caused by the rupture of a vessel containing a pressurised liquid above its boiling point. This is a rare event that can occur only if safety measures fail completely or in other very unusual circumstances.

Activity	Potential impact	Effect	Magnitude	Sensitivity	Significance
		boundary. Effects at this distance could be sufficient to cause disturbance and damage to plants and animals.			
Decommissioning					
Activities likely to be undertaken will be similar in nature to those during construction but will likely be less extensive and intensive. These activities may include plugging and abandoning geothermal wells.	<p>An indicative operational lifetime for the Project is 30 years. After this point, a programme of activities will be required to decommission the above-ground facilities and remediate the site to an agreed level.</p> <p>Because of the long timescale until this phase of the Project occurs, it is recommended that a separate assessment of impacts is undertaken at that time, including all mitigation and monitoring required to avoid significant adverse impacts on OUV.</p>				

3.2 Alternatives

The preferred power plant site and reinjection pipeline route were selected through a multi-criteria assessment process covering a range of technical, socio-economic and environmental issues. The presence of the WHS was one of the environmental considerations.

3.2.1 Reinjection Route

In July 2016, eight possible routes for the reinjection pipeline were identified. Three were shortlisted on the basis of constructability, topography, and proximity to local villages. Following public consultation and the completion of a LIDAR survey, a preferred option was selected. The Preferred Route comprises sections along the general alignment of 'H' and 'F' (see Figure 3.1); this route passes furthest from the WHS of the eight, and also had advantages in respect of safety during construction, disturbance to the local community, potential for interference with existing infrastructure, possible impacts on tourism, and long-term resilience to flooding events.

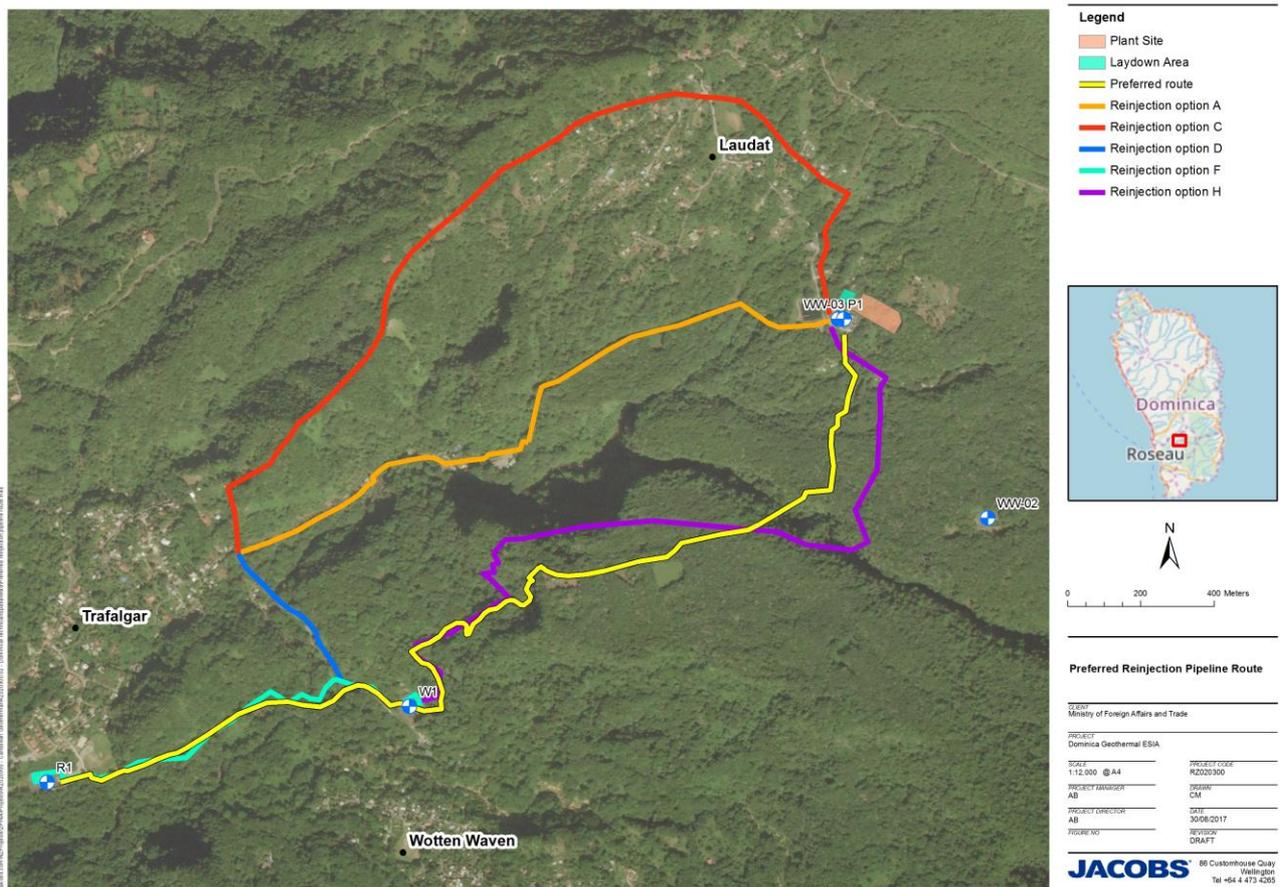


Figure 3.1: Reinjection line route options considered, including the Preferred Route

3.2.2 Project Site Alternatives

Three sites were considered for the power plant (1/1A, 2 and 3), each situated around WW-P1. ESIA Volume 1: Introduction, Section 4 provides a detailed assessment of alternatives and justification for the proposed option. Because the options are situated close together, there were no considerations between the three in relation to the WHS. The preferred option was selected on other grounds.

3.2.3 'No Project' Option

The 'do-nothing' option for the Project would result in the continued 'status-quo' for energy generation and reliance on diesel power within Dominica. The proposed Project represents a step change for Dominica in moving towards renewable sources of energy generation, increasing competitiveness, and providing improved energy security. The 'do-nothing' option is therefore not considered viable as it does not meet the Government's policy objectives, as detailed in the ESIA Volume 1: Introduction, Section 4.

Renewable energy is considered of particular relevance to Dominica in light of its island status and therefore its susceptibility to climate change-related increases in sea-level, and increased incidence and magnitude of tropical storms and hurricanes. Reliance on fossil fuels for energy, and the associated air emissions, is known to be a major contributor to climate change.

4. Mitigation and Monitoring

4.1 Mitigation for Minor Impacts

No significant (greater than minor) negative impacts have been identified through the assessment process. Although non-significant, the IUCN guidance requires that “adequate” mitigation is also identified for minor impacts on OUV. Mitigation for minor effects identified in Table 4.1 is detailed in Table 4.2.

4.2 Generic Good Practice Mitigation

The following generic good practice mitigation is considered adequate to further minimise adverse impacts, including negligible impacts:

- Implement dust-suppression measures such as covering vehicles transporting materials, ensuring vehicles use wheel wash facilities at site, and use of water spray dust suppression systems.
- Highly noisy activities should be undertaken during daylight hours where possible.
- Inductions/tool-box talks for staff should include reference to measures required to protect biodiversity.
- Proposals for the MTPNP buffer zone should be progressed, and this area maintained as a development-free zone. Activities that would facilitate access to the MTPNP should not be encouraged.
- Standard safe storage for n-pentane includes storage under a nitrogen blanket; incorporation of a Pressure Relief Valve; appropriate bunding; and a deluge fire extinguishment system. Heat and pentane sensors are also fitted around the storage tank and the plant to detect any leaks and heat changes.

4.3 Implementation of Mitigation

Implementation of mitigation will be prior to the phase in which the corresponding impact is expected to occur. Responsibility for the implementation of mitigation set out in the ESIA will become the responsibility of the appointed Engineering, Procurement, and Construction Contractor, overseen by the Dominica Geothermal Development Company Ltd.

Morne Trois Pitons National Park Impact Assessment

Table 4.1: Mitigation for minor impacts, and resulting residual effects

Activity	Potential impact	Potential Impact	Significance	Mitigation	Residual
Vegetation clearance	<ul style="list-style-type: none"> Loss of habitat outside the WHS Reduction of ecological connectivity 	<p>Habitat loss and resulting fragmentation outside the WHS has a low likelihood of indirectly and/or cumulatively contributing to similar effects within the WHS, including Critical habitat.</p> <p>This is because of the scale of the Project infrastructure and high degree of regeneration post- disturbance.</p> <p>Removal of nests or nesting habitat outside the WHS which would otherwise act as fringe habitat and extend the range of a species, including species which are threatened and/or protected.</p> <p>Reduction of foraging habitat for species which may move in and out of the site.</p>	Minor	<ul style="list-style-type: none"> Vegetation clearance activities should commence outside the breeding season for five key threatened species identified, to minimise impacts on breeding animals. The breeding seasons of the three bird species are overlapping, between January and August⁹. The amphibian species are thought to breed year-round, but primarily between May and July¹⁰. Habitat cleared should be the minimum possible, with any way-leave area required of the minimum width necessary. Use temporary fencing to prevent inadvertent damage outside designated construction areas. Avoid piling of clear-felled vegetation on standing live vegetation which would hinder movement of wildlife. 	Negligible
Construction activities including earthworks, excavations, creation/widening of access roads, and the operation of construction plant	<ul style="list-style-type: none"> Introduction/spread of invasive plant species Release of hazardous substances from accidental spillage or major accident 	<p>Spread of invasive species into the WHS, which may outcompete native species. However, no air-dispersed plant species are known to be of concern in this area. Construction plant and vehicles will not drive onto the WHS so no impacts will occur.</p> <p>Uncontrolled discharges of geothermal fluids (brine and condensate) can be harmful to the environment, containing substances such as arsenic and boron. Brine is also very hot. Unless occurring on a major scale, however, release of contaminants is unlikely to result in significant impacts, as the WHS is upstream of the Project site.</p> <p>Uncontrolled discharges of geothermal fluids</p>	Minor	<ul style="list-style-type: none"> Any replanting / landscaping should use native or endemic species to prevent the incursion of opportunistic invasive species. Machinery and vehicles should be cleaned upon entry/exit, and any soil brought on or off site screened for invasive species or plant pathogens. Minimise potential for sedimentation impacts by ensuring good construction site practices are implemented. Appropriate disposal of solid and liquid wastes, in line with recommendations in international and national standards, and using designated facilities as required. Any effluent discharged to surface watercourses must meet the more stringent of international water quality discharge standards prior to release to remove pollutants. 	Negligible

⁹ <http://www.iucnredlist.org/> (Accessed September 2017)

¹⁰ <http://www.amphibianark.org/pdf/Husbandry/Leptodactylus%20fallax%20-%20Management%20Guidelines.pdf> (Accessed September 2017)

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Activity	Potential impact	Potential Impact	Significance	Mitigation	Residual
		(brine and condensate)			
	<ul style="list-style-type: none"> Run-off or sedimentation 	Unless occurring on a major scale, contamination of watercourses is unlikely to result in significant impacts, as the WHS is upstream of the Project site.	Minor	<ul style="list-style-type: none"> Minimise potential for pollutants and surface water run-off to migrate off-site by ensuring standard good construction site practices are implemented. 	Negligible
Storage and use of the flammable substance n-pentane	<ul style="list-style-type: none"> Boiling liquid expanding vapour explosion (BLEVE)¹¹ 	Under the modelled scenario the thermal radiation from this event sufficient to cause pain (to humans) within 60 seconds extends to 462m from the incident location, which is approximately 140m from the WHS boundary. Effects at this distance could be sufficient to cause disturbance and damage to plants and animals.	Minor	<ul style="list-style-type: none"> Detailed measures to minimise the likelihood and magnitude of a BLEVE occurring is provided in ESIA Volume 2: EIA, Chapter 15, including: <ul style="list-style-type: none"> - Induction and training; - Standard Operating Procedures; - Routine inspections; - Good record keeping; and - Suitable firefighting equipment. 	Negligible

¹¹ A BLEVE is an explosion caused by the rupture of a vessel containing a pressurised liquid above its boiling point. This is a rare event that can occur only if safety measures fail completely or in other very unusual circumstances.

4.4 Monitoring

The MTPNP supports at least five species considered Threatened by IUCN: giant ditch frog, imperial parrot, red-necked parrot, forest thrush, and a species of tree frog (*Eleutherodactylus amplinympha*). The UNESCO Mission Report (UNESCO, 2017b) considered that habitat loss required for the construction of the power plant and installation of the pipeline could negatively impact the red-necked parrot – and potentially other Threatened species. Measures identified in Sections 4.2 and 4.3 will minimise habitat loss in the vicinity of the Project infrastructure and no habitat loss will take place within the WHS.

In addition, and in line with the UNESCO Mission Report (UNESCO, 2017b) it is recommended that a programme of monitoring be implemented. This should comprise firstly a programme of monitoring for the five key species identified, recommended to be at every six months from pre-construction until the completion of one year of construction, and annually thereafter for a minimum of five years of operation. The programme should also include the ongoing monitoring in the Laudat and Trafalgar area for any other potential impacts on the OUV of the WHS.

Monitoring will be detailed in an Environmental and Social Management Plan (ESMP), to be developed following detailed design of the Project. The Plan will be agreed with input from the MTPNP managing authorities (National Parks Unit of the Division of Forestry, Wildlife and National Parks), and implemented prior to construction where appropriate. The monitoring programme outlined will enhance understanding of the ecology of the MTPNP and surrounding areas, and ensure that if any adverse effects on OUV were to occur, these would be detected in a timely manner and properly mitigated.

Independent third-party auditing of the implementation of the ESMP will be undertaken at regular intervals. The budget for this auditing and its frequency will be specified in the ESMP and verified by the relevant regulators.

4.5 Residual Impacts

Following the implementation of mitigation measures set out within this document and within the ESIA Volume 4: ESMP, Framework ESMS and Assessment Against WBG Standards, no significant adverse effects on OUV of the MTPNP are predicted. Because of the sensitivity and importance of the WHS it is also recommended that the monitoring is undertaken.

4.6 WHC/IUCN recommendations

A number of recommendations were made following the WHC/IUCN mission (2017b). A number are addressed in the execution of this assessment, whilst others are beyond the scope of this ESIA, however they complement and are complemented by the mitigation and monitoring recommended within this document. The full text of the recommendations is provided in Appendix A.

- **Recommendation 1** - Ensure that no hydropower or geothermal projects are allowed within the boundaries of the WHS, and foresee an EIA for each of the future hydropower or geothermal projects in its vicinity, assessing potential impacts on the OUV in line with the IUCN guidance.
- **Recommendation 2** - Continue monitoring in the area of Laudat and Trafalgar for any potential impacts on the OUV from the exploration phase of the geothermal project.
- **Recommendation 3** - Undertake an assessment of potential impacts of the geothermal project on the OUV.
- **Recommendation 4** - Establish an effective buffer zone of the Morne Trois Pitons.
- **Recommendation 5** - Finalize the preparation of an updated management plan for the WHS in the framework of the project financed to this end by UNDP.
- **Recommendation 6** - Further consolidate the governance of all protected areas of Dominica.
- **Recommendation 7** - Develop and implement a long-term monitoring programme of climate change impacts on biodiversity values, with special attention given to the most sensitive species and habitats.

5. Summary

MTPNP is a site of global importance and one of the world's Key Biodiversity Areas. It contains Critical habitat and supports at least five species considered Threatened by IUCN: two amphibians, two parrots and one passerine bird.

Impacts associated with the proposed geothermal Project will be experienced downstream of and outside the boundaries of the WHS and its proposed buffer zone. No construction or other Project activities will take place within the site, there will be no clearing of vegetation or habitat within the site, and no significant cumulative impacts have been identified.

Provided that the appropriate generic good practice and specific mitigation set out in this document and the Project ESMP is properly implemented, none of the activities to be undertaken has been identified as likely to result in significant adverse impacts on the Outstanding Universal Value of the site, either now or in future, via direct or indirect means. The recommendations set out by the 2017 mission report (2017b) sit alongside the mitigation and monitoring, and are congruent with it.

On this basis the development proposal is considered acceptable in respect of impacts on the WHS.

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Appendix A. WHC / IUCN Recommendations

Recommendation 1

Ensure that no hydropower or geothermal projects are allowed within the boundaries of the property as they are incompatible with its World Heritage status, and foresee an EIA for each of the future hydropower or geothermal projects in the vicinity of the property, assessing potential impacts on the Outstanding Universal Value (OUV) in line with the IUCN World Heritage Advice Note on Environmental Assessment, before making any decisions that are difficult to reverse, in accordance with paragraph 172 of the Operational Guidelines.

Recommendation 2

Continue monitoring in the area of Laudat and Trafalgar for any potential impacts on the OUV of the property from the exploration phase of the geothermal project and to ensure that any impacts from the operational phase can be detected in a timely manner and properly mitigated.

Recommendation 3

Undertake, as foreseen in the terms of reference of the Environmental and Social Impact Assessment (ESIA), an assessment of potential impacts of the geothermal project on the OUV of the property, in line with IUCN's World Heritage advice note on environmental assessment) considering any necessary mitigation measures, and submit a copy of the ESIA to the World Heritage Centre for review by IUCN, prior to any decision to approve the operational phase of the project.

Recommendation 4

Establish an effective buffer zone of the Morne Trois Pitons, in the framework of the project financed to this end by the GEF, ensuring that threats to OUV, including conditions of integrity, are clearly considered in this process and, once the buffer zone of the National Park has been established, to develop a minor boundary modification proposal to officially establish a buffer zone of the property.

Recommendation 5

Finalize the preparation of an updated management plan for the property in the framework of the project financed to this end by UNDP.

Recommendation 6

Further consolidate the governance of all protected areas of Dominica, taking into consideration the institution of a national park service, based on the conclusions of the study funded by the Caribbean Development Bank and in conformity with the original provisions of the National Parks and Protected Areas Act (1975).

Recommendation 7

Develop and implement a long-term monitoring programme of climate change impacts on biodiversity values, with special attention given to the most sensitive species and habitats.

Appendix H. Technical Report – Terrestrial Ecology Impact Assessment



Dominica Geothermal Development – Environmental and Social Impact Assessment

Ministry of Foreign Affairs and Trade

Terrestrial Ecology Impact Assessment

RZ020300-0002-NP-RPT-0013 | V2

August 2018



Dominica Geothermal Development – Environmental and Social Impact Assessment

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Revision	Date	Description	By	Review	Approved
A	13/09/17	First draft	H Greene	P Rogers	P Rogers
B	08/03/18	Second draft – post-Hurricane Maria situation and actions	P Rogers	I Pearson	I Pearson
C	2/5/18	Minor edits to finalise report	H Greene	P Rogers	B Clarke
V1	15/6/18	FINAL for ISSUE	H Greene	P Rogers	B Clarke
V2	01/08/18	Critical habitat assessment and minor updates following WBRSS review	H Greene	P Rogers	B Clarke

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Glossary

DOMLEC	Dominica Electricity Services Limited
EIA	Environmental Impact Assessment
EHS	Environmental Health and Safety
GoCD	Government of the Commonwealth of Dominica
ESIA	Environmental and social impact assessment
IFC	International Finance Corporation
IUCN	International Union for the Conservation of Nature
MTPNP	Morne Trois Pitons National Park
MW	Megawatt
PS	Performance Standard
ToR	Terms of Reference
UNESCO	United Nations Educational, Scientific Cultural Organisation
WHS	World Heritage Site

1. Introduction

1.1 Overview

The Commonwealth of Dominica is a small island developing state in the Caribbean Sea. It has a population of approximately 72,000 people and a land area of approximately 750 km². Around 22% of the island is a protected area, of which approximately 9% is designated by the United Nations Educational, Scientific Cultural Organisation (UNESCO) as the Morne Trois Pitons National Park (MTPNP) World Heritage Site (WHS).

This report is one of several technical reports prepared as supporting documentation for an Environmental and Social Impact Assessment (ESIA) of the proposed 7 megawatts (MW) Dominica Geothermal Project (the Project), which is being developed by the Dominica Geothermal Development Company Ltd – a government owned Special Project Vehicle.

The location of the Project is shown in Figure 1.1. The Project infrastructure is shown in more detail in Figure 1.2. As shown in Figure 1.1, the proposed development is located approximately 450 m from the WHS boundary at the closest point. As such, an assessment of potential impacts on the WHS has been prepared as a separate document, which should be read in conjunction with this assessment.

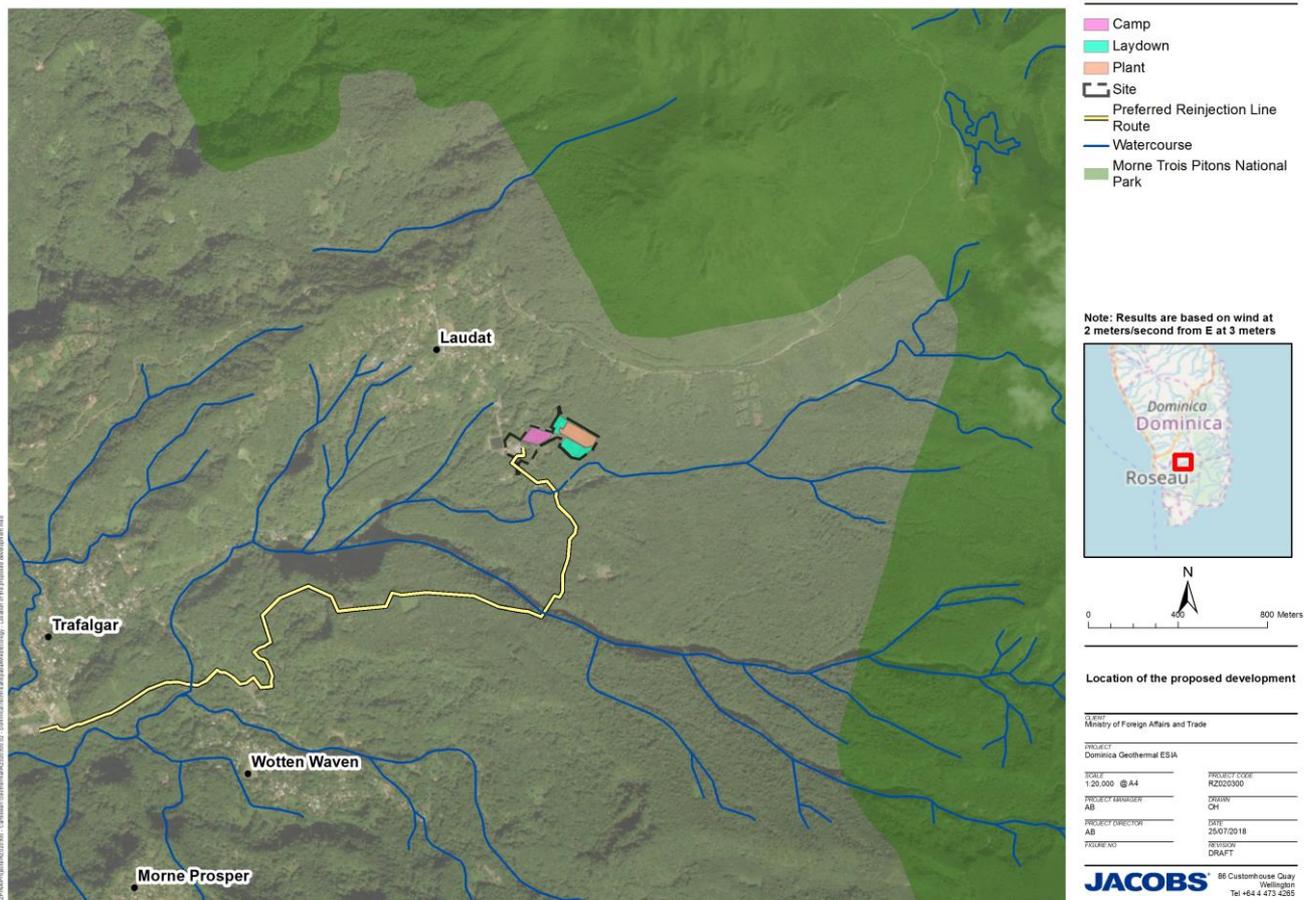


Figure 1.1: Location of the proposed development

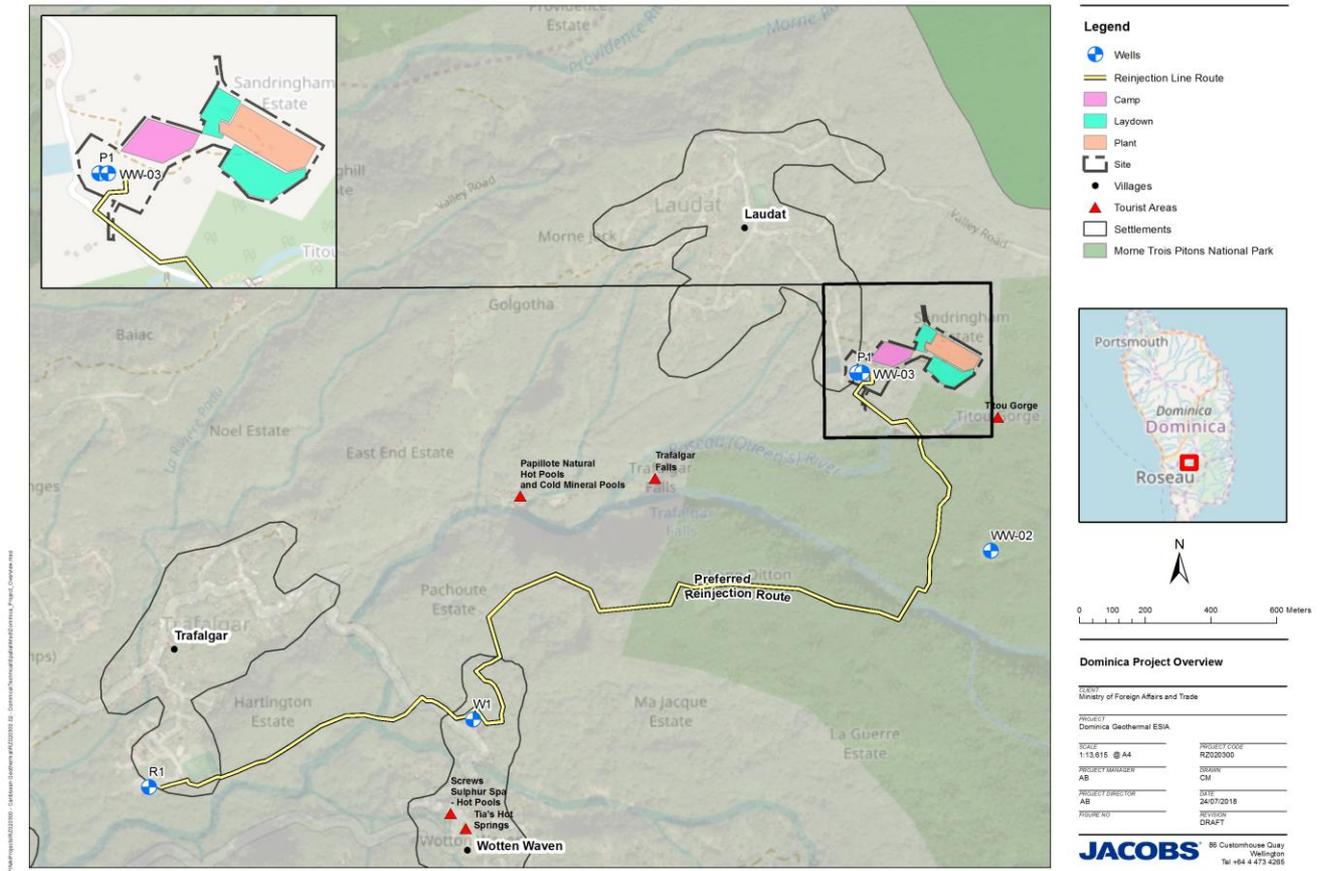


Figure 1.2: Location of power plant and reinjection pipeline (the Project) in the Roseau Valley

1.2 Proposed Development

The Project is proposed as a two-unit geothermal power plant with a gross capacity of 7 MW. Detailed descriptions of the Project infrastructure are provided in the Process Description, and summarised below.

- Power plant comprising 2 x 3.5 MW units (binary or steam condensing), located adjacent to wells WW-P1 and WW-03;
- Production well WW-P1 – an existing geothermal production well at Laudat will be the sole production well for the Project;
- Injection of used geothermal fluids (brine) to wells WW-R1 and WW-01 via a pipeline of 3.25km in length;
- Steamfield infrastructure adjacent to WW-P1 including injection of steam condensate to well WW-03;
- Supporting infrastructure including existing well pads, turbine building, primary and ancillary equipment, cooling system, and water supply;
- Access road; and
- 11kV interconnection to the Dominica Electric Utility Company (DOMLEC) electricity grid at the power plant site. Three new cables will be run under or directly alongside the proposed access road into the Project site. The length of this route is approximately 440m.

No part of the infrastructure lies within the boundaries of the WHS. Further details of the specific Project elements are provided in ESIA Volume 1: Introduction and ESIA Volume 5: Technical Appendices, Technical Report – Detailed Process Description.

1.3 Activities Proposed

Since the commencement of exploratory drilling in 2011, five wells have been drilled (WW-P1, WW-R1, WW-01, WW-02 and WW-03). The Project will use the wells which have already been drilled and tested. As such this document assumes no drilling of new wells in advance of operation. If additional ‘make-up’ wells are required during the lifespan of the Project, a separate ESIA will be undertaken when the requirements are known. Maintenance of the existing wells is, however, considered within this ESIA. Project-related activities expected to be required are set out in Table 1.1. Construction of the Project will take 18 months to two years.

Table 1.1: Indicative activities required during each phase of the Project

Activity
Construction
<ul style="list-style-type: none"> • Vegetation clearance for the power plant site, laydown areas, reinjection route and creation/widening of access roads • Earthworks for the power plant site, laydown areas, reinjection route and creation of access tracks for the reinjection line • Digging of trenches for the 11 kV interconnection • Operation of construction plant • Increased presence of vehicles • Increased human presence • Release of run-off or sediments during construction • Accidental spillage of chemical or hydrocarbon loads • Use of water for equipment washdown, workers (potable and sanitary uses), and potentially a reserve for fire-fighting. Water could be abstracted from Titou Gorge Stream (c.150 m south of the plant).
Operation
<ul style="list-style-type: none"> • Monitoring and maintenance of the geothermal reservoir, including well workovers, as detailed in ESIA Volume 5: Technical Appendices, Technical Report – Detailed Process Description. • Water use - for workers, supply for fire-fighting, and for maintenance and plant cleaning. This would be sourced from surface water sources and/or brought in from off-site • Water abstraction – possible requirement to pump cold water from the Roseau River to increase well injection capacity • Increased human presence • Emissions to air of non-condensable gases • Air coolers, which do not have a visible plume of water vapour but may exhibit a heat haze OR water cooling towers, which have a visible plume of water vapour when the relative humidity of the atmosphere is high • Other routine maintenance works • If Organic Rankine Cycle (ORC) technology is selected, the flammable substance n-pentane will be required (c. 30 tonnes), to be stored in a banded storage tank in the power plant site, and in the condenser and process lines of the power plant.
Decommissioning
<ul style="list-style-type: none"> • Activities likely to be similar in nature to those during construction, above, but less extensive and intensive • Plugging and abandoning geothermal wells

1.4 Assessment Methodology

This impact assessment describes and assesses the potential impacts from the proposed Project on the important terrestrial ecology features of the Project site and surroundings, during each phase of the Project. Impacts on features of the aquatic ecological environment are considered in Chapter 8.

As set out in ESIA Volume 1: Introduction, Chapter 2, national legislation of particular relevance to the assessment is:

- Forestry and Wildlife Act, 1976 (amended, 1982 and 1990);
- Forest Act (1959), Chapter 60:01;
- National Parks and Protected Areas Act (1975); and

- Physical Planning Act (2002).

The International Finance Corporation (IFC) Performance Standard (PS) 6: *Biodiversity Conservation and Sustainable Management of Living Natural Resources*, is also applicable.

In order to ensure that data collected during biodiversity field surveys would be adequate to produce a report in accordance with laws of the Commonwealth of Dominica (GoCD) and international standards, a set of Biodiversity Terms of Reference (ToR) were developed. This scope was reviewed by a World Bank Regional Safeguard Advisor, and was provided to the field survey team for their reference. The Biodiversity ToR can be found in ESIA Volume 5: Technical Appendices, Appendix D. The focus for survey data and assessment was floral and faunal diversity, including rare and/or threatened species and habitats which support those species. Threatened species are those classified as Critically Endangered (CE), Endangered (EN) or Vulnerable (VU) by the International Union for the Conservation of Nature (IUCN) Red List (IUCN, 2017).

Survey data was collected in 2017 by Dominica-based consultancy Eclipse Inc. Note that the surveys were undertaken prior to Hurricane Maria (see Section 1.5 below). The impact assessment also takes supplementary information from desk-based sources.

The impact assessment has been conducted in accordance with the assessment methodology outlined in ESIA Volume 1: Introduction, Chapter 2. Mitigation has been identified where necessary to reduce the scale and nature of potential impacts. Proposed monitoring is also detailed, and any residual effects are summarised.

1.5 Hurricane Maria

On the evening of Monday 18 September 2017 the eye of a devastating Category 5 hurricane (Hurricane Maria) reached the shores of Dominica. With winds of 165+ mph travelling over the island at 9 mph, Hurricane Maria left a trail of devastation to infrastructure and nature alike. First hand observations mention forest defoliation of between 80 to 90% ultimately leading to tree deaths (DominicaVibes, 2017) with Dominica's wildlife having been severely hit. Conservation efforts associated with the island's rare bird species (Imperial Parrot and Red-necked parrot) ensured that a number kept in captivity were held safe (American Bird Conservancy, 2018) and there have been sightings of further birds flying in the wild.

The baseline surveys and impact assessment were undertaken prior to Hurricane Maria, and as such this document presents the baseline at that time in Section 2. Following Hurricane Maria, the report has been revised to provide high-level updates to baseline conditions (Section 2.9), and to the proposed ecological mitigation and monitoring (Section 4.2).

2. Existing Environment

2.1 Data Collection Prior to 2017

An initial flora and fauna analysis was carried out in 2008 to gain a preliminary understanding of the biodiversity of the Roseau Valley. Three areas were selected in 2011 for detailed flora and fauna assessment, and a fourth was added in 2015. At each of these four areas the dominant habitat and flora and fauna species was described and matched to vegetation type descriptions.

2.2 Data Collection in 2017

2.2.1 Survey Methods

A more targeted approach was required for the ESIA, focussed on habitats in the area of potential impact, i.e. along the preferred re-injection line route and other sites selected for the plant infrastructure.

A preliminary land-use/habitat classification of the study area was prepared in GIS by interpreting satellite imagery and aerial photography. This information was used to stratify the vegetation to ensure that the full range of habitats was systematically sampled. Field ecologists were then able to ground-truth vegetation types using a rapid assessment approach.

Surveys for birds, herpetofauna and mammals was also undertaken. Survey methodologies were replicable and scientifically robust, and used primarily visual and aural methods. Limited nocturnal survey for animal species was also undertaken at accessible locations.

2.2.2 Survey Locations

A combination of transects and plot-based surveys was used. The route of the proposed reinjection line was the basis for establishing a transect spanning three following locations: Trafalgar, Trois Bitons, Wotten Waven and Laudat:

- Trafalgar – 7 quadrats and Wotten Waven – 1 quadrat;
- Trois Bitons – 15 quadrats; and
- Laudat – 6 quadrats.

In addition, in order to enable the evaluation of potential impacts of the proposed infrastructure the biodiversity of the Wotten Waven reinjection site and the proposed construction location in Laudat were surveyed separately. Data collection locations are shown on Figure 2.1.

Particular attention was paid to dominant, rare, endemic, threatened, protected, invasive species, and to those species that are of importance to local communities.

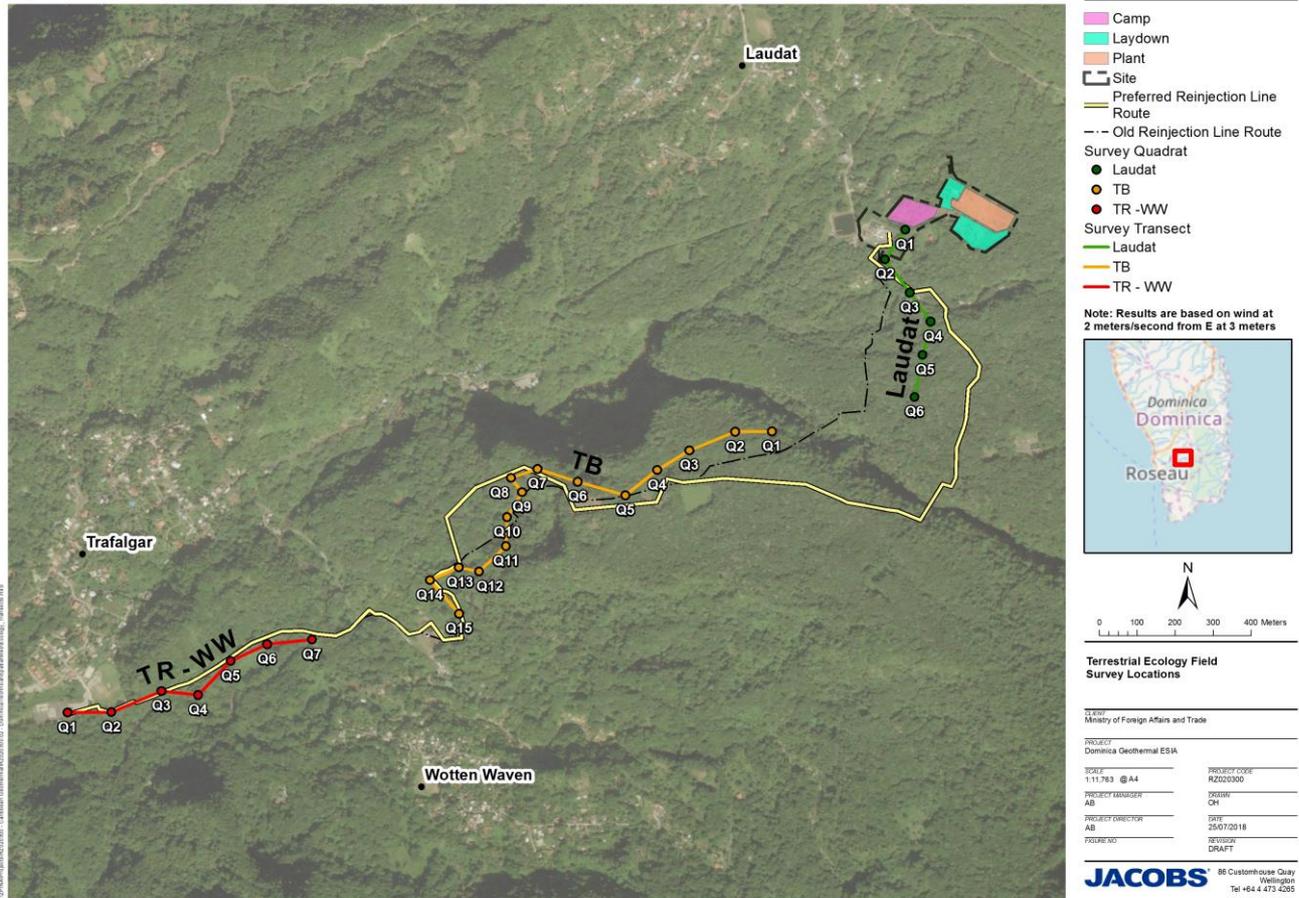


Figure 2.1. Field survey locations

2.3 Limitations and Assumptions

The following limitations and assumptions apply to this assessment:

- Biodiversity data for the Roseau Valley collected in 2008 was not available for review, and thus the more recent data from 2017 has been used in this assessment.
- Some parts of the survey transects were not surveyed due to accessibility and health and safety concerns. Where possible these locations were surveyed from a distance and descriptions provided.
- Where conflicting information within the raw data was provided, professional judgement has been used to make an appropriate and precautionary assessment.

2.4 Protected Areas

The protected area of principal relevance to the project is Morne Trois Pitons National Park, a World Heritage Site which lies approximately 600m northwest, and upstream, of the proposed Project infrastructure. Impacts on the ecology of the site have been considered separately and are not discussed further here, other than in the context of the wider diversity of the area.

The MTPNP, along with three other sites on the island, is also designated by BirdLife International as an Important Bird Area (IBA). Two small coastal/island IBAs are located on the south and southeast coasts, and the Morne Diablotin National Park in the north of the island, is the other. The designation also renders all four sites Key Biodiversity Areas (KBA). In addition, an Endemic Bird Area (EBA) extends across the whole of the

Lesser Antilles, and supports seven endemic bird genera. Dominica has three endemic bird species of its own¹, and also supports 18 restricted-range bird species.

Nationally, Dominica recognises 10 protected areas, covering 22% of the terrestrial habitat, and 0.01% of the marine area. No other established or proposed protected areas have been identified.

2.5 Habitats

The major vegetation type in all areas surveyed is secondary rain forest at varying stages of succession. Some agricultural habitats were also present, both those currently under cultivation and those apparently abandoned.

No rare or threatened plant species were identified in any of the transects or plot-based surveys.

2.5.1 Trafalgar - Transect

This transect runs along the southern side of the Trafalgar playing field in a south-easterly direction, through privately-owned land with active and abandoned agriculture. The line ends at the Trafalgar River gorge.

The Trafalgar area is typically secondary rainforest as a result of disturbance, primarily from housing and agricultural development and the impact of Hurricane David. In some areas, vestiges of old stands remain, surrounded by smaller re-growth.

Quadrat 1 (Q1) is adjacent to an access road which leads to the geothermal reinjection line. It supports savannah-like species, with some secondary rainforest vegetation, including some areas which have been cleared. Invasive *Mimosa* spp. were noted to be dominant here. Q2 features a steep slope down to the Roseau River, rendering it inaccessible but it was visually assessed to have a dense secondary forest emerging, with full canopy cover. Q3 is similarly partly inaccessible, being located in an elevated forested area, with evidence of landslides historically. Q4 to Q6 feature flatter terrain and with a greater proportion of active agriculture. Q7 is located towards the edge of a cliff overlooking the river, and has no evidence of active agriculture.

2.5.2 Trois Bitons - Transect

This is an estate on an elevated plateau north of the village of Wotten Waven. The site is flanked by a steep escarpment on its southern and western sides, and with the deep gorge of the Trois Pitons River on the north and north-eastern sides. This natural barrier limits access into the area.

The predominant vegetation type is secondary rainforest, with some areas which have been subjected to logging and agriculture. The second half of the route was not safely accessible, and so visual observations were made from the trail that traverses the area. Much of this part of the route was apparently abandoned agricultural land. Q14 and Q15 showed more signs of human activity, in the form of small farming activities, tourism and street vendors, and the main road from Trafalgar to Wotten Waven.

2.5.3 Laudat - Transect

The transect was located southeast of the village of Laudat and comprised largely secondary rainforest. The primary forest has been extensively impacted by road construction, establishment of electricity infrastructure, shifting agriculture, tourism development and the impact of extreme weather events, especially Hurricane David in 1979. The DOMLEC pipeline passes near to Q2/Q3.

Some remnants of rainforest were identified, surrounded by natural regeneration, however generally there are few typical rainforest trees present.

¹ Jamaican petrel *Pterodroma caribbaea* (CR), red-necked Amazon *Amazona arausiaca* (VU), Imperial Amazon *Amazona imperialis* (EN).

2.5.4 Laudat - Infrastructure Location

A plot-based survey was undertaken at the proposed location for the power plant site and laydown area. This area includes an abandoned dwelling, and agricultural land with low-growing ground cover and some trees. The primary remaining crop was citrus fruits.

2.5.5 Wooten Waven – Infrastructure Location

This site is adjacent to the Wooten Waven to Trafalgar main road, approximately 140 m from the Wooten Waven Sulphur Springs tourist site. The site was originally selected for exploratory drilling and is one of the proposed reinjection wells.

The area is characterized by a high water table, and there is a wetland/marsh area, with patches of fumarolic vegetation and hot water pools. To the southwest and the north lies secondary rainforest and agricultural land, where crops such as banana, coconut, mango and breadfruit are cultivated.

2.6 Birds

95% of Dominica's 206 resident and visiting bird species are categorised as Least Concern by IUCN, whilst 2% are Near Threatened, and 3% (equating to 6 species) are Globally Threatened, which comprise the categories: Vulnerable (3); Endangered (2); and Critically Endangered (1)². None of these species were recorded during field surveys.

Along the Trafalgar transect, 325 individual birds of 26 species were identified during the survey, all of Least Concern. In addition, the barn owl (*Tyto alba nigrescens*) was recorded during a night-time survey. A further three species are thought to frequent the area, one of which is the Vulnerable red-necked parrot (*Amazona arausiaca*), reported to be a frequent visitor earlier in the year, foraging on citrus tree fruits.

At the Wooten Waven proposed infrastructure site, 14 species were recorded and a further 12 were not encountered but have been verified as present by residents and a local guide. At the Laudat proposed infrastructure site, 17 species were recorded and a further 9 are considered to be present.

At all three locations, the same five species endemic to the Lesser Antilles, five endemic to the Caribbean and two native to a small number of Lesser Antillean islands were present. These Dominican endemics/near endemics are the blue-headed hummingbird (*Cyanophaea bicolor*) and plumbeous warbler (*Dendroica plumbea*). Both have small ranges and declining population, but are within the limits of the category Least Concern. All remaining species are considered common or abundant resident breeders and are also of Least Concern. Across all sites a total of 31 species were identified or verified to be present generally in the area.

2.7 Mammals

Mammalian diversity was very low at all surveyed locations. Along the Trafalgar transect and at the Wooten Waven and Laudat proposed infrastructure sites, unidentified insectivorous and frugivorous bat species was recorded. At all locations, field signs of agouti (*Dasyprocta antillensis*) were noted, and common opossum (*Didelphys marsupialis*) and rats (*Rattus rattus*) are reported.

2.8 Herpetofauna

Along the Trafalgar transect and at the Wooten Waven and Laudat infrastructure locations, one amphibian was recorded, the Near Threatened tink frog *Eleutherodactylus martinicensis*. This was in greatest abundance at Trafalgar, with 140 individuals recorded, and only two at Wooten Waven.

² Leach's storm-petrel *Hydrobates leucorhous* (VU), black-capped petrel *Pterodroma hasitata* (EN), Jamaican petrel *Pterodroma caribbaea* (CR), red-necked Amazon (VU), Imperial Amazon (EN), forest thrush *Turdus lherminieri* (VU)

The Puerto Rican crested anole (*Anolis cristatellus*) is an introduced species identified at Trafalgar and the Wooten Waven and Laudat infrastructure sites. It is considered invasive due to its competition with the native anole (*Anolis oculatus*). The latter is thought to be present at Laudat, but was not recorded, and despite the impact of the non-native species, the native species is considered of Least Concern. Another endemic, Dominican ground lizard (*Ameiva fuscata*) was recorded at Trafalgar and has not been assessed for its conservation status.

The Dominican boa (*Boa constrictor nebulosi*), black-and-white checkered snake (*Liophis juliae juliae*), house gecko (*Hemidactylus mabouia*), dwarf gecko (*Sphaerodactylus vincentii*), and golden skink (*Mabouya mabouya*) were not observed during surveys but are considered present in the Trafalgar area. Previous survey data indicated their presence at Laudat also.

2.9 Evaluation

No species which are Threatened or rare have been recorded in the study area during surveys. One Threatened species which is verifiably understood to be present, is:

- red-necked parrot: Vulnerable

A Critical Habitat screening assessment has been undertaken based on the presence of this species, provided in Appendix 1, including an analysis of Modified, Natural and Critical habitats within the Project area.

In addition to the red-necked parrot, the following endemic or near-endemic species are of unknown or less than Threatened conservation status, but are considered to be of relevance to the assessment:

- tink frog, Near Threatened
- Dominican ground lizard, Not Assessed;
- Dominica anole; Least Concern;
- blue-headed hummingbird, Least Concern; and
- plumbeous warbler, Least Concern.

2.10 Post-Hurricane Maria

The Project footprint as described in Section 1 of this report has been revisited since the hurricane. Dominica Geothermal Development Company Ltd (DGDC) conducted an assessment of their existing assets, the condition of the proposed Project sites and their continued viability (DGDC, 2017). The DGDC report does not provide any specific detail on the condition of the environment or surrounding habitats, however, photographic records have been taken which do provide some level of detail as to the environmental state.

Observations include the following with references to corresponding figures (photographs) within DGDC (2017):

- Higher exposed areas such as hill-tops have been stripped of tree cover, medium to small trees remain on lower slopes only, but it is clear that some if not all of these have been defoliated to some extent. Ground cover plants and habitats remain intact (see DGDC report; Figure 1 and 2);
- Lower more sheltered areas appear to show good vegetation cover that has not been so badly damaged (DGDC, Figure 3);
- Landslides and hill slips have occurred especially along access tracks destabilising vegetation and exposing bare rock and soil to the elements (DGDC, Figure 4, 6, 7);
- Grassed areas on flat surfaces e.g. those around wellheads (see DGDC, Figure 8, 9, 12) appear intact and have not incurred storm damage;
- Some trees located around the proposed power plant site appear to have been defoliated (See DGDC, Figure 13). Text in 3.2.1 notes large quantities of fallen trees and minor edge collapses into river gorges. Large amount of debris in river courses carried downstream;

- Fallen or semi-fallen trees remain a risk along access tracks and may need to be felled to ensure safe passage (see DGDC, Figure 14 and Section 3.2.1);
- Steeper hillside vegetation has been badly damaged which could lead to further erosion and slips (see DGDC, Figure 16). Major landslides evident which could destabilise further in time should another storm event occur;
- River courses have become choked with new debris, rocks, fallen tree materials and other detritus (see DGDC, Figure 18); and
- Defoliated trees around existing infrastructure are likely to die possibly leading to greater exposure until vegetation cover is restored (see DGDC, Figure 19).

Rainforest ecosystems such as those found on Dominica have been through previous hurricane events and vegetation cover and habitat integrity has returned rapidly (within 2 years as reported by DominicaVibes, 2017). Indeed, such events provide many species with new opportunities e.g. similar to when a mature tree is felled in a rainforest, opening up the canopy, and providing dormant seeds the chance to grow. It is clear that the environment has dramatically changed as a result of Hurricane Maria, and natural habitat regrowth will be different from what was there before. However, studies completed to date since the hurricane have indicated the presence of a mature habitat representative of the island. It is therefore proposed that no further ecological studies are undertaken as this would not provide any new information on the underlying habitats present. Instead, the situation post-Maria does provide new opportunities for the Project to work with nature through proposed mitigation actions e.g. tree planting to stabilise slopes and stop further erosion and restoring river courses. These actions are described further in Section 6.

3. Assessment of Impacts

The significance of an impact can be considered a product of the magnitude of the impact and the sensitivity of the feature. The term ‘magnitude’ encompasses: duration and spatial extent of the impact; reversibility; likelihood; and compliance with legal standards and established professional criteria. ‘Sensitivity’ is a measure of the feature’s capacity to absorb proposed changes and/or the opportunities for mitigation.

Significance is classified in accordance with the impact evaluation matrix in Table 3.1, which considers the magnitude and sensitivity of the impact.

For the species and habitats evaluated in Section 2.8 as important to this assessment, the activities detailed in Section 1.3 which may impact the feature directly, indirectly and/or cumulatively, are detailed in Table 3.2. Where an impact is initiated in construction but also occurs throughout operation (e.g. permanent habitat removal), it is discussed only within operational impacts.

Table 3.1: Impact evaluation matrix

		Magnitude			
		Major	Moderate	Minor	Negligible
Sensitivity	High	Major	Major	Moderate	Negligible
	Medium	Major	Moderate	Minor	Negligible
	Low	Moderate	Minor	Negligible	Negligible
	Negligible	Minor	Negligible	Negligible	Negligible

Table 3.2: Assessment of significance of impacts in the absence of mitigation

Activity	Potential impact	Effect	Significance
Construction			
Construction activities including earthworks, excavations, creation/widening of access roads, and the operation of construction plant	<ul style="list-style-type: none"> noise 	Construction noise levels have been modelled for receptor locations around the Project area. Noise levels during construction are predicted to be inaudible or of negligible significance under all 13 construction scenarios.	Negligible
	<ul style="list-style-type: none"> harmful air emissions dust night-time illumination of platforms 	<p>Air emissions and dust during construction have been modelled for receptor locations at and around the source points.</p> <p>Dust emissions from ‘small’³ earthworks are considered negligible at distances >200 m. As the sensitivity of the area is classified as ‘Low’, the resulting risk is classified as ‘Negligible’ for ecological impacts.</p> <p>There is a small potential for cumulative impacts of SO₂ and particulate matter, however the effect would be highly localised.</p> <p>Lighting of platforms could cause minor disturbance to animals in the immediate vicinity of the construction area.</p>	Negligible

³ As defined in the Institute of Air Quality Management (IAQM) (2011). For details see the ESIA Volume 3: EIA, Chapter 4 - Air Quality.

Activity	Potential impact	Effect	Significance
	<ul style="list-style-type: none"> introduction/spread of invasive plant species 	The transport of significant quantities of soil on or off site is not expected. Spread of invasive species which may outcompete native species is possible, although based on the scale of the construction area, is unlikely to be significant.	Negligible
	<ul style="list-style-type: none"> release of hazardous substances from accidental spillage or major accident 	Uncontrolled discharges of geothermal fluids (brine and condensate) can be harmful to the environment, containing substances such as arsenic and boron. Brine is also very hot. Impacts could occur downstream, including damage to plant tissue, necrosis and animal sickness or mortality. Release on a scale which would have a significant effect would be unlikely.	Minor
	<ul style="list-style-type: none"> run-off or sedimentation 	If not treated, run-off and sedimentation will reduce water quality and increase deposition downstream, potentially contaminating drinking water used by animals, and inhibiting plant growth. Release on a scale which would have a significant effect would be unlikely.	Minor
Increased presence of vehicles	<ul style="list-style-type: none"> noise and vibration dust emissions to the air collision with animals 	Effects from noise, vibration and dust would be as above, but not on a scale greater than negligible. Direct mortality of individuals from collisions or entrapment in uncovered holes, pipes or machinery is unlikely to occur in sufficient numbers to affect the wider population.	Negligible
Increased human presence	<ul style="list-style-type: none"> encroachment 	An influx of workers in search of employment, and associated businesses and services, may result in settlements growing. This may place increased pressure on resources such as land, water, waste disposal procedures. The Project size and location is unlikely to attract large numbers of job-seekers. Localised inappropriate waste disposal may however occur.	Negligible
Temporary removal of terrestrial habitats to accommodate the construction corridor for the reinjection line. During construction, the corridor will be 10 m wide (of which 3-4 m will be permanent loss, see below).	<ul style="list-style-type: none"> loss of habitat reduction of ecological connectivity 	Temporary reduction in extent of secondary rainforest and agricultural land, and associated impacts on animal communities associated which rely on these habitats for food, shelter and breeding. Parts of the habitats to be lost could support threatened species but are not considered to be core habitat. The extent of the habitat loss is relatively small, and the vegetation along the reinjection line is expected to regenerate rapidly.	Negligible
Operation			
Permanent removal of terrestrial habitats to accommodate footprint of construction. The land required for the power plant site is expected to be between 0.32 ha and 1.42 ha, all of which is Modified. In addition, the 3.25 km pipeline will have a permanent wayleave of 3-4m,	<ul style="list-style-type: none"> loss of habitat reduction of ecological connectivity 	Permanent reduction in extent of secondary rainforest and agricultural land, and associated impacts on animal communities associated which rely on these habitats for food, shelter and breeding. Parts of the habitats to be lost could support threatened species but are not considered to be core habitat. The extent of the habitat loss is	Minor

Activity	Potential impact	Effect	Significance
with an associated loss of 1.4 ha Modified Habitat and 1.7 ha Natural Habitat.		relatively small; however, some severance of habitats will result.	
Operation of power plant (including turbines, fans, pumps etc.), reinjection wells, and steam pressure releases during commissioning of both power plant and reinjection wells	<ul style="list-style-type: none"> noise 	Operational noise levels have been modelled for 13 locations. Noise levels are predicted to be inaudible or of negligible significance in all scenarios, except one. Under the commissioning scenario, there are exceedances at three locations: Trafalgar, Laudat and Wotten Waven, however it is understood that commissioning testing will only occur for a relatively short period.	Minor
	<ul style="list-style-type: none"> harmful air emissions 	If of sufficient magnitude, air emissions and dust could result in disturbance to animals, and associated stress and reduction in fecundity. Air emissions such as H ₂ S, SO ₂ and mercury have been modelled throughout the project area. Small exceedances may occur close to the emission sources, however concentrations will decrease rapidly with distance and adverse impacts are not expected.	Negligible
Maintenance activities including well workovers and cleanouts, which could include small-scale drilling	<ul style="list-style-type: none"> Release of toxic gas e.g. hydrogen sulphide Noise vibration 	In high concentrations hydrogen sulphide can result in necrosis and mortality. Vibration, noise and lighting may affect fauna, resulting in stress, behavioural changes, reduced breeding success. These activities would be relatively infrequent and short-term and thus not expected to be significant.	Negligible
Increased human presence	<ul style="list-style-type: none"> encroachment 	A workforce of only two or three workers is expected during operation, therefore no impacts are expected.	Negligible
If ORC technology is selected, storage and use of the flammable substance n-pentane	<ul style="list-style-type: none"> leak or rupture of n-pentane storage tank at the power plant 	Based on the Areal Locations of Hazardous Atmospheres (ALOHA) modelling detailed within ESIA Volume 2: EIA, Chapter 15, the spatial extent and level of consequence of a three scenarios at the power plant was estimated. The level of impact under this scenario was found to be contained within the power plant, and the level of impact on surrounding areas of Negligible significance.	Negligible
	<ul style="list-style-type: none"> leak or rupture of n-pentane storage tank at the power plant resulting in a pool fire in the bund 	A burning pool fire which could affect animals and habitats outside the power plant is possible but highly unlikely. The level of impact on the areas surrounding the power plant were assessed as of Negligible significance.	Negligible
	<ul style="list-style-type: none"> boiling liquid expanding vapour explosion (BLEVE)⁴ 	Under the modelled scenario the thermal radiation from this event sufficient to cause pain (to humans) within 60 seconds extends to 462 m from the incident location. Lethal effects may extend to 209 m, with an intermediate category of	Minor

⁴ A BLEVE is an explosion caused by the rupture of a vessel containing a pressurised liquid above its boiling point. This is a rare event that can occur only if safety measures fail completely or in other very unusual circumstances.

Activity	Potential impact	Effect	Significance
		2 nd degree burns (to humans) extending to 296 m. Such an incident could have substantial and wide-ranging consequences for animals and habitats, but is a very unlikely occurrence.	
Decommissioning			
Activities likely to be undertaken will be similar in nature to those during construction but will likely be less extensive and intensive. These activities may include plugging and abandoning geothermal wells.	An indicative operational lifetime for the Project is 30 years. After this point, a programme of activities will be required to decommission the above-ground facilities and remediate the site to an agreed level.	Because of the long timescale until this phase of the Project occurs, it is recommended that a separate assessment of impacts is undertaken at that time, including all mitigation and monitoring required to avoid significant adverse impacts.	

4. Mitigation and Monitoring

The important species and habitats identified in the assessment were red-necked parrot, tink frog, Dominican ground lizard, Dominica anole, blue-headed hummingbird, and plumbeous warbler, and their habitats. No likely significant (greater than minor) negative impacts have been identified through the assessment process, and thus no specific mitigation is required for these species.

Part of the reinjection line corridor is currently Natural Habitat (see Appendix 1). In line with Performance Standard 6, in areas of Natural Habitat, mitigation has been designed to achieve No Net Loss of biodiversity, where feasible. This has included / will include the following activities:

- A number of options for the reinjection in route were considered, with consideration for ecological impacts, to avoid sensitive habitats.
- Habitat cleared will be minimum possible, with any way-leave area required of the minimum width necessary. This will contribute to minimising habitat fragmentation.
- The 6-7m of the construction corridor of the reinjection line that is not required permanently will be replanted with native species as soon as possible after construction.
- A biodiversity offset will be created to a minimum extent of 1.7 ha (equivalent to the Natural Habitat lost under the Project Area). A Habitat Management Plan (HMP) will be developed to establish the biodiversity offset required to achieve No Net Loss of Natural Habitats, with input from local specialists and stakeholders as appropriate. The biodiversity offset will also incorporate the measures identified in Section 6: Post-Hurricane Maria Actions, where appropriate.

A minor impact was identified as a result of fragmentation of habitats by the reinjection line. In order to minimise severance effects, the pipeline will have under/overpasses installed at intervals along its length. The exact nature and positioning of these will be developed during detailed design. In addition, because the pipeline is located above-ground, smaller animals are expected to be able to pass under it.

Furthermore, standard good practice measures such as the following will however help to further minimise adverse impacts:

- Implement dust-suppression measures such as covering vehicles transporting materials, ensuring vehicles use wheel wash facilities at site, and use of water spray dust suppression systems.
- Highly noisy activities should be undertaken during daylight hours where possible.
- Inductions/tool-box talks for staff should include reference to measures required to protect biodiversity.
- Appropriate provision should for be made for waste disposal.
- Vegetation clearance activities should commence outside the breeding season for red-necked parrot (breeding is between February and June). Where possible it should avoid the primary amphibian breeding season between May and August also.
- Use temporary fencing to prevent inadvertent damage outside designated construction areas.
- Avoid piling of clear-felled vegetation on standing live vegetation which would hinder movement of wildlife.
- Any replanting / landscaping should use native or endemic species to prevent the incursion of opportunistic invasive species.
- Machinery and vehicles should be cleaned upon entry/exit, and any soil brought on or off site screened for invasive species or plant pathogens.
- Minimise potential for sedimentation impacts by ensuring good construction site practices are implemented.
- Appropriate disposal of solid and liquid wastes, in line with recommendations in international and national standards, and using designated facilities as required.
- Any effluent discharged to surface watercourses must meet the more stringent of international water quality discharge standards prior to release to remove pollutants.

- Minimise potential for pollutants and surface water run-off to migrate off-site by ensuring standard good construction site practices are implemented.
- Ensure all standard safe storage measures for n-pentane are implemented, as detailed in ESIA Volume 2: EIA, Chapter 15.

These measures will be included within the Environmental and Social Management Plan (ESMP), to be developed following detailed design of the Project. The Plan will be agreed with input from relevant authorities and implemented prior to construction where appropriate. It will also include mitigation/monitoring measures identified as required in the MTPNP assessment. As detailed above, an HMP will be developed to establish the biodiversity offset required to achieve No Net Loss of Natural Habitats. It should be noted that the additional mitigation and monitoring set out within the MTPNP assessment are of relevance to ecological receptors generally, and should be considered alongside this assessment.

Provided the mitigation described is implemented effectively, no specific monitoring plan is considered to be required.

5. Residual Impacts / Summary

The field surveys and desk study information indicate a relatively low diversity and abundance of important ecological features, with the majority of important habitats and species being instead concentrated within the MTPNP. Whilst the surrounding areas provide important functions in terms of connectivity and supplementary habitat, there is no identified Critical Habitat and the only Threatened species thought to use the area finds its core habitat within the MTPNP. No culturally or socially important plant species were identified.

Impacts identified were notably loss of secondary rainforest and agricultural habitats, and the small likelihood but potentially substantial consequences of a major leak, fire or explosion. None of the impacts identified would be greater than minor significance and thus no specific mitigation was required. A biodiversity offset is proposed to ensure the Project achieves No Net Loss of Natural Habitats, and as close to No Net Loss of all habitats as possible. In addition, a range of standard good practice measures are recommended to minimise adverse impacts further. These measures are consistent with the recommendations of the assessment of impacts on the MTPNP, and will assist in maintaining the values, integrity and protection of that site too.

6. Post-Hurricane Maria Actions

Despite the damage that Hurricane Maria has caused to surrounding ecosystems and habitats, it does present the Project with a number of opportunities which would serve to support the project, but could also improve and contribute towards a better natural environment. The following are actions that will be undertaken by DGDC under a Habitat Management Plan, and which will be complementary to the biodiversity offset identified in Section 4:

- **Stabilising bare slopes or improve resilience on slopes where trees have fallen** – promote tree and shrub planting to stabilise loose soil and rock, prevent further erosion and slips. This could also include supporting local nurseries to grow more trees which in turn could be used by local communities;
- **Areas of fallen trees surrounding well pads and other infrastructure** – plant native tree species to stabilise ground conditions, improve ecological resilience and reduce rainwater run-off which in turn could pollute water courses and cause soil erosion;
- **Restore river courses** – remove bulky items where possible such as fallen trees, logs and other detritus and large rocks which could block river flow and cause flooding; destabilise slopes or cause soil erosion to surrounding terrestrial areas;
- **Removal of habitat cover** – provide hibernacula of log piles, stone/rock piles for amphibians and other animals which might have been lost along with tree canopy cover;
- **Exposed ground** - plant native grass seed with fertilizer where exposed ground is still visible or where slopes are too steep or where soil has been washed away; and
- **Baseline monitoring** – although detrimental in general terms, the recent decimation of local habitats and ecosystems at least provides a clear baseline to develop a monitoring programme especially for forest recovery and the key animal groups that use it along with monitoring improvements of aquatic species in water courses.

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Appendix A. Critical Habitat Screening

A.1 Introduction

Under IFC Performance Standard 6 (PS6), habitats can be defined as Modified, Natural or Critical. Definitions of these habitats can be variable according to setting but are broadly defined as follows.

- **Modified Habitat:** Modified habitats are areas that may contain a large proportion of plant and/or animal species of non-native origin, and/or where human activity has substantially modified an area's primary ecological function and species composition. Modified habitats may include areas managed for agriculture, forest plantations, reclaimed coastal zones, and reclaimed wetlands.
- **Natural Habitat:** Natural habitats are areas composed of viable assemblages of plant and/or animal species of largely native origin, and/or where human activity has not essentially modified an area's primary ecological functions and species composition,
- **Critical Habitat:** Critical habitats are areas with high biodiversity value, including:
 - (i) habitat of significant importance to Critically Endangered and/or Endangered species;
 - (ii) habitat of significant importance to endemic and/or restricted-range species;
 - (iii) habitat supporting globally significant concentrations of migratory species and/or congregatory species;
 - (iv) highly threatened and/or unique ecosystems; and/or
 - (v) areas associated with key evolutionary processes.

A Critical Habitat Assessment determines whether or not Critical Habitat is present in the Project area and wider habitats, and thus what, if any, additional requirements are triggered as a result. Because of their greater importance for biodiversity and conservation, PS6 typically places additional constraints on the development that can take place, and the mitigation required, within areas of Critical habitat.

This Critical Habitat assessment considers species identified during desktop review and through baseline surveys as being IUCN Red List Threatened (that is, Vulnerable, Endangered or Critically Endangered) and potentially present in the Project area.

Available baseline information indicates that the Project area may support the Vulnerable red-necked parrot. A Critical Habitat screening process has therefore been undertaken, in line with the principles laid out in PS6 and the associated Guidance Note 6 (GN6).

A.2 Habitats within the Project Area

Based on the terrestrial ecology surveys and desk-based assessment undertaken to date and discussed in Section 2, the Project area comprises predominantly secondary rainforest and agricultural habitats.

Figure A1 below provides an overview of Modified and Natural habitats along the reinjection line, based on survey information and recent (2018) high-resolution orthophotography. The construction corridor along the reinjection line is 10 m wide (reduced to 3-4 m during operation), giving a total area of 4.0 ha. Of this, 2.3 ha (58%) is considered to be Modified Habitat and the remaining 1.7 ha (42%) is considered to be Natural Habitat. In addition, the entirety of the main power plant site is also Modified habitat (1.4 ha).



Figure A1 : Modified and Natural Habitat within the Project Area. Yellow shaded areas are Modified Habitats. Note that Modified Habitats have been captured more widely than the reinjection corridor. This is shown for context but not included in the calculations of habitat loss.

In line with PS6 Paragraph 15, in areas of Natural Habitat, mitigation is required to achieve no net loss of biodiversity where feasible, following the mitigation hierarchy. Mitigation for the loss of Natural Habitat is included within Section 4 in accordance with this requirement.

A.3 Criteria for Critical Habitat

Critical Habitat criteria are defined in IFC Guidance Note 6, paragraphs GN69 to GN97. Table A1 below summarises the Critical Habitat Criteria 1 to 5.

Table A1 : Critical Habitat Criteria

Criteria	Tier 1	Tier 2
Criterion 1: Critically Endangered (CR) / Endangered (EN) Species	<p>(a) Habitat required to sustain ≥ 10 percent of the global population of a CR or EN species/subspecies where there are known, regular occurrences of the species and where that habitat could be considered a discrete management unit for that species.</p> <p>(b) Habitat with known, regular occurrences of CR or EN species where that habitat is one of 10 or fewer discrete management sites globally for that species.</p>	<p>(c) Habitat that supports the regular occurrence of a single individual of a CR species and/or habitat containing regionally- important concentrations of a Red-listed EN species where that habitat could be considered a discrete management unit for that species/subspecies.</p> <p>(d) Habitat of significant importance to CR or EN species that are wide ranging and/or whose population distribution is not well understood and where the loss of such a habitat could potentially impact the long-term survivability of the species.</p>

Criteria	Tier 1	Tier 2
		(e) As appropriate, habitat containing nationally/regionally important concentrations of an EN, CR or equivalent national/regional listing.
Criterion 2: Habitat of Significant Importance to Endemic and / or Restricted-Range Species	(a) Habitat known to sustain ≥ 95 percent of the global population of an endemic or restricted-range species where that habitat could be considered a discrete management unit for that species (e.g., a single-site endemic).	(b) Habitat known to sustain ≥ 1 percent but < 95 percent of the global population of an endemic or restricted-range species where that habitat could be considered a discrete management unit for that species, where data are available and/or based on expert judgment.
Criterion 3: Habitat Supporting Globally Significant Concentration of Migratory Species and / or Congregatory Species	(a) Habitat known to sustain, on a cyclical or otherwise regular basis, ≥ 95 percent of the global population of a migratory or congregatory species at any point of the species' lifecycle where that habitat could be considered a discrete management unit for that species.	<p>(b) Habitat known to sustain, on a cyclical or otherwise regular basis, ≥ 1 percent but < 95 percent of the global population of a migratory or congregatory species at any point of the species' lifecycle and where that habitat could be considered a discrete management unit for that species, where adequate data are available and/or based on expert judgment.</p> <p>(c) For birds, habitat that meets BirdLife International's Criterion A4 for congregations and/or Ramsar Criteria 5 or 6 for Identifying Wetlands of International Importance.</p> <p>(d) For species with large but clumped distributions, a provisional threshold is set at ≥ 5 percent of the global population for both terrestrial and marine species.</p> <p>(e) Source sites that contribute ≥ 1 percent of the global population of recruits.</p>
Criterion 4: Highly Threatened and / or Unique Ecosystems	<p>Criterion 4 has no tiered system although recent publication (Keith et al, 2013) may introduce this. This criterion must include one of the following</p> <p>a) the ecosystem is at risk of significantly decreasing in area or quality;</p> <p>b) has a small spatial extent; and /or</p> <p>c) Contains unique assemblages of species including assemblages or concentrations of biome-restricted species. Highly threatened or unique ecosystems are defined by a combination of factors which may include long-term trend, rarity, ecological condition, and threat.</p>	
Criterion 5: Areas Associated with Key Evolutionary Processes	<p>The criterion is defined by:</p> <p>a) the physical features of a landscape that might be associated with particular evolutionary processes; and/or</p> <p>b) Sub-populations of species that are phylogenetically or morphogenetically distinct and may be of special conservation concern given their distinct evolutionary history. The latter includes evolutionarily significant units and evolutionarily distinct and globally endangered species.</p>	
<p>Notes:</p> <ul style="list-style-type: none"> No Tier system is in place for Criterion 4 and 5. 		

A.4 Discrete Management Unit

As part of the process of determining whether Critical Habitat is present, the IFC Performance Standard 6 Criteria 1-3 requires a project to determine the Discrete Management Unit (DMU), which is the area of habitat to be considered for the Critical Habitat assessment. The DMU should have a sensible and definable ecological or political boundary *'within which the biological communities and/or management issues have more in common with each other than they do with those in adjacent areas'*.

DMUs do not imply management control or responsibility by the Project, and often include areas outside of their control. The DMU also does not indicate Project footprint or impacted area, and in most cases is larger than either of these. This ensures impacts on biodiversity values in the larger landscape are adequately considered.

The delineation of the management unit depends on the species of concern. Available baseline information indicates that the Project area may support the IUCN Vulnerable red-necked parrot. The DMU is therefore defined for this species.

The red-necked parrot occurs primarily in rainforest canopies, but is known to visit coastal areas to search for food. It is increasingly observed on agricultural land, feeding on citrus, passion fruit and mango plantations. Breeding is between February and June, with nests usually situated in the cavities of large forest trees.

The IUCN reports the red-necked parrot's range as primarily the Morne Diablotin Massif (north central Dominica) with birds also occupying habitats in the far north, east, south-east and centre of the island, and including the MTPNP. It should be noted that information on the ecology of the bird dates prior to Hurricane Maria but these broad locations are likely to have remained unchanged.

The DMU has been defined as encompassing the MTPNP, the Project Area, and the adjoining areas of habitat. Figure A2 shows the MTPNP, the Project Area, and the range of the red-necked parrot within the southern part of Dominica, as identified by IUCN⁵. It should be noted that IUCN reports the area outwith the orange shaded area as "possibly extinct" for this species although the bird is understood to be extant in the Project area and its surroundings.



Figure A2: Relative locations of the MTPNP, the Project Area, and range of the red-necked parrot

Key: green star = project location; red outline = MTPNP; orange shading = red-necked parrot extant (resident); red/white shading = red-necked parrot possibly extinct based on IUCN mapping

Critical Habitat Candidate Species

Further information on the species has been sought through a desktop review of available literature. It should be noted that the available literature on the red-necked parrot is limited, and that information almost exclusively dates from prior to Hurricane Maria. Table A2 outlines the Critical Habitat triggers for Criterion 1 to 3 with respect to this species.

⁵ <http://maps.iucnredlist.org/map.html?id=22686395>

Table A2 : Critical Habitat triggers for Criteria 1 to 3: red-necked parrot

Species	Common Name	IUCN Listing	Criterion 1	Criterion 2	Criterion 3	Observation Type and Locations	Species Information	Criterion Rationale
<i>Amazona arausiaca</i>	red-necked parrot	V	N	N	N	Secondary evidence through baseline surveys.	<p>This species is endemic to Dominica. It has distinctive bright green plumage, and takes its name from the bright red feathers around its throat.</p> <p>Its numbers declined during the 20th century due historically to hunting and illegal trade, and more recently to clearance for agriculture, although when planted, the species may benefit from the fruit crops. Conservation action has helped this species recover from an all-time population low in 1980, with abundance increasing eight-fold, from c.150 to c.1200 (IUCN, 2017). Its numbers are however still low, and its range restricted to a single island.</p> <p>It occurs primarily in rainforest canopies up to 800 m and occasionally to 1200 m, but is also known to visit coastal areas to search for food. It is increasingly observed on agricultural land, feeding on citrus, passion fruit and mango plantations. Breeding is between February and June, with nests usually situated in the cavities of large forest trees.</p> <p>The IUCN reports the red-necked parrot's range as primarily the Morne Diablotin Massif (north central Dominica), with birds also occupying habitats in the far north, east, south-east and centre of the island, and including the MTPNP.</p> <p>During Hurricane Maria a number of birds were kept in captivity were held safe and wild birds have been sighted since the hurricane (American Bird Conservancy, 2018).</p>	<p>Criterion 1 requires the species to be CR or EN, which this species is not. It is possible that the species conservation status may have changed since Hurricane Maria, however early reports indicate that the species has survived relatively well.</p> <p>Criterion 2 relates to Habitat of Significant Importance to Endemic and / or Restricted-Range Species. The species has a restricted range on the basis of its number of locations and total population size. No sightings or other evidence of the species was made during surveys however the species is reported as known from the area and considered locally to be present in/around the project area. Desk study sources indicate its presence in the MTPNP. Given the greater quality and extent of habitat within the MTPNP it is likely that birds use the national park as primary habitat but may also pass through or feed within the Project area. The Project area is therefore not considered to sustain $\geq 95\%$ or $\geq 1\%$ but $< 95\%$ of the global population, and as such is not deemed to trigger Criteria 2.</p> <p>Criteria 3 requires the species to be migratory or congregatory, which this species is not.</p>

Critical Habitat Criterion 1 – 3

The results of the Critical Habitat Screening assessment as outlined in Table A2 above identified that no species trigger either Tier of Criteria 1 to 3.

Critical Habitat Criterion 4

PS6 describes this Criterion to be highly threatened or unique ecosystems including those:

- that are at risk of significantly decreasing in area or quality;
- with a small spatial extent; and
- containing unique assemblages of species including assemblages or concentrations of biome-restricted species.

Highly threatened or unique ecosystems are defined by a combination of factors which may include long-term trend, rarity, ecological condition, and threat. The habitats within the Project area and DMU do not fall within these criteria. The habitats such as secondary forest and agricultural land are common within the wider area and are not under threat. The assemblage of species is relatively poor in diversity and abundance within the Project area and DMU.

Critical Habitat Criterion 5

PS6 describes this Criterion as relating to:

- physical features of a landscape that might be associated with particular evolutionary processes; and/or
- subpopulations of species that are phylogenetically or morphogenetically distinct and may be of special conservation concern given their distinct evolutionary history.

There are no physical features within the Project area and DMUs that are known to be associated with evolutionary processes. The baseline surveys did not identify any species subpopulations known to be phylogenetically or morphogenetically distinct. As a result, it is determined that the Project area and DMUs is not important in the conservation of Key Evolutionary Processes.

A.5 Other Recognised High Biodiversity Values

Determination of Critical Habitat is not necessarily limited to the five criteria above. Other recognised high biodiversity values can also support a Critical Habitat designation, and should be considered on a case-by-case basis. A number of example high biodiversity values are set out in Table A3, together with a summary of whether these values are triggered by the Project. Shaded cells indicate that the value is, or may be, met.

Table A3 : IFC High Biodiversity Values

IFC High Biodiversity Values	Assessment
Areas required for the reintroduction of CR and EN species and refuge sites for these species (habitat used during periods of stress (e.g. flood, drought or fire)).	The Project area is mainly secondary rainforest and agricultural land. Whilst these may provide limited habitat of use to CR and EN species they are far poorer in extent and quality than the nearby MTPNP and not specifically required for reintroductions. Not met.
Ecosystems of known special significance to CR and EN species for climate adaptation purposes	The Project area is dominated by secondary rainforest and agricultural land and is not therefore considered of low value of significance for CR and EN species in respect of climate adaptation. Not met.
Concentrations of Vulnerable (VU) species in cases where there is uncertainty regarding the listing, and the actual status of the species may be EN or CR.	A single Vulnerable species, the red-necked parrot may be present in the Project area but is not thought to find core habitat there. Following Hurricane Maria, it is likely that the actual conservation status of the species is uncertain, although early evidence indicates the species is doing relatively well.

IFC High Biodiversity Values	Assessment
	It is considered that this does not constitute a concentration of Vulnerable species. Not met.
Areas of primary / old growth / pristine forests and/or other areas with especially high levels of species diversity.	The Project area contains remnants of old growth forest, though these are typically isolated and small. They do not however have especially high levels of species diversity. Not met.
Landscape and ecological processes (e.g. water catchments, area critical erosion control, disturbance regimes (e.g. fire, flood) required for maintaining critical habitat.	The Project area has a varied topography but does not support landscape and ecological processes stated. No Critical Habitat has been identified. Not met.
Habitat necessary for the survival of keystone species.	The Project area is mainly secondary rainforest and agricultural land and does not comprise habitat necessary for the survival of keystone species. Not met.
Areas of high scientific value such as those containing concentrations of species new and/or little known to science.	The Project area is mainly secondary rainforest and agricultural land and does not comprise an area of high scientific value. Not met.
Areas that meet the criteria of the IUCN's Protected Area Management Categories Ia, Ib and II, although areas that meet criteria for Management Categories III-VI may also qualify depending on the biodiversity values inherent to those sites.	The Project area is not within a IUCN Protected Area. Not met.
UNESCO Natural World Heritage Sites that are recognised for their Global Outstanding Value.	The site lies approximately 600 m from the UNESCO World Heritage Site, MTPNP. Not met.
The majority of Key Biodiversity Area (KBAs) which encompass <i>inter alia</i> Ramsar Sites, Important Bird Area (IBA), Important Plant Areas (IPA) and Alliance for Zero Extinction Sites (AZE).	The nearest KBA is the MTPNP World Heritage Site, approximately 600 m from the Project area. Not met.
Areas determined to be irreplaceable or of high priority / significance based on systematic conservation planning techniques carried out at the landscape and/or regional scale by governmental bodies, recognised academic institutions and/or other relevant qualified organisations (including internationally recognised NGOs)	The Project area has not been identified as irreplaceable or of high priority / significance for conservation. There are however moves to create a buffer zone around the MTPNP, located 600 m from the Project area. The extent of the proposed zone is unknown, though it is possible the buffer could potentially extend to this distance. Possibly met.
Areas identified by the client as High Conservation Value (HCV) using internationally recognised standards, where criteria used to designate such areas is consistent with the high biodiversity values listed in paragraph 16 of IFC Performance Standard 6.	Project area is predominantly secondary rainforest and agricultural land and is not identified by the client as a HCV area due to it not containing areas of outstanding or critical importance for biodiversity. Not met.

One High Biodiversity Value could possibly be met but is not considered sufficient to render the relevant habitats as being Critical.

A.6 Conclusion

The Critical Habitat Screening Assessment found that none of the Criteria for Critical Habitat are triggered for the red-necked parrot, and the High Biodiversity Values are insufficiently met to trigger Critical Habitat status.

The assessment identifies that 1.7 ha of Natural Habitat would be lost under the Project footprint, specifically the reinjection line corridor. A mitigation measure for a biodiversity offset is included within Section 4, in line with the PS6 requirement for No Net Loss within Natural Habitats.

Appendix I. Working Conditions, Occupational Health and Safety



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Dominica Geothermal Development – Environmental and Social Impact Assessment

Ministry of Foreign Affairs and Trade

Occupational Health and Safety and Working Conditions

RZ020300-0000-NP-RPT-0003-0015 | V2

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Appendix A. Grievance Form

1. Introduction

This Technical Report provides a high-level overview of the proposed labour and working conditions, and sets out a framework as to occupational health and safety systems and practices which will be implemented in the construction, operation and maintenance of the Project. It is anticipated that detailed labour, health and safety documents will be prepared by the EPC Contractor prior to commencement of project construction works and by Dominica Geothermal Development Company (DGDC) prior to commissioning the plant. These would cover hazard identification, safe work practices, emergency response plans, incident/accident management, auditing and review etc.

1.1 Structure of the Report

This Technical Report is structured as follows:

- Section 2 describes the relevant international and Dominica legislation and guidelines;
- Section 3 describes how the Project will comply legislation relating to labour and working conditions;
- Section 4 describes the worker's grievance mechanism;
- Section 5 gives an overview of the construction / operation Occupational, Health and Safety (OHS) Plans;
- Section 6 describes the site safety management and awareness measures; and
- Section 7 outlines the relevant reporting, reviewing and auditing procedures to be implemented on site.

2. Legislation and Guidelines

The following national and international legislation and guidelines are relevant to this report. Reference should also be made to the Volume 1 – Section 2: Policy, Legal and Administrative Framework.

2.1 World Bank Performance Standards for Private Sector Activities May 2013

The following national and international legislation and guidelines are relevant to this report. Reference should also be made to the Technical Report – Policy, Legal and Administrative Framework.

The World Bank Performance Standards (PSs) relevant to this report are as follows:

PS1: Assessment and Management of Environmental and Social Risks and Impacts:

- To identify and evaluate environmental and social risks and impacts of the project.
- To adopt a mitigation hierarchy to anticipate and avoid, or where avoidance is not possible, minimize, and, where residual impacts remain, compensate/offset for risks and impacts to workers, Affected Communities, and the environment.
- To promote improved environmental and social performance of clients through the effective use of management systems.
- To ensure that grievances from Affected Communities and external communications from other stakeholders are responded to and managed appropriately.
- To promote and provide means for adequate engagement with Affected Communities throughout the project cycle on issues that could potentially affect them and to ensure that relevant environmental and social information is disclosed and disseminated.

PS2: Labour and Working Conditions of the Equator Principles require the Project's proponent:

- To promote the fair treatment, non-discrimination, and equal opportunity of workers.
- To establish, maintain, and improve the worker-management relationship.
- To promote compliance with national employment and labour laws.
- 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.
- To promote safe and healthy working conditions, and the health of workers.
- To avoid the use of forced labour.

PS4: Community Health, Safety and Security:

- To avoid or minimise risks to and impacts on the health and safety of the local community during the Project life cycle.
- To ensure that the safeguarding of personnel and property avoids or minimises risks to the community's safety and security.

2.2 World Bank Environmental, Health and Safety (EHS) Guidelines

Occupational safety and health systems for the development will also need to be compliant with the requirements set out in the World Bank General Environmental, Health and Safety (EHS) Guidelines. The EHS Guidelines contain international performance levels and measures that are generally considered to be achievable in new facilities by existing technology at reasonable costs. They are designed and should be used together with the relevant industry sector guidelines. The most applicable EHS guidelines to this Project are:

- EHS General Environment, Health and Safety (EHS) General Guidelines (April 2007).
- EHS Guidelines Geothermal Power Generation (2007); and

- EHS Guidelines for Electric Power Transmission and Distribution (2007).

2.3 Dominica

Dominica legislation pertaining to Labour is made up of a number of Acts (Database of Labour Legislation, 2017). Acts relevant to occupational health and safety, working conditions and contracts of employment include the following:

- Accidents and Occupational Diseases (Notification) Act;
- Employment and Training Act;
- Employment Safety Act;
- Labour Standards Act and Labour Standards (Amendment) Act, 1991;
- Protection of Employment Act;
- Protection of Wages Act;
- Recruitment of Workers Act; and
- Trade Unions Act.

All activities conducted in relation to the Project shall comply with the laws and regulations of Dominica.

3. Labour and Working Conditions

3.1 Compliance with the Labour Code and WBG EHS Guidelines

The Project shall be constructed and operated in accordance with the laws and regulations pertaining to employment, human rights and worker rights in Dominica. As discussed in Section 2 above, it shall also abide by the policies of the WBG EHS Guidelines.

A Human Resources Policy to demonstrate compliance with Dominica Labour Legislation and WBG EHS Guidelines will be developed prior to commencement of any work by employees of either DGDC or the EPC Contractor on the Project. This policy shall be regularly reviewed as the Project progresses.

3.2 Contracts of Employment

All employees working on the Project shall have a mutually agreed Contract of Employment with their employer. This contract will include:

- Type of employment;
- Period of employment - working hours, working days and length of employment;
- Holidays – annual leave and public holidays;
- Duties and job title;
- Payment including overtime;
- Insurance;
- Procedures to deal with personal grievances; and
- Termination of employment.

In addition, the following will be a requirement of the EPC Contractor or DGDC in regards to labour and working conditions:

- Provision of information throughout the recruitment process on the employer's labour, health and safety policies;
- Assignment of tasks to employees that are consistent with their physical capacities and job skills ;
- Operation of programmes for employees' health management, including regular health checks; and
- Ongoing safety education and training as required to perform, supervise, and manage assigned tasks without mishap.

3.3 Health Checks

Regular health assessments of all staff at the site shall be carried out during the Project. Costs for these assessments shall be borne by the employer. An example of the type and frequency of health checks is provided in Table 3-1.

Table 3-1: Example Health Assessment Schedule

Type of Health Inspection	Personnel	Frequency	Comments
Pre-employment health check	Potential employees	Before signing of employment contracts	
Routine health inspection	All workers (including subcontractors)	Once a year	

Type of Health Inspection	Personnel	Frequency	Comments
Special health inspections	Workers who handle heavy metals and organic solvents	If requested	
	Workers exposed to noise/vibration, dust or harmful rays	If requested	Special tests where appropriate including lung function, sight and hearing, etc

As well as regular worker health assessments, occupational health monitoring will be conducted at the site. This includes:

- noise monitoring;
- electric and magnetic field monitoring; and
- occupational hygiene air quality monitoring.

3.4 Training

Training will be an important component of health and safety for both the construction and operation / maintenance of the power plant. All staff will receive appropriate health and safety training so they can undertake their work tasks in a safe manner. The level of health and safety training provided will depend on the health and safety hazards of each individual's work.

3.4.1 Induction Training

Health and safety induction training will be provided for all new Project employees prior to the commencement of their duties. The training will cover health and safety, familiarisation with the site and site-specific hazards. All new employees will be required to attend the safety induction course prior to receiving entry badges for authorisation to enter the project site.

Induction training will be conducted by the OHS Manager. It will be the responsibility of the DGDC and EPC Contractor to ensure all staff receives induction training.

The induction programme will cover the following:

- Site safety policy;
- Project safety objectives and behavioural based health and safety;
- Site safety rules;
- Work permit and security systems;
- Job safety analysis / risk assessment;
- Communicate HSSE roles and responsibilities of respective positions (e.g. managers, supervisors, HSSE personnel and workers);
- The site hazard labelling / signage system;
- Personal protective equipment (PPE);
- Hazards and accident reporting; and
- Emergency procedures.

Visitors to the site shall also attend a visitor orientation and control programme to ensure they do not enter hazardous areas unescorted.

3.4.2 Ongoing Health and Safety Training

As well as a site induction for new workers, ongoing health and safety training shall be provided by the DGDC or EPC Contractor. This will be sufficient to ensure that staff have the appropriate technical skills and safety awareness to perform their assigned jobs properly and safely. Staff involved in potentially hazardous tasks, e.g. working in hazardous areas, working at heights, working in confined spaces etc., where additional skills are needed, will be given specialised training as per the job requirement.

A proportion of employees will be required to attend additional training courses, such as basic industrial first aid or firefighting.

An example of the type and frequency of safety training is provided in Table 3-2. The DGDC or EPC Contractor may also provide further training as part of their internal requirements.

Table 3-2: Example Safety Training Requirements

Type of Training	Personnel	Frequency	Comments
Regular training	Site staff	2 hours/ month	Including subcontractors
Training by OHS Manger	Staff higher than foreman position	16 hours / year	Including subcontractors
Adaptation training	Staff whose work activity has changed	Dependent on activity	
Special training	Staff engaged in hazardous activities	Dependent on activity	
Basic fire fighting	All staff or not less than 40% of all people on site	Once a year	By a third party
Emergency drill	All staff or not less than 80% of all people on site	Once a year	

The level and type of safety training provided shall be documented in a Safety Training Register.

3.5 Discipline

Discipline of employees is addressed in Protection of Employment Act. Both the EPC Contractor and DGDC will be required to have discipline measures and procedures included within their Human Resource Policy.

3.6 Dispute Resolution

The Trade Unions Act provides details for the resolution of labour disputes. The Human Resource Policy will include procedures for dispute resolution, including details of external mediators.

4. Worker's Grievance Mechanism

4.1 Overview

A worker's grievance mechanism will be established as part of the Environmental and Social Management System (ESMS). This grievance mechanism will be designed to receive and facilitate resolution of concerns and grievances about the Project's working conditions and safety performance. It will be scaled to the risks and impacts of the Project and have workers as its primary user. It will seek to resolve concerns promptly, using an understandable and transparent consultative process that is culturally appropriate, readily accessible, at no cost, and without retribution to the party that originated the issue or concern. The mechanism should not impede access to judicial or administrative remedies. The Project Sponsors will inform the workers about the mechanism in the course of the workers engagement and induction process.

4.2 Proposed Grievance Mechanism

Site preparation, construction activities and the use of temporary worker accommodation pose potential risks to the health, safety, and security and therefore well-being of construction workers if not managed appropriately. Community health and safety risks associated with the use of temporary accommodation sites include those relating to sanitation, disease, cultural alienation and fire. Similarly, there are potentially negative occupational health and safety impacts related to personal accident or injury on any construction site. There are also potential adverse impacts on workers related to their terms of engagement and relationship with their employer.

The Project will establish a grievance mechanism for workers, which will include any concerns related to health and safety. Each affected person will be free to register a grievance, in accordance with procedures specified below. This mechanism covers any type of complaint, and includes three main steps:

- The registration of the complaint or dispute;
- The amicable resolution of the complaint; and
- Use of mediation if necessary.

Most of these issues can often be resolved by a good faith discussion with the complainant and may be resolved by additional communication (e.g. providing detailed information about the rights of the workers on the Project). However, some issues may only be able to be resolved through a formal legal process. Figure 4-1 shows the proposed complaints handling mechanism.

4.3 Recording of Complaints

The Project will use the following means to register complaint from workers:

- Provision of a dedicated phone number to provide information on the Project, and register complaints; and
- Provision of a comment box / complaints register in DGDC or the EPC Contractor's site offices once the construction has started. Workers will be able to lodge complaints using a Grievance Form (Appendix A). Any oral complaint given to the Health and Safety Office of DGDC or the EPC Contractor or will also be registered.

The existence of this register and access conditions will be widely disseminated to workers during induction activities.

Workers complaints relating to employment and health and safety issues of the Project will be recorded and kept in a communications / complaints log book and in a database. A quarterly report monitoring the complaints recorded will be generated for the attention of the management of DGDC or the EPC Contractor.

When a complaint is received, it must be recorded in the Grievance Mechanism and Complaints Form in Appendix B. The complaint should be recorded by the Health and Safety (HS) Manager and the Human Resources (HR) Manager, or other members of the Project Team receiving the complaint before being passed onto the HS Manager and the HR Manager to action. The HS Manager and the HR Manager will then follow up with the complainant directly to discuss options for a resolution.

All communications or complaints must be acknowledged by the HS Manager and the HR Manager within 5 business days and a response must be made to the complainant within 30 business days.

If the complaint is resolved internally, details of the complaint and resolution should be provided in the complaints form and filed. If the complaint cannot be resolved, the HS Manager and the HR Manager shall organise a mediation session with the local authority.

4.4 Mediation by Local Authorities

If the solution proposed by DGDC or the EPC Contractor is rejected by the complainant, and no amicable solution can be found, the issue will be transmitted to the Provincial People's Committees / Provincial Departments. All evidence and documentation will be transmitted, in order to allow the authorities to understand the issue at stake. The Provincial People's Committees / Provincial Departments will then hold a mediation session with the affected parties and relevant members of the Project Team in order to develop a solution. If the complainant is not satisfied with the solution, the matter must then be referred to the Judicial Courts.

4.5 Complaint Processing Time

All communications or complaints will be acknowledged within five business days and a response within 30 business days.

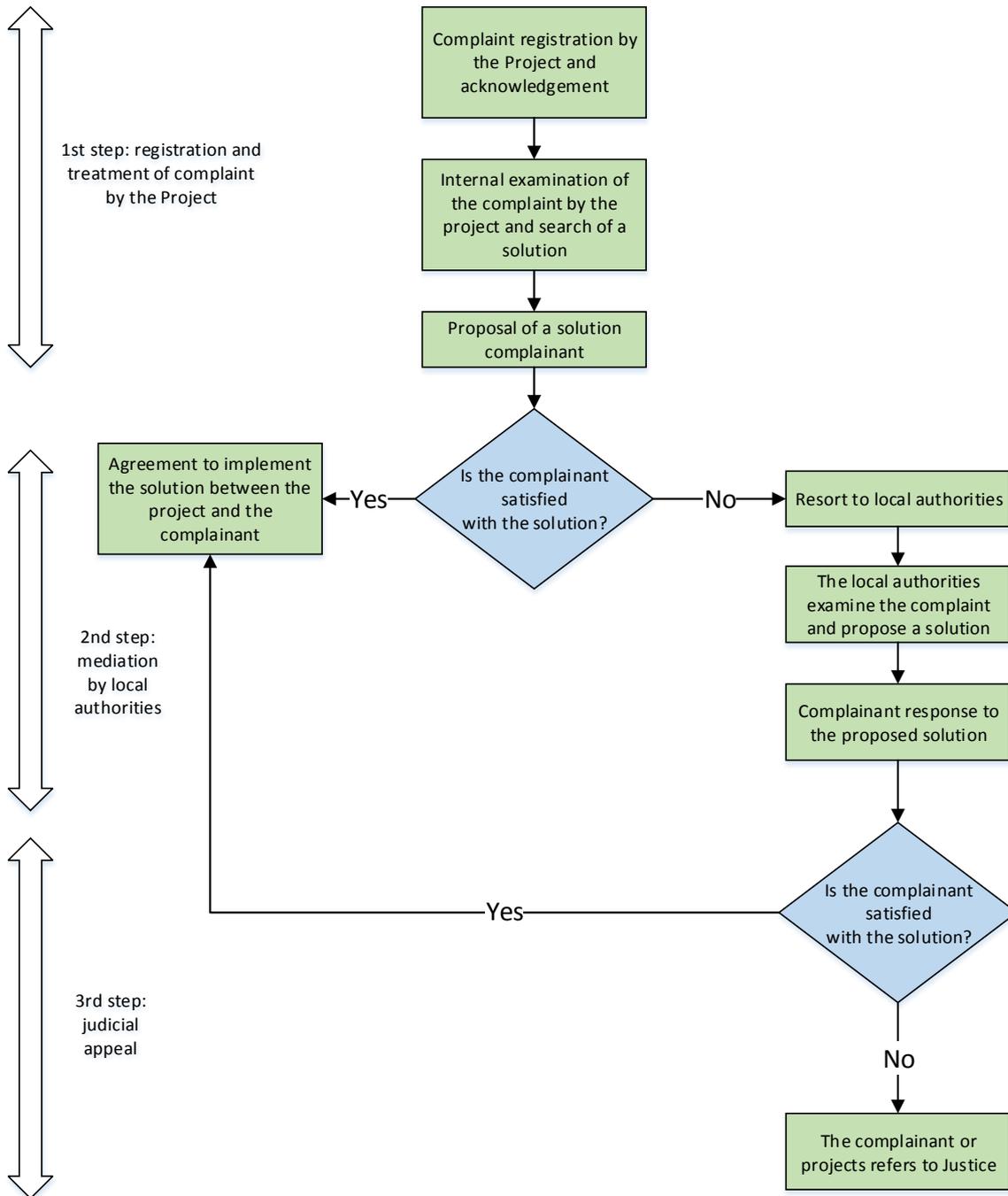


Figure 4-1: Grievance/ Complaints Handling Process

5. Overview of the Construction / Operation OHS Plans

The Employment Safety Act is the principal form of legislation pertaining to Occupational Health and Safety although specific Occupational Diseases are covered within the Accidents and Occupational Diseases (Notification) Act.

DGDC and the EPC Contractor will be required to develop OSH Plans for the construction and operation activities at the Project, which will apply to all personnel involved in the Project, including sub-contractors and part-time workers.

The primary health and safety objectives will be to ensure effective measures and management of occupational health and safety to minimise workplace accidents and injuries.

The health and safety procedures within the OHS Plans will be developed to form a comprehensive Health and Safety Management System. They will also meet the requirements specified in the WBG EHS Guidelines pertaining to occupational safety and health.

Set out in the following sections are the key elements of the site health and safety procedure to be included within the OHS Plans. This report provides a high level overview of health and safety considerations only, with further detail being provided in the final OHS Plans prepared by DGDC and EPC Contractor prior to commencement of onsite work.

5.1 Plan Requirements

The OHS Plans will outline the procedures essential for the protection of personnel during construction and operation. They will be designed to assist all those who deal with OHS as a functional responsibility within the context of their job.

Occupational health and safety performance should be evaluated against internationally published exposure guidelines, of which examples include:

- Threshold Limit Value (TLV) occupational exposure guidelines and Biological Exposure Indices (BEIs) published by American Conference of Governmental Industrial Hygienists (ACGIH) (various dates);
- Pocket Guide to Chemical Hazards published by the United States National Institute for Occupational Health and Safety (NIOSH) (2007);
- Permissible Exposure Limits (PELs) published by the Occupational Safety and Health Administration of the United States (OSHA) (various dates);
- Indicative Occupational Exposure Limit Values published by European Union member states (2017);
- or other similar sources.

In particular, they will include:

- Demonstration of compliance with Dominica Labour Legislation and World Bank EHS Construction related Occupational Health and Safety Guidelines (Section 1.2 of the WBG EHS Industry Guidelines – Geothermal Power Plants (2007) and Section 1.2 of the WBG EHS Guidelines – Electric Power Transmission and Distribution (2007)), including consideration of the following risk that are directly related to geothermal developments:
 - Geothermal gas exposure;
 - Confined Spaces;
 - Heat; and
 - Noise.
- OHS responsibility / reporting structure;

- Details of site inductions and ongoing training;
- Hazard identification and risk assessment;
- Mitigation measures including mandatory personal protection equipment (PPE);
- Safe working procedures and safety rules (includes permit-to-work procedures, working at height, etc)
- Response to health and safety incidents, including investigation and reporting;
- Emergency response plans;
- Reporting, auditing and record keeping systems;
- Scheduled OSH meetings; and
- Inspection and auditing procedures.

The key goal of the plans will be to instil a safety culture within the site employees through education, good communication, a motivated workforce, recognition of individual/team effort and safety incentive programmes.

The OSH Plans will be living documents that will be regularly updated throughout the life of the Project to ensure compliance with changes in regulation and industry practice.

5.2 Health and Safety Responsibilities

It is the responsibility of all individuals working within the Project to be aware of health and safety hazards. Health and safety should be encouraged by example, knowledge, skills, overall attitude, and involvement in the OHS Plans.

DGDC and the EPC Contractor will establish a hierarchy of responsibility with regards for the provision of health and safety. The precise titles and roles of each member will be determined by the DGDC and the EPC Contractor prior to work on the site; however, the following is an indicative list of personnel with specific OHS responsibilities:

- Construction / Operation Site Manager;
- OHS Manager;
- OHS Supervisors / Safety Officers;
- Work Supervisors;
- All Staff; and
- Visitors.

The OHS Plans will define the responsibilities of these personnel. These will include those who will enforce the OHS plans, the reporting lines for OHS management, discipline procedures for safety violations, etc. An example is given in Table 5-1.

Table 5-1: Example of Health and Safety Responsibility Hierarchy

Position	Responsibility
Construction / Operation Site Manager	Establishment of the OHS programme, ensuring that it meets the Owner's contractual requirements
OHS Manager	Head of emergency response Inspecting safety equipment, PPE and firefighting equipment, and taking action as required when equipment does not meet the required standard Choosing suitable products when purchasing protective equipment, hazardous machines, instruments and facilities Organising safety training

Position	Responsibility
	Instructing the site security team on their role Investigating the causes of accidents and ensuring the appropriate follow-up measures are undertaken Discipline of personnel who violate safety rules Maintaining OHS records and reporting to the Health and Safety Committee on a monthly basis and to the appropriate authorities when required Managing the medical care of patients who are injured in a workplace accident
OHS Supervisors / Safety Officers	Routine checking of equipment, facilities and instruments to identify hazards and ensure safe operation Training and instruction in the use of protective equipment Accident reporting on any incidents within their area of responsibility
Work Supervisors	Ensuring machinery / equipment is used by appropriately trained personnel in a safe manner Ensuring personnel working with / in hazardous substances or locations have the appropriate level of protection before work commences Ensuring appropriate permits-to-work have been obtained
All Staff and Visitors	Duty of care Identification and communication of hazards Compliance with instructions and the OHS Plans

In addition, any subcontractors appointed by the DGDC or the EPC Contractor will be required to submit their own OHS Plan, with an appropriate responsibility hierarchy, for approval prior to appointment.

A Health and Safety Committee will be formed, comprising members of senior management and any subcontractor's representatives. This committee will meet on a monthly basis to discuss labour, health and safety concerns.

6. Site Safety Management and Awareness

The following outlines the general safety measures to be applied during the construction, operation and maintenance of the Project.

6.1 Site Management Systems

As well as the main OSH Plans, specific procedures which will be contained in the Health and Safety Management Systems (HSMS) shall be developed for each element of the Project (construction and operation), including the following:

- Safety management organisation / reporting chain;
- Design safety and constructability program;
- Construction methodology;
- Hazard / risk assessment and proposed mitigation measures; and
- Safety checklists.

6.1.1 Hazard / Risk Assessment

The aim of the hazard and risk assessment is to limit the risks to life, prevent injury and property loss by identifying and mitigating the potential hazards posed during the various activities undertaken in the construction, operation and maintenance of the Project.

Each Safety Management System will have a procedure for identifying all hazards associated with the activity in question. A hazard in this context is defined as any aspect of the Project activities which could result in harm to onsite personnel. These may include some of the following:

- Non-ionizing radiation;
- Heat;
- Noise;
- Confined spaces;
- Electrical hazards;
- Fire and explosion hazards;
- Chemical hazards; and
- Dust.

Each hazard will then be assigned a risk level based on the likelihood and severity of the consequence of exposure using a matrix system, such as that provided in Table 2.1.1 of the WBG EHS General Guidelines: Occupational Health and Safety. Depending on the assigned level of risk appropriate mitigation measures will be proposed to eliminate, control or minimise the risks associated with each hazard. It shall be DGDC and the EPC Contractor's responsibility to ensure these measures are undertaken. The output from this hazard identification and risk assessment process will be a Hazard Register and a series of corrective actions required to implement the mitigation proposed to reduce the level of risk of a hazard to an acceptable level. The Hazards Register will be regularly reviewed and updated.

6.2 Personal Protective Equipment

All workers shall at a minimum wear safety shoes, safety helmets and safety glasses. Some personnel will require additional specialist PPE if exposed to specific hazards. An example of PPE requirements for specific tasks is set out in Table 6-1. Other tasks that are not included within this table may have further PPE requirements.

Table 6-1: Example of PPE Requirements

Work	Minimum Items to be Supplied
All workers	Safety helmet, safety shoes and safety glasses
Work at heights	Safety harness and rope
Work where oxygen deficiency is expected	Portable or supplied air (fixed lines) On-site rescue equipment
Work producing harmful gas	Facemasks with appropriate filters for air purification (chemicals, mists, vapours and gases) Single or multi-gas personal monitors
Electrical work	Live wire alarm Safety gloves
Work producing dust	Facemasks with appropriate filters for dust removal and air purification
Welding and grinding work	Face shield / welder goggles and earmuffs Protective clothing
Work producing noise greater than 85 dB over an 8 hour day or an instantaneous noise of greater than 140 dB	Earplugs / earmuffs
Work handling poison and toxic substances	Gloves, apron, splash suits, face shield or goggles
Harmful radiation such as X-rays	Protective glasses with side-shields Radioactive meter

6.3 Safe Work Rules and Procedures

The safe construction and operation of the site will be reliant on staff comprehending and obeying safety rules and restrictions. Because of this, the dissemination of safe work rules and procedures will be crucial.

Generic rules shall be provided within employment contracts and task specific procedures will be communicated during tool box talks and displayed on machinery or within hazardous work areas. An example of some basic safety rules include:

- All site safety signage shall be obeyed;
- No unauthorised staff shall enter restricted areas;
- No work shall be undertaken without prior instruction;
- No staff shall undertake work for which they have not received adequate training;
- No running or horseplay within the site;
- All staff shall use designated safe walkways and site entrances and exits;
- All staff shall wear provided personal protective equipment, which at a minimum shall include safety shoes, safety glasses and fastened safety helmets;
- Operating machinery shall not be left unattended; and
- Zero tolerance policy on alcohol or drugs in the work place.

In addition to rules, safe work procedures will be developed for operating equipment and work around machinery. These are likely to include the following (not a comprehensive list):

- Fire prevention;
- Jjob site safety inspection;
- Transportation;
- Excavations, trenching and shoring;

- Asbestos and other fibres;
- Welding, cutting and brazing;
- Piling operations;
- Work place ladders and scaffolding;
- Hand tools and power tools;
- Paints and coatings;
- Concrete forms and shorings;
- Crane and lifting equipment;
- Slings and lifting gear (rigging);
- Mechanical equipment;
- Material handling;
- Electricity;
- Ionizing radiation;
- Liquefied petroleum gases; and
- Chemicals.

A comprehensive catalogue of safe work procedures shall be developed as part of the OHS Plans and Safety Management Systems.

Compliance with safe work rules and procedures will be an important facet of the employment contracts between Project employers and employees and failure to comply will result in disciplinary action.

6.4 Permits to Work

All hazardous work shall be completed in accordance with a Permit-to-Work System which will require the completion of a permit-to-work form and approval by the OHS Manager prior to commencement. Hazardous work is likely to include the following (not a comprehensive list):

- Work with or near hazardous substances;
- Welding and cutting of containers and pipes where explosives or inflammables may remain;
- Work in confined spaces where toxic gases may be present;
- Work at heights;
- Installing and repairing hazardous equipment;
- Work with live electrical systems; and
- Radioactive work.

6.5 Site Safety Facilities

The facilities provided at the site shall be to a level that allows health and safety standards to be maintained. These shall include:

- Provision of first-aid equipment and stations;
- An onsite medical facility including trained medical staff;
- Clean eating areas;
- Sanitary facilities;
- Safe access to work and communal areas;

- Sufficient air supply in indoors work areas;
- Emergency response equipment; and
- Appropriate labelling / signage of equipment and hazards.

6.6 Meetings

It is imperative that health and safety messages are communicated so that all staff are aware of their responsibilities.

6.6.1 Daily Tool Box Talks

Daily 5-10 minute meetings shall be conducted by Site Supervisors before commencing work to publicize and emphasize safety and health procedures relevant to the nature and location of work taking place on that day. Where work permits are required, the Site Supervisor will use this time to ensure that personnel involved are fully aware of all limitations and restrictions, safety requirements, and job execution details. This will ensure that all personnel working at the site are aware of hazards and controls required at the start of each day's work.

6.6.2 Weekly OHS Meetings

Weekly OHS meetings shall be conducted by the OHS Manager. The purpose of these meetings will be to:

- Provide a regular update of safety alerts;
- Review all incident reports and make recommendations;
- Review tool box meeting minutes/topics;
- Review weekly inspections/audits; and
- Provide an opportunity for staff to raise health and safety concerns.

6.6.3 Safety and Health Management Committee

The Construction Site Manager and the Operation Site Manager shall appoint a Health and Safety Management Committee, which will include members of subcontractor organisations. The Committee shall meet every month to undertake a joint safety check. The Committee shall review the following:

- Summary of current health and safety issues;
- Evaluation of the state of health and safety controls at the site;
- Evaluation of the communication of health and safety messages to staff;
- Assessment of any health and safety incidents (especially lost time incidents);
- Recommended changes to equipment, policy and / or procedure as a result of injury, damage or failure;
- Recognition of health and safety success and failures; and
- Any other matters raised as necessary for the management of health and safety.

These meetings will provide an on-going forum for managing health and safety at the site and reacting to changing conditions and work activities. The outputs from these meetings will be a monthly report, which will be provided to the local labour authority.

6.7 Monitoring and Inspections

The OHS Plans and Health and Safety Management Systems will include a schedule of regular safety inspections and monitoring of exposure to hazards. This will include the state of the site as well as the maintenance of equipment and a comparison to internationally published exposure guidelines. Table 6-2 sets out an example schedule for conducting safety checks and inspections.

Table 6-2: Example of Inspections and Monitoring Schedule

Description	Site Area	Frequency	Inspector	Focus
Safety patrol	All the areas in the construction site	Every day	Work Supervisors	Filling out the safety check form
Weekly check	Work place hazards and construction equipment / machinery	Weekly	OSH Safety Manager	Hazards / defects in equipment
Maintenance checks	Hazardous machines, facilities and tools	More than once in every quarter or as given in supplier's specifications	Specialist	Safety of machinery / tools
Noise levels	Where exposure to noise is likely to occur	upon commencement then twice a year if there is not a problem or at a frequency as determined by the hazard assessment.	Specialist	Compliance with threshold values**
Electric and magnetic field monitoring	Where exposure to electric and magnetic fields is likely to occur	upon commencement then twice a year if there is not a problem or at a frequency as determined by the hazard assessment	Specialist	Compliance with threshold values*
Occupational air quality monitoring	Where exposure to hazardous air emissions is likely to occur	upon commencement then twice a year if there is not a problem or at a frequency as determined by the hazard assessment	Specialist	Compliance with threshold values**

*As given in the WBG's Environmental, Health, and Safety Guidelines: Thermal Power Plants

**As given in the WBG's General Environmental, Health, and Safety Guidelines: Occupational Health and Safety

The Site Manager shall instigate measures to correct non-conformance in safety performance found during safety checks and inspections. A record of the safety checks and inspections, and resulting actions, shall be provided to the Health and Safety Management Committee every month.

6.8 Security Procedures

A security procedure shall be included within the OHS Plan and HSMS. The document shall cover the following issues:

- Areas of security control;
- Working hours;
- Prohibited articles / activities on the site;
- Duties of security staff;
- Entry and exit from the site; and
- Application, issue and display of security passes (including vehicle passes).

The security procedures will be communicated to all site personnel as part of their induction training. It will outline the duties, tasks and responsibilities of employees working on the Project. It will also provide actions in the event of an identified security breach.

6.9 Emergency Response Procedures

Emergency Response Procedures will form an integral part of the OHS Plans and HSMS. As part of these, an Emergency Response Plan shall be prepared to address emergencies of all scales, such as:

- Small incidents such as minor spillages or individual incidents resulting in minor harm;

- Large incidents major spillages or failure of control equipment that could result in offsite impacts or severe injuries or even fatalities;
- Natural disasters such as tsunami or an earthquake;
- Fires or explosions; or
- Release of toxic gases or substances.

This plan will include responsible personnel in the event of an accident / incident or emergency, procedures to be followed, a site evacuation plan and contact details of emergency response facilities.

DGDC and the EPC Contractor shall also co-ordinate and provide training for a disaster action team.

The site shall at all times have adequate and functioning firefighting facilities. The Safety Manager shall conduct regular training for workers on how to use firefighting equipment safely.

Accident / incident and disaster reporting requirements will also be detailed in the Emergency Response Plan.

6.10 Accident /Incident Reporting and Investigation

All employees, contractors and visitors will be required to report any incidents that occur, including fire, explosion, natural disaster, equipment failure, plant, vehicle or other accident, other incidents or near misses during the construction and operation of the power plant. Procedures will be developed by the construction contractor and the plant operator for the reporting, investigating of all accidents and incidents that as a minimum result in first aid treatment or are deemed to be a near miss which for other reason could have resulted in an accident that caused significant injury or even a fatality.

The procedures will cover:

- Responsibilities for employees, site supervisors, and managers for notifying the incident/accident, investigating and reporting on the incident/accident and for implementing any recommended corrective actions as a result of the incident/accident investigation.
- All incidents, including near misses to personnel, plant and equipment damage must be reported to the person's immediate supervisor or foreperson.
- How the incident (lost time accident (LTA), no lost time accident (NLTA) or near miss) is recorded in the site's Accident Register and who is required to complete the initial sections of the Incident Investigation Report Form.
- Who should undertake the incident investigation and the information that shall be recorded on the Incident Investigation Report Form including all recommendations including improvements, work practice changes, disciplinary actions, etc.
- Procedures for notifying incidents/accidents to government and provincial agencies, including the time period allowed for reporting such incidents.
- How corrective actions as a result of the incident/accident investigation are implemented and the Hazards Register is amended.

7. Reporting, Reviews and Audits

7.1 Reporting to the Local Labour Authority

DGDC and the EPC Contractor shall establish contact with the local labour authority to determine the appropriate reporting channels. Once construction has commenced the following shall be communicated:

7.1.1 Bi-annual Reports

The output of the Health and Safety Management Committee's meeting will be a bi-annual report provided to the local labour authority. This will summarise the actions undertaken as the result of onsite meetings, any current health and safety issues and an evaluation of the current state of health and safety at the site.

7.1.2 Labour Disputes and Dismissals

If any issues are raised by either employers or employees relating to labour or working conditions, such as contravention of site rules or contractual disputes, these shall in the first instance be dealt with as outlined in the site Human Resource Policy. Where a disciplinary action results in a dismissal or contractual mediation is required this shall be reported immediately to the local labour authority.

7.1.3 Notification of Accidents/Incidents

All accidents and incidents which result in first aid treatment during the construction and operation of the power plant shall be reported via the appropriate channels to the Health and Safety Management Committee. Minor incidents along with the incident/accident investigation report shall be supplied to the local labour authority along with the monthly report. Serious accidents that result in serious harm or a fatality should be reported immediately to the local labour authority.

7.2 Management Review

This report outlines the requirement for a number of site documents and procedures, including a Human Resource Policy, OHS Plan, Health and Safety Management System, Hazard Register and Emergency Action Plan. As discussed previously these should be all be 'living' documents and procedures in that they should be regularly reviewed and updated when required.

Together, they comprise the site labour, occupational safety and health system. This should be overhauled on at least an annual basis to ensure it is inclusive of new guidelines and legislation and that the existing systems are working as required. The Construction / Operation Site Manager shall be responsible for ensuring this is undertaken.

7.3 External Auditing of Health and Safety Systems

Independent audits of the Construction and Operation OHS Plans shall be undertaken by an appropriately qualified person to ensure compliance with Dominica Labour Legislation and World Bank EHS Guidelines. In addition, onsite audits shall be conducted on a timeframe specified within the plans to ensure the health and safety practices are compliant.

If unsafe practices are identified during the audits, immediate cessation of the work shall ensue until the situation has been remedied to an acceptable level. Corrective actions will be documented and provided to the Health and Safety Management Committee.

The accident and fatality rates of the Project shall be benchmarked against the performance of other facilities in this sector in developing countries through consultation with published sources.

8. Conclusions

The report demonstrates that the development will meet the requirements of the World Bank EHS Construction related Occupational Health and Safety Guidelines and that the proposed occupational health and safety systems for each stage will meet good international industry practice. The EHS Guidelines contain the performance levels and measures that are generally considered to be achievable in new facilities by existing technology at reasonable costs.

Appendix A. Grievance Form

GRIEVANCE REGISTRATION		
Date:	Filled by:	
Plaintiff's name :	Plaintiff's gender: M / F	Plaintiff occupation:
Plaintiff's contact (address, tel. number):		
<input type="checkbox"/> The plaintiff is filling an individual complain		
<input type="checkbox"/> The plaintiff is representing an individual or group of workers		
- Name of the individual or group of worker: - Nature of the individual or group of workers: - Location/address:		
Description of the grievance:		
GRIEVANCE TREATMENT		
Date of the response:	Filled by:	
Proposed action(s) to remedy to the grievance:		
Plaintiff's acceptance of the proposed action:		
GRIEVANCE CLOSURE		
Date of grievance closure:	Filled by:	
Ending of the grievance treatment:		

Appendix J. Stakeholder Engagement – Meeting Minutes



COMMONWEALTH OF DOMINICA

**MINISTRY OF PUBLIC WORKS, ENERGY AND PORTS
GEOTHERMAL PROJECT MANAGEMENT UNIT**

Tel: (767) 266 3616/7/8 266 3298
Fax: (767) 448 0182
E-mail: geothermal@dominica.gov.dm

3rd Floor, Government Headquarters
Kennedy Avenue
Roseau
Commonwealth of Dominica

FROM: Project Officer / Geothermal Project Management Unit
TO: Permanent Secretary/ Ministry of Public Works, Energy & Ports
DATE: January 25, 2014
SUBJECT: Community Meeting – Project Update - Laudat

A community meeting was held on Thursday January 23, 2014 at the Laudat Primary School to inform residents of the Roseau Valley and more specifically those of Laudat of the on-going drilling activities.

In attendance were:

Hon. Dr. John Collin McIntyre: Parliamentary Representative for the Roseau Valley
Alexis George: GPMU
Clarence Reems/ Verrette Sampson: Drilling Supervisors, GRG.
Annette Mortensen: Geologist, ISOR
Mandela Christian: Office of Disaster Management
Aaron Rolle: Community Liason Officer
Members of the Laudat Improvement Committee
Residents of Laudat and neighbouring communities (approximately 60)
Quick Links Productions: Provided video coverage

The GPMU representative gave welcome remarks and acknowledged the presence of the Parliamentary Representative and the team from GRG and ISOR.

Mr. George delivered a brief power point presentation of the status of drilling activities. The floor was then opened for question and answer session.

Questions and comments included the following:

- In case of emergency what has been put in place for the residents? There should be information placed on notice boards, leaflets, brochures, to indicate what is to be done in the event of an emergency.
- What are the direct benefits of the project to the communities of the Roseau Valley and to the country?
- Why haven't the land owners been compensated for use of their land from the exploratory phase to date? That confirms the level of disrespect shown to land owners.
- Has the EIA's been made available to the public? Is so where can it be accessed?
- What about the health risk/ hazards? Will the residents be provided with masks?
- What about the persons who don't attend the meetings, how are they informed and kept up to date as to what's going on? There is need to improve on the public relations and dissemination of information.

- Concerns related to the environment: who performed the EIA's? Who were the persons surveyed in the Roseau Valley that is mentioned in the EIA? We believe the drilling activity is negatively affecting the tourist/ visitor experience due to the noise etc. and the whole idea of being in the natural environment.
 - Is GoCD concerned about the state of the Rain Forest Aerial Tram?
 - Will the land owners be compensated fairly and in a timely manner if their land is acquired?
 - In 1949 CDC purchased land in Laudat for the Hydro Project and land owners received payment before any work was undertaken on the ground; can we expect the same for the Geothermal Project?
 - If directional drilling is targeted towards the Valley of desolation or Boiling Lake, Will these areas be monitored during the Well Testing Activities?
 - Will the GoCD consider that residents receive some compensation for every KW of electricity generated or get special concessions or reductions on their electricity bills?
 - Where do we go from here? We need adequate responses to our questions/ concerns at the next community meeting.
-
- The EIA is very technical; we need a better understanding of it.
 - The Permanent Secretary and Minister for PWEF as well as the Prime Minister should attend the meetings.
 - Signage should be placed along the route to the site highlighting that there is drilling activity on-going. Residents living in close proximity to the site should be made more aware and there is need to perform a simulation exercise in the event of an emergency situation.
 - The Health Centre is not adequately supplied.
 - The Village Improvement Committee is not providing adequate representation to the community of Laudat.
 - GoCD needs to look at an alternate exit route for Laudat.
 - In the event that there is an emergency on site there should be a system put in place that will automatically inform the Police, Fire and Ambulance Service and for the residents, text messages (through LIME/ DIGICEL) could be sent to alert them.
 - Banks will not guarantee loans to persons whose property is in close proximity to existing drill sites or within the geothermal project area. ***Flagged***
 - In respect to the cost to land owners in terms of not being able to fully develop their properties in one way or another because of the uncertainty that exists whether their property will be acquired or not; can a fund be set up for the affected land owners for that purpose.
 - Two residents (Mary Ralph and Mr. Magloire) complained of irritation to the nose and throat since drilling commenced.
 - Residents would like a meeting to be held with the Policy makers but would like to receive a written proposal of the developmental plans of the project and the effect on land owners/ residents before said meeting.

Submitted for your information.

Alexis V. George
Project Officer, GPMU



COMMONWEALTH OF DOMINICA

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3rd Floor, Government Headquarters
Kennedy Avenue
Roseau
Commonwealth of Dominica

FROM: Project Officer / Geothermal Project Management Unit
TO: Permanent Secretary/ Ministry of Public Works, Energy & Ports
DATE: January 8, 2013
SUBJECT: Summary of Meetings held by the PMU in the Roseau Valley

Below is a summary of Meetings held by the Geothermal Project Management Unit in the Roseau Valley.

Wotten Waven

January 16, 2011 5:30 pm
November 10, 2011 6:00pm
June 13, 2012 5:30 pm

Trafalgar

January 12, 2011 7:00pm
November 8, 2011 6pm
March 28, 2012 6pm

Laudat

January 20, 2011 6:30 pm
November 11, 2011 7:00pm
February 15, 2012 7:00pm
April 13, 2012 7:00 pm
April 16, 2012 7:00 pm

Drilling Environmental Impact Assessment (EIA)

- Contractor: Caraibes Environnement (Guadeloupe)
- Funding Agency: ADEME
- Work commenced on island: March 2011 (Hydrobiology and Landscape studies)
- First draft submitted: July 28, 2011
- Second Draft submitted: December 2011
- Final version submitted: January 22, 2012 (endorsed by ADEME)

Visit to Schools in Roseau Valley (presentation of project and distribution of promotional items to students and staff)

- Wotten Waven Primary School: February 8, 2012
- Trafalgar Primary School: February 16, 2012
- Morne Prosper Primary School: February 8, 2012
- Laudat Primary School: March 8, 2012

Site Visit – Laudat Primary School

The Laudat Primary School visited Site WW-3 during drilling operations on March 7, 2012. The students and staff got a tour of the site and were to

.....
Geothermal PMU



DRAFT

Report on Community Consultations

Report on Community Consultation

Laudat Community at Laudat Primary School 29 June 2017 – 7pm

Introduction

This report is to inform on the community consultation as recommended in the Stakeholder Engagement Plan for the Dominica Geothermal Project. One of the main objectives of the consultation is to have open comprehensive engagement activities to build trust, encourage participation and facilitate community understanding of the project. During the consultation, an update was given as to the current state of the project and any planned activities

The objective of this report is to provide information three areas.

1. Attendance
2. Concerns about the project
3. Expectations



Dr Vince Henderson addressing members of the Laudat community

Attendance

MP Dr John Collin McIntyre

MP Ian Douglas

Ambassador Dr Vince Henderson

Members of the Board of DGDC

Project Manager – Mark Tomkins

Employees of DGDC

World Bank team

Jacobs team

IRC – Francis Paul, Glenn Khan

Members of the community of Laudat

Concerns

Will the re-injection pipeline pass through the village?

Noise level and effect on the community

When and how will Payment for property be made if acquired?

What is meant by market value for land?

During Hydro expansion lands were acquired no payment to date.

How is the community going to benefit, medical, education, sports?

Will shares be available for purchase?

Jacobs Engineering

- Global engineering firm with >70,000 staff
- World leader in geothermal energy with 100 geothermal staff in New Zealand:
 - ✓ **Resource:** geoscience, reservoir engineering
 - ✓ **Drilling services:** Well design, supervision, contracts
 - ✓ **Engineering:** Concept & detailed design
 - ✓ **Project delivery:** Manage delivery
 - ✓ **Environmental studies:** baseline, ESIA, consenting
 - ✓ **Studies & DD:** Feasibility studies, lenders advisory
- Been involved with >50% of global installed geothermal generation - NZ , SE Asia, Central & America, Africa, Europe

06/29/2017 19:55
JACOBS

5



Dorney addressing Laudat community

**Geothermal Power Plant Development Project
Presentation to Community leaders of The Roseau Valley
Wednesday December 14 2016
Time: 5:30 PM**

Attendance List

N o	Name	Organisation	Contact Info
1	Jeffery Charles		jeffery1269@gmail.com/2857347
2	Glenn Khan	IRC- Executive Director	
3	Garry Shillingford	Community Liaison Officer - MTEE	
4	Alfred Rolle		
5	Hon.Dr Collin Intyre	Parliamentary Representative	
6	Dr. Vince Henderson	Ambassador to United States & OAS	
7	Alaistair Brookes	Jacobs	
8	Peter Gabriel	Jacobs	
9	David Wenstrup	Clean Infra Partners	
10	Edward Lambert	Special Advisor	
11	Joan & Algenon Ducreay	Petit Paradise	lpetitparadise20@hotmail.com ; 2762761/4404352
12	Janet Taylor		440 3118
13	Lilian Xavier	Trafalgar Vendors Association	sexylily71@hotmail.com ; 617 3996
14	Government Information Service		
15	Electrical Division		
16	Michael Fadelle	Renewable Energy Coordinator - MTEE	
17	Ernest Fontaine	Da-Scape	616 6800
18	Francis Paul	IRC Commissioner	
19	Alexis George	Ministry of Public Works	
20	Daniel Fadelle		
21	Esther Lambert		
22	Bernadette Lambert	IRC - Chairperson	2959590
23	Marilyn Cuffy-Morris		276 2689
24	Nahgie Laflout		nahjielaflout@hotmail.com ; 245 4328
25	Atherton Martin		athiemartin@gmail.com ; 2761878
26	Bernicia Allan	Trafalgar Village Council	berniciakallan@gmail.com ; 2767029/6174768

27	Anne Jno Baptiste	Papillote Wilderness Retreat	
28	Patricia Rolle		
29	Bertillia McKenzie	DOMLEC - GM	
30	Ellise Darwton	DOMLEC	
31	Dave Stamp	DOMLEC	
32	Fitzroy Jones	DOMLEC/ Land Owner	
33	Charles McClean	DOMLEC	2658640
34	Claudette Rolle	Community Leader – Fresh water Lake facility	
35	Kelvin Rolle	Chief Physical Planner	
36	Rudolph George	Wotten Waven Improvement Committee	
37	Sylvanie Burton	Permanent Secretary - MTEE	
38	Justinn Kase	IRC	
39	Elizabeth Hill	IRC-Commissioner	
40	Eisenhower Douglas	IRC-Commissioner	
41	Gregor Nassief	DHTA	
42	Helene Rolle	Tourism Stakeholder	

Meeting was called to order by Mr. Edward Lambert at 5:53 pm with a prayer.

Members of the head table:

Ambassador Henderson, Hon Dr. McIntyre, Mr. Lambert, David Wenstrup, Alastair Brookes, Peter Gabriel.

Ambassador Henderson moderated the meeting.

Questions to panel after presentations:

1. What are the plans for resettlement & compensation?
2. Is Jacobs going to be a shareholder in the Company?
3. What size plant did Kenya start with?
4. How many people work in Geothermal Unit?
5. What is the cost of administration for the Geothermal Unit?
6. The wells in the Roseau Valley have been capped for how long?
7. How much has been spent to maintain them?
8. Why isn't the government interested in transmission instead of generating and selling to DOMLEC?
9. The people of Laudat have been unfairly treated in the past and had crimes worse than slavery committed against them. There are delicate property issues in Laudat. Are there any plans to take care of them?

10. Geographic Area covered by the EIA – a French group has done a baseline assessment where the Roseau Valley has been redefined to include the City- is the city to be included in the scope of works for this ESIA?
11. An ESIA could reveal information which says that the project should not go forward YET project seems to be a fait accompli. The RE policy in existence for Dominica speaks to simultaneous effort at developing at least two or three RE projects, not just geothermal. TS Erika has taught us that an entire geographical area can be compromised. Is there a plan B? What is the plan B.? Note that all other areas spoken of in the presentations are huge countries and it is a matter of scale.
12. Will electricity bills decrease as a result of this initiative?





Geothermal Power Plant Development Project Presentation to Community Leaders

Wotten Waven Community Centre

December 14, 2016, from 5.30 p.m.

Draft Agenda

Chair: Ambassador Edward Lambert

5.30 p.m. **Welcome and Opening Remarks** - Hon. Dr. John Collin McIntyre, Parliamentary Representative

5.45 p.m. **Summary of Government Policy, and Purpose of the meeting** – Hon Douglas, Minister for Energy

6.00 p.m. **Overview of project roles and different parties** - Mrs. Sylvanie Burton, Permanent Secretary, Ministry of Trade, Energy and Employment

6.15 p.m. **Overview of project development to date, timelines, interaction of commercial/financial, technical considerations** – Mr. Alastair Brookes, Caribbean Geothermal Advisor, Contracted by New Zealand Aid

6.45 p.m. **Overview of the Environmental and Social Impact Assessment process** – Mr. Pete Gabriel, Environmental Consultant, Jacobs New Zealand Ltd.

7.30 p.m. **Questions and answer**

Vote of Thanks - community member (Wotten Waven??)

Refreshments

Report on Community Consultations

Focus Group Accommodation

Papillote Wilderness Retreat 30 June 2017 – 6:30 pm

Attendance

DGDC Staff

Lyn Fontenelle

Justen Kasey

Allan Toussaint

Jacobs

Dorney Burgdorf

Accommodation

Chez Ophelia – Mark Marie

Rocky Mountain Lodge – Emmanuel Rock

Papillote Wilderness Retreat – Ann Jno Baptiste

Concerns

What will be the total Cost of the project?

What will be the effect of Geothermal Plant, if shut down, on National grid?

Was consideration given for a bank of batteries to store excess energy?

Is there a plan for worst case scenario?

When will shares be available for purchase?

Why not solar? – Less intrusive

Why was this type of Consultation not done before decision was made to drill?

Why did trees close to balancing tank turn brown?

What will be noise level?

What will be the visual impact?

Will there be a social development fund for education and health?

Considering that risks and exposure will be borne by residents, should they have special benefits?

Examples of benefits – Low or no electricity bills, State of the art recording studio

What metal will be used for plant? - concerns of corrosive atmosphere

One member of the group is totally against the project because of negative effects

Very concerned on negative impact on Tourism any activity in the Roseau valley will affect Tourism

Expectations

Hope to see at least 50% reduction in Electricity bills

More consultation in the future

Increased use of their services during the project

Focus Group Watton Waven Vendors

Wotton Waven Community Centre 12 July 2017 – 6:30pm

Attendance

Firstly, Members of the DGDC in attendance at that consultation were,

Justinn Kase

Lyn John Fontenelle

Garry Shillingford

Allan Toussaint

Vendors from the Wotton Waven community were also in attendance

Edrice George

Minovia Joseph

Flavia Damier

Pamela Sampson

Julian George

Nastia George

Gloria Damier

Helen Sergeant

Catherine Joseph

Mr. Justin Kasen and Lyn Fontenelle gave a short overview and current state of the project. The involvement of stakeholders like Jacobs and the world bank was shared and the reasons and importance of the meeting was expressed.

Concerns

Secondly, the vendors were allowed to freely state their concerns with the project. Most of their concerns were in the form of questions as listed below:

What happen if the reinjection pipe has a leak and dangerous fluids are flowing on the surface?

What impact will the project have on our vending business in terms of the volume of traffic, time of transporting (Tourist season)?

How long will the project take to complete?

Will the area where vendors are located be acquired for reinjection pipeline?

Will there be fumes, dust and noise affecting our business?

If you have to transfer vendors where will be the new location?

Will we be allowed to vend during construction of Reinjection pipeline?

What size pipes will be transported to the community?

When is the project due to start in our community?

Concern from Melo (rastaman)

I believe if we are impacted we will not be compensated, we have not been regarded. I am in favour of the project but afraid of the impact as far as impact on Tourism is concerned. We will get less Tourist or no Tourist.

Expectations

Finally, the vendors were asked about expectations of the project. Generally, the most common expectation of the project was lower electricity bills. Most see the production of power for local consumption using the geothermal resource should mean using a lot less diesel for power production. As a result, it is expected that the fuel surcharge component on their electricity bill will be drastically reduced or even disappear. Additionally, they expect jobs to be made available to residents during the construction and production phase.

Conclusion

All members of the DGDC were involved in assisting vendors in completing the questionnaires

The consultation was positive and informative. However, consideration must be given to producing an animation of how the production of electricity using geothermal really works. This will help our stakeholders better understand the process. A second animation depicting the power station site and the reinjection site with a view of what is happening below the surface of the earth will answer a lot of questions, particularly how geothermal is renewable. It is apparent from constant interaction with community members that they find it difficult to imagine how the reinjected fluid will find its way back to the production well.

Trafalgar Vendors

Trafalgar Tourism Facility – July 2, 2017 – 3pm



Dorney explaining the process to the vendors

Dorney Burgdorf from Jacobs made a short presentation on the current state of the project. An overview of the project was given including Jacobs past and future involvement in the project.

Attendance

Project Manager – Mark Tomkins

Jacobs team

Employees DGDC

Trafalgar Vendors

Concerns

Q - Will the project affect the waterfall

Q -Will the project affect the business environment

Dorney – During drilling was there any effect on your businesses

Dorney – How would you want the project to contribute to your community, education, health, sports.

Focus Group

Wotton Waven Spa operators

This group was met one on one after they did not attend a planned meeting. Generally, they had the same concerns and fears about the project.

The group includes:

Ti Kwen Glo Cho – Henry George

Screws – Edison Joseph

Bongo Baths – Helen Rolle

Tia Bamboo Cottages – Tia Joseph

Concerns

What effect will production and re-injection have on our hot water supply?

If negative will we be compensated?

Would the geothermal company be willing to give us a supply from their pipeline if our supply is affected?

Toxic fumes and noise

Traffic of large trucks

How will the community benefit from the project?

What is in it for the people?

Expectations

Employment generation

Cheaper power

More business during construction



COMMONWEALTH OF DOMINICA

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Commonwealth of Dominica

FROM: Project Officer / Geothermal Project Management Unit
TO: Permanent Secretary/ Ministry of Public Works, Energy & Ports
DATE: November 13, 2013
SUBJECT: **Community Meeting – Trafalgar**

A community meeting was held on Tuesday November 12, 2013 at the Trafalgar Community Centre to inform residents of the Roseau Valley and more specifically those of Lily Valley of the on-going drilling activities, likely impacts to the community and also to present the Environmental Impact Assessment Study (EIA).

In attendance were:

Dr. Colin McIntyre: Parl. Representative for Roseau Valley
Lucien Blackmoore: Permanent Secretary, MPWEP
Alexis George/ Lyn Fontenelle: GPMU
Kelvin Rolle: Chief Physical Planner (Ag)
Mandela Christian: Office of Disaster Management
Olivier Felicite: Team Leader, Caraïbe Environnement
Gaelle Herbert: Caraïbe Environnement
Paul Bonnetblanc: Teranov
Frederic Gerard: Teranov
Aaron Rolle: Community Liason Officer
Members of the Trafalgar Village Council
Residents of Trafalgar and neighbouring communities (approximately 30)
Members of the Media (Marpin 2k4)

The GPMU gave an update on the project and informed the meeting of the likely impacts to include:

- Visual/ landscape
- Noise/ lights at night (24 hour operation)
- Traffic/ road conditions (movement of heavy equipment to site)
- Potential hazards (H₂S gas, hot water / steam release, fire)

Residents were informed of the main results of the EIA and some of the mitigation measure that would be adopted.

Upon completion of the power point presentations by the Project Officer and the EIA team, there was a lengthy interaction between the panel and the audience which was well received.

The overarching concern was with the safety of the drilling operation and more importantly that of the residents in the event of an incident. Other points raised included the following:

- Possibility of training opportunities for residents of the Roseau Valley as well as providing financial assistance to persons who are currently studying in geothermal related fields
- Having weekly or biweekly updates on the project aired on radio or published online
- Persons indicated that the use of websites or social media such as facebook to disseminate information would be welcome
- Persons who own land in close proximity to the well pad asked whether it was safe to build their house since they already had planning permission and whether they would be compensated in the event there was an incident that would prevent them from building or continue residing in the houses
- Sponsorship of community activities; whether the project would assist with the infrastructural and social development of the community
- Why the existing site was selected as the location for the reinjection well. Why wasn't another location in a less populated area selected
- Where will the pipeline for reinjection run and will it be safe, how will it be monitored
- When will the power plant come online
- Will the one production well be sufficient to supply the 15 – 20 MW plant
- Will the drilling mud cause any pollution...are the chemicals that will be used toxic
- What role will DOMLEC play in the development, will there be power purchase agreements
- Will there be training for interested persons within the community to be first responders for geothermal hazards
- Why is the noise level from the drill site high at some times and low at other times

Submitted for your information.

Alexis V. George
Project Officer, GPMU

GEOHERMAL RISK DEVELOPMENT PROJECT – DOMINICA

WOMEN FOCUS GROUP MEETING – WOTTEN WAVEN

A Focus Group Meeting with the Women of Wotten Waven was held for the Geothermal Risk Development Project – Dominica on Saturday March 24th, 2018 at the Wotten Waven Resource Centre. --- women attended.

The Meeting was coordinated by Marie-Jose Edwards of Eclipse Inc. In attendance were Mrs. Lyn Fontanelle and Mr. Allan Toussaint of the Geothermal Development Company Ltd and Mr. Lennox St. Aimee, a member of the Eclipse Inc team.

The Administrative and Safeguards Officer and provided answers to questions and queries brought up by attendees throughout the sessions, she outlined the grievance mechanisms in place for the Project and indicated that grievance forms will be available at strategic locations and informed the group that future meetings will be held to update them on the status of the project and to provide additional data and information on the project. The liaison Officer re-introduced himself and provided his contact to all attendees, encouraging them to contact him for additional information / queries.

The meeting started at 3.55 PM, with about 10 women present. The Meeting ended at 5:00 PM, with seventeen (17) women in attendance.

OUTCOME OF FOCUS GROUP MEETING

In response to the question, “What impact did Hurricane Maria have on you, as an individual, and the community?”

- 90 % of respondents indicated that they have lost the roofs of their homes while 95% have lost their livelihood.

- Other responses were as follows:
 - One woman said that the hurricane has affected customers to her business. She noted that “right now it is the peak season, but the visitors are very few” and that it has been a big blow for her. She also mentioned that she lost part of her roof, as well as her fridge getting ‘messed up’, and complained about the condition of the road/bridge to the community. She noted as her priority:

- Getting her business back on track;
 - Needing money;
 - Repairs to her roof; and
 - Fixing of the damaged bridge & road.
- A second participant related that her house was uncovered and that she had to live in a church with her three children for a while. She noted that she was a single parent and supported her children as a small roadside vendor of primarily ice pops & plantain chips. Her fridge, she mentioned, also got ‘messed up’. This small vendor was “not in favor of how the authorities were going about assisting the vendors”. She noted that the government was requesting that only registered small businesses would obtain assistance. That her business was not registered and at this juncture, she did not have the \$80.00 to register a small business;
- Most participants thought that a few persons in the community were still traumatized although some counselling was provided

When asked about priority needs post Maria the responses were as follows:

- The covering of their roofs;
- Restoring basic livelihood;
- That there has been counselling but more is required.
- Vendors indicated that they have not been updated on assistance to them from the small business assistance fund since it was discussed in January and that they would like the GDC to raise this issue with the relevant government authorities on their behalf. One participant suggested that, as an alternative to the way the assistance is being given by the authorities, the payment for the registration of the small business be deducted from the amount given.

The vendors were then asked, “What do you think about the Geothermal Project?”. Vendors views on the project were as follows:

- Of the 12 persons present at the start of the meeting three (3) persons indicated support for the project, five (5) were against, four (4) remained neutral.

- A participant noted that several meetings were being held and the same questions were being asked. She stated “I am not for the project.... lights are not going to be cheaper. We are surrounded by many volcanoes and they are all connected”;
- One woman felt that the project was going to affect their livelihood. She noted “I do not really like the idea; we are in a volcanic basin”.
- Another participant pointed out that she “Believed good things will come out of it”, referring to the project;

When asked why so many persons were against the project some of the responses were as follows:

- A woman noted ‘not enough education’ and there was general agreement by members on this.
- Another stated that she does not think that electricity bill will be lower as a result
- Another woman noted that she had no problem with geothermal and pointed out that “People are generally afraid of change” and noting that there will be more jobs.

Women’s views on the Impact of the Geothermal project on the community were as follows:

When asked whether the community would be better off without the project, there was an emphatic “YES” from 80% of the participants

One participant stated that “We do not know”.

In terms of benefits to the community the overall general responses were as follows:

- Paying less money for electricity;
- Generating jobs; and
- The village will be developed;
- A participant pointed out that “When big companies come to a community they usually give something to the community” and went on to ask “What is in it for the community? Can we get a road or a community Centre?”

When asked if the women had questions to pose to the DGDC the following were posed as well as comments:

- What would be the impact of the project on the rainforest.
- Another participant noted that the well was in a tender area and wanted to know how often the well would be maintained.
- A question was also asked about the company's plan to educate the children and youth of the community.
- A participant pointed out that "the project will be good for business when it comes on board, but I can do without it";
- The last comment from the Group was a woman saying, "I am afraid" and indicating the possibility of an explosion

Social impact of the project on the community

The group (95%) indicated that there is no evidence of domestic violence in the Wotten Waven Community

95% of the women felt that an influx of workers in the community would have no effect on persons in the community

Additional Information Requested by the Community

When asked what additional information was required, 70% indicated that they will need additional information on the operations of the project despite having attended several meetings. The following constitute some of the information needs as outlined by the women:

- Will there be a plant in Wotten Waven;
- Where the pipes will be running;
- What effect is the project going to have on the spas.

Other questions asked were as follows:

- Will we be inhaling the fumes;
- What will be its effects on vegetation and backyard gardens;

- What effect will the smell have on the people; and
- She also suggested the need for an exit if evacuation is needed, further suggesting a road from Wotten Waven to Morne Prosper.

APPENDICES

AGENDA - WOMEN FOCUS GROUP MEETING

Venue – Wotten Waven

Date & Time: March 24th, 2018 / 3:00 PM

- Opening Prayers
- Introduction
- Introduction of participants
- Open Discussion
- Any other questions
- Closing remarks

QUESTIONS

What impact did Hurricane Maria have on you and your family?

What is your priority for recovering from H Maria? Outline at least 3 priority areas

What are the needs of your community post Maria

Do people still suffer from trauma and do you think there is a need for counselling?

What do you think about the Geothermal Project?

What information do you have on the Project?

What additional information would you like to have on the project

What impacts will do you think the project will have on and your family?

(Will the project have any impact on your livelihood)

What improvements or disadvantages will this project have on your livelihood

What does your family think about the project?

In what ways do you think you will be better off without this project?

What are the benefits of the project on your community?

Will households in the community benefit from such a project?

What contribution will the project make to the community?

Will the community be better off without having such a project?

What changes do you think the project will have on your community and on your lives?

What effects will it have on the current lifestyle of the community

How do you intend to manage any changes that occur?

What worries you most about the project

What should be done to make you less worried about the project

What is the History of domestic violence in your community?

There might be an influx of male workers in your community during project construction, how do you think it will affect your community?

- Will it spur on teenage pregnancy, drugs etc.
- Is there any semblance of sex trade in your community?

GEOHERMAL RISK DEVELOPMENT PROJECT – DOMINICA

WOMEN FOCUS GROUP MEETING – LAUDAT

A Focus Group Meeting with the women of the Laudat community was held for the Geothermal Risk Development Project – Dominica on Saturday March 17th, 2018 at the Laudat School Building.

The meeting was coordinated by Ms. Marie-Jose Edwards of Eclipse Inc. In attendance were Mrs. Lyn Fontenelle, Administrative and Safeguards Officer. Mr. Allan Toussaint, Community Liaison Officer and Mr. Shillingford of Dominica Geothermal Development Company Ltd and Mr. Lennox St. Aimee, a member of the Eclipse Inc. team.

The Administrative and Safeguards Officer and provided answers to questions and queries brought up by attendees throughout the sessions, she outlined the grievance mechanisms in place for the Project and indicated that grievance forms will be available at strategic location and informed the group that future meetings will be held to update them on the status of the project and to provide additional data and information on the project. The liaison Officer re-introduced himself and provided his contact to all attendees, encouraging them to contact him for additional information / queries.

The meeting started at 3.55 PM with eleven (11) women and ended at 5:00 PM, with seventeen (17) women.

OUTCOME OF FOCUS GROUP MEETING:

In response to a question “What impact did Hurricane Maria on you and your family?”

Responses were along these lines:

- 90% of the women present stated that Hurricane Maria went away with their small businesses which were associated with the tourism sector. 75% of the women lost their houses or roofs and over 50% reported that they had either lost their poultry farms and/or vegetable gardens. About 50% of the women indicated that they were no longer able to bring an income to the household. About 75% of the women noted that they had received some form of assistance as small farmers but stated that they would like to see their place of employment, Fresh water lake facility, restored.

In terms of the community, the major concerns were as follows:

The priority needs in terms of post Maria recovery were said to be:

- Recovering of roofs and repairs of houses;
- Restoration of chicken farms & vegetable gardens;
- Counselling for people who are still traumatized;
- To return to stable jobs with good pay;

The group was then asked, “What do you think about the Geothermal Project?”. The women responded to the question as follows:

- About 50% of the women were not in favor of the project while 25% indicating that they were in favor. The remaining 25% remained neutral. The reasons cited against and for the project were, as follows:
 - the fragility of the soil;
 - concerns about safety;
 - electricity will not be cheaper;
 - the project is being promoted as clean energy;
 - electricity will be cheaper; and
 - even not in my time, my children or grandchildren will benefit.

In response to a question, “What impact will the project have on women and your family?”.
The women responded as follows:

- 40% of the women felt that it could become a tourism attraction;
- 90% felt that it could also bring more employment to the women of the community.
- About 50% felt that the community would be better off without the project.

1. The Group was then asked, “**What changes do you think the project will have on your community and on your lives?**”,

The response indicated the following:

- 98% of the women indicating that they were in favor of the project, with one woman against;
- Safety concerns were cited by the woman who indicated that she was against the project;
- A concern was also raised in relation to rumors of a possible leak on the site. Mrs. Fontenelle cleared the air on this rumor;
- Paying less for electricity, (as being promoted);
- A question as to whether there are other such projects in the Caribbean and are there related health issues;
- A need for more education/information was suggested;
- A question asked of the effect of the gas on farming people and the environment;
- A woman asked, “What are the byproducts of this project and how can it be used?”;
- Someone wanted to know the areas of study for jobs that might be available;
- A question was asked as to when the project would be on stream.
- A member of the group wanted to know if there would be monitoring of the effect of the project on the community; and
- A question as to whether water sources would be affected ended this section.

Social impact of the project on the community

95% of the women indicated that there were no open cases of domestic violence known to the community.

1. The Group was informed that **“When there is an influx of male workers in any community there tend to be social disruption”** and then asked, “What are your thoughts on this in respect to your community?”

The general conscientious was that this had not happened in the past with other project and the hope was that it would not happen with this project. The incident of teenage pregnancy was not a problem in the community. Generally, the group felt that there was a low level of crime in the community.

2. The Group was then asked if they had any question for the facilitators and/or the project personnel.

The following questions were asked:

- What benefits would accrue to the community.
- Were there would be safeguards in the project’s design?
- Will the project affect the volcanoes, “as we are living on a volcanic island”?

The facilitator asked the group what they think there are benefits that they think could come to the community through this project: The following benefits were suggested:

- More jobs could be created;
- Cheaper electricity for consumers;
- Electricity at half price or free;
- Having an individual from the community on the Board of the Company;
- The establishment of a skills development fund for the community;

3. In her final comments, Mrs. Fontenelle addressed most of the concerns raised by the group. She went on to explain the grievance mechanism that was in place for the project. She noted the presence of Mr. Allan Toussaint, the project's community liaison officer, who she advised would be the first point of contact for complaints. She also mentioned that complaint forms would be placed at accessible locations in the community. She promised that the company will be back for a community meeting in early April, when a power point presentation on the project will be shown.

AGENDA -VENDORS / WOTTEN WAVEN

Venue – Wotten Waven

Date & Time: March 24th, 2018 / 5:00 PM

- Opening Prayers

- Introduction
- Introduction of participants
- Open Discussion
- Any other questions
- Closing remarks

QUESTIONS

What impact did Hurricane Maria have on you and your family?

What is your priority for recovering from H Maria? Outline at least 3 priority areas

What are the needs of your community post Maria

Do people still suffer from trauma and do you think there is a need for counselling?

What do you think about the Geothermal Project?

What information do you have on the Project?

What additional information would you like to have on the project

What impacts will do you think the project will have on and your family?

(Will the project have any impact on your livelihood)

What improvements or disadvantages will this project have on your livelihood

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What effects will it have on the current lifestyle of the community

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What worries you most about the project?

What should be done to make you less worried about the project

What is the History of domestic violence in your community?

There might be an influx of male workers in your community during project construction, how do you think it will affect your community?

- Will it spur on teenage pregnancy, drugs etc.
- Is there any semblance of sex trade in your community?

GEOTHERMAL RISK DEVELOPMENT PROJECT – DOMINICA

VENDORS FOCUS GROUP MEETING – TRAFALGAR

A Focus Group Meeting with the Vendors of Trafalgar was held for the Geothermal Risk Development Project – Dominica on Sunday March 25th, 2018 at the Trafalgar Tourism Facility. The Meeting coordinated by Ms. Marie-Jose' Edwards of Eclipse Inc. The Meeting started at 3:40 p.m. with ten (10) vendors present.

The Meeting was coordinated by Marie-Jose Edwards of Eclipse Inc. In attendance were Mrs. Lyn Fontanelle and Mr. Allan Toussaint of the Geothermal Development Company Ltd and Mr. Lennox St. Aimee, a member of the Eclipse Inc team.

The Administrative and Safeguards Officer and provided answers to questions and queries brought up by attendees throughout the sessions, she outlined the grievance mechanisms in place for the Project and indicated that grievance forms will be available at strategic locations and informed the group that future meetings will be held to update them on the status of the project and to provide additional data and information on the project. The liaison Officer re-introduced himself and provided his contact to all attendees, encouraging them to contact him for additional information / queries.

The Meeting ended at 4:35 PM, with about fifteen (16) vendors in attendance.

OUTCOME OF FOCUS GROUP MEETING:

In response to the question, “What impact did Hurricane Maria had on you, as an individual, and on the community?”

- 90% of the vendors indicated that they had no job and no money. One vendor pointed out that “everybody was in the same boat”;
- 95% of the vendors said that they needed finance to get back on their feet. They also noted that the authorities need to speed up the process of helping vendors;
- 80% of the vendors reported that their roofs or houses were destroyed. One vendor reporting that she has since recovered her house;
- The vendors reported that their supplies were usually left at the Tourism facility and that Hurricane Maria blew away 100% of these supplies;

In terms of impact on the community, the major concerns were:

- The recovering of their roofs;
- Restoring basic livelihood;
- Better roads;
- Being still traumatized; and
- The need for counselling which they noted should have been done already.

When asked about the priority needs post Maria, the responses were as follows:

- Better roads;
- Repairs to houses and roofs

Vendors were then asked, “What do you think of the Geothermal Project?”. The responses from the vendors were as follows:

- 50% of the vendors saw it was a good idea, if it was going to benefit them, such as lowering electricity rates;
- 90% of the vendors also noted that the community needed more information about the project;
- 95% of the vendors indicated that they had previously attended meetings of the project;

The Group was then asked, “What worries you most about the project?”. The responses were as follows:

- The quality of the air will be affected;
- An increase of Sulphur in the air;
- The possibility of tremors;
- Contamination of water supply;
- It will affect the waterfall; and
- Possible health issues

The meeting was then asked, “Do you think that the project will affect you, as vendors?”.

The vendors responded as follows:

- About 50% felt that if it does not come to their area, then they had no problem;
- About 95% of the vendors indicated that if it does not affect the waterfalls, then no problem either;
- 90% felt it would have a positive effect on livelihood, such as lower electricity bills;

The Group was then asked the question “What is the History of domestic violence in your community?”

There was a response from one member stating that “It is not a problem here”. 90% of the vendors agreed that it was not a problem but felt that it was not 100% free of domestic violence.

The vendors were also asked “Is there any semblance of sex trade in your community?”.

All the responses from the vendors indicated that there was none:

- It is not a problem;
- I have not heard of any such cases;
- No history of such.

The facilitator then asked the vendors whether they had any questions of their own. The following questions were asked by the group:

- Will there be any fumes or leaks;
- What if DOMLEC changes the price at which power is sold to them;
- In case the waterfall changes its course, will the geothermal authority come to our assistance;
- Will it affect the volcanoes;
- Are the route of the reinjection pipes prone to landslide;
- Will the plant be noisy;
- A question was also asked concerning the Visitors’ Centre at Laudat.

In response to a question from the facilitator, the group indicated that the main occupation of the community was farming & vending. They also noted that the community had a youthful population. They also stated that there were twenty (20) vendors at the facility and about another ten (10) in the village.

APPENDICES

AGENDA – Vendors / Wotten Waven

Venue – Wotten Waven

Date & Time: March 24th, 2018 / 5:00 PM

- Opening Prayers
- Introduction
- Introduction of participants
- Open Discussion
- Any other questions
- Closing remarks

QUESTIONS

What impact did Hurricane Maria have on you and your family?

What is your priority for recovering from H Maria? Outline at least 3 priority areas

What are the needs of your community post Maria

Do people still suffer from trauma and do you think there is a need for counselling?

What do you think about the Geothermal Project?

What information do you have on the Project?

What additional information would you like to have on the project

What impacts will do you think the project will have on and your family?

(Will the project have any impact on your livelihood)

What improvements or disadvantages will this project have on your livelihood

What does your family think about the project?

In what ways do you think you will be better off without this project?

What are the benefits of the project on your community?

Will households in the community benefit from such a project?

What contribution will the project make to the community?

Will the community be better off without having such a project?

What changes do you think the project will have on your community and on your lives?

What effects will it have on the current lifestyle of the community

How do you intend to manage any changes that occur?

What worries you most about the project?

What should be done to make you less worried about the project

What is the History of domestic violence in your community?

There might be an influx of male workers in your community during project construction, how do you think it will affect your community?

- Will it spur on teenage pregnancy, drugs etc.
- Is there any semblance of sex trade in your community?

GEOHERMAL RISK DEVELOPMENT PROJECT – DOMINICA

VENDORS FOCUS GROUP MEETING – WOTTEN WAVEN

A Focus Group Meeting with the Vendors of Wotten Waven was held on Saturday March 24th, 2018 at the Wotten Waven Resource Centre. There are between 17 – 21 registered vendors in the area

The meeting was coordinated by Ms. Marie-Jose Edwards of Eclipse Inc. In attendance were Mrs. Lyn Fontenelle, Administrative and Safeguards Officer, Mr. Allan Toussaint, Community Liaison Officer and Mr. Shillingford of Dominica Geothermal Development Company Ltd and Mr. Lennox St. Aimee, a member of the Eclipse Inc. team.

The Administrative and Safeguards Officer provided answers to questions and queries brought up by attendees throughout the sessions, she outlined the grievance mechanisms in place for the Project and indicated that grievance forms will be available at strategic locations and informed the group that future meetings will be held to update them on the status of the project and to provide additional data and information on the project. The liaison Officer re-introduced himself and provided his contact to all attendees, encouraging them to contact him for additional information / queries.

The meeting started at 5.20 PM, immediately following the Women Focus Group Meeting, with 9 vendors present at the start. The meeting ended at 6:15 PM.

OUTCOME OF FOCUS GROUP MEETING

In response to the question, “What impact did Hurricane Maria have on you, as an individual, and the community?”

- 90 % of respondents indicated that they have lost the roofs of their homes while 95% have lost their livelihood. In terms of livelihood they specifically referred to the destruction of their vending stalls and goods for sale as well as the loss of most cruise ships and the revenue which could accrue to them from sales of goods and services. They commented on the fortnightly visit of one of the cruise lines and the minimum revenue that this ship generates when compared to post Maria calls and sales

In terms of impact on the community the major concerns were as follows:

- Destruction of the main roads
- Destruction of access bridge. One person indicated that he had lost access to his property and home as a result
- Absence of tourists and loss of revenue
- A small percentage of persons indicated that some persons suffered trauma as a result

When asked about priority needs post Maria the responses were as follows:

- Repair of houses and roofs; and
- Repair or replacement of vending stalls by government
- Return of tourist to the community
- Return of tourist to the community
- There was a mixed response to counselling for community member but, generally, it was felt needed;

The vendors were then asked, “What do you think about the Geothermal Project?”.

Vendors views on the project were as follows:

- 60 % of vendors did not support the project. The reasons cited were as follows:
- Impact on the health of the community. Fear for our health” as stated. Some of the vendors felt that they should be relocated since their vending stalls were too close to the reinjection site. Participants enquired as to whether they were going to be relocated. In fact, the vendors indicated that one government official informed them that they would be relocated within the Shangri La area once transactions with the company was finalized.
- Most vendors felt that relocation would put them at a disadvantage given the existing route undertaken by cruise visitors.
- Impact on the vulcanism of the island and the danger of volcanic eruption and earthquakes. One vendor stated that “It was a poor chance to have such a project among the people, the boiling lake can erupt at any time”

Vendors views on the Impact of the Geothermal project on the community

- 90% of vendors were not sure that the community would benefit from the geothermal project.

Other indicated the following:

- “maybe jobs”
- Lower electricity bill
- The greatest fear of the project as indicated by vendors is the impact on their health. Most vendors feel that the project will have a negative impact on their health.

In response to a question as to whether the project would bring changes to the community, the group responded, as follows:

- One vendor noted noise, especially at nights. Others felt that people would get accustomed to the noise;
- Another vendor stated that “It will change things for the better, not for worst”.
- A vendor also suggested the need for additional educational open sessions in the community by project personnel.

In terms of priority needs of the community with respect to the operations of the geothermal project the vendors cited the following:

- Proper roads;
- Bridge to be in good condition;
- Exit points in the event of an evacuation; and
- Safe guard measures for the community in case of any emergencies resulting from the project

Social Impact of the Project on the Community

The group (95%) indicated that there is no evidence of domestic violence in the Wotten Waven Community

1. The Group was informed that “There might be an influx of male workers in your community during the project’s construction, how do you think it will affect your community?”.
 - 95% of the vendors felt that, generally, there would not be a problem; they indicated that there has been no history of this type of behavior in the community

APPENDICES

AGENDA – VENDORS / WOTTEN WAVEN

Venue – Wotten Waven

Date & Time: March 24th, 2018 / 5:00 PM

- Opening Prayers
- Introduction
- Introduction of participants
- Open Discussion
- Any other questions
- Closing remarks

QUESTIONS

What impact did Hurricane Maria have on you and your family?

What is your priority for recovering from H Maria? Outline at least 3 priority areas

What are the needs of your community post Maria

Do people still suffer from trauma and do you think there is a need for counselling?

What do you think about the Geothermal Project?

What information do you have on the Project?

What additional information would you like to have on the project

What impacts will do you think the project will have on and your family?

(Will the project have any impact on your livelihood)

What improvements or disadvantages will this project have on your livelihood

What does your family think about the project?

In what ways do you think you will be better off without this project?

What are the benefits of the project on your community?

Will households in the community benefit from such a project?

What contribution will the project make to the community?

Will the community be better off without having such a project?

What changes do you think the project will have on your community and on your lives?

What effects will it have on the current lifestyle of the community

How do you intend to manage any changes that occur?

What worries you most about the project?

What should be done to make you less worried about the project

What is the History of domestic violence in your community?

There might be an influx of male workers in your community during project construction, how do you think it will affect your community?

- Will it spur on teenage pregnancy, drugs etc.
- Is there any semblance of sex trade in your community?

GEOTHERMAL RISK DEVELOPMENT PROJECT – DOMINICA

WOMEN FOCUS GROUP MEETING – TRAFALGAR

Introduction

A Focus Group Meeting with the women of the Trafalgar community was held for the Geothermal Risk Development Project – Dominica on Sunday March 18th, 2018 at the Trafalgar School Building.

The meeting was coordinated by Ms. Marie-Jose Edwards of Eclipse Inc. In attendance were Mrs. Lyn Fontenelle, Administrative and Safeguards Officer, Mr. Allan Toussaint, Community Liaison Officer and Mr. Shillingford of Dominica Geothermal Development Company Ltd and Mr. Lennox St. Aimee, a member of the Eclipse Inc. team.

The Administrative and Safeguards Officer and provided answers to questions and queries brought up by attendees throughout the sessions, she outlined the grievance mechanisms in place for the Project and indicated that grievance forms will be available at strategic locations and informed the group that future meetings will be held to update them on the status of the project and to provide additional data and information on the project. The liaison Officer re-introduced himself and provided his contact to all attendees, encouraging them to contact him for additional information / queries.

The meeting started at 3.35 p.m. with four (4) women present. The meeting ended at 5:00 p.m. with seventeen (17) women in attendance.

OUTCOME OF FOCUS GROUP MEETING

In response to the question, “What impact did Hurricane Maria have on you, as an individual, and the community?”

- 90 % of respondents indicated that they have lost the roofs of their homes while 95% have lost their livelihood.

Other responses were as follows:

- Some women stated that Hurricane Maria affected their farms but most noted that they are back on track;
- Damages to houses & roofs were recorded at five (5) of those present;
- One woman lost her work but has since found another job while two (2) other women indicated that their livelihood have been affected;
- Two women reported that they are still suffering from the shock of the hurricane;

When asked about priority needs post Maria the responses were as follows:

- The covering of their roofs and rehabilitation of their houses
- Restoring basic livelihood
- Recovering of roofs and rehabilitation of houses;
- Counselling for people who are still traumatized;

The vendors were then asked, “What do you think about the Geothermal Project?”. Vendors views on the project were as follows:

80 % of persons were generally in favour of the project but express the following concerns

- One participant felt that “It would be good for us in Trafalgar”. However, she was not in favor of the country sending energy overseas;
- Another participant wanted to know what the plant would be like and sought an explanation on the health risk to the community
- Another wanted to know how the energy will be generated. She was skeptical about tampering with nature and inquired why is not wind and solar energy attempted first.
- A woman noted that there was a promise of cheaper electricity with the hydro project, but it was not so; she hoped that this would not be the same with geothermal;
- A concern also surfaced of the leaves of trees turning to different colors when it rains.

When asked the following question “What Impact do you think that the project will have on you, as an individual, your family and the community?”

- 85% of the participants had a positive view of the project with some areas of concerns as expressed in the following responses:
- The Group felt that the project could do the following:
 - Bring money back in one’s pocket;
 - Create extra employment for certain person;
 - Provide educational opportunities for new skills; and
 - May have positive or negative social impact on the community.

In response to what the group saw as its biggest fears for themselves and the community, 40 % expressed fears. Some of the responses were as follows:

- The plant refusing to work, or something goes terrible wrong;
- What can happen is unknown, therefore, one does not know what to expect;
- What if a volcano explodes;
- A negative effect on the tourism industry; and
- It is rumored that it can generate cancer

Women’s views on whether the community would be better off without this project were as follows:

- 80 % of the women felt that the community would benefit from the project.
- There was an anticipation from a participant that it would be better off;
- Another participant suggested the need for a disaster plan; and
- The participants agreed that more information is needed by the community.

Social impact of the project on the community

When asked about the history of domestic violence in their community?”

The women generally agreed that there was moderate to very little domestic violence in the community. Their responses were as follows:

- The group agreed to a response from a member that “It has cool out a little but there was in the community”;
- However, they would not speculate as to the current level of domestic violence in the community;
- In response to a query from the facilitator, the group felt that domestic violence could be managed by:
 - Speaking to the individuals involved; and
 - The need to follow up by the authorities when complaints are made to them.

In response to a possibility of an influx of male workers in the community during the project’s construction, and any potential impact on the community, the response was as follows:

- A participant noted the need to ensure that such workers are properly screened;
- Another participant saw the possibility of an increase of drugs and alcoholism;
- A participant noted the possibility of community impacting its culture on the foreign workers;
- A woman indicated the need for education starting at the home, as to what to expect; and
- There was also a suggestion for targeted sessions to various sections of the community;

APPENDICES

AGENDA- MEETING WITH THE VENDORS / TRAFALGAR

Venue – Trafalgar Primary School Building

Date & Time: Sunday March 18th, 2018 / 3:00 PM

- Opening Prayers
- Introduction
- Introduction of participants
- Open Discussion
- Any other questions
- Closing remarks

QUESTIONS

What impact did Hurricane Maria have on you and your family?

What is your priority for recovering from H Maria? Outline at least 3 priority areas

What are the needs of your community post Maria

Do people still suffer from trauma and do you think there is a need for counselling?

What do you think about the Geothermal Project?

What information do you have on the Project?

What additional information would you like to have on the project

What impacts will do you think the project will have on and your family?

(Will the project have any impact on your livelihood)

What improvements or disadvantages will this project have on your livelihood

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What should be done to make you less worried about the project

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There might be an influx of male workers in your community during project construction, how do you think it will affect your community?

- Will it spur on teenage pregnancy, drugs etc.
- Is there any semblance of sex trade in your community?



Dominica Geothermal Power Plant

Environmental and Social Impact Assessment

July 2018



**Dominica Geothermal
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Agenda

1. Project Overview
2. Technology Overview
3. Construction and Operational Phase Outline
4. ESIA Process
5. ESIA Studies
6. Environmental Impacts, Mitigation and Monitoring
7. Community and Social Impacts
8. Conclusions
9. Project Consultation
10. Grievance Mechanism

Project Components Overview

- Geothermal Power Plant (7 MW) at Laudat
- Production well (called WW-P1) which provides steam and brine to drive the power plant at Laudat
- Reinjection wells called WW-R1 (Trafalgar) and WW-01 (Wotten Waven) for the return of brine to the below ground geothermal reservoir
- Brine reinjection line running from Laudat to Trafalgar, a 12 inch line with a 10 metre maximum corridor
- 11 kV underground power line connecting power plant Laudat Hydropower Station

Project Area of Influence



Power Plant Layout



Power Plant Technology Options

Typical Organic Rankine Cycle



Typical single flash stream condensing cycle



- Larger footprint (size)
- Potentially less visual vapour
- Least efficient / most expensive

- Smaller footprint (size)
- Potential visual vapour (depending on weather)
- Most efficient / least expensive

Example of a Reinjection Pipeline



Pre-Construction Phase

- Land valuations
- Negotiations on land
- Land acquisition and compensation paid
- Process to be completed according to World Bank requirements, prior to construction commencement

Construction Phase

- Anticipated to begin late 2018 or early 2019 and last 18 months
- For 2 months - site clearing and earth movement, establishment of temporary construction facilities and roadways
- For 7-9 months major civil and structural works
- For last 3 months, testing and commissioning

Operational Phase

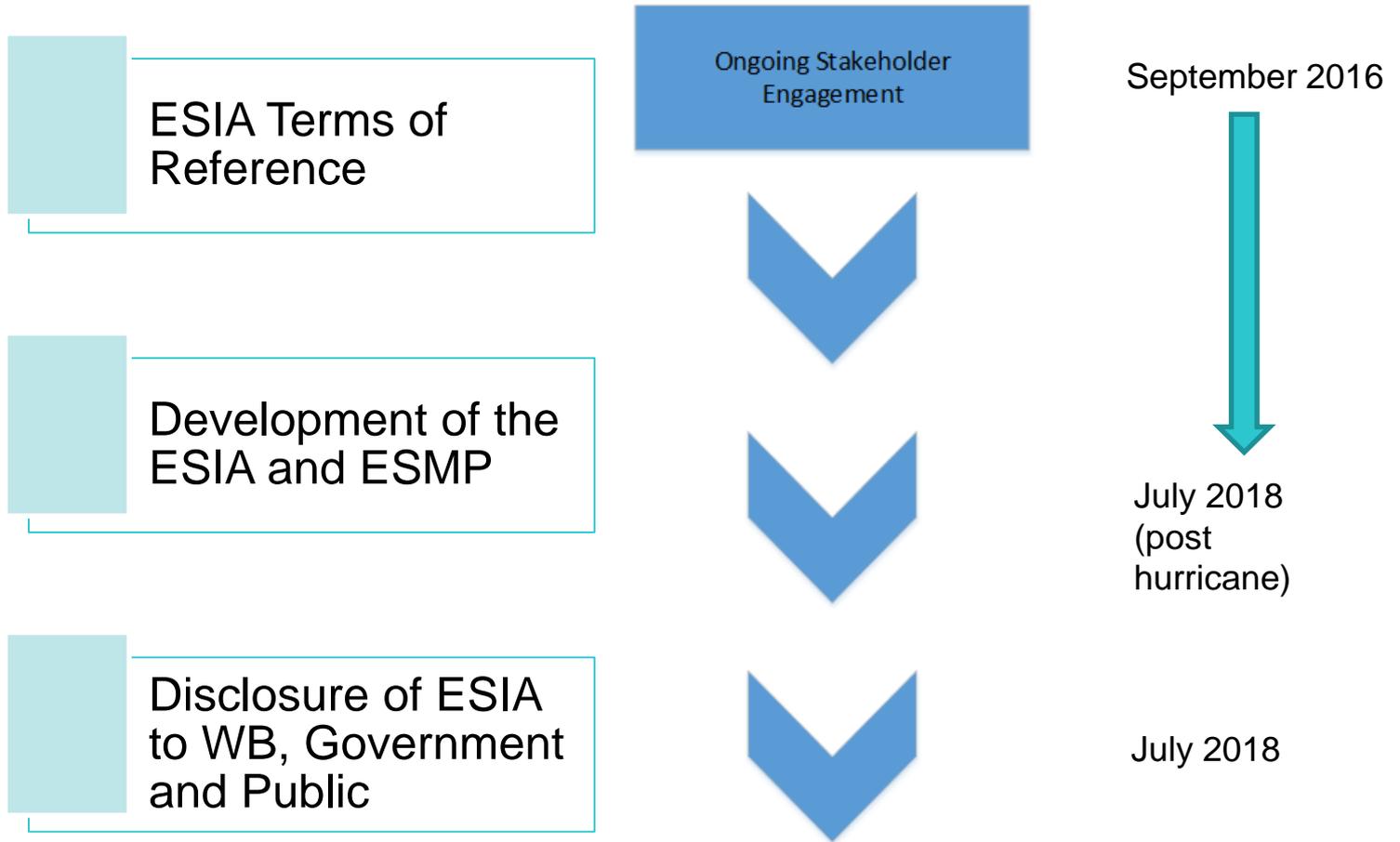
- **Start-up** - Mid 2020
- **Maintenance** - Envisaged that a unit maintenance shut-down will occur annually. Lasting roughly seven days

What is an ESIA?

ESIA = Environmental and Social Impact Assessment

- The goal of the ESIA for the Project is to evaluate the temporary and permanent impacts of the construction, operation and decommissioning of the Project on the natural and human environment.
- Based upon this evaluation, mitigation measures are developed to reduce all impacts to acceptable levels.

ESIA Process



Impact Level Determination

- An impact is essentially any change to a resource or receptor brought about by the presence of the proposed project component, project discharge or by the execution of a proposed project related activity.
- Level of impact can range from ‘major’, ‘moderate’, ‘minor’ or ‘negligible’ based on consideration of parameters such as:
 - Duration of the impact – ranging from ‘well into operation’ to ‘temporary with no detectable impact’.
 - Spatial extent of the impact – for instance, within the site boundary, within district, regionally, nationally, and internationally.
- Mitigation measures are proposed for any impacts that are minor significance or above.

What are the present environmental conditions in the Project area?

- Air Quality
- Water Quality
- Ecology and Natural Resources
- Natural hazards
- Noise
- Landscape and Visual



What are the findings of the ESIA?

Air Quality and Public Health

Impacts:

- Minor temporary impacts from dust during construction
- Hydrogen sulphide releases - no anticipated health effects during operations are predicted levels to be well below World Health Organisation (WHO) thresholds of observed adverse effect levels, however, potential for increased odour near the Power Plant

Mitigation and Monitoring:

- Dust prevention measures during construction as outlines in Air Quality Management Plan
- Dust and air quality monitoring during construction against WHO ambient air guidelines
- Monitoring at residences near the Power Plant and in Roseau for hydrogen sulphide

Noise

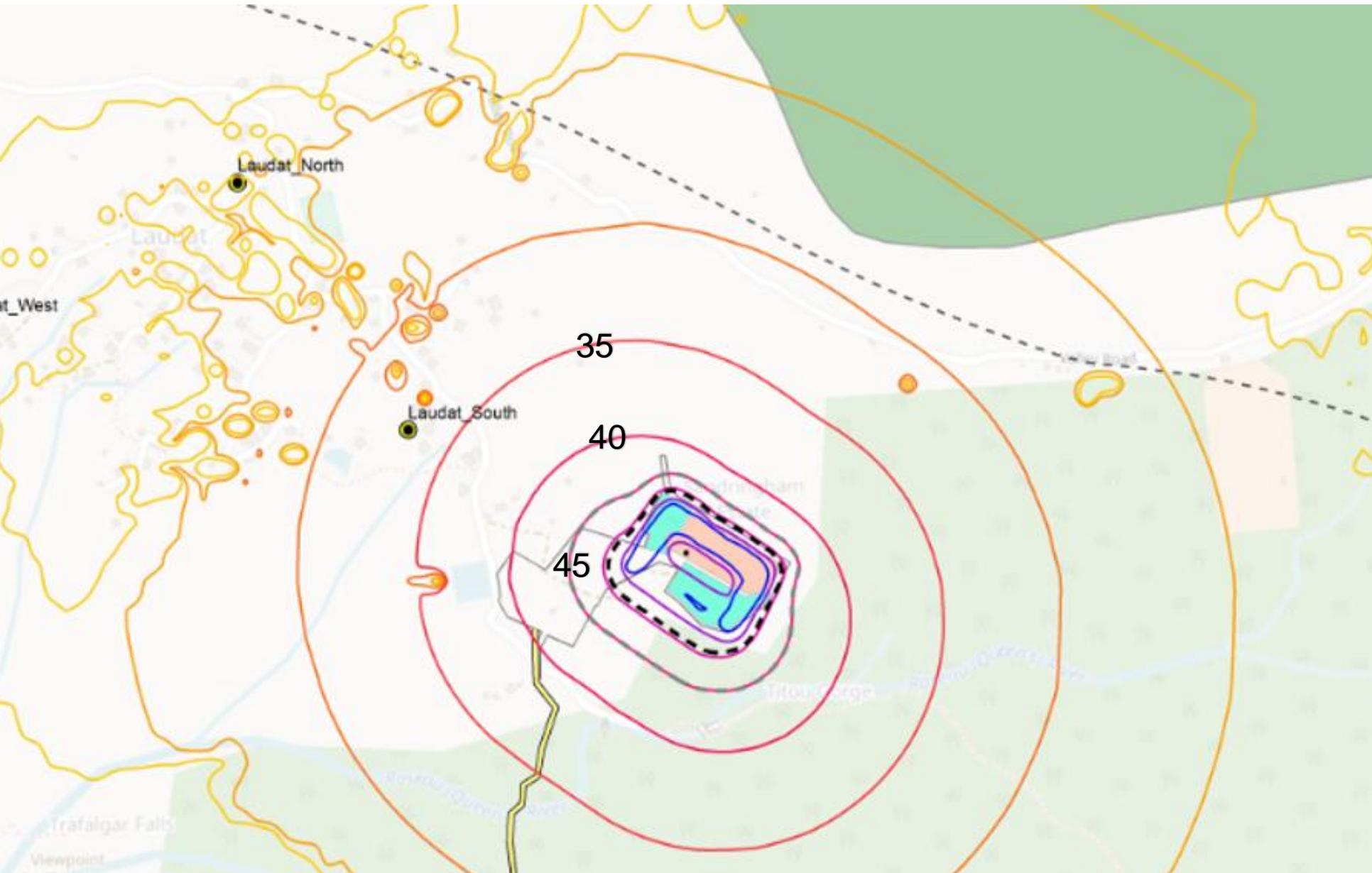
Impacts:

- Minor temporary noise increases impacting residents during construction
- Noise impacts during steam blowing (1 week), commissioning works will be intermittent over a three month period and is dependent on the activities being undertaken and testing periodically (hour or two).
- Operational noise levels at the Power Plant are predicted to comply with WHO noise standards (55 db(A) during day and 45 dB(A) at night) at all surrounding residences

Mitigation and Monitoring:

- Restrict noisy activities during commissioning to daytime
- Temporary localised screening during construction
- Monitoring to ensure noise levels are within limits

Noise Levels Predicted During Operation



Water Quality

Impacts:

- When vegetation is cleared for Power Plant, potential for increased soil erosion and run-off during construction which could affect Roseau river water quality.
- Also potential for soil erosion at stream crossings for reinjection pipelines

Mitigation and Mitigation:

- Development of erosion and sediment control procedures and stormwater management and site drainage design.
- Interceptors, silt fences and sumps to reduce sediment run off into the water course and clean water diversions at stream crossings
- A monitoring program will be put in place for monitoring discharges from sediment control devices

Ecology

Impacts:

- Overall ecology effects expected to be minor
- When vegetation is cleared from Power Plant or r-injection area, this could cause changes in fish habitat
- Changes in river sediment characteristics and amount during construction
- No habitat loss and negligible impact on MTPNP

Mitigation and Monitoring:

- Erosion and sediment control procedures
- Landscaping and replanting
- Monitoring of 5 key species at a frequency of every six months during construction and annually thereafter in Project area

Landscape and Visual

Impacts:

- Short term changes during clearance while vegetation regrows
- Views from properties surrounding the Power Plant may be degraded in the short term
- Due to the size of the pipeline corridor (10 m) and the pipeline itself (30 cm), it is unlikely that during operation the pipeline will not drastically change the view

Mitigation and Monitoring:

- Planting regimes are expected to reduce visual impacts over time and restore them to acceptable levels

Natural Hazards and Geothermal Features

Impacts:

- Potential for landslides and natural hazards.
- The reinjection pipeline will be at some risk from flooding as occurred during the Hurricane Maria
- Geothermal features – not anticipated to be impacted as the project will be 1000 metres down and pools are surface features

Mitigation and Monitoring:

- Flooding on the reinjection pipeline will be minimised by careful route construction and design of river crossing structures.
- Landslide Management Procedure
- A monitoring program will be put in place for the hot pools to monitor any changes

Traffic

Impacts:

- Increased levels of traffic during construction, with potential temporary diversions and minor delays particularly for pedestrians and cyclists

Mitigation:

- Development of a Traffic Management Plan
- Workers Camp to minimise daily traffic during construction

Community and Social Impacts

- The Project will have a beneficial impact on employment during construction in the Roseau Valley. Additional jobs created indirectly (through retail, hospitality, transportations, etc.) would also bring minor beneficial impacts for employment in the local area.
- The unskilled and semi-skilled workforce is anticipated to generally come from the local area but will not be large in number.
- GoCD has indicated that funding for some community development initiatives along with development of the power plant will be provided.
- Construction of Visitors Center adjacent to the Power Plant which could generate positive impacts on tourism

Community and Social Impacts (cont.)

- Approximately 12 properties or portions of properties would need to be acquired. For proposed land acquisitions and resettlement associated with the Project, an Abbreviated Resettlement Action Plan (ARAP) has been prepared.
- General community health impacts of the Project are considered to be minor. Community safety impacts from increased traffic and associated safety risks would create moderate impacts. However, impacts would likely be short-term and localised and risks would be highest during the peak construction period.

Monitoring

- Wastewater effluent quality
- Stormwater quality
- Biodiversity
- Slope stability
- Geothermal features
- Air quality
- Noise
- Social surveys



Conclusions

- The ESIA summarises a large amount of technical work undertaken to assess the impacts of the proposed Project.
- Main impacts include: noise, land acquisition, traffic, natural hazards, erosion, and temporary changes associated with construction.
- Mitigation and monitoring actions have been set out in the Environmental and Social Management Plan that address the key environmental and social impacts identified in the analysis.
- Implementation of the mitigation, management and monitoring measures in the ESMP for each phase of the Project will ensure that the environmental and social impacts of the Project overall will be acceptable.

Project Consultation Going Forward

- **Community Liaison Officer – Alan Toussant**

allan.toussaint@geodominica.com

(767) 448-6178 / 79

(767) 275-7392 (cell)

- **Grievance Mechanism:**

Concerns and complaints during construction and operations to be recorded and addressed – form online

- **Ongoing Land Acquisition Process**



Grievance Mechanism

- This is a process which allows the communities impacted by the development to lodge their concerns with DGDC in regards to potential issues with the development that may arise during the construction and operation of the geothermal development
- DGDC will receive the grievance, evaluate it and act upon.
- The party submitting the grievance will be advised of the actions undertaken to resolve the issue

Questions?

Thank you for listening



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Dominica Geothermal Development Company
ESIA – Non-Technical Summary Community Consultations
July 2018

Meetings were held in the communities as follows:

Laudat – Tuesday 4th July 2018 6:00 PM

Trafalgar – Wednesday 5th July 2018 6:00 PM

Wotten Waven – Thursday 6th July 2018 6:00 PM

All meetings started at 6:30 PM. Community Liaison Officer – Allan Toussaint Chaired all the meetings.

DGDC was represented at the meetings by: Mark Tomkins, Lyn John-Fontenelle, Rawlins Bruney, Dalton Eloi, Allan Toussaint, Garry Shillingford. Fidel Grant attended the meeting in Laudat.

Jacobs was represented by Dorney Burgdorf.

The meetings were generally well attended (see attendance lists in Appendix 1) and very interactive. The NTS was disclosed on the DGDC's and Gov't of Dominica's website from June 25th 2018 (www.geodominica.com & www.dominica.gov.dm), hardcopies were available at the DGDC offices and at public spaces in the Roseau Valley (Resource Centre in Wotten Waven, Health Centres in Trafalgar & Laudat). Notices were placed on local radio (DBS Radio) and online newspaper (Dominicanewsonline.com) inviting the public to the consultations and directing them to the NTS document.

The Agenda followed for all meetings was:

AGENDA

Allan Toussaint/Community Liaison Officer, DGDC
Opening Prayer

Apologies for absence of Minister/Parliamentary Representative (off-island)

Welcome & Introductory Remarks
Chairperson

Overview of the Geothermal Project
Mark Tomkins, Project Manager

Overview re ESIA
Dorney Burgdorf/ESIA Specialist

Question and Answers

Thank you and Closing Remarks

APPENDIX 1

Attendance list Laudat

NO.	NAME	ADDRESS	OCCUPATION	EMAIL ADDRESS	TELEPHONE NO.
1	Joel Lambert	Laudat			
2	Alfred Rolle	Laudat			
3	Henry	Copt Hall			
4	Kleen Burnette	Laudat			
5	Aaron Rolle	Laudat			
6	Berani Rolle	Laudat			
7	Claudette Rolle	Laudat			
8	Earl Jno Lewis	Laudat			
9	Charles McClean	Laudat			
10	Ralph Magloire	Laudat			6128853
11	Kyle Sylvester	Shawford	Sales Clerk	Sylvesterkyle@hotmail.com	3179974
12	Donna Sylvester	Shawford	Sales Clerk	Moartess2008@hotmail.com	6142689
13	Dr. Patrick Cloos	Laudat	Medical Professional	Patrick.cloos@umontreal.com	
14	Augustus Junkere	Laudat	Mechanic		2658445
15	Christiana Abraham	Laudat	Researcher	Christianabraham@hotmail.com	2255056
16	George Daway	Laudat			
17	Fabiana Moses	Laudat			2779323
18	Cyril Daway	Laudat			
19	James Daway	Laudat			

Attendance List Trafalgar

NO	NAME	ADDRESS	OCCUPATION	EMAIL ADDRESS	TELEPHONE NO.
1	Barbara Barrie	Trafalgar	NEP Worker	Conniebarrieroberts@gmail.com	2776400
2	Vernanda Raymond	Shawford	Chief Librarian	Vernandara@gmail.com	2457966
3	Kyle Toussaint	Shawford	Mechanic	Kyle.Toussaint94@gmail.com	6130560
4	Khern Toussaint	Shawford	Student		
5	Ashton Rolle	Trafalgar	Trademan		
6	Laura Denis	Trafalgar	Vendor		2250815
7	Miranda Baptiste	Shawford			3165039
8	Sandra St Jean	Trafalgar	NEP Worker		
9	Alexandrine Rolle	Trafalgar			
10	Arthurton Bellot	Trafalgar	GIS Intern (NEP)	Brettson92@gmail.com	
11	Michael Ross	Trafalgar	Administrative Assistant	Treasure18@gmail.com	2455699
12	Joanne Bellot	Trafalgar	Assistant Manager	Bellot70@yahoo.com	2253459
13	Annalisa Jensen	Trafalgar	Artist/Teacher		2654000
14	Mitch Francis	Trafalgar	Carpenter	Mitchfrancis1988@gmail.com	6130380
15	Dabria Toussaint	Shawford	Student		
16	Jannelle Raymond	Shawford	Student		
17	Corrie Phillip	Shawford	Student		
18	Allianne Toussaint	Shawford	Student		
19	Evette Daniel				
20	Vera Daniel	Trafalgar			

Attendance list Wotton Waven

NO	NAME	ADDRESS	OCCUPATION	EMAIL ADDRESS	TELEPHONE NO.
1	Dayne o. George	Wotton Waven	Self Employed	Raw_stylez@yahoo.com	2257222
2	Dale Joseph	Wotton Waven	-	Lyfestarle@gmail.com	2258218
3	Rudolph George	Wotton Waven		wottonwaven@gmail.com	2356074
4	Julian Joseph	Wotton Waven	-		
5	Edward Green	Canefield	-		
6	Joanalie Ducreay	Wotton Waven		yducreay@gmail.com	3167732
7	Hezron Ducreay	Wotton Waven	Teacher	elducreay@hotmail.com	2857425/3173463
8	McCarthy Marie	Copt Hall	Economist	mccarthymar@gmail.com	6168000
9	Virginia Bedneau	Wotton Waven	Vendor		3163515
10	Sherwin	Wotton Waven	Host at Guest house		6120403
11	Dorienn Joseph	Wotton Waven	Contractor	Guroo27@hotmail.com	2251641
12	Jamon Francis	Wotton Waven			
13	Mary Abraham	Wotton Waven			
14	Alina Morancie	Wotton Waven	Farmer		
15	Celsa Joseph	Wotton Waven			
16	George	Wotton Waven			
17	Kendell Ducreay	Wotton Waven			
18	Jose Allan	Wotton Waven			
19	Brenda Joseph	Wotton Waven			

Questions /Suggestions/Comments:

Laudat:

1. Will the WB review the assessment?
2. Was it necessary to dig the wells at different locations?
3. What is being put in place for pipes being passed over water sources? Why over Titou Gorge?
4. How many lands is the government going to acquire for the project?
5. The NTS does not answer what is actually going to happen on the ground or long-term health issues
6. What are the concrete measures to address concerns raised?
7. Has a public health assessment been done?
8. (linking the relation between geothermal activities and volcanic eruptions) Can you exclude that this type of activity will exclude a major earthquake? Re: geothermal plant in Basel Switzerland?
9. Are there two ESIA's? Does not see any content dealing with social issues in the NTS. Asks for policy makers and cabinet of Ministers to meet with the community – What if the company (DGDC) is sold afterwards?
10. Is there a policy in place for people not to become poorer? What is there for the community?
11. Not because it is funded by the WB its ok
12. An insurance fund should be established with \$5M for the community
13. How is the community as a whole going to benefit directly from the project?
14. The stakes are high for the people of Laudat – what is the value of the properties? Whose land is going to be taken for the project
15. Did the ESIA take into consideration future expansion?

Trafalgar:

1. Why the great distance between the production plant and reinjection wells?
2. On the natural hazards slide- there is mention of natural and other hazards.....what are the other hazards?
3. Is an emergency response plan included in the ESIA?
4. Is it standard for a production plant to be built so close to where people live?

Wotten Waven:

1. What is the difference in the way the different plants work?
2. How many people will be needed to run the plant? Comment: So, it is not going to generate any employment
3. What measures are on place if something goes wrong? E.g. release of poisonous steam
4. Counselling should be arranged for the people of Laudat to allay their fears with respect to this project and the dangers
5. Could there be a process for people of the Valley to have free hot water?
6. How will the plant be affected if there is an earthquake given that Dominica is due for one?
7. Will there be any effect on the Spas?
8. Will the plant contribute to global warming?
9. Would an earthquake have any effect on the wells?
10. How many gallons (of water) does 3 hours translate to?

11. What is the estimated lifespan of a production well?
12. How long have the wells in New Zealand lasted?
13. In terms of wells not producing – would it be due to the metal deteriorating?
14. Suggestion – that the project gives weekly updates to the communities
15. Is DGDC selling a product? How sure are we that electricity will be cheaper since DOMLEC has a monopoly?
16. Is there geothermal power in Hawaii?
17. Is Dominica due for a volcanic eruption?
18. Suggestion: People of the Valley should be compensated for the increased risk by having no electricity bills
19. How much power/electricity will we get out of the plant?
20. How much (electricity) is DOMLEC putting out?
21. What are the minor health impacts spoken about (in presentation)?
22. What happens to the waste from the plant?
23. What effects would a leak (of the reinjection line) have on the environment?
24. Will the pipeline interfere with the national trail?
25. What happens when the trail is shut down for maintenance?
26. How are private landowners being compensated?
27. What percentage of energy is from geothermal in NZ?
28. How soon will there be a reduction in electricity bills?
29. Suggestion – that guest houses in the Roseau Valley be used as accommodation for workers on plant
30. Where are the 12 properties to be acquired?
31. 4.4.2 of NTS can you clarify the comment on thermal spas.

Appendix K. Stakeholder Engagement Plan including Community Grievance Mechanism



Dominica Geothermal Development – Environmental and Social Impact Assessment

Ministry of Foreign Affairs and Trade

Stakeholder Engagement Plan

RZ020300-0002-NP-RPT-0003 | V2

July 2018



Dominica Geothermal Development – Environmental and Social Impact Assessment

Project No: RZ020300
 Document Title: Dominica ESIA Stakeholder Engagement Plan
 Document No.: RZ020300-0002-NP-RPT-0003
 Revision: V2
 Date: July 2018
 Client Name: Ministry of Foreign Affairs and Trade
 Project Manager: Alastair Brookes
 Author: Dorney Burgdorf
 Project No: RZ020300
 Document Title: Dominica ESIA Stakeholder Engagement Plan

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Document history and status

Revision	Date	Description	By	Review	Approved
A	5 Oct 2016	Draft for Issue to Client	D Burgdorf	T Strange	A Brookes
B	17 Oct 2016	Revision including Potentially Affected Parties	T Strange		
C	11 September 2017	Minor revisions following recent stakeholder consultation activities.	P Gabriel	D Burgdorf	
D	March 2018	Minor updates following World Bank comments	L. Turk	D Burgdorf	
E	April 2018	Updates following community surveys post Hurricane Maria	K Ashdown	L.Turk	
V1	June 2018	FINAL for ISSUE WITH ESIA	K Ashdown	L.Turk	A Brookes
V2	July 2018	ESIA Updated incorporating WB Comments	D. Burgdorf	B. Clarke	A. Brookes

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Appendix A. Stakeholder Engagement and Consultation Meeting Minutes

Appendix B. Summary of Focus Group Meetings

Appendix C. Grievance Mechanism Complaint Form

Appendix D. Grievance Mechanism Process

Appendix E. Communications Protocol

E.1 Introduction

E.2 Stakeholders Involved

E.3 Communications Capture

E.3.2 What communication does not need to be captured?

E.3.3 Style of Communications Stakeholders

E.4 How to capture the information

E.5 Time Frames

E.6 Communications Contact List

E.6.1 Points of contact

Appendix F. Communications Record

Important Note About Your Report

The sole purpose of this report and the associated services performed by Jacobs New Zealand Limited (“Jacobs”) is to describe the Stakeholder Engagement Plan (SEP) for the Dominica Geothermal Power Project in accordance with the scope of services set out in the contract between Jacobs and the New Zealand Ministry of Foreign Affairs and Trade (the Client). That scope of services, as described in this report, was developed with the Client, the Government of the Commonwealth of Dominica (GoCD) and the Developer (Dominica Geothermal Development Company (DGDC) established and owned by the GoCD).

Jacobs has been contracted by the Client to undertake the conceptual design and overall project definition through their engineering team. In preparing this ESIA report, Jacobs has relied upon, and presumed accurate, any information (or confirmation of the absence thereof) provided. Except as otherwise stated in the ESIA report, Jacobs has not attempted to verify the accuracy or completeness of any such information. If the information is subsequently determined to be false, inaccurate or incomplete then it is possible that our observations and conclusions as expressed in this report may change.

Jacobs derived the data in this report from information sourced as noted in the ESIA volumes and/or available in the public domain at the time or times outlined in this report. The passage of time, manifestation of latent conditions or impacts of future events may require further examination of the project and subsequent data analysis, and re-evaluation of the data, findings, observations and conclusions expressed in this report. Jacobs has prepared this report in accordance with the usual care and thoroughness of the consulting profession, for the sole purpose described above and by reference to applicable standards, guidelines, procedures and practices at the date of issue of this report. For the reasons outlined above, however, no other warranty or guarantee, whether expressed or implied, is made as to the data, observations and findings expressed in this report, to the extent permitted by law.

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Glossary

Acronym	Meaning
ADEME	French Environment and Energy Management Agency
AFD	Agence Francaise de Developpement
CLO	Community Liaison Officer
DGDC	Dominica Geothermal Development Company Ltd
DHTA	Dominica Hotel and Tourism Association
DOMLEC	Dominica Electricity Services Limited
DOWASCO	Dominica Water and Sewerage Company Limited
EIA	Environmental Impact Assessment
EHS	Environmental Health and Safety
GoCD	Government of the Commonwealth of Dominica
EMS	Environmental Management System
EPFI	Equator Principle Financial Institutions
ESMP	Environmental and social management plan
ESIA	Environmental and social impact assessment
IFC	International Finance Corporation
MWe	Mega Watt
MWe	Mega Watt Electric
NGO	Non-Government Organisation
O&M	Operations & Maintenance
OP	World Bank Operational Policy
PAP	Project Affected Persons
PPA	Power Purchase Agreement
PS	Performance Standard
RoW	Right of Way
SEP	Stakeholder Engagement Plan

1. Introduction

1.1 Background

The Commonwealth of Dominica is a small island developing state in the Caribbean Sea with a population of approximately 72,000 people and a land area of approximately 750 km². About 60% of the land is classified as a World Heritage site by UNESCO, due to its rich biodiversity. It is located near the centre of the string of islands known as the Lesser Antilles, between the neighbouring French territories of Martinique and Guadeloupe. The capital Roseau is located to the south west of the island and has a population of around 15,000 people.

Dominica’s power system relies heavily on diesel imports to generate electricity. Improving the power generation mix and reducing the cost and volatility of electricity prices have become a development priority for Dominica. To this end, geothermal exploration has been conducted in the Laudat-Wotten Waven-Trafalgar geothermal field in the Roseau Valley (Figure 1-1) and has proven the existence of a geothermal resource suitable for power generation.

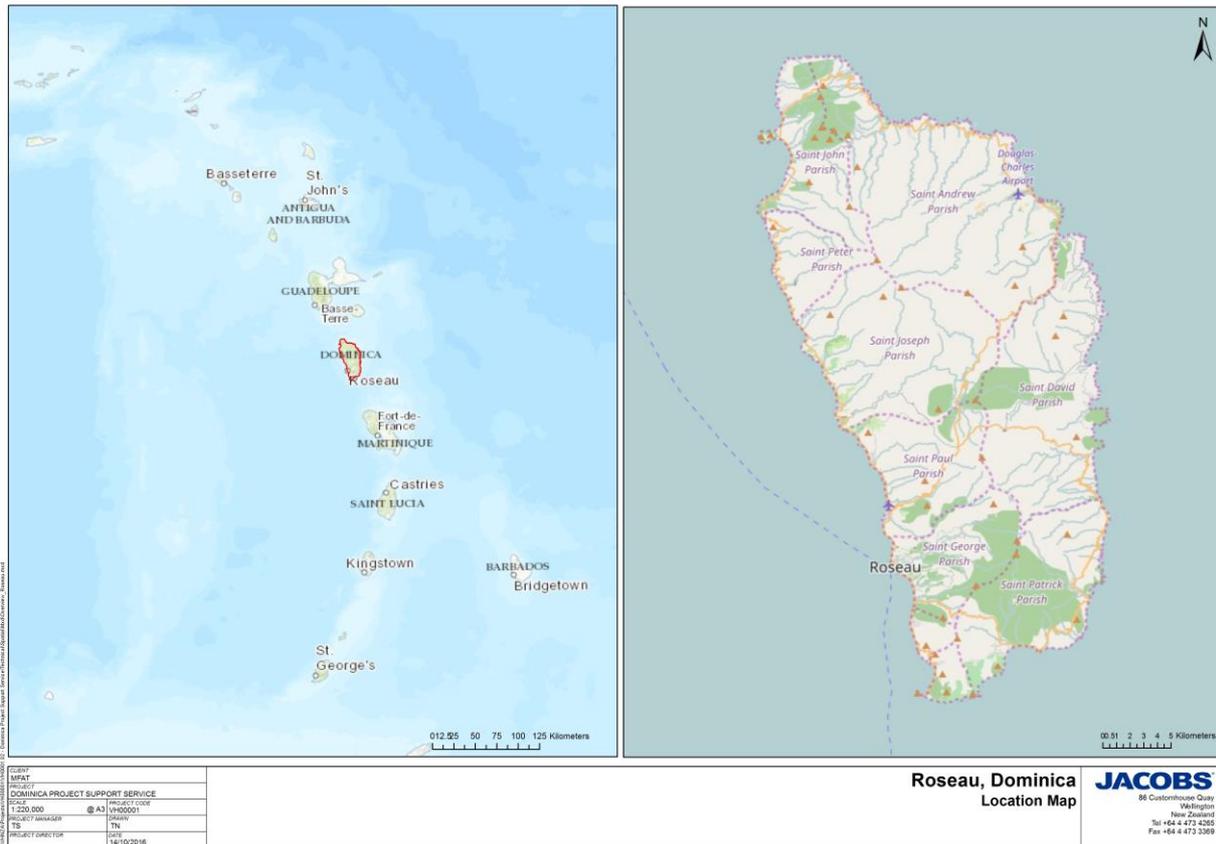


Figure 1.1 : Dominica’s location in the Caribbean

As with many other island nations, Dominica’s primary source of electricity production is from diesel generation, which exposes the country’s economy to uncertainty in regard to the cost and supply of diesel imports. Changing the power generation mix and reducing the cost and volatility of electricity prices have become development priorities for Dominica. Being a relatively young volcanic island, Dominica has significant geothermal resource potential. Therefore, since 2006 the Government of the Commonwealth of Dominica (GoCD) has pursued an exploration programme to evaluate the viability of geothermal resource in the Roseau Valley.

1.2 Purpose

This document is a Stakeholder Engagement Plan (SEP) for the Dominica Geothermal Project that sets out the approach to stakeholder and community consultation and disclosure for the lifecycle of the Dominica Geothermal Power Project (“the Project”).

The SEP was developed based upon a commitment to thorough stakeholder identification followed by open and comprehensive engagement activities to build trust with Project stakeholders. It sets out to define a framework of standardised measures to be undertaken to proactively engage Project stakeholders, undertake consultation and encourage participation in line with the relevant legal and regulatory requirements including good international industry practice and national legislation, while also being meaningful, well-coordinated and culturally appropriate. This process is critical to facilitate community understanding of the Project, manage expectations and concerns, and ensure that representation from all community groups including vulnerable stakeholders is included.

The SEP is an active working document which will be reviewed and updated on a regular basis by the Dominica Geothermal Development Company Ltd (DGDC) and the operator, should this ultimately be a different entity.

1.3 Objectives

The objectives of this SEP are to:

- Identify the local legal framework of consultation activities and disclosure requirements, particularly in respect of those public consultation activities that are directly required under the local permitting process;
- Identify potential stakeholders in the area of influence, as well as relevant interested parties such as government agencies and other key stakeholders;
- Record all consultation activities, including those prior to the commencement of the environmental and social impact assessment (ESIA) process;
- Describe how concerns or grievances will be handled;
- Provide an action plan for further consultation during preparation, construction and operational phases of the Project, including details on appropriate formats for effective and culturally meaningful interaction with the community and relevant stakeholders; and
- Provide a disclosure plan, including the identification of any locations where relevant Project documentation will be available locally and elsewhere as well as languages to be used.

1.4 Structure of Plan

The SEP is structured in accordance with the following chapters:

- Section 1 – Introduction
- Section 2 – Project Description
- Section 3 – Regulatory Requirements (public consultations and information disclosure requirements)
- Section 4 – Review of previous stakeholder engagement activities
- Section 5 – Stakeholder Identification
- Section 6 – Engagement Activities
- Section 7 – Implementation Timescales
- Section 8 – Grievance Mechanism
- Section 9 – Monitoring and Reporting

2. Project Overview

2.1 Geothermal Development Process

The overall geothermal development process is executed as follows (Table 2.1).

Table 2 1 : Geothermal Development Phases

No	Phase Name	Activities
1	Preparation	Project establishment, geoscientific investigations
2	Exploration	Exploration drilling and resource assessment
3	Appraisal	Appraisal drilling and bankable feasibility study
4	Construction	Production drilling; power plant construction and start-up

These phases are followed by commercial operation over the life of the plant and decommissioning in due course (or repowering if appropriate).

Transition from one phase to the next flows from a major investment decision, based on the prior work completed. Associated with this there will be a period during which funds are secured. The first phase culminates in the decision to undertake the exploration drilling programme (Phase 2). The second phase culminates in the decision to proceed with the appraisal drilling (Phase 3). The third phase culminates in the decision to construct the power plant (Phase 4). The fourth phase culminates in commercial operation of the power plant. For this project, the preparation and exploration phases are now complete.

2.2 Project Description

The Project comprises the development of a two-unit geothermal power plant with a gross capacity of 7 MWe in the Roseau Valley, Dominica. This covers the following stages: construction, completion, testing, commissioning, ownership, operation and decommissioning, including the steamfield, required electrical connections and integration with associated infrastructure. The preliminary design for the Project is ongoing, with detailed design to be completed following a formal tender process for an Engineer, Procure and Construct contractor(s) in 2018.

The power plant is proposed to be located in the village of Laudat. Three well pads will be used for the Project, located near Wotten Waven along with one reinjection well pad.

The Government has ownership of the existing well pads (WW-01, WW-02 and WW-03), whose locations are presented in Figure 2.1, along with the preferred injection line route. This route alignment will be finalised in close co-ordination with process engineering, mechanical, geotechnical and civil engineering design disciplines, along with the Government, Land and Survey Division and environmental and social scientists.

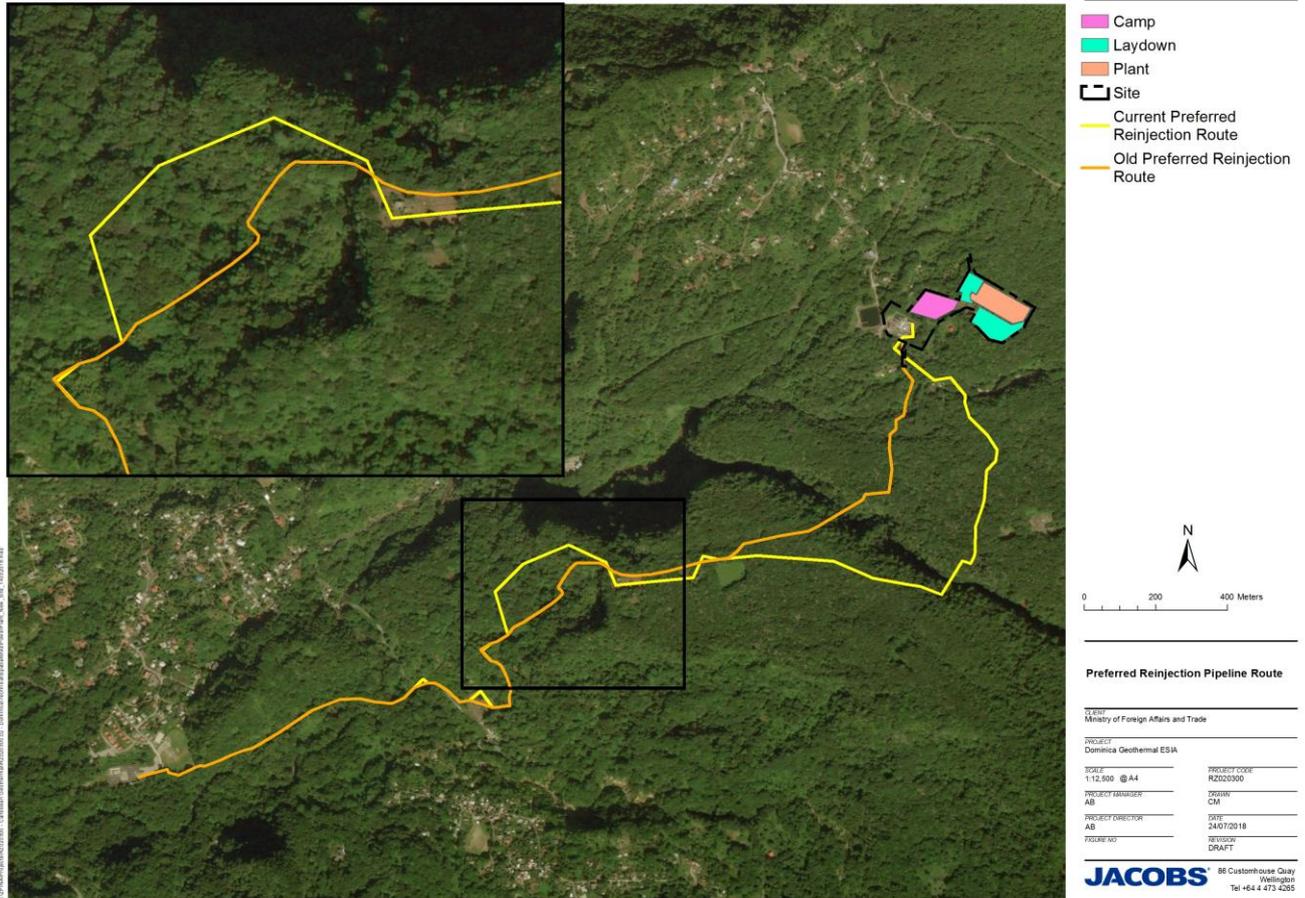


Figure 2.1: Preferred injection pipeline route from WW-P1 to WW-01 and WW-R1

The conceptual power plant layout is displayed in Figure 2.2 and land will have to be acquired to site the power plant and other associated infrastructure.

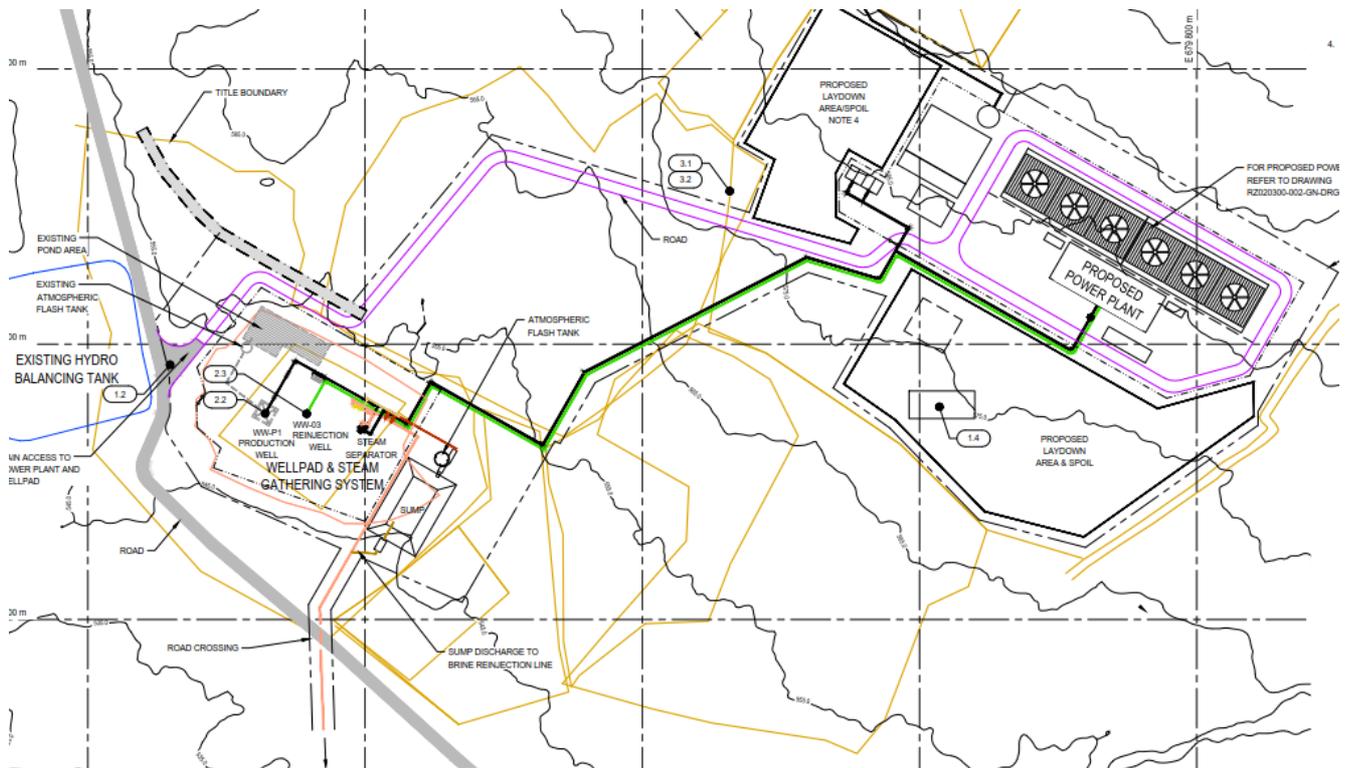


Figure 2.2 : Proposed Power Plant Site and Production Steamfield Layout

The area proposed for Project development is generally sparsely populated, characterised by some agroforestry and naturally vegetated areas. Brief descriptions of the main locations of Project infrastructure are as follows:

- Power plant comprising 2 x 3.5 MW_e units (either single flash steam condensing cycle or organic Rankine cycle units (binary turbine), which will be adjacent to wells WW-P1 and WW-03. The binary power plants may use wet cooling or dry cooling;
- Production well WW-P1 – The existing geothermal production well at Laudat is indicated to have potential to generate 6 to 9 MW_e and will be the sole production well for the project;
- Reinjection wells WW-R1 (located in Trafalgar) and WW-01 (located in Wotten Waven) – The used geothermal fluid (brine and possibly some steam condensate) produced from production well WW-P1 would be disposed of into reinjection wells WW-R1 and WW-01 via a 250 to 300 mm diameter reinjection pipeline of up to 3.5 km in length;
- Steamfield infrastructure including two phase piping, steam separator, atmospheric flash tank, brine collection and disposal system, condensate collection and disposal system, pressure relief system, storage sump and rock muffler;
- Supporting infrastructure including existing well pads, turbine building, primary and ancillary equipment, cooling system, and water supply; and
- 11 kV interconnection to the DOMLEC electricity grid at the power plant site.

Figure 2.3 provides the locations of the well pads (WW-P1, WW-03, WW-R1 and WW-01) and reinjection lines. For further details, reference should be made to the ESIA Volume 1: Introduction and ESIA Volume 5: Technical Appendices, Technical Report – Detailed Process Description

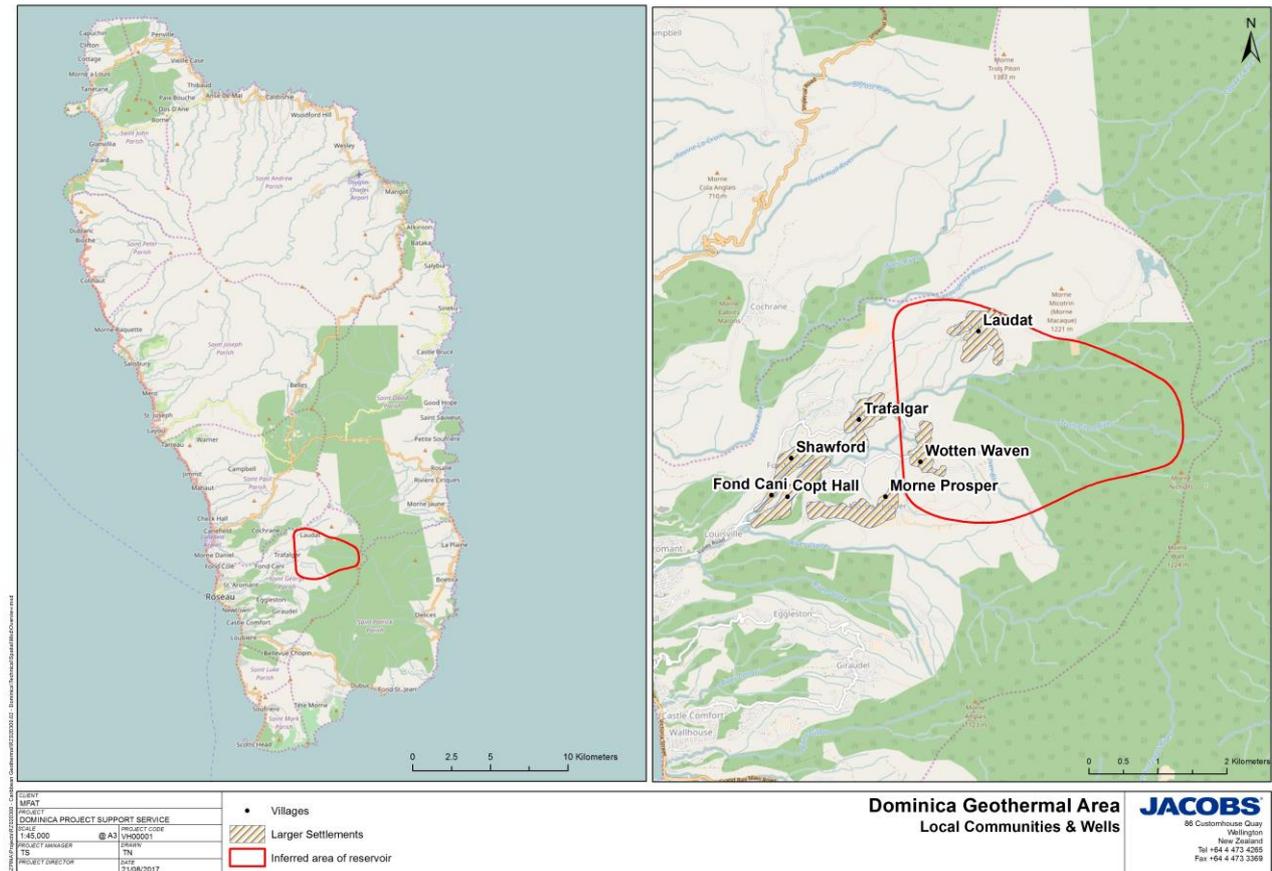


Figure 2.3 : Location of Roseau Valley and Inferred Area of Geothermal Reservoir (Site of proposed Geothermal Power Plant)

The exploration programme has been conducted in a phased manner over the course of approximately 10 years and is summarised in Table 2.2.

Table 2 2 : The phases of the Dominica geothermal exploration programme.

No.	Phase	Activities	Status
1	Preparation	Project establishment, geoscientific investigations	Complete
2	Exploration	Exploration drilling of three slim hole wells and resource assessment	Complete
3	Production & Testing	Production drilling and testing of one full size well and drilling of one reinjection well	Complete
4	Planning / Construction	Present phase comprising power plant and reinjection pipeline construction and start-up	Ongoing

The geothermal project started as part of the European cooperation programme INTERREG III-B Caribbean space, in partnership with the Regional Councils of Guadeloupe and Martinique, the 'Agence de l'Environnement et de la Maîtrise de l'Energie' (ADEME), the 'Bureau de Recherches Géologiques et Minières' (BRGM) and the French company 'CFG Services'. The geothermal study area of interest was identified in June 2008 by BRGM after evaluation of resources and exploratory drilling programme. Focused on the Roseau Valley geothermal field, and located about 8 km east north east of the Capital of Roseau, it includes most part of the high temperature reservoir (210-230°C) (Figure 1.2).

To prove the existence of a viable geothermal resource, an exploratory phase was launched between 2011 and 2012 and involved the drilling of three test (slim) wells in the villages of Wotten Waven (well site WW-01) and Laudat (well sites WW-02 and WW-03). The final drilling depths were between 1200 m and 1613 m and

confirmed the presence of a geothermal resource with a 50% probability of having sufficient capacity for approximately 65 MW of power generation.

The next phase of the project commenced in 2013, included drilling and testing of two full size production wells, with a view to developing a 10-15 MW small geothermal power plant. It comprised the installation of a production platform, drilling and testing a production well in Laudat (WW-P1) and a re-injection well in Trafalgar (WW-R1). The drilling of these two full-size wells, with a depth comprised between 1501 m and 1915 m, was completed in 2014.

The GoCD has now proceeded with the planning and construction phase of the Project, establishing the Dominica Geothermal Development Company Ltd (DGDC), which is tasked with developing and operating a 7 MW geothermal power plant. DGDC will sell electricity to DOMLEC under the regulatory framework established through the Electricity Supply Act 2006. DGDC will operate as a private company under the laws of the Commonwealth of Dominica.

The Project will be financed using grant monies from international agencies (the New Zealand Aid Programme) and bilateral partners (United Kingdom Department for International Development (DFID), Small Island Development States (SIDSDOCK), the World Bank Group (WBG) and with the GoCD's own resources.

2.2.1 Environmental and Social Work Completed

The Project benefits from having a wealth of environmental studies data collected for environmental assessments for exploration and drilling phases. To date the following environmental and social studies have been completed:

- Caraïbes Environnement Développement & Coll (2009) Regulatory Impact Assessment on the Initial Environment - Environmental Feasibility Study.
- Caraïbes Environnement Développement & Coll (2011) Stage 1: Exploration Drilling Process – Environmental Impact Assessment.
- Caraïbes Environnement Développement & Coll (2013) Stage 2: Preliminary Environmental Impact Assessment of Geothermal Production and Re-Injection Drilling Wells in Dominica – Environmental Impact Assessment.

To support the preparation of an ESIA for the Project, baseline surveys of the social, physical and biological environment within the Roseau Valley were completed between October 2013 and April 2015. These were summarised in the following reports (collectively referred to as the 'Baseline Study'):

- Caraïbes Environnement Développement & Coll (2015a) Initial environmental status of the Roseau Valley in Dominica, planned for development of geothermal electricity production. Final report, May 2015. Section 3 Biodiversity / Terrestrial Flora and Fauna.
- Caraïbes Environnement Développement & Coll (2015b) Initial environmental status of the Roseau Valley in Dominica, planned for development of geothermal electricity production. Final summary report.

As part of the work undertaken by Jacobs in the ESIA Terms of Reference (TOR), a review of these previous studies was carried out (provided for reference in Appendix C of the ESIA). Further details of these studies are provided in Volume 2 – Environmental Impact Assessment.

A draft ESIA for the current Project was completed in September 2017. The ESIA has since been updated following Hurricane Maria, which devastated the island in September 2017. It was reported that the majority of the island's inhabitants have been affected by the Hurricane. Impacts include loss of homes, business, schools, social infrastructure and basic amenities such as water and electricity.

2.3 Project Governance

In line with the establishment of the DGDC, execution of the Project will be structured as follows:

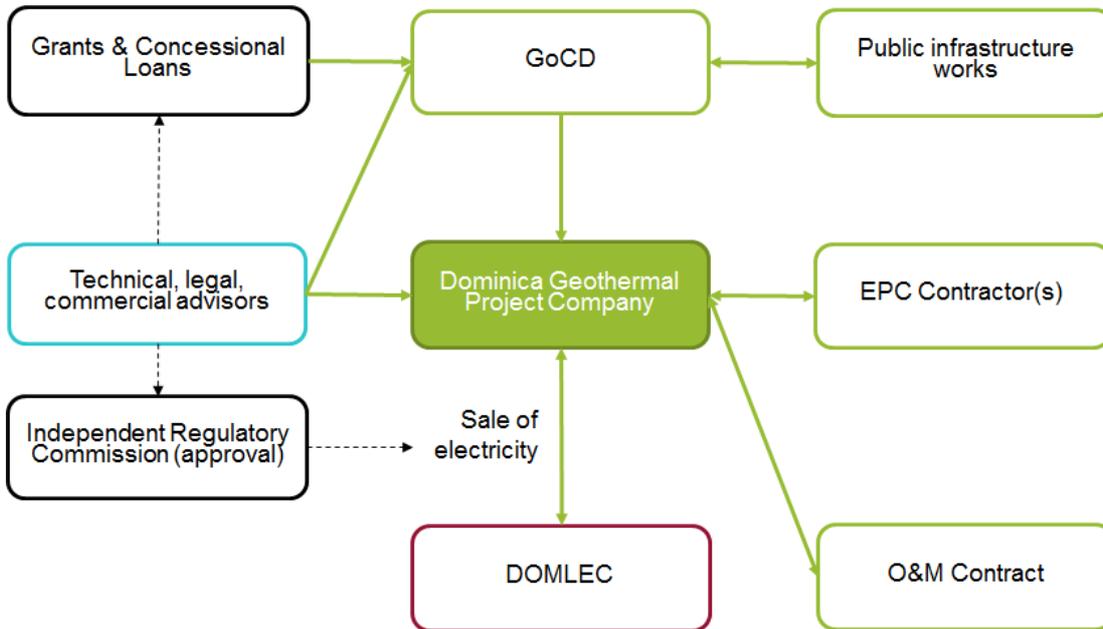


Figure 2.4 :Proposed Project Structure

2.4 Key Issues

The key environmental and social issues/risks associated with this Project, which were identified through a preliminary screening exercise, are highlighted in Table 2.3 below:

Table 2 3 : Key Issues/Risks to be addressed in ESIA

Aspect	Potential Impact
Air Quality	<ul style="list-style-type: none"> Emission of gases such as hydrogen sulphide from the power plant during operation Generation of dust through earth moving activities.
Natural Hazards	<ul style="list-style-type: none"> Risks related from natural hazards, such as seismic activity, landslides, hurricanes and flood inundation.
Community Health	<ul style="list-style-type: none"> Potential impacts on community health, such as through emission of hydrogen sulphide and generation of dust.
Social (including land acquisition)	<ul style="list-style-type: none"> Any physical displacement of members of the community as a result of land acquisition for the development of the power plant and steamfield. Physically displaced parties may require assistance with relocation. Any economic displacement which may occur through construction of the geothermal power plant and steamfield inhibiting use of land acquired for the development. There is also the potential for temporary effects upon tourism if works inhibit access to tourist attractions. Appropriate consideration will be given to livelihood restoration for any parties that are economically displaced by the Project. Positive impacts upon the local community through the generation of employment opportunities.
Working Conditions	<ul style="list-style-type: none"> Consideration of the working conditions of employees/contractors engaged in construction and operation.

Aspect	Potential Impact
Noise	<ul style="list-style-type: none"> Construction and operation of the power plant will generate noise which may impact upon the surrounding communities and wildlife.
Pest species	<ul style="list-style-type: none"> Importation of machinery/equipment for use in construction and operation can lead to introduction of pest species.
Soil and Groundwater	<ul style="list-style-type: none"> Spillage of hazardous substances stored/used in construction and operation of the power plant.
Terrestrial flora and fauna	<ul style="list-style-type: none"> Removal of vegetation and earthworks to enable construction of the re-injection pipeline, which could result in impacts on biodiversity. Special reference will be made to any rare or threatened species as well as endemic species of both animals and plants.
Visual Amenity	<ul style="list-style-type: none"> Construction of new infrastructure will alter the visual landscape.
Water Quality	<ul style="list-style-type: none"> Re-injection of brine and condensate. Sedimentation of water courses during construction as result of run-off from earthworks. Spillage of hazardous substances used during construction and operation of the power plant. Discharge of stormwater containing contaminants from the power plant to local water courses. Periodic release of cooling water to local water courses (if water cooling proposed).
Water resources	<ul style="list-style-type: none"> Abstraction of water for use in cooling system (if water cooling proposed). Abstraction of water for domestic purposes within power plant.

3. Regulations and Requirements

3.1 Introduction

The following provides a brief summary of the international and national legislation and standards applicable to consultation for the Project.

3.2 Legislation of the Commonwealth of Dominica

In accordance with the Commonwealth of Dominica Physical Planning Act 2002, development permission is required before the construction of the Project may commence. Clause 17 of the Act states:

‘No person shall carry out any development of land except under and in accordance with the terms of a development permission granted in that behalf prior to the commencement of such development...’

Applications for development permission must be submitted to the Physical Planning Department within the Ministry of Agriculture and Environmental Protection along with an Environmental Impact Assessment (Clause 20(1)(b)).

Further, in accordance with Clause 22(3), where an Environmental Impact Assessment is required, the Authority shall:

- a) publish a notice in at least one daily newspaper and affix a notice on the land to which the application relates that an application to develop land has been received and will be determined on a date specified in the notice; and
- b) invite comments and representations either in writing or orally on such application.

3.3 World Bank Operational Policies

This study was conducted taking into account Dominica’s regulations and the requirements of lenders, in this case the World Bank Group (WBG). This includes examination and verification of the project’s compliance with WBG’s Operational Policies. The applicable policies to this project are: OP4.03 (World Bank Group Performance Standards for Private Sector Activities) and OP4.12 (involuntary Resettlement). Under OP4.03, the applicable performance standards are:

- Performance Standard 1: Assessment and Management of Environmental and Social Risks and Impacts;
- Performance Standard 2: Labour and Working Conditions;
- Performance Standard 3: Resource Efficiency and Pollution Prevention;
- Performance Standard 4: Community Health, Safety, and Security
- Performance Standard 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources;
- Performance Standard 7: Indigenous Peoples; and
- Performance Standard 8: Cultural Heritage.

PS 7 - Indigenous People does not apply to the Project. People living in the Project area are not categorized as Indigenous People. They are part of the mainstream Dominican society, and do not have any specific economic or cultural activity different from the rest of the society. They participate fully in the socioeconomic life of the society.

3.3.1 Performance Standard 1: Assessment and Management of Environmental and Social Risks and Impacts

IFC Policy requires project proponents to engage with affected communities through disclosure of information, consultation, and informed participation, in a manner commensurate with the risks to and impacts on the affected communities. PS1 contains clear requirements for community engagement, disclosure of information and consultation. The key objectives of PS1 are given as follows:

- To identify and evaluate environmental and social risks and impacts of the project.
- To adopt a mitigation hierarchy to anticipate and avoid, or where avoidance is not possible, minimize, and, where residual impacts remain, compensate/offset for risks and impacts to workers, Affected Communities, and the environment.
- To promote improved environmental and social performance of clients through the effective use of management systems.
- To ensure that grievances from Affected Communities and external communications from other stakeholders are responded to and managed appropriately.
- To promote and provide means for adequate engagement with Affected Communities throughout the project cycle on issues that could potentially affect them and to ensure that relevant environmental and social information is disclosed and disseminated.

Performance Standard 1 requires that particular attention be given to:

- *Vulnerability:* As part of ESIA, individuals and groups that may be differentially or disproportionately affected by the project because of their disadvantaged or vulnerable status must be identified. Where groups are identified as disadvantaged or vulnerable, the project must propose and implement differentiated measures if necessary so that adverse impacts do not fall disproportionately on them and they are not disadvantaged in sharing development benefits and opportunities.
- *Community engagement:* Community engagement must be undertaken with affected communities on an ongoing basis and must include disclosure of information. Engagement must be free of external manipulation, interference, coercion or intimidation, and must be conducted on the basis of timely, relevant, understandable and accessible information.
- *Disclosure:* During the process of Environmental and Social Assessment (ESIA), the Project must publicly disclose the ESIA document, including an Environmental and Social Management Plan (the document which describes the measures to be put in place to manage impacts). If communities may be affected by risks or adverse impacts from the Project, the Project must provide such communities with access to information on the purpose, nature and scale of the project, the duration of proposed project activities, and any risks to and potential impacts on such communities. This must be undertaken in a manner that allows sufficient time for the affected communities to consider the issues and provide feedback. For projects with adverse social or environmental impacts, disclosure must occur early in the ESIA process, in any event before the project construction commences, and on an ongoing basis.
- *Community risk and impact:* If affected communities may be subject to risks or adverse impacts from a project, the proponent must undertake a process of consultation in a manner that provides the affected communities with opportunities to express their views on project risks, impacts, and mitigation measures, and allows proponents to consider and respond to any comments received. Consultation must be undertaken in a manner that is inclusive and culturally appropriate.
- *Informed participation:* For projects with significant adverse impacts on affected communities, the consultation process must ensure that free, prior and informed consultation with affected communities occurs and that processes exist to facilitate participation by those affected. Informed participation involves organized and iterative consultation, leading to the proponent incorporating into their decision making process the views of the affected communities on matters that affect them directly, such as proposed mitigation measures, sharing of development benefits and opportunities, and implementation issues.
- *Grievance mechanism:* The proponent must establish a grievance mechanism to receive and facilitate resolution of the affected communities' concerns and grievances regarding the project's social and environmental performance. The grievance mechanism must be scaled to the risks and adverse impacts of

the project. It must address concerns promptly, using an understandable and transparent process that is culturally appropriate and readily accessible to all segments of the affected communities, at no cost and without retribution.

- *Broader stakeholder engagement:* The proponent must identify and engage with stakeholders that are not directly affected by the Project but those that have established relationships with local communities and/or interest in the Project – local government, civil society organisations, etc. – and establish a dialogue.
- *External reporting:* The proponent must provide periodic reports that describe progress with implementation of the Environmental and Social Management Plan on issues that involve ongoing risk to or impacts on affected communities, and on issues that the consultation process or grievance mechanism has identified as of concern to those communities. These reports must be in a format accessible to the affected communities. The frequency of these reports must be proportionate to the concerns of affected communities but not less than annually. During the construction period of the Project, feedback must be provided to the affected communities on a monthly basis.

3.3.2 OP 4.12- Involuntary Resettlement

According to OP 4.12, involuntary resettlement may cause severe long-term hardship, impoverishment, and environmental damage unless appropriate measures are carefully planned and carried out. For these reasons, the overall objectives of the Bank's policy on involuntary resettlement are the following:

- (a) Involuntary resettlement should be avoided where feasible, or minimized, exploring all viable alternative project designs.
- (b) Where it is not feasible to avoid resettlement, resettlement activities should be conceived and executed as sustainable development programs, providing sufficient investment resources to enable the persons displaced by the project to share in project benefits. Displaced persons should be meaningfully consulted and should have opportunities to participate in planning and implementing resettlement programs.
- (c) Displaced persons should be assisted in their efforts to improve their livelihoods and standards of living or at least to restore them, in real terms, to pre-displacement levels or to levels prevailing prior to the beginning of project implementation, whichever is higher.

OP 4.12 covers direct economic and social impacts that both result from Bank-assisted investment projects and are caused by:

- (a) the involuntary taking of land resulting in relocation or loss of shelter;
 - (1) lost of assets or access to assets; or
 - (2) loss of income sources or means of livelihood, whether or not the affected persons must move to another location; or
 - (3) the involuntary restriction of access⁹ to legally designated parks and protected areas resulting in adverse
- (b) impacts on the livelihoods of the displaced persons.

3.4 Good International Industry Practice

The preparation of this SEP has been informed by the following IFC good practice guidance documents:

- Stakeholder Engagement: A Good Practice Handbook for Companies Doing Business in Emerging Markets (May 2007); and
- Doing Better Business Through Effective Public Consultation: A Good Practice Manual (November 1998).

World Bank Operational Policy (OP) 4.01 Environmental Assessment states that for all Category A and B Projects proposed for World Bank financing, during the ESIA process the borrower must consult Project-affected persons (PAPs) and groups and local non-governmental organizations (NGOs) about the Project's environmental aspects and takes their views into account. The borrower must initiate such consultations as early as possible.

WB OP 4.01 also specifies information disclosure requirements. For meaningful consultation between the borrower and Project-affected groups and local NGOs on all Category A and B Projects, the borrower must provide relevant material in a timely manner prior to consultation and in a form and language that are understandable and accessible to the groups being consulted.

4. Review of Stakeholder Activities to Date

4.1 Overview

The following presents a summary of the consultation activities undertaken to date and on-going for the Project.

4.2 General Project Consultation Activities and Consultation During Previous Geothermal Phases

During the geothermal drilling phase, eleven general public meetings were held in the potentially affected communities in November and December 2013 and January 2014. Five were held in Laudat, three in Trafalgar and three in Wotten-Waven. A visit to the current geothermal power plant in Guadeloupe was also conducted in 2012 with members of the community to experience first-hand the workings of an operational plant. Additionally, school visits were conducted in February and March 2012 from the Wotten Waven Primary School, Trafalgar Primary School, Morne Prosper Primary School, Laudat Primary School, and Laudat Primary School where students and staff toured the drilling sites. Press releases were published in June, August, and September 2017 informing the community about the Project and again in February, March and April 2018.

4.3 ESIA Consultation Activities

During the current Project development phase, a town hall meeting was held in Trafalgar in December 2016 with approximately 40 in attendance to discuss the current project and ESIA. Another town hall meeting was held in Laudat in July 2017 with 43 in attendance. A third town hall meeting was held in Wotten Waven in August 2017. A final townhall meeting will be held to present the findings of the ESIA in May or June 2018. In order to facilitate further understanding of community needs and conditions, focus group meetings were held in 2016, 2017 and 2018 in Wotten Waven, Trafalgar and Laudat, described in further detail below. Because the total population of the Project AOI is relatively small (approximately 1,600), and given that the general public and many of the focus groups and landowners that would be affected by the Project are the same parties, the four formal public meetings and 15 informal forums held on the Project were considered representative of the community.

A total of 15 focus group meetings were held as part of the ESIA baseline data collection. A meeting with six representative community leaders from all of the potentially affected communities was held in Trafalgar in November 2016 to discuss the Project and the most effective means of stakeholder engagement. Focus groups meetings were also held in June, July and August of 2017 including meetings with representatives of local hotels and resorts, handicraft vendors, hot springs businesses, and unemployed parties in the area. Groups consisted of 5-15 people and targeted questions were asked and recorded.

Five of the focus group meetings were held in the communities in March 2018 following Hurricane Maria. These included meetings with community women in Laudat, Wotton Waven and Trafalgar, and vendor meetings in Wotton Waven and Trafalgar, to identify the impacts on the community of Hurricane Maria which hit Dominica in September 2017 and to understand how conditions in the Project area have changed since the ESIA baseline data was collected pre-Hurricane Maria. A Table showing the types of comments made during the ESIA Consultation Activities and where subsequent responses can be found in the ESIA is included below.

Table 4.1: Summary of Consultation Comments and where Further Information can be Found in the ESIA

Consultation	Comment Category	ESIA Reference
Laudat Community at Laudat Primary School (29/06/2017)	Noise level of the project and effect on the community	EIA (Volume 2) Section 12 – Noise (Section 12.5 – Assessment of Impacts)
Papillote Wilderness Retreat (30/06/2017)		
Wotton Waven Spa Operators		
Laudat Community at Laudat Primary School (29/06/2017)	Community benefits	Employment and community benefits: SIA (ESIA Volume 3) Section 6.1.1 –
Papillote Wilderness Retreat (30/06/2017)		

Consultation	Comment Category	ESIA Reference
Wotton Waven Spa Operators		Assessment of Impacts and SIA (ESIA Volume 3) Section 8.1.1 Employment and Tourism
Papillote Wilderness Retreat (30/06/2017)	Will there be a social/community development fund	Employment and community benefits: SIA (ESIA Volume 3) Section 6.1.1 – Assessment of Impacts and SIA (ESIA Volume 3) Section 8.1.1 Employment and Tourism
Laudat Community at Laudat Primary School (29/06/2017)	Will the re-injection pipeline pass through villages?	Preferred route of re-injection pipeline: SIA (ESIA Volume 3) Figure 4.3 Location of Power Plant and Reinjection Pipeline
Papillote Wilderness Retreat (30/06/2017)	What will be the visual impact of the project	EIA (ESIA Volume 2) Section 9 – Landscape and Visual (Section 9.3 – Assessment of Impacts)
Papillote Wilderness Retreat (30/06/2017)	What will the impact on tourism be? Concerns that it will have a negative impact	Tourism impacts: SIA (ESIA Volume 3) Section 6.2.5 Impacts to Tourism Tourism enhancement and mitigation: SIA (ESIA Volume 3) Section 8.1.1 Employment and Tourism
Papillote Wilderness Retreat (30/06/2017)	Traffic impacts on the community and local businesses	Traffic impacts: EIA (ESIA Volume 2) Section 16 – Traffic and Access (Section 16.3 Assessment of Impacts)
Wotton Waven Spa Operators		
Papillote Wilderness Retreat (30/06/2017)	Air quality impacts	Air Quality impacts: EIA (ESIA Volume 2) Section 4 – Air Quality (Section 4.3 Assessment of Impacts)
Wotton Waven Spa Operators		
Papillote – Community Leaders of the Roseau Valley	Resettlement and land acquisition impacts and plans for the community and businesses	Resettlement mitigation plans: SIA (ESIA Volume 3) Section 8.1.2 Physical and Economic Displacement Land acquisition impacts: SIA (ESIA Volume 3) Section 6.2 Land Acquisition, Physical Displacement and Resettlement Impacts
Papillote Wilderness Retreat (30/06/2017)		
Wotton Waven Spa Operators		
Wotton Waven Spa Operators	What happen if the reinjection pipe has a leak and dangerous fluids are flowing on the surface?	ESIA Volume 2, section 15, Hazardous Substances and Waste and ESIA Volume 3, SIA, Emergency Response Plan
Laudat Community at Laudat Primary School (29/06/2017)	When and how will payment be made for property and land acquisitions?	See the ARAP.
Laudat Community at Laudat Primary School (29/06/2017)	Potential for community shares in the Project	Outside of the scope of ESIA
Papillote Wilderness Retreat (30/06/2017)		
Papillote Wilderness Retreat (30/06/2017)	Why was solar power not considered?	See ESIA Volume 1: Introduction.
Papillote Wilderness Retreat (30/06/2017)	Why was this type of consultation not done	See SEP for a full list of consultation activities in Appendix C of the ESIA.

Consultation	Comment Category	ESIA Reference
	before decision was made to drill?	
Papillote Wilderness Retreat (30/06/2017)	Total cost of the Project	Outside of the scope of ESIA
Wotton Waven Spa Operators	Project start date and duration	See ESIA Volume 1: Introduction.

The details of consultation activities held as part of the ESIA process for the current Project are presented in the appendices to this report and include the following:

Laudat - Public Meetings:

- January 20, 2011;
- November 11, 2011;
- February 15, 2012,
- April 13 and 16th 2012;
- November 14, 2013;
- December 11th 2013;
- January 23, 2014;
- July 2017; and
- March 17, 2018.

Trafalgar - Public Meetings:

- January 12, 2011;
- November 8, 2011;
- March 28, 2012;
- November 12, 2013;
- December 12th, 2013;
- December 2016; and
- March 18 and 25, 2018.

Wotten-Waven - Public Meetings:

- January 16, 2011;
- November 10, 2011;
- June 13, 2012;
- December 13, 2013;
- March 24, 2018.

In addition, the following visits were conducted at the site with schools from Roseau Valley - presentation of Project and distribution of promotional items to students and staff:

- Wotten Waven Primary School: February 8, 2012;
- Trafalgar Primary School: February 16, 2012;
- Morne Prosper Primary School: February 8, 2012; and
- Laudat Primary School: March 8, 2012.

4.3.1 ESIA Disclosure

The ESIA Non-Technical Summary was disclosed to the communities of the Roseau Valley via three public meetings: one in Laudat, one in Trafalgar, and one in Wotten Waven in the first week of July. Meetings were attended by Jacobs, DGDC, and approximately 20 members of each community. The community had another opportunity to express concerns and ask questions about the Project and ESIA findings. Concerns generally included community health and safety issues, natural hazards, employment and construction impacts. A summary of the issues raised by each community is provided below.

4.3.1.1 Laudat

In Laudat, a community meeting was held on Tuesday 4th July 2018. Concerns expressed by the community included technical questions about the pipeline and public health considerations associated with operations of the plant. Community members also voiced concerns about the risks associated with volcanic activity near the project, equipment failure, and other natural disasters. Community members also expressed the desire to see policy changes associated with the Project and the need for some community benefit projects that would be realised in the community. They also asked about land acquisition and noted that Laudat has been the location for several other projects where few benefits were realised in the local community. The DGDC Team explained the costs and the benefits of the project and the ESIA findings in terms of H2S. DGDC also explained the technology being utilised in the plant and the low risks associated with this type of equipment. The DGDC Team further explained the risks and the planning and design measures that were selected for this project given the topography, risk of landslides and recent flooding from Hurricane Maria and the EPC Contractor requirements that will be put in place to reduce nuisance and community health and safety impacts such as the emergency response and other planning procedures. The current status of land acquisition was also explained and the need to complete compensation before construction can begin, as per Op 4.12. Ongoing monitoring and preventative measures such as the traffic management plan and erosion control measures were also explained. Comments on policy and community benefits were noted, but it was explained that this is ultimately under the control of government and policymakers, rather than the project.

4.3.1.2 Trafalgar

In Trafalgar, a community meeting was held on Wednesday 5th July 2018. Fewer comments were made at this meeting than in Laudat or Wotten Waven, likely because the community is further from the power plant site. The community asked a few technical questions about the distance of the pipeline and natural hazards that could affect the project. They also asked about the proximity to the nearby communities from the power plant and emergency response. The DGDC Team explained the risks and the planning and design measures that were selected given the topography, risk of landslides and recent flooding from Hurricane Maria. DGDC also explained the emergency response and planning procedures that will be put in place for the Project. Examples of other projects where a geothermal plant was located in close proximity to the community were given.

4.3.1.3 Wotten Waven

In Wotten Waven, a community meeting was held on Thursday 6th July 2018. A lot of concern was expressed at the meeting particularly about public health issues, employment, and direct benefits to the community. Specifically, people asked about job requirements, accidents at the plant and/or the pipeline, detrimental effects on thermal spas, the expected lifespan of a well, consumer benefits on electricity bills, health impacts of construction and noise, and property acquisition. A community member also suggested the need for a weekly briefing in the community during the construction phase. The DGDC Team explained the design of the plant and reinjection route given the topography, risk of landslides and recent flooding from Hurricane Maria and to reduce noise and visual affects at properties near the power plant. DGDC also explained the technology being utilised in the plant and the low risks associated with this type of equipment. The lack of changes anticipated for the thermal surface features were also explained given the depth of the wells and associated activity and the plan to conduct ongoing monitoring of these features was also shared. The DGDC Team further explained in detail the noise associated with the steam blowing phase and the limited timeframe for this testing. The current status of land acquisition was also explained and the need to complete compensation before construction as per OP 4.12.

Following the disclosure of the NTS, the full ESIA will be made available to the community in August 2018 via the internet, a hard copy will be available at DGDC's offices, and additional public meetings will be held and publicised by the media.

5. Stakeholder Analysis

5.1 Socio-economic Profile of the Community

The Project is located in the Roseau Valley which consists of 1,823 residents. The Valley contains 4 hamlets including Laudat (population 321), Wotten Waven/Casseau (population 313), Copthal (population 230) and Trafalgar (population 959). The creole culture is predominant and 80% of the population speak Creole even if English remains the official language. Households in the area consist of 2.7 people and women are in the minority (representing 48 percent of the population). The area is rural, but located in close proximity to the town of Roseau and poverty is lower in this area compared to the rest of the country. Tourism is the predominant income source in the community followed by agriculture. Based upon consultation conducted to date, there is a great deal of community concern about the health and safety and the economic impacts of the Project.

5.2 Project Stakeholders

Stakeholders can be individuals and organisations that may be directly or indirectly affected by the Project either in a positive or negative way, and who may wish to express their views. DGDC has undertaken an initiative to identify key stakeholders relevant to the Project. As part of this process, it is important to identify individuals and groups outside of the mainstream who may find it more difficult to participate in public consultation activities and those who may be disproportionately affected by the Project because of their vulnerable status in society or the community.

Details of community stakeholders are described in more detail below. Baseline studies undertaken during the ESIA, land acquisition process and local level engagement were used to inform this process. Table 5-1 identifies potential stakeholders and their interest in the Project.

Table 5.1 : Potential stakeholders and their interest in the Project

Group	Stakeholders		Interest in Project
A. Directly or indirectly affected by the Project	A1.	Landowners and landowner family owners	Land acquisition, compensation
	A2.	Farmers cultivating land or animals in and around the Project site	Resettlement, loss of access to resources, compensation, environmental impact, employment and community benefits
	A3.	Communities within Roseau Valley	Environmental impact, employment and community benefits, possible overlap with A2 above
	A4.	Communities in the path of the transmission line	Resettlement, loss of access to resources, compensation, environmental impact, employment and community benefits
	A5.	Communities affected by the traffic of the construction and the transport of all materials for construction	Environmental impact, employment and community benefits
	A6.	Local Businesses, Tourism, Hotels in the Roseau Valley	Environmental Impact, Economic impact, regulate P
	A7.	Regulatory agencies	Environmental Impact, Economic development, regulate Project
	A8.	Local Authorities and Administrations (Roseau Valley Parliamentary)	Social & environmental impact, employment and community benefits, economic development
	A9.	Central Authorities and Administrations (Ministry of Public Works, Energy and Ports)	Environmental responsibility, economic development

Group	Stakeholders		Interest in Project
B. Have an “interest” in the Project or Project Sponsor	B1.	Local NGOs, local political or community organizations (e.g. youth associations, environmental NGOs)	Environmental and social impacts, alternatives to the use of hydro-power
	B2.	International NGOs with general interest in the area	Environmental and social impacts, alternatives to the use of hydro-power
	B3.	Media	Already aware of the Project
	C1.	Local and Province level regulatory agencies	See A.7 above
C. Have the potential to influence Project outcomes	C2.	Local Authorities and Administrations	See A.8 above
	C3.	Other Ministries and government organizations (Ministry of Agriculture, etc.)	See A.9 above

The relevance of each stakeholder to the Project has been considered in terms of whether they are:

- “Impact based” (typically primary stakeholders): directly affected stakeholders through adverse and beneficial Project impacts such as physically or economically displace groups or individuals – the intensity of engagement will be greatest with impact based stakeholders and special efforts will need to be made to reach out to disempowered, socially excluded and/or vulnerable groups who may not have a good understanding of their rights or entitlements and may not be familiar with engagement activities; or
- “Interest based” (typically secondary stakeholders): who may have an interest to influence the Project for their own objectives and be able to influence the Project or public perception, for example NGOs – it is important to ensure that potential critics of the Project and those who can positively influence the Project design are appropriately engaged at the correct moments in order to facilitate their effective input and to manage potential negative perceptions or outcomes (such as organised objection/disruption).

It is important to note that “impact-based” stakeholders are on the whole “interest based as well;” for example local communities may be impacted by construction activities and effects such noise and dust, whilst at the same time they have an interest in leveraging community benefits and employment opportunities.

The following stakeholders have participated in engagement activities to date:

Table 5.2 : Stakeholders Engaged During the Drilling Phase

Sector	Type	Name	Organisation
Coordinating Authorities	Government Departments	Annie Edwards	Housing and Planning Division of Planning
		Lloyd Pascal	Environmental Coordination Unit
		Alexis George	Geothermal Project Management Unit
		Michael Fadelle	Geothermal Project Management Unit
		David Williams	Forestry Department
		Michael Savarin	Invest Dominica Authority
		Greg Steadman	Statistics Department
		M Scotland	Environmental Health Department
		Sylvester St Ville	Environmental Health Department
		Colin Piper	Discover Dominica Authority
		Defroy Williams	Ministry of Agriculture
Economic Partners	Locally Elected Officials	Trafalgar Counsellors	
		Collin McIntyre	Roseau Valley Parliamentary Representative

Sector	Type	Name	Organisation
	Local Economic Partner Organisations	Magnus Williams	DOWASCO
		Juliana Boston	DOWASCO
		Colin Power	DOMLEC
	Professional Associations	Unnamed	Dominica Hotel and Tourism Association
	Financiers	Incomplete	
	Companies	Incomplete	
General Public	Residents of Trafalgar	Peter Madison Charles	Resident of Lily Valley, Trafalgar
		Public Meeting 12/12/13	
	Residents of Wotten Waven	Japson Rowl	
		Richardson Charles	
		Unnamed female resident	
		Public Meeting 13/12/13	
	Residents of Laudat	Thomas Jequential	
		Ralph Magaw	
		Francesca Magloire	
		Public Meeting 11/12/13	
	Ecologists	Athie Martin	Small hotel owner, environmental scientist, involved in the business of water, conservationist
		Hadanauer Douglas	Free-lance consultant, involved in geothermal development
	Associations	Jeffrey Charles	Chairman of Geothermal Awareness Committee
	Political Parties	Lennox Linton	United Workers Party
		Edison James	United Workers Party

The parties were engaged during the current project phase.

Table 5.3 : Government Stakeholders

Organisation	Name	Position
Government of Commonwealth of Dominica	Hon. Ian Douglas	Minister for Trade, Energy and Employment
Roseau Valley Constituency	Dr John Collin McIntyre	Parliamentary Representative Minister for Planning, Economic Development and Investment
Independent Regulatory Commission	Mr Alan Khan	Executive Director
Dominica Water and Sewerage Company Ltd	Mr Bernard Etinoffe	General Manager
Ministry of Planning, Economic Development and Investment	Mr Keith Stephens	Chief Physical Planner
Environmental Coordinating Unit	Mr Lloyd Gabriel Pascal	Ambassador
Environmental Health Unit, Ministry of Health and Environment	Mr Anthony Scotland	Chief Environmental Health Officer

Organisation	Name	Position
Ministry of Housing, Lands and Water Resource Management and Ministry of Information, Science, Telecommunications and Technology	Mr Lucien Blackmoore	Permanent Secretary
Ministry of Lands, Housing, Settlements and Water Resource Management	Mr Marcus Lastrade	Director of Surveys and Commissioner of Lands

Table 5.4 : Community Groups

Community	Group	Contact
Laudat	Village Improvement Committee	Mr. Albert Noel
	Laudat Football Club	Mr. Berani Rolle
	Laudat Church Committee	Anthia Bertrand
	Laudat Farmers Group	Dr. Curlson George
	Laudat Primary School	Ms. Eugenia Richards
	Laudat Health Centre	
	Caldera Dining and Aquatic (Fresh Water Lake)	Ms. Claudette Rolle
	Café C'est Mon Plaisis	Mr. Garry Shillingford
	Rainforest Cottages	Mr. Nahgie Lafleur
Wotten Waven	Wotten Waven Improvement Committee	Mr. Kelvin Elize
	Wotten Waven Development Committee	Mr. Rudolph George
	Wotten Waven Farmers Group	
	Wotten Waven Football Club	
	Wotten Waven Rounders Club	
	Wotten Waven Primary School	
		Mr. Jeffrey Charles
Trafalgar	Trafalgar Village Council	Ms. Joanne Bellot
	Trafalgar Vendors Association	Lilian Xavier
	Trafalgar Rounders Sports Club	
	Trafalgar Football Club	Mr. John Joseph
	SHAFOND Development Committee	
	Trafalgar Church Committee	Mr. Anthony Leblanc
	Trafalgar Farmers Group	
	Trafalgar Primary School	Ms. Doreen Watt

Table 5.5 : Accommodation providers, tour guides and local vendors

Community	Group	Contact
Laudat	Vendor	Bertha Boyer
Wotten Waven	Vendor	Minova Joseph
	Vendor	Catherine Joseph
	Vendor	Gloria Damier
Trafalgar	Vendor	Laura Denis

Community	Group	Contact
	Vendor	Sandrine Younis
	Vendor	Lilian Xavier
	Vendor	Theresa Anthony
Accommodation Providers and Restaurants	Chez Ophelia	McCarthy & Ophelia Marie
	Tia's Bamboo Cottages	Tia Joseph
	Le Petit Paradis	Joan Ducreay
	Cocoa Cottages	Iris Metawi
	Papillote Wilderness Retreat	Ann Jno. Baptiste
	Sunshine Cottage & Restaurant	Sabine and Marco Ueker
	Symes Zee Villa	Timothy Symes
	Roxy's Mountain Lodge	Maria Hodge
	Rainforest Cottages	Mr. Nahgie Lafleur
	Caldera Dining and Aquatic (Fresh Water Lake)	Ms. Claudette Rolle
	Café C'est Mon Plaisis	Ms Patricia Rolle
Guides	Tour Guide	Simon Rolle
	Tour Guide	Garry Shillingford
	Tour Guide	Kelvin Noel
	Tour Guide	Naithan Rolle
	Tour Guide	Rudolph George

5.3 Methods of Communication

Appropriate methods of engagement have been selected with consideration of each stakeholder group's relevance (the extent to which the Project will influence them or to which they can influence the Project), their level of literacy, comfort with engagement culture and environment (e.g. office meetings vs. community meetings) and the need for focussed topic specific meetings as opposed to disclosure of general information.

Table 5.6 : Stakeholder Groups and Methods of Engagement

Stakeholder Group	Public Meetings and Exhibitions	Private Meetings and Workshops	Focus Groups	Mass Media Communications	Disclosure of Written Information	Community Liaison
National Government Departments	✓	✓		✓	✓	
National Bodies	✓	✓		✓	✓	
Provincial / Local Government Departments	✓	✓		✓	✓	
Financial Institutions	✓	✓		✓	✓	
Local Project Affected Communities	✓		✓	✓	✓	✓
Physically and economically displaced Project Affected People (PAPs)	✓	✓	✓	✓	✓	✓
Civil Society, NGOs & Research Bodies	✓	✓	✓	✓	✓	

Stakeholder Group	Public Meetings and Exhibitions	Private Meetings and Workshops	Focus Groups	Mass Media Communications	Disclosure of Written Information	Community Liaison
Employees and labour	✓	✓	✓	✓	✓	
Industry & Business	✓	✓	✓	✓		
Media & Press	✓			✓		

6. Stakeholder Engagement Program

6.1 Introduction

This section presents the programme for engaging stakeholders by describing the activities to be undertaken throughout the ESIA process and on an on-going basis throughout the life of the Project.

A number of consultation activities have taken place throughout the ESIA process. The format of the meetings will generally be comprised of introductions, followed by a Project description (including phasing and timelines) and then a question and answer session regarding the ESIA approach with feedback from the stakeholder regarding the Project and potential environmental and social issues. Where practicable and/or appropriate, the responses from consultation activities will be considered in either the approach for the ESIA assessment or the mitigation measures included within the ESMP.

The stakeholder engagement process has also been used to gather socio-economic baseline data to inform the social impact assessment.

6.2 Stakeholder Engagement Plan Purpose, Goals and Key Principles

The purpose of the stakeholder engagement programme is to ensure that all key stakeholders are involved in the consultation process throughout the development of the Project and to minimise the Project impacts on key stakeholders, including landowners, nearby communities, and downstream river users.

This stakeholder engagement plan is about building and maintaining constructive relationships with Project stakeholders throughout the duration of the Project, including ensuring stakeholders are engaged with in a culturally appropriate manner and that relevant and understandable information is provided in a timely manner.

The key principles of stakeholder engagement are:

- Providing meaningful information in a format and language that is readily understandable and tailored to the needs of the target stakeholder group(s)
- Providing information in advance of consultation activities and decision-making
- Disseminating information in ways and locations that make it easy for stakeholders to access it
- Respect for local traditions, languages, timeframes, and decision-making processes
- Two-way dialogue that gives both sides the opportunity to exchange views and information, to listen, and to have their issues heard and addressed
- Inclusiveness in representation of views, including women, vulnerable and/or minority groups
- Processes free of intimidation or coercion
- Clear mechanisms for responding to people's concerns, suggestions, and grievances
- Incorporating feedback into project or program design, and reporting back to stakeholders.

6.3 Individual Meetings and Workshops

Individual meetings are targeted ways in which to engage with stakeholders. They permit in-depth meetings about Project plans and allow the opportunity to go into more detail about technical aspects of the Project or address specific concerns raised by one or a group of stakeholders. These meetings mainly involve interest-based stakeholders who have most influence over the Project such as government regulatory bodies or relevant industry leaders.

Regular workshops are also a constructive way in which to involve key stakeholders throughout the duration of the ESIA, construction and operation periods so that issues and any grievances can be raised and addressed as they emerge.

One to one meetings with individual stakeholders have been undertaken to inform the ESIA process and to discuss specific Project elements or concerns. Individual meetings will continue throughout the Project development phases as needed.

In addition to key stakeholders in the government, meetings have been and will continue to be held with the other commercial and industrial users in the area to share knowledge and concerns over the Project.

6.4 Focus Groups

Focus groups allow targeted dialogue with key stakeholders. They provide an opportunity to explore community concerns in further detail and facilitate better understanding of the Project components, the ESIA process and its requirements. As such, focus groups have been held in the potential Project impact zone including representatives from key stakeholder groups from the communities and settlements surrounding the Project.

The following groups of people within each community were identified for the focus group meetings:

- Village elders or community representatives;
- Religious groups;
- Women's groups;
- Farmers;
- Youth groups;
- Any vulnerable groups such as members of the Roseau Valley impacted by Hurricane Maria, those with disabilities, widows or elderly members of the community with access restrictions.

Familiar locations in each community have been used for the focus group meetings as these are conducive to productive and interactive consultation for the following reasons:

- They lend transparency to the process: community members can witness the process and stay informed about what is being discussed on their behalf, and what has been agreed at the close of consultation or negotiations.
- They increase accountability of local leaders: community members will know what they are entitled to, and they will be able to monitor its delivery.
- They send the message that companies value the input of communities enough to travel there and spend time there.
- They contribute to community members' empowerment and feeling of ownership over the engagement process: community members say that the opportunity to have input into the public meetings gives them a sense of having a role in the outcome of decisions.
- Finally, they allow community members to identify their own representatives, preventing illegitimate representation from persons claiming that they speak for communities.

The general proceedings and responses from focus groups that have been conducted to date are presented in Appendix B.

Focus group meetings will continue throughout the Project lifecycle and be conducted by DGDC and its Community Liaison Officer (CLO) as required to address topical issues and issues of interest / concern to local community groups.

6.5 Project Affected Persons (PAPs)

Physically and economically displaced people will be the most directly affected stakeholders and it is important that they are effectively engaged and that this engagement is planned well in order to avoid encroachment and to accurately assess impacts and determine entitlements and costs.

Face-to-face interviews and phone discussions were held in April 2018 with the PAPs to collect census level information and verify physical assets. Some of the PAPs could not be contacted as they now live overseas and so certain census survey data was unable to be obtained. Additionally, some other potentially affected property owners in the project vicinity were interviewed.

6.6 Communication Tools

6.6.1 Media and Disclosure of Written Information

DGDC will set up a Project specific website (address to be confirmed) which is regularly updated highlighting progress, minutes of meetings that have taken place, the latest grievances that have been raised and other issues as appropriate. This site will be functional throughout the duration of the scoping and construction periods and for at least the first years of operation.

6.6.2 Community Visual Aids

The DGDC will produce visual aids to support community engagement. Visual aids shall describe the Project and impacts using images and photographic examples of the types of activities and infrastructure planned. Images shall be used to facilitate discussion potential impacts.

6.6.3 Community Meeting Records

Records of community consultation meetings, meetings with government and civil society shall be kept in a separate document with the detailed stakeholder database. All records shall include attendance lists and photos.

6.6.4 Language

All community materials shall be translated into Creole and English to meet the needs of local stakeholders. Meetings shall be conducted in English and Creole as necessary. Materials for government and civil society stakeholders shall be in Creole and/or English.

7. Implementation

7.1 Overview

It is important that consultation and disclosure undertaken as part of the Project occurs at appropriate timescales to allow stakeholders to be informed and contribute to the appropriate management of environment and the development of the Project. This section assigns timescales and responsibilities to the activities identified in the previous section.

7.2 Timetable

Table 7-1 below provides an overview of engagement activities with suggestions regarding when they should be implemented and the various people who have responsibility. It should be noted that some activities have already been undertaken.

Table 7.1 : Stakeholder Engagement Implementation Timescales and Responsibilities

Activity	Timing	Responsibility
ESIA Engagement		
Draft ESIA disclosure on Project website	July/August 2018	DGDC
Individual meetings with stakeholders	Undertaken as necessary over the duration of the ESIA process to collect data and register / concerns opinions with stakeholders. Meetings will continue as required throughout the Project development phase.	DGDC
Focus groups discussions with community representatives including vulnerable groups	November and December 2016, May-August 2017, March 2018/2017	DGDC with support from Jacobs
Media communications	A Project specific website set up (address to be confirmed) which is regularly updated highlighting progress, minutes of meetings that have taken place, the latest grievances that have been raised and other issues as appropriate. This site will be functional throughout the duration of the feasibility, scoping and construction periods and for at least the first years of operation.	DGDC
Construction Phase Engagement		
Grievance logging	Weekly grievance reporting during construction.	DGDC
Media notifications of Project progress	Prior to the start of construction Prior to the completion of construction	DGDC
Updating SEP	Prior to the completion of construction	DGDC
Operation and Decommissioning Phase Engagement		
Decommissioning consultation event with affected staff and communities	With staff prior to retrenchment proceedings With communities prior to ceasing operations	DGDC
Updating SEP	Annually	DGDC

7.3 Responsibilities

It is the responsibility of DGDC to ensure that documents are distributed to the appropriate stakeholders. During construction and operational activities, the DGDC and contractors will be responsible for meeting with stakeholders and implementing the grievance mechanism. Person(s) are to be appointed to document all interactions with stakeholders and log grievances. All grievances are to be resolved in a timely manner in collaboration with the EPC contractor and DGDC.

8. Responsibilities and Management Functions

8.1 The Developer

8.1.1 Dominica Geothermal Development Company Limited

The Project will be developed by the DGDC, which was legally established by the GoCD in the last quarter of 2016 and became operational in June 2017. The Government's role is as equity provider and lender to the company. The GoCD has all shareholder rights with Directors appointed and replaceable by the shareholder. Initially, four Directors have been appointed, including an Executive Chairman. The GoCD is also responsible for managing and implementing the acquisition of land for the Project.

8.1.2 Roles

DGDC has five permanent staff members, a Board and the Project Manager. The company will operate under the guidance of technical, legal, strategic and commercial advisors. The roles for the DGDC staff are as follows:

- A Board of Directors – company oversight to ensure it meets shareholder expectations;
- The Directors will have an Executive Chairman with decision making powers;
- Director of Accounts to establish the financial and administrative capabilities of the DGDC including financial control systems, corporate compliance, establishing the Code of Ethics, taxation and human resources. They will establish bank accounts, develop the annual budget and execute the financial transactions of the company;
- A Project Co-ordinator/Officer to work with Government agencies and assist the Project Manager as required;
- An Administration and Safeguards Officer to be responsible for office management and administration of stakeholder engagement systems;
- A Community Liaison Officer to be the first point of contact for community queries and to share information with community members; and
- A Site and Office Attendant to monitor sites for maintenance purposes, to provide local guiding services to visitors and undertake office activities as required.

The Government of New Zealand is funding a Project Manager position for a period of two (plus one) years. The Project Manager will be based in Dominica and perform the following functions:

- Oversee the technical scope and engineering design of project, ensuring that the feasibility of the scope and structure of the project meets good industry practice and international standards;
- Oversee the overall construction of the power plant and its subsequent commissioning;
- Ensure the project meets the necessary environmental and social requirements and oversee the preparation of an ESIA;
- Responsible for overseeing the successful procurement of all goods, services, and skills necessary for the construction and operation of the geothermal power plant;
- Support finalisation of the financing arrangements, including responding to and meeting lender technical due diligence requirements in an efficient and timely manner;
- Work with advisors to finalise all off-take arrangements with DOMLEC; and
- Secure the services of and overseeing the work of various consultants.

DGDC will appoint a technical advisor acting as an Owner's Engineer who will be responsible for a wide range of services pre and post Financial Close. To date geothermal project development technical advisory services have been provided by Jacobs New Zealand Ltd (Jacobs), who were appointed by the Government of New Zealand following a competitive bidding process to deliver their Caribbean Geothermal Technical Assistance

Programme. At the time of writing Jacobs are currently in the final steps of formalising a role as Owner’s Engineer to DGDC.

Clean Infra Partners has been appointed by DGDC as a business advisor to conduct Power Purchase Agreements (PPA) negotiations with DOMLEC, undertake financial analysis, and support development of the Financing Plan and business plan.

Holland & Knight has been retained as legal counsel to DGDC with services to include preparation and review of the Geothermal Concession Agreement, Power Purchase Agreement, EPC Contract, Operations & Maintenance contracts and financing agreements.

These roles are summarised below in Figure 8.1 (correct as of August 2017).

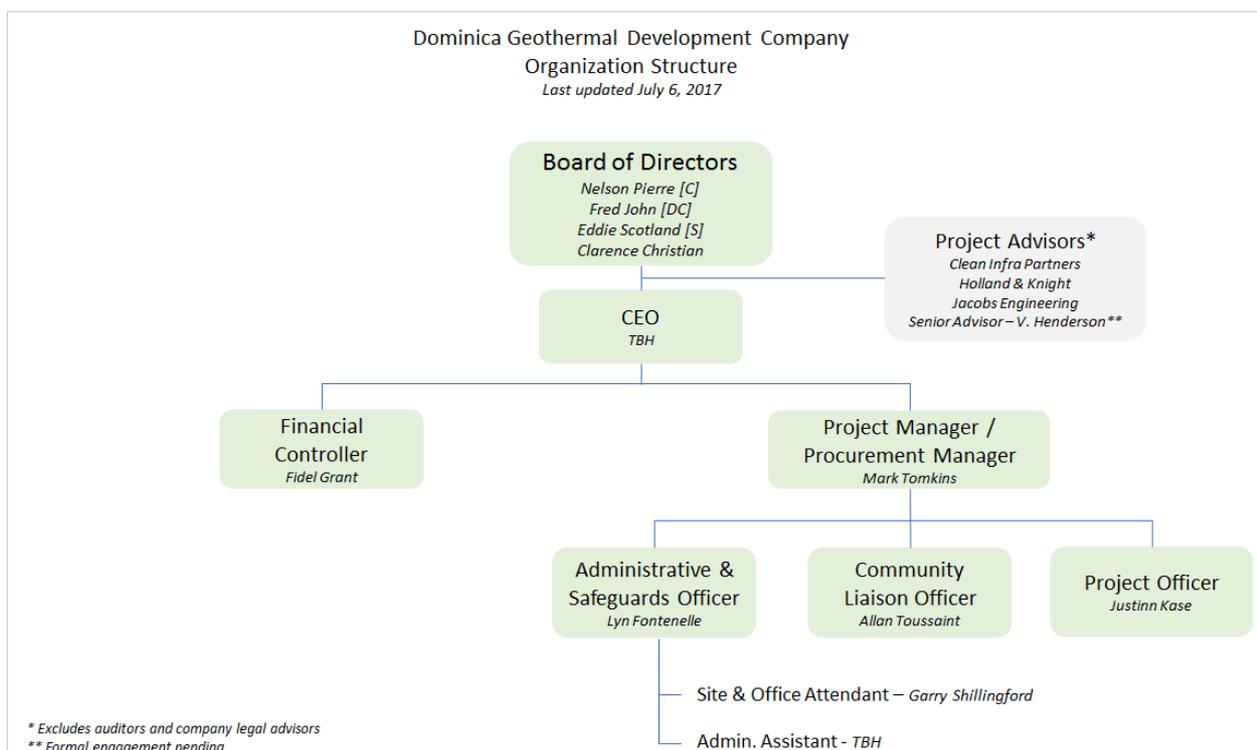


Figure 8.1 : Geothermal Project Governance

8.1.3 Overview

This section presents a preliminary structure for management and responsibilities in relation to the SEP. The Project Team structure will be confirmed in accordance with the consultation activities.

Specific members of the Project Team will be responsible for implementation of the SEP. The Project Team may include the following:

- The Project Sponsor’s Executive Management Team
- The Senior Manager
- The Community Liaison Officer
- ESIA Consultants/Technical Specialists.

8.1.4 Executive Management Team

The Executive Management Team will have the overall responsibility for stakeholder engagement, including provision of the guiding principles for the stakeholder engagement, the allocation of budget for the effective implementation of the SEP and, if necessary, participation in the dialogue with administrations in the resolution of any issues.

8.1.5 Project Manager

The Project Manager will be responsible for the implementation of the SEP. His/her task will be overseeing the work carried out by the Community Liaison Officer, Social Safeguards Specialist, and rest of the Team. He or she will be the point of contact with the regional and local authorities with respect to public consultation.

The Project Manager's tasks will include:

- Managing implementation of the SEP;
- Managing response to concerns and ideas raised through public consultation;
- Allocating Project finance to public consultation, community development and training;
- Undertaking frequent and regular visits to the Project site and local communities with the Community Liaison Officer to demonstrate the Project's commitment of to the local economy;
- Liaising between the Community Liaison Officer and the Executive Management Team; and
- Ensuring that all public consultation and information disclosure requirements of investors have been met, including the documentation of results.

8.1.6 The Social Safeguards Specialist

Primary responsibility will include, monitoring the implementation of both the requirements of the SEP and preparing project related resettlement plans for the Project and evaluating and ensuring that appropriate actions are taken to address potential resettlement problems. He or she will also manage project recordkeeping and coordination with government agencies on related tasks. The Social Safeguards Specialist is a core and permanent member of the DGDC team.

8.1.7 Community Liaison Officer

The Community Liaison Officer's primary role is to act as an interface between the Project and the community. The Community Liaison Officer is an employee of DGDC, but the Community Liaison Officer will have an independent and positive relationship with community members. The Community Liaison Officer will be responsible for working alongside the Social Safeguard Specialist to gather the required information for resettlement planning needs, disclosing information and actions to the affected communities and acting as a go between the communities and DGDC on community grievances associated with the Project. He/she will also be responsible for documenting the results of public consultation and preparing reports internal and external for disclosure.

8.1.8 ESIA Consultants / Technical Specialists

The ESIA Consultants / Technical Specialists will assist the Project throughout the ESIA Processes.

The responsibilities will be:

- Researching local demographic, socioeconomic, and organizational environments;
- Identifying stakeholders and stakeholder representatives;
- Undertaking community consultation as part of the ESIA process;
- Undertaking environmental and social baseline studies;
- Preparing the ESIA and ESIA executive summary;

- Preparing the ESMP; and
- Providing capacity building and other support during the monitoring and implementation phases of the Project.

8.2 Management Functions

The execution of the SEP will be coordinated and systematic. The key elements of the management of the stakeholder engagement are discussed below.

8.2.1 Coordination of activities and overall responsibility

The Executive Management Team will have the oversight for the SEP. However, the Senior Manager will coordinate and have overall responsibility for the implementation of the SEP. The Senior Manager will have the high-level oversight of all activities involved in the SEP to ensure information provided to stakeholders and larger Project Team members is consistent and accurate.

8.2.2 Employment and Human Resources

The Senior Manager, with the oversight of the Executive Management Team, will also be responsible for ensuring appropriate staff are engaged throughout the duration of the SEP and ensuring staff are appropriately trained to consult with the range of different stakeholders.

The Senior Manager will also ensure the effective management of contractors with respect to local residents and maintenance of good relations through:

- Awareness training of all contractors to the respect of local people and communities' culture, way of life and beliefs;
- Providing all contractors will a copy of the SEP and any updates to stakeholder engagement activities; and
- Providing a line of reporting between contractors and the Community Liaison Officer to address any concerns raised by the community to contractors.

8.2.3 Internal Communications

Clear reporting lines will be established between members of the Project Team to ensure the stakeholder engagement activities are core to the implementation of the Project. This will include:

- Circulating the SEP to all members of the Project Team and the Project Sponsor;
- Ensuring all communications are filed in accordance with the Communications Protocol (examples referred to in Section 9 and Appendix E and F); and
- Establishing direct reporting lines between the Community Liaison Officer and the Executive Management Team to effectively control risk.

8.2.4 Updating the SEP

The SEP will continue to be reviewed throughout the Project construction phases. Once the Project is operational, a review will be conducted annually by the CLO in order to assess whether:

- The type of consultation and disclosure activities are appropriate for the different stakeholder audiences;
- The frequency of consultation activities is sufficient; Grievances have been adequately dealt with; and
- The stakeholder list remains appropriate and whether the engagement should cease or be extended to any stakeholders.

9. Monitoring and Reporting

9.1 Monitoring

Monitoring will be carried out in accordance with the Environmental and Social Management Plan, which is to be prepared through the ESIA process. This is likely to include:

- Monitoring environmental and social performance indicators defined in the ESIA;
- On-going monitoring of grievances through the grievance mechanism;
- On-going monitoring of stakeholder database;
- On-going monitoring of the commitments register; and
- Monitoring of concerns or issues expressed by local or governmental authorities.

9.2 Reporting

Key indicators will need to be reported internally, within the Project Company and externally, to the community, regulatory authorities and lenders. The following sections describes the minimum reporting to be conducted.

9.2.1 Meeting Minutes

Records of community consultation meetings, meetings with government and civil society shall be kept in a separate document with the detailed database maintained by the CLO. All records shall include attendance lists and photos.

9.2.2 Recording Grievances

A formal log of grievances will be developed and the CLO will be responsible for logging all grievances except those related to land acquisition which will be handled directly by designated government representative] of the GoCD. A comments sheet will also be provided for complaints or other comments. Comments or complaints can be made directly to DGDC or the contractor, through the CLO or through a community representative (e.g. through the village elders). See further detail of this process in Section 10.

9.2.3 Stakeholder Database

The Project Sponsor will maintain a current and regularly updated stakeholder engagement database. The database will contain:

- details of the various stakeholder groups (including their representatives, their interests and concerns);
- details of any consultations held (including when these took place, the topics discussed and the outcomes);
- any commitments made by the Project Sponsor to stakeholder groups, including outstanding commitments and commitments that have been delivered; and
- a record of specific grievances lodged and the status of their resolution.

9.2.4 Commitments Register

The Project Sponsor will maintain a commitments register that keeps track of the commitments made by the Project Sponsor throughout stakeholder consultation (including those made by any contractors or members of the Project Team).

9.3 Annual Reporting

The Community Liaison Officer will maintain engagement reports on a monthly basis. The objective of these engagement reports are to demonstrate and record the ongoing engagement process and progress made.

These shall be submitted monthly to the DGDC. These reports may include records of engagement including meeting registers, photographs.

These reports will be used to address and incorporate social issues into Project management. Engagement reports shall be stored with the detailed stakeholder database and retained for a minimum of five years.

At a minimum these reports will contain:

- Engagement activities undertaken;
- Grievances received as per grievance management;
- Updated stakeholder database;
- Feedback received during the engagement process;
- Update on complaints and grievances, expectations and requests,
- Investment made, and commitments and promises made; and
- Key records of communication with stakeholders.

9.4 Communications

Relevant communications with identified stakeholders will be recorded and documented in a timely manner. To ensure this is carried out consistently a Communications Protocol was developed. The communications protocol establishes how different communications are to be documented during the Project. The purpose of the Communications Protocol would be to provide a documented record of the communications that are involved in community consultation for the Project, in keeping with the requirements of the World Bank Group Guidelines A general communications flow chart is provided below in Figure 9.1. Details of the Communications Protocol are provided in Appendices E and F.

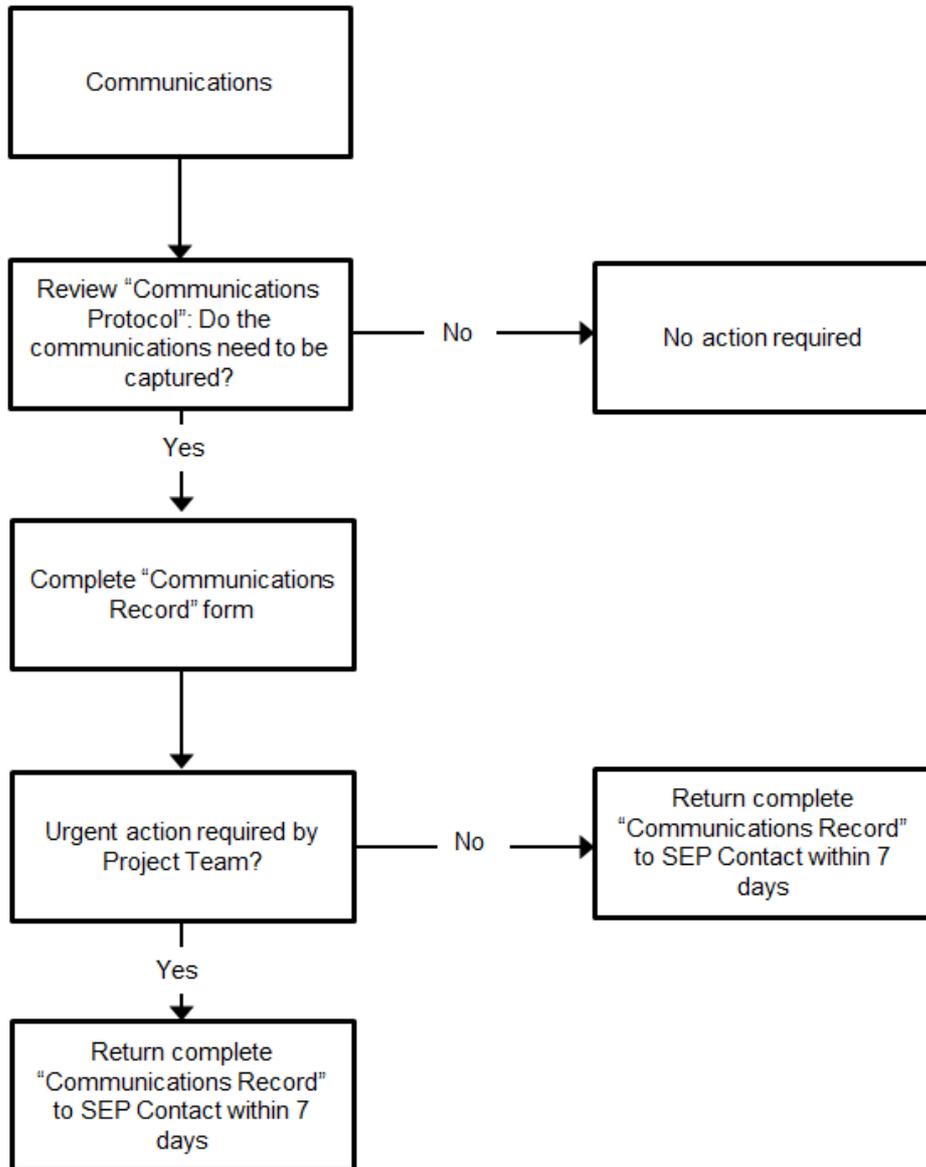


Figure 9.1 : Communications Flow Chart

10. Grievance Mechanisms

10.1 Overview

A grievance can be defined as an actual or perceived problem that might give grounds for complaint. As a general policy, DGDC will work proactively towards preventing grievances through the implementation of mitigation measures (as identified by the ESIA) and liaising with the community. These activities are designed to anticipate and address potential issues before they become grievances. This will be the responsibility of the Project Manager and the CLO. However, all grievance related to land acquisition will be handled directly by designated government representative] of the GoCD.

The sections below consider types of grievances that may arise, confidentiality and anonymity, and the Project's grievance resolution process.

The grievance mechanism covers the various aspects of the Project, including:

- The Project in general, including planning, construction and operation;
- The process of environmental impact assessment; and
- The compensation and resettlement processes.

Each affected person is free to register a grievance, in accordance with procedures specified below. The grievance process focuses on first identifying whether the grievance can be addressed through additional communication between the complainant and members of the Project Team, or by providing additional information to the complainant. If the grievance cannot be resolved internally, the Project Team will then seek to resolve the grievance through mediation by local authorities, and finally, if a resolution cannot be reached, judicial appeal.

The grievance flow chart is provided in Appendix D.

10.2 Type of Grievances

Potential impacts and effects that are most likely to give rise to grievances for this Project include:

- Resettlement/livelihood restoration;
- Noise of construction works;
- Presence, and potential disruption, of the construction labour force and the effects on communities, local services and infrastructure;
- Community health and safety in relation to impacts of increased traffic on nearby residents;
- Visual intrusion (construction and operation);
- Congestion of and access to local ports (construction and operation);
- Damage to surrounding natural environment (construction and operation); and
- Disappointment related to expectations about employment from the Project.

Anyone can submit a grievance to the Project if they believe it is causing a detrimental impact on the community, the environment, or on their quality of life. They may also submit comments and suggestions. Grievances could include:

- Negative impacts on a person or a community (e.g. financial loss, physical harm, nuisance);
- Dangers to health and safety or the environment;
- Failure of the DGDC, its sub-contractors and their workers or drivers to comply with standards or legal obligations;
- Harassment of any nature;

- Criminal activity;
- Improper conduct or unethical behaviour;
- Financial malpractice, impropriety or fraud; and
- Attempts to conceal any of the above.

During construction grievances will be investigated by DGDC, the GoCD and the CLO to determine the validity and associated responsibility. The CLO will explain in writing (or where, literacy is an issue, orally) the manner in which the review was carried out, the results of the review, any changes to activities that will be undertaken to address the grievance and how the issue will be managed to meet appropriate environmental and social management systems requirements. A template for a Grievance Complaint form is presented in Appendix C.

10.3 Confidentiality and Anonymity

The Project will aim to protect a person’s confidentiality when requested and will guarantee anonymity in annual reporting. Individuals will be asked permission to disclose their identity. Investigations will be undertaken in a manner that is respectful of the aggrieved party and based upon the principle of confidentiality. There may be situations when disclosure of identity is required. If this is the case, the CLO and DGDC will identify this and ask if the aggrieved party wishes to continue with the investigation and resolution activities.

10.4 Grievance Reporting and Resolution

A formal log of grievances will be developed and the CLO will be responsible for logging all grievances. A comments sheet will also be provided for complaints or other comments. Comments or complaints can be made directly to DGDC or the contractor, through the CLO or through a community representative (e.g. through the village elders). The procedure for lodging grievances and their resolution will be included in appropriate Project communication materials such as non-technical summaries or the Project. In the first instance, grievances will be directed to the CLO who will classify grievance according to Table 10.1.

Table 10.1 : Classification of Grievances

Classification	Risk Level	Validity	Response
Low	No or low	Unsubstantiated	CLO will conduct investigation, document findings and provide a response
Medium	Possible risk and likely a one off event	Possible substantiation	CLO and an appropriate investigation team will conduct investigation. The Site Manager or Occupation Health and Safety Manager may decide to stop work during the investigation to allow the corrective preventive actions to be determined. The CLO will provide a response.
High	Probable risk and could reoccur	Probable substantiation	CLO will get the contractor to organise a Major Investigation Team including DGDC for prompt investigation and resolution. Work will be stopped in the affected area. The CLO will provide a response.

The CLO will log the receipt of a comment, formally acknowledge it, track progress on its investigation and resolution, and respond in writing with feedback to the aggrieved party. They will initiate the investigation and ensure its speedy conclusion aiming to provide a response with ten working days, unless there are exceptional circumstances. If the Project receives a large number of unsubstantiated grievances, the process will be reviewed to define instances when no response is needed.

Where investigations are required, Project staff and outside authorities as appropriate will assist with the process. The CLO will collaborate with DGDC to identify an appropriate investigation team with the correct skills to review the issue raised and to decide whether it is Project related or whether it is more appropriately addressed by a relevant authority outside the Project.

The investigation will also aim to identify whether the incident leading to the grievance is a singular occurrence or likely to reoccur. Identifying and implementing activities, procedures, equipment and training to address and prevent reoccurrence will be part of the investigation activities. In some cases it will be appropriate for the CLO to follow up at a later date to see if the person or organisation is satisfied with the resolution or remedial actions.

The CLO will summarise grievances to report on Project performance weekly during construction and bi-annually during operation, removing identification information to protect the confidentiality of the complainant and guaranteeing anonymity.

Comments relating to the Project can be addressed to the Community Liaison Officer at DGDC:

Name:	Allan Toussant
Address:	PO Box 1454, 18 Kennedy Avenue, Roseau, Commonwealth of Dominica
Email:	allan.toussaint@geodominica.com
Telephone Number:	(767) 448-6178 / 79

Appendix A. Stakeholder Engagement and Consultation Meeting Minutes

Refer to ESIA Volume 5: Technical Appendices Appendix J. Stakeholder Engagement – Meeting Minutes

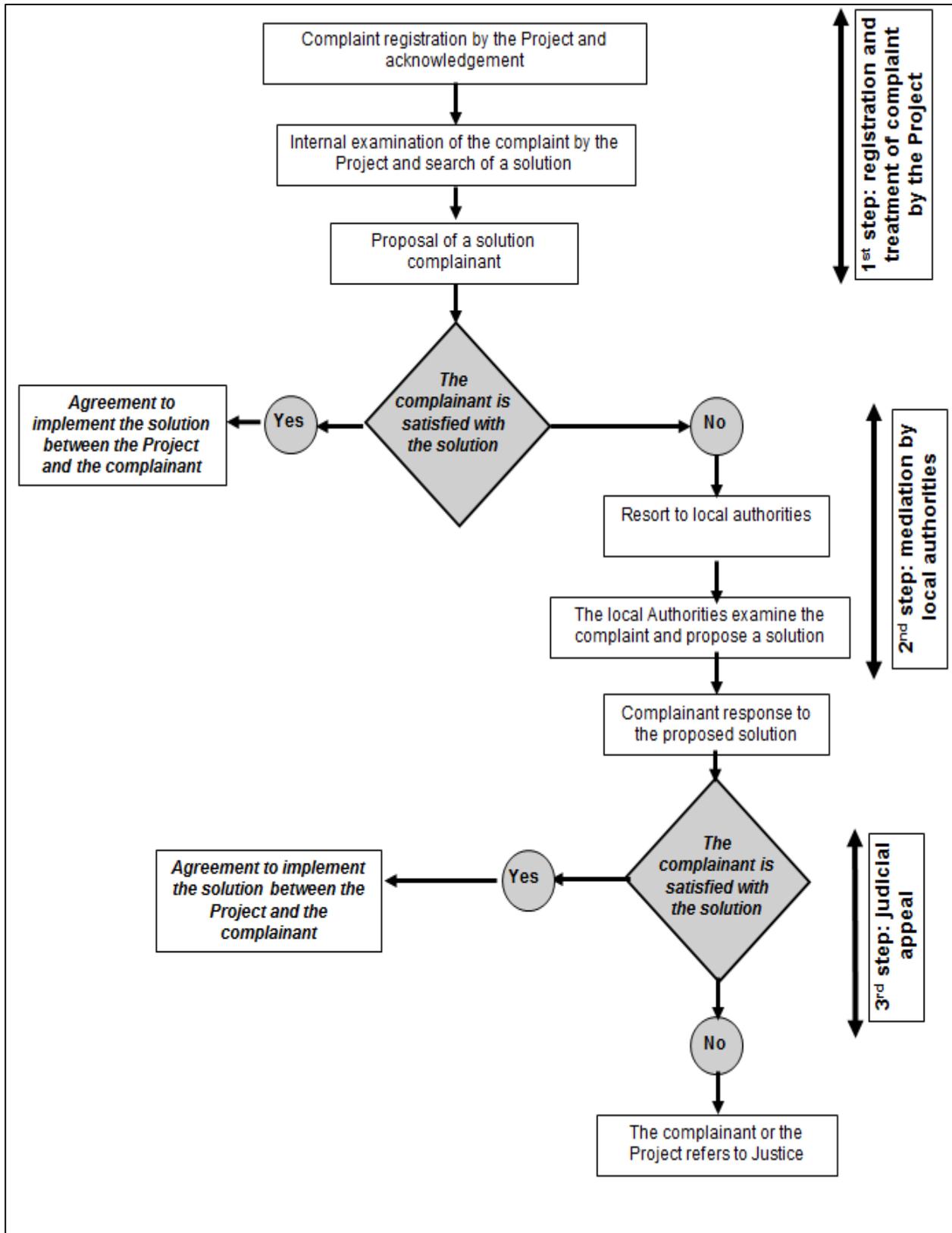
Appendix B. Summary of Focus Group Meetings

Refer to ESIA Volume 5: Technical Appendices - Appendix J. Stakeholder Engagement – Meeting Minutes

Appendix C. Grievance Mechanism Complaint Form

GRIEVANCE REGISTRATION		
Date:	Filed by:	
Plaintiff's name :	Plaintiff's gender: M / F	Plaintiff occupation:
Plaintiff's contact (address, tel. number):		
<input type="checkbox"/> The plaintiff is filling an individual complain		
<input type="checkbox"/> The plaintiff is representing a group or a community		
- Name of the group or community: - Nature of the group or community: - Location/address:		
Description of the grievance:		
GRIEVANCE TREATMENT		
Date of the response:	Filed by:	
Proposed action(s) to remedy to the grievance:		
Plaintiff's acceptance of the proposed action:		
GRIEVANCE CLOSURE		
Date of grievance closure:	Filed by:	
Ending of the grievance treatment:		

Appendix D. Grievance Mechanism Process



Appendix E. Communications Protocol

E.1 Introduction

Relevant communications with identified stakeholders must be documented in a timely manner. The purpose of this protocol is to create a documented record of the communications that are involved in the community consultation for the project. This is a requirement under the WB Performance Standards and needs to be followed.

When a piece of communications is to be conducted, a member of the Project Team should review the “Communications Flow Chart”, see Figure 9.1, to ascertain if the communications needs to be documented as per the communications protocol.

The attached “Communications Record” reference in Appendix F is to be used when communications between a member of the Project Team and the wider community. Any communications that have been recorded are to be documented and forwarded as soon as practicable.

At all times the Project Team should make information free, prior and informed. Meaning that information supplied “should be “free” (free of external manipulation, interference or coercion, and intimidation), “prior” (timely disclosure of information) and “informed” (relevant, understandable and accessible information)”.

This communications protocol is a fluid document which will be changed and updated as required.

E.2 Stakeholders Involved

The following have been identified as stakeholders who are or are likely to be involved within the consultation process:

- Local community
- Local business and interest groups
- Local government
- Regional, Provincial and National government
- NGOs/Media
- General public
- Vulnerable people
- People affected by economic or physical displacement.

E.3 Communications Capture

E.3.1 What communications and consultation are to be captured?

The information supplied to the wider community is to be documented and recorded. When there is engagement with the community and disclosure about Project relevant information, these need to be captured by the “Communications Record”. Examples of communications that must be captured are:

- Information exchange with the community: All information verbally or written that is supplied to the community about the Project must be captured. For example if a member of the local community requests information, questions, issues or makes comment on the Project, these communications must be recorded.
- Information exchange with government agencies: For example where a government agency contacts the Project Team for information, raises issues or makes statements regarding the Project
- Media requests: Any information placed in the media or when the media has requested information to be supplied must be recorded.

- Workshops: Responses from the wider community at the workshops.
- Individual meetings and interviews must be recorded including responses to community questions and concerns.
- Approvals from government departments or agencies: Agreements reached with government departments and/or agencies.
- Requests for action from the community: If an action is requested by the Project Team by the local community then this needs to be recorded.
- Formal meetings with community and government.

E.3.2 What communication does not need to be captured?

When information about the Project is not supplied but communications have occurred with the community, this does not have to be captured. Examples of communications that does not need to be captured are:

- Meeting requests/appointments: For example, communications arranging an open day or meeting with the community
- Information about the process or Project Team Members: If the wider community is asking specific information on the process or the Project Team Members
- Data collection: Teams collecting data for the Project.

E.3.3 Style of Communications Stakeholders

The following methods for communication to stakeholder may be used:

- Emails
- Phone
- Fax
- Face to face meetings
- Letter
- Media (Newspaper ads).

E.4 How to capture the information

Appendix F provides the “Communications Record”. This sheet needs to be filled in the relevant areas to explain the communications that has occurred. If there are documents that are relevant to the communications (i.e. emails, faxes, letter, minutes of meetings etc) please make copies of the relevant documents and forward with the “Communications Record”. The “Communications Record” does not replace current practices (i.e. minutes of meetings) but is an extra document to track the flow of communications. Copies should be made both of the communications record and the documents supplied so both the Project Team and the person making the communications has a record.

The “Communications Record” will be kept by the Project Team and a communication spreadsheet will be created to track the communications and consultation documents for the project.

E.5 Time Frames

“Urgent” communications that require action from a member of the Project Team needs to be forward to the Project Team within 24 hours.

“Non-Urgent” communications needs to be forwarded to the Project Team within 5 working days.

E.6 Communications Contact List

E.6.1 Points of contact

Points of contact for the communications protocol are provided in Table E.1.

Table E.1: Communications contact table

Name	Position	Company	Role in Project	Email	Phone No.

Appendix F. Communications Record

COMMUNICATIONS RECORD

Dominica Geothermal Project

Project Team Member*							
Company							
Correspondence Type (Please Circle)*:	Email	Fax	House Call	Letter	Meeting	Phone	Other
Date of Communication*:							

Stakeholder Details*			
Name*:			
Position:			
Organisation:			
Phone:		Fax:	
Mobile:		Email:	

Property Address (If required)	
Address:	

Issue Raised in Communication (Please Circle)*					
Property Value	Access	Water Pollution	Noise	Dust	Complaint
Employment Issues	Economic Effects	Traffic	General Information	Hours of Operation	Regulatory Requirements
		Other (Please list)			
What they said*:					

Appendix L. Caraïbes Environnement Développement & Coll 2015 – Final Summary Report



Initial environmental status of the Roseau Valley in Dominica, planned for development of geothermal electricity production

Volet 1 - T.1.2.1.
Final Summary

May 2015

GÉOTHERMIE CARAÏBE 2

PRODUIRE NOTRE ÉLECTRICITÉ AUTREMENT



PROGRAMME
INTERREG CARAÏBES



Initial environmental status of the Roseau Valley in Dominica, planned for development of geothermal electricity production

Final Summary

REPORT-E3B2-R0390/15/OF/HG/SB/IB/VD-EN
May 2015

Study made for the “Géothermie Caraïbes phase 2” project

Caraïbes Environnement Développement

In collaboration with

**Asconit Consultants, Teranov, IMSRN, Eclipse Inc., Adret & Territoires,
SEGE Biodiversité, 2AF Gamba Acoustique, EnviroConsult et ISL**



In the bibliography, this report will be quoted as following :

Caraïbes Environnement Développement & Coll. (2015) – Initial environmental status of the Roseau Valley in Dominica, planned for development of geothermal electricity production. Final summary. REPORT-E3B2-R0390/15/OF/HG/SB/IB/VD-EN.



INTRODUCTION

In 2005, Dominica initiated a programme for construction of a geothermal project in the Roseau Valley, in cooperation with France, in the framework of the inter-regional Caribbean cooperation objectives.

The ultimate goal of the project is to bring energy independence to Dominica and to supply neighbouring Guadeloupe and Martinique with additional renewable energy on an ad-hoc basis. These Caribbean Islands predominantly use fossil fuels (oil and coal) for electricity production.

Initial studies have shown the feasibility of such a project from a technical, financial and environmental point of view. Dominican regulations require that the project be subject to an environmental impact study.

The environmental pre-feasibility study carried out in 2009 revealed an absence of descriptive data necessary to characterise the initial status enabling an evaluation of the impact of this project on the environment.

In cooperation with the Dominican government, ADEME launched the following mission: Project Interreg IV “Caribbean Geothermal– Phase 2” - An initial environmental status report on the Roseau Valley in Dominica, planned for development of geothermal electricity production projects.

Issues for the study are as follows:

- Carry out a zero status environmental study in the Roseau Valley, serving as a base for future determination of impacts and measures.
- A need for quantitative data, of good quality, acquired through standard protocols, which can be reproduced over time. The themes involved are specifically natural risks (flooding, ground movements, and seismic), acoustics, aerology, climatology and hydrography.
- Particular attention to land and aquatic biodiversity, through inventories, as well as lifestyle, landscape and heritage. These elements are particularly sensitive for residents of the Roseau Valley and therefore essential for a dialogue with the local population.
- Facilitate the implementation of international cooperation between the State of Dominica and the French State, through regular communication on the implementation of studies and involvement of local players.
- Develop social acceptance of the geothermal project within the local population, transparently informing the population on the studies underway and involving the population in a genuine process of cooperation, based on participative meetings.
- Involve local human resources in the studies and ensure skills transfer.
- Technically enrich the debate on geothermal energy with a voluntary policy on energy transition in Guadeloupe and Martinique (notably through the presentation of studies in technical seminars).

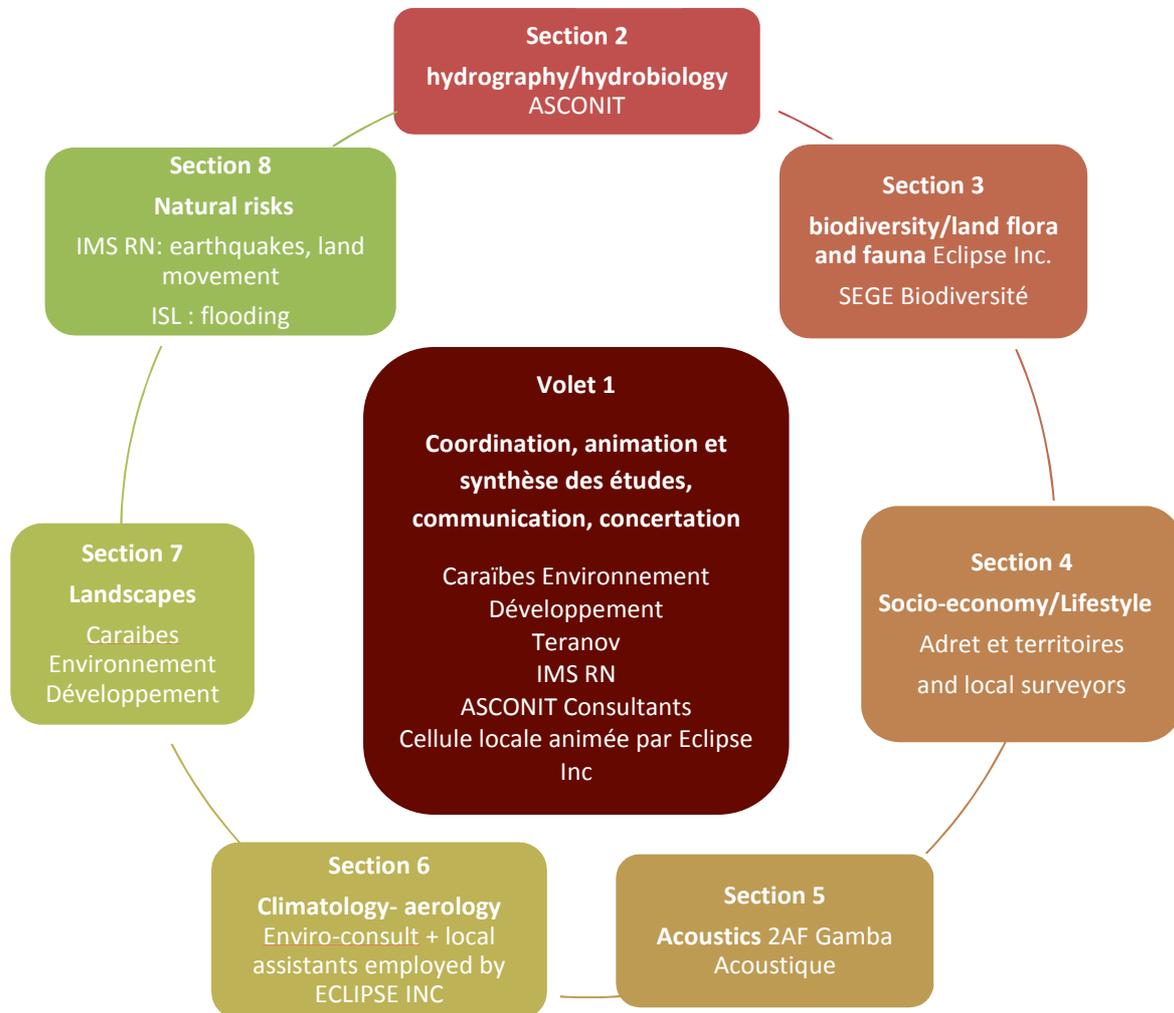
- For organisation of the study, the need for ADEME to have a single, long-lasting contact in Guadeloupe, Caraïbes Environnement Développement, who will relay advances in the study and ensure a coherence of reporting.

This mission should enable studies on the initial status of the Roseau Valley on the following themes

- Hydrography and hydrobiology;
- Land flora and fauna;
- Socio-economy and lifestyle;
- Acoustics;
- Climatology and aerology;
- Landscape;
- Natural risks.

This document summarises the initial environmental status study for the Roseau Valley.

The 8 Sections of the study on the initial status of the Vallée de Roseau



The study in figures

- ❖ A team of 10 multidisciplinary companies
- ❖ 18 months of studies, 8 months in the field
- ❖ Intervention of fifty phds, engineers, researchers and technicians (plus administrative staff)
- ❖ Around 900 cumulative work days
- ❖ 1 year of weather measurement
- ❖ 3 languages used English, French and Creole
- ❖ Teams in 2 countries: Dominica and France
- ❖ Teams in two geographical zones, mainland France and the Lesser Antilles (Dominica, Guadeloupe and Martinique)

SECTION 1: COORDINATION, ANIMATION, STUDY SUMMARIES, COMMUNICATION/CONSULTATION

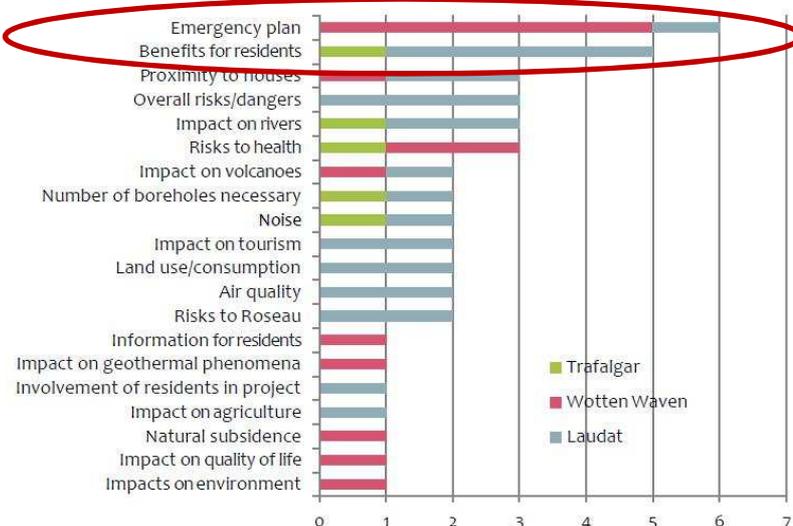
Goal of consultation

- ❖ To define the players involved in the project
- ❖ To understand their expectations in respect of the geothermal project in order to best target the fields of study
- ❖ To keep the parties informed of the progress of the study



Results of consultations

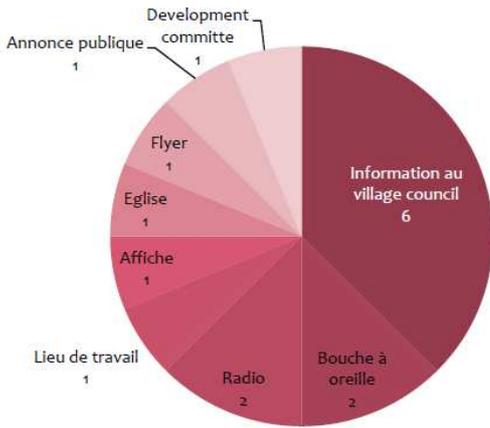
- ❖ Satisfaction of the population regarding the goal of carrying out studies to deepen understanding of the environment
- ❖ Great expectations of the results of these studies
- ❖ Request for a health study of valley populations.
- ❖ Full cooperation with the various Dominican services in order to find other applications



Principal concerns of the population regarding the project:

- ❖ Evacuation of the Valley in the event of major accident
- ❖ Benefits for residents

Environmental initial state – Final summary

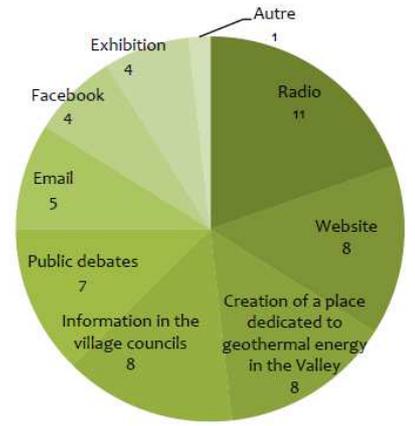


How were you informed about this evening's meeting?

Expectations of information tools

- ❖ Monthly or quarterly information rhythm

By radio and via Village Councils



What methods would you like us to use to keep you updated?

Numerous players, with different expectations, on several scales



COORDINATING AUTHORITIES	Government departments	<ol style="list-style-type: none"> Annie Edwards – Housing & Planning, Division of planning Lloyd Pascal, Environmental Coordination Unit Alexis Georges & Michael Faudelle, GPMU David Williams, Forestry Department Michael Savarin, Senior Investor Services officer, Invest Dominica Authority Greg Steadman, Statistics Department M. Scotland, head officer & Sylvester St Ville, Senior Environmental Health Officer, Environmental Health Department Colin Piper, Discover Dominica Authority Delroy Williams, Agricultural Officer with the Ministry of Agriculture 		
	Locally elected officials	<ol style="list-style-type: none"> Trafalgar councillors Dr Collin McIntyre, Roseau Valley parliamentary representative (also Trade and Industry Minister) 		
	ECONOMIC PARTNERS	Local economic partner organisations	<ol style="list-style-type: none"> Magnus Williams, Chef Engineer & Juliana Boston, Financial Controller – DOWASCO Colin Power, Domlec 	
		Professional associations	<ol style="list-style-type: none"> Dominica Hotel and Tourism Association (DHTA) 	
		Financiers	To be completed by ADEME, AFD, Guadeloupe and Martinique regions, and?	
	Companies	To be completed by GDF Suez?		
	GENERAL PUBLIC	Residents of Trafalgar	<ol style="list-style-type: none"> Peter Madison Charles, resident of Lilly Valley, Trafalgar 	
		Residents of Wotten Waven	<ol style="list-style-type: none"> Public meeting 12/12/13 Japson Rowl, resident of Wotten Waven Richardson Charles, resident of Wotten Waven A female resident Wotten Waven (shopkeeper) 	
			<ol style="list-style-type: none"> Public meeting 13/12/13 	
			Residents of Laudat	<ol style="list-style-type: none"> Thomas Jequential, Laudat Ralph Magaw, resident of Laudat Francesca Magloire, female resident of Laudat
				<ol style="list-style-type: none"> Public meeting 11/12/13
Ecologists		<ol style="list-style-type: none"> Athie Martin, small hotel owner, environmental scientist, involved in the business of water, conservationist Hadenauer Douglas, free-lance consultant, involved in geothermal development 		
Associations		<ol style="list-style-type: none"> Jeffrey Charles, resident of Wotten Waven, chairman of Geothermal Awareness Committee 		
Political parties		<ol style="list-style-type: none"> Lennox Linton & Edison James, United Workers Party 		

Wide variety of expectations identified

- ❖ Players associate geothermal activity with around 40 issues
- ❖ One single issue is considered positive, the rest are considered to be negative

SOCIO-ECONOMIC ISSUES	<i>The ECONOMIC sphere looks to "human capital SERVICES" (and also "social capital") for economic well-being. This means, on the one hand, growing opportunities for wealth, income, property and services but, on the other hand, exploitation and disturbance of existing forms of community. For the SOCIAL sphere, the ECONOMIC sphere is a means, not an end in itself. The question is to know whether the "opportunities" provided by the latter maintain or threaten existing values and the FORMS OF COMMUNITY.</i>	<ol style="list-style-type: none"> 1. Job creation 2. Population displacement 3. Infrastructures 4. Tranquillity / Easy lifestyle 5. Noise 6. Risk of major accident 7. Health 8. Local skills
SOCIO-ENVIRONMENTAL ISSUES	<i>This interface is the domain of ENVIRONMENTAL VALUES and the "culture" matrix that determines the "MEANINGS OF NATURE" or the spectrum of "environmental functions" identified by or for a society, e.g. nature as a cosmology, roles as "sources" of well-being or wealth, a landscape's perceived quality. It is therefore the meanings' material and symbolic extent that (among other aspects) enables members of society to articulate "risks" and affirm values: the whys and wherefores of sustainability, and for whom (e.g. productive land usage, biodiversity conservation, love of nature; the right of today's generation to consume natural resources versus the duty to respect them for the sake of future generations, etc.).</i>	<ol style="list-style-type: none"> 9. Mother Nature

<p>ECONOMIC ISSUES</p>	<p><i>Economic self-organisation, e.g. contracts, performance obligations such as efficiency, growth, production, transport and consumption.</i></p>	<p>10. Price of energy 11. National revenues/Balance of trade 12. Cost of project/ Investment 13. Development of commercial relations 14. Safeguarding of energy supplies 15. Valley development 16. Taxes and duties 17. Agriculture 18. Tourism 19. DOMLEC development</p>
<p>ECO-ENVIRONMENTAL ISSUES</p>	<p><i>The ECONOMIC sphere looks to the "SERVICES" of "natural resources" for economic well-being as a production factor. This causes "ENVIRONMENTAL PRESSURES" and "IMPACTS" on the functioning of the environment and on future services, including payback effects (sometimes interrupted) on the economy and the community.</i></p>	<p>20. Natural hazards 21. Geothermal properties 22. Land consumption 23. Water 24. Air 25. Soil 26. Visual impact 27. Vibrations 28. Waste 29. Ecosystem / biodiversity 30. Carbon credits 31. Greenhouse gas emissions/Climate change 32. Environmental hazards</p>

- ❖ Governance issues are rated negatively:
 - absence of consultation
 - problems with project management (*EIA after works*)
 - share of foreign countries and Dominica in the project

GOVERNANCE ISSUES

An organisation's governance is expressed via the emergence of rules and procedures that regulate each sphere in relation to the others so as to ensure the simultaneous compliance with (or fulfilment of) each of the three spheres' performance/quality objectives. It is the sphere of mediation between different principles and of the communication of interests, created de facto or deliberately by using force or institutional arrangements ranging from cities or local councils to UN international agencies as well as national government structures.

- 33. Consultation
- 34. Corruption
- 35. Energy mix/policy
- 36. Project management
- 37. Project governance
- 38. Dominica's image
- 39. Regulatory framework
- 40. Operations monitoring
- 41. Alignment with national policy

- ❖ Valley residents appear the most unfavourable to the project.
- ❖ Other players appear more nuanced.

	GENERAL PUBLIC						COORDINATING AUTHORITIES			ECONOMIC PARTNERS		SYNTHESIS
	Laudat residents	Trafalgar residents	Wotten Waven residents	Associations	Ecologists	Political parties	GPMU	Government departments	Locally elected representatives	Partner companies	Regional economic actors	
Socio-economic issues	☹	☹	☹	?				😊	😊		☹	☹
Socio-environmental issues	☹	☹	☹									☹
Economic issues	☹	☹	☹	😊	😊	😊	😊	😊	😊	😊	😊	😊
Eco-environmental issues	☹	☹	☹	☹	☹	😊	😊	?	☹	😊		☹
Governance issues	☹	☹	☹	☹	☹	😊	☹	☹	😊	☹	☹	☹
SYNTHESIS	☹	☹	☹	☹	☹	😊	😊	😊	😊	😊	☹	

☹ Negative opinion 😊 Ambivalent opinion 😊 Positive opinion ? Questions

Results

Ecological status of monitored watercourses

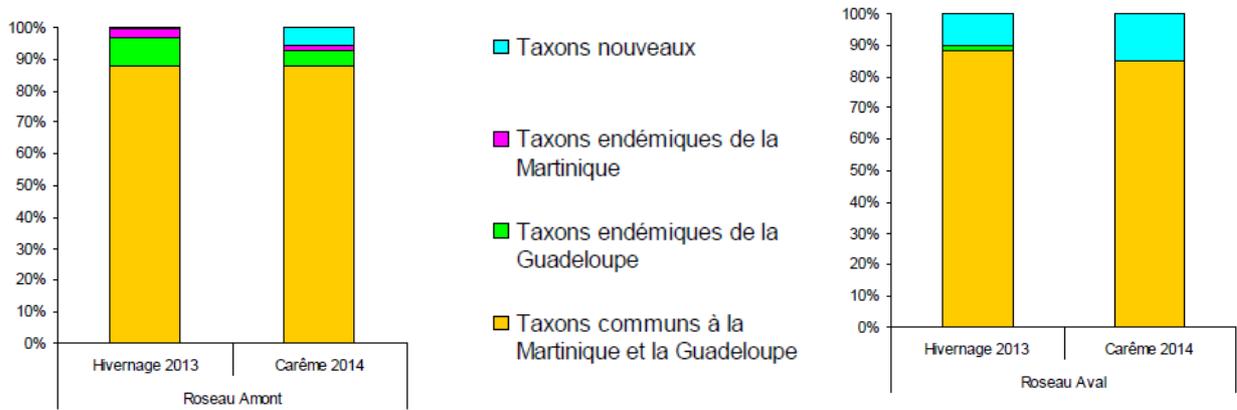
	Hydromorphologie	Diatomées	Macro-invertébrés	Poisson et macro-crustacés	Qualité physico-chimique
Roseau Amont ☺ : état écologique au moins bon	☹ impactée par les aménagements : écoulement perturbé (facès d'écoulement lentisques), ripisylve préservée	☺ bonne diversification (40 taxons) dominé par taxons polluant résistants bon état écologique	☺ bonne diversification (31 taxons) bon état écologique	☹ faible diversification (5 espèces) densités faibles	☺ aucun micropolluant organique, Minéralisation importante bonne qualité
Roseau Aval ☺ : état écologique au moins bon	☺ naturelle, non impactée par l'homme	☹ faible diversification (23 taxons), taxons ubiquistes et polluant résistants	☺ bonne diversification (34 taxons) bon état écologique	☹ faible diversification (7 espèces) densités très faibles	
Rivière Blanc Amont ☺ : état écologique au moins bon	☺ naturelle, non impactée par l'homme	☹ faible diversification (25 taxons), taxons ubiquistes et polluant résistants (indice peu fiable)	☺ faible diversification (25 taxons) mais très bon état écologique	☹ très faible diversification (3 espèces) densités faibles	∅ pas d'analyses
Rivière Blanc Aval ☹ : état écologique moyen	☹ très impactée par les activités anthropiques : écoulement perturbé (érosion, colmatage minéral), ripisylve préservée	☹ taxons ubiquiste et polluant résistants = apports organiques et minéraux importants (indice peu fiable, peut être dû à la proximité des sources thermales)	☹/☺ « état médiocre » à « bon » bonne diversification (31 taxons) Mais légère perturbation dû au colmatage minéral : surabondance de <i>Chironomidae</i> <i>Orthocladinae</i>	☹ très faible diversification (4 espèces) densités faibles Composés sulfurés d'origine naturelle « impactent » les communautés biologiques : même si l'eau est de bonne qualité physico-chimique , la station est sans doute peu « apte à la biologie » tout en étant non perturbée.	☺ aucun micropolluant organique, Minéralisation importante bonne qualité

The results obtained show a status of NOT DEGRADED BY MAN

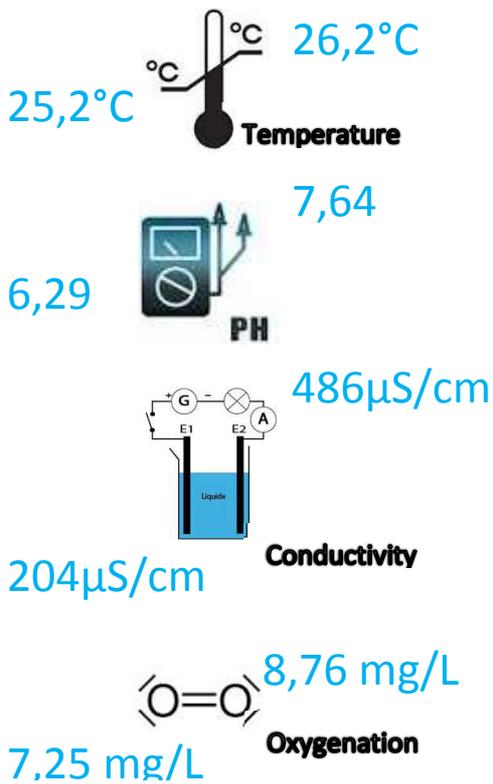


The ABSENCE of a local baseline means that the FRENCH BASELINE has to be used to establish the ecological status, though this is **not perfectly suited** (absence of reliability of the diatom index, conflicting results in the benthic macroinvertebrates index for the Blanc and Roseau rivers, etc.)

Diatom population containing taxa present in Guadeloupe and/or Martinique and **new taxa**



Water conditions:



1 species of fish present in all stations and dominating populations



Sicydium sp

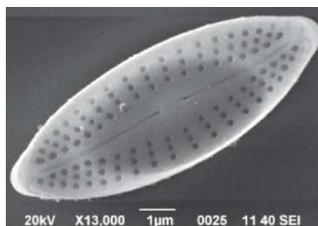
Species of crustacean Widespread



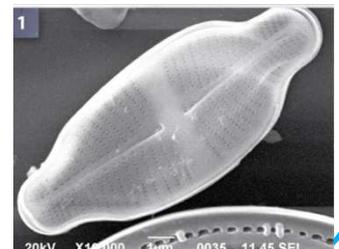
Macrobrachium heterochirus

Presence of pollutant-resistant diatoms in all stations

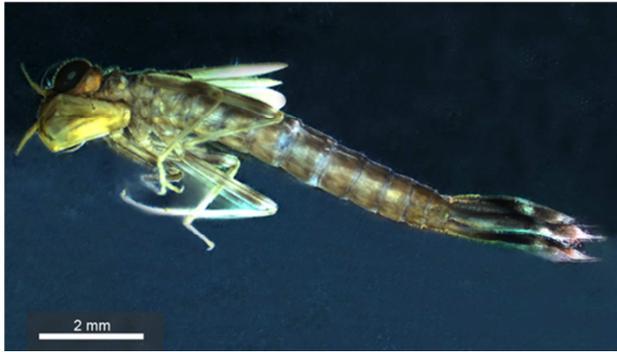
Achnanthisdium subhudsonis



Achnanthisdium exiguum



3 species of interest identified (native to the Lesser Antilles):



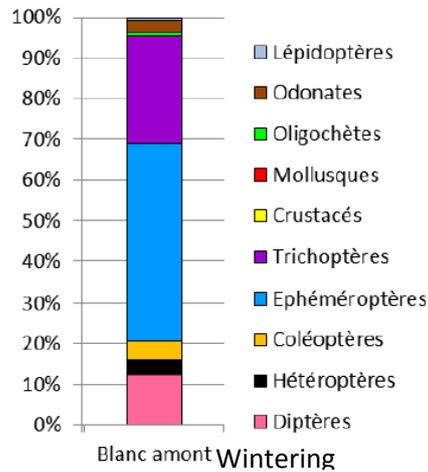
Argia concinna
(present on all stations)

Guinotia dentata (Roseau Upstream)

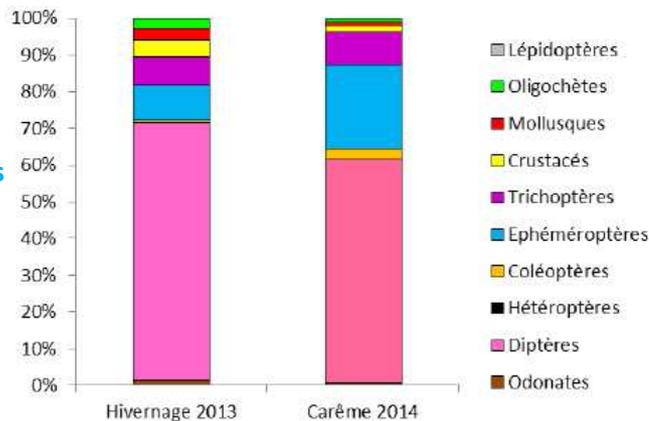
Xiphocaris elongata
(Roseau Upstream)



Dominance of **trichoptera** and **mayflies** shows a **good ecological status** (French baseline) on the Upstream **Station of Rivière Blanc**



Dominance of **Chironomidae** (diptera) and **Oligochaetes** shows an **average ecological status** (French baseline) at the downstream **station Blanc**



SECTION 3 : BIODIVERSITY / LAND FLORA AND FAUNA

Goal of the study

- To identify the flora and fauna of the region
- To determine the most sensitive sites in the Roseau Valley



Method used

An initial flora and fauna analysis was carried out in 2008 by Mr Arlington James, forest officer and expert in flora and fauna. The goal was to have an introduction to the Roseau Valley, the legal context related to forest clearing and protected natural spaces. Three sites were studied by Mr Arlington James assisted by Mr Phillip Matthew for field reconnaissance.

The botanist and ecologist Félix Lurel went further with this analysis by increasing the inventories on different sites and enlarging the panel of plant groups covered. His involvement permitted the examination of various aspects:

- Field inventory
- Phonological status
- List of species

Twelve areas were studied in an area bordered by:

- Morne Louis and Morne Bruce to the west of the valley (entrance downstream of valley);
- Morne Jack and Morne Micotrin to the north and north east;
- Boiling Lake to the east;
- Mount Watt and Morne John to the south east;
- Morne Prosper to the south.

The 12 study areas are listed on the map on the next page

The campaigns consisted of:

- 19 field prospections
- Identification of species by visual and vocal recognition (Fauna).

4 large zones identified

Large zone 1 is highly influenced by the Trafalgar and tourist activities. It is considerably degraded by past and present human activity.

Reed formations are regularly burned.

These are the natural areas and tourist sites that are most accessible.

All of Morne Prosper and Wotten Waven constitutes an agricultural sector.

This large zone 1 seems the most impacted by reeds which developed after roadworks.

Large zone 2 (Laudat, Aerial Tram, Titoo Gorge) is a sector of Rain forest where numerous trees are felled for development and economic reasons.

Large Zone 3 encloses a forest formation at different stages of development depending on the history of the individual place. The humid zone is a prairie with *Symphonia globulifera* trees, and whilst suffering the anthropic impacts, it merits special attention.

Large Zone 4 concerns hydrophilic mountain and summit forests, Elfin forest. It is extremely sensitive and is home to numerous native Dominican species. These species can also be found on the Island.

River banks and ravines are the key places for any environmental study. They exercise essential ecological functions such as the prevention of flooding and erosion, and the habitat for varied fauna, etc.

Humid zones

Open herbaceous prairies:

- Vegetation made up of plants, predominantly hydrophilic such as grasses and sedges.
- Characteristic taxa: ferns (*Nephrolepis multiflora*, *Pterolepis glomerata*, *Thelypteris reticulata*, *Ludwigia octovalvis*), rushes (*Fuirena umbellata*), sedges *Eleocharis mutata* et *Eleocharis flavescens*



Eleocharis sp. and Pterolepis glomerata

Wooded wetlands:

- Wetland area colonised on its external borders by Pink apples *Syzygium jambos* or apricots *Clusia major*



- Dominant taxa: Yellow mangroves (*Symphonia globulifera*) and epiphytes



Rain forest

Luxuriant formation of tall trees. It reaches between 500 and 1 000 metres altitude with an annual rainfall of 2 000 to 5 000 mm and a temperature varying between 20 and 25°C

The dense forest is characterised by shelves of vegetation made up of different plant groups. The internal layout reflects the competition between species for space and light.

It is made up of nearly 300 species of trees and shrubs.

The dominant trees are the gum tree (*Dacryodes excelsa*), the Bwa dyad (*Licania ternatensis*), the Karapit (*Amanoa caribaea*), the “Chatannyé” (*Sloanea spp.*) and the “Bwa kot” (*Tapura latifolia*).



Bwa kot *Tapura latifolia*



Bwa riviye *Chimarrhis cymosa*



Tectaria trifoliata, *Epidendrum sp.* and *Erythrodes plantaginea*

It is also made up of a large number of ferns and orchids.

High forest with low vegetation: Montan forest

The mountain forest is subject to fairly low nocturnal temperatures, winds that can be strong, rains (rainfall over 8 000 mm) and significant cloud at this altitude.

The vegetation has adapted to these difficult environmental conditions. The trees and bushes are smaller and sturdier, thanks to their ball shape. The forest appears closed, practically impenetrable with an abundance of shrubs.

Large herbaceous, other than grasses, with large leaves such as Heliconiaceae (*Heliconia bihai*, *Heliconia caribaea*), land Cyclanthaceae (*Asplundia insignis*, *Asplundia dussii*), Gesneriaceae (*Besleria*), Zingiberaceae (*Renealmia*, *Costus*) and Rubiaceae (*Psychotria*) characterise this forest.



Heliconia bihai



Besleria



Anthurium



Elaphoglossum

Epiphytes, mainly vascular, and pseudo-lianas are very abundant.

The microclimate favours these plants, including Araceae (*Anthurium*, *Philodendron*) and ferns, in this case *Elaphoglossum*, *Polypodium*, *Trichomanes*.

Cultivated zones

Man has mainly cleared mid-humid forests for the requirements of urbanisation and to ensure a source of food (crops, pasture).



Muskad *Myristica fragrans*



Mango *Mangifera indica*



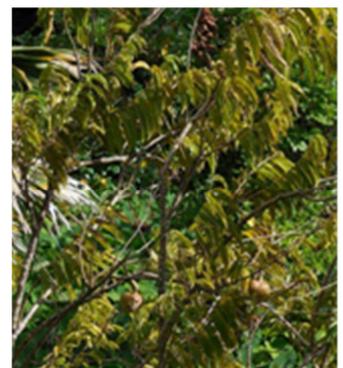
Vangueria madagascariensis

Cultivated species joined or replaced the original vegetation at this level. The landscape has been enriched by ornamental plants, fruit trees, food plants, herbs and stimulant plants.

Ancient degradation allowed the installation of species that were initially cultivated, or often escaped from garden settings. They are now widely naturalised to the point of becoming Alien Invasive Species.

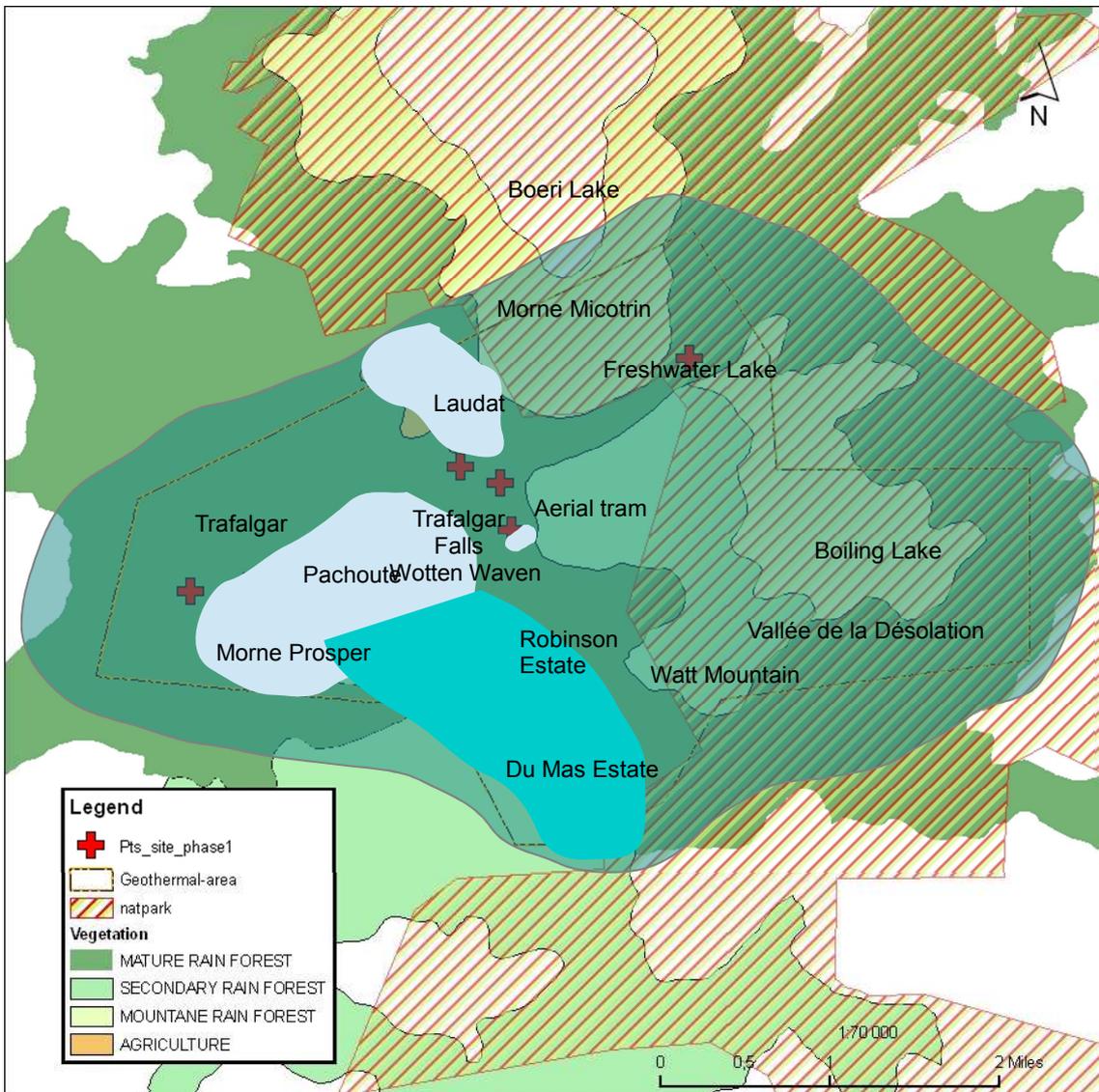


Coconut palms and Gabon tulip tree



Kè a bèf *Annona reticulata*

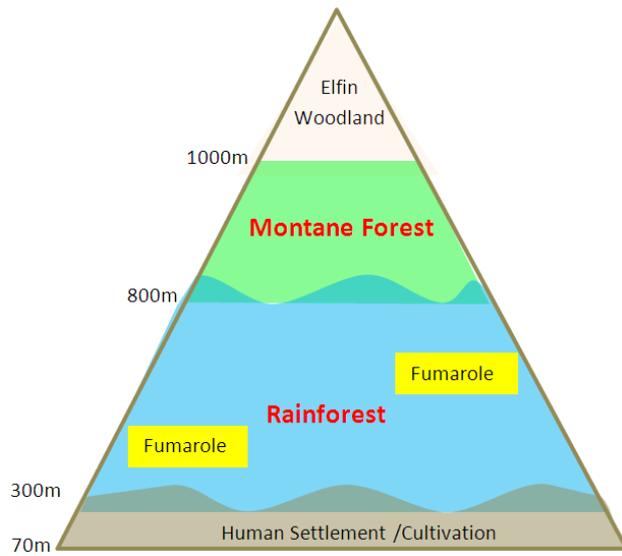
Environmental sensitivity maps



 Sensitivity 1 (low) = agricultural and urbanised environments under strong anthropic influence

 Sensitivity 2 (medium) = lightly urbanised environments of mid altitude with almost unaltered vegetation

 Sensitivity 3 (high) = sub climactic natural environments, mainly dense tropical forest and high altitude formations



Most sensitive habitats for fauna:

The **Montane Forest** and the **Rainforest** are habitats presenting the greatest biodiversity and the largest abundance of individuals of interest (native, protected, etc.)

Other habitats are more inhospitable for fauna

Location of 5 types of ecological habitats distributed by altitude in the project zone: Roseau Valley





Boa constrictor Tet Chien (Boa Constrictor)



Tree Frog (*Eleutherodactylus amplinympha*)



Hercules Beetle (*Dynastes hercules*)

Valley fauna

- ❖ 4 types of vertebrates : birds, mammals, reptiles and amphibians
- ❖ Mammals and reptiles are uncommon (number of species and abundance). 12 species of bats are found in the Montane forest and the Rainforest. The study of their population is to be extended.
- ❖ Bird fauna is the best-represented group (176 species listed by Durand and Baptiste) with the most species of ecological interest: 3 species have the status of threatened at the UICN¹ and 2 are protected in Dominica, 10 species native to the Lesser Antilles.



Brown trembler



Sisserou parrot (*Amaazona imperialis*)



Blue headed Hummingbird (*Cyanophaia bicolor*)

¹ International Union for the Conservation of Nature - <http://www.iucn.org/fr/>

Location of the most difficult fauna issues

- ❖ **Primary forest** (rich and serving as a biodiversity reservoir, e.g. Parc National–Central Forest Reserve)
- ❖ **Corridors** used by species to circulate between their principal habitats. The recommendation is to avoid fragmenting habitats
- ❖ Existence of some **reservoir islands** like Morne Prosper, the favoured habitat of the Red Parrot, to be preserved
- ❖ **band of 300m around the National Park** of Morne Trois Pitons

Other habitats are less favourable to the development of fauna

SECTION 4: SOCIO-ECONOMY / LIFESTYLE

Aims of this section

To present a socio-economic overview of the Roseau Valley taking account of the following components:

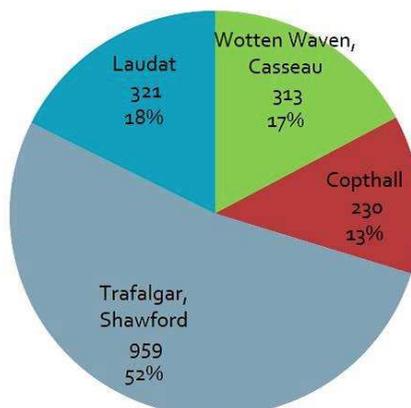
- ❖ Population and lifestyles
- ❖ Education
- ❖ Health
- ❖ Habitat
- ❖ Insecurity and criminality
- ❖ Employment
- ❖ Economy
- ❖ Governance

Methods used

- ❖ Analysis of bibliographical sources
- ❖ Interviews (25)

Population and lifestyles

- ❖ Half of the population is located in Trafalgar (Central statistical office, 2011) :



- ❖ Population development of 32% between 2001 and 2011, partly due to the proximity of Roseau
- ❖ Average 2.7 people per household
- ❖ Relatively high standard of living compared to the rest of Dominica
- ❖ 80 % of residents speak Creole as well as English, the official language

Education

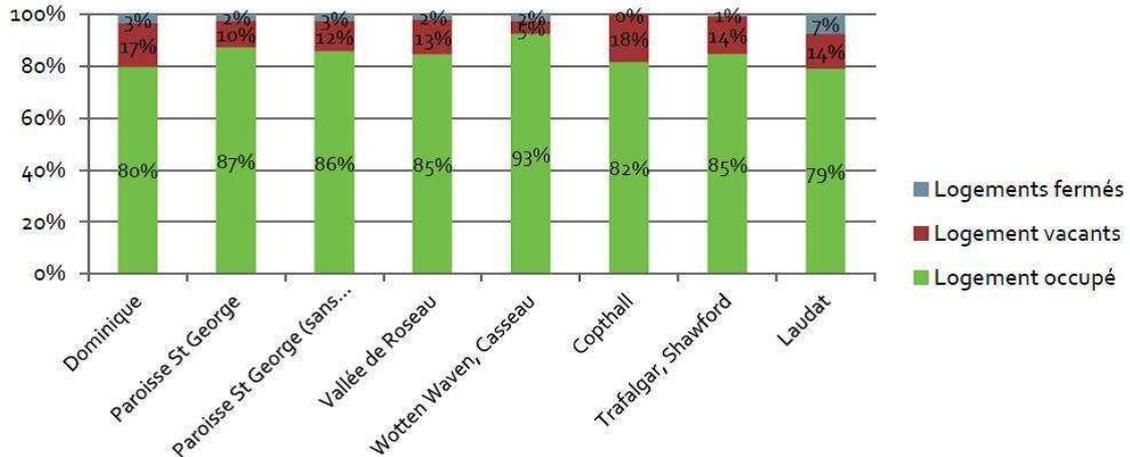
- ❖ Primary school in each village in the valley
- ❖ Secondary school at Roseau only
- ❖ High level of scolarity as school is mandatory to secondary level (97-98 %)

Health

- ❖ Three health centres in the valley: Trafalgar, Wotten Waven and Laudat
- ❖ Proximity of the capital Roseau and particularly the Princess Margaret hospital
- ❖ No health data concerning the Roseau Valley
- ❖ A relatively high number of people over one hundred years old and a life expectancy among the highest in the Caribbean

Habitat

- ❖ The valley had 769 dwellings in 2011 with low development over the past few years according to the Housing Ministry
- ❖ A little under one property in five is unoccupied or closed up (Central Statistical Office, 2012)



- ❖ All of the housing in the valley has electricity, with the exception of a few isolated houses.
- ❖ According to DOWASCO, all properties are connected to the drinking water in the valley
- ❖ Good quality of drinking water

Employment

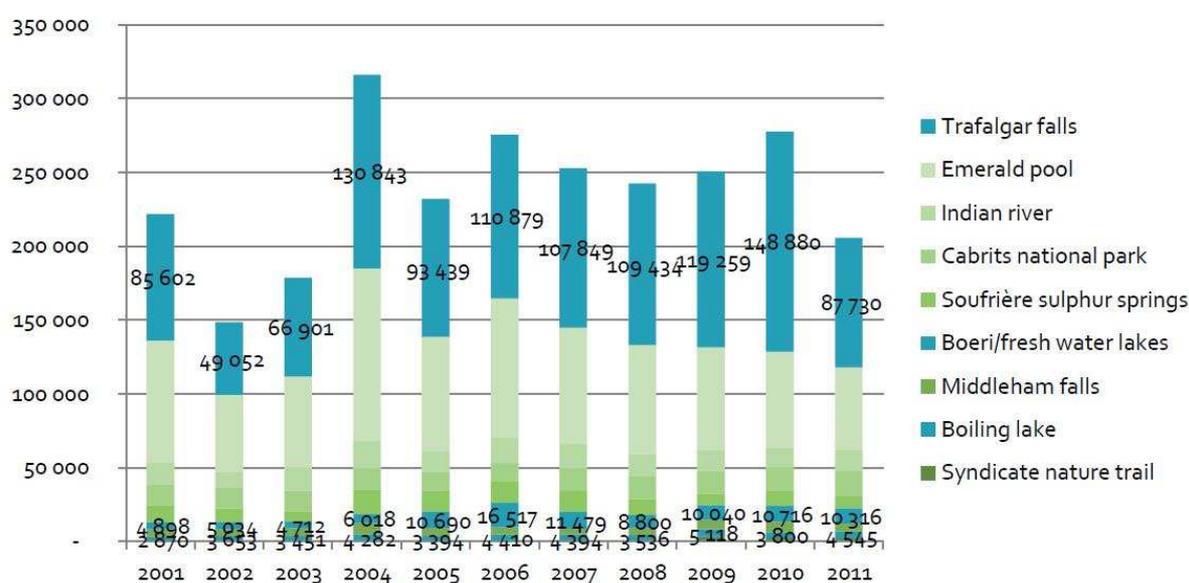
According to interviews, there is not sufficient employment in the valley, residents are obliged to travel to Roseau for work.

There is no data on unemployment rates in the Roseau Valley.

However, nationally, the unemployment rate is 11.1% for men and 17.6% for women.

Economy

- ❖ Tourism and agriculture are the two pillars of the Dominican economy and, a fortiori, in the Valley which is the home of some of the most visited tourist sites on the Island (cf. Trafalgar Falls, Boiling Lake and Fresh Water Lake)
- ❖ Visitor rates for the principal natural tourist sites in Dominica between 2001 and 2011 (sites in the Roseau Valley in blue) (Central Statistical Office, 2012)



- ❖ Increasing numbers of residents are leaving agriculture for tourism which they believe is more profitable.
- ❖ Like the rest of Dominica, the Valley suffers from certain economic problems: lack of employment and expensive accommodation. Young people are unable to stay.

Governance

The Dominican political system allows significant participation of residents in public life. Its residents are therefore very involved politically. On a local scale, the territory is divided into districts, which are, themselves, divided into village councils. Officials in councils are appointed by the government they represent. One third of the officials, notably, are women.

SECTION 5: ACOUSTIC

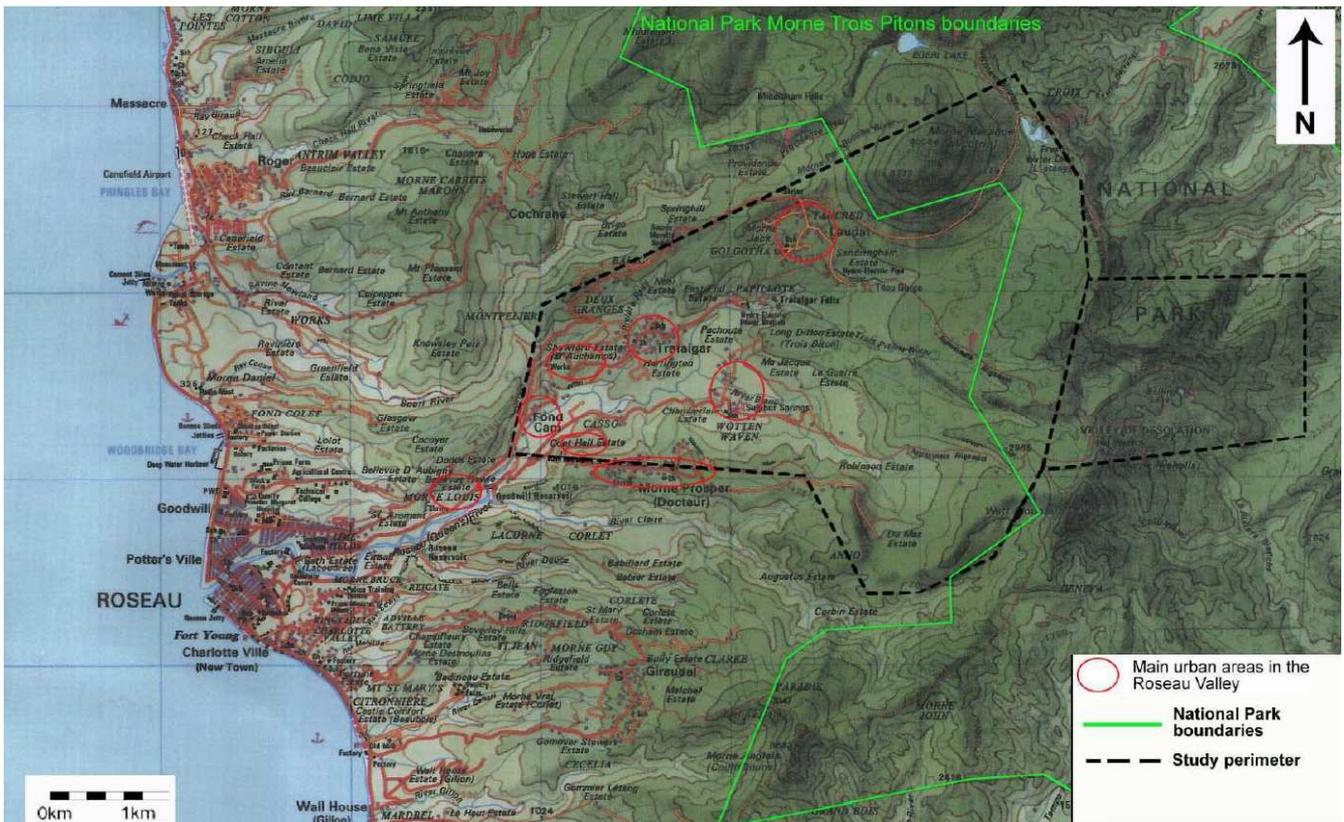
Aims of this section

- ❖ Measurements of the sound level in the principal residential zones, the main tourist sites and valley hotels
- ❖ Determination of the initial “zero” acoustic level of the potential project zones
- ❖ Definition of the maximum sound levels to be authorised after the three geothermal installations are operative

Methods used

- ❖ 2 noise measurement campaigns carried out in the tourist high season (December 2013) and low season (April 2014)
- ❖ 5 residential zones studied: Laudat, Fond Cani North / Fond Cani West & South, Trafalgar, Wotten Waven, Morne Prosper
- ❖ 54 acoustic measurement points analysed in day and night times





Trafalgar
Point 10: Trafalgar Falls



Fond Cani « West and South »
Point 7



Wotten Waven
Point 9

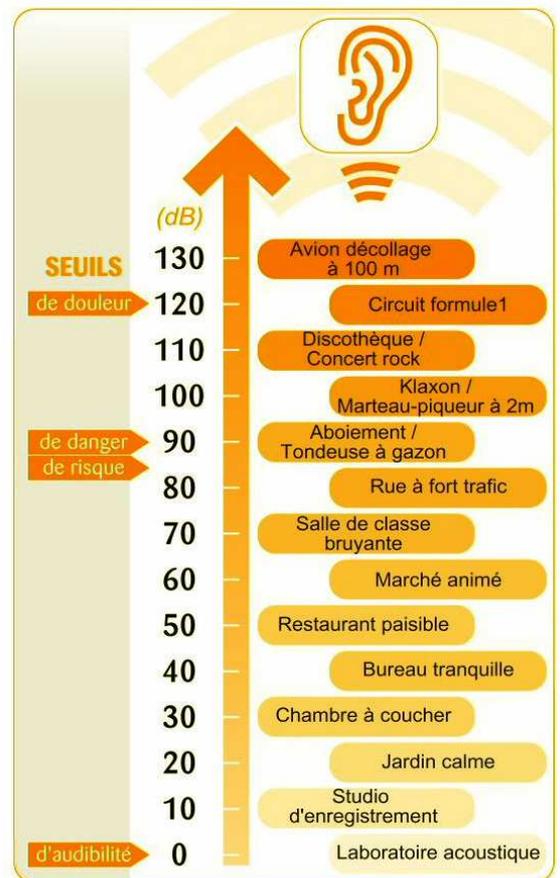


Scenarios and standards used

- ❖ **Initial sound levels used:** minimum sound levels encountered during the two acoustic campaigns
- ❖ **Maximum authorised ambient sound levels:** the absence of Dominican standards means that the French standards for the limitation of noise in the environment by Installations Classified for Environmental Protection are applied.

Key data regarding the initial sound level

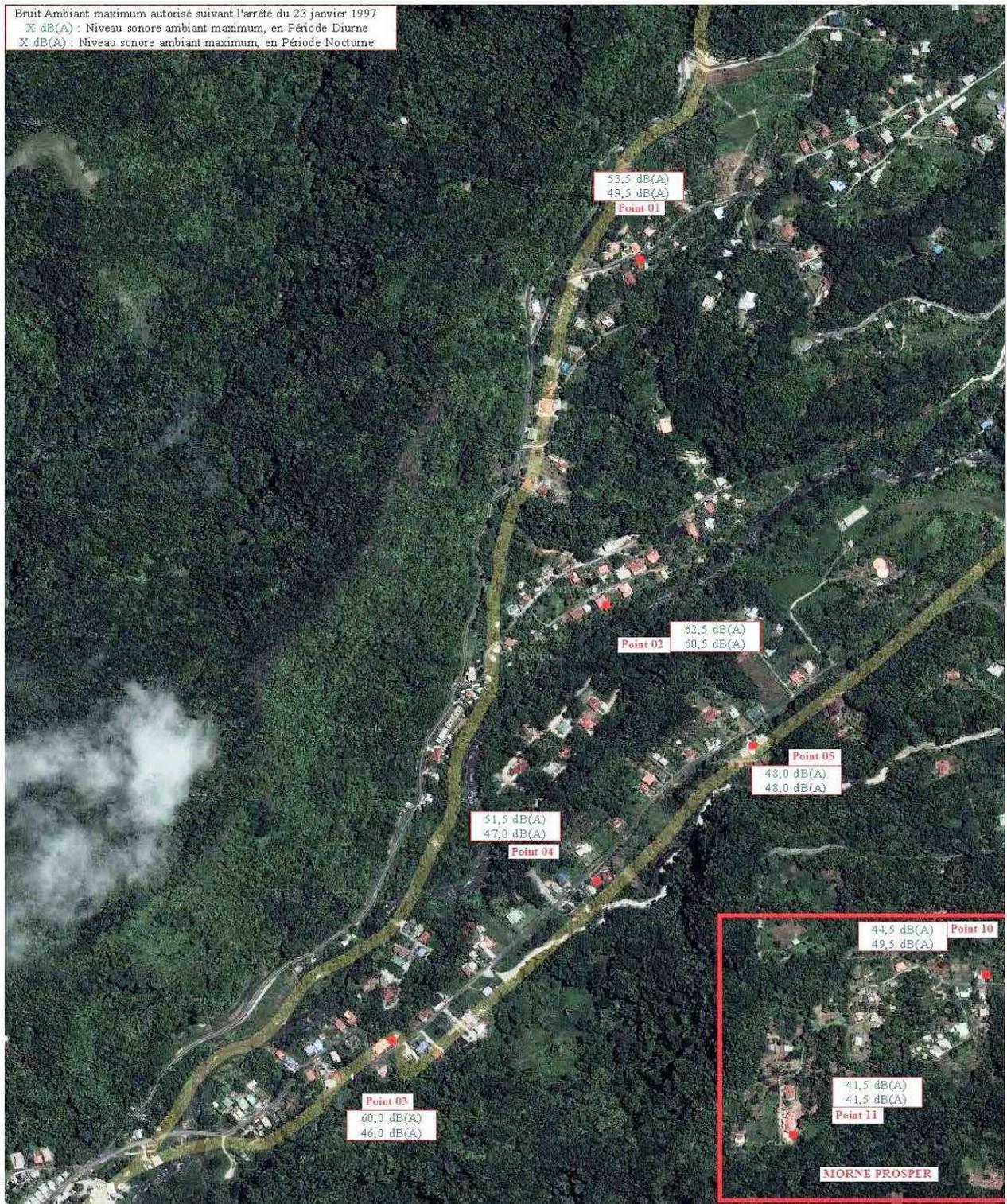
- ❖ Ambient noise, mainly due to local fauna, human activity, wind noise in the vegetation and running water (rivers and waterfalls, etc.)
- ❖ Ambient sound levels are generally higher at night due to local fauna
Ex: On Laudat, In December, sound levels close to property vary between 35.5 and 43.5 dB in the day and between 40 and 45 dB at night
- ❖ Higher ambient sound levels close to tourist sites and hotels
Ex: Sound levels at Trafalgar Falls in April reach 55.5 dB



Noise scale (source: www.bruitparif.fr)

Maximum authorised sound levels Example the site of Fond Cani “West and South”

SITE DE FOND CANI « WEST & SOUTH » :



SECTION 6: CLIMATOLOGY – AEROLOGY

Aims of this section

- ❖ Air quality measurement campaign enabling:
 - monitoring of concentrations of target pollutants
 - determination of potential health impact: sensitive or exposed zones, taking into account potential exposure to hydrogen sulphide
- ❖ Selection of the location and installation of a reference weather station, enabling measurement of the principal weather features over a year, in the absence of existing data.

Pollutants considered

- ❖ Sulphur dioxide (SO₂)
- ❖ Hydrogen sulphide (H₂S)
- ❖ Nitrogen oxides (NO_x)– Nitrogen dioxide (NO₂)
- ❖ Fine dust PM₁₀ and ultra-fine PM_{2.5}
- ❖ Ozone (O₃)

Regulatory references

The absence of a local reference requires the definition of reference values using an analysis of the regulations in force in Europe as well as the United Kingdom, complemented by WHO recommendations.

Air quality data for the air in Guadeloupe and Martinique are also taken into account.



Weather station installation

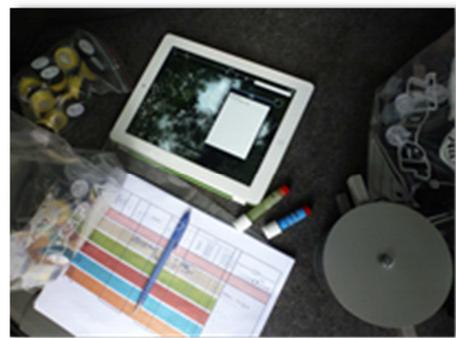


Methodological approach

- ❖ Situational analysis of environmental data in terms of air quality and weather, topographic and climate data, etc.
- ❖ Identification of potential measurement sites
- ❖ Technical implementation of the weather conditions monitoring station
- ❖ Technical implementation of campaigns for air quality assessment: two measurement campaigns for 30 measurement points; one in the dry period and the other in the humid period

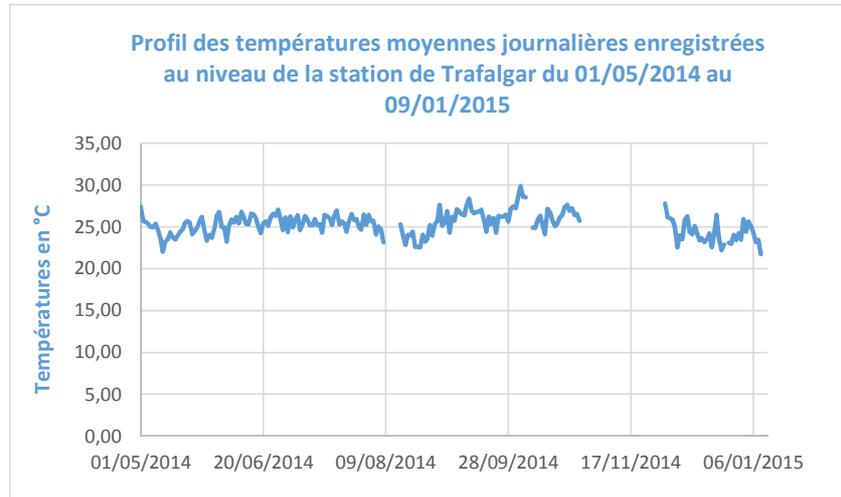


Air quality campaign measurement



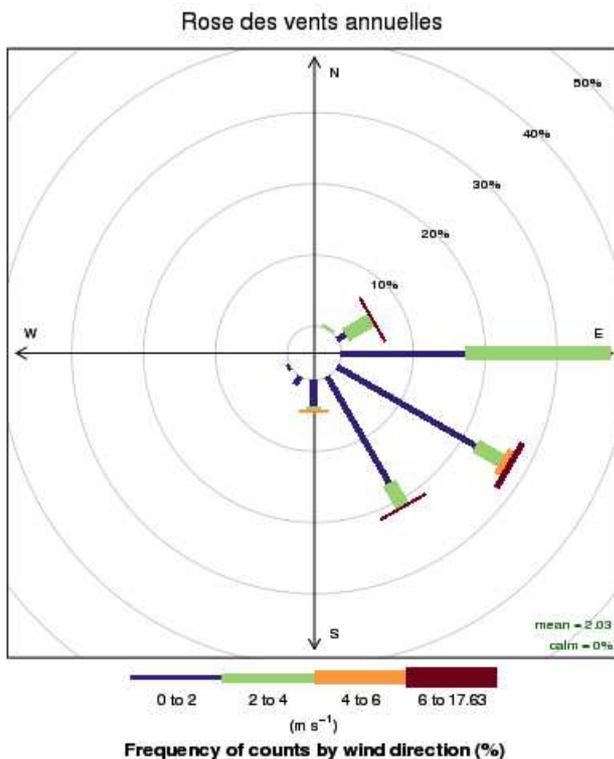
Key weather data

Average daily temperature 25.3 °C



Low rainfall in 2014: daily average 0.08 mm

Elevated rain frequency in 2014: only 39 dry days in the year!



Predominantly south and south east sector winds with occasional south-south east sector winds in August and December; and north and north west in August and October.

Example of Trafalgar from 01/05/2014 to 09/01/2015

Environmental initial state – Final summary

Pollutants	Reference values considered for the study	
PM10	Limit value: 50 µg/m ³ average over 24 hours 40 µg/m ³ annual average	Recommendations WHO: 20 µg/m ³ annual average
PM2.5	Limit value: 25 µg/m ³ annual average	Recommendation WHO: 25 µg/m ³ 24 hrs Quality goal and WHO recommendation: 10 µg/m ³ annual average
NO₂	Limit value – recommendations WHO: 40 µg/m ³ annual average	Limit value for vegetation: 30 µg/m ³ annual average
SO₂	Limit value: 125 µg/m ³ / day not to exceed 3 days pa	Quality goal : 50 µg/m ³ annual average Recommendation WHO: 20 µg/m ³ average over 24 hrs
O₃	Target value: 120 µg/m ³ average over 8 hrs	Recommendations WHO: 100 µg/m ³ average over 8 hrs French network reference values: 50 µg/m ³ annual average in urban station 60 µg/m ³ annual average in rural station Reference values for the Guadeloupe and Martinique network: 34 µg/m ³ annual average in peri urban and urban stations
H₂S	Recommendation WHO for nuisance threshold: 7 µg/m ³ (over 24 hrs)	Recommendation WHO for the detection threshold: 0,2 µg/m ³ (over 30 mins)

Key data for measuring air quality

The greatest pollutants are H2S and SO2:

- ❖ Odour threshold $0.2\mu\text{g}/\text{m}^3$ systematically exceeded for H2S with 2 exceptions (Fresh Water Lake and a site in Laudat)
- ❖ Raised concentrations not related to drilling in December 2013 since higher levels measured in the second campaign (outside of drilling period)
- ❖ Natural emanation called “natural pollution” due to geothermal activity in the valley
- ❖ Possibility of odour nuisance for the population in view of the H2S peaks measured

Other pollutants did not have a threshold in excess of reference values.

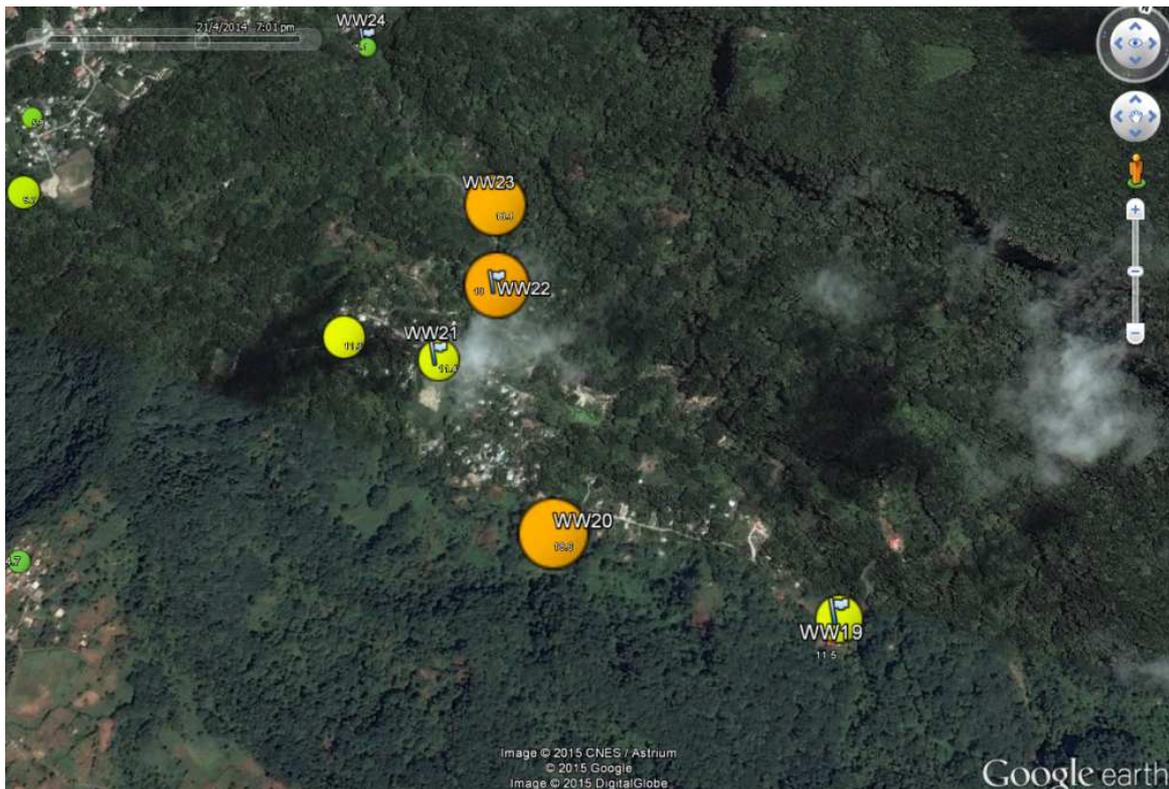
The zones “sensitive” to SO2: **Wotten Waven and Morne Prosper**; respectively $58.4\mu\text{g}/\text{m}^3$ and $64.3\mu\text{g}/\text{m}^3$ measured on average on the 2nd campaign, over the WHO threshold of $50\mu\text{g}/\text{m}^3$



Mapping focus on the Wotten Waven sites for average SO2 measurement

Zones “sensitive” to H₂S: all sites are sensitive to H₂S but the **Wotten Waven** site is more so than the others, with average values approaching 20µg/m³ and 30µg/m³ in certain residential sites.

N.B. : odour threshold fixed by WHO: 0.2µg/m³



Mapping focus on the sites of Wotten Waven for average H₂S measurements

SECTION 7: LANDSCAPE AND HERITAGE

Aims of this section

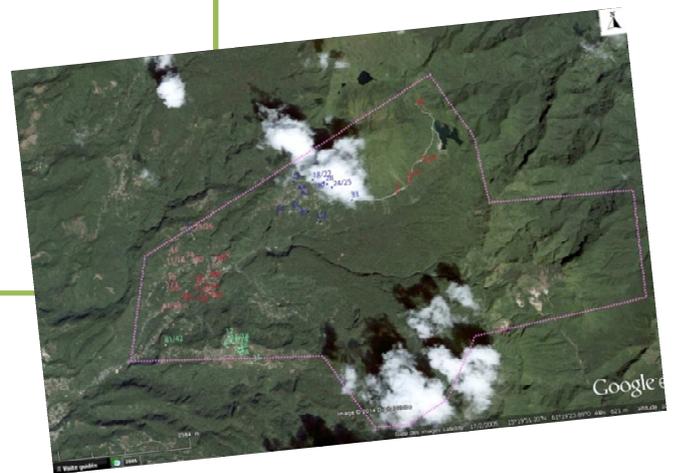
- ❖ Listing the historic heritage of the valley
- ❖ Listing archaeological/geological heritage of the valley
- ❖ Analysis of architectural developments of the valley under various influences
- ❖ Analysis of the landscape dynamic, past and present
- ❖ Listing landscapes of local interest/Analysis of iconographic representations of landscapes
- ❖ Listing visibility points

Methods used

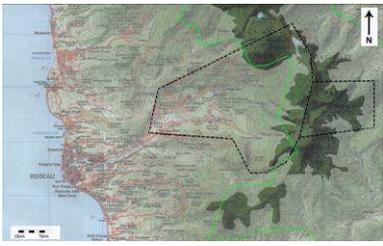
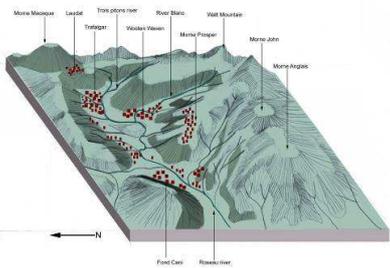
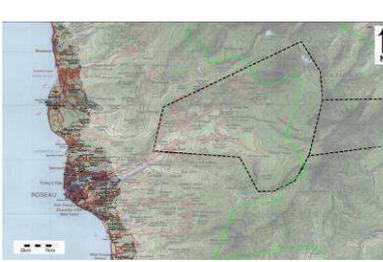
- ❖ Field campaigns:
 - Listing and location of view points over the valley from high points
 - Listing and analysis of landscape and architectural characteristics of the territory

- ❖ Meeting specialists and players on the territory:
 - A historian from Dominica, Mr Honychurch
 - A botanist, Mme Edwards
 - Residents, farmers from Laudat

- ❖ Documentary research and development:
 - For analysis of landscape development
 - For iconographic analysis
 - For analysis of architectural evolution



Analysis of landscape components

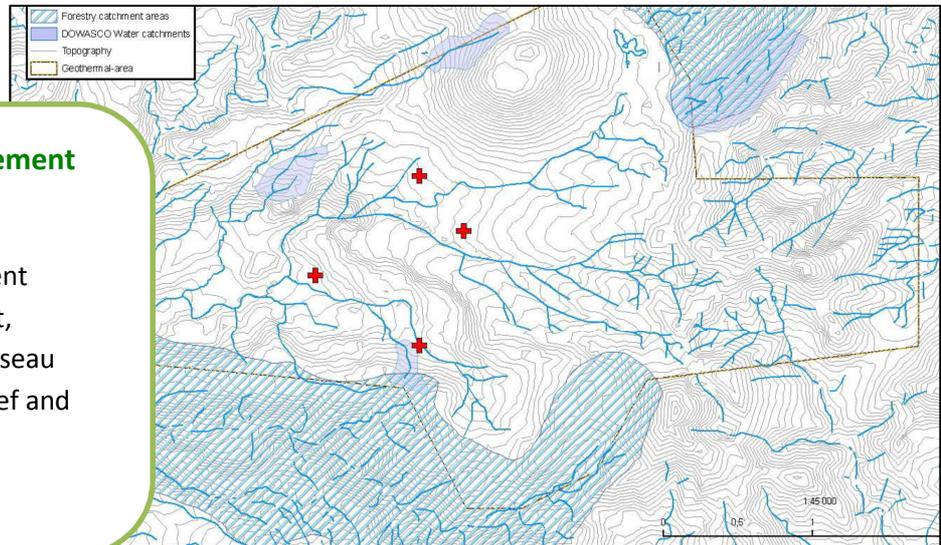
Landscape Units		Characteristics
<p><i>The majestic Mornes</i></p>		<ul style="list-style-type: none"> • Altitude up to 1 250 metres • Organisation: series of mornes with westerly silhouettes • Urbanisation: no urbanisation, inaccessible zones • Perceptions: majesty, strength, respect, peace, Large landscape
<p><i>Powerful plateaux and foothills</i></p>		<ul style="list-style-type: none"> • Altitude: between 300 and 800 metres • Organisation: two long main plateaux making transitions between the Roseau Valley and neighbouring valleys • Urbanisation: urbanisation on the Morne Prosper plateau • Perceptions: inaccessible, imposing foothills, balance (successive plateaux from successive levels), visibility (height) and open on the large landscape
<p><i>Urbanised areas</i></p>		<ul style="list-style-type: none"> • Altitude: between 150 and 250 metres • Organisation: particularly in north and east part in the Roseau Valley • Urbanisation: 8 urban communities distributed like clusters between the valley floors and the plateaux • Perceptions: village spirit, tranquillity, small scale, residential, dynamism (constructions)
<p><i>Valleys perpendicular to the sea</i></p>		<ul style="list-style-type: none"> • Altitude: between 150 and 250 metres • Organisation: series of narrow valleys perpendicular to the sea • Urbanisation: at valley floor in clusters • Perceptions: enclosed, shade, humidity in places, proximity to water
<p><i>Narrow urbanised plain</i></p>		<ul style="list-style-type: none"> • Altitude: between 0 and 150 metres • Organisation: narrow and long, with sharp reliefs • Urbanisation: spread out along the Roseau compared to valleys • Perceptions: lively, heritage, architectural, markets, noise, travel (port and airport), opens to the sea

Presence of different forms of water in the Roseau Valley

- ❖ Lakes (Freshwater Lake)
- ❖ Rivers and Gorges (Titou Gorge)
- ❖ Boiling Lake
- ❖ Hot springs (Wotten Waven)
- ❖ Fumaroles (Valley of Desolation)
- ❖ Waterfalls (Trafalgar Falls)

Water, structural element of the valley

Water is an omnipresent structuring component, fundamental to the Roseau Valley sculpting its relief and influencing its human occupation.



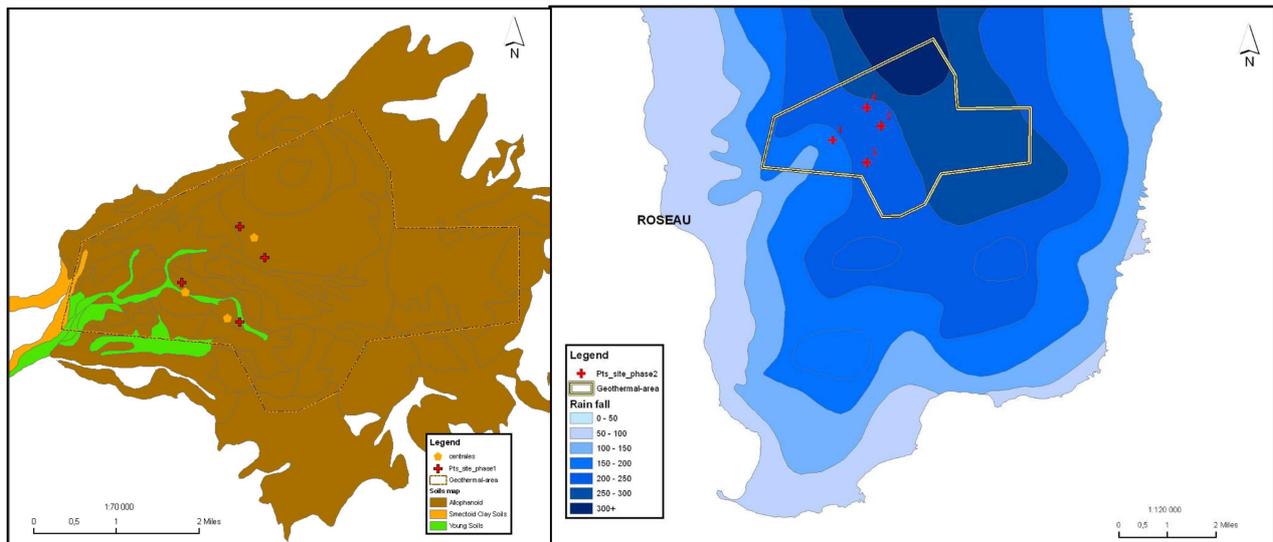
Principal structured volcanic reliefs closing views above the Roseau Valley creating a sensation of unity:

- ❖ Morne Trois Pitons: 1423m
- ❖ Morne Micotrin 1221m
- ❖ Mont Watt: 1224m



Geology, soil and climate characteristic of the Roseau Valley: Land made of volcanic rocks with generally fertile and porous topsoil.

- ❖ Accidental landslip
- ❖ Young plateau soil, mornes and slopes made of clay to allophane
- ❖ Typical tropical humid climate: high temperatures and heavy rain
- ❖ Rainfall on the west coast (leeward coast) much more moderate



Variable plant palette depending on reliefs, rainfall, soil nature, current and past use, enabling the following to be distinguished:

- ❖ Tropical forest
- ❖ Mountain forest
- ❖ Semi deciduous forest
- ❖ Vegetation of fumarole sites
- ❖ Swamp vegetation
- ❖ Savannah vegetation
- ❖ Vegetation of old fallow lands

Luxuriant natural vegetation:

Rainfall, humidity and heat of the valley help create luxuriant landscapes, where vegetation is omnipresent. Whilst “natural” vegetation seems to erase most anthropic traces (houses etc.), it has been impacted by use and human activities, particularly urbanisation, the growing of crops and the creation of roads (cutting).

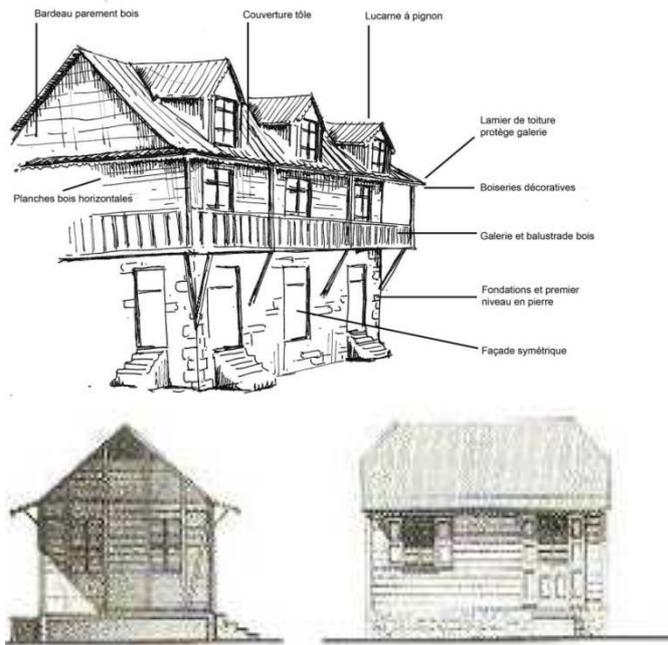


Analysis of architectural developments in the valley in view of the various influences

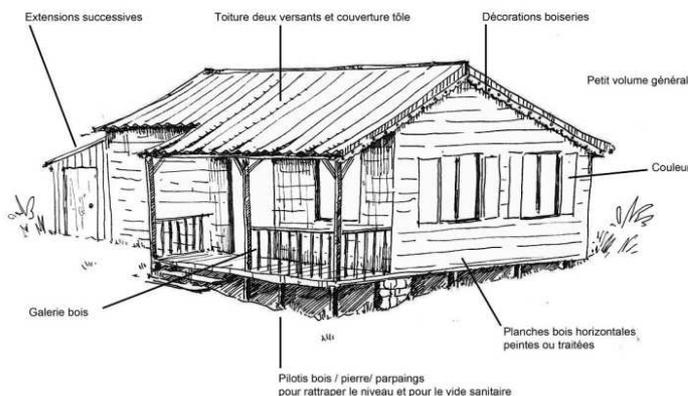
The complex and ancient history of human occupation of the island has led to numerous influences on current and past architecture in the Roseau Valley. We distinguish:

- ❖ American Indian influences
- ❖ Colonial type houses
- ❖ Traditional XXth century houses
- ❖ Neo classic inspired contemporary villas

LA MAISON DE TYPE «COLONIALE»



LA MAISON TRADITIONNELLE





Multiple architectural influences:

The town of Roseau was built on the site of the former Sairi village of the Kalinago Indians, the oldest town on the island. It has a combination of contemporary, modern and colonial architecture in French and British styles, since the island was successively in the possession of France, until 1814, and then England.

Many architectural elements have traversed history, whilst continuously adapting to development and access to new construction materials to address the constraints and peculiarities of the environment (topography, humidity, heat, run-off, hurricanes forest cover).

Infrastructures reflecting the constraints and natural advantages of the valley

Equipment that shape and enhance the landscape:

- ❖ Mountain top roads (etc.)
- ❖ Valley bottom roads
- ❖ Electricity production equipment
- ❖ Aqueducts
- ❖ Bridges





Agriculture characteristic and creative of landscapes:

With its humid climate, the Roseau Valley is favourable for the development of agricultural activity.

Agricultural use of the valley land is closely linked to its soil: younger soils are better for growing crops. This soil can be found mainly on the top of *Morne Prosper* and at the bottom of the valley of *Trafalgar* and *Wotten-Waven* where vegetables, condiments, herbs and orchards grow. These agricultural plots have great views over distant landscapes, limited by the valley hill crests.

However the steep slopes make the exploitation of land difficult. The types of cultivation are therefore very different: here small subsistence crops are grown related to the residential areas.

Ornamental vegetation embellishing villages:

Cultivated vegetation, the mark of land appropriation, is widespread in the valley.

These initiatives, mainly personal and voluntary, which decorate the division between public and private areas, give a certain style and character to the valley.



Visibility points

A road network giving a view of the valley landscape:

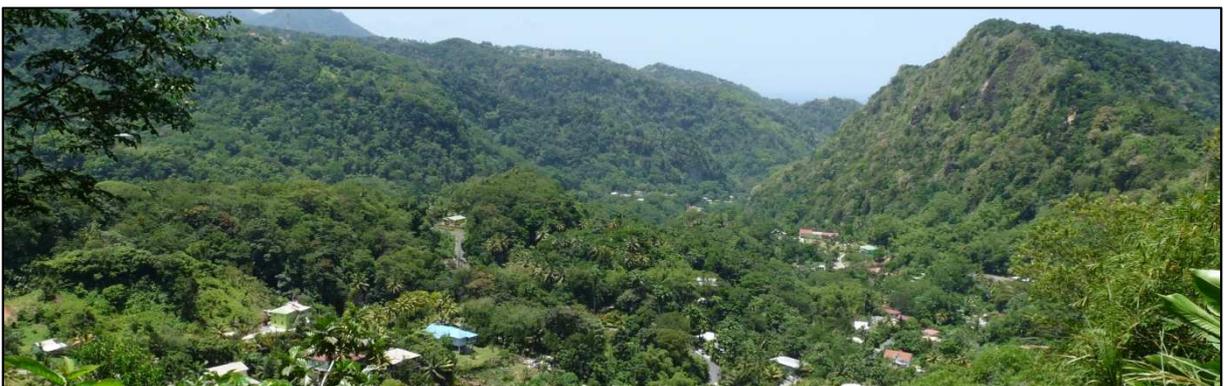
- ❖ From hilltop roads
- ❖ From roads on the valley floor
- ❖ From valley villages

Analysis of views across the valley and potential geothermal exploitation sites:

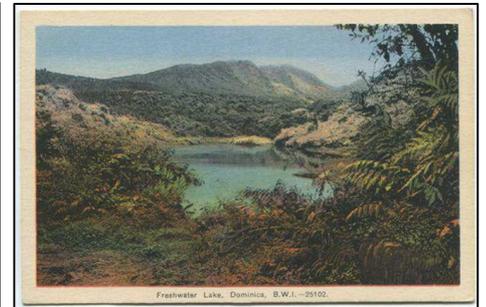
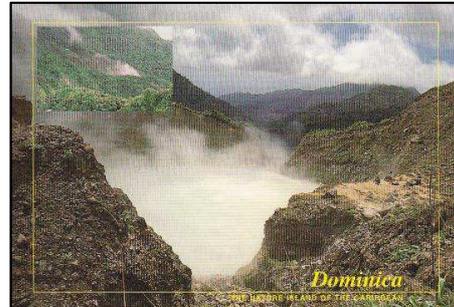
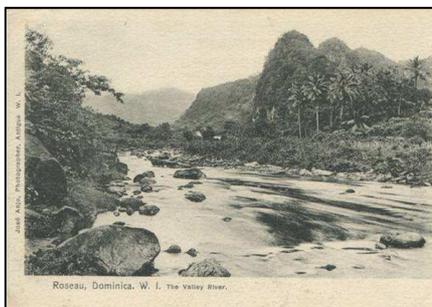
The steep relief, crossed by several roads and lanes, gives remarkable visibility points over the Roseau Valley from a number of urban, rural or natural levels. Within the framework of the geothermal project it is important to record the most noteworthy views across the valley from the most frequently visited places, in order to identify the view points and take them into account when choosing potential geothermal production sites.

Each noteworthy view point identified was described using the following criteria:

- ❖ GPS coordinates
- ❖ Orientation of the photo
- ❖ Degrees of optical view
- ❖ Position on a map



Scenery of local interest



Virgin nature landscape symbolic of the country across the Caribbean:

The iconographic and tourism documents considered during the study show a similar image of Dominica. Since the end of the XIXth century, the image commonly used to represent Dominica is the Garden of Eden. An almost virgin natural area where the sole anthropic presence takes the form of traditional occupation rooted in its territory and its scenery.

Water is, without a doubt, the element the most frequently represented in the iconography studied (drawings, postcards, antique books and magazines, etc.):

- ❖ Fumaroles of the Valley of Desolation
- ❖ Springs
- ❖ Mountain lakes, specifically Freshwater Lake
- ❖ Torrents and rivers, particularly the Roseau
- ❖ Waterfalls, particularly Trafalgar Falls
- ❖ Boiling Lake
- ❖ Forest crests of Trois Pitons National Park and the Waitukubuli National Trail

Authentic scenery symbolic of a life philosophy rooted in tradition:

The idea of a people that has remained “authentic” is widespread in the various communications media and the introduction of Dominica and especially in the Roseau Valley.

We note that this imagery is not disconnected from the genuine respect that the population has for nature. There is a culture, even a shared ethic around the environment. This vision of the world may be viewed as the heritage of African populations sent to Dominica as slaves, whose religion was animism.

Today, the Rastafarian culture, with its Somalian roots, widespread in Dominica since the 1970s, particularly in the areas of the valley bottom more secluded than Roseau, is also the expression of an “environmentalist philosophy” of life.



National iconography: the flag

The three bands of colour represent the three major aspects of the Dominican island scenery:

- Yellow for the sun and the main crops of bananas and lemons
- Black for African heritage brought by colonisation
- White for European influences, rivers and waterfalls.

At the heart of the central red circle of the flag is the *Sisserou* parrot or *'Amazona imperialis'*, symbol of the Dominican equatorial forest and the national bird.

The image of the country provided by the national flag is orientated more towards the land than the sea. Green is very dominant and the blue of the sea is absent, unlike the flags of most Caribbean Islands.



Anthropic landscape dynamics

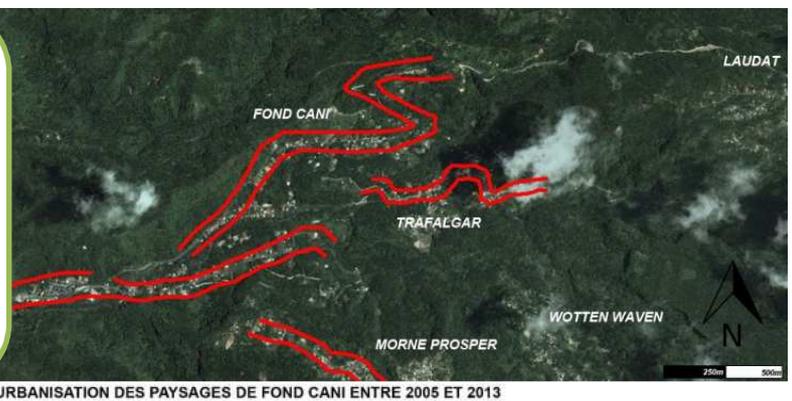
Fallow agricultural plots

Mountain slopes at the bottom of the Roseau Valley are today only rarely cultivated. Some colonial exploitations remain, some isolated Creole gardens, but the trend is more towards abandoning inaccessible land and the shallow soil of the slopes.



Linear urbanisation

The search for a pleasant lifestyle encouraged suburban urbanisation of the Roseau Valley along the main road, expanding existing hamlets. The risk of this is the elimination of urban limits and the transformation of the scenery.



URBANISATION DES PAYSAGES DE FOND CANI ENTRE 2005 ET 2013

Urban sprawl

Housing estates are the most visible representation of horizontal urbanisation in the area. These estates or groups of houses built at the same period are built independently and apart from traditional residential areas and call territorial organisation into question.



Canis depuis le Sud



Photo aeriennne 2013 Fond Cani depuis le Sud

Modification of land use and occupation

The Roseau Valley is popular for addressing the growth of urbanisation. It shows signs of change (recent, non-concentrated urbanisation and a road network less and less suitable for users' needs).

The population living the valley mainly works in the capital. On its doorstep this vast forest area offers free land and an exceptional lifestyle. The busier coastal plains have no more development potential and Dominica seems to be heading future development towards secondary valleys and some central plateaux.

Valley infrastructures dedicated to energy (hydroelectric stations, reservoirs), the various urban communities being developed as well as the development of tourism all bear witness to a real dynamism.



Vertical urbanisation

A current pattern of construction can be seen in the Roseau Valley, the extension of existing habitats. A patchwork of materials colours and architectural styles in the same urban setting can be most unexpected. However the advantage of this vertical urbanisation is that it does not impinge on surrounding agricultural or forest lands. It even helps strengthen the urbanity of some underpopulated and undefined suburbs.



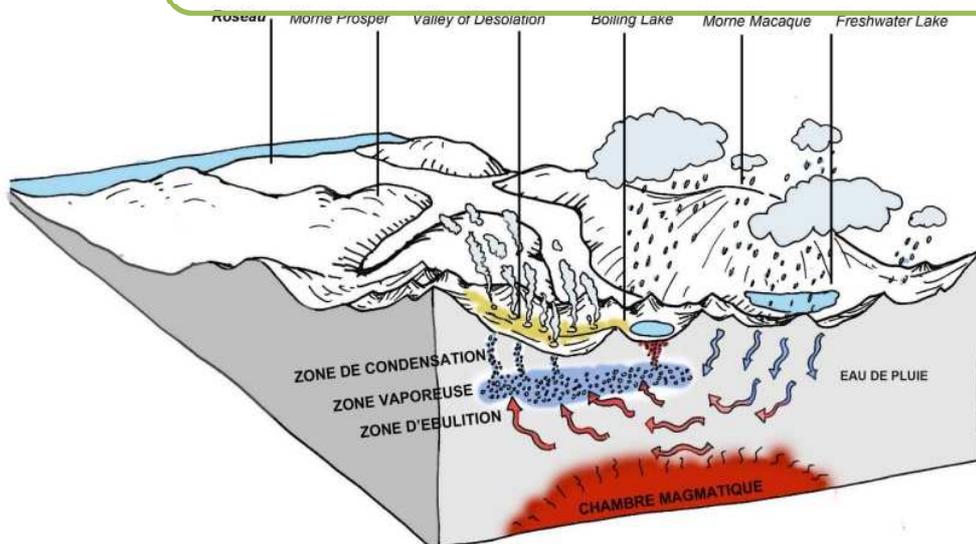
Tourist development in the valley

Since the 1990s there has been a considerable development in tourism services in the Roseau Valley. This is centred on walking and the hot sulphur water spas particularly at *Papillote* and *Wotten Waven*. This development has been accompanied by construction in the area, or renovation of buildings for hotels and restaurants. This construction has different aspects:

- Organised and high-level and integrated into the valley scenery
- More spontaneous

In general, buildings and tourist amenities are created with genuine care. Architecture (cabins) and materials (wood) used integrate a natural aspect into this environment and add to the cachet of the valley.

Natural landscape dynamics



Hydro thermal influences

The *Valley of Desolation* is an uncertain landscape that is permanently evolving. From one day, month or year to another, the fumaroles and water table events are very irregular in both frequency and quantity.

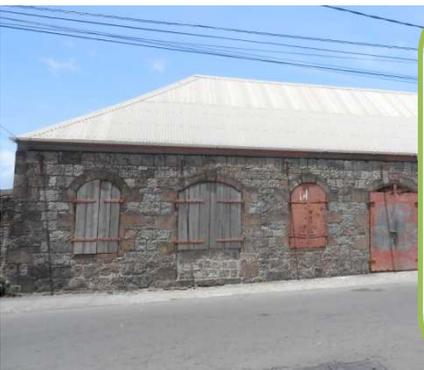
Historic heritage



Agricultural heritage

In *Wotton Waven*, is one of the rare agricultural ruins to be seen in the Roseau Valley, dating from the XVIIIth century. Today only the river-stone walls of this watermill remain.

This ruin evokes the agricultural and colonial past of this enclave.



Architectural heritage

A few attractive town houses, some dwellings or public buildings in stone have resisted the hurricanes to remain visible in the valley, especially in *Roseau*. These bring the external cultural influences that the country has known across the decades.



Small heritage

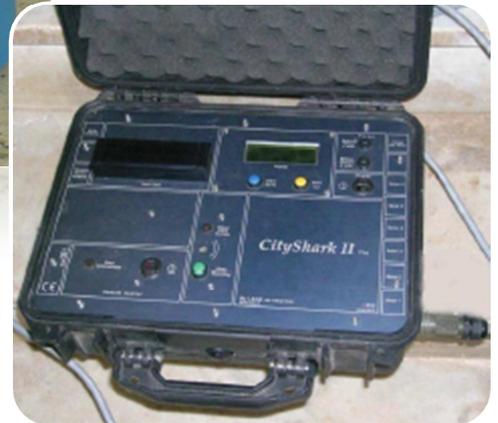
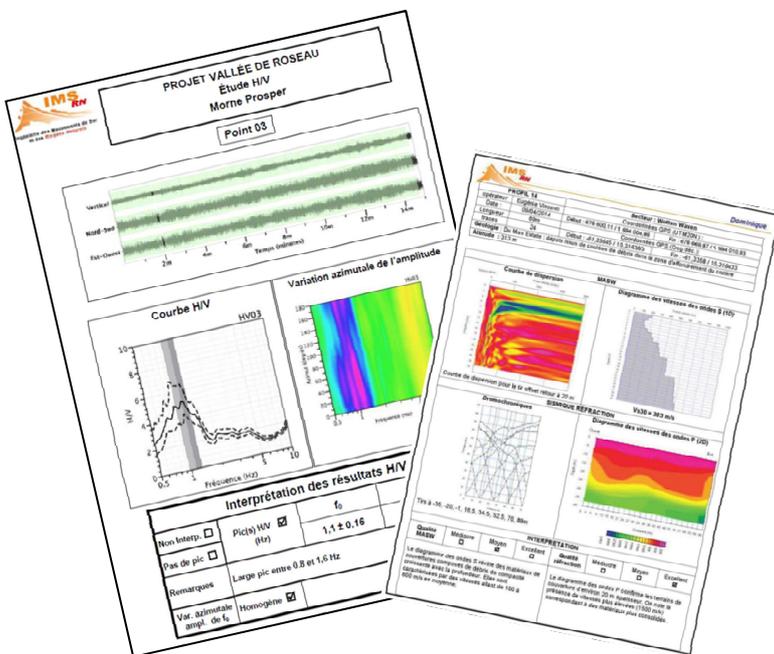
The history of the *Roseau Valley* has mostly been written by the farmers, slaves or otherwise, who, over the centuries, cultivated and sculpted mountain sides that have now mostly returned to forest.

The history of the territory and important events such as access to freedom and property for certain communities or major climate phenomena (devastating hurricanes, etc.) can be seen in numerous sculptures and markers.

SECTION 8: NATURAL RISKS

Aims of this section

- ❖ Listing historical events
- ❖ Identification of circumstances leading to these phenomena
- ❖ Hazard mapping



Methodology

Collection of bibliographical data was carried out for the Roseau Valley. This enabled missing data to be identified, specifically:

- For flooding, the measurement and monitoring of water flow rates in the valley
- For earthquakes and land movements, historical documents recounting these hazards or a precise geological map of the valley.

This collection was complemented by field data amassed when travelling in Dominica.

This field data allowed the determination of:

- The hydrological characteristics of the valley (water tables, flooding zones, population survey).
- Natural phenomenon index (lithology, slope, geomorphology)
- Correlation with hazards observed on neighbouring islands

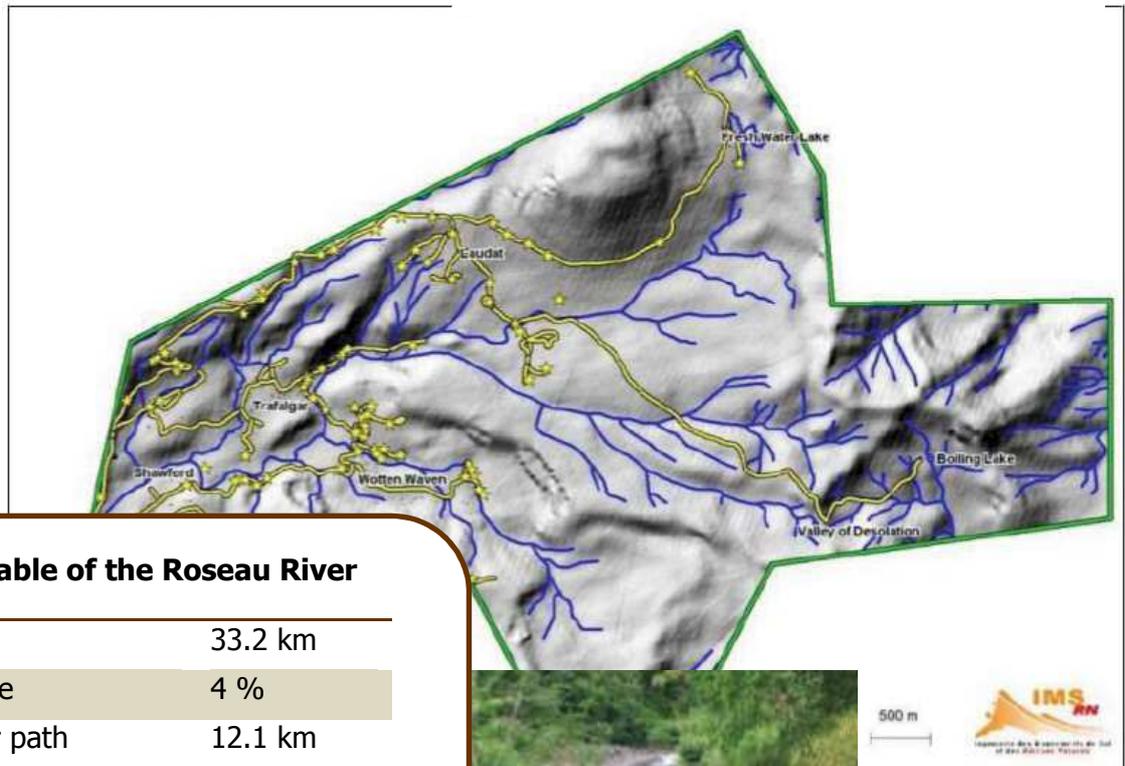
Analysis of this data led to the creation of modelling and hazard mapping for the valley.

Methods used

- ❖ 4 field campaigns between December 2013 and April 2014
- ❖ Modelling of floods for ten and one hundred years in the Roseau Valley
- ❖ Geophysical measurements
- ❖ Analysis of aerial photos
- ❖ Analysis of geological maps
- ❖ Recognition of geological formations in the field
- ❖ Population survey on past hazards

Results – Flood risks

PATHWAYS AND OBSERVATION POINTS FOR GROUND MOVEMENTS



Water table of the Roseau River

Surface	33.2 km
Average incline	4 %
Longest water path	12.1 km
Altitude min - Altitude max	0 m - 1 200 m
Concentration time	2.8 h



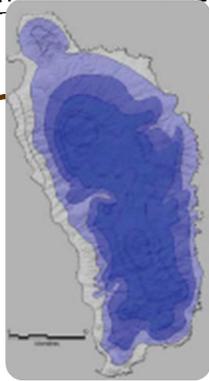
Rivière Roseau



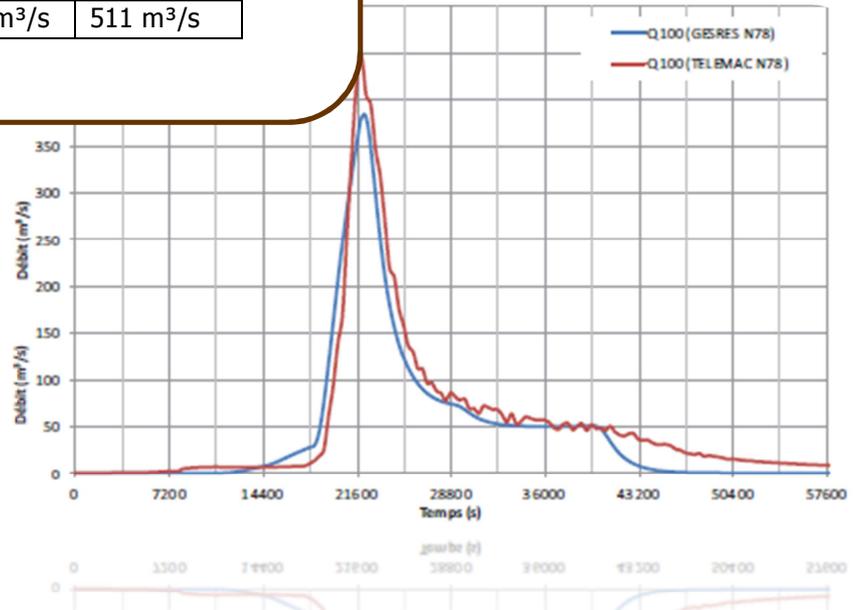
Rivière Roseau dans la traversée du centre de Roseau

Hydrological modelling GESRES^{ISL}

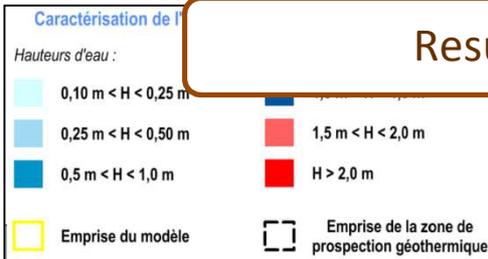
	T = 10 yrs	T = 100 yrs
Peak flow		
Downstream of study zone	244 m ³ /s	384 m ³ /s
Upstream of Roseau	378 m ³ /s	597 m ³ /s
Mouth of Caribbean sea	324 m ³ /s	511 m ³ /s



EXAMPLE: MODELLED HYDROGRAPHS



Results of modelling – Flood zones



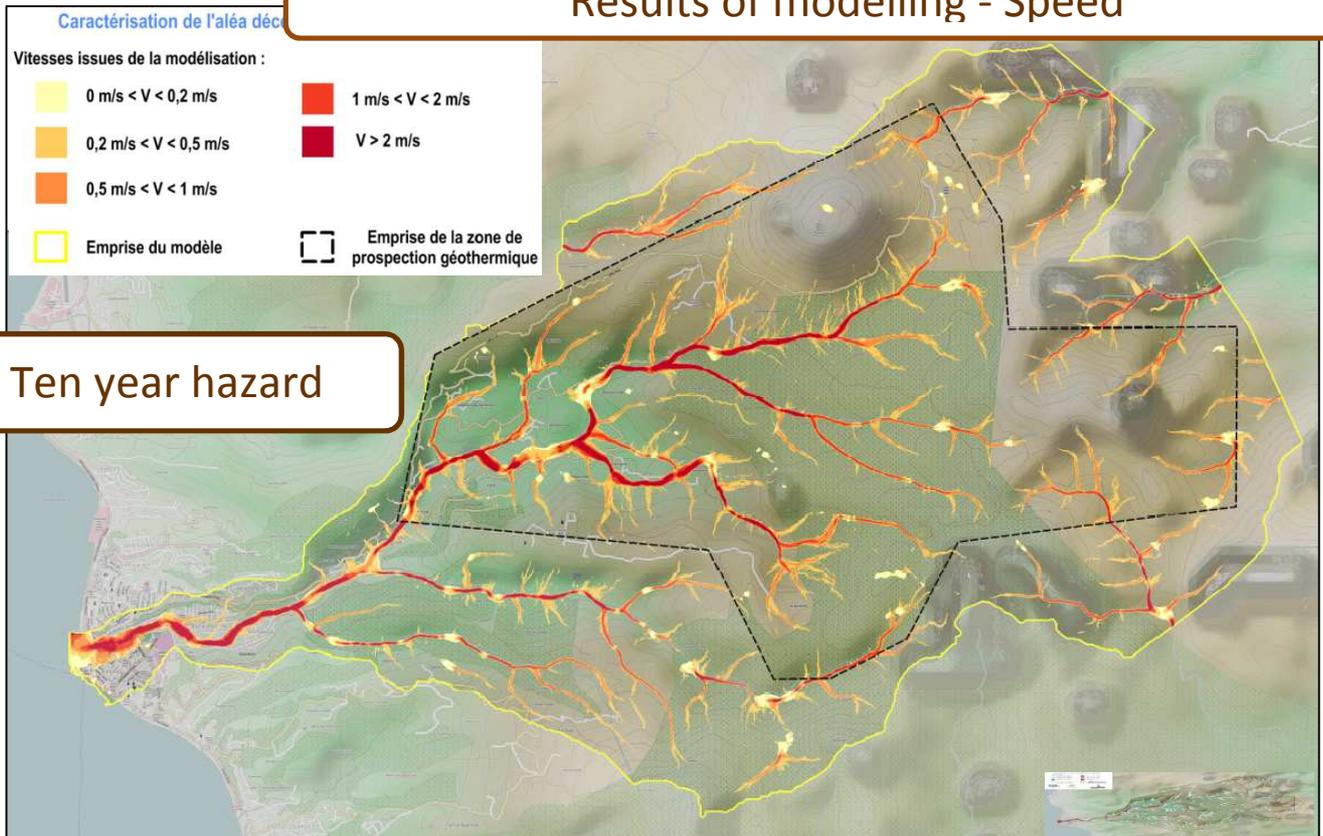
Ten-year hazard



Characteristics of floods

- ❖ Short response time between rain and flood
- ❖ Torrential watercourses
- ❖ Floodwater carrying material

Results of modelling - Speed



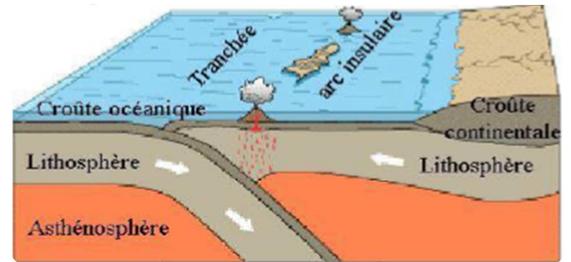
Results – earthquake risks

Three types of earthquake

- ❖ Subduction earthquakes
- ❖ Superficial local earthquakes
- ❖ Earthquakes linked to volcanic activity

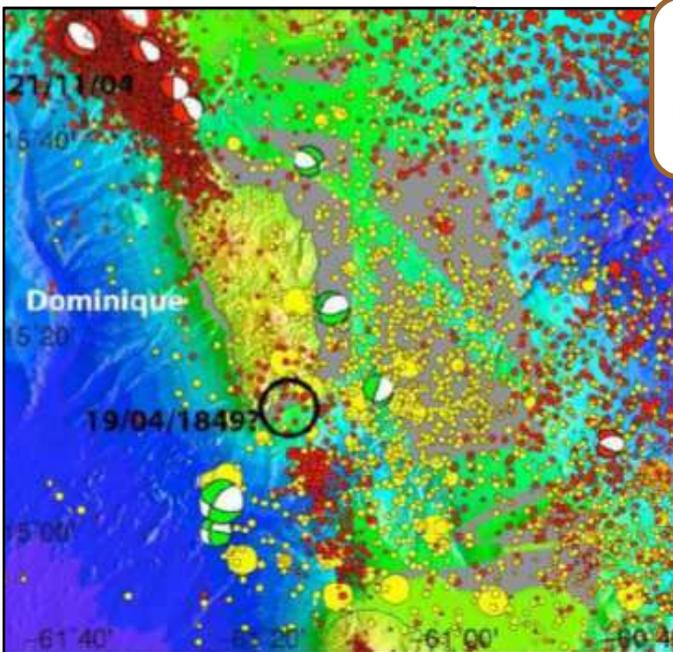
Max magnitude for a subduction earthquake: 8.6

SIMPLIFIED SUBDUCTION DIAGRAM

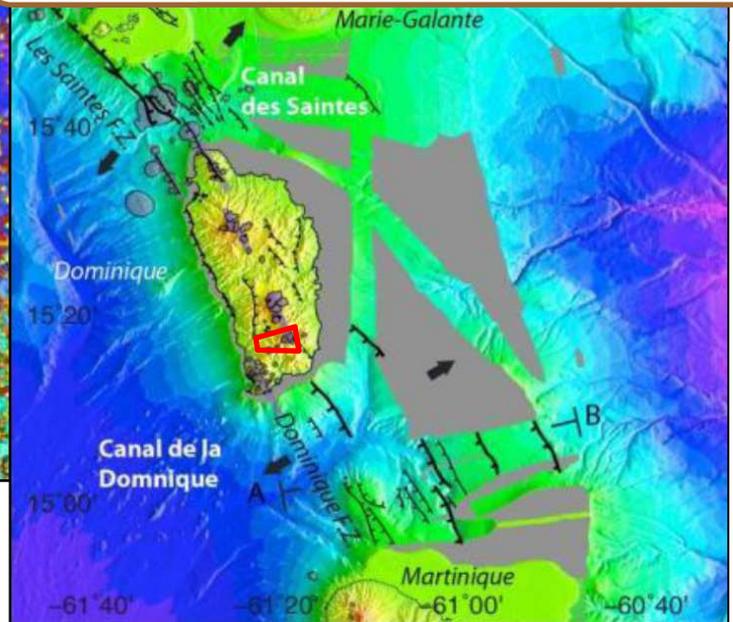


- ❖ NNE-SSE orientated faults
- ❖ Recent and active NE Extension

Max estimated magnitude for local earthquakes: 7.5



MAP OF INSTRUMENTAL SEISMICITY REGISTERED IN 1950 AND 2014



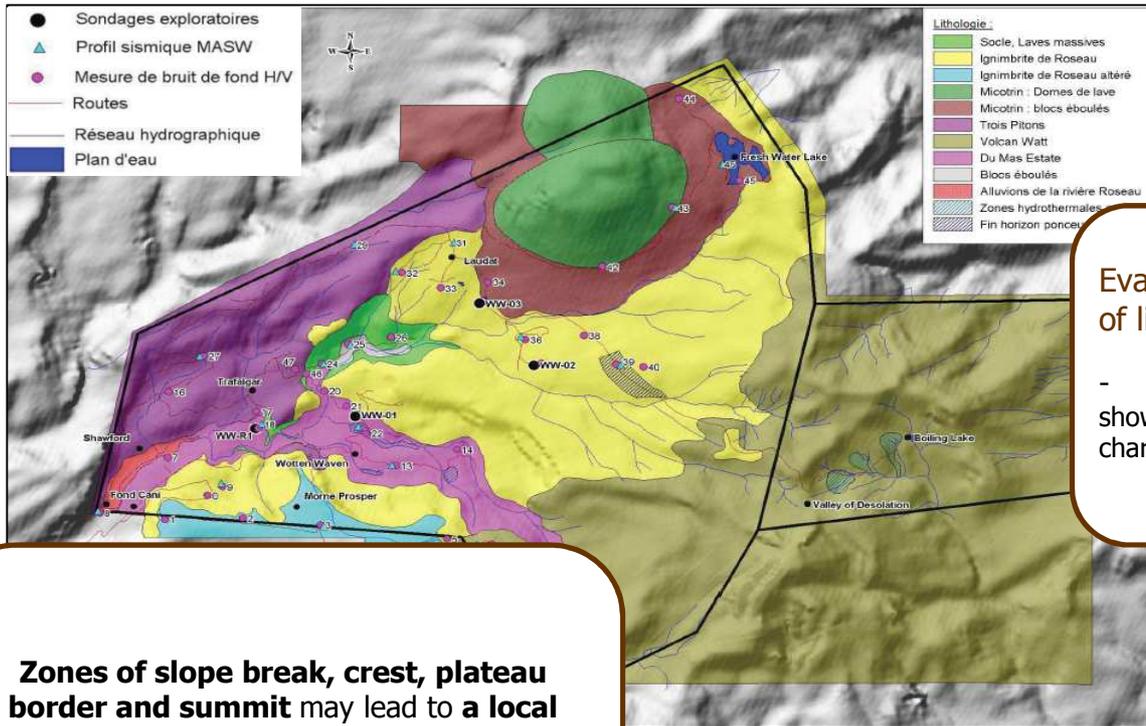
MAP OF ACTIVE FAULTS AROUND DOMINICA

Estimate of maximum acceleration ground is likely to be subjected to (rock acceleration):

Determination of the recommended PSA for the site:
Classified as zone 5 (high earthquake hazard) and buildings IV (Buildings providing public energy distribution)*, for earth A: rock

European earthquake resistant building standards (Eurocode 8: EC8)

CARTE LITHOLOGIQUE



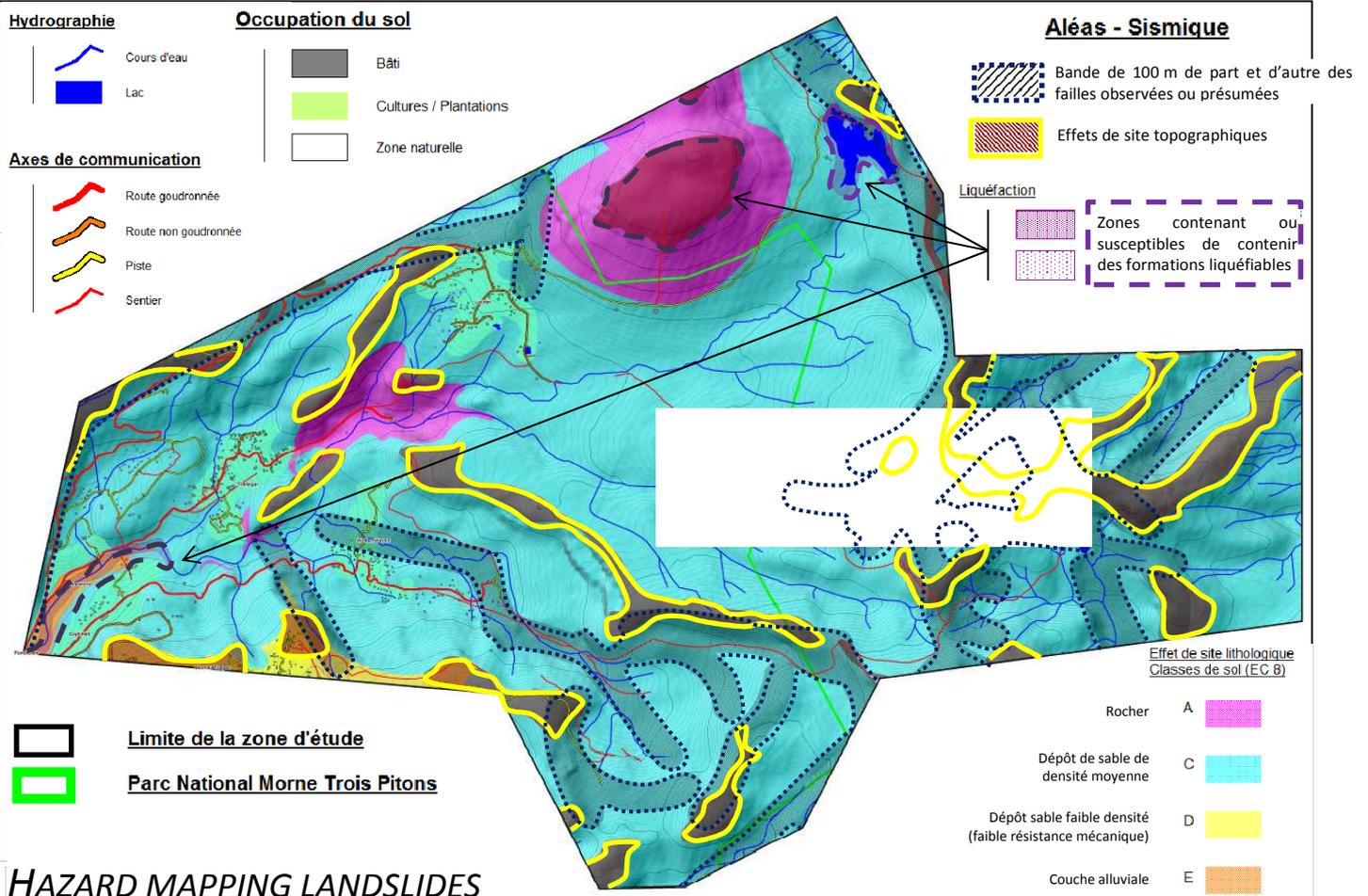
Evaluation of the effects of lithological sites

- **10 uniform zones** showing geo mechanical characteristics

Zones of slope break, crest, plateau border and summit may lead to a local increase in intensity of earthquakes.

The increase is notable when the inclines are part of hills and slopes of **over 30m high**.

Risk of local liquefaction on the alluvial plain downstream of Trafalgar and on the perimeter of Fresh water Lake



Results – Risks of land movements



CONCEPTUAL DIAGRAM OF LANDSLIDE PHENOMENON

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