Limited ESIA for Cyclic Steam Stimulation Enhanced Oil Recovery in the Tambaredjo Oilfield in Saramacca, Suriname

Draft Limited ESIA Report and EMMP

Report Prepared for

Staatsolie Maatschappij Suriname N.V.

SRK Report Number 550457/1

Report Prepared by

November 2019

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Profile and Expertise of Consultant

SRK Consulting (South Africa) Pty Ltd (SRK) has been appointed by Staatsolie Maatschappij Suriname N.V. (Staatsolie) to undertake a Limited Environmental and Social Impact Assessment (ESIA) and compile an Environmental Management and Monitoring Plan (EMMP), required for the proposed Cyclic Steam Stimulation Enhanced Oil Recovery process in Saramacca, Suriname.

SRK Consulting was established in 1974 and comprises over 1 400 professional staff worldwide, offering wide-ranging expertise in the natural resources and environmental sectors. SRK's Cape Town environmental department has a proven track record of managing large, complex environmental and engineering projects in the Western Cape, Africa and internationally, including in Suriname, amongst others for the SPCS Power Plant Expansion, EBS Power Plant, Staatsolie Refinery Expansion and Bakhuis Mining and Transportation Projects. SRK has rigorous quality assurance standards and is ISO 9001 certified.

The qualifications and experience of the key independent environmental consultants undertaking the Limited ESIA are detailed below.

Project Director and Reviewer: Christopher Dalgliesh, BBusSc (Hons); MPhil (EnvSci)
Chris Dalgliesh is a Partner and Principal Environmental Consultant with over 26 years' experience, primarily in South Africa, Southern Africa, West Africa and South America (Suriname). Chris has worked on a wide range of projects, notably in the natural resources, Oil & Gas, energy generation, infrastructure and industrial sectors. He has directed and managed numerous Environmental and Social Impact Assessments (ESIAs) and associated management plans, in accordance with international standards. He regularly provides high level review of ESIAs, frequently directs Environmental and Social Due Diligence studies for lenders, and also has a depth of experience in Strategic Environmental Assessment (SEA). He holds a BBusSci (Hons) and MPhil (Environmental Management).

Project Manager: Sue Reuther, BSc Hons (Econ); MPhil (EnvMgt)
Sue Reuther is a Principal Environmental Consultant and Associate Partner with more than 15 years of experience researching and working on issues in the environmental assessment sector. She has been involved in a variety of ESIAs, as well as due diligence reviews against IFC and World Bank Standards.
Sue has managed projects across South Africa and sub-Saharan Africa and Suriname for a range of sectors, including mining, infrastructure, industrial and coastal developments, power generation, aquaculture and oil and gas. Sue has two years of previous experience in strategy and financial research and assessment (London). She holds a BSc (Hons) in Economics and MPhil (Environmental Management).

Statement of SRK Independence

Neither SRK nor any of the authors of this Report have any material present or contingent interest in the outcome of this Report, nor do they have any pecuniary or other interest that could be reasonably regarded as being capable of affecting their independence or that of SRK.

SRK has no beneficial interest in the outcome of the assessment which is capable of affecting its independence.

Disclaimer

The opinions expressed in this report have been based on the information supplied to SRK by Staatsolie. SRK has exercised all due care in reviewing the supplied information, but conclusions from the review are reliant on the accuracy and completeness of the supplied data. SRK does not accept responsibility for any errors or omissions in the supplied information and does not accept any consequential liability arising from commercial decisions or actions resulting from them. Opinions presented in this report apply to the site conditions and features as they existed at the time of SRK's investigations, and those reasonably foreseeable. These opinions do not necessarily apply to conditions and features that may arise after the date of this Report, about which SRK had no prior knowledge nor had the opportunity to evaluate.

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Acronyms and Abbreviations

AoI	Area of Influence
bgl	Below ground level
CIA	Cumulative Impact Assessment
CITES	Convention on the International Trade in Endangered Species of Wild Flora and Fauna 1973
CO_2-e	CO_2-equivalent
CSS	Cyclic Steam Stimulation
DC	District Commissioner
EA	Environmental Assessment
EBS	N.V. Energie Bedrijven Suriname
EHS	Environmental, Health and Safety
EMMP	Environmental Management and Monitoring Plan
EOR	Enhanced Oil Recovery
EPC	Engineering, Procurement and Construction
ESIA	Environmental and Social Impact Assessment
EU	European Union
GFI	General Field Instruction
GHG	Greenhouse Gases
GIIP	Good International Industry Practice
HFO	Heavy Fuel Oil
HSEC	Health, Safety, Environment and Community
HSEQ	Health, Safety, Environment and Quality
IFC	International Finance Corporation
IUCN	International Union for Conservation of Nature
L_{Aeq}	Equivalent A-weighted sound level
MSDS	Material Safety Data Sheet
MUMA	Multiple Use Management Area
MW	Megawatt
NIMOS	Nationaal Instituut voor Milieu en Ontwikkeling in Suriname
OECD	Organisation for Economic Co-ordination and Development
ppm	parts per million
PS	Performance Standard
SIA	Social Impact Assessment
SOM	Staatsolie Maatschappij Suriname N.V.
SPCS	Staatsolie Power Company Suriname
SRK	SRK Consulting (South Africa) (Pty) Ltd
Staatsolie	Staatsolie Maatschappij Suriname N.V.
SWM	Suriname Waterleiding Maatschappij
USEPA	United States Environmental Protection Agency
VECs	Valued Environmental and Social Components
WHO	World Health Organisation

Units:

“	Inches
bbl	Barrels (1 barrel contains 159 litres)
bpd	Barrels per day
°C	Degrees Celsius
dB(A)	Decibels (weighted)
°F	Degrees Farenheit
ft	Feet (1 foot converts to 0.3048 m)
ha	Hectare
km	Kilometre
km^2	Square kilometre
km/h	Kilometres per hour
L	Litres
m	Metre
MSTB	Thousand stock tank barrels
psi	Pounds per square inch

Chemical compounds:

CO	Carbon monoxide
CO_2	Carbon dioxide
H_2S	Hydrogen sulphide (also hydrogen sulfide)
NO_2	Nitrogen dioxide
NO_X	Oxides of nitrogen
PM	Particulate matter
SO_2	Sulphur dioxide (also sulfur dioxide)
VOC	Volatile Organic Compounds

Glossary

Aquifer	An underground body of permeable rock or unconsolidated materials (gravel, sand or silt) which can contain or transmit groundwater.
Avifauna	The collective birds of a given region.
Baseline	Information gathered at the beginning of a study which describes the environment prior to development of a project and against which predicted changes (impacts) are measured.
Biodiversity	The diversity, or variety, of plants, animals and other living things in a particular area or region. It encompasses habitat diversity, species diversity and genetic diversity.
Construction Phase	The stage of project development comprising site preparation as well as all construction activities associated with the development.
Consultation	A process for the exchange of views, concerns and proposals about a project through meaningful discussions and the open sharing of information.
Cumulative Impacts	Direct and indirect impacts that act together with current or future potential impacts of other activities or proposed activities in the area/region that affect the same resources and/or receptors.
dB(A)	A unit of sound level - a weighted sound pressure level with the use of the A metering characteristic and weighting specified in ANSI Specifications for Sound Level Meter.
Electrical Conductivity (in water)	Reflects the capacity of water to conduct electrical current and is directly related to the concentration of salts dissolved in water.
Ecology	The study of the interrelationships of organisms with and within their physical surroundings.
Ecosystem	The interconnected assemblage of all living organisms that occupy a given area and the physical environment with which they interact.
Endemic / Endemism	Species unique (native or restricted) to a defined geographic location, i.e. ecological state of a species being unique to a defined geographic location.
Environment	The external circumstances, conditions and objects that affect the existence of an individual, organism or group. These circumstances include biophysical, social, economic, historical and cultural aspects.
Environmental and Social Impact Assessment	A process of evaluating the environmental and socio-economic consequences of a proposed course of action or project.
Environmental Impact Assessment Report	The report produced to relay the information gathered and assessments undertaken during the Environmental Impact Assessment.
Environmental and Social Management Plan	A description of the means (the environmental specification) to achieve environmental objectives and targets during all stages of a specific proposed activity.
Fauna	The collective animals of a particular region, habitat or geological period.
Feasibility study	The determination of the technical and financial viability of a proposed project.
Flora	The collective plants of a particular region, habitat or geological period.
Geohydrology	The study of the character, source and mode of occurrence of groundwater

Heritage Resources	Refers to something tangible or intangible, e.g. a building, an area, a ritual, etc. that forms part of a community's cultural legacy or tradition and is passed down from preceding generations and has cultural significance.
Herpetofauna	Amphibians and reptiles of a particular region, habitat or geological period.
Hydrology	(The study of) surface water flow.
Impact	A change to the existing environment, either adverse or beneficial, that is directly or indirectly due to the development of the project and its associated activities.
Integrated Environmental Management	The practice of incorporating environmental management into all stages of a project's life cycle, namely planning, design, implementation, management and review and closure.
Mitigation measures	Design or management measures that are intended to avoid and / or minimise or enhance an impact, depending on the desired effect. These measures are ideally incorporated into a design at an early stage.
Operational Phase	The stage of the works following the Construction Phase, during which the development will function or be used as anticipated in the Environmental Authorisation.
Polymer Flooding	The mixing of water with long chain polymer molecules to increase the water viscosity, and injection thereof into oil wells to enhance the recovery of oil through improved vertical and areal sweep efficiency.
Polder	A low-lying tract of land enclosed by dikes that form an artificial hydrological entity: it has no connection with outside water other than through canals and manually operated devices (e.g. pumps and sluices).
Produced fluid	The fluid mixture of oil, gas and water in formation that flows to the surface of an oil well from a reservoir.
Produced water	A term used in the oil industry to describe water that is produced as a by-product along with the oil and gas.
Production String	That part of an oil well comprising the production tubing and other completion components and serving as the conduit through which the production fluid flows from the oil reservoir to the surface through the wellhead.
Scoping	A procedure to consult with stakeholders to determine issues and concerns and for determining the extent of and approach to an ESIA (one of the phases in an ESIA). This process results in the development of a scope of work (or Plan of Study) for the ESIA and specialist studies.
Specialist study	A study into a particular aspect of the environment, undertaken by an expert in that discipline.
Stakeholders	All parties affected by and/or able to influence a project, often those in a position of authority and/or representing others.
Sustainable development	Sustainable development is generally defined as development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs.
Viscosity	Viscosity is a measure of a fluid's resistance to flow. For example, oil has a higher viscosity than water.

1 Introduction

1.1 Background and Introduction

Staatsolie Maatschappij Suriname N.V. (Staatsolie) is the Surinamese State oil company founded in 1980 and wholly owned by the Republic of Suriname. The company explores, produces and refines crude oil. Staatsolie operates three oilfields in the Saramacca District of Suriname: Tambaredjo, Tambaredjo North-West and Calcutta, as well as three processing plants: TA-58, Jossie and Catharina Sophia (CS). The Tambaredjo Oilfield is located 40 km west of Paramaribo and 8 km south of the Atlantic coast, north of the East-West Connection Road (*Oost-West Verbinding*) (see Figure 1-1).

Staatsolie aims to improve recovery of remaining oil reserves from the operating Tambaredjo Oilfield by using Enhanced Oil Recovery (EOR) techniques. Following earlier implementation of Polymer Flooding EOR pilot project, Staatsolie proposes to implement a Cyclic Steam Stimulation (CSS) project in the Tambaredjo Oilfield (the project). The process entails the injection of steam into the reservoir down a well for ~20 days, followed by a soaking period of ~10 days and subsequent extraction of the oil from the same well for ~1 year, before the cycle is repeated. Two injections cycles are planned for this project.

Staatsolie has appointed SRK Consulting (South Africa) (Pty) Ltd (SRK), an international consultancy with extensive experience in Suriname, as independent consultants to undertake the Limited Environmental and Social Impact Assessment (ESIA)[1] process and compile the Environmental Management and Monitoring Plan (EMMP) required for the project.

1.2 Purpose of the Report

This Limited ESIA Report documents the steps undertaken during the Limited ESIA (also referred to as the "ESIA") process to assess the significance of potential impacts and determine measures to mitigate the negative impacts and enhance the benefits (or positive impacts) of the proposed CSS project. The report presents the findings of the Limited ESIA process.

The ESIA Report is accompanied by an EMMP, which documents the management and monitoring measures that need to be implemented during the design, construction and operation phases of the project to ensure that impacts are appropriately mitigated and benefits enhanced.

More specifically, the objectives of this ESIA Report are to:

- Inform the stakeholders about the proposed project and the Limited ESIA process followed;
- Obtain contributions from stakeholders and ensure that all issues, concerns and queries raised are fully documented and addressed;
- Assess in detail the potential environmental and socio-economic impacts of the project; and
- Identify environmental and social mitigation measures to address the impacts assessed.

This report will be submitted to the Nationaal Instituut voor Milieu en Ontwikkeling in Suriname (NIMOS) for their comment, acceptance and advice.

[1] Based on screening checklist submitted by Staatsolie, the regulator (NIMOS) confirmed that a Limited ESIA and an EMMP are required.

1.3 Structure of this Report

This report discusses relevant environmental legislation and its application to this project, outlines the Limited ESIA process, presents a detailed project description and environmental baseline, details the stakeholder engagement process and assesses the potential impacts of the project before concluding the report with a set of pertinent findings and key recommendations, which are reflected in the EMMP. The report consists of the following sections:

Section 1: Introduction

Provides an introduction and background to the proposed project and outlines the purpose of this document and the assumptions and limitation applicable to the study.

Section 2: Governance Framework and Environmental Process

Provides a brief summary and interpretation of the relevant legislation as well as pertinent strategic planning documents, and outlines the approach to the environmental process.

Section 3: Project Description

Describes the location and current status of the site and provides a brief summary of the surrounding land uses as well as background to, motivation, and description of, the proposed project.

Section 4: Description of the Affected Environment

Describes the biophysical and socio-economic characteristics of the affected environment against which potential project impacts are assessed.

Section 5: Stakeholder Engagement

Details the stakeholder engagement approach and summarises stakeholder comments that informed the impact assessment.

Section 6: Environmental Impact Assessment

Describes the specialist studies undertaken and assesses the potential impacts of the project utilising SRK's proven impact assessment methodology.

Section 7: Conclusions and Recommendations

Provides the key findings and conclusions of the Limited ESIA Report.

Section 8: Way Forward

Concludes the document with an outline of the remaining steps in the Limited ESIA process.

Appendix A: Environmental Management and Monitoring Plan

Presents the measures that need to be implemented to ensure that impacts are appropriately mitigated and monitored.

1.4 Assumptions and Limitations

As is standard practice, the report is based on a number of assumptions and is subject to certain limitations. These are as follows:

- Information provided by Staatsolie, other consultants and specialists is assumed to be accurate and correct. This includes an assumption that thermal well design complies with applicable specifications and standards and the proposed locations and pumping rates of thermal wells;
- SRK's assessment of the significance of impacts of the proposed project on the affected environment is based on the assumption that the activities will be confined to those described in

Section 3. If there are any substantial changes to the project description, impacts may need to be reassessed;

- As per NIMOS' requirements, the report is based on secondary data. Primary fieldwork was not considered necessary for this study, as existing data was deemed adequate;
- It is assumed that no significant developments or changes took place in the area of influence in the period between secondary data collection and submission of the report;
- Where detailed design information is not available, the precautionary principle, i.e. a conservative approach that overstates negative impacts and understates benefits, has been adopted;
- Negotiations with landowners on whose property wells may be drilled are excluded from the scope of work; and
- Staatsolie will in good faith implement the agreed mitigation measures identified in this report. To this end it is assumed that Staatsolie will commit sufficient resources and employ suitably qualified personnel.

Notwithstanding the above, SRK is confident that these assumptions and limitations do not compromise the overall findings of the report.

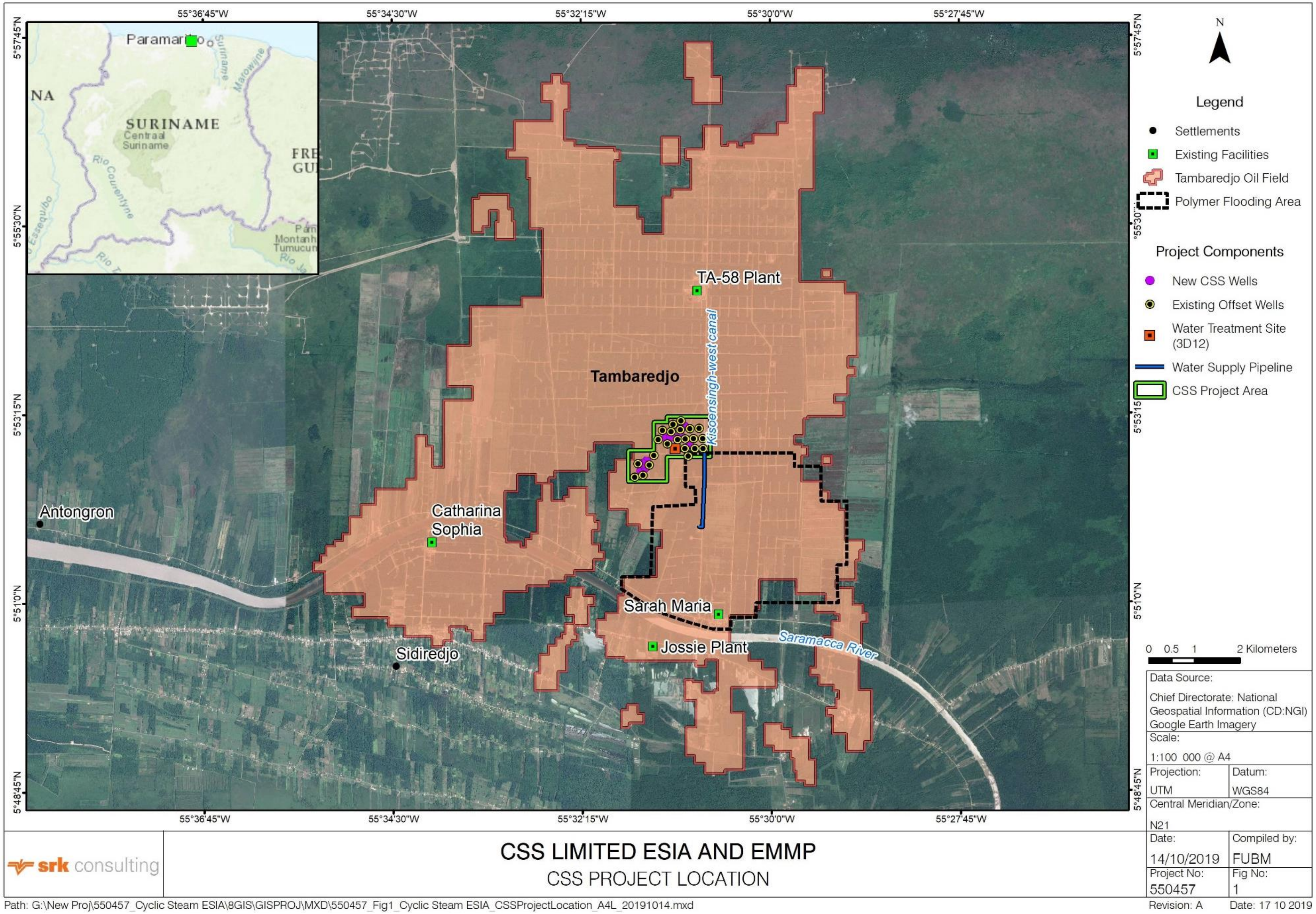


Figure 1-1: CSS Project location

2 Governance Framework and Environmental Process

2.1 Introduction

Suriname is governed in terms of the 1987 Constitution of the Republic of Suriname, reformed in 1992, which provides for a legal basis for the country's environmental policies. Article 6g states that "the social objective of the State is directed towards the creation and stimulation of conditions necessary for the protection of nature and the maintenance of ecological balance".

Suriname does not have an approved national environmental policy and there is no promulgated legislation dealing specifically with environmental management. However, environmental legislation is under development and various guidelines for environmental assessment have been released. The Limited ESIA process for the proposed CSS project will comply with relevant guidelines and other relevant legislation.

In addition to national regulatory requirements, the Limited ESIA process will be guided by Good International Industry Practice (in this report generally referred to as [international] best practice), notably standards and guidelines such as those prescribed by the World Bank Group for Bank-funded private sector development projects[2], as well as those of the International Finance Corporation (IFC). The World Bank Group standards and guidelines include environmental and social guidelines and standards that relate to the implementation and scope of the ESIA process. Where applicable, the application of the standards and guidelines will be modified to reflect the scale of the project and other relevant factors.

The key national and international legislative, regulatory and institutional requirements *relevant to and guiding* the proposed ESIA process are discussed in more detail in Sections 2.2 and 2.3 below.

Note that other requirements, e.g. related to occupational health and safety, may pertain to the proposed project, but identification and interpretation of these is beyond the brief of this study. As such, the list provided below is not intended to be definitive or exhaustive and serves to highlight key environmental legislation and obligations only.

2.2 Suriname Legal Requirements

2.2.1 Legal Requirements Regarding Environmental Assessment

NIMOS was established in 1998 as an autonomous Government Foundation and currently reports on its activities to the Environmental Coordination Department in the Cabinet of the President. The Office of Environmental and Social Assessments, a division of NIMOS, is responsible for the administration of ESIA processes in Suriname.

A **draft Environmental Act** has been developed as an environmental framework law in response to the 1992 Rio declaration. The draft Act lays down rules for the conservation, management and protection of a sound environment within the framework of sustainable development. The Act was submitted to Parliament on 23 January 2019, as draft law (ontwerpwet). Nevertheless, the principles in the draft Act provide guidance for EIA in Suriname.

Draft EIA Regulations, to be promulgated under the Environmental Act once in force, have also been developed since 2003 and contain requirements for EIA processes and public participation. The draft EIA Regulations are under review and are not yet in force.

[2] The World Bank Group standards are applied as best practice guidelines and not as an investment requirement.

NIMOS has published **Guidelines for Environmental Assessment** (EA) in Suriname. The Guidelines stipulate the EA process that should be undertaken once the environmental framework law and EIA Regulations are in place (NIMOS, 2017). The EA Guidelines are being applied by NIMOS as part of the project assessment process and project developers are expected to comply with the guidelines.

The EA Guidelines series consists of the following volumes:

- **Volume I: Generic (2009)** – This volume contains general guidelines for determining whether an EA is required, the nature and extent of the analysis required and the procedure that should be followed in the conduct of an EA. The guidelines cover aspects such as project screening, classification of projects, scoping guidelines, public consultation, structure of EA reports and the EA report review process, including criteria for review and a compliance checklist. Project screening is required to determine if EA is required and the appropriate level (category) of EA. Projects are classified into one of three categories, namely Category A (EA is mandatory), Category B (some form of EA is required) or Category C (no EA is required).

  Based on screening checklist submitted by Staatsolie, NIMOS confirmed that the CSS project is classified as a "Category B path 2 project", for which a Limited ESIA and an EMMP are required.
- **Volume II: Mining (2005)** – These guidelines provide an outline of the requirements for conducting EA for mining (including oil and gas) projects.
- **Volume III: Forestry (2005)** – *These guidelines are not relevant to this project.*
- **Volume IV: Social Impact Assessment (2005)** – These guidelines provide an outline of the requirements for conducting Social Impact Assessment, whether as part of an EA process or required independently for projects that have potential impacts on the social environment.
- **Volume V**: **Power Generation and Transmission Projects (2005)** – *These guidelines are not relevant to this project.*
- **Volume VI: Aquaculture Projects (2011)** – *These guidelines are not relevant to this project.*
- **Volume VII: Agriculture Project (2013)** – *These guidelines are not relevant to this project.*

As a supplement to the more comprehensive Environmental Assessment Guidelines (Volume I), NIMOS released a **Guidance Note NIMOS Environmental Assessment Process (2017)**, which highlights the EA process that is implemented in the current legislative environment (prior to the promulgation of the Environmental Act and EIA Regulations). It defines five EIA process phases, *viz.* Screening, Scoping, Assessment, Review and Decision-making phases, and associated reporting requirements, as well as NIMOS decision-making timeframes. The process flow diagram is shown in Figure 2-2.

At the conclusion of an EA process, NIMOS provides environmental advice regarding approval or denial of the project to the agency authorized to issue a permit to undertake the development or activity.

2.2.2 Other Environmental Legal Requirements

Selected legal instruments governing environmental management in Suriname are included in Table 2-1 below. Note the table only lists key instruments and is not necessarily comprehensive, and not all of the listed instruments necessarily apply to this project.

Table 2-1: Selected relevant national environmental legislation

Title	Objective	Implementing agency	Relevance
Prevention of pollution			
Hinderwet, G.B. 1930 no. 64 z.l.g. bij S.B. 2001 no. 63 (Nuisance Act G.B. 1930 no. 64 as amended by S.B. 2001 no. 63)	Controls industrial pollution (noise, air and waste)	District Commissioners are responsible for enforcement and issue permits in consultation with Ministries of Health, Labour and NIMOS	Permits are required for industrial development projects.
Politiestrafwet, G.B. 1915 no. 77, z.l.g. bij S.B. 1990 no. 24. (Police Criminal Act, G.B. 1915 no.77 as amended by S.B. 1990 no. 24	Contains many general environmental provisions with respect to public places, including waste disposal, noise, control of pests, hunting and fishing, water pollution, etc.	Ministry of Justice and Police Public Prosecution Department (Openbaar Ministerie)	Article 39a penalizes the disposal of waste in public places. Article 51 penalizes the contamination of a water resource.
Wetboek van Strafrecht G.B. 1911 no.1 z.l.g. bij S.B. 2015 no 44 (Penal Code G.B. 1911 no. 1 as amended by S.B. 2015 no. 44)	Stipulates penalties for a range of offenses	Ministry of Justice and Police Public Prosecution Department (Openbaar Ministerie)	Articles 225a and 225b stipulates penalties for environmental pollution.
Petroleumwet 1990 S.B. 1991 no. 7, z.l.g. bij S.B. 2001 no. 58 (Petroleum Act 1990 S.B. 1991 no. 7, as amended by S.B. 2001 no. 58)	Specifies that petroleum activities should be carried out in such a way as to prevent negative environmental impacts and that state land should be returned to its original condition as far as reasonably possible upon termination of activities.	Ministry of Natural Resources	Environmental impacts of oil production must be managed. Provisions should be made for the decommissioning and rehabilitation of the oilfield.
Decreet E-8B, S.B. 1981 No. 59 houdende machtiging tot verlening aan de Staatsolie Maatschappij Suriname N.V. van een vergunning voor het doen van onderzoek naar en van een concessie voor de ontginning van koolwaterstofvoorkomens	Article 9 specifies that Staatsolie must take all reasonable measures in line with “good oilfield practice” to undertake its activities in a safe manner. Staatsolie is also responsible for the management of effluent discharge and oil waste.	Ministry of Natural Resources	Environmental impacts of oil production must be managed. Provisions should be made for the decommissioning and rehabilitation of the oilfield.
Decreet Mijnbouw S.B. 1986 no. 28, S.B. 1997 no. 44. Decreet van 8 mei 1986, houdende algemene regelen omtrent de opsporing en ontginning van delfstoffen	Artikel 16 states that all measures must be taken to ensure the safety and rehabilitation of a mined-out area. If the rights holder fails in this duty, the State may rehabilitate the area and recover the costs from the rights holder.	Ministry of Natural Resources	Environmental impacts of oil production must be managed. Provisions should be made for the decommissioning and rehabilitation of the oilfield.
Staatsbesluit Onshore, Wayambo Gebied (S.B. 2000 no. 86);	Facilities for Staatsolie and the Contractor that perform petroleum activites for Staatsolie	Ministry of Natural Reserves	Environmental impacts of oil production must be managed.

Title	Objective	Implementing agency	Relevance
Staatsbesluit van 31 juli 2000, houdende voorzieningen t.b.v. contracter partijen van de "Overeenkomst betreffende de Exploratie, Ontwikkeling en productiedeling van petroleum voor Offshore Suriname (S.B. 2000 no. 89);	Regulations concerning the petroleum agreement signed by Staatsolie and the contractor	Ministry of Natural Reserves	Environmental impacts of oil production must be managed.
Staatsbesluit van 31 juli 2000, houdende voorzieningen van Contractor partijen van de "Overeenkomst betreffende de Exploratie, Ontwikkeling en productiedeling van petroleum voor Onshore Suriname, het wayambo gebied (S.B. 2000 no. 87)	Provisions for the contractor with whom Staatolie has an agreement signed	Ministry of Natural Reserves	Environmental impacts of oil production must be managed.
Protection of biodiversity resources			
Natuurbeschermingswet 1954 G.B. 1954 no.26 z.l.g. S.B. 1992 no. 80 (Nature Conservation Act 1954 G.B. 1954 no.26 as amended by S.B. 1992 no. 80)	Establishment and management of conservation areas and wildlife	Ministry of Spatial Planning, Land and Forestry Management	The Coppename Monding Nature Reserve is located along the coast east of the Coppename River mouth, north of the project area. The project has no direct impacts on the nature reserve. Indirect impacts, if any, will be considered.
Jachtwet G.B. 1954 no. 25 z.l.g. bij S.B. 1997 no. 33 (Game Act G.B. 1954 no. 25 as amended by S.B. 1997 no. 33)	Provides for the protection of game as well as threatened species; game species are categorized and subject to an open and closed hunting season	Ministry of Spatial Planning, Land and Forestry Management	Certain species in Suriname are protected in terms of the Game Act. However, these are not expected to occur in the study area or to be affected by the project.
Beschikking Beheersgebied Noord Saramacca S.B. 2002 no. 88 (Ministerial Order North Saramacca MUMA S.B. 2002 no. 88)	The area between the Coppename River in the west, the boundary of the Saramacca District in the east and the Wayambo Road and Saramacca River in the south, including the sea to 6 m depth, is designated the North Saramacca Multiple Use Management Area (MUMA)	Ministry of Spatial Planning, Land and Forestry Management	The project is located within the North Saramaca MUMA. A MUMA is designated to maintain biological productivity, ensure the health of globally significant wildlife and protect resources for sustainable livelihoods, but may also be commercially utilised within sustainable limits. Permits are required for research and resource extraction. The project is located within an existing operating oilfield.
Beschikking Richtlijnen Gronduitgifte Estuariene Beheersgebieden S.B.	Provides guidelines for the issuance and use of domain land within the	Ministry of Spatial Planning, Land and	The proposed project falls outside (south) of the

Title	Objective	Implementing agency	Relevance
2005 no.16 (Ministerial Order on Guidelines for land issuance in the estuarine management areas S.B. 2005 no. 16)	estuarine zone to maintain natural functions	Forestry Management	designated area. The project has no direct impacts on the designated area. Indirect impacts, if any, will be considered.
Protection of heritage resources			
Monumentenwet S.B. 2002 no. 72 (Monuments Act 2002, S.B. 2002 no. 72)	Preservation of historical monuments and architecture in Suriname	Ministry of Education and Community Development	Applies to any archaeological items that may be encountered during construction. However, the project is located within an existing operating oilfield.

A **draft Waste Act** (2004) has been compiled but has not been promulgated. The draft Act sets out regulations for the treatment of waste materials to protect the environment, based on the "polluter pays" principle. Different types of waste materials are identified, and rules prescribed for adequate storage, transportation and treatment (including recycling, composting and disposal) of each waste type. The Act makes provision for the prosecution of transgressors.

A **draft Act** concerning the extraction of **groundwater** prohibits the extraction of groundwater without a license from the Minister of Natural Resources. The permitting procedure is also regulated through this Act. In addition, the Act also provides technical specifications for drilling. Staatsolie is not planning to abstract any groundwater for the CSS project.

Legislation relating to **Occupational Health and Safety** is given effect through Staatsolie's General Field Instructions (GFIs), including those listed in Appendix F of the EMMP provided in Appendix A. As this legislation governs occupational, and not environmental, management aspects, it is not discussed further in this section.

Legal requirements are tracked by the Staatsolie Corporate Legal Department, where appropriate. Staatsolie complies with and implements provisions through various internal processes and plans, e.g. Health, Safety, Environment and Quality (HSEQ) Policy, Project Health, Safety, Environment and Community (HSEC) Inductions, General Field Instructions (GFIs), Waste Management Plan, EMMP and appropriate contractual agreements with Contractors.

Agencies which will or may be involved in various approval or consultation processes applicable to this project are expected to include the:

- Ministry of Labour (*Ministerie van Arbeid)* – which is responsible for the supervision of compliance with employment protection and health and safety inspection regulations;
- *NIMOS* – which is an autonomous Government Foundation. The Office of Environmental and Social Assessments, a division of NIMOS, is responsible for the administration of EIA processes in Suriname;
- Ministry of Natural Resources (*Ministerie van Natuurlijke Hulpbronnen)* – which is responsible for policy and compliance monitoring with regards to the exploitation and management of mineral and energy resources;
- Ministry of Regional Development (*Ministerie van Regionale Ontwikkeling)* – which is responsible for nature conservation and the development of rural areas and the provision of services outside Paramaribo through the District Commissioners;

- Ministry of Public Health (*Ministerie van Volksgezondheid*) – which is responsible for general public health management; and
- Ministry of Spatial Planning, Land and Forest Management (*Ministerie van Ruimtelijke Ordening, Grond- en Bosbeheer)* – which is responsible for city and land use planning and forest, flora and fauna resource management.
- Ministry of Agriculture, Husbandry and Fisheries-(*Ministerie van Landbouw Veeteelt en Visserij*)_ - which is primarily responsible for policy with regard to agriculture, animal husbandry, fishing and beekeeping.

2.2.3 Planning Framework

According to the Resolution on Land Allocation in Coastal Zone Management Areas (2005), in the area between the Atlantic Ocean and the Saramacca River, land to the north of the red line shown in Figure 2-1 acts as a buffer zone to the Coppename-monding Nature Reserve and is reserved for coastal protection and sustainable production. No land can be allocated for other use in this area.

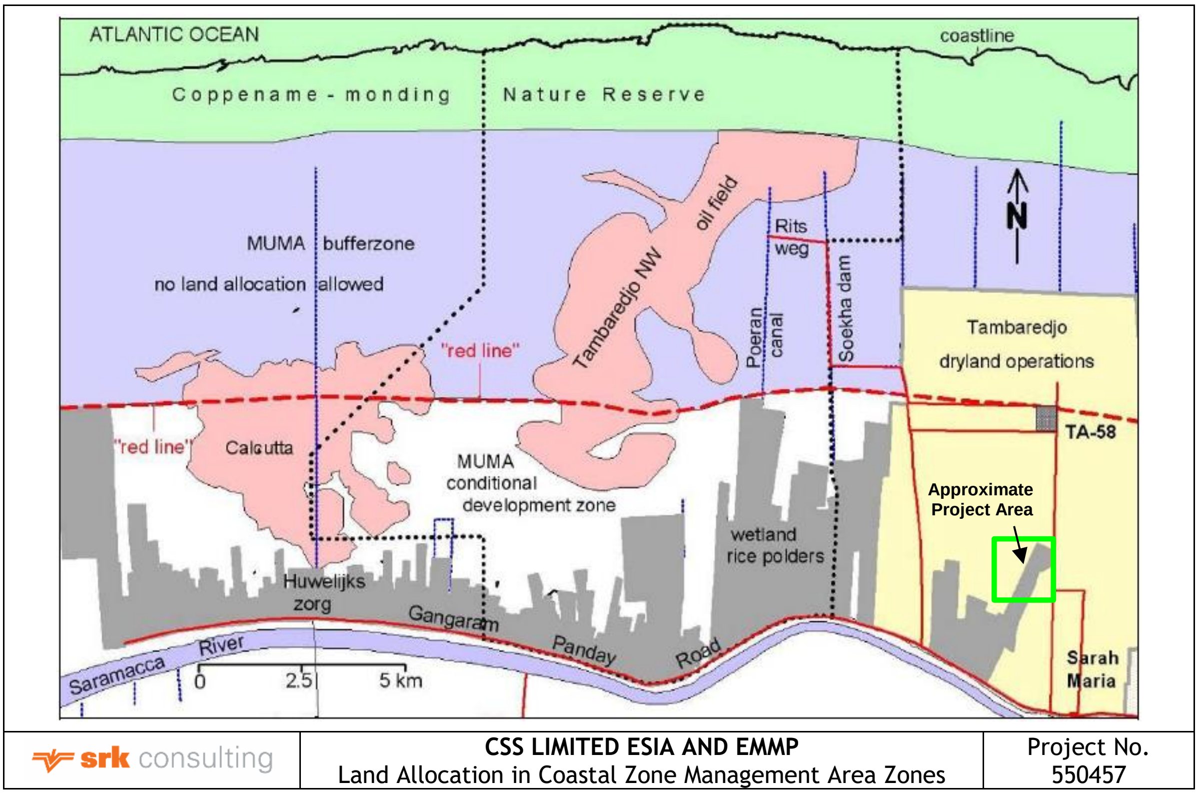


Figure 2-1: Land Allocation in Coastal Zone Management Area Zones

Source: Noordam (2014)

Land can be allocated for other uses south of the red line. Restrictions in this area stipulate that no water extraction from the seaside drainage basin is allowed and that excess water should be drained into the Saramacca River.

Staatsolie's proposed CSS project lies south of the red line within an operating oilfield, and the project is thus expected to be compatible with the Resolution on Land Allocation in Coastal Zone Management Areas.

2.2.4 International Agreements

Suriname is signatory to a number of international agreements and conventions relating to environmental management. The international conventions are not always translated into national legislation. An overview of selected agreements relevant to this project is provided in Table 2-2 below.

Table 2-2: Overview of international agreements relevant to the project

Agreement / Convention	Purpose	Relevance
Biodiversity		
The Ramsar Convention on Wetlands of International Importance especially as Waterfowl Habitat, 1971 *Suriname ratified in 1985*	Intergovernmental treaty for the conservation and sustainable use of wetlands.	The Coppename-monding Nature Reserve, located ~10 km north of the project site, is a Ramsar wetland. The project has no direct impacts on the designated area. Indirect impacts, if any, will be considered.
Convention on Nature Protection and Wildlife Preservation in the Western Hemisphere, 1940	Provides for the establishment of protected areas, research co-operation between governments, listing of species for special protection and control of trade in protected fauna and flora.	The Coppename-monding Nature Reserve, located ~10 km north of the project site, is a Western Hemisphere Shorebird Reserve. The project has no direct impacts on the designated area. Indirect impacts, if any, will be considered.
Convention on the International Trade in Endangered Species of Wild Flora and Fauna 1973 (CITES) *Suriname ratified in 1980*	International agreement between governments to ensure that international trade in specimens of wild animals and plants does not threaten their survival	Several fauna species found in the greater project region are listed in annexures of CITES. However, these are not expected to occur in the study area or to be affected by the project.
Convention on Biological Diversity, 1992 *Suriname ratified in 1996*	Development of national strategies for the conservation and sustainable use of biological diversity	Suriname has a National Biodiversity Strategy that aims to value and protect biological diversity, including natural and cultural resources, through equitable and sustainable use for present and future generations. However, the project is located within an existing operating oilfield.
Air quality and climate change		
Vienna Convention for the Protection of the Ozone Layer, 1985 *Suriname acceded in 1997*	Protection of the ozone layer, came into force in 1988.	Oil production may generate ozone-depleting substances.
Montreal Protocol on Substances that Deplete the Ozone Layer, 1989 *Suriname acceded in 1997 and ratified all amendments in 2006*	Protection of the ozone layer.	Oil production may generate ozone-depleting substances.
United Nations Framework Convention on Climate Change (UNFCC), 1994 *Suriname ratified in 1997*	Control of and limiting greenhouse gas emissions.	Oil production emits and contributes to greenhouse gases. Suriname has prepared a Climate Change Action Plan 2008-2013.
Kyoto Protocol, 1997 *Suriname ratified in 2006*	Provides for greenhouse gas emissions targets.	Oil production emits and contributes to greenhouse gases. Suriname has prepared a Climate Change Action Plan 2008-2013.
Paris Agreement, 2015 *Suriname signed in 2016* *Suriname has not yet ratified*	Limit the global average temperature increase above pre-industrial levels to well below 2°C. The Nationally Determined Contribution (NDC) of Suriname included commitments to improve	Oil production emits and contributes to greenhouse gases.

Agreement / Convention	Purpose	Relevance
	sustainable forest management to enhance the country's carbon sink potential, but no targets in terms of absolute or relative Greenhouse Gas (GHG) emissions by 2030.	

2.3 International Standards, Requirements and Guidelines

2.3.1 Environmental Assessment

SRK will be *guided* by international standards and best practice in conducting the Limited ESIA and associated public consultation and information disclosure process, primarily the Performance Standards (PS) of the IFC – the private sector arm of the World Bank Group – which contain guidelines on how to undertake ESIAs and various specialist studies (see Table 2-3).

Table 2-3: IFC Performance Standards

Note: **Bold text** indicates standards that may be relevant to the Limited ESIA.

Performance Standard	Aims and objectives	Applicability to this project
PS 1: Assessment and Management of Environmental and Social Risks and Impacts	Requires the proponent to conduct a process of environmental and social assessment and to establish and maintain an Environmental and Social Management System (ESMS), appropriate to the nature and scale of the project and commensurate with the level of its environmental and social risks and impacts. PS1 aims to: • Identify and evaluate environmental and social risks and impacts of the project; • 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; • Promote improved environmental and social performance of clients through the effective use of management systems; • Ensure that grievances from affected communities and external communications from other stakeholders are responded to and managed appropriately; • Promote and provide means for adequate engagement with affected communities throughout the project cycle on issues that could potentially affect them; and • Ensure that relevant environmental and social information is disclosed and disseminated.	PS1 is relevant to the project. PS1 has guided the ESIA process, specifically the: • Engagement of stakeholders during the Limited ESIA process; • Identification and assessment of project impacts, as well as the identification of strategies to avoid, minimise or offset these impacts; and • Development of an EMMP for the construction and operation of the CSS project.
PS 2: Labor and Working Conditions	Recognizes that the pursuit of economic growth through employment creation and income generation should be accompanied by protection of the fundamental rights of workers. PS2 aims to: • Promote fair treatment, non-discrimination and equal opportunity of workers; • Establish, maintain and improve the worker-management relationship; • Promote compliance with national employment	As the project will employ a (limited) number of workers, PS2 is relevant to the project. However, employment will follow established procedures at Staatsolie.

Performance Standard	Aims and objectives	Applicability to this project
	and labour laws; • 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; and • Promote safe and healthy working conditions and the health of workers; and avoid the use of forced labour.	
PS 3: Resource Efficiency and Pollution Prevention	Recognizes that increased economic activity and urbanization often generate increased levels of pollution to air, water, and land, and consume finite resources in a manner that may threaten people and the environment at the local, regional, and global levels. Thus, PS3 aims to: • Avoid or minimise pollution from project activities; • Promote more sustainable use of resources (including energy and water); and • Reduce project-related Greenhouse Gas (GHG) emissions.	As oil production utilises and generates polluting substances, contributes to GHG emissions and utilises energy and other resources, PS3 is applicable to the project. PS3 has guided the ESIA process, specifically the: • Identification of potential impacts on human health and the environment, as well as strategies to avoid, minimise or offset these impacts; and • Compilation of an EMMP which includes strategies to avoid, minimise or offset these impacts, as required.
PS 4: Community Health, Safety and Security	Recognizes that project activities, equipment, and infrastructure can increase community exposure to risks and impacts. PS4 aims to: • Anticipate and avoid adverse impacts on the health and safety of affected communities during the project life from both routine and non-routine circumstances; and • 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.	As the project will generate some noise and gaseous emissions (including GHG) in publicly accessible areas (notably roads) during construction, PS4 is applicable to the project. PS4 has guided the ESIA process, specifically the: • Identification of potential impacts on human health and safety; • Engagement of community members about the project; and • Compilation of an EMMP which includes measures to address risks that have been identified.
PS 5: Land Acquisition and Involuntary Resettlement	Recognizes that project-related land acquisition and restrictions on land use can have adverse impacts on communities and persons that use this land. PS5 thus aims to: • Avoid, and when avoidance is not possible, minimize displacement by exploring alternative project designs; • Avoid forced eviction; • Anticipate and avoid, or where avoidance is not possible, minimize adverse social and economic impacts from land acquisition or restrictions on land use by (i) providing compensation for loss of assets at replacement cost and (ii) ensuring that resettlement activities are implemented with appropriate disclosure of information, consultation and the informed participation of those affected; and • Improve, or restore, the livelihoods and standards of living of displaced persons.	As the site is not inhabited, is not used for any income generating activities, and is leased by the applicant, PS5 is not applicable to the project.

Performance Standard	Aims and objectives	Applicability to this project
PS 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources	Recognizes that protecting and conserving biodiversity, maintaining ecosystem services, and sustainably managing living natural resources are fundamental to sustainable development. PS6 aims to: • Protect and conserve biodiversity; • Maintain the benefits from ecosystem services; and • Promote the sustainable management of living natural resources through the adoption of practices that integrate conservation needs and development priorities.	Although the project is located in an existing oilfield with more than 1 700 active wells, areas with secondary vegetation, more pristine areas and a nature reserve are located in the vicinity. PS6 is thus applicable to the project. PS6 has guided the ESIA process, specifically the: • Assessment of ecological impacts; and • Compilation of an EMMP which includes measures to address impacts that have been identified.
PS 7: Indigenous Peoples	Recognizes that Indigenous Peoples, as social groups with identities that are distinct from mainstream groups in national societies, are often among the most marginalized and vulnerable segments of the population. PS7 thus aims to: • Ensure that the development process fosters full respect for human rights, dignity, aspirations, culture and natural resource-based livelihoods of Indigenous Peoples; • 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; • Promote sustainable development benefits and opportunities for Indigenous Peoples in a culturally appropriate manner; • Establish and maintain an ongoing relationship based on informed consultation and participation with the Indigenous Peoples affected by a project throughout the project's life-cycle; • Ensure the Free, Prior and Informed Consent of the affected communities of Indigenous Peoples when the circumstances described in this Performance Standard are present; and • Respect and preserve the culture, knowledge and practices of Indigenous Peoples.	As the site is not inhabited or used by Indigenous People, PS7 is not applicable to the project.
PS 8: Cultural Heritage	Recognizes the importance of cultural heritage for current and future generations. As such, PS8 aims to: • Protect cultural heritage from the adverse impacts of project activities and support its preservation; and • Promote the equitable sharing of benefits from the use of cultural heritage.	Archaeological sites, such as graves and remnants of previous activities, are distributed throughout Suriname and not well documented. As such, PS8 could be applicable to the project. However, the project is located within an active oilfield, and the polder on which the project is located has significantly transformed the natural swamp and would have impacted on any artefacts. The ESIA process recommends a chance finds procedure for use during construction.

Where appropriate, application of the standards and guidelines will be customised to reflect the scale of the project and other relevant factors (e.g. time constraints). Other selected relevant international guidelines will be taken into account where appropriate.

2.4 Corporate Requirements

Staatsolie has adopted procedures for protecting the environment which comply with international standards. An integrated HSEQ Policy and Management System is implemented across Staatsolie operations to monitor its effects on the health and safety of its employees, contractors and affected communities, as well as impacts on the environment.

Box 1. Staatsolie HSEQ Policy

Staatsolie demonstrates a firm commitment to Health, Safety, Environment & Quality (HSEQ) by effectively using an integrated management system, through which we continuously:

- Comply with relevant laws and legislation, and Staatsolie's requirements, while taking the needs of our stakeholders into account;
- Identify risks, determine mitigating measures, and apply these measures to our work in order to prevent incidents and damage to the environment;
- Hold all employees and contractors accountable to follow Staatsolie's HSEQ requirements, in order to achieve excellent performance with zero harm;
- Continually improve our management system by enhancing processes, services, and our product quality through the setting of explicit performance objectives;
- Involve all employees and contractors in the decision-making processes of our HSEQ management system.

2.5 Limited ESIA Process

An ESIA is a systematic process to identify, predict and evaluate the environmental[3] effects of a proposed project. The purpose of an ESIA is to:

- Provide information for decision-making on the environmental consequences of proposed actions by identifying the potentially significant environmental effects and risks of a proposed project (i.e. ensure that environmental factors are considered in decision-making processes along with economic and technical factors). This means that the outcome of an ESIA process provides advice to the decision-makers, and is not a final decision in itself; and
- Promote environmentally sound and sustainable development through the identification of appropriate enhancement and mitigation measures.

Sustainable development has been defined in many ways, but the most frequently quoted definition is that of the Brundtland Commission (WCED, 1987): *Sustainable development is 'development that meets the needs of today's generation without compromising those of future generations'.*

It is widely accepted that adverse environmental impacts of projects and development need to be prevented or minimised, and ESIA has become an important tool in achieving this through the integration of environmental considerations into proposed projects. Recommendations made by an ESIA may necessitate the redesign of some project components, require further studies, identify

[3] 'Environment' is used in the broadest sense (including social and cultural aspects of the environment).

changes which alter the economic viability of the project or cause a delay in project implementation. An ESIA should also lead to a mechanism whereby adequate monitoring is undertaken to achieve effective environmental management of the project during implementation.

The general approach to the Limited ESIA will be guided by the requirements of NIMOS, as stipulated in the EA Guidelines (2009) and Guidance Note Environmental Assessment Process (2017), and international best practice.

Relevant principles underpinning the ESIA are:

- Assessment based on appropriate information;
- Accountability for information on which decisions are made;
- Broad interpretation of the term “environment” (inclusion of social and biophysical environment);
- An open and transparent participatory approach;
- Consultation with stakeholders;
- Due consideration of alternatives;
- Attempt to mitigate negative impacts and enhance positive impacts;
- Attempt to understand the social costs and benefits of the proposed project;
- Regard for individual and community rights and obligations; and
- Opportunity for public and specialist input in the ESIA process.

The main objectives of the ESIA are to:

- Document and contextualise the ecological baseline conditions of the study area and the socio-economic conditions of affected communities;
- Assess in detail the environmental and socio-economic impacts that may result from the project;
- Inform and obtain contributions from stakeholders, including relevant authorities and the public, and address their relevant issues and concerns;
- Identify environmental and social mitigation measures to address the impacts assessed; and
- Develop an EMMP, based in part on the mitigation measures developed in the ESIA Report.

The EA process as prescribed by NIMOS is shown in Figure 2-2. Staatsolie completed the screening phase of the EA process prior to SRK’s appointment. NIMOS advised that the project should follow a Category B path 2 process in terms of NIMOS’s EA Guidelines, and requested that a Limited ESIA process be conducted and an EMMP, including impact assessment, be produced and submitted to NIMOS.

The dashed red box in Figure 2-2 indicates the EA aspects covered by SRK in the Limited ESIA process.

A more detailed overview of SRK’s proposed Limited ESIA process is provided in Figure 2-3.

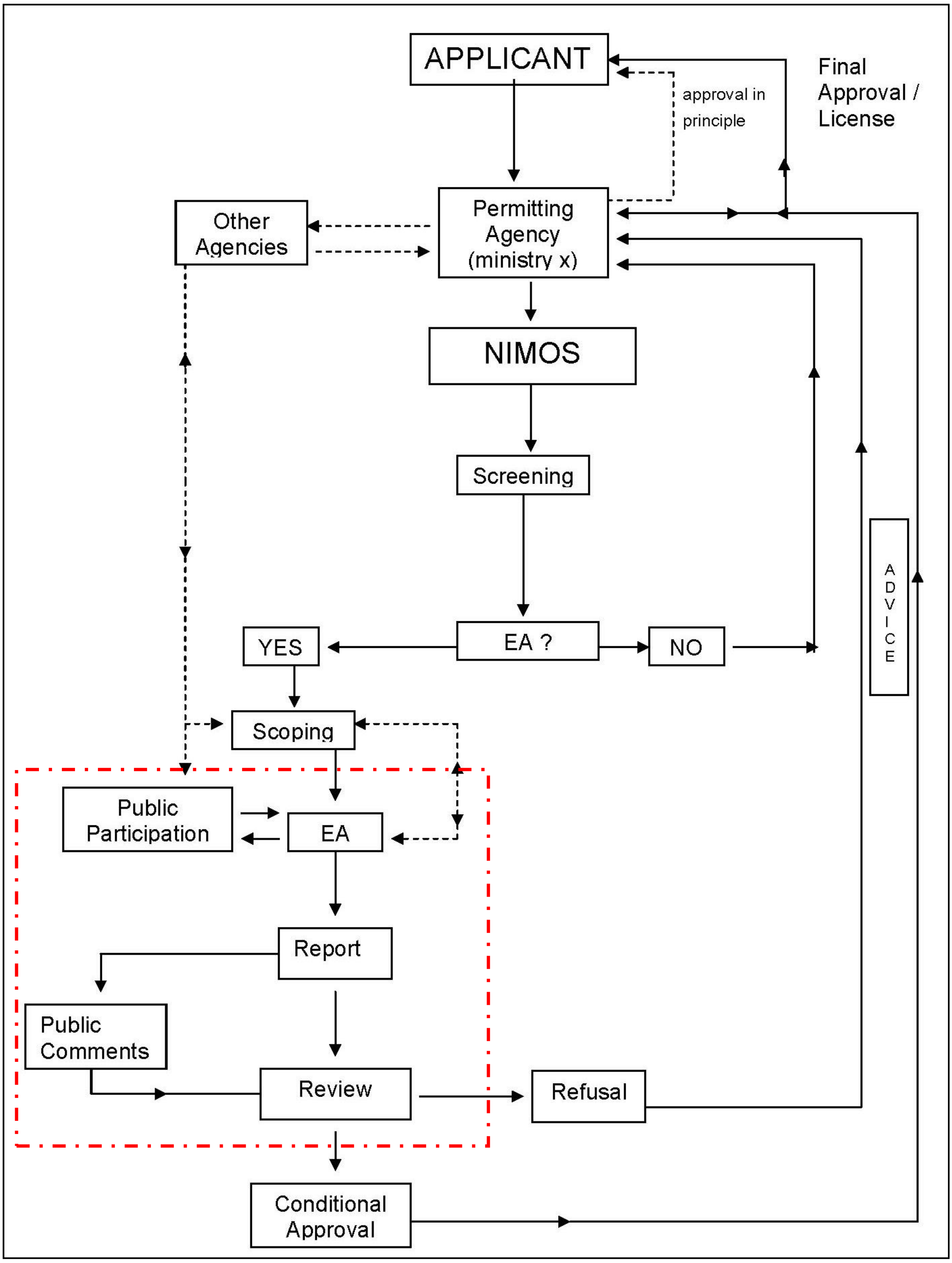


Figure 2-2: NIMOS Environmental Assessment flow diagram

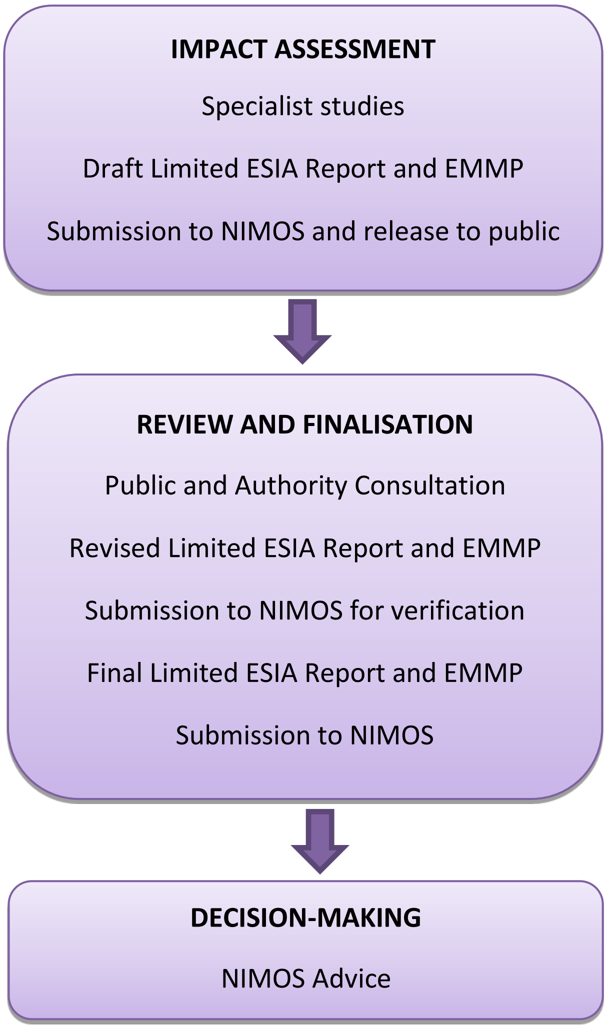


Figure 2-3: Overview of the Limited ESIA process

3 Project Description

3.1 Introduction to EOR methods

Oil production generally occurs in three stages: primary, secondary and tertiary. Enhanced Oil Recovery (EOR) is a tertiary strategy option that is employed when primary (natural flow) and secondary (water and gas injection) techniques are no longer effective.

Three main EOR techniques are:

- *Gas:* Injection of gases into the reservoir to maintain reservoir pressure and displace (“drive”) more oil towards producer wells;
- *Thermal:* Injection of steam to heat the oil, effectively making it more permeable and easier to extract; and
- *Chemical:* Injection of chemicals as dilute solutions to make the oil more mobile and/or increase the viscosity (“thickness”) of injected water, to “drive” more oil towards producer wells.

CSS is a thermal EOR technique. It entails the injection of steam into the reservoir down a well, followed by a soaking period during which the well is sealed and the oil becomes less viscous, and subsequent extraction of the oil from the same well. The EOR effect of CSS is localised to the area surrounding the stimulated well.

3.2 Description of the Project Area

3.2.1 Site Description

The project area is located in the Tambaredjo Oilfield, 40 km west of Paramaribo and 8 km south of the coast, in the Saramacca District of Suriname. The Tambaredjo field is located between the East-West Connection Road and the coast, and mostly north of the Saramacca River (see Figure 1-1).

The oilfield has been operated by Staatsolie since the 1990s. The original swamp habitat has been replaced by secondary marsh vegetation, which is characterised as a modified habitat. The polder is used for oil production from a large number of wells (see Figure 3-1). The polder is traversed by unpaved (shell sand) roads and anthropogenic activity levels are intense. The polder is drained by a system of roadside ditches that are connected to main canals (see Figure 3-2). The north-south trending canals drain into the Saramacca River.

The proposed CSS project is located in the central section of the Tambaredjo Oilfield. New wells will be drilled between existing oil producer wells, in an area where Staatsolie has been producing oil since the 1990s, and where ~1 700 operational wells are located (see Figure 3-6). The CSS project is located west of the south-north aligned Kisoensingh-west Canal, one of the main drainage features of the Tambaredjo Oilfield, and north-east of the Polymer Flooding project area (see Figure 1-1).

3.2.2 Surrounding Land Use

Staatsolie explores, produces and refines crude oil in Suriname. In the Saramacca District, Staatsolie operates three oilfields: Tambaredjo, Tambaredjo North-West and Calcutta. The proposed CSS project is located in the Tambaredjo Oilfield (see Figure 1-1).

Staatsolie commenced construction of the Tambaredjo Polder in the 1990s, to facilitate dryland oil production. The polder covers approximately 10 000 ha and is drained by a system of roadside ditches that are connected to north-south aligned canals which drain into the Saramacca River to the south. Oil is extracted from a large number of wells in 200 x 200-metre grids across the polder. The wells are connected by unpaved (shell sand) roads to a series of secondary access roads which ultimately connect to the Gangaram Pandayweg.

srk consulting	CSS LIMITED ESIA AND EMMP Oil well along the road to TA-58	Project No. 550457

Figure 3-1: Oil well along the road to TA-58

Source: R. Bong A Jan (1 August 2018)

srk consulting	CSS LIMITED ESIA AND EMMP Unpaved roads and roadside ditches in the Tambaredjo Oilfield	Project No. 550457

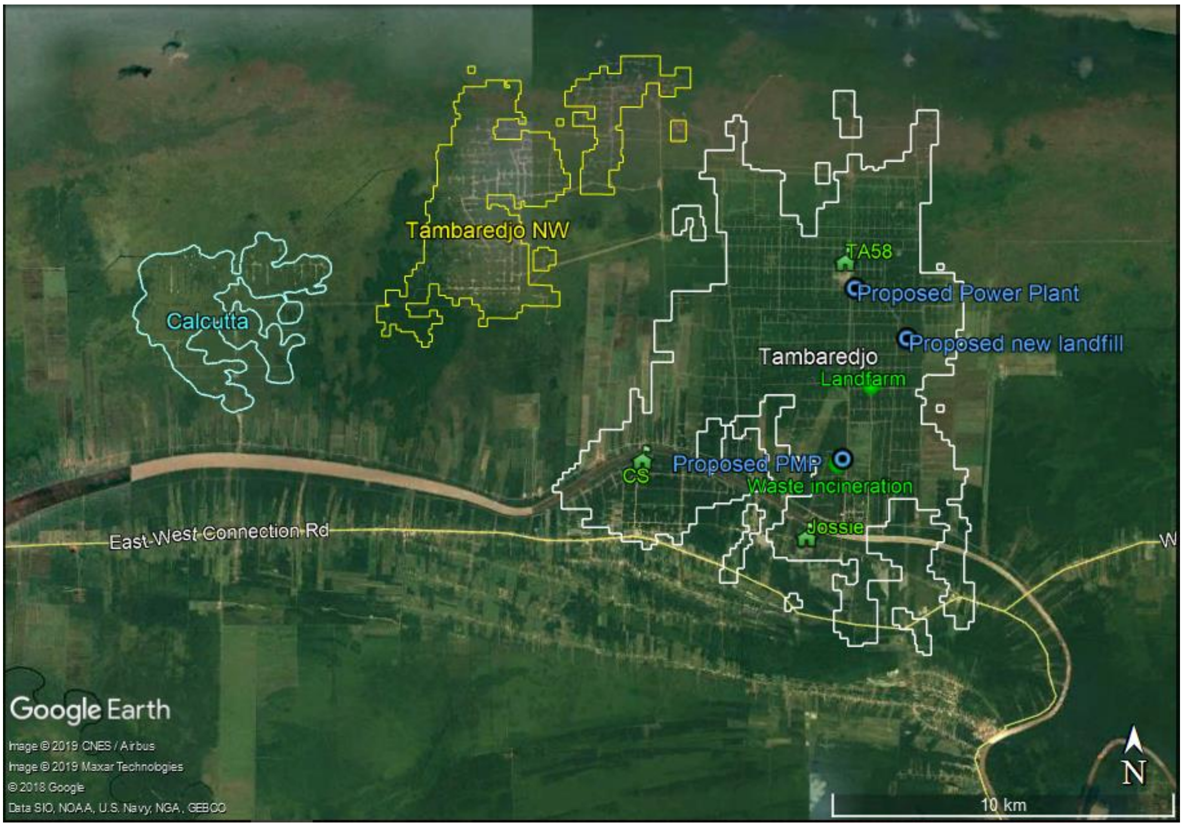
Figure 3-2: Unpaved roads and roadside ditches in the Tambaredjo Oilfield

Source: S. Reuther (1 August 2018)

Staatsolie's TA-58, Jossie and CS crude treatment plants separate the water and crude oil extracted from the wells in the Tambaredjo Oilfield (see Figure 3-3). The oil-water separation plants comprise pumps, processing facilities and oil storage tanks. Backup generators for the Sarah Maria facility are also located at TA-58.

Waste incineration pits and a landfarm on the Tambaredjo Polder provide for waste disposal (see Figure 3-3). Domestic and industrial waste from upstream operations is disposed at an open dumpsite and incinerated in two open pits. The 7 ha landfarm is used to bioremediate oil-contaminated soil, sludge from oil spills and waste from cleaned storage tanks. The landfarm is bunded and designed to contain contaminated water, including runoff.

Processed crude oil (product) from the TA-58 and Jossie plants is conveyed by pipeline to the refinery and export terminals at Tout Lui Faut, south of Paramaribo.



srk consulting	CSS LIMITED ESIA AND EMMP Location of Staatsolie oilfields in the Saramacca District	Project No. 550457

Figure 3-3: Location of Staatsolie oilfields and facilities in the Saramacca District

Several new facilities and projects are under consideration or construction in the Tambaredjo oilfield (see Figure 3-3), including:

- A new ~10 ha landfill and incinerator to improve waste management;
- A new proposed power plant near TA-58 to improve energy security; and
- Drilling of 79 new wells and construction of a polymer mixing plant (PMP) as part of the Polymer Flooding project.

3.3 Proponent's Project Motivation

Staatsolie continuously explores for and develops new oil reserves. However, the implementation of EOR techniques to extract crude oil that cannot be extracted otherwise offers an opportunity to extend the lifespan of existing oilfields.

Based on a prior EOR screening exercise, it emerged that the Tambaredjo Oilfield qualifies as a reasonable candidate for EOR processes such as chemical and thermal EOR. Staatsolie carried out a CSS pilot project in 1985 in the Catharina Sophia area in the south-western portion of the Tambaredjo Oilfield, and recently re-evaluated the pilot. The results of the 1985 pilot indicate a positive reservoir response to the steam injection, despite some operational problems, notably injectivity problems. These were the result of restricted mechanical completion of the wells (designed with 5-1/2” x 2-3/8” casing) and, possibly, the distance between the steam generator and injector wells, so the optimum injection pressure was not achieved.

In order to reassess the potential for CSS in the Tambaredjo Oilfield, Staatsolie proposes to conduct a second pilot project *(this project)*. To address the injectivity issues previously experienced, the new CSS wells will be designed with a 7” casing, 4 ½” liner and a 3 ½” injection tubing, and the steam generator will be moved from well to well and located close to the well head during injection.

This second CSS pilot project will be executed in the central area of the Tambaredjo Oilfield in-between existing oil production wells and facilities. Ten new wells will be injected with two steam slugs each to achieve longer production periods and minimise injectivity problems.

It is expected that CSS will increase oil production by four to six times compared to primary (cold) production, and that up to 50 thousand stock tank barrels (MSTB) of oil can be recovered per well. If successful, the CSS project will extend the life of the viable reserve, generates income for Staatsolie and Suriname and prolongs employment.

3.4 Project Alternatives

An ESIA process should identify and describe alternatives to the proposed activity that were considered, or, failing that, provide adequate motivation for not considering alternatives. Different types or categories of alternatives can be identified, e.g. location alternatives, type of activity, design or layout alternatives, technology alternatives and operational alternatives.

Not all categories of alternatives are applicable to all projects. However, the consideration of alternatives is inherent in the detailed design and the identification of mitigation measures, and therefore, although not specifically assessed, alternatives have been and will be taken into account in the project design and ESIA processes. Staatsolie considered and evaluated a number of alternatives relating to:

- EOR techniques to stimulate the oil;
- Water supply; and
- Disposal of produced water.

An overview of alternatives considered by the Staatsolie project team to date is included as Table 3-1. Alternatives shaded in grey are not further assessed in the Limited ESIA.

Table 3-1: CSS Project alternatives

Aspect	Alternatives	Considerations	Finding
EOR techniques	CSS	A 1985 CSS pilot project indicated positive reservoir response. A second pilot is now planned to reassess the potential for CSS in the Tambaredjo Oilfield.	Assessed in ESIA

Aspect	Alternatives	Considerations	Finding
	Polymer flooding	A Polymer Flooding pilot project has been successful at increasing oil recovery in the Tambaredjo Oilfield. A commercial-scale Polymer Flooding project is currently being considered in the Tambaredjo Oilfield and subject to a separate assessment.	Proposed to be implemented in another section of the Tambaredjo Oilfield and subject to a separate ESIA process
	Other EOR techniques	Not suitable / considered because other EOR technologies are still being prepared for piloting and are not yet mature / proven technologies in Tambaredjo Oilfield.	Screened out
Water supply	Surface water	Surface water is abundant and not the main source of potable water for communities.	Assessed in ESIA
	Groundwater	This option is not preferred, because the water-holding sands (aquifers) are mostly classified as freshwater, making them candidates for potable water sources. It is preferred to not utilise this water for industrial purposes but rather to retain it as a potential potable water source.	Screened out
Power supply	Staatsolie's grid	This option is not feasible, as the grid cannot provide the required load for steam generators.	Screened out
	Power generator	This option is the remaining available option. The type of fuel for the power generators is vendor-dependant.	Assessed in ESIA

3.5 Project Description

3.5.1 CSS Process

The CSS process for each well consists of three phases per cycle (see Figure 3-4):

- Injection phase: A predetermined amount of steam is injected into a well that has been drilled and converted for steam injection;
- Soaking phase: The wells is shut in to allow the steam to heat or "soak" the oil producing formation around the well; and
- Production phase: Once the oil producing formation has adequately soaked (heated), oil is produced from the well until the temperature of the reservoir cools down and the oil viscosity returns to original levels.

The CSS process cycle can be repeated until incremental oil production becomes too low due to declining natural reservoir pressure. Staatsolie anticipates that two CSS cycles will be implemented during the project.

A period of cold production (conventional oil extraction) precedes the injection phase for this project, as it involves the use of newly drilled wells and existing wells. The cold production period is intended to "clean up" the well and test for cold production potential (of new wells). The process flow diagram in Figure 3-5 shows the steps in the CSS project, which involves water abstraction, treatment and storage prior to steam generation, followed by injection and production of produced fluid, which is then separated and treated in the same way and at the same treatment facilities as the fluid produced at existing wells in the Tambaredjo Oilfield.

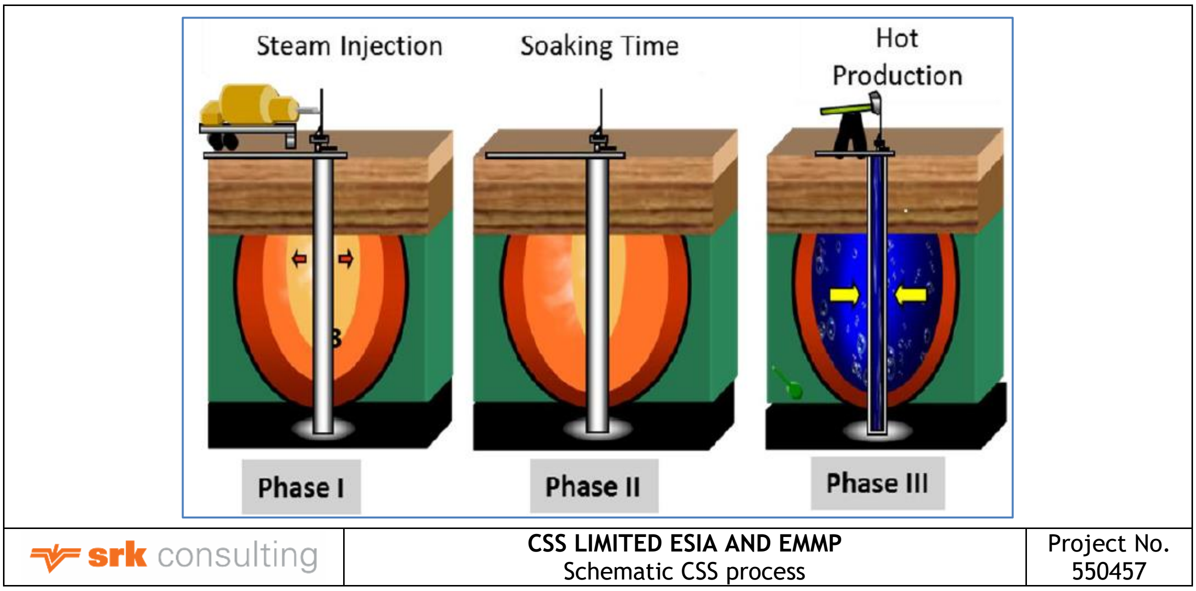


Figure 3-4: Schematic of one cycle of the CSS process

Source: Staatsolie

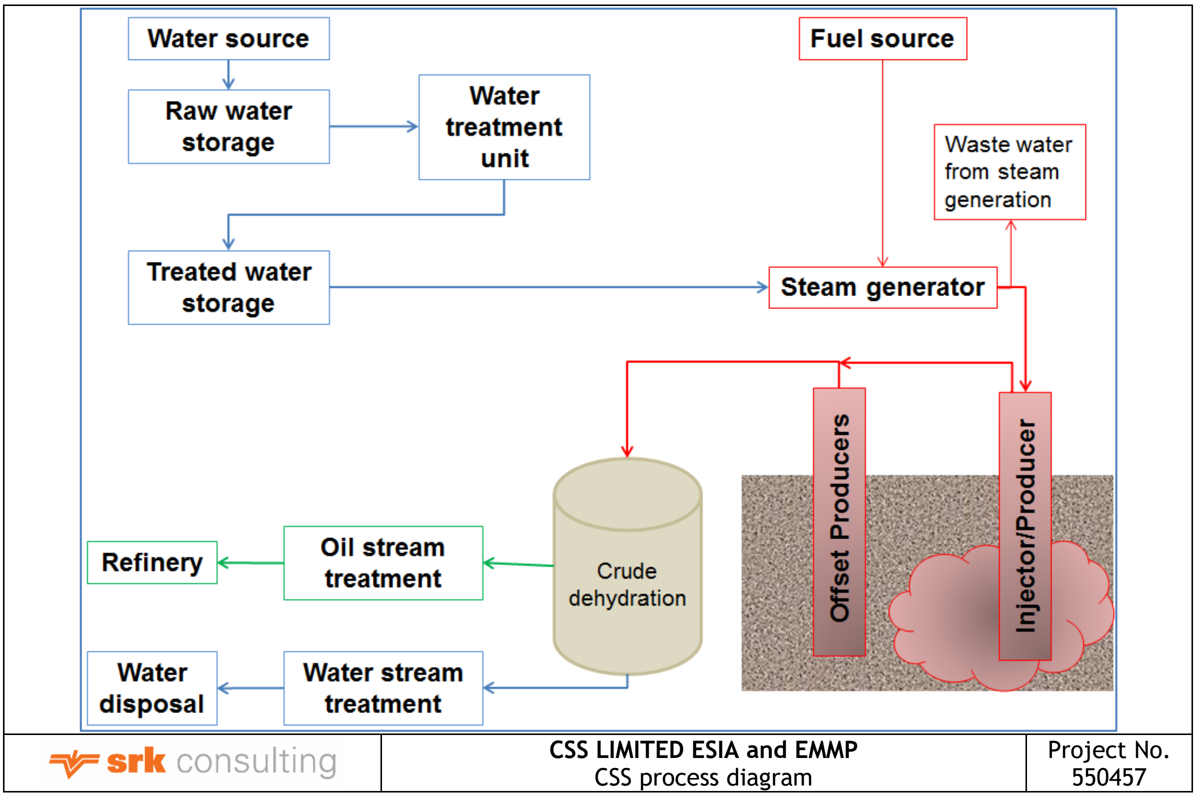


Figure 3-5: CSS process flow diagram

Source: Staatsolie

3.5.2 Project Components

3.5.2.1 Wells

Ten new CSS wells will be drilled between existing producers in the Tambaredjo Oilfield (see Figure 3-6). These will be thermally completed (see Section 3.5.3.1). Each CSS wellsite will also include a power generator, fuel tanks, water storage tanks, steam generator, effluent tanks, injection pump, injection line, storage facility, laboratory and sanitary facilities (see Figure 3-7).

The CSS area includes 27 active wells; most of these were drilled between 2004 – 2005, while three were drilled in 2008, one in 2010 and one in 2013. These wells will be used to monitor some of the CSS project effects. The 21 active wells within ~100 m of new CSS wells are referred to as direct offset wells or first line spacing row, while the remaining six existing wells, located ~200+ m from CSS wells, are second row offset wells (see Figure 3-6).

3.5.2.2 Water Treatment Plant

Water treatment (filtering and softening) is required to assure the mechanical integrity of the steam generators and to generate steam with a minimum steam quality of 80%.

The water treatment plant will be located at former well 3D12, which has been plugged and abandoned. The plant will service all CSS wells for the duration of the project. The facility includes power generators, fuel tanks, water storage tanks, water treatment equipment, effluent tank, chemical storage, data transmission cabin and staff and sanitary facilities (see Figure 3-8).

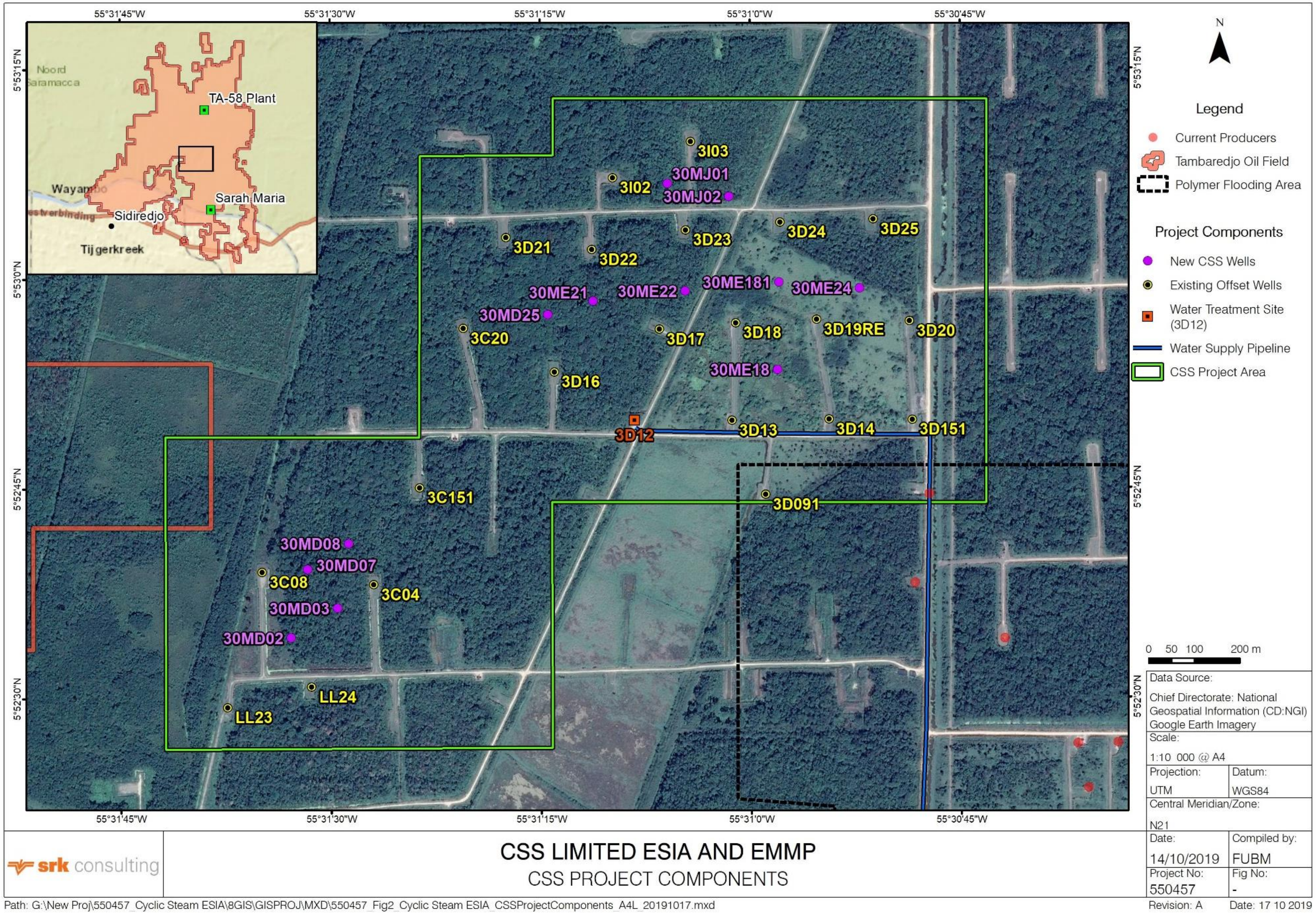


Figure 3-6: CSS project components

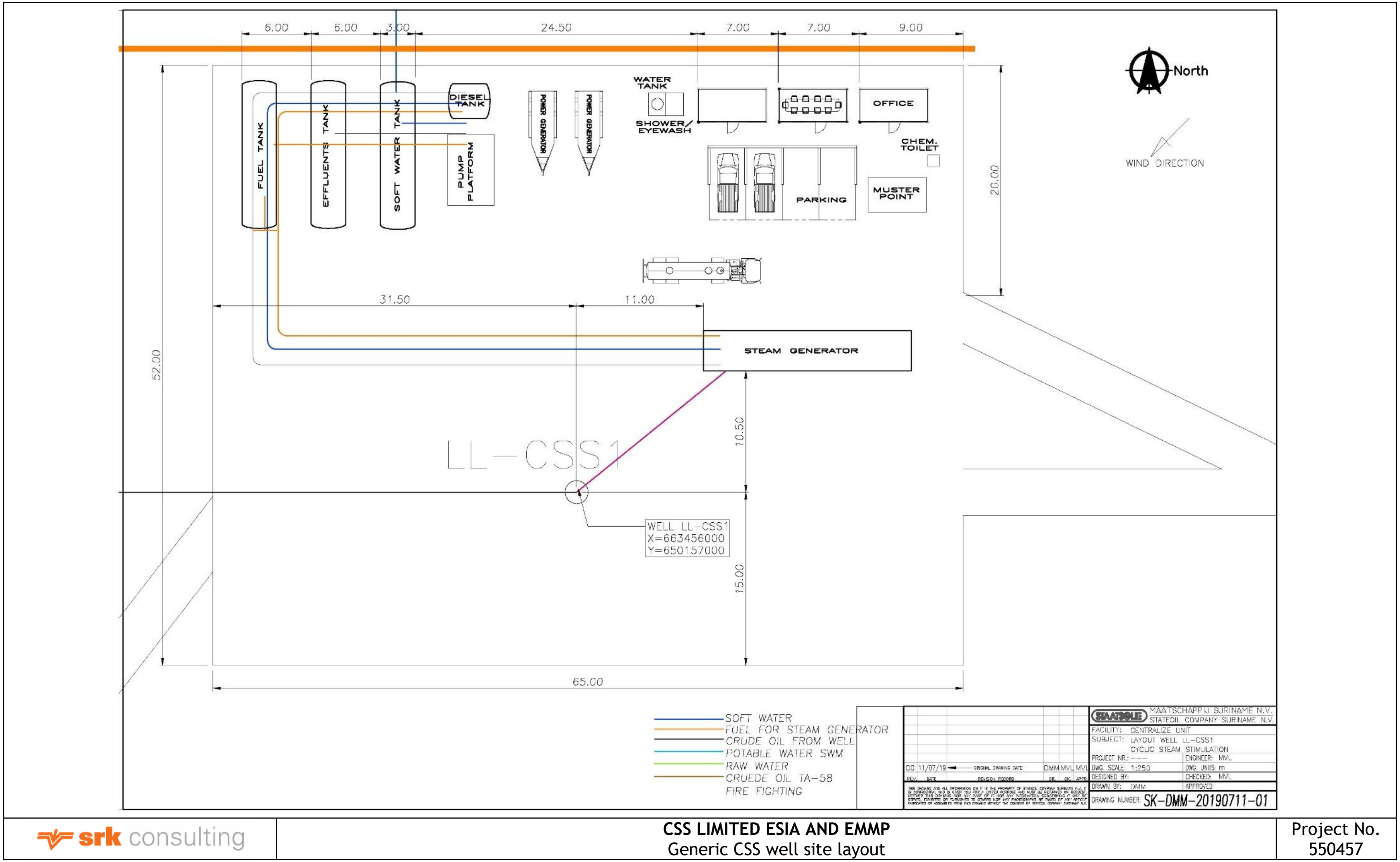
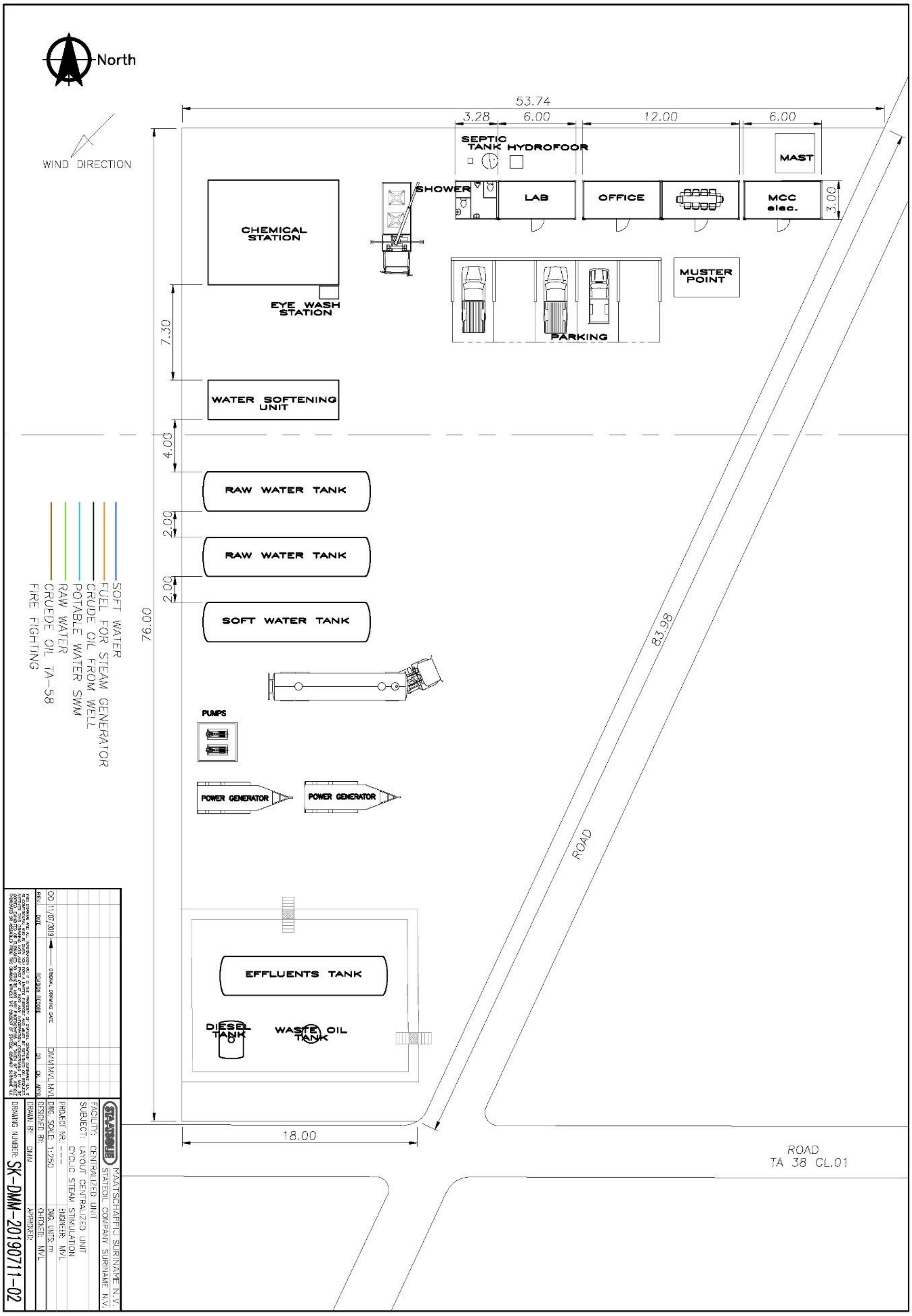


Figure 3-7: Generic CSS well site layout

Source: Staatsolie



srk consulting	CSS LIMITED ESIA AND EMMP Preliminary layout of water treatment plant at 3D12	Project No. 550457

Figure 3-8: Preliminary layout of water treatment plant at 3D12

Source: Staatsolie

3.5.2.3 Infrastructure

New infrastructure required for the CSS project includes:

- Water pipeline from the treated water storage tanks at the future Polymer Mixing Plant to the water treatment site at 3D12 (see Figure 1-1);
- Water pipelines from the water treatment site at 3D12 to each CSS well location;
- Crude pipeline from TA-58 to each CSS well location if Heavy Fuel Oil (HFO) is chosen as generator fuel;
- Access roads to the CSS well locations;
- Power supply cables for illumination and equipment at each CSS well location; and
- Production pipelines and sub headers from each CSS wells to existing headers (pipelines) in the area.

To collect and transport the produced fluid, each CSS well will be connected by a new flow line to a new dedicated sub-header, which then will be connected to the existing production flow system in the pilot area. The new pipelines between the CSS wells and the existing facilities will be designed to convey both cold and hot produced fluid, to ensure integrity of the pipeline.

3.5.3 Construction

3.5.3.1 Wells

Each CSS well site has a ~6 700 m^2 footprint that will be cleared of vegetation to accommodate all equipment, allow for required minimum distances between equipment and personnel access. Civil and mechanical works required during construction of CSS well locations include:

- Verify well coordinates;
- Clear well site and surrounding ditches;
- Level the area around the well;
- Drain the site in preparation for drilling; and
- Lay a concrete foundation for heavy steam generation and injection equipment.

Once sites are prepared, the cellar[4] is installed at the centre point of the well coordinates (see Figure 3-9).

Wells will be constructed using a rig and pulling unit. Drilling of a CSS well, including the drilling fluids used, is identical to conventional well drilling. However, the installed casing and equipment components must comply with specific standards to withstand exposure to heat (steam and produced fluid) and possible higher concentrations of highly corrosive hydrogen sulphide (H_2S) in the produced fluid or escaping gas. Cement slurry must also meet thermal specifications. As such, the new CSS wells will have thermal lower completion and thermal upper completion[5] compliant with the American Petroleum Institute (API) standards and international best practices.

To prevent heat loss to the reservoir, and in conformance with Staatsolie standard practice described in the Well Integrity Manual, at least three barriers between the injected steam / produced

[4] The cellar is an excavation around the wellhead to provide space for items of equipment at the top of the wellbore.
[5] The ""Lower Completion" refers to the portion of the well across the production or injection zone. The ""Upper Completion" is the connection from the lower completion to the well head at the surface.

fluid and the formation will be installed: (1) injection tubing, (2) casing and (3) cement behind the casing.

3.5.3.2 Water Treatment Plant

The water treatment plant site has a footprint of ~3 500 m^2. Civil and mechanical works required during construction of the water treatment plant include:

- Clear site;
- Level the area;
- Drain the site in preparation for installation of equipment; and
- Lay a concrete foundation for water treatment equipment.

3.5.3.3 Infrastructure

Civil and mechanical works will be required to install pipelines to convey water to the steam generator (boiler) and produced fluid from the wells to existing headers (pipelines) in the area.

Roads for general access to new wells will be rehabilitated or constructed using sand as base layer, providing a coarse road surface capable of supporting vehicles transporting large, heavy steam injection equipment.

3.5.3.4 Construction Equipment

Key equipment required during the construction phase is listed in Table 3-2.

Table 3-2: Construction equipment

Equipment	Units	Activity
Low boy 30 tons	1	Clearing, earthmoving, site preparation, road construction
Excavator (standard beam 8 m, 750 l bucket)	4	Clearing, earthmoving, site preparation, road construction
Kip cars	4	Site preparation, road construction
Tractor incl. boxblade	2	Site construction, road construction
Wheel-loader	1	Site preparation, road construction
10-wheel dumping truck	10	Sand, base coarse transportation for back fill sites/ construction roads
Motor grader	1	Road construction (profiling)
6-inch dewatering pump	1	Site preparation
4-ton truck with hoisting device	1	Site preparation
2-ton dump truck	2	Site preparation, road construction
Rig	1	Drilling of wells
Pulling Unit	1	Well completion

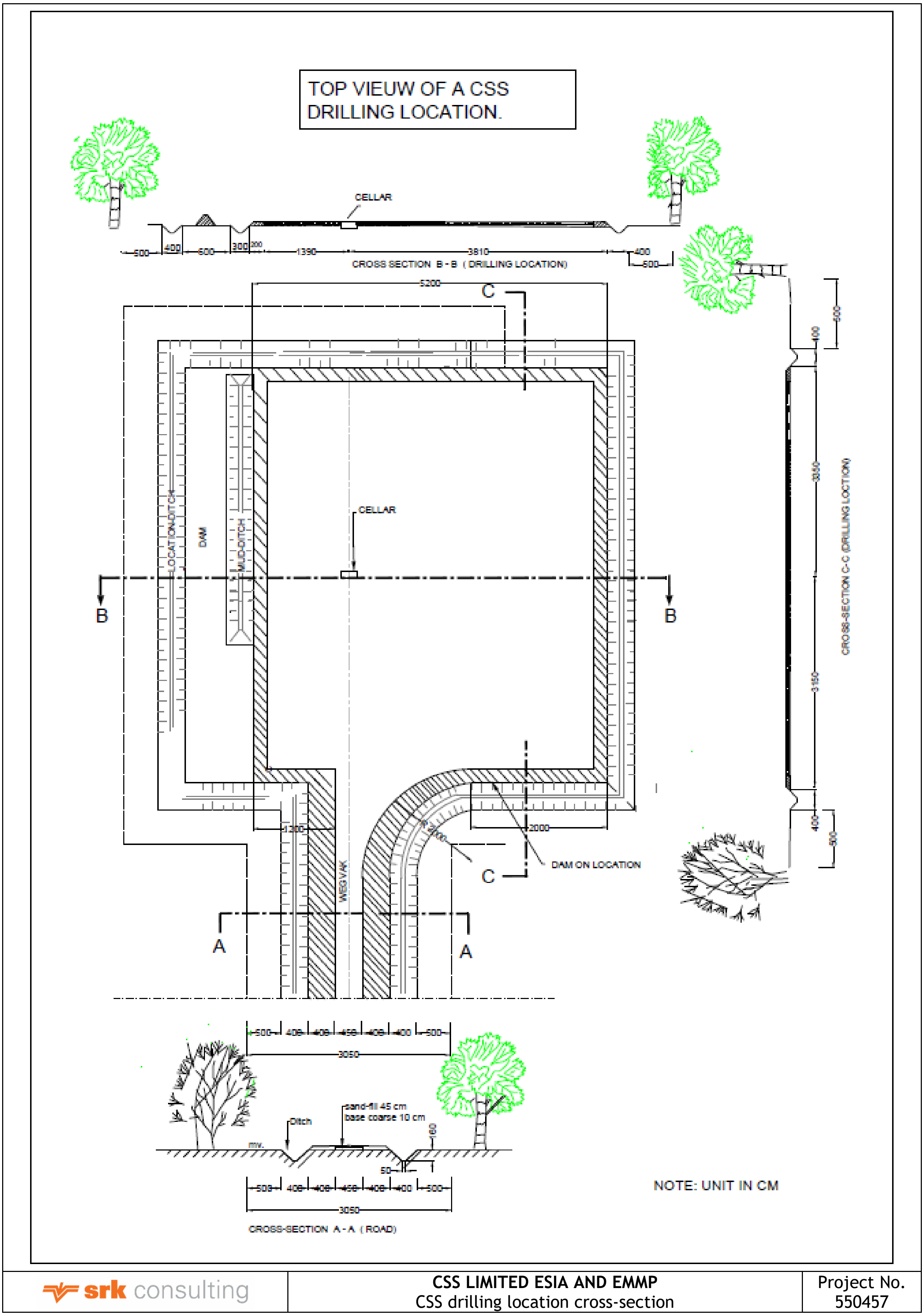


Figure 3-9: CSS drilling site cross-section

Source: Staatsolie

3.5.4 Operations

3.5.4.1 CSS and Oil Production

The CSS and oil production process (for each well) is described below and depicted in Figure 3-10.

Cold Production

Oil - from the T1 and T2 layers - will be produced from the new CSS wells in the conventional way (cold production) for at least two months prior to CSS. Other (conventional and Polymer Flooding) wells in the Tambaredjo Oilfield also produce from this layer (see Section 4.1.1).

Steam Injection

After the initial cold production ends, the well will be converted for steam injection and hot production by retrieving the conventional production string and installing a thermal-specific injection tubing, thermal-resistant pump and thermal-rated downhole pressure and temperature gauges.

Steam will be produced by a Once-Through Steam Generator (OTSG) fed with water from the water treatment plant. Some 150 - 200 tons of steam (equivalent to 945 – 1 260 bbl water) will be injected per well per day at a maximum temperature of 600 ºF (315 ºC) for 15 - 20 days.

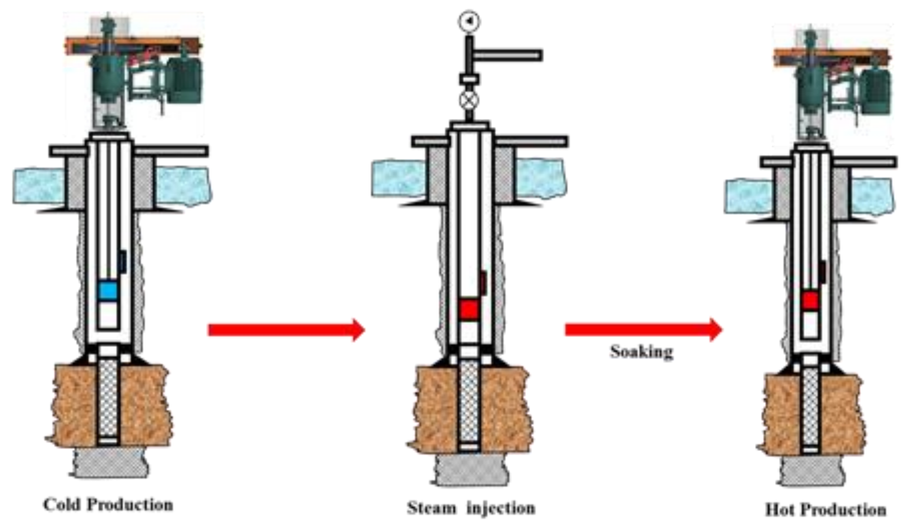
The maximum steam injection pressure (up to 700 psi) is dictated by the regional overburden pressure, to avoid steam distribution exceeding the target range. The surrounding offset producers will be monitored to verify whether they are affected by the steam injection.

Soaking

After steam injection, the well will be shut for 7 to 10 days to allow the heat to dissipate in the near-well area, reducing the oil viscosity and facilitating oil flow towards the well. As the effect of steam is intended to affect only the area around the injection well, surrounding offset producers will be monitored to verify whether they are affected.

Hot Production

After soaking, the well will be converted to a hot producer by installing and/or connecting the pump to initiate production that will generate hot oil and water as well as possibly increased gas volumes. Anticipated volumes of produced fluid, oil and water are shown in Figure 3-11 and Figure 3-12.



srk consulting	CSS LIMITED ESIA AND EMMP Well operation during CSS phases	Project No. 550457

Figure 3-10: Well operation during CSS phases

Source: Staatsolie

3.5.4.2 Treatment

Crude dehydration and produced water clarification

Taking into consideration that the produced fluid from CSS may have different fluid characteristics, treatment of the produced fluid could be more challenging. Therefore, with the emulsion stability test results, a plan including potential additional investment should be worked out to properly handle (e.g. separate collection) and treat this CSS produced fluid (dehydration of crude and water clarification). Based on the location of the pilot area it is anticipated that this fluid will be treated at the TA-58 crude treatment plant and the treated effluent will ultimately be discharged into the Saramacca river.

The total volume of produced fluid that needs to be treated is expected to reach a maximum of 1 300 bbl per day for a ~30-month period commencing at the end of the first injection cycle in all ten wells, i.e.at the end of Year 1 of the CSS project. For most of the project duration, less than 200 bbl of produced fluid will be produced per day (see Figure 3-12).

Gas / Hydrogen sulphide management

Staatsolie is reviewing current H_2S and Methyl Mercaptane levels from the Saramacca oilfields that are reporting to the treatment plants. Studies are underway to determine the levels of H_2S and Methyl Mercaptane at the TA-58 Crude Treatment Plant at Saramacca.

3.5.4.3 Well Injection Cycles

In the first cycle, wells will be injected sequentially, as only one steam generator will be used. Once injection is completed for a CSS well, the steam generation and injection equipment will be moved to the next well. It is expected that all wells will be injected within one year.

After hot production for 12 – 18 months, the well can be prepared for another steam injection cycle. This requires a well workover, i.e. removing the flowline and drive head and disconnecting the production pump, before injection can take place.

The proposed injection strategy entails two steam cycles per well. The associated production profile for a single CCS well is shown in Figure 3-11. After an initial, brief cold production period (producing less than 100 bbl of fluid per day), production ceases during steam injection and soaking. The commencement of hot production produces a spike in produced fluid (as the injected water is produced back) and produced oil (which is heated and less viscous). Both then decline in the following months until they stabilise at normal rates, whereupon a second injection cycle is initiated.

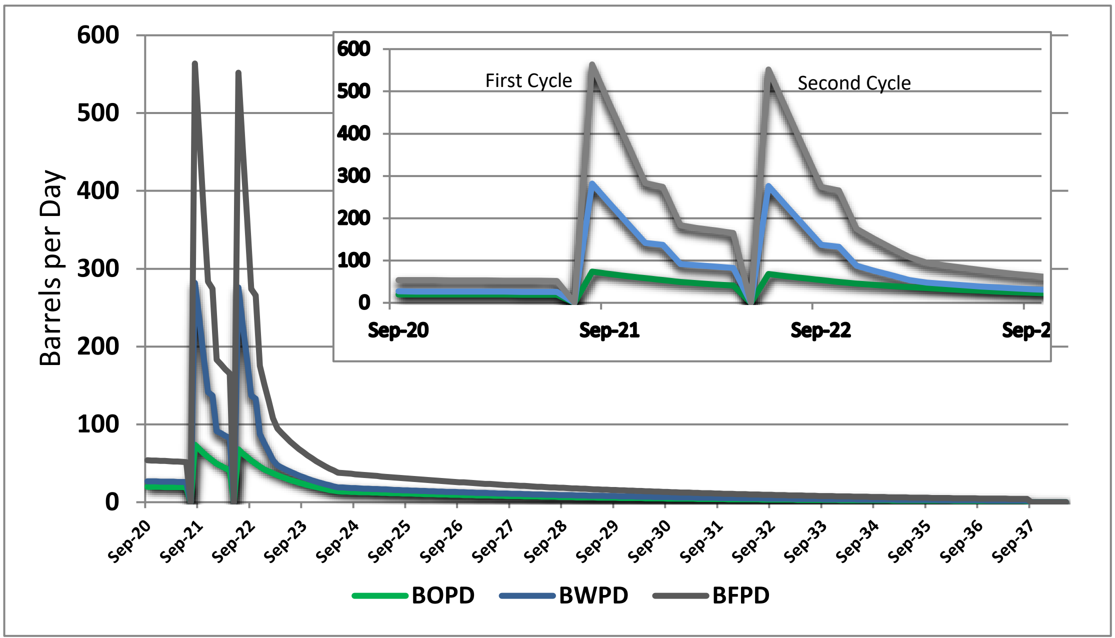


Figure 3-11: Expected production profile for one CSS well

Source: Staatsolie

Note: BOPD – Barrels of oil per day, BWPD – Barrels of water per day, BFPD – Barrels of fluid per day

The production profile is smoother when considering all wells combined, due to the sequential stimulation of wells (see Figure 3-12), spiking at just under 500 BOPD (for over a year) before declining fairly rapidly to 100 BOPD, and then lower.

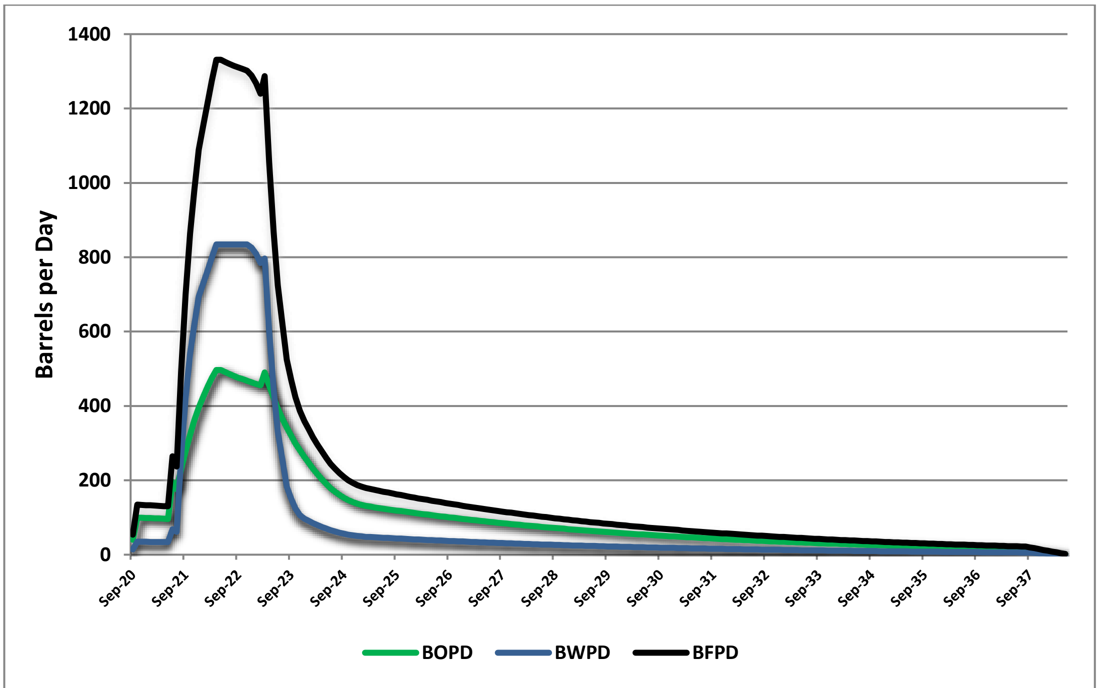


Figure 3-12: Expected combined production profile for 10 CSS wells

Source: Staatsolie

Note: BOPD – Barrels of oil per day, BWPD – Barrels of water per day, BFPD – Barrels of fluid per day

Figure 3-13 shows the predicted reservoir temperature profile for one CSS well for the first injection cycle. The reservoir temperature profile for one CSS well during the full process over two cycles, shown in Figure 3-14, mirrors the production profile in Figure 3-11.

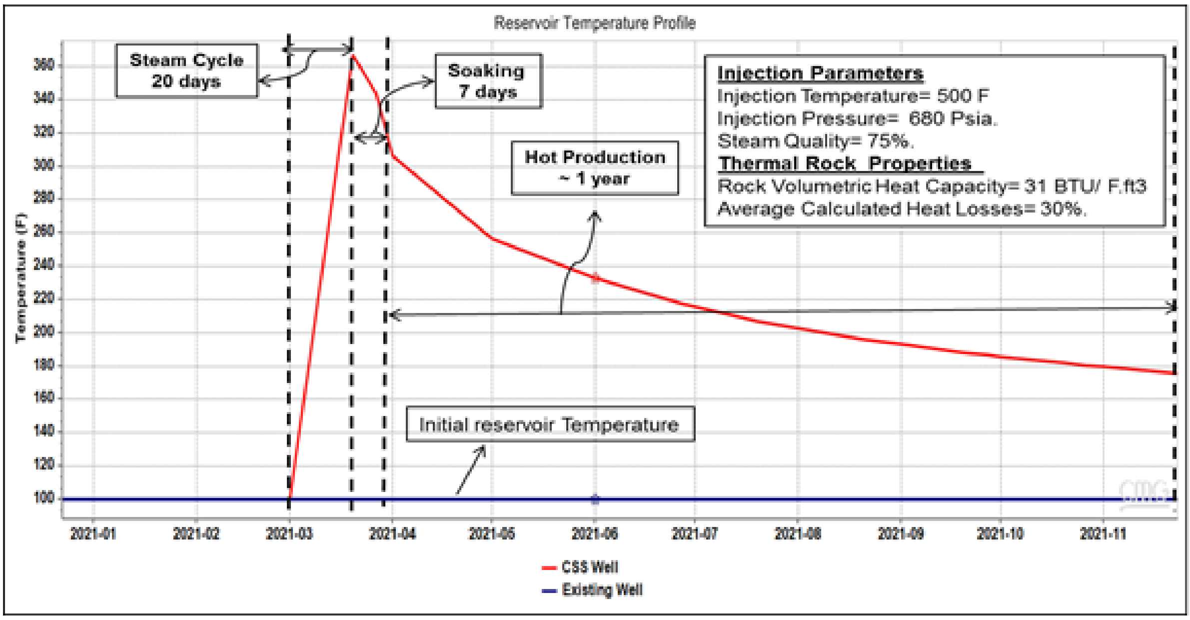


Figure 3-13: Expected reservoir temperature profile for one CSS well – initial eight months

Source: Staatsolie

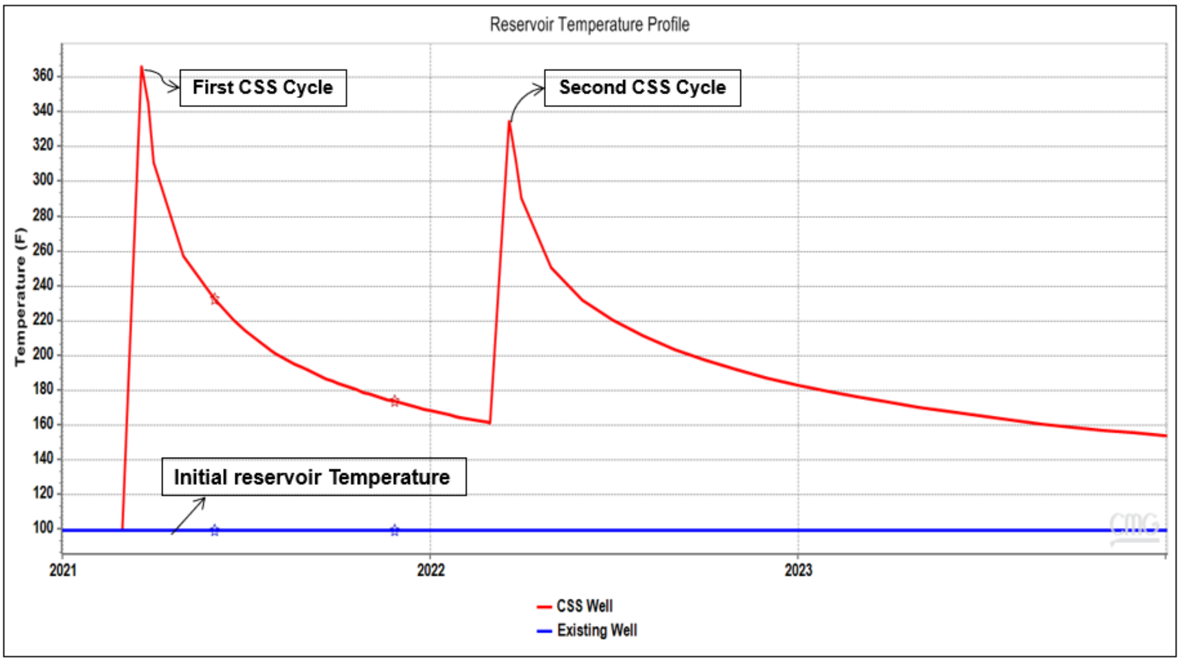


Figure 3-14: Expected reservoir temperature profile for one CSS well – two injection cycles

Source: Staatsolie

3.5.4.4 Monitoring of CSS Operations

Staatsolie will monitor the water treatment plant and the CSS and offset wells during the entire injection and production cycle, to ensure integrity of the CSS and offset wells and safe operations.

Aspects that will be monitored include, *inter alia,* water and steam quality, injection rate and volume, injection and bottom-hole pressure, bottom-hole temperature and oil, gas and water production rates and properties (such as oil viscosity, water salinity and H_2S concentration in gas and oil, among others).

3.5.4.5 Operation Equipment

Key equipment and facilities required during the operation phase is listed in Table 3-3.

Table 3-3: Operation equipment

Equipment	Units	Activity
Cold production		
Multiphase flow meter or testtank	1	Production testing
Laboratory facilities		Fluid sampling & analysis
Remote well monitoring system	1	Realtime monitoring of temperature and pressure through data transmission of downhole gauge data
Steam injection and soaking		
Mobile water treatment unit	1	Treat raw water from the water well into specs required for steam generation equipment
Steam generator	1	Generate steam and inject in pilot well
Power generator	2	Supply power load for water treatment equipment, steam generators, auxiliaries on the injection site
Water storage tanks	1 - 2	Store raw water from the source and have a buffer of water storage to feed the steam generator
Well integrity monitoring equipment		Downhole Thermal gauge for Realtime monitoring of temperature in annular space
Remote well monitoring system	1	Realtime monitoring of temperature and pressure through data transmission of downhole gauge data
Hot production and transportation		
H_2S sequestration equipment & chemicals	1	Capture H_2S gas (possible byproduct of steam injection and hot oil production)
Remote well monitoring system	1	Realtime monitoring of temperature and pressure through data transmission of downhole gauge data
Production flow system (flow lines, cooling system, (sub)headers including monitoring devices	1	Transport of produced fluid to tie-in on existing production system with appropriate monitoring devices for mainly temperature to ensure integrity of the existing production facilities
Multiphase flow meter	1	Production testing
Production Test tank	2	Production testing

The water treatment, steam generation and injection facilities will be leased from service providers who are likely to import (and later re-export) required equipment and plant through the Port of Suriname, from where it will be trucked to Staatsolie's facilities at Saramacca. Relevant authorities will be informed and consulted to ensure safe and efficient transportation.

3.5.5 Decommissioning of CSS Project

Depending on the results of the CSS project, wells may be subject to additional steam injection cycles and/or other subsequent EOR methods. Failing that, wells will continue producing as regular cold production wells while economically viable.

As such, the end of the CSS pilot project does not necessarily signal the end of (cold) oil production at the CSS wells or the Tambaredjo Oilfield in general, and only partial decommissioning of CSS components would be required if CSS is discontinued. Leased equipment (such as the steam generator) will be shipped back to the service provider(s) after completion of the steam injection program. Pipelines will be removed if no longer required.

3.5.6 Utilities and Services

3.5.6.1 Power Supply

Power supply for the CSS well production and monitoring equipment will be provided from the existing Staatsolie power distribution network. Power for the water treatment plant and steam generator will be provided by mobile power generators, because Staatsolie's network cannot supply the required load.

3.5.6.2 Fuel Supply

The OTSG uses diesel or HFO, while mobile power generators will use diesel. Depending on the equipment leased, the OTSG is expected to use 21 000 liters of diesel or 19 000 liters of HFO per day. HFO would be supplied by pipeline from TA-58.

3.5.6.3 Water Supply

Each well requires 945 to 1 260 bbl water[6] per day for steam generation during each ~20-day injection cycle. This translates to water demand of 18 900 to 25 200 bbl of water per well for each cycle. Total project water demand is 378 000 to 504 000 bbl for two steam injection cycles in ten wells.

Water abstracted from the Saramacca River will be conveyed to the CSS water treatment plant using facilities and infrastructure installed for the Polymer Flooding project. The Polymer Flooding facilities have sufficient water treatment and storage capacity to supply the CSS project[7], even in the event of equipment downtime, and no additional back-up water sources are required. Smaller volumes of water will be stored at CSS sites.

Although the water delivered through the Polymer Flooding facilities has been treated, additional treatment for steam generation will be required to adjust hardness and pH and eliminate H_2S, bacteria and oxygen.

3.5.7 Employment

The construction phase is expected to create ~30 jobs, while the operational phase generates no additional employment, as existing Staatsolie staff and/or contractors will operate the project.

3.5.8 Project Programme

The timeline for key project initiation milestones is currently anticipated as shown in Table 3-4. Note that dates may shift in the event of delays.

Table 3-4: Key project milestones

Activity	Start date	Finish date
Site preparations	Aug-19	Feb-21
Drilling and completion of CSS wells:		
- 30ME22, 30MJ01, 30MJ02, 30ME21, 30MD25	Sep-20	Oct-20
- 30ME18, 30ME24, 30ME181,30MD03, 30MD02	Apr-21	May-21
Cold production period	Sep-20	Feb-22
Installation of water and fuel supply infrastructure	Jan-21	Mar-21
First steam injection cycle (10 wells)	Jun-21	May-22

[6] 6.3 bbl water are required to generate 1 ton of steam.
[7] In addition to the 21 000 bbl/d of water required for the Polymer Flooding project during the water injection cycle.

Activity	Start date	Finish date
First hot production cycle (10 wells)	Jul-21	Jun-23
Second steam injection cycle (10 wells)	Jun-22	May-23
Second hot production cycle (10 wells)	Jul-22	Jun-24

4 Description of the Affected Environment

The following chapter presents an overview of the biophysical and socio-economic environment in which the proposed project is located to:

- Understand the general sensitivity of and pressures on the affected environment;
- Inform the identification of potential issues and impacts associated with the proposed project, which were assessed in the Impact Assessment section; and
- Start conceptualising practical mitigation measures.

The description of the affected environment is based on existing information provided in previous studies by SRK and specialists for the Proposed Power Plant (SRK Consulting, 2019a) and the Polymer Flooding project (SRK Consulting, 2019b) in the Tambaredjo Oilfield, as well as Noordam Environmental Consultancy studies for developments located just west of the project area, notably the Tambaredjo North-West Oilfield Development ESIA (Noordam, 2010), Farmersland Production Development ESIA (Noordam, 2014) and Calcutta-North Appraisal Drilling ESIA (Noordam, 2018). Where information has been obtained from different sources, it is appropriately referenced.

4.1 Biophysical Environment

4.1.1 Geology and Geomorphology

Geologically, Suriname is part of the Precambrian Guiana Shield. In the north, the shield shows a seaward dip and is covered by Late Cretaceous and Cenozoic deposits of the Guiana Basin. The shield consists mainly of granitoid and metamorphic rocks (De Vletter, Aleva, & Kroonenberg, 1998).

The Precambrian Guiana Shield started to receive a wedge of sediments in the Late Jurassic-Early Cretaceous with the opening of the Atlantic. The oldest sediments are of Early Senonian (Late Cretaceous) Age. The youngest sediments cropping out in the young coastal plain are of Holocene age (see Figure 4-1). The surface and subsurface sediments of the Coastal Plain area have been grouped into the Corantijn Group (Sabajo, 2016).

The study area is located in the Young Coastal Plain of the Guiana Basin, on Holocene deposits of the Coronie Formation. The area is situated on predominantly marine clay sediments deposited less than 1 000 years ago (Brinkman and Pons, 1968).

The Corantijn Group consists of a monoclinical northern dipping (*c*.1°) section of predominantly clastic sediments. These sediments form a regular alternation of sands, clays, siltstones and minor shales. Occasional marls, lignites and gravel may be intercalated locally. The sediments were deposited under fluvial to marginal conditions. Several regressive and transgressive phases as well as major periods of non-deposition can be recognized. The total thickness of the Group increases from south to north and from east to west (Sabajo, 2016).

The CSS project will be implemented in the Paleocene T-unit, which is the oil-bearing layer directly overlaying the Cretaceous unconformity (see Figure 4-1) which is targeted by all oil production in the Tambaredjo Oilfield. The sediments of the T-unit are fluvial channels deposited in a continental fluvial plain. They are subdivided into the T1, T2 and the T3 sands layers.

The T1 and T2 sands layers were deposited within a similar fluvial plain in a medium energy environment during a transgressive phase. The T3 layer at the top of the T-unit sequence was deposited in a low to very low energy environment during the end of the transgression and consists mostly of shale. In the CSS area the fluvial channels of the T1 and T2 sands are between 10 ft and 30 ft thick (see Figure 4-2 and Figure 4-3) and lie at a depth of 1 000 ft to 1 130 ft (see Figure 4-4). The CSS area in particular has more T2 than T1 sands due to the high elevation condition during the

Paleocene, when a pillar structure developed in the Central Tambaredjo Field (Staatsolie, pers. comm.).

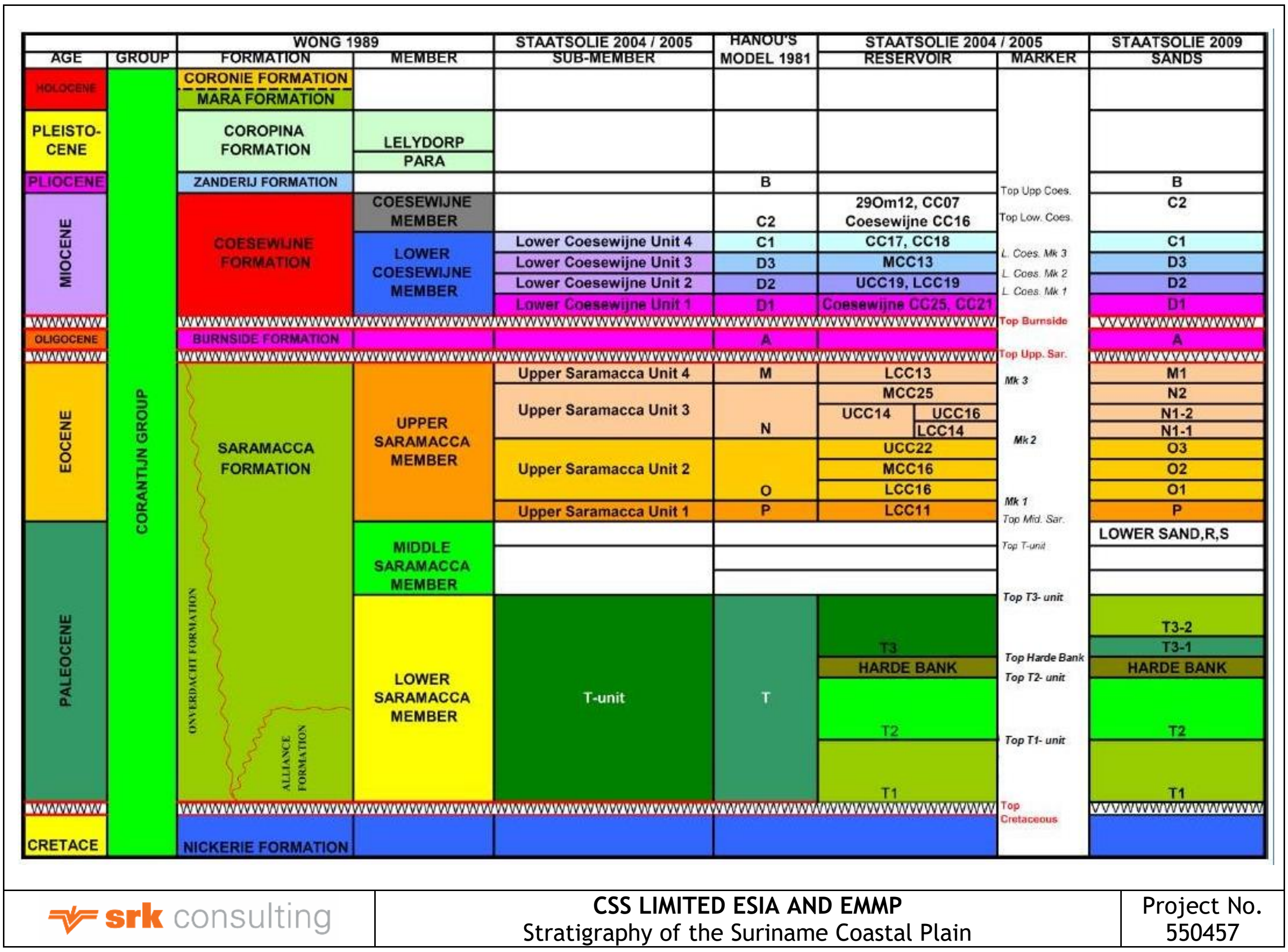


Figure 4-1: Stratigraphy of the Suriname Coastal Plain

Source: Staatsolie

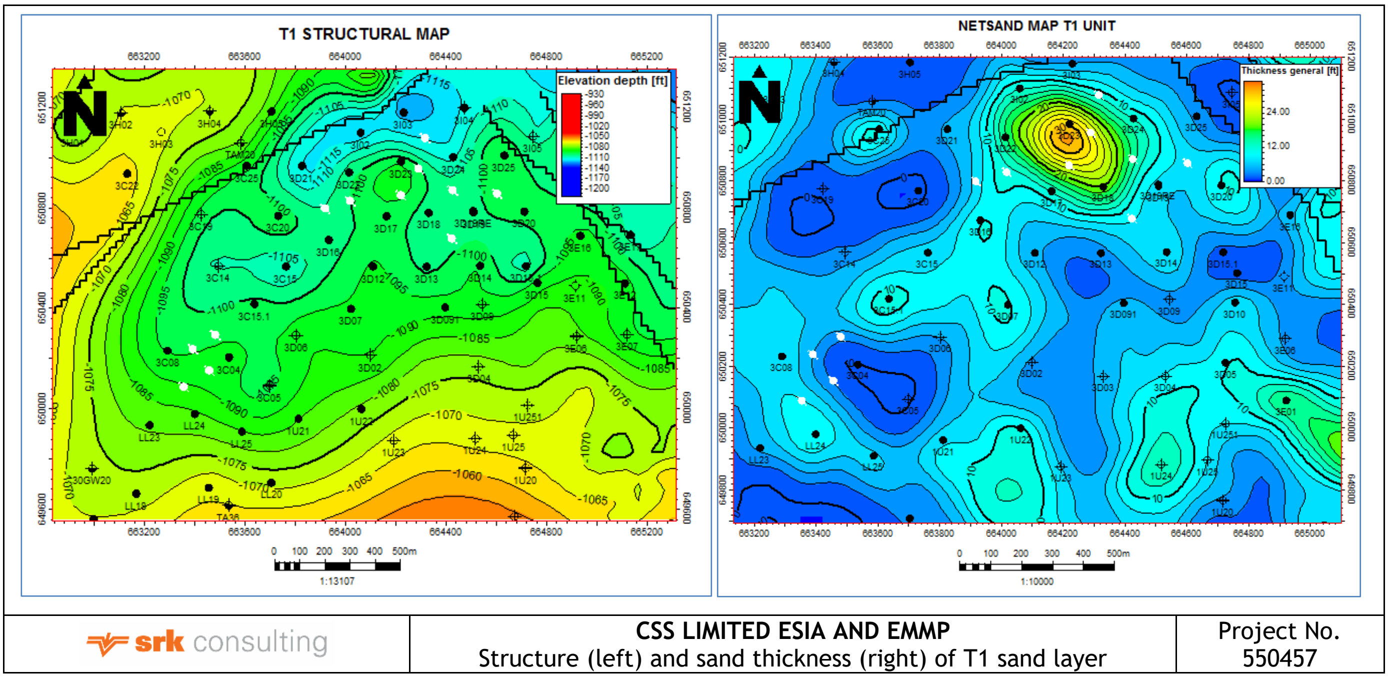


Figure 4-2: Structure (elevation / depth) (left) and sand thickness (right) of T1 sand layer

Source: Staatsolie

Note: Proposed CSS wells are shown as white dots. Black zig-zag lines depict faults.

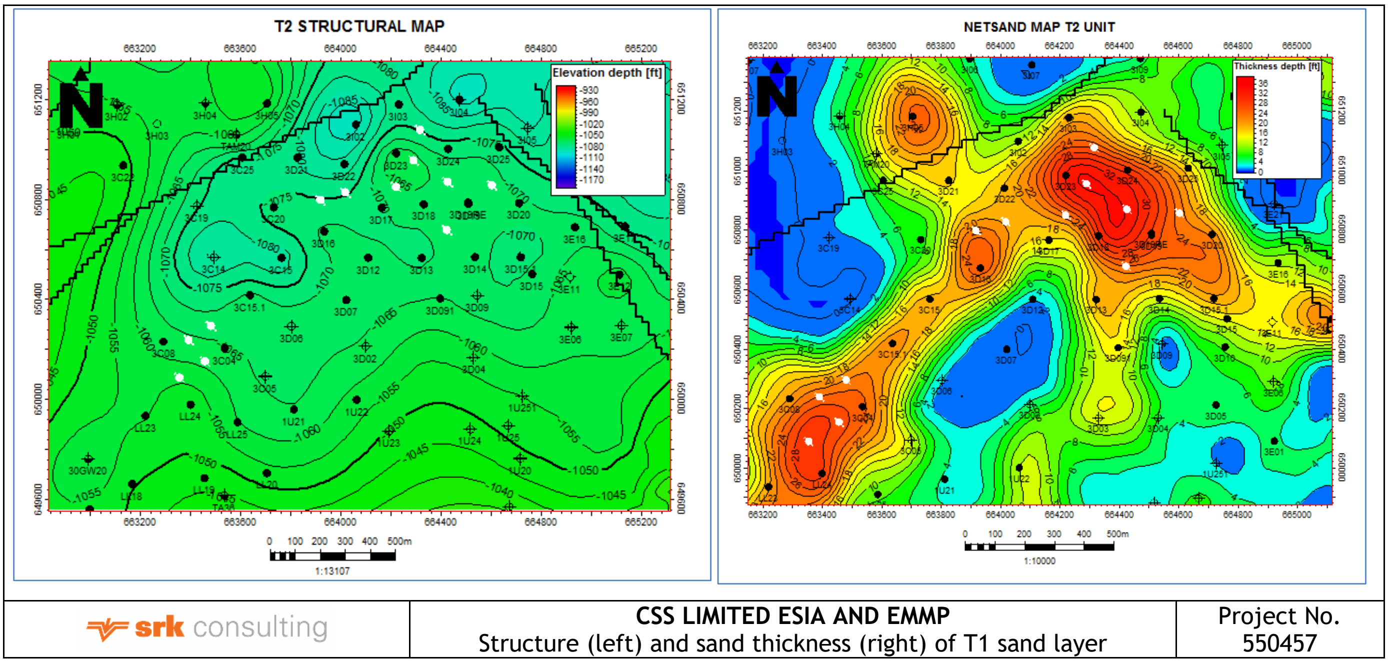
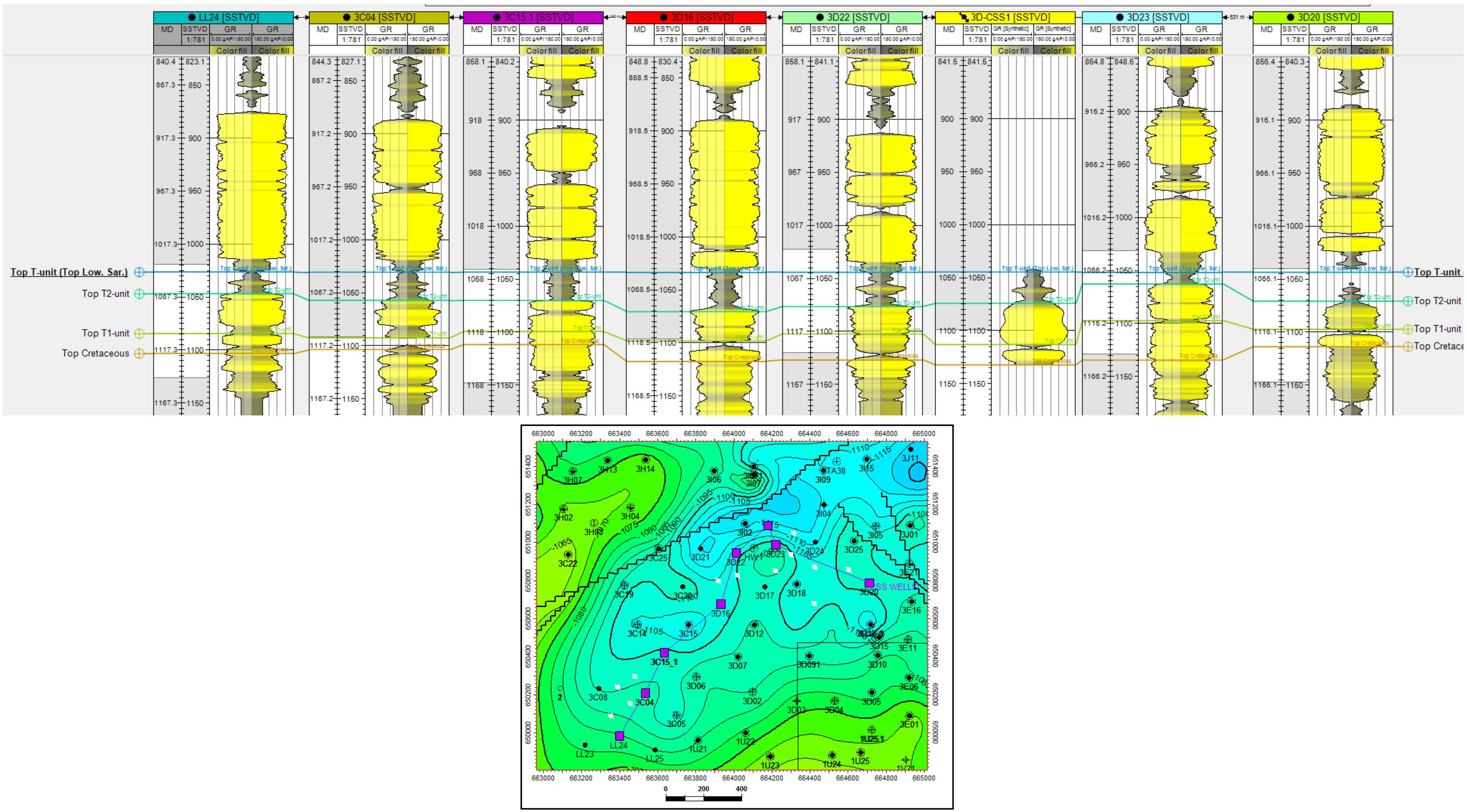


Figure 4-3: Structure (elevation / depth) (left) and sand thickness (right) of T2 sand layer

Source: Staatsolie

Note: Proposed CSS wells are shown as white dots. Black zig-zag lines depict faults.



srk consulting	CSS LIMITED ESIA AND EMMP Stratigraphy across the CSS area	Project No. 550457

Figure 4-4: Stratigraphy across the CSS area

Note: Cross sections are for the oil-producing wells shown in purple in the lower figure. MD - Measured depth, SSTVD - Sub Surface True Vertical Depth. Yellow depicts sand layers, grey depicts clay / shale layers. Different width of yellow and grey bars are for visualization purposes only.

4.1.2 Climate

4.1.2.1 General Description of Regional Climate

Suriname has a typical tropical climate with high rainfall and high temperatures. Most rainfall in the region falls in two rainy seasons, interspersed with two 'dry' seasons as follows (Webster & Roebuck, 2001):

- Short rainy season – early December until early February;
- Short dry season – early February until mid-April;
- Long rainy season – mid-April until mid-August; and
- Long dry season – mid-August until early December.

4.1.2.2 Rainfall

Rainfall data acquired over a period of 39 years (see Figure 4-5) indicates a long-term average of approximately 2 200 mm per annum in Paramaribo.

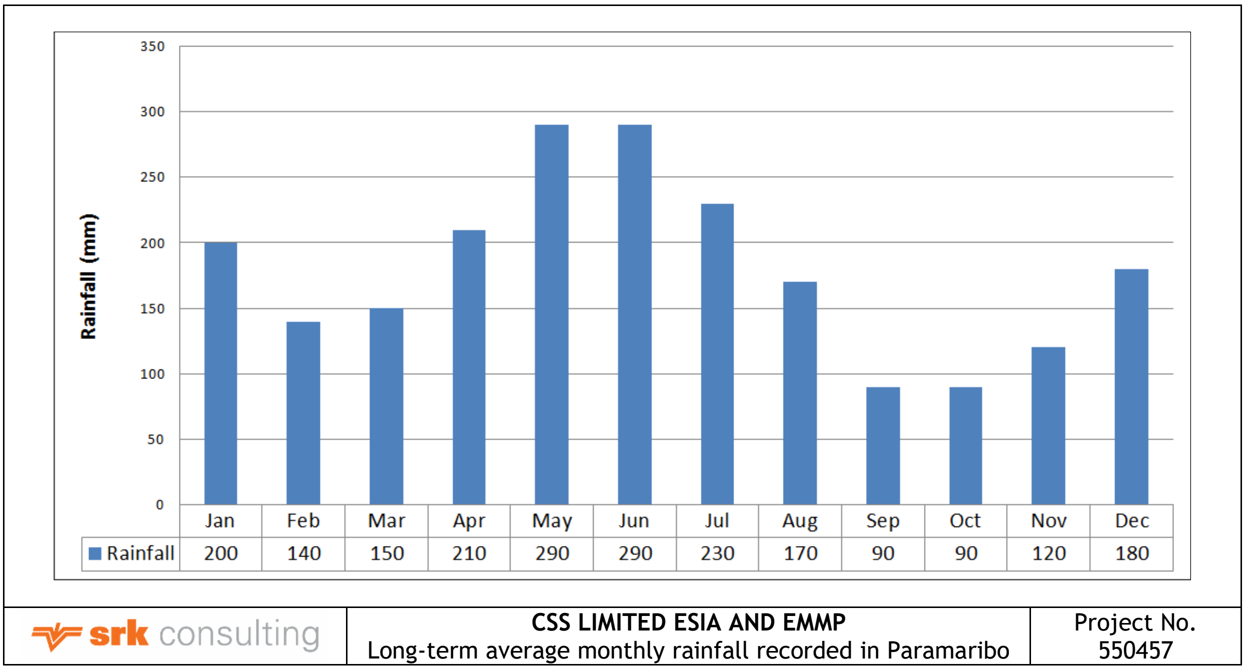
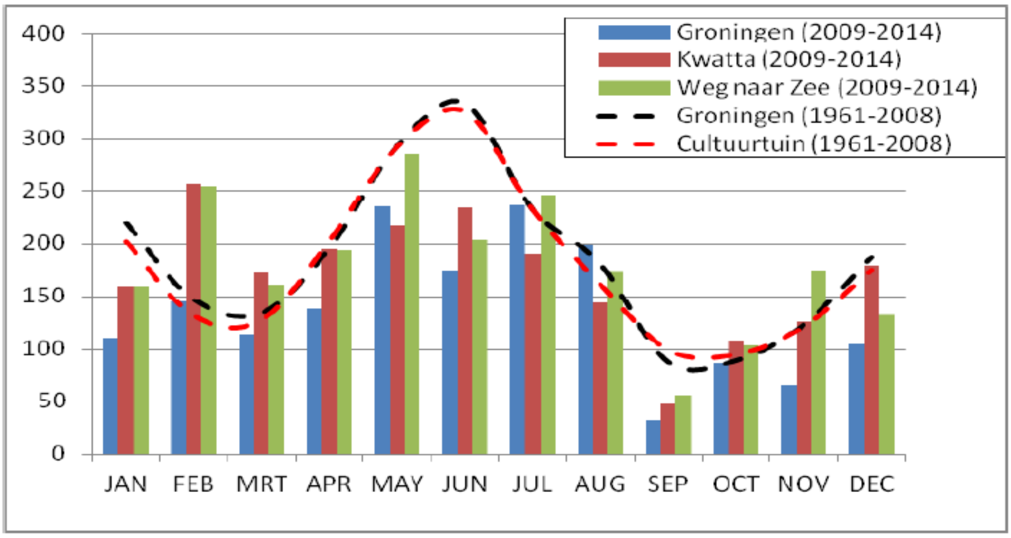


Figure 4-5: Long-term average monthly rainfall recorded in Paramaribo over 39 years

Source: Weatherbase, 2013

Measurements of rainfall in the study area between 2009 and 2014 indicate similar annual rainfall and trends (Noordam, 2014). Average annual rainfall was 2018 mm at Kwatta and 2186 mm at Groningen in the period, compared to a long-term annual average of 2 233 mm at Groningen and 2 248 mm at Cultuurtuin, with a peak in May to July.



srk consulting | CSS LIMITED ESIA AND EMMP
Average rainfall for 2009 - 2014 (Groningen, Kwatta, Weg naar Zee) and 1961 - 2008 (Groningen, Cultuurtuin) | Project No. 550457

Figure 4-6: Average monthly rainfall for 2009 – 2014 (Groningen, Kwatta, Weg naar Zee) and 1961 – 2008 (Groningen, Cultuurtuin)

Source: Noordam (2014)

Rainfall is an important parameter with respect to air quality, which deteriorates during dry conditions and improves during the wet season. However, in Suriname even during the dry season(s) rainfall is relatively high. During wet periods, rain suppresses dust particles in the atmosphere and alleviates air pollution. Dust emissions are further reduced by damp soil conditions. During dry periods, dust emissions generally increase as the soils become desiccated.

Humidity is generally high throughout the year, varying between 80% and 90% on the Coastal Plain and 75% in the Interior. The highest humidity values are recorded from May to July and the lowest from September to November.

4.1.2.3 Ambient Temperature

In Suriname, the period between July and October tends to be warmest, with daily temperatures reaching (average) highs of more than 31°C. The period from December to March is coolest, with daily temperatures in the coolest month, January, reaching a high of approximately 30°C. Minimum temperatures throughout the year are between approximately 22°C and 24°C. Monthly average, maximum and minimum temperatures obtained for the period January 2015 to December 2017 are shown in Table 4-1.

Table 4-1: Minimum, maximum and mean temperature 2015 – 2017, Suriname

	Jan	Feb	March	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Maximum	29.5	29.7	30.4	30.8	31.7	31.1	31.5	31.7	32.3	31.7	30.9	30.7
Minimum	22.5	22.8	22.8	22.1	23.8	23.8	22.9	22.5	23.1	22.8	22.3	23.5
Average	26.0	26.0	26.4	26.6	27.1	27.1	27.2	27.1	27.3	27.1	26.8	26.6

Source: MM5 Data January 2015 – December 2017 (Airshed Planning Professionals, 2018)

Daily and monthly temperature trends are presented in Figure 4-7.

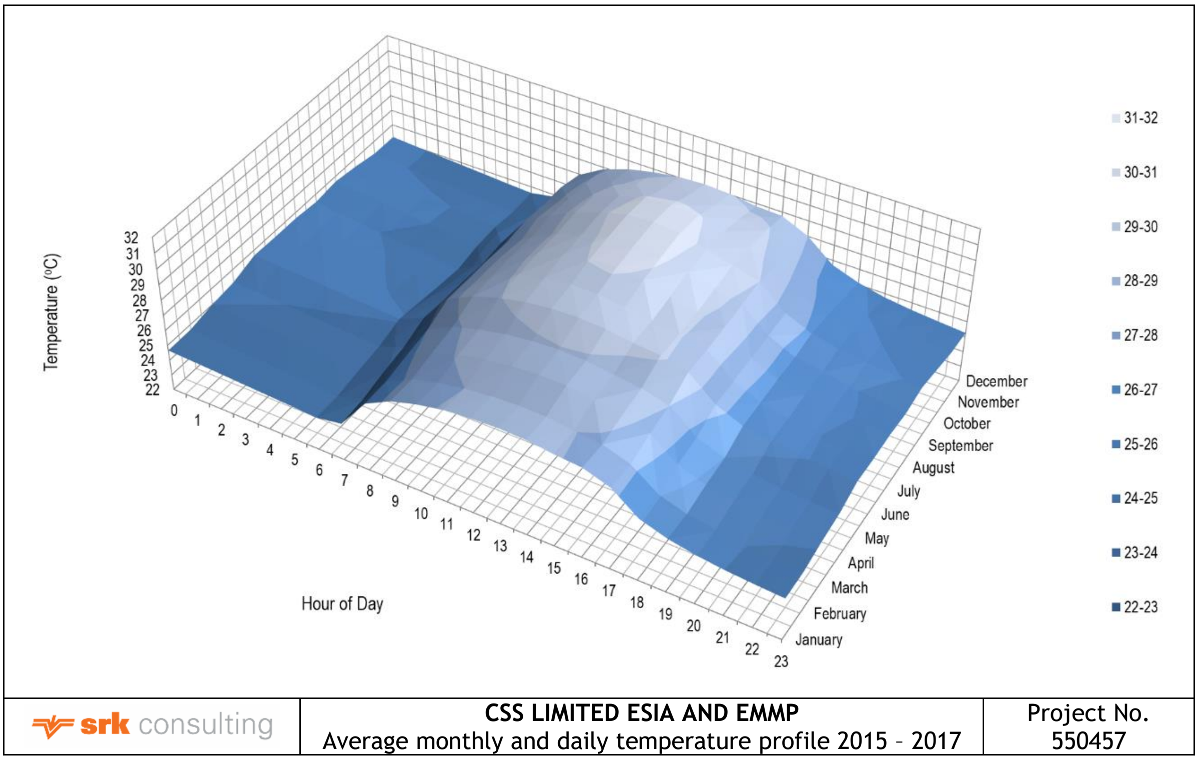


Figure 4-7: Average monthly and daily temperature profile 2015 – 2017, Saramacca

Source: MM5 Data January 2015 – December 2017 (Airshed Planning Professionals, 2018)

The atmospheric boundary layer is normally unstable during the day as a result of the turbulence due to the sun's heating effect on the earth's surface. The depth of this mixing layer depends predominantly on the extent of solar radiation, growing gradually from sunrise to reach a maximum at about 5-6 hours after sunrise. During night-time conditions a stable layer with limited vertical mixing exists. During windy and/or cloudy conditions the atmosphere is normally neutral (Airshed Planning Professionals, 2012).

4.1.2.4 Wind

Suriname does not experience hurricanes like the rest of the Caribbean region, but powerful winds do blow during strong storms. The dominant wind direction is easterly and north-easterly, with little variation between day and night-time wind directions.

Winds speeds are generally lower during the night, with a high frequency of 3 - 4 m/s winds evident at night, with no winds in excess of 5 m/s. During the day, wind speeds tend to be higher and occasionally exceed 6 m/s. Calmer conditions are more frequent at night than during the day (see Figure 4-8). The period average wind speed was calculated as 3.2 m/s (Airshed Planning Professionals, 2018).

Seasonal wind patterns show an increase in the occurrence of high wind speeds from March – May, and to a lesser extent from December – February. From June – August, calm conditions and south-easterly winds increase.

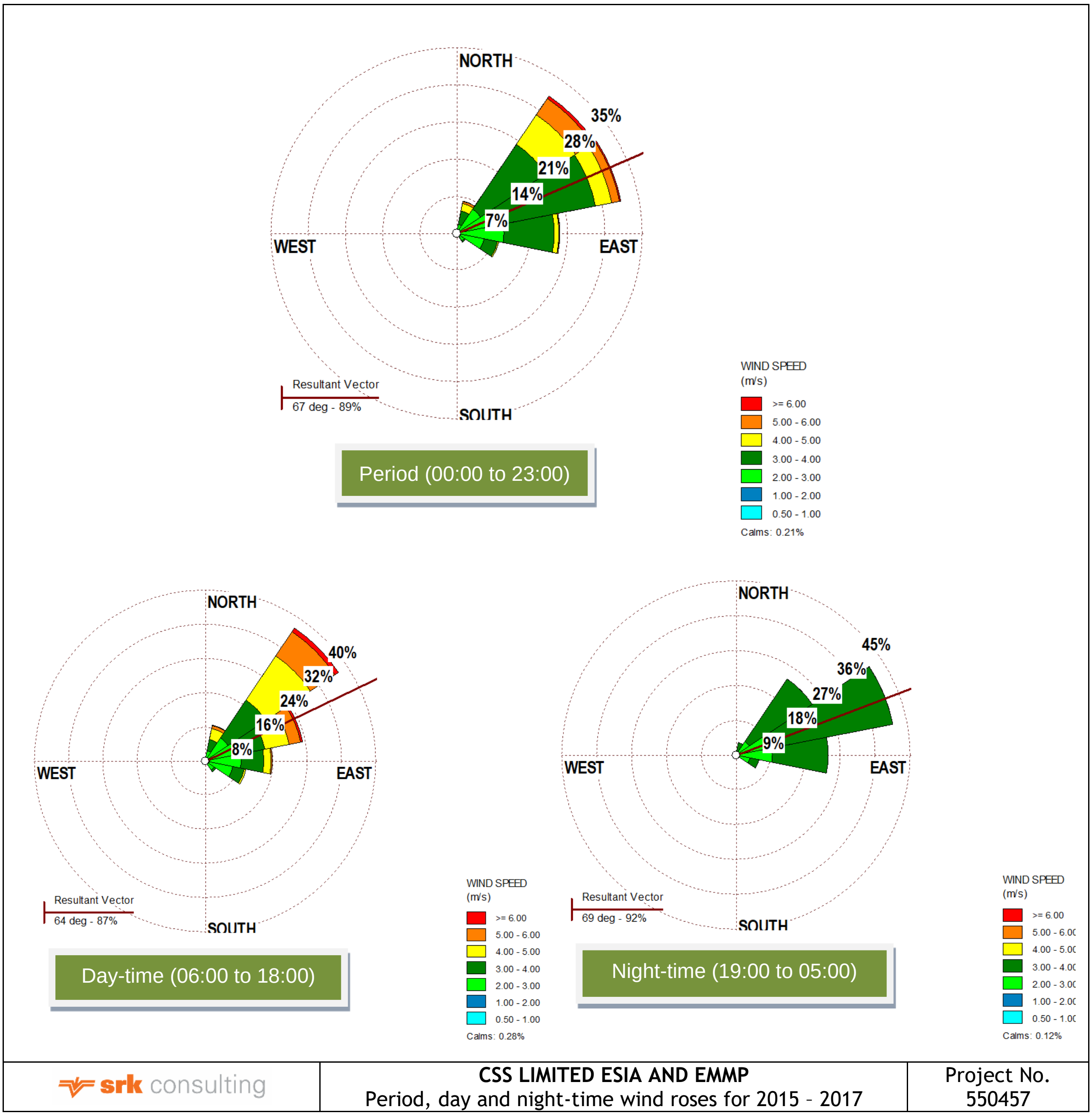


Figure 4-8: Period, day and night-time wind roses for 2015– 2017, Paramaribo

Source: MM5 Data January 2015 – December 2017 (Airshed Planning Professionals, 2018)

Note: Wind roses comprise 16 spokes that represent the directions from which winds blow during a specific period. The colours in the wind roses reflect the different wind speeds. The dotted circles provide information regarding the frequency of occurrence of wind speed and direction. The frequency with which calms occur, i.e. periods during which the wind speed is below 0.5 m/s, is indicated above or next to each wind rose.

4.1.3 Air Quality

There are few significant sources of air pollution in the area. The TA-58 plant, located ~7 km north of Gangaram Pandayweg, releases some atmospheric emissions and is the main (continuous) contributor to localised air pollution. Backup generators for the Sarah Maria facility are also located at TA-58 and emit exhaust fumes when operational. Passive air quality sampling was conducted in August 2018 in the vicinity of TA-58, ~5 km north of the proposed PMP. All measured pollutants were low, and well below their respective extrapolated seven-day screening limits, indicating that baseline air quality is good (Airshed Planning Professionals, 2018).

Staatsolie proposes to construct a new power plant ~150 m south-east of the TA-58 plant. Based on modelling, emissions, and ambient pollution levels, are expected to be relatively low and localised (Airshed Planning Professionals, 2018).

Other sources of air pollution include vehicles entraining dust on unpaved roads and farming activities generating mainly airborne particulates during harvesting, burning of surplus biomass and spraying of fields with pesticides. Public roads, notably Gangaram Pandayweg, and the nearest rice farms are located ~2 km to the south from the proposed PMP and not expected to significantly impact air quality at the project site.

Traffic volume in the Tambaredjo Oilfield is very low, and stringent speed limits apply. Staatsolie vehicles are thus not expected to generate significant dust in the concession area.

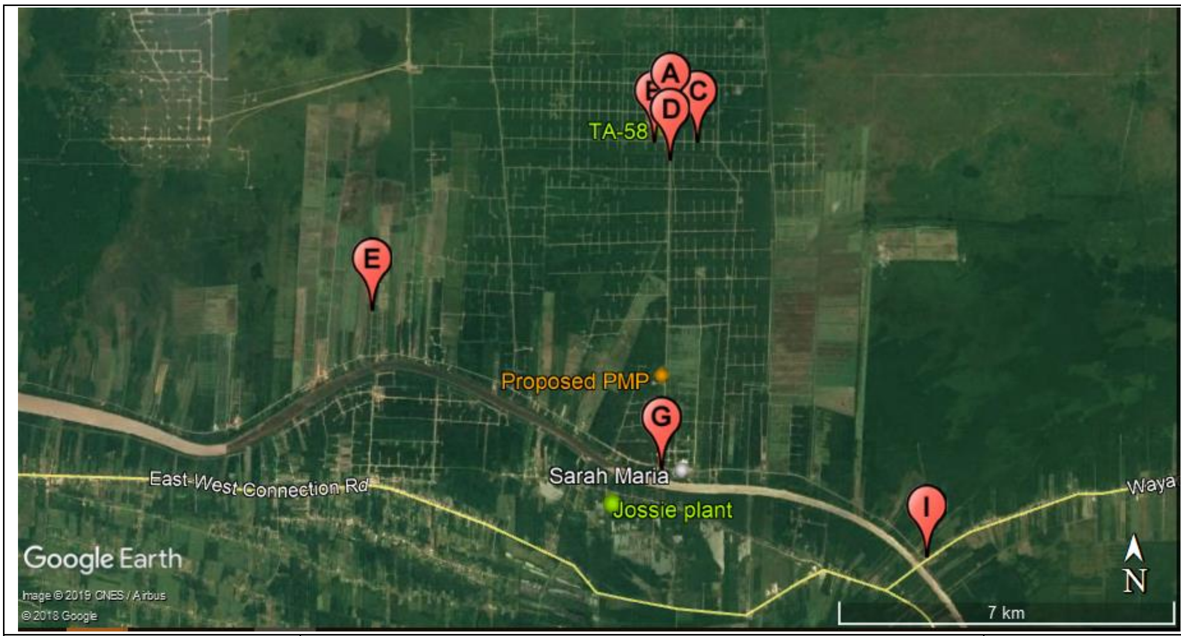
Waste is burned twice per week at Staatsolie's waste incineration site, which will affect air quality. However, Staatsolie is preparing a new Waste Management Facility, which will include an incinerator and a landfill.

4.1.4 Noise

Key sources of environmental noise include the TA-58 plant, which generates a low frequency hum, local fauna, such as birds, insects, primates and dogs, and vehicle traffic within the Sarah Maria facility and on public roads adjacent to the concession.

Noise measurements taken in August 2018 at several locations in and outside of the Tambaredjo Oilfield (see Figure 4-9) indicated that baseline noise levels are typical of rural areas, with daytime sound pressure levels ranging from 46 dBA at location B (in the oilfield west of TA-58, where there is little traffic) to 66 dBA at Location I (outside of the oilfield at the intersection of Wayamboweg and Gangaram Pandayweg, which is characterised by significant light and heavy vehicle traffic) (SRK Consulting, 2019a).

Sampled daytime Equivalent Sound Pressure Levels (L_{Aeq}) (Figure 4-10) were highest at sampling locations D, G and I where traffic volumes are highest; however, in the absence of the vehicle traffic, environmental noise at these locations is quite low.



srk consulting	CSS LIMITED ESIA AND EMMP Location of August 2018 ambient noise measurement points	Project No. 550457

Figure 4-9: Location of August 2018 ambient noise measurement points

Source: SRK Consulting (2019a)

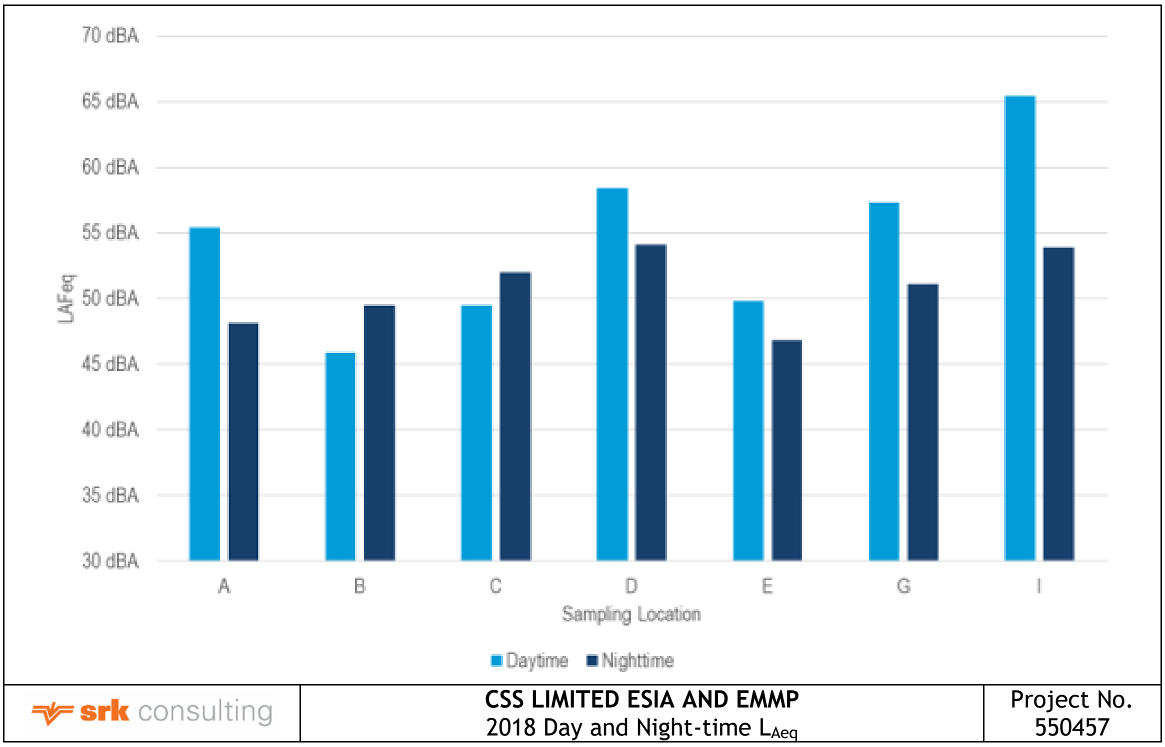


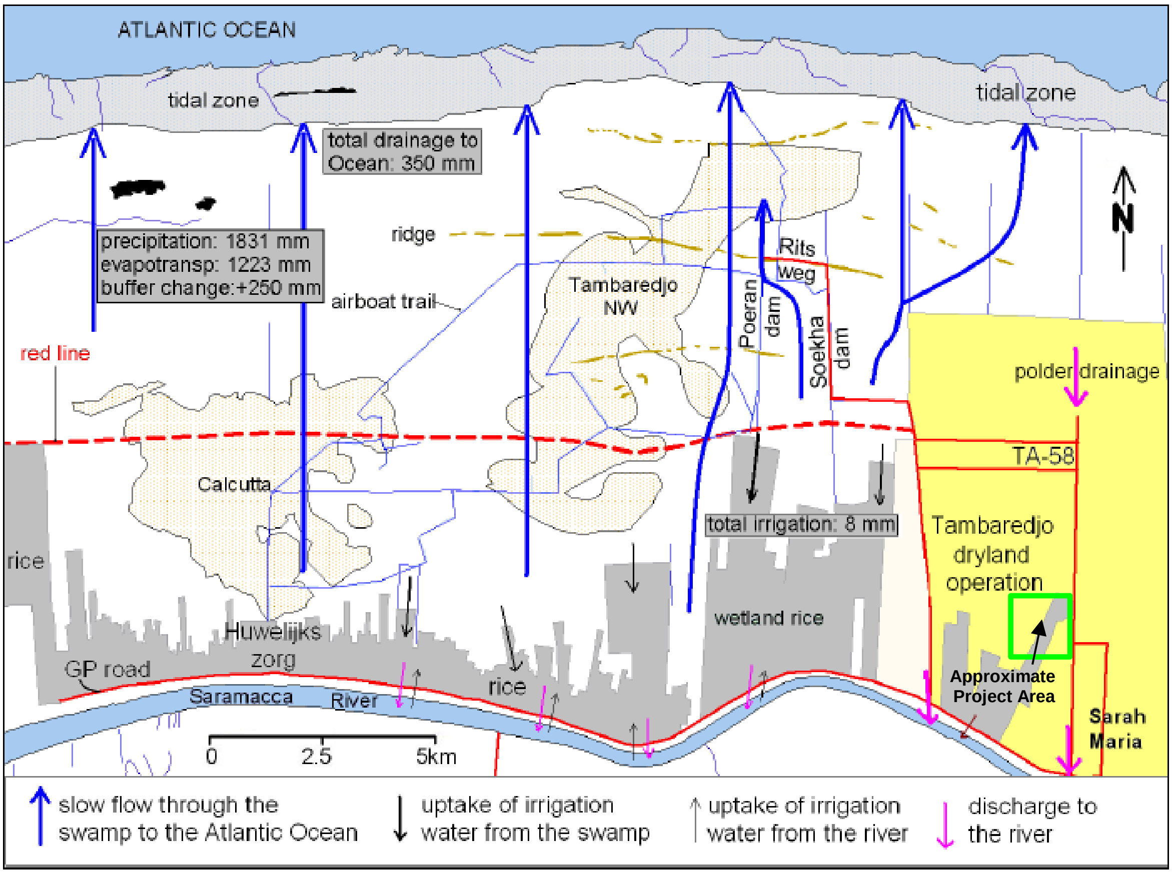
Figure 4-10: Sampled 2018 day and night-time Equivalent Sound Pressure Levels L_{Aeq} levels

Source: SRK Consulting (2019a)

4.1.5 Hydrology

The Saramacca District has approximately 3 320 km^2 of coastal wetlands, of which 370 km^2 support mangrove forest. Most wetlands consist of swamplands with poorly to very poorly drained soils, which are inundated either permanently or at least during the greater part of the year. Areas along the coast or tidal river sections are inundated twice a day during high tide. Water quality in the Coastal Plain varies from saline to brackish near the coast to freshwater further south.

Historically, the northern part of the swamp drained north towards the sea, while the southern part drained south towards the Saramacca River. The approximate catchment boundary is indicated by the red line in Figure 4-11. The area draining northwards is considered to support important ecosystem goods and services that are particularly sensitive to the hydrology and water quality, and includes the Coppename Monding Nature Reserve (see Figure 4-12). The CSS area lies in the south-draining area of the Coastal Plain.



srk consulting | CSS LIMITED ESIA AND EMMP
Surface water drainage patterns in the project region | Project No. 550457

Figure 4-11: Surface water drainage patterns in the project region

Source: Noordam (2010)

Volumes refer to the study period from 18 November 2008 to 23 July 2009.

The natural hydrological conditions of the area draining southwards have been affected over time by dryland cropping, road construction, development of rice polders, abstraction and discharge of irrigation water and the development of the Tambaredjo oil polder. As a result, water levels have changed, flow of swamp water to the Saramacca River has been obstructed in certain areas, and drainage patterns have changed as indicated in Figure 4-11, i.e. more water drains northwards than previously, while the entire Tambaredjo Polder drains southwards.

The Tambaredjo Oilfield (outlined in white in Figure 4-12) was developed in a former wetland area located between the Buru and Wayambo Swamps. The polder is characterised by south-north aligned dams and canals that obstruct the natural water flow in the swamp. The entire polder area now drains via two main canals towards the Saramacca River.

CSS project components are located on the Tambaredjo Polder, from which excess water is discharged into the Saramacca River by a number of large north-south aligned canals. In addition to these north-south aligned canals there are also a number of east-west aligned canals that connect the north-south aligned canals. The north-south aligned canals drain into the Saramacca River through culverts. The project site drains through the Kisoensingh-west Canal that runs along the main access road of the polder.

Potential sources of surface water pollution include the TA-58 plant, the Sarah Maria facility, the waste incineration area and the landfarm in the Tambaredjo Polder (see Figure 3-3). Staatsolie implements management measures to prevent pollution.

srk consulting	CSS LIMITED ESIA AND EMMP Location of Tambaredjo oil polder relative to other features	Project No. 550457

Figure 4-12: Location of Tambaredjo oil polder relative to other hydrological features

4.1.5.1 Tambaredjo Polder Water Quality

Noordam (2018a) reports that historic water quality data (1999) for the Tambaredjo polder recorded elevated chloride (salinity) >250 ppm chloride at the outlet of the TA-58 oil-water separator, where effluent is released into the canal. It is, however, expected that salinity will be considerably reduced downstream at the outfall into the Saramacca River due to dilution of the effluent by stormwater.

Very low pH was measured near TA-58, but in the remainder of the locations pH is much higher. Overall pH during the dry season is higher than during the rainy season. Dissolved oxygen (DO) levels vary from low to medium, with overall higher DO in the dry season.

Very high turbidity was measured at one location, but typically varies between 35 and 66 Nephelometric Turbidity Unit (NTU), consistent with data for a 2016-17 sampling campaign (Staatsolie), for which 90% of the results are between 41 and 114 FTU. These turbidity values correspond with Total Suspended Solids (TSS) values between 31 and 82 mg/L (Staatsolie data 2015-2016, sampling Kisoensingh-west Canal).

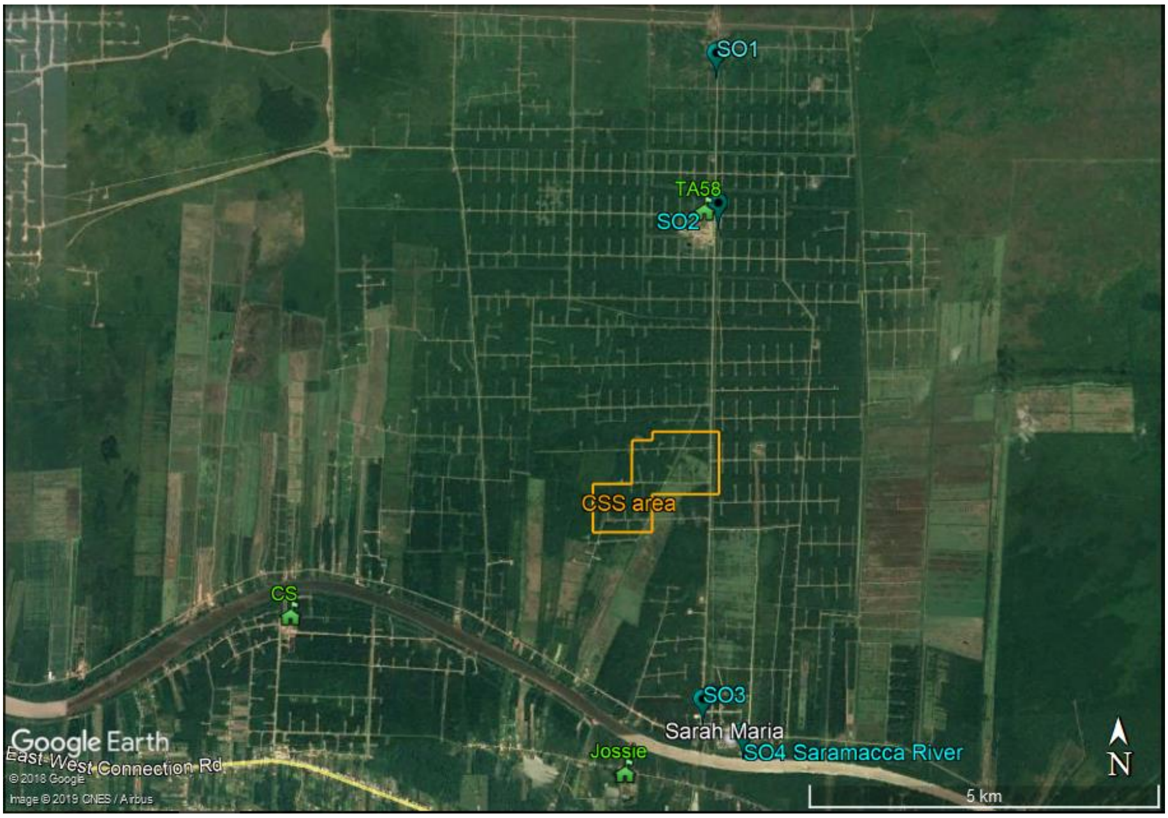
Nitrate and ammonia levels are very low, which is normal for unpolluted natural waters. The phosphate levels are very low to medium. The measured nutrient levels do not point to organic pollution.

In July and October 2018, surface water samples were taken in the Kisoensingh-west Canal at locations SO1-SO3 (and the Saramacca River at location SO4) (see Figure 4-13), during the rainy and dry season, respectively, to determine the baseline water characteristics and concentration of key pollutants. Aside from higher pH, all other parameters are more or less within the same range as in 1999.

A number of metals are found in the water, of which barium, arsenic and zinc are encountered in at least 50% of the samples. Arsenic exceeds the guideline value for consumption of organisms by humans, but it is below the value for aquatic life. The elevated barium levels could be related to spills of barite or spent drilling mud**.** The SO3 dry season sample exceeds the United States Environmental Protection Agency (USEPA) guideline for consumption of organisms.

Furthermore, there are a number of chemical compounds, of which toluene and diazinon are found in all rainy season samples and phenols in both rainy and dry season samples. These origins of these compounds are not clear, and findings could possibly be related to a release during processing of crude oil (toluene), a spill or leak of certain chemicals like wood preservatives (phenols) and the use of insecticides (diazinon). However, the diazinon levels in the canal can also be considered to represent natural background levels, as they are in the same range as found in the rivers.

Of interest is the presence of PCB's in sample SO2 during the rainy season sampling. The sample is taken near TA-58 and most likely points to pollution from that source. The level is well above the USEPA guideline level for human consumption of 0.000064 µg/L and close to or slightly above the guideline level for aquatic life of 0.014 µg/L. Minor diesel and gasoline spills can be observed in samples SO1 (rainy season) and SO2 (dry season).



srk consulting	CSS LIMITED ESIA AND EMMP Location of 2018 surface water sampling points	Project No. 550457

Figure 4-13: Location of 2018 surface water sampling points

Source: SRK Consulting (2019a)

4.1.5.2 Saramacca River Water Quality

A 2018 study (Noordam, 2018a) found that pH is slightly acidic, while salinity is very low. There is, however, a slight increase in pH and EC for the Long Dry Season, but there is no indication of salt intrusion from the ocean, which would be indicated by EC values > 1 mS. Dissolved Oxygen is moderate with values of 5.5 mg/L.

Total Suspended Solids (TSS) is higher than the TSS in the Kisoensingh-west canal (except for sample SO2), probably under influence of the tidal movement. Phosphorus is lower than in the canal, because the canal water has more exchange with soil and organic debris.

Rainy and dry season samples from the Saramacca River (SO4) adjacent to the Tambaredjo Polder, showed elevated levels for barium, zinc and diazinon in both seasons. Similar levels of barium and diazinon have also been recorded in the Suriname and Coppename Rivers (NEC & Ilaco, 2016), with 6-12 µg/L barium and 0.3-0.7 µg/L diazinon. It should be noted that the Coppename River is considered an unpolluted river. The elevated concentrations of these compounds are thought to be the result of natural processes and therefore represent natural background levels in these rivers.

Elevated levels for toluene and Total Petroleum Hydrocarbon were measured in the rainy season sample. These are likely the result of an oil spill or leakage.

Apart from the latter, the Saramacca River water can be characterised as unpolluted.

4.1.6 Geohydrology

The flat marine plain of the project area is primarily underlain by clays with elongated East-West running beach barrier deposits “ritsen” as the main morphological features. The plain is an assembly of clay plates (“schollen”) dissected by numerous swamps and creeks filled with Holocene clay and peat. The vegetation originally comprised dry-land forest on the beach barriers and better drained parts of the clayey plain, and by swamp forest on the low-lying parts (Sabajo, 2016).

In the Tambaredjo Oilfield, the swamp has been drained and infilled to facilitate “dryland” oil exploitation (in contrast to the more recently developed Tambaredjo North-West and Calcutta North fields, where “wetland” drilling is practised).

The Coastal Plain of Suriname is underlain by three major aquifers within the Corantijn Group (SRK Consulting, 2013) and (US Army Corps of Engineers, 2001) (see also Figure 4-1):

- The A-sand aquifer (in the Burnside Formation) contains freshwater in many locations. It is found at an approximate depth of 150 m to 180 m in the coastal area. The aquifer thickness varies from 10-60 m. The A-Sand aquifer is not directly recharged by rainwater, and it is suspected that upward leakage of groundwater from the older, underlying formation is likely;
- The Coesewijne aquifer contains freshwater in many locations of the coastal plain. It is found at a depth of 70 m to 110 m in the coastal area. The Coesewijne sands are in hydraulic contact with the overlying Zanderij Formation, with groundwater flow in the southern Young Coastal Plain (Helena Christina road – Lelydorp) and diffusion in the northern Young Coastal Plain; and
- The Zanderij aquifer contains mostly brackish water in the Young Coastal Plain. The Formation crops out in the Savanna Belt and dips to the north. At Paramaribo it is found at depths of about 30-50 m. The Zanderij Formation is in hydraulic contact with the sandy deposits of the Coropina Formation (Lelydorp Deposits) south of Lelydorp. In the study area the aquifer does not have hydraulic contact with surface deposits due to the heavy clay in overlying layers.

Saline water zones underlie the freshwater zones in the coastal area, and may intrude into freshwater when pumped.

The oil-bearing sand is found below these aquifers (in the T-unit in Figure 4-1) and forms the basal unit of the Saramacca Formation, which was deposited on top of an erosional surface that marks the transition from the Cretaceous to the Tertiary (Palaeocene).

Rainfall in clayey terrain is mainly discharged via overland flow and interflow to creeks, swamps and man-made drainage channels. Phreatic groundwater flow systems are poorly developed because of the low permeability and flat topography.

Groundwater from aquifers north of the Saramacca River is naturally brackish and/or has an objectionable oily taste, and potable (drinking) water is not abstracted in the project area (Noordam, 2018a). Drinking water is abstracted from the Coesewijne aquifer south of the Saramacca River, e.g. in Tijgerkreek, Tambaredjo and Groningen (SRK Consulting, 2013). Although the groundwater underlying the site is generally brackish and not potable nor abstracted for domestic use, fresh to slightly saline water is encountered at depth (e.g. A-sand aquifer) (Sabajo, 2016).

4.1.7 Flora

This section also incorporates observations from fieldwork undertaken in October 2018 to groundtruth secondary data (Noordam, 2018b).

The coastal region is characterised by vegetation succession from saline mangroves to freshwater habitats. Along the coast, young Black Mangrove (*Avicennia germinans*) develops where mudflats silt up above mean sea level. With the prevailing net coastal accretion, a closed-to-open Black Mangrove belt has developed. South of the Black Mangrove belt, herbaceous brackish water swamps (with or without scattered Black Mangrove trees) have developed on firmer soils on which a peat layer develops. Further inland, grass swamps become fresh and richer in species. Gradually low-to-high species-rich swamp wood may develop.

Original vegetation in the project area is expected to include Herbaceous brackish water swamp, dominated by Cat tails (*Typha dommingensis*) with or without scattered Black Mangrove trees, High swampwood, dominated by Swamp cork wood (*Pterocarpus officinalis*) and White cedar *(Tababuia insignis),* and Swamp scrub and bushes characterized by Swamp Plumb (*Chrysobalanus icaco*) and Swamp Soursop (*Annona glabra*).

The Tambaredjo Polder area has been substantially transformed by human activities such as dryland cropping, road construction, development of rice polders, abstraction and discharge of irrigation water and the development of the Tambaredjo oil polder. Natural swamp and marsh habitat in most of the study area was cleared and drained / infilled to create polders for agriculture.

Secondary marsh forest, dominated by Mira Udu (*Triplaris surinamensis*), has developed on long-abandoned land, where exotic formerly cultivated trees, such as Almond (*Terminalia catappa*) Coconut palm (*Cocos nucifera*), Guava (*Psidium gujave*) and Royal Palm (*Roystonia regia*), are also encountered, while Pina palm (*Euterpe oleracea*) is also commonly found. In addition, six other tree species were recorded in the marsh forest. Much of the forest edges is covered by Patatatetei (*Ipomoea tiliacea*). Ditches are present along all forest edges, and Mokomoko (*Montrichardia arborescens*) has developed in and along these ditches. On the excavated material, locally Busipapaya (*Cecropia obtusa*) has developed.

The secondary marsh forest has low plant diversity compared to undisturbed similar habitats. Secondary vegetation on land abandoned less than 10 years ago comprises shrubs, bushes and small trees. Temporary fallow land has low vegetation with grasses, rushes and herbs with very low biodiversity. The invasive[8] water hyacinth (*Eichhornia crassipes*) is also present in the area.

The observed low secondary marsh forest contains commonly encountered species, is still in its early stage of development and is relatively low in species diversity. No vulnerable, rare or endangered plant species are present in the study area. The study area is not deemed sensitive with regards to ecosystems and floral biodiversity.

[8] Although native to the Amazon Basin, including Suriname, the plant is invasive in the area.

4.1.8 Fauna

This section also incorporates observations from fieldwork undertaken in October 2018 to groundtruth secondary data (Noordam, 2018b).

The mudflats and the mangrove zone between the Coppename and the Suriname Rivers are important feeding and nesting areas for residential coastal **birds**, and important feeding and wintering grounds for migratory birds. Breeding colonies of Scarlet ibises and heron species are present in the young Black Mangrove forests along the Saramacca coast from March/April to August/September. The Saramacca coast hosts 13 bird species of international importance. It is expected that the bird species found in the study area also occur in similar (near-) coastal habitats throughout Suriname.

A 1999 survey recorded 41 bird species, noting that the great majority of the bird species observed in the Tambaredjo polder is found in neighbouring swamp habitats, including the coastal strip, while all species are also present elsewhere in the Young Coastal Plain. According to the IUCN Red List, all bird species in the estuarine zone are of Least Concern (IUCN 2018). However, two bird species of the estuarine zone are listed on CITES Appendix I, and therefore should be considered endangered species on a global scale: Jabiru (*Jabiru mycteria)* and Peregrine Falcon (*Falco peregrinus).*

Twenty-four bird species are listed on CITES Appendices II and III, and therefore should be considered vulnerable species on a global scale:

- Scarlet Ibis (*Eudocimus ruber*);
- American Flamingo (*Phoenicopterus ruber*);
- Osprey (*Pandion haliaetus*);
- All parrots (2 species);
- All hummingbirds (4 species in the estuarine zone);
- All hawks, except for the Peregrine Falcon = CITES Appendix I (9 species);
- All New World vultures (3 species); and
- All owls (3 species).

Some of above species may be present in the Tambaredjo polder periodically or fly over the polder. Apart from the breeding colonies and migrant birds, seasonal patterns in bird distribution are not apparent.

A 1998 study of **fish** communities in the Tambaredjo Oilfield (near the TA-58 plant) identified various Characidae (particularly *Ctenobrycon spilurus*) and Cichlidae species as well as Guyana leaffish *(Polycentrus schomburgkii)* and Guppy *(Poecilia reticulate)*. Fish diversity in the Tambaredjo Oilfield was higher compared to undisturbed *Typha* swamp and high swampwood habitas in adjacent areas. This may indicate that river fish (Warawara [*Hypostomus* sp.]) enter the Tambaredjo oil polder via canals from the Saramacca River and that certain species (e.g. Swamp eel [*Synbranchus marmoratus*], Ston-walapa [*Erythrinus erythrinus*] and Datrafisi [*Crenicichla saxatilis*]) have low abundance or are difficult to catch in their natural swamp(wood) habitat.

Herpetofauna diversity in the area is expected to be limited. Reptiles occurring in the study area will include Iguana (*Iguana-iguana*), Spectacled Caiman (*Caiman crocodilus*) and Anaconda (*Eunectes murinus*); these are common in Suriname but diminishing in populated areas. No unique, *Rare, Endangered, Vulnerable* or biogeographically important species were previously found in the Buru Swamp area. The Saramacca coast north of the project area does not provide sand and shell beaches for sea turtle nesting. Most of the snakes and amphibians recorded in the Tambaredjo polder are also known to occur in the neighboring swamp habitats.

A number of **mammals**, including Capybara (*Hydrochoerus hydrochaeris)* and Howler monkey (*Alouatta)*, are known to occur in the region[9]. None of the mammals occurring in the coastal area and listed on the IUCN Red List are confined to the coastal area, and none of them are listed as *Vulnerable* or *Endangered*. All mammals recorded in the Tambaredjo polder are also known to occur in the neighbouring swamp habitats.

The Jaguar (*Panthera onca*), Giant Anteater (*Myrmecophaga tridactyla*) and the Neotropical Otter (*Lontra longicaudis enudris*) are included on the IUCN Red list and CITES appendices. The Brown Capuchin (*Cebus apella*) and the Spectacled Caiman (*Caiman crocodilus*) are included in Appendix II of CITES, indicating a globally vulnerable status. All other species expected to occur on the site and listed in Annexure B, are of Least Concern (IUCN Red list) and not included in the CITES Appendices

Overall, the secondary marsh forest found at the project site is expected to have relatively low fauna diversity compared to undisturbed similar habitats, due to the fragmentation of higher secondary vegetation (which is more likely to harbour animals) and human activity in the area. The study area is not deemed sensitive with regards to ecosystems and fauna.

4.1.9 Conservation Areas

The Coppename Monding Nature Reserve was first established as a bird sanctuary in 1953 along the coast east of the Coppename River mouth, and declared a nature reserve in 1966 for the purpose of research, nature education and tourism. It is also listed as a Wetland of International Importance (RAMSAR site).

The southern boundary of the eastern-most portion of the Coppename Monding Nature Reserve is located ~2.5 km north of the Tambaredjo polder and ~10 km north of the proposed CSS project area (see Figure 4-12).

4.2 Socio-Economic Environment

This section is largely based on Social Solutions (2018). The project is located in the 872 km^2 Wayambo resort, which has the smallest population of the resorts of Saramacca district, with 1 186 residents, less than 10% of the district population of 15 696.

The only inhabited areas on the right (northern) bank of the Lower Saramacca River are located along (parts of) the Gangaram Pandayweg, which branches off Wayambo Road (that leads towards Paramaribo) and extends for 30 km towards the west along the right bank of the Lower Saramacca River. Roughly 345 persons (less than 100 families) live permanently along the Gangaram Pandayweg, in four settlements: Sarah Maria (near the existing Staatsolie facility), La Prevoyance (10-12 residences and local government institutions), Bombay (15-16 residences) and Huwelijkszorg (~30 residences).

Residential areas located nearest to the project area are shown in Figure 4-14. Eight residential clusters comprising three to four households each and one allotment project comprising four houses are located in the 8 km section from the intersection with Wayambo Road that leads past the Sarah Maria facility.

[9] See Annexure B of Noordam (2018b) for a more detailed list.

Most families residing along the Gangaram Pandayweg practise horticulture (domestic cultivation). Crops include tomatoes, eggplant, beans and oerdi, the latter for commercial purposes. Farming activities include animal husbandry (cows and chickens) and cultivation of plantains and rice. Most farmland in the area lies fallow or has been abandoned. One sawmill operates along Gangaram Pandayweg; logs are transported by river and processed planks are transported to Paramaribo by pick-up truck on the Gangaram Pandayweg every two weeks. Approximately 20-25 persons living along Gangaram Pandayweg are currently employed by Staatsolie.

Three school buses transport pupils to and from school on the Gangaram Pandayweg. Other traffic on the road is used by commuting residents, Staatsolie personnel driving to and from the Sarah Maria facility, Staatsolie contractors/subcontractors driving to and from Staatsolie facilities and non-residents visiting their weekend/holiday homes and/or outsiders visiting the fishing spots.

Field observations noted frequent truck movements (sand transport). Traffic intensity peaks between 07h00 – 09h00 and 12h00 - 15h00, attributed to commuter traffic to and from the Sarah Maria facility.

Fishing spots are located on the private terrain of land owners living along the Gangaram Pandayweg. During fishing season (usually the dry season), fishing spots or 'fish holes' (of which five are well known) are opened to the public. Staatsolie representatives reported that people illegally use Staatsolie's concession area on the Tambaredjo polder for fishing and hunting.

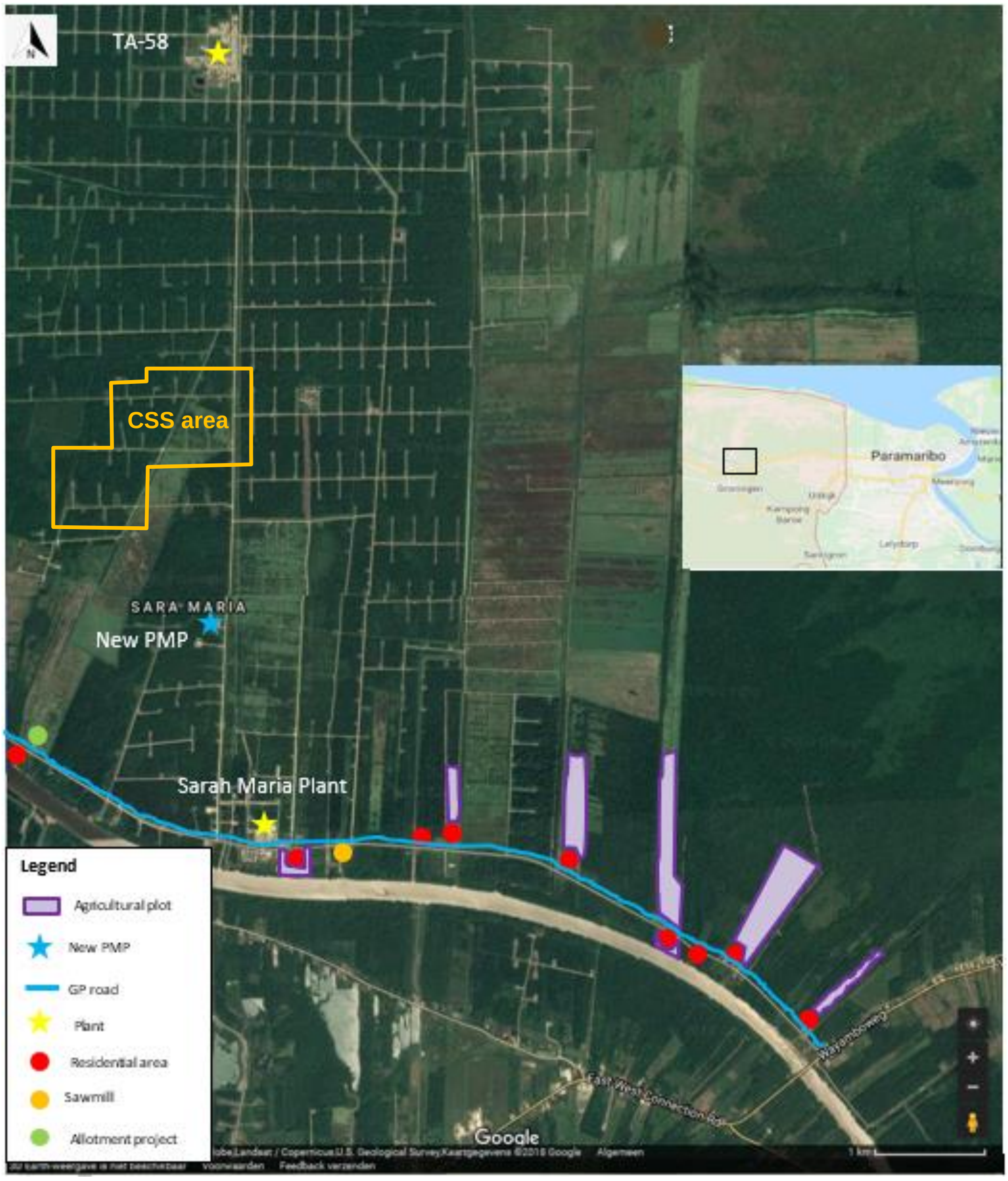
Some households have access to tap water, but most depend on rain water for drinking water. Water pipelines have been installed along Gangaram Pandayweg from the intersection with Wayambo (km 0) to Km 3 and from Km 7 to Km 11.5, but as of July 2019 none of the households had been connected yet. All household along Gangaram Pandayweg have access to electricity.

While the district of Saramacca accommodates a multicultural society with different ethnic groups, the Hindustani and Javanese ethnic groups dominate the cultural landscape in this part of the country. Population data from 2014 show that 53.3% of the total district population is of Hindustani ethnic descent, while other ethnic groups included Javanese and Creole people (people of African descent).

The Gangaram Pandayweg and its surrounding area is not a traditional residential area of Indigenous Peoples and Maroons, and these tribal communities are not present in the vicinity of the Tambaredjo Oilfield.

The main religion practised in Saramacca district is Hinduism (44.6%). Other religions practised in this district include Christianity (23.5%), Islam (18.8%), and other religions (3%).

Three archaeological sites – all settlements with graves - are located in the area, on the left bank of the Saramacca River: they will not be affected by the project. Two Hindu temples located along the Gangaram Pandayweg, one at Bombay and another one at Huwelijkszorg.



srk consulting	CSS LIMITED ESIA AND EMMP Socio-economic features in the study area	Project No. 550457

Figure 4-14: Socio-economic features in the study area

Source: adapted from Social Solutions (2018)

5 Stakeholder Engagement

Stakeholder engagement forms a key component of the ESIA process. The objectives of stakeholder engagement are outlined in this section, followed by a summary of the approach to be followed, in compliance with best practice and NIMOS guidelines.

5.1 Objectives and Approach to Stakeholder Engagement

The overall aim of public consultation is to ensure that all stakeholders have adequate opportunity to provide input into the process and raise their comments and concerns. More specifically, the objectives of public consultation are to:

- Identify stakeholders and inform them about the proposed development and Limited ESIA process;
- Provide stakeholders with the opportunity to participate effectively in the process and identify relevant issues and concerns associated with the proposed project; and
- Provide stakeholders with the opportunity to review documentation and assist in identifying mitigation and management options to address potential environmental issues.

5.2 Stakeholder Engagement Activities

The activities undertaken and planned during the Limited ESIA process are outlined in Table 5-1.

Table 5-1: Stakeholder engagement activities

Task	Objectives	Dates
Identify and compile a stakeholder database	To determine initial key stakeholders	October 2019
Release Limited ESIA Report and EMMP, including a Non-Technical Summary, and place on SRK website and at the offices of the DC of Saramacca and NIMOS	To provide stakeholders with access to the ESIA Report.	13 November 2019
Advertise public stakeholder meeting and notification to key stakeholders	To notify stakeholders of the opportunities to engage the ESIA and Staatsolie project teams and comment on the project.	13 November 2019
Public comment period	To provide stakeholders with the opportunity to engage the ESIA and Staatsolie project teams and comment on the project.	14 November – 13 December 2019
Public meeting	To present the findings of the Limited ESIA Report to stakeholders and provide an opportunity for questions and discussion.	28 November 2019
Compile Issues and Responses Summary and finalise Limited ESIA Report	To record all issues and concerns raised and collate these comments in the final report which provides NIMOS with information to compile their advice.	December 2019 / January 2020

The key activities are described in more detail below.

5.2.1 Identification of Key Stakeholders

Relevant district and national authorities, organisations and representatives as well as surrounding landowners were identified by Staatsolie and SRK and registered as stakeholders on the initial project database. These stakeholders have been notified of the Limited ESIA and the release of this report for comment.

In accordance with the best practice and NIMOS guidelines, all other persons can request in writing to be placed on the register, submit written comments or attend meetings in order to be registered as stakeholders and included in future communication regarding the project. All persons who do so will be registered as stakeholders, and advertisements advise that stakeholders register as such.

A list of registered stakeholders is provided in Table 5-2.

Table 5-2: Stakeholder database

Name	Organization
van Klaveren, W	Kabinet van de President Coördinatie Milieu
Sabajo, V.	Kabinet van de President Coördinatie Milieu
Nelom, C	NIMOS
Sewnath, M	NIMOS
Tjon Akon, Q.	NIMOS
Woei, L	Ministerie van Ruimtelike Ordening, Grond-en Bosbeheer
Abeleven, D	Ministerie van Natuurlijke Hulpbronnen
Soman, S	Ministerie van Openbare Werken, Transport en Communicatie
Tewarie, A	Ministerie van Openbare Werken, Transport en Communicatie
Doebay, L	DC Saramacca
Asmowidjojo, Schubert	DC Saramacca
Meghoe-Bhairo, L.	DC Commissariaat Saramacca
Oedai, R.	BO Wayambo
Bakker, J.	RR Wayambo
Esajas, H	LBB
Oosterling, M.	SWM
Valdink, R	SWM
Linger, A	SWM
Lingers-Ligeon, C.	SWM
Kromotani, R	SWM
Abboud, T.	Landowner

5.2.2 Notification of the Limited ESIA Process and ESIA Report for Public Comment

Newspaper advertisements announcing the availability of the ESIA Report for stakeholder review and inviting stakeholders to register on the project database will be placed in newspapers.

Hard copies of the full report will be available for public viewing at the following venues:

- NIMOS; and
- Office of the Saramacca District Commissioner at Groningen.

An electronic version of the ESIA Report can also be accessed on SRK's website **www.srk.co.za** (via the 'Library' and 'Public Documents' links).

Stakeholders will be provided with a 30-day comment period.

5.2.3 Public Meeting

A public meeting is a public forum at which the findings of the ESIA are presented for discussion. A public meeting will be held during the comment period to provide stakeholders with the opportunity to ask questions and discuss any concerns related to the project.

The public meeting will be held on:

- Date: 28 November 2019
- Venue: Staatsolie Flora Office

Additional meetings may be scheduled with key stakeholders if required.

6 Environmental Impact Assessment

6.1 Introduction

6.1.1 Environmental Impacts Identified

Based on the professional experience of the ESIA team, legal requirements (Section 2), the nature of the proposed activity (Section 3) and the nature of the receiving environment (Section 4), the key environmental issues – potential negative impacts and potential benefits – were identified and are assessed in Section 6.2.

6.1.2 Specialist Studies Undertaken

Groundwater and geochemical specialist input was provided to investigate the key potential direct, indirect and cumulative impacts (negative and positive) of the project on groundwater.

The impact assessment is further based on a number of specialist studies conducted for the proposed Saramacca Power Plant (SRK Consulting, 2019a) and the Polymer Flooding project (SRK Consulting, 2019b) in the Tambaredjo Oilfield, which provide SRK with a detailed understanding of air quality, noise, surface water, groundwater, terrestrial ecology and social aspects.

6.1.3 Alternatives Assessed in the ESIA

During the Prefeasibility phase of most projects various development alternatives are investigated. Depending on the specific project circumstances the following alternatives may be considered:

- Site Alternatives;
- Design Alternatives;
- Process Alternatives; and
- The No-Go Alternative.

In the case of the CSS project, alternatives were considered during the Concept and Feasibility phases of the project. Only one feasible alternative was identified for each project aspects (refer to Section 3.4). As such, only those aspects (in addition to the No-Go alternative) will be assessed in Sections 6.2:

- EOR technique: CSS;
- Water supply: surface water (Saramacca River); and
- Power supply: power generator.

6.1.3.1 No-Go Alternative

The No-Go alternative entails no change to the status *quo*, in other words no CSS is undertaken to extract additional oil, and current oil production in the Tambaredjo Oilfield continues while economically viable. This means that the ten CSS wells are not drilled, additional infrastructure is not constructed and there is no additional demand for surface water and power generation.

6.1.4 Impact Rating Methodology

The assessment of impacts was based on specialists' expertise, SRK's professional judgment, field observations and desk-top analysis.

The significance of potential impacts that may result from the proposed project was determined in order to assist decision-makers (typically by a designated competent authority or state agency, but in some instances, the applicant).

The **significance** of an impact is defined as a combination of the **consequence** of the impact occurring and the **probability** that the impact will occur.

The criteria used to determine impact consequence are presented in the table below.

Table 6-1: Criteria used to determine the consequence of the impact

Rating	Definition of Rating	Score
A. *Extent* *– the area (distance) over which the impact will be experienced*		
Local	Confined to project or study area or part thereof (e.g. the Tambaredjo Oilfield)	1
Regional	The region (e.g. Saramacca District, Saramacca River catchment, aquifers underlying the oilfield)	2
(Inter) national	Nationally or beyond	3
B. ***Intensity*** *– the magnitude of the impact in relation to the extent of the impact and sensitivity of the receiving environment, taking into account the degree to which the impact may cause irreplaceable loss of resources*		
Low	Site-specific and wider natural and/or social functions and processes are negligibly altered	1
Medium	Site-specific and wider natural and/or social functions and processes continue albeit in a modified way	2
High	Site-specific and wider natural and/or social functions or processes are severely altered	3
C. ***Duration*** *– the timeframe over which the impact will be experienced and its reversibility*		
Short-term	Up to 2 years and reversible	1
Medium-term	2 to 15 years and reversible	2
Long-term	More than 15 years and irreversible	3

The combined score of these three criteria corresponds to a **Consequence Rating**, as follows:

Table 6-2: Method used to determine the consequence score

Combined Score **(A+B+C)**	3 – 4	5	6	7	8 – 9
Consequence Rating	Very low	Low	Medium	High	Very high

Once the consequence was derived, the probability of the impact occurring was considered, using the probability classifications presented in the table below.

Table 6-3: Probability classification

Probability *– the likelihood of the impact occurring*	
Improbable	< 40% chance of occurring
Possible	40% - 70% chance of occurring
Probable	> 70% - 90% chance of occurring
Definite	> 90% chance of occurring

The overall **significance** of impacts was determined by considering consequence and probability using the rating system prescribed in the table below.

Table 6-4: Impact significance ratings

		Probability			
		Improbable	Possible	Probable	Definite
Consequence	Very Low	INSIGNIFICANT	INSIGNIFICANT	VERY LOW	VERY LOW
	Low	VERY LOW	VERY LOW	LOW	LOW
	Medium	LOW	LOW	MEDIUM	MEDIUM
	High	MEDIUM	MEDIUM	HIGH	HIGH
	Very High	HIGH	HIGH	VERY HIGH	VERY HIGH

Finally the impacts were also considered in terms of their status (positive or negative impact) and the confidence in the ascribed impact significance rating. The prescribed system for considering impacts status and confidence (in assessment) is laid out in the table below.

Table 6-5: Impact status and confidence classification

Status of impact	
Indication whether the impact is adverse (negative) or beneficial (positive).	+ ve (positive – a ‘benefit’)
	– ve (negative – a ‘cost’)
Confidence of assessment	
The degree of confidence in predictions based on available information, SRK’s judgment and/or specialist knowledge.	Low
	Medium
	High

The impact significance rating should be considered by authorities in their decision-making process based on the implications of ratings ascribed below:

- **INSIGNIFICANT**: the potential impact is negligible and **will not** have an influence on the decision regarding the proposed activity/development.
- **VERY LOW**: the potential impact is very small and **should not** have any meaningful influence on the decision regarding the proposed activity/development.
- **LOW**: the potential impact **may not** have any meaningful influence on the decision regarding the proposed activity/development.
- **MEDIUM**: the potential impact **should** influence the decision regarding the proposed activity/development.
- **HIGH**: the potential impact **will** affect the decision regarding the proposed activity/development.
- **VERY HIGH**: The proposed activity should only be approved under special circumstances.

Practicable mitigation and optimisation measures are recommended and impacts are rated in the prescribed way both without and with the assumed effective implementation of mitigation and optimisation measures. Mitigation and optimisation measures are either:

- **Essential**: measures that must be implemented and are non-negotiable; and
- **Best Practice:** recommended to comply with best practice, with adoption dependent on the proponent’s risk profile and commitment to adhere to best practice, and which must be shown to have been considered and sound reasons provided by the applicant if not implemented.

In addition to essential and best practice measures, a very extensive suite of Staatsolie standard management measures and procedures will be implemented. These are referred to in the EMMP.

6.2 Impact Assessment

6.2.1 Air Quality

Above certain concentrations, air pollutants may have public health impacts, such as increasing the rate of certain cardiovascular (heart) and pulmonary (lung) diseases, cancers and strokes (AGI, 2018). Common "criteria" pollutants include sulphur dioxide (SO_2), nitrogen dioxide (NO_2), particulate matter (PM), carbon monoxide (CO) and volatile organic compounds (VOCs).

Air quality measurements undertaken in 2018 showed that baseline air quality is generally good, despite existing operations in the Tambaredjo Oilfield (see Section 4.1.3). The extent of increased ambient pollutant concentrations from the CSS project will depend on the nature and scale of the project. The most significant atmospheric emissions during *construction* include:

- Fugitive particulate matter (Total Suspended Particulates, PM_{10} and $PM_{2.5}$[10]) due to bulk earthworks, windblown dust from exposed surfaces, stockpiles and the construction of infrastructure; and
- Particulate matter and gases from combustion of fuels by mobile equipment (CO, PM_{10}, $PM_{2.5}$, SO_2 and VOCs).

The Gangaram Pandayweg is the only (local) access road leading to the Tambaredjo Oilfield. Any additional vehicles transporting persons, material and equipment for the project will add to dust generated by vehicles on the road, further impairing air quality which may pose a human health risk. Furthermore, dust settles on the roofs of houses, cars and any other surface within the homes, posing a nuisance to residents living along the road. However, additional traffic generated by the CSS project will be relatively limited compared to existing traffic on Gangaram Pandayweg.

The project area is largely vegetated, and the nearest sensitive receptors (residences) are located ~4 km to the south (see Figure 6-3). As such, ambient concentrations of pollutants from emissions during construction are expected to be below guideline values at receptors.

The most significant atmospheric emissions during *operation* include:

- Vaporisation (volatilisation) of extracted, stored and transported oil and gas (CO, PM_{10}, $PM_{2.5}$, SO_2 and VOCs). However, additional oil production by the CSS project will be relatively limited compared to existing oil production and processing in the Tambaredjo Oilfield; and
- Particulate matter and gases from combustion of fuels by mobile equipment, notably the OTSG and other generators.

Primary pollutants from combustion engines are SO_2, NO_x, CO and, to a lesser extent, VOCs. PM is also a primary pollutant for combustion engines using liquid fuels. The formation of NO_x is strongly dependent on the high temperatures developed in the combustor; while CO, VOC, hazardous air pollutants (HAPs), and PM emissions are primarily the result of incomplete combustion. Oxides of sulphur (SOx) will be emitted in a significant quantity when HFO is utilised; otherwise, they are emitted in trace to low amounts. SO_2 emissions are directly related to the sulphur content of the fuel (US EPA, 2000).

The most important source of combustion emissions is the mobile OTSG used to generate up to 12 tons of steam per day. Depending on the equipment leased, the generator will use diesel

[10] Particles with an aerodynamic diameter less than 10 micron and less than 2.5 micron, respectively

(21 000 liters / day) or HFO (19 000 liters / day)[11]. The OTSG will be moved from well to well and operate almost continuously for ~2 years, when the second injection cycle is complete.

Ground level concentrations for combustion pollutants were modelled for the Saramacca Power Plant project for six power generators each using 28 000 litres of HFO per day (SRK Consulting, 2019a); i.e. eight times the anticipated fuel consumption – and associated combustion emissions – of the OTSG. Modelled concentrations for all Saramacca Power Plant pollutants of interest were very low at receptors (only SO_2 and NO_2 emissions were expected to reach more than 1% of the limit value at receptors) and did not result in any expected exceedances of applicable limits anywhere in the Tambaredjo Oilfield.

As the fuel consumption by and associated emissions from the OTSG are much lower, and measured baseline concentration of pollutants in the region are also very low, impacts due to the proposed project are expected to be negligible with little discernible effect on air quality in the region.

The impact is assessed to be of ***very low*** significance with and without the implementation of mitigation (Table 6-6).

Table 6-6: Significance of impaired human health from increased ambient pollutant concentrations

	Extent	*Intensity*	*Duration*	*Consequence*	*Probability*	*Significance*	*Status*	*Confidence*
Without mitigation	Local 1	Low 1	Short-term 1	**Very Low 3**	Probable	**VERY LOW**	– ve	High
Essential mitigation measures: During construction: • Limit and phase vegetation clearance and the construction footprint to what is essential. • Reduce airborne dust through e.g. dampening dust-generating areas, roads and stockpiles with water. • Maintain all generators, vehicles and other equipment in good working order to minimize exhaust fumes. During operation: • Adopt appropriate technology to ensure power generating units meet appropriate standards and emission guidelines. • Operate the OTSG and any other power generating units according to design specifications and manufacturer's instructions to meet the emission limits. • Regularly maintain the OTSG to minimise exhaust emissions. • Maintain infrastructure and equipment such as tanks, pipelines, valves and fittings in good working order to prevent leaks and minimise evaporation of oil. • Maintain vehicles in good working order to minimise atmospheric emissions.								
With mitigation	Local 1	Low 1	Short-term 1	**Very Low 3**	Improbable	**INSIGNIFI-CANT**	– ve	High

Best practice air quality mitigation measures during construction are as follows:

- Schedule logistics to minimise traffic on the Gangaram Pandayweg;
- Inform nearby residents and businesses in a timely manner of delivery schedules;
- Avoid deliveries at night;
- Publicise delivery schedules on social media;
- Test exhaust emissions of the OTSG once it is fully operational, to confirm emission rates and compliance with equipment manufacturer emission specifications.

[11] Staatsolie requires that all equipment complies with relevant codes and specifications, such as those by the ASME (American Society of Mechanical Engineers), Power Boiler Code Section I, NFPA-85 (Boiler and Combustion Systems Hazards Code), NEC (National Electrical Code), ASTM (American Society for Testing and Materials) and ANSI/ISA (American National Standards Institute / International Standards of Automation).

- Monitor trucks at strategic points along the Gangaram Pandayweg to determine compliance with traffic rules agreed between Staatsolie and contractor; and
- Intensify the dust suppression programme on the Gangaram Pandayweg during construction, especially the section from the beginning of the Gangaram Pandayweg (Km 0) to the entrance to the Tambaredjo Oilfield (Km 6).

6.2.2 Noise

The most significant sources of noise during *construction* include:

- Transportation of persons, materials and equipment. As the Gangaram Pandayweg is the only road providing access to the Tambaredjo Oilfield, traffic is expected to increase during project implementation and will generate noise. Excessive noise will disturb local area users, including residents living along the road. At night, noise may disturb residents living further from the road; and
- Construction activities, such as vegetation clearing and the use of heavy vehicles and mobile power generators, will generate noise. However, the nearest receptors are located ~4 km from the project area, and noise from construction activities is not expected to exceed guidelines and be of concern.

Similarly, the use of the OTSG during the first two years of operation will generate noise at the well sites, but such noise is not expected to be audible at the nearest receptors.

The impact is assessed to be of ***very low*** significance (Table 6-7). No mitigation is necessary.

Table 6-7: Significance of increased noise levels along access roads

	Extent	***Intensity***	***Duration***	***Consequence***	***Probability***	***Significance***	***Status***	***Confidence***
Without mitigation	Local 1	Low 1	Short-term 1	**Very Low 3**	Definite	**VERY LOW**	– ve	High
Essential mitigation measures: • None.								
With mitigation	Local 1	Low 1	Short-term 1	**Very Low 3**	Definite	**VERY LOW**	– ve	High

Best practice noise mitigation measures during construction are as follows:

- Schedule logistics to minimise traffic on the Gangaram Pandayweg;
- Inform nearby residents and businesses in a timely manner of delivery schedules;
- Avoid deliveries at night;
- Publicise delivery schedules on social media; and
- Monitor trucks at strategic points along the Gangaram Pandayweg to determine compliance with traffic rules agreed between Staatsolie and contractor.

6.2.3 Surface Water

The most significant sources of surface water impacts during *construction* include:

- Site preparation;
- Drilling of CSS wells;
- Construction of the water treatment plant and infrastructure; and
- Leaks and spills of contaminants.

Contaminated stormwater will likely result in minor direct impacts on the water quality in the Kisoensingh-west Canal and other canals draining the Tambaredjo polder, which discharge into the Saramacca River. These canals are already impacted by Staatsolie activities in the polder. The most likely potential contaminants and their potential effects are:

- Hydrocarbons, such as oil, petrol or diesel powering construction equipment. Accidental spills or leaks could contaminate stormwater and/or discharge directly into receiving water bodies, impacting water quality. Small amounts of hydrocarbons readily break down in the soil and aquatic environment, and only larger volumes are of significant concern; and
- Suspended solids, which can also be harmful to biota and the aquatic environment as they affect benthic ecosystems, block respiratory organs of fish, reduce photosynthesis in plants, etc.

Given the artificial and somewhat disturbed characteristics of the receiving canal environment (see Section 4.1.5.1), impacts due to contamination are considered of medium intensity in localised areas close to point source discharges.

The most significant sources of potential surface water impacts during *operation* include:

- Abstraction of surface water from the Saramacca River, possibly affecting other users; and
- Discharge of effluent generated by the CSS project (including effluent from the treatment of water and produced fluid) into the canals in the Tambaredjo Oilfield, which flow into the Saramacca River.

The CSS process requires 945 to 1 260 bbl (112 to 150 m^3 [12]) of water per day for steam generation for ~2 years, assuming ten CSS wells are sequentially injected for two consecutive injection cycles (i.e. only one well is injected at any one time). The water will be supplied by infrastructure installed for the Polymer Flooding project, which requires ~21 000 bbl (2 504 m^3) of water per day during the ~25-year project duration (SRK Consulting, 2019a). For two years, the water demand of the CSS project equates to 6% of the water abstracted for the Polymer Flooding project during that same period.

Staatsolie has confirmed that water abstracted from the Saramacca River for the Polymer Flooding project is not expected to impact on farmers who also abstract from the Saramacca River, as the water will be directly abstracted from the river and not affect reservoirs used by the farmers. Noting the comparatively small CSS water demand, no significant impact is expected on other users of the Saramacca River.

Produced fluid from CSS wells will be conveyed to the TA-58 plant for processing. Produced water is treated to the same specifications as other effluent from the Tambarejo Oilfield prior to discharge into the Saramacca River. The volume of produced water (assumed to be equivalent to discharge volume) is closely related to the injection cycles – it spikes shortly after injection and then quickly drops thereafter (see Figure 3-11). For the CSS project as a whole, maximum volumes of produced water of up to ~834 bbl/d are expected in Years 2 and 3. For most of the project duration, produced water volumes are well below 100 bbl/d. Produced fluid from CSS wells is expected to contain higher concentrations of H2S due to the hot production at the wells; Staatsolie is currently identifying appropriate treatment options.

Similarly, waste arising from water treatment for the CSS process, and appropriate treatment methods, will be confirmed once a supplier and water treatment system have been selected. It is expected that wastes can be treated to the appropriate standards.

[12] 1 fluid bbl = 0.1192 m^3

The impact is assessed to be of **very low** significance with and without the implementation of mitigation (Table 6-8).

Table 6-8: Significance of surface water contamination and abstraction

	Extent	Intensity	Duration	Consequence	Probability	Significance	Status	Confidence
Without mitigation	Local 1	Medium 2	Short-term 1	**Very Low 4**	Definite	**VERY LOW**	– ve	High
Key essential mitigation measures: • Complete studies to determine the most appropriate treatment of produced fluid from CSS wells (including H_2S management). • Implement good housekeeping practices to prevent discharge of contaminated water to surface water bodies. • Treat produced water before discharge.								
With mitigation	Local 1	Medium 2	Short-term 1	**Very Low 4**	Definite	**VERY LOW**	– ve	High

6.2.4 Groundwater

Potential sources of groundwater pollution during *construction* include:

- Leaks and spills of contaminants; and
- Drilling of CSS wells.

Leaks and spills of contaminants during construction could, in principle, contaminate groundwater. However, there is no shallow (superficial) groundwater below the project site, only deep aquifers covered by thick impermeable clay layers with no connectivity to, and isolated from, the surface. As such, contaminants are unlikely to migrate to aquifers and surface spills are unlikely to result in groundwater contamination.

CSS wells drilled to ~1 000 ft below ground level (bgl) will intersect aquifers. Brackish water is contained in an aquifer at ~790 ft bgl, i.e. ~230 ft above the oil reservoir. Freshwater is contained in the aquifer at ~490 ft bgl (~530 ft above the oil reservoir). This aquifer is tapped by the abstraction well at Tijgerkreek, ~14 km to the south-west of the project area.

Drilling could be a pathway for pollutants to reach groundwater if e.g. toxic drilling fluid is used. Given low transmissivity, it is unlikely that any contamination would reach the abstraction point at Tijgerkreek in concentrations exceeding guidelines. Groundwater is not abstracted for drinking purposes in the vicinity of the Tambaredjo Oilfield, but some is abstracted for process water. In the event of contamination reaching groundwater, it is likely to persist for the medium term. Staatsolie has drilled more than a thousand wells in the Tambaredjo Oilfield and has an established protocol that is followed during well drilling.

Potential sources of groundwater pollution during *operation* arise from possible thermal alteration of the chemical characteristics of groundwater.

Up to 200 tons of steam (equivalent to 1 260 bbl / 150 m^3 of water) per day will be injected at each CSS well at a maximum temperature of 600 ºF (315 ºC) for up to 20 days. After a 10-day soaking period, continuous pumping will commence at a rate of 65 m^3/day for 1 year. The injection cycle is then repeated.

The injection of steam will increase the temperature within the oil reservoir close to the CSS well. Over time, the temperature increase could spread horizontally within the reservoir and vertically into overlying (and underlying) layers.

Two-dimensional axisymmetric thermal modelling of the CSS process was undertaken to assess the potential impact of thermal alteration of chemical characteristics within the brackish and freshwater aquifers, using the FEFLOW 7.1 (DHI-WHASY GmbH) software. Modelling was based on the following assumptions:

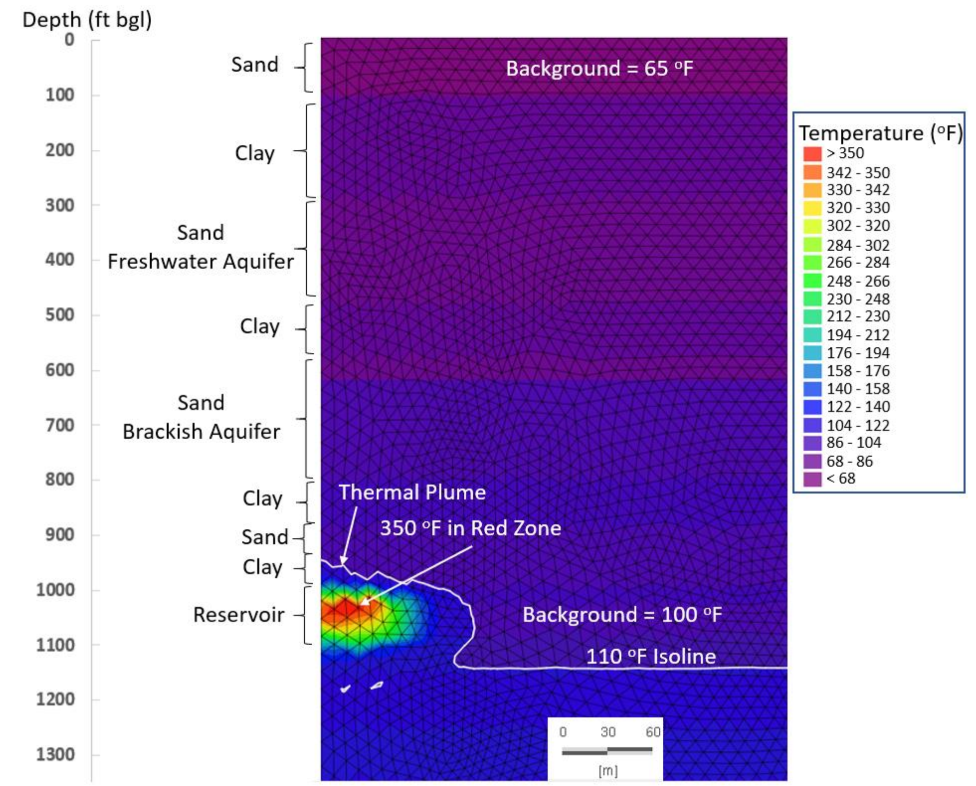
- Pre-CSS groundwater temperature is ~65 ºF (~18 ºC) near the surface, gradually increasing to ~100 ºF (~38 ºC) at oil reservoir depth;
- The lithology, comprising alternating sandy and clayey layers, previously modelled for the Polymer Flooding groundwater assessment (SRK Consulting, 2019b) was used and updated based on local borehole logs, indicating the oil reservoir to be at a depth of ~1 040 ft bgl to ~1 100 ft bgl (Figure 4-4); and
- Hydraulic and thermal parameters used in the thermal modelling (see Table 6-9) are based on literature values, information provided by Staatsolie and previous modelling.

Table 6-9: Hydraulic and thermal parameters used in the groundwater model

Parameter	Sand layer above reservoir	Clay layer above reservoir	Oil reservoir
Horizontal hydraulic conductivity	~13 m/d	~0.01 m/d	~13 m/d
Vertical anisotropy	50	20	10
Effective porosity	~25 %	~1 %	~30 %
Specific storage	~0.0002 m^{-1}	~0.003 m^{-1}	~0.0002 m^{-1}
Longitudinal dispersivity	~200 m	~100 m	~200 m
Transverse dispersivity	~10 m	~100 m	~10 m
Volumetric heat-capacity of the solid	~1.6 $MJ/m^3.K$	~2.4 $MJ/m^3.K$	~1.6 $MJ/m^3.K$
Volumetric heat-capacity of the fluid	~4.2 $MJ/m^3.K$	~4.2 $MJ/m^3.K$	~5 $MJ/m^3.K$
Thermal conductivity of the solid	~3 J/m/s/K	~1.5 J/m/s/K	~3 J/m/s/K
Thermal conductivity of the fluid	~0.65 J/m/s/K	~0.65 J/m/s/K	~0.4 J/m/s/K

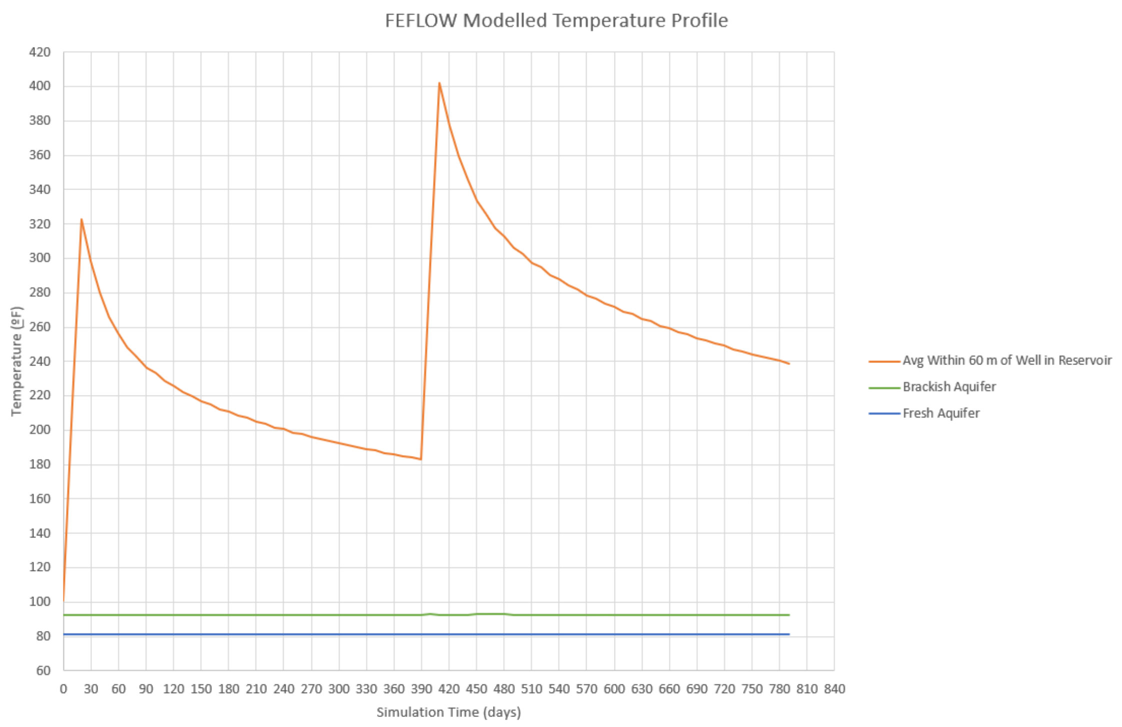
The modelled temperatures immediately after the second injection cycle, when they are at their highest, are shown in cross section view in Figure 6-1. The vertical extent of the modelled thermal plume, indicated by the 110 ºF isoline, only extends into the base of the overlying sand layer. Above this line, thermal variations above background are insignificant. At the end of the second injection cycle, temperatures in the reservoir are between 350 ºF and 400 ºF, as shown by the red zone.

Within the near vicinity of the CSS well (~60 m), the average oil reservoir layer temperature peaks at the end of each injection cycle and decreases rapidly thereafter. The modelled temperature in the brackish and freshwater aquifer due to the CSS process essentially remains unchanged (see green and blue lines in Figure 4-14) and changes are too low to effect thermal changes of the groundwater chemistry.



srk consulting	CSS LIMITED ESIA AND EMMP Modelled temperatures immediately after second injection cycle	Project No. 550457

Figure 6-1: Modelled temperatures immediately after second injection cycle



srk consulting	CSS LIMITED ESIA AND EMMP FEFLOW modelled temperature profile of the oil reservoir, brackish aquifer and fresh water aquifer	Project No. 550457

Figure 6-2: FEFLOW modelled temperature profile of the oil reservoir, brackish aquifer and fresh water aquifer

The impact is assessed to be of ***very low*** significance and with the implementation of mitigation is reduced to ***insignificant*** (Table 6-10).

Table 6-10: Significance of contamination of groundwater

	Extent	*Intensity*	*Duration*	*Consequence*	*Probability*	*Significance*	*Status*	*Confidence*
Without mitigation	Local 1	Medium 2	Medium 2	**Low 5**	Possible	**VERY LOW**	– ve	Medium
Key essential mitigation measures: During construction: • Use non-toxic drilling fluids when drilling through freshwater aquifers. • Ensure well casing and cementing meets best practice methods and Staatsolie standards to prevent thermal losses into the upper layers above the oil reservoir; • Develop (or maintain and adapt) procedures for the safe transport, handling and storage of potential pollutants; • Design and construct hazardous material storage facilities with suitable impermeable materials and a minimum 110% containment capacity; • Ensure all on site staff are trained in the use of spill prevention measures; and • Clean up any spills immediately, through containment and removal of free product and appropriate rehabilitation or disposal of contaminated soils. During operation: • Manage injection pressures to ensure that steam is not chased / forced beyond the confines of the oil reservoir; • Develop (or maintain and adapt) procedures for the safe transport, handling and storage of potential pollutants; • Ensure all on site staff are trained in the use of spill prevention measures; • Clean up any spills immediately, through containment and removal of free product and appropriate rehabilitation or disposal of contaminated soils; • Monitor groundwater quality and temperature at water abstraction points; and • Monitor the surrounding offset producers to verify whether the thermal flow (conductance) from steam injection is as predicted by design and models. During decommissioning: • Remove all old surface equipment, contaminated soil from small spills and other waste at the surface; and • Plug the well in accordance with Staatsolie's General Plug & Abandon Requirement to prevent leaks of fluids and gas to the surface and of oil, gas or salty water into freshwater aquifers.								
With mitigation	Local 1	Low 1	Short-term 1	**Very Low 3**	Improbable	**INSIGNIFI-CANT**	– ve	Medium

The following monitoring measures are recommended:

- Monitor groundwater quality and temperature in the water supply boreholes within the Tambaredjo Oilfield (1J22, 30HW25 and 3Z14) and the Tijgerkreek borehole before initiation of the commercial CSS project and quarterly thereafter; and
- Install a single monitoring well into the deeper brackish aquifer to act as a sentinel well should high temperatures migrate through the clay layers. This well would also serve as confirmation that the reservoir and groundwater models are valid for any future CSS expansions. Monitor this well quarterly for water quality and temperature.

6.2.5 Ecology

Secondary marsh forest vegetation dominates the vacant portions of the Tambaredjo Oilfield, including where new CSS wells will be installed. However, all CSS wells and infrastructure are located between and close to existing producers and infrastructure on the Tambaredjo Oilfield (see Figure 3-6). The water treatment plant will be installed at a previous well location that is cleared. As such, most of the project is located in highly disturbed areas. The vegetation is of low sensitivity, does not comprise vulnerable, rare or endangered plant species and occurs commonly in the Young Coastal Plain.

The project has a total footprint of ~7 ha, spread over the ten well sites and associated infrastructure, though not the entire footprint will be cleared. Through vegetation clearance some loss of habitat will occur. Potential disturbances to wildlife will be caused mainly by vehicles, construction machinery, and human presence. However, in general, the species present in the vicinity of the project site are already adapted to a comparable amount of disturbance from oil production activities. Wildlife in the surrounding area may be temporarily disturbed during the construction period. However, there is sufficient opportunity to move to less noisy areas in the surrounding marsh forest.

The impact is assessed to be of ***very low*** significance (Table 6-11). No mitigation is necessary.

Table 6-11: Significance of vegetation clearing and habitat loss

	Extent	*Intensity*	*Duration*	*Consequence*	*Probability*	*Significance*	*Status*	*Confidence*
Without mitigation	Local 1	Low 1	Short-term 1	**Very Low 3**	Definite	**VERY LOW**	– ve	High
Essential mitigation measures: • Limit and phase vegetation clearance and the construction footprint to what is essential.								
With mitigation	Local 1	Low 1	Short-term 1	**Very Low 3**	Definite	**VERY LOW**	– ve	High

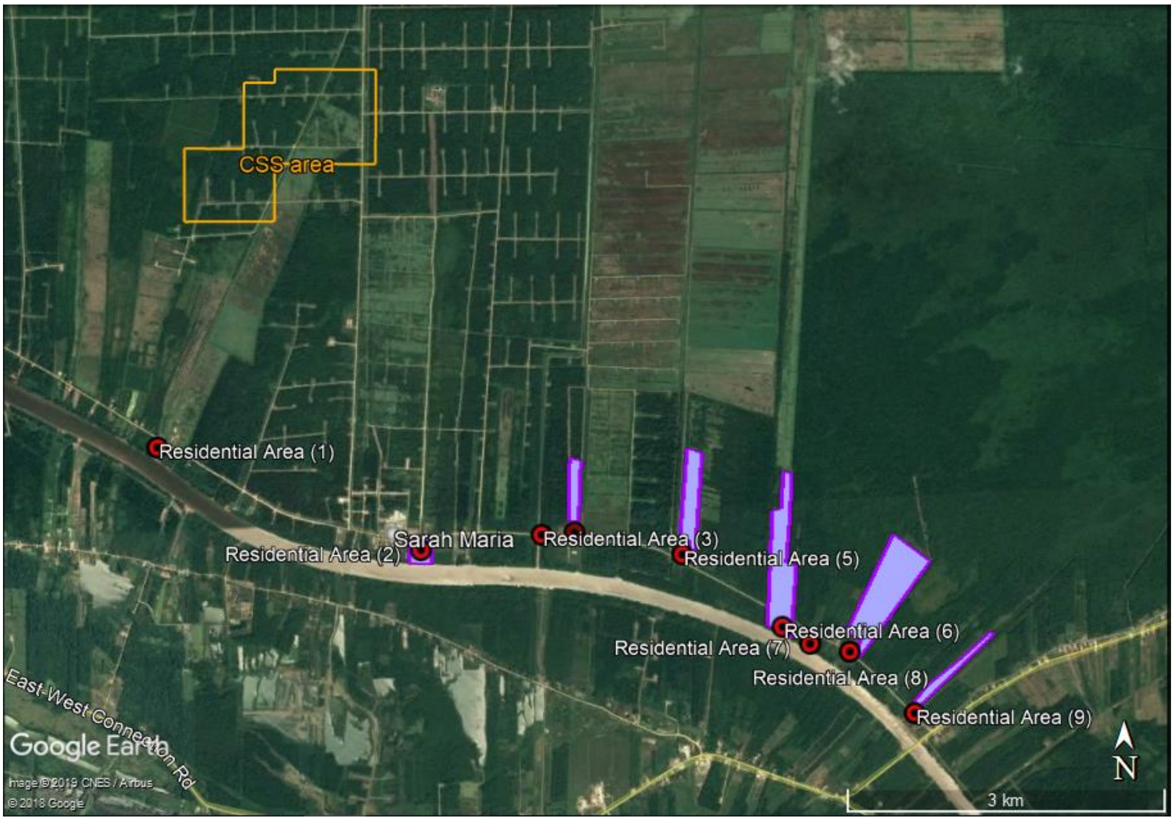
6.2.6 Socio-economics

Eight residential clusters comprising three to four households each and one allotment project comprising four houses are located in the 8 km section from the intersection with Wayambo Road that leads past the Tambaredjo Oilfield (see Figure 6-3).

Potential socio-economic impacts during *construction* include:

- Compromised drinking water quality from dust generated by project traffic, as households located along the Gangaram Pandayweg are not yet connected to the water distribution network. As such, most families living along the road rely on the harvesting of rain water for use as drinking water. Traffic on the unpaved Gangaram Pandayweg, generates dust, which settles on roofs and in gutters, contaminating drinking water collected in storage tanks. However, traffic related directly to the CSS project is expected to be a minor component of total traffic on Gangaram Pandayweg;
- Increased safety risk from heavy vehicles during construction, as residents living along the Gangaram Pandayweg complain that the speed limit (40 km/h) is regularly exceeded by heavy vehicles. More traffic (and speeding) increases the risk of accidents;
- Employment opportunities created by the project, as construction activities will provide jobs to local construction firms and workers, including subcontractors. National producers and suppliers of construction materials may experience increased business. However, construction jobs will be relatively short-term and limited, and are likely to be executed largely by specialist suppliers; and
- Damage to archaeological sites due to site clearing and earthworks. However, no known archaeological sites will be affected by the project. Unregistered sites could exist in the project footprint, as few places have been excavated, but the project is located within a dense well field that would have likely affected those sites already.

Most families residing along the Gangaram Pandayweg practise horticulture (domestic cultivation). Some agricultural fields are located in close proximity to the Tambaredjo Oilfield. However, new CSS wells will be at least ~4 km from agricultural areas (see Figure 6-3), while existing producer wells are located much closer (~100 m). As such, the new wells are not expected to impact existing agricultural activities.



srk consulting	CSS LIMITED ESIA AND EMMP Agricultural and residential sites in the project area	Project No. 550457

Figure 6-3: Agricultural and residential sites in the project area

Source: Agricultural plots and residential areas from Social Solutions (2018)

Thermal well modelling has shown that the effect of injected steam will be very localised and not affect groundwater (see Section 6.2.4), while surface spills are likely to be localised and unlikely to spread unless they occur near drainage canals discharging into the Saramacca River, away from agricultural areas. Abstraction of water from the Saramacca River is also not expected to affect current users (see Section 6.2.3).

The impact is assessed to be of ***very low*** significance (Table 6-12). No mitigation is necessary.

Table 6-12: Significance of employment and impact on adjacent communities

	Extent	*Intensity*	*Duration*	*Consequence*	*Probability*	*Significance*	*Status*	*Confidence*
Without mitigation	Local 1	Low 1	Short-term 1	**Very Low 3**	Possible	**INSIGNIFI-CANT**	– ve	High
Essential mitigation measures: • None.								
With mitigation	Local 1	Low 1	Short-term 1	**Very Low 3**	Possible	**INSIGNIFI-CANT**	– ve	High

The above socio-economic assessment is based on the assumption that the following measures are implemented as part of ongoing Staatsolie operations:

- Continue to publicise and implement the existing Staatsolie grievance mechanism;
- Clean up any spills and contaminated soil immediately, and inform potentially affected landowners;
- Procure and utilise local skills and resources wherever possible;
- Train local people to acquire skills required for the project; and

- Compile and implement a chance finds procedure.

6.2.7 Visual

The current visual quality and sense of place of the project area is largely defined by existing oil production activities on the site.

Potential sources of visual impacts include construction equipment and activities during construction, and the new CSS wells and associated structures and activities during operation. The magnitude of potential visual impacts from the above sources is considered *insignificant*, as:

- No public receptors (communities and commuters) are located near the site, which is located within Staatsolie's concession area and not publicly accessible;
- The CSS equipment and infrastructure are visually congruent with Oil and Gas equipment and infrastructure in the area;
- The visual screening capacity of the surrounding vegetation is considered to be high, as trees will effectively shield visual impacts; and
- The visual impacts of construction activities are of short duration.

The above assessment is based on the assumption that the following measures are implemented in the project design, construction and operation phases:

- Retain screening vegetation around the site (wells) as much as possible;
- Reduce airborne dust through e.g. dampening dust-generating areas, roads and stockpiles with water; and
- Regularly collect and dispose of redundant equipment, waste and litter.

6.2.8 Traffic

The Sarah Maria facility and Tambaredjo Oilfield are serviced by the East-West Road and Gangaram Pandayweg. These public roads are also used by many other private and commercial vehicles as well as Staatsolie employees and contractors currently working at Sarah Maria, and traffic is heavier during the morning and afternoon rush hour.

During *construction*, potential sources of traffic impacts include construction vehicles travelling to and from the CSS well field, to transport workers, execute works or deliver materials. The magnitude of potential traffic impacts from the above sources is considered *very low*, as:

- The construction workforce is relatively small;
- Material will mostly be delivered outside of peak rush hour(s); and
- The construction period is relatively short.

During *operation*, potential sources of traffic impacts include employees travelling to work, and some ongoing commercial deliveries. The magnitude of potential traffic impacts from these sources during the operation of the CSS project is considered *insignificant*, as the project will largely be serviced by the existing workforce.

The above assessment is based on the assumption that the following measures are implemented in the project design, construction and operation phases:

- Schedule delivery of material transported by road to times that fall outside of rush hour(s);
- Ensure that trucks transporting large equipment or hazardous material are clearly marked and accompanied by safety vehicles; and

- Inform relevant authorities of special loads vehicles.

6.2.9 No-Go Alternative

The No-Go alternative entails no change to the *status quo*, in other words no CSS is undertaken to extract additional oil, while current oil production in the Tambaredjo Oilfield continues while economically viable. This means that the CSS wells (and associated infrastructure) and water treatment plant are not constructed.

The impacts associated with the CSS project are generally of very low significance and very small compared to the overall impact of oil production in the Tambaredjo Oilfield. It is also possible that many of the impacts will be incurred in the No-Go alternative if new wells are constructed in the CSS project area for use as conventional wells, as part of existing oil production in the Tambaredjo Oilfield.

While impacts of the CSS project are thus minor and largely similarly to those of ongoing operations, a successful CSS project would provide an opportunity to increase oil production in the Tambaredjo Oilfield by implementing CSS to other existing and/or infill wells in an already disturbed area.

As such, the No-Go alternative is not preferred.

6.3 Potential Contribution to Climate Change

6.3.1 Overview for Suriname

Suriname has a low-lying coastal zone where 80% of the population lives and most economic activities take place. As such, Suriname is highly susceptible to the effects of sea level rise and is considered one of the so-called small island developing states, a group of developing countries that were recognised as low lying coastal countries that tend to share similar sustainable development challenges including small but growing populations, fragile environments, vulnerability to external shocks and few or no opportunities to create economies of scales (Kromosoeto, 2011).

Suriname has a small industrial sector, previously dominated by alumina refining and smelting. GHG emissions declined sharply in 1999 due to the closure of the aluminium smelter but grew again in subsequent years. It is likely that GHG emissions again declined in 2016 after the closure of the alumina refinery. Energy is derived mainly from hydrocarbons and hydropower. The energy sector is the largest GHG source / emitter (~59% of 2008 emissions), followed by land-use change and forestry and agriculture (NIMOS, 2005), (RoS, 2016).

Suriname's GHG balance has been quantified in various – sometimes inconsistent – reports:

- Total GHG emissions were reported as:
  - 8.9 million tonnes CO_2-equivalent (Mt CO_2-e) in 2003 (NIMOS, 2005);
  - 6.4 Mt CO_2-e in 2008 (RoS, 2016); and
  - 8.04 Mt CO_2-e in 2014 (Climate Watch , 2018);
- Total CO_2 removal (GHG sinks) capacity, primarily from forestry and agriculture, was reported as:
  - 3.8 Mt CO_2-e in 2003 (NIMOS, 2005); and
  - 8.2 Mt CO_2-e in 2008 (RoS, 2016); and
- Based on the above numbers, Suriname either is a:
  - Net emitter (NIMOS (2005) reported net emissions of 5.1 Mt CO_2-e in 2003); or

- Net sink (the Republic of Suriname (RoS, 2016) reported net capture of 1.8 Mt CO_2-e in 2008).

6.3.2 Contribution by the CSS Project

The project will use and produce fossil fuels and require vegetation clearing and land transformation. Combustion of fossil fuels and reduction in vegetation cover are generally accepted to be factors contributing to climate change, from direct emissions and reduction in carbon sequestration capacity respectively. As such, the project is likely to have an impact on climate change.

GHG emissions from the CSS project can be grouped into three scopes / categories, as defined by the GHG Protocol (2019) and India GHG Programme (2019) (see Figure 6-4):

- Scope 1 emissions are direct emissions from owned or controlled sources. They can include emissions from combustion in owned or controlled boilers, furnaces, vehicles and emissions from chemical production in owned or controlled process equipment;
- Scope 2 emissions are indirect emissions from the generation of purchased energy consumed by a company / project. Purchased electricity is defined as electricity that is purchased or otherwise brought into the organizational boundary of the company. Scope 2 emissions physically occur at the facility where electricity is generated; and
- Scope 3 emissions are all indirect emissions (not included in Scope 2) that occur in the value chain of the reporting company, including upstream and downstream emissions. Scope 3 emissions are a consequence of the activities of the company but emanate from sources not owned or controlled by the company. Examples of Scope 3 activities are extraction and production of purchased materials, transportation of purchased fuels and use of products and services.

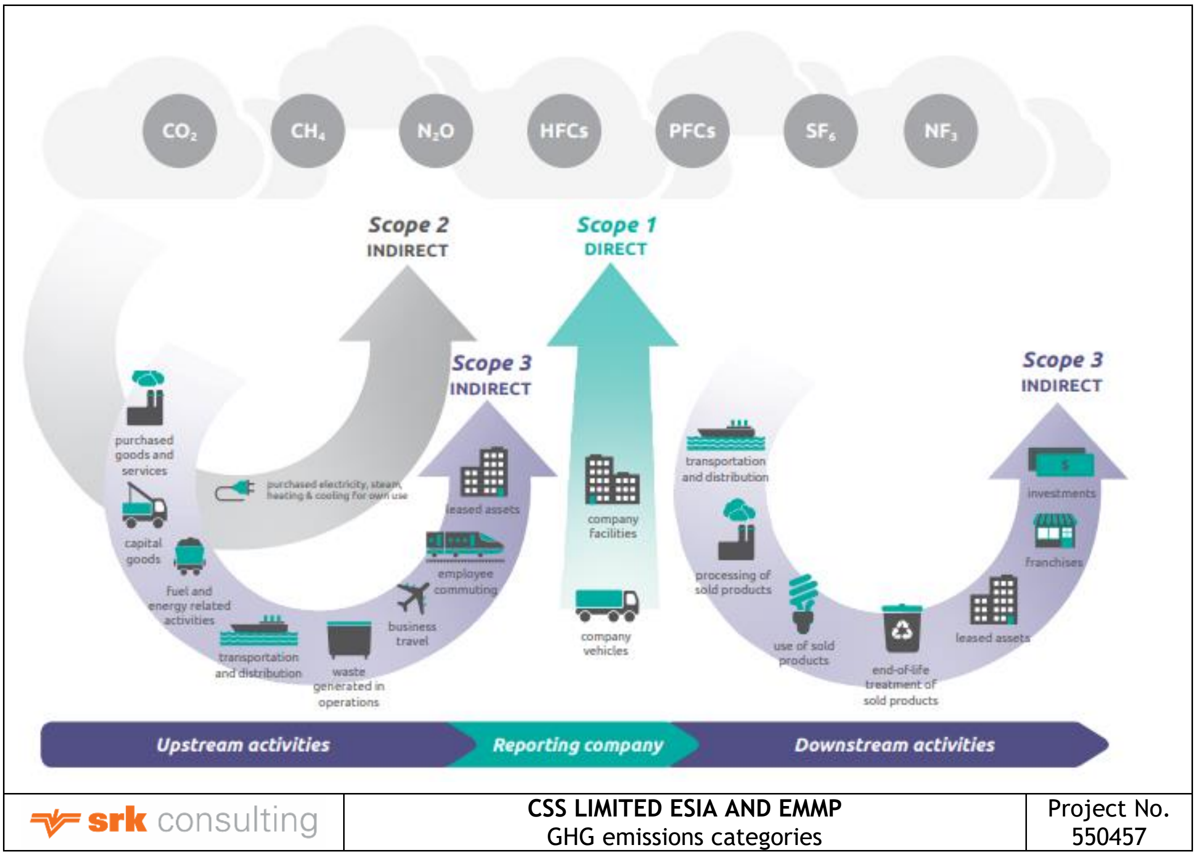


Figure 6-4: GHG emission categories

Source: Greenhouse Gas Protocol (2019a)

6.3.2.1 Scope 1 Emissions

Scope 1 emissions from directly controlled or owned sources are primarily from the burning of fossil fuels for the OTSG. Approximately 21 000 liters of diesel or 19 000 litres of HFO will be used per day for ~2 years to power the OTSG. Annual fossil fuel consumption is estimated at ~7.67 million litres of diesel or 6.94 million litres of HFO[13].CO_2 released by the combustion of fossil fuel by the OTSG is estimated at approximately 20 000 t CO_2-e per year[14] for two years.

Other sources of GHGs are deemed less material and have not been quantified, including emissions from:

- Vegetation clearing, which are a function of the scale and method of clearing. However, for the CSS project, the extent of vegetation clearing is relatively limited;
- Construction equipment, which emits GHG from combustion of liquid fuels. However, the construction phase is relatively short and activities limited;
- Use of electricity generated onsite by Staatsolie's own (planned) power plant or generators in the Tambaredjo Oilfield. However, the project is primarily supplied by dedicated mobile generators; and
- Natural gas escaping from the ten CSS wells and associated new pipeline sections.

Vegetation clearing also leads to a reduction in carbon sequestration by vegetation in the area. However, for the CSS project, the extent of vegetation clearing is relatively limited, and secondary vegetation (re)grows prolifically in the area.

The total CO_2 emissions from the CSS project from the combustion of HFO are the approximate equivalent of:

- Approximately 0.6% of Suriname's total GHG emissions (for a period of two years), as reported in the 2008 inventory (or 0.5% of estimated 2014 emissions); and
- Approximately 0.5% of Suriname's total GHG removals (sequestration) by its forest, as reported in the 2008 inventory.

6.3.2.2 Scope 2 and 3 Emissions

The project is primarily powered by one OTSG and possibly other mobile generators, and does not procure meaningful quantities of electricity generated offsite, e.g. by the N.V. Energiebedrijven Suriname (EBS). As such, Scope 2 emissions are very small.

Scope 3 emissions arise primarily from the emission of GHG through the subsequent use of the oil extracted by the CSS project. Although produced oil volumes, and their ultimate use, are not currently known, Staatsolie expects that the CSS project will increase oil production by four to six times compared to primary (cold) production, and that up to 50 MSTB of oil can be recovered per

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[13] It is assumed that this is approximately equivalent to 6 940 tonnes, i.e. that one litre of diesel weighs one kilogram.

[14] *If diesel is used:* 1 litre of diesel results in the release of 2.6 kg CO_2 (University of Calgary, 2019). Annual consumption of 7.76 million litres results in the release of 19 942 tons CO_2.

If HFO is used: The CO_2-emissions generated by the combustion of HFO is calculated as follows (TÜV, 2007):

CO_2 = (mass of fuel) x (carbon content) x (molecular weight of CO_2/atomic weight of C) x oxidation factor, where:

- mass of fuel = mass of HFO = 6 940 t
- carbon content = 0,8806 t C / t fuel (based on analysis of the HFO used at the Vasilikos Power Station)
- molecular weight of CO_2/atomic weight of C = 44 / 12 = 3,667
- oxidation factor = 0,995, giving:

CO_2 = 6 940 x 0,8806 x 3.667 x 0,995 = 22 300 t CO_2

well. It is likely that the oil will be burned, emitting ~255 400 t CO_2[15]. This is in line with findings for the industry in general that "Scope 3 emissions from use of sold products is by far the largest share of oil and gas producers' lifecycle emissions" (Transition Pathway Initiative, 2018).

The effects of climate change are global, and CO_2 is emitted worldwide from a vast number of sources. Seldom is any one source a significant emitter, but combined they emit enormous quantities of CO_2. As such, it is difficult to meaningfully rate the contribution of the CSS project as a single emission source, and the impact has not been rated formally.

The CO_2 emissions associated with the project will be largely equivalent to the amount of oil that is produced. Due to the higher energy input required for steam generation and higher oil production per well compared to conventional (cold) production, the CSS project has a significantly higher carbon footprint relative to conventional production.

Overall production from the CSS wells will be very significantly less than what has already been produced by the Tambaredjo Oilfield. Oil production rates and volumes in Suriname are very low compared to major global oil producers.

Measures to reduce the CO_2 emission volumes associated with the CSS project can include operational changes (e.g. increasing energy efficiency), green completions of wells (capturing and using/selling of natural gas [methane][16]) and use of cleaner electricity (e.g. renewable). However, the implementation of such measures is expected to require operational adjustments that might not be technically or financially feasible.

Offset measures, such as the support of carbon-reducing schemes, can also be considered, but it is noted that the 2008 inventory identifies Suriname as a net GHG sink.

6.3.3 Climate Change Resilience

The project area is located in Suriname's low-lying coastal plain on a polder surrounded by swamp. This area is likely to be vulnerable to possible effects of climate change such as sea level rise, coastal erosion, salination or rise of the groundwater and changing rainfall and wind patterns.

The CSS project area is located ~12 km inland from the coast on a polder, previously constructed and drained to allow for dryland oil production. It is assumed that Staatsolie will take measures, if necessary, to monitor and protect production areas in the Tambaredjo Oilfield to ensure resilience to climate change.

6.4 Cumulative Impacts

6.4.1 Introduction

Anthropogenic activities can result in numerous and complex effects on the natural and social environment. While many of these are direct and immediate, the environmental effects of individual activities (or projects) can combine (additive impact) and interact (synergistic impact) with other activities in time and space to cause incremental or aggregate effects. Effects from ongoing but unrelated activities may accumulate or interact to cause additional effects (Canadian Environmental Protection Agency), known as "cumulative" effects or impacts (hereafter cumulative impacts).

[15] Total production of 500 MSTB from 10 wells = 79.5 million litres (http://www.unitconverterapp.com/quantity/volume), assumed to be equivalent to ~79 500 tonnes. Based on the assumptions provided in footnote 12, combustion of this oil would emit ~255 400 t CO_2.

[16] If methane cannot be sold, then flaring is a less attractive alternative but preferable to venting methane into the atmosphere, as the CO_2 generated by flaring is a less potent GHG than methane (AGI, 2018).

Cumulative impacts are defined by the International Finance Corporation (IFC, 2013) as "those that result from the successive, incremental, and / or combined effects of an action, project, or activity when added to other existing (i.e. ongoing), planned, and / or reasonably anticipated future" actions, projects or activities.

Key to the theoretical understanding of cumulative impacts is that the effects of previous and existing actions, projects or activities are already present and assimilated into the biophysical and socio-economic baseline. For the purposes of this report, cumulative impacts are defined as 'direct and indirect project impacts that act together with external stressors and existing or future potential effects of other activities or proposed activities in the area/region that affect the same resources and/or receptors, also referred to as Valued Environmental and Social Components (VECs)'.

For the most part, cumulative effects or aspects thereof are too uncertain to be quantifiable, due to mainly lack of data availability and accuracy.

6.4.2 Methodology

The IFC Good Practice Handbook for Cumulative Impact Assessment (2013), describes five / six key steps and considerations in the assessment of cumulative impacts:

- Definition of the Area of Influence (AoI);
- Identification of VECs, and their baseline condition;
- Identification of activities or stressors that contribute or are anticipated to contribute to cumulative effects in the foreseeable future (i.e. for all phases of the project);
- Implementation of a suitable methodology to assess cumulative impacts and evaluate their significance; and
- Identification of measures to manage and monitor cumulative impacts.

The **Area of Influence** (AoI) can be defined as the area likely to be affected, and the period or duration of occurrence of effects. In practice the AoI is a function of a large number of factors which have changing and varying degrees of influence on the areas surrounding the project throughout the course of the project cycle. The geographical extent of some of these factors can be partially quantified (e.g. air emissions can be defined by a delineated plume under specified meteorological conditions), whilst the extent of others is very difficult to measure (e.g. direct and indirect socio-economic effects).

In CIA it is good practice to focus on **VECs**, which are environmental and social attributes that are considered to be important in assessing risks and can be defined as essential elements of the physical, biological or socio-economic environment that may be affected by a proposed project. Types of VECs include physical features, habitats, wildlife populations (e.g. biodiversity), ecosystem services, natural processes (e.g. water and nutrient cycles, microclimate), social conditions (e.g. health, economics) or cultural aspects (e.g. traditional spiritual ceremonies). VECs should reflect public concern about social, cultural, economic, or aesthetic values, and also the scientific concerns of the professional community (Beanlands & Duinker, 1983).

Activities of potential interest include other past, present and future activities that might have caused or may cause impacts on the VECs affected by the project, and / or may interact with impacts caused by the project under review:

- **Cumulative impacts of past and existing activities**: It is reasonably straightforward to identify significant past and present projects and activities that may interact with the project to produce cumulative impacts, and in many respects, these are taken into account in the descriptions of the biophysical and socio-economic baseline (see respective sections in Section 3) and assessment of impacts (Section 6); and

- **Potential cumulative impacts of planned and foreseen activities**: Relevant future projects that will be included in the assessment are defined as those that are 'reasonably foreseeable', i.e. those that have a high probability of implementation in the foreseeable future; speculation is not sufficient reason for inclusion.

Stressors can be defined as natural or anthropogenic aspects which cause a change in, i.e. impact on, the structure or function of the environment. Natural and anthropogenic stressors often have similar effects, e.g. both drought and wood harvesting result in a loss of habitat. Due to rapid increases in human population, anthropogenic stressors on the environment have increased greatly (Cairns, 2013).

6.4.3 Cumulative Impact Assessment

Cumulative impacts for this project have been identified based on the extent and nature of the AoI of the projects, status of VECs and understanding of external natural and social stressors. These insights have been informed by engagements with project stakeholders, review of existing documentation, field observations and data collection.

As the cumulative impacts of past and existing projects are incorporated in the baseline, the focus hereafter is on planned and foreseen projects and activities. Given the limited detail available regarding such future developments, the analysis is of a more generic nature and focuses on key issues and sensitivities for the project and how these might be influenced by cumulative impacts with other activities. The future developments that are considered are:

- Those for which approvals have already been granted;
- Those that are currently subject to environmental applications and for which there is currently information available; and
- Those forming part of district or national initiatives.

Where further developments are identified, but are not yet at the stage of planning as detailed above, these are noted in the cumulative impact assessment.

Projects and stressors that have been considered in the cumulative impact analysis are listed in Table 6-13.

Table 6-13: Projects / stressors considered in the cumulative impact analysis

Project / stressor	Common VECs
Past and present projects / stressors	
Agricultural activities in the resort	Air quality Surface water Groundwater Ecology
Existing conventional oil production on the Tambaredjo, Tambaredjo NW and Calcutta oilfields	Air quality Surface water Groundwater Ecology Noise
Future projects / stressors	
Polymer flooding project in the Tambaredjo Oilfield	Air quality Surface water

Project / stressor	Common VECs
	Groundwater Ecology Noise
Saramacca Power Plant in the Tambaredjo Oilfield	Air quality Surface water Ecology Noise
Possible EOR using similar / other techniques in the Tambaredjo Oilfield and / or adjacent oilfields (Tambaredjo NW and Calcutta),	Air quality Surface water Groundwater Ecology

Cumulative impacts are assessed for VECs on which the CSS project has a potentially significant impact. The cumulative impacts considered are:

- Decline in air quality;
- Decrease in surface water quality; and
- Loss of habitat due to vegetation clearing.

In the sections below, the severity and extent of cumulative impacts is qualitatively rated to derive a high, medium or (very) low significance rating.

6.4.3.1 Cumulative Air Quality Impacts

Emissions from the OTSG during the CSS project will affect local air quality.

A number of existing emission sources are likely to contribute to air pollution in the region, including oil fields in the Saramacca District, oil processing plants in the Tambaredjo Oilfield, traffic on the Gangaram Panday Road, river traffic on the Saramacca River and – during the dry season – commercial agricultural activities. A 36 MW power plant is also proposed in the Tambaredjo Oilfield. These sources (will) emit a number of primary pollutants, including SO_2, HF, NO_{xes}, PM, CO and VOCs (such as toluene, benzene, xylene etc).

Emissions from the TA-58 and the proposed Saramacca Power Plant, both located ~3 km north of the CSS project area, are most pertinent to the assessment of cumulative air quality impacts in the CSS project area.

The cumulative effect of emissions from these sources was taken into account in the baseline and impact assessment (see Section 6.2.1) and is reflected in the very low significance impact rating of the CSS project. Concentrations of all previously measured pollutants are low, and well below their respective extrapolated seven-day screening limits, indicating that baseline air quality is good.

Modelled pollutant concentrations for the proposed power plant, which will use eight times the fuel used by the OTSG, did not show any exceedances of applicable limits anywhere in the Tambaredjo Oilfield. Modelled emission plumes are localised around the power plant and not expected to overlap with emission plumes from the OTSG.

As the fuel consumption by and associated emissions from the OTSG are much lower, and measured baseline concentration of pollutants in the region are also very low, impacts due to the proposed project are expected to be negligible with little discernible effect on air quality in the region.

The cumulative impact on ambient air quality in the study area is assessed to be of ***very low*** significance.

6.4.3.2 Cumulative Surface Water Impacts

The CSS process requires up to 1 260 bbl of water per day (or 460 000 bbl / annum), for two years, to be abstracted from the Saramacca River. In comparison, the proposed Polymer Flooding project requires ~21 000 bbl of water per day (7.7 million bbl / annum) for 25 years, also abstracted from the Saramacca River (SRK Consulting, 2019a). The water demand of the CSS project thus represents a minor (6%) portion of the water to be abstracted from the Saramacca River for the proposed Polymer Flooding project.

The CSS project will discharge up to ~834 bbl/d of produced water into the Saramacca River. Discharge peaks in Years 2 and 3, but is well below 100 bbl/d for most of the project duration. This compares to a maximum estimated discharge volume of ~9 925 bbl/d of produced water for the proposed Polymer Flooding project. Staatsolie also discharges additional produced water from existing oil production wells and facilities in the Tambaredjo Oilfield via the TA-58, Jossie and CS treatment plants into the Saramacca River.

Depending on the quality of the discharged water, cumulative impacts on surface water could arise if different waste streams contain similar contaminants. To mitigate this, all wastewater is treated prior to discharge. The CSS project represents a very minor portion of the total discharge volume.

The cumulative impact of water abstraction and discharge was taken into account in the baseline and impact assessment (see Section 6.2.3) and is reflected in the very low significance impact rating of the CSS project.

The cumulative impact on surface water use and quality is assessed to be of ***very low*** significance.

6.4.3.3 Cumulative Ecological Impacts

The Tambaredjo polder area has been substantially transformed by human activities and is characterised by secondary marsh forest of low plant diversity compared to similar undisturbed habitats. The study area is not deemed sensitive with regards to ecosystems and floral biodiversity. Similarly, the secondary marsh forest found at the project site is expected to have relatively low fauna diversity and the study area is not deemed sensitive with regards to ecosystems and fauna.

Cumulative impacts, therefore, are mainly a consequence of prior agricultural activity and oil production, and the vegetation clearing required for the CSS project – up to 7 ha spread over ten well sites – will not have any meaningful cumulative effects.

The cumulative ecological impact in the study area is assessed to be of ***very low*** significance.

6.4.4 Management of Cumulative Impacts

The management of cumulative impacts will depend on the context in which the development is occurring, i.e. the impacts from other projects and natural drivers that affect the VECs, and the characteristics of the of the CSS project impacts. Since cumulative impacts result from the actions of multiple Staatsolie operations / departments, the responsibility for their management is collective.

6.5 Environmental Management and Monitoring Plan

It is critical that mechanisms are in place to ensure that the recommendations and mitigation measures contained in the ESIA Report are fully and effectively implemented. Typically, a customised management plan is the mechanism through which these measures are implemented.

The preparation of management plans is also consistent with the EA Guidelines (Annex 7) published by NIMOS, which require, *inter alia*, that ESIA reports should include:

(8) Proposed Mitigation Measures or an Environmental Management Plan (EMP);

(11) Follow Up & Monitoring Plan[17]; and

(12) Decommissioning Plan.

An EMMP (provided in Appendix A) has been developed by SRK as part of the Limited ESIA process. The objective of the EMMP is to set out the management and monitoring measures required to both minimise any potentially adverse environmental impacts and enhance the environmental benefits of the project. A further objective of the EMMP is to ensure that responsibilities and appropriate resources are efficiently allocated to implement the plan.

Management and monitoring measures have been developed from the recommendations and mitigation measures listed in the Limited ESIA Report. By formally documenting environmental management measures and commitments, the EMMP serves a vital role in ensuring that potential impacts of the project are minimised, and that the significance of those impacts is as predicted by the Limited ESIA process. The EMMP has been formatted so that it can be developed into a practical document for implementation on site and incorporated into tender documents where appropriate, and also contains environmental management and training requirements to implement the EMMP.

The appended EMMP is released to stakeholders for comment together with the Limited ESIA Report. It is important to recognise that management plans in general are living documents that will need to be periodically reviewed and updated even after their initial completion.

[17] Monitoring measures are recorded in the EMMP.

7 Conclusions and Recommendations

Staatsolie proposes to implement a CSS project in the Tambaredjo Oilfield to gauge the viability of the CSS process in light of challenges encountered during a previous pilot project, and to increase the extraction of oil that could cannot be otherwise extracted from Staatsolie's existing operations in Saramacca. In accordance with NIMOS's EA guidelines and screening conclusions, a Limited ESIA process has been undertaken for the project, and an EMMP compiled.

The Limited ESIA has examined the available project information and drawn on available (secondary) baseline data to identify and evaluate environmental (biophysical and socio-economic) impacts of the proposed CSS project. The Limited ESIA Report aims to inform decision-makers of the key considerations by providing an objective and comprehensive analysis of the potential impacts and benefits of the project and has created a platform for the formulation of mitigation measures to manage these impacts, presented in the appended EMMP, which should be read together with the Limited ESIA Report.

This chapter evaluates the impact of the proposed CSS project and presents the principal findings of the Limited ESIA. It further summarises the general conclusions that have been drawn from the Limited ESIA process and which should be considered in evaluating the project. It should be viewed as a supplement to the detailed assessment of individual impacts presented in Chapter 6.

7.1 Summarised Evaluation of Impacts

The evaluation is undertaken in the context of:

- The project information provided by the proponent;
- The assumptions made for this ESIA Report;
- The assumption that the recommended (essential) mitigation measures will be effectively implemented; and
- The input provided by specialists.

This evaluation aims to provide answers to a series of key questions posed as objectives at the outset of this report, which are repeated here:

- Assess in detail the environmental and socio-economic impacts that may result from the project;
- Identify environmental and social mitigation measures to address the impacts assessed; and
- Produce a Limited ESIA Report that will assist NIMOS's evaluation of the project.

The evaluation and the basis for the subsequent discussion are represented concisely in Table 7-1, which summarises the potentially significant impacts and their significance ratings before and after application of mitigation and/or optimisation measures.

Table 7-1: Summary of potential impacts of the CSS project

Potential negative impacts are shaded in reds, benefits are shaded in greens. Insignificant impacts have not been shaded. Only ***key (non-standard essential)*** *mitigation/optimisation measures are presented. Other management measures are presented in the ESMP.*

Impact	Significance rating		Key mitigation/optimisation measures
	Before mitigation/ optimisation	After mitigation/ optimisation	
Air quality: Impaired human health from increased ambient pollutant concentrations	Very Low	Insignificant	• Limit and phase vegetation clearance and the construction footprint to what is essential. • Reduce airborne dust through e.g. dampening dust-generating areas, roads and stockpiles with water. • Adopt appropriate technology to ensure power generating units meet appropriate standards and emission guidelines.
Noise: Increased noise levels along access roads	Very Low	Very Low	• None.
Surface water: Surface water contamination and abstraction	Very Low	Very Low	• Ensure produced water is treated before discharge.
Groundwater: Contamination of groundwater	Very Low	Insignificant	• Use non-toxic drilling fluids when drilling through freshwater aquifers. • Ensure that well casing and cementing meets best practice methods and Staatsolie standards to prevent thermal losses into the upper layers above the oil reservoir. • Manage injection pressures to ensure that steam is not chased / forced beyond the confines of the oil reservoir. • Monitor groundwater quality and temperature at water abstraction points. • Monitor the surrounding offset producers to verify whether the thermal flow (conductance) from steam injection is as predicted by design and models.
Ecology: Vegetation clearance and habitat loss	Very Low	Very Low	• Limit and phase vegetation clearance and the construction footprint to what is essential.
Socio-economic: Employment and impact on adjacent communities	Insignificant	Insignificant	• None.
Visual: Change in visual quality and sense of place	Insignificant	Insignificant	• None.
Traffic: Increased number of vehicles	Insignificant	Insignificant	• Schedule delivery of material transported by road to times that fall outside of rush hour(s); • Ensure that trucks transporting large equipment or hazardous material are clearly marked and accompanied by safety vehicles; and • Inform relevant authorities of special loads vehicles.

7.2 Principal Findings

The proposed CSS project will entail so-called triple bottom line costs and/or benefits. The triple bottom line reflects the three pillars of sustainability and concerns itself with environmental (taken to mean biophysical) sustainability, social equity and economic efficiency and is typically employed by companies seeking to report on their performance. The concept serves as a useful construct to frame the evaluation of the effects of the project.

The challenge for NIMOS is to consider a project which should aim to be sustainable in the long term, but which will probably entail trade-offs between social, environmental and economic costs and benefits. The trade-offs are documented in the report, which assesses environmental impacts and benefits and compares these to the No-Go alternative.

There are a number of minor or insignificant impacts associated with the CSS project. These impacts are not expected to be significant nor long-term and include socio-economic, visual and traffic impacts.

Relevant observations with regard to potentially more significant impact ratings, assuming mitigation measures are effectively implemented, as summarised in Table 7-1, are:

- The predicted **air quality** impacts due to combustion of fuel for the OTSG are expected to be *insignificant*, based on prior modelling of air quality impacts for the proposed Saramacca Power Plant and measured baseline concentration of pollutants in the region, which are very low.
- The predicted **surface water** impact due to contamination during construction as well as abstraction of water and discharge of treated effluent into the Saramacca River and affected portions of canals in the Tambaredjo Oilfield is deemed to be of *very low* significance. Produced water is treated prior to discharge and no impact on other users abstracting water from the Saramacca River is expected.
- The predicted **groundwater** impacts due contamination during construction and possible thermal alteration of the chemical characteristics of groundwater are *insignificant*. The vertical extent of the modelled thermal plume only extends into the base of the overlying sand layer and any minimal changes in the brackish and freshwater aquifers due to the CSS process are too low to effect thermal changes of groundwater chemistry.

Cumulative impacts may derive from existing oil production in the Tambaredjo Oilfield and associated discharge of produced water to the Saramacca River, and planned projects including Polymer Flooding and the proposed Saramacca Power Plant. Cumulative impacts include a reduction in surface water quality and habitat due to vegetation clearing. Possible cumulative impacts should be managed by appropriately treating effluent prior to discharge and minimising the construction footprint and vegetation clearing.

The No-Go alternative entails no change to the status *quo*, no CSS to extract additional oil, while current oil production in the Tambaredjo Oilfield continues while economically viable. This means that the CSS wells (and associated infrastructure) and water treatment plant are not constructed. The impacts associated with the CSS project are generally of very low significance and very small compared to the overall impact of oil production in the Tambaredjo Oilfield, while a successful CSS project would provide an opportunity to increase oil production. As such, the No-Go alternative is not preferred.

A number of mitigation and monitoring measures have been identified to avoid, minimise and manage potential environmental impacts associated with the proposed CSS project. These are further laid out in the EMMP.

7.3 Recommendations

The specific recommended mitigation and optimisation measures are presented in Chapter 6 and/or the EMMP, and key measures are summarised in Table 7-1 above. Staatsolie would need to implement these mitigation measures to demonstrate compliance and adherence to best practice.

Key recommendations, which are considered essential, are:

1. Implement the EMMP to guide design, construction, operation and decommissioning activities and to provide a framework for the ongoing assessment of environmental performance;
2. Ensure that well casing and cementing meets best practice methods and Staatsolie standards to prevent thermal losses into the upper layers above the oil reservoir;
3. Manage injection pressures to ensure that steam is not chased / forced beyond the confines of the oil reservoir;
4. Treat produced water before discharge;
5. Limit and phase vegetation clearance and the construction footprint to what is essential;
6. Monitor groundwater quality and temperature at water abstraction points;
7. Ensure that the appropriate personnel and sufficient resources are allocated to expedite implementation of the EMMP;
8. Ensure adequate response mechanisms are in place and corrective action is taken to address any instances of non-compliance with standard management measures or procedures;
9. Maintain lines of communication with the local communities in the vicinity of the Tambaredjo Oilfield. Ensure that local communities are aware of the Staatsolie grievance mechanism and how to utilise it. Maintain a complaints registry and investigation procedure to ensure that all grievances are adequately addressed; and
10. Adapt Staatsolie's Emergency Response Plan prior to commencing with the CSS project, setting out roles, responsibilities and procedures to address potential incidents during the CSS process.

8 Way Forward

This draft Limited ESIA Report has identified and assessed the potential impacts associated with the proposed Staatsolie CSS project at the Tambaredjo Oilfield. The draft Limited ESIA Report and draft EMMP are now available for public comment and we invite stakeholders to review the report and to participate in the stakeholder engagement process.

This draft Limited ESIA Report and draft EMMP are not final reports and may be amended based on comments received from stakeholders. An (English and Dutch) Non-Technical Summary (NTS) of the ESIA Report is also available to all stakeholders. Copies of the complete draft Limited ESIA Report and draft EMMP are available for viewing at the following venues:

- NIMOS; and
- Office of the Saramacca District Commissioner at Groningen.

An electronic version of the reports can also be accessed on SRK's website www.srk.co.za (via the 'Library' and 'Public Documents' links) and on Staatsolie's website www.staatsolie.com.

Stakeholders are invited to attend a **Public Meeting** where the information presented in the ESIA Report and EMMP will be discussed and additional concerns and issues can be raised with the environmental consultants and the project team.

The public meeting will be held on 28 November 2019.

The public is invited to review the draft Limited ESIA Report and draft EMMP and send written comment to:

SRK Consulting:		Staatsolie:
Contact persoon: **Sue Reuther**	of	Contact persoon: **Farina Ilahibaks**
E-mail: sreuther@srk.co.za		**E-mail:** FIlahibaks@staatsolie.com
Tel: + 27 21 659 3060 **Fax**: +27 21 685 7105		**Tel:** +597 375222 toestel 66761

Stakeholders will be provided with a 30-day comment period. For comments to be included in the Final Limited ESIA Report and EMMP, they must reach one of the above contact persons **no later than 13 December 2019.**

Once stakeholders have commented on the information presented in the draft Limited ESIA Report and draft EMMP, the Final Limited ESIA Report will be prepared and submitted to NIMOS for consideration. NIMOS will evaluate the environmental and social sustainability of the proposed project and advise Staatsolie of their decision.

Prepared by

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Reviewed by

Chris Dalgliesh
Partner

All data used as source material plus the text, tables, figures, and attachments of this document have been reviewed and prepared in accordance with generally accepted professional engineering and environmental practices.

9 References

AGI. (2018). *Petroleum and the Environment.* American Geosciences Institute. Retrieved July 2019, from https://www.americangeosciences.org/sites/default/files/AGI_PetroleumEnvironment_web.pdf

Airshed Planning Professionals. (2012). *Air Quality Impact Assessment for the Proposed Expansion of the Staatsolie Power Company Suriname (SPCS) Power Plant.*

Airshed Planning Professionals. (2018). *Air Quality Specialist Report for the Proposed Staatsolie Thermal Power Plant in Saramacca, Suriname.*

Al Kalbani, H., Al-Hadrami, H., Philip, G., Nesbit, J., Gil, L., & Gaillard, N. (2014). Treating Back Produced Polymer to Enable Use of Conventional Water Treatment Technologies. *Society of Petroleum Engineers*(SPE-169719-MS).

Al Manahali, M. (n.d.). *Appendix A Chamical and Gas Injection EOR methods*. Retrieved from https://www.ros.hw.ac.uk/bitstream/handle/10399/2822/AlManahaliMOS_0510_ipe%281%29.pdf?sequence=3&is%20Allowed=y

BAMM. (2013). *Acrylic Acid: A Summary of Safety and Handling.* 4th Edition Basic Acrylic Monomer Manufacturers, Inc. Retrieved Juy 2019, from http://msdssearch.dow.com/PublishedLiteratureDOWCOM/dh_0933/0901b80380933166.pdf?filepath=acrylates/pdfs/noreg/745-00006.pdf&fromPage=GetDoc

Beanlands, G., & Duinker, P. (1983). *An ecological framework for environmental impact assessment in Canada.* Dalhousie University, Halifax, NS, and Federal Environmental Assessment Review Office, Hull, QC. Institute for Resource and Environmental Studies.

Beychok, M. R. (2005). *Fundamentals of stack gas dispersion* (4th ed.). Published by the author.

Cairns, J. (2013). Environmental Stress. In S. Levin (Ed.), *Encyclopaedia of Biodiversity, second edition, Volume 7* (pp. 39-44). Waltham, MA: Academic Press.

Canadian Environmental Protection Agency. (n.d.). *Reference Guide: Addressing Cumulative Environmental Effects.* Retrieved August 2007, from http://www.ceaa-acee.gc.ca/013/0001/0008/ guide1_e.htm#6.2

Climate Watch . (2018). *Suriname.* Retrieved January 2019, from https://www.climatewatchdata.org/countries/SUR

Crocker, M. J. (1998). *Handbook of Acoustics.* (M. J. Crocker, Ed.) John Wiley & Sons, Inc.

De Vletter, D., Aleva, G., & Kroonenberg, S. (1998). Research into the Precambrian of Suriname. In T. Wong, D. de Vletter, L. Krook, J. Zonneveld, & A. van Loon, *The History of Earch Sciences in Suriname* (pp. 15-64). Royal Netherlands Academy of Arts and Sciences, Netherlands Institute of Applied Geoscience TNO.

dw.com. (2019, October 23). Retrieved from https://www.dw.com/en/oil-giants-face-shareholder-pressure-on-climate-emissions-greenhouse-gas-targets/a-48802418

EU. (2002). *European Union Risk Assessment Report ACRYLAMIDE.* CAS No: 79-06-1, EINECS No: 201-173-7. Retrieved July 2019, from https://echa.europa.eu/documents/10162/50218bf9-ba0f-4254-a0d9-d577a5504ca7

Greenhouse Gas Protocol. (2019). Retrieved from https://ghgprotocol.org/sites/default/files/standards_supporting/FAQ.pdf

Greenhouse Gas Protocol. (2019a). *Technical Guidance for Calculating Scope 3 Emissions.* Retrieved October 2019, from https://ghgprotocol.org/sites/default/files/standards/Scope3_Calculation_Guidance_0.pdf

IFC. (2007). *General Environmental, Health and Safety Guidelines.*

IFC. (2013). *Good Practice Handbook for Cumulative Impact Assessment and Management: Guidance for the Private Sector in Emerging Markets.* Retrieved July 2019, from https://www.ifc.org/wps/wcm/connect/58fb524c-3f82-462b-918f-0ca1af135334/IFC_GoodPracticeHandbook_CumulativeImpactAssessment.pdf?MOD=AJPERES&CVID=kbnYgI5

INCHEM. (1997). *Environmental Health Criteria 191. Acrylic Acid International Programme on Chemical Safety.* Retrieved July 2019, from http://www.inchem.org/documents/ehc/ehc/ehc191.htm

India GHG Programme. (2019). Retrieved from https://www.indiaghgp.org/explaining-scope-1-2-3

Kromosoeto, G. (2011). *Statement by the Minister of Labour, Technological Development and Environment of the Republic of Suriname on the ocassion of the joint High-level Segment of COP and CMP, United Nations Climate Change Conference, December 8, 2011, Durban, South Africa.* Retrieved October 2012, from http://unfccc.int/files/meetings/durban_nov_2011/statements/application/pdf/111208_cop17_hls_suriname.pdf

Logisticon Water Treatment. (2017). *Ultrafiltration Unit – Process Design.*

NEC, & Ilaco. (2016). *Water quality investigation at the Coppename and Suriname Rivers, Suriname. Report prepared for Amazon Resources.*

NIMOS. (2005). *Republic of Suriname: First National Communication to the United Nations Framework Convention on Climate Change.* Retrieved October 2012, from http://www.nimos.org/pdf/documenten/Klimaatrapport.pdf

NIMOS. (2018, December 18). Screening Cyclic Steam Stimulation Pilot Project, Ref: 18-497/GDN/ESA/ms.

Noordam, D. (2010). *Tambaredjo North-West Oil Field Development ESIA.*

Noordam, D. (2014). *Farmersland Production Development ESIA.*

Noordam, D. (2018). *Calcutta-North Appraisal Drilling ESIA.*

Noordam, D. (2018a). *Staatsolie Power Plant Project ESIA: Baseline Study and Impact Assessment: Water Quality.*

Noordam, D. (2018b). *Staatsolie Power Plant Project ESIA: Baseline Study and Impact Assessment: Flora and Fauna.*

RoS. (2016). *Office of the President of the Republic of Suriname: Second National Communication to the United Nations Framework Convention on Climate Change 2008-2012, edited by Dr. Haydi J. Berrenstein.* Retrieved January 2019, from https://unfccc.int/resource/docs/natc/surnc2.pdf

Sabajo, V. (2016). *Assessment of Groundwater Salinities in the Aquifers of the Coastal Plan in Suriname. A thesis submitted in partial fulfillment of the requirement for the degree of Master of Science in Mineral Geoscience.* Anton de Kom University, Department of Geology and Mining. .

SANS 10103. (2008). *The Measurement and Rating with Environemntal Noise with Respect to Annoyance and to Speech Communication.* Pretoria: Standards South Africa.

Social Solutions. (2018). *Social Impact Assessment For a Proposed Staatsolie Thermal Power Plant in Saramacca.*

Sojka, R., Biorneberg, D., Entry, J., Lentzl, R., & Orts, W. (2007). Polyacrylamide In Agriculture And Environmental Land Management. *Advances in Agronomy, 92*.

SRK Consulting. (2013). *Environmental and Social Impact Assessment for proposed 84 MW N.V.EBS Power Plant in Saramaccastraat, Paramaribo, Final ESIA Report. SRK Report Number 455230/5.*

SRK Consulting. (2019a). *ESIA for Proposed Staatsolie Power Plant in Saramacca, Suriname: Final ESIA Report.*

SRK Consulting. (2019b). *Limited ESIA for Polymer Flooding Enhanced Oil Recovery in the Tambaredjo Oilfield in Saramacca, Suriname.* Report 545842.

Transition Pathway Initiative. (2018). *Carbon Performance Assessment in Oil and Gas: Discussion paper.* Retrieved October 2019, from http://www.lse.ac.uk/GranthamInstitute/tpi/wp-content/uploads/2018/11/Oil-and-gas-discussion-paper.pdf

TÜV. (2007). *Verification Report on the Annual Emission Reports 2006 proposed by the Electricity Authority of Cyprus for its installations covered by the EU Emissions Trading Scheme.* TÜV Immissionsschutz und Energiesysteme GmbH. Retrieved October 2012, from http://www.eac.com.cy/GR/CorpSocialResponsibility/Documents/%CE%95%CE%BA%CF%80%CE%BF%CE%BC%CF%80%CE%AD%CF%82%20%CF%81%CF%8D%CF%80%CF%89%CE%BD%20Verification%20Report_Final.pdf

University of Calgary. (2019). Retrieved from https://energyeducation.ca/encyclopedia/Diesel_generator

US Army Corps of Engineers. (2001). *Water Resources Assessment of Suriname.* Retrieved October 2019, from http://www.swris.sr/wp-content/uploads/2017/12/Suriname-water-resources-assessment.pdf

US EPA. (2000). *AP42, 5th Edition, Volume 1, Chapter 3: Stationary Internal Combustion Sources, 3.1 Stationary Gas Turbines.*

Webster, T., & Roebuck, L. (2001). *Water Resources Assessment of Suriname.* Retrieved July 2019, from http://www.swris.sr/wp-content/uploads/2017/12/Suriname-water-resources-assessment.pdf

WHO. (2005). *WHO Air Quality Guidelines, Global Update.* World Health Organisation.

WHO. (2011). *Acrylamide in Drinking-water. Background document for development of WHO Guidelines for Drinking-water Quality. WHO/SDE/WSH/03.04/71/Rev/1.* Retrieved July 2019, from https://www.who.int/water_sanitation_health/dwq/chemicals/acrylamide.pdf

Appendices

Appendix A: Environmental Management and Monitoring Plan

SRK Report Distribution Record

Report No. 550457/1

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Name/Title	Company	Copy	Date	Authorised by
Monique Sewnath	NIMOS	1	12 Nov 2019	S. Reuther
District Commissioner	District Commissioner Saramacca	2	12 Nov 2019	S. Reuther
Ricardo Soekhlal	Staatsolie Maatschappij Suriname	3	12 Nov 2019	S. Reuther
Sue Reuther	SRK Consulting	PDF	12 Nov 2019	S. Reuther

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