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Power Plant Location Assessment Update

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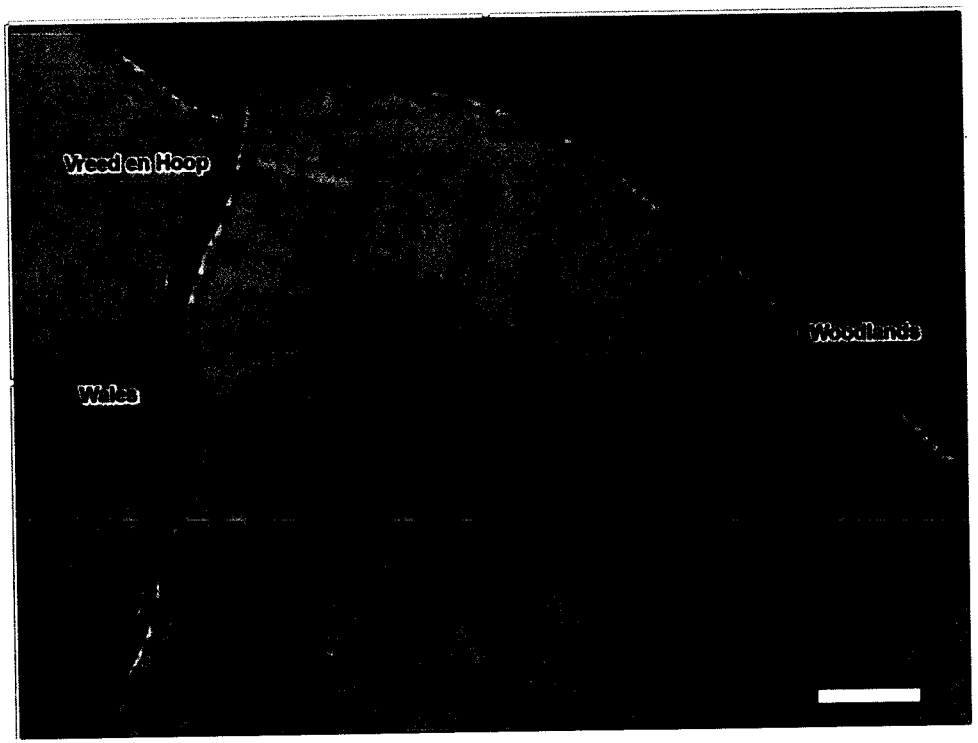
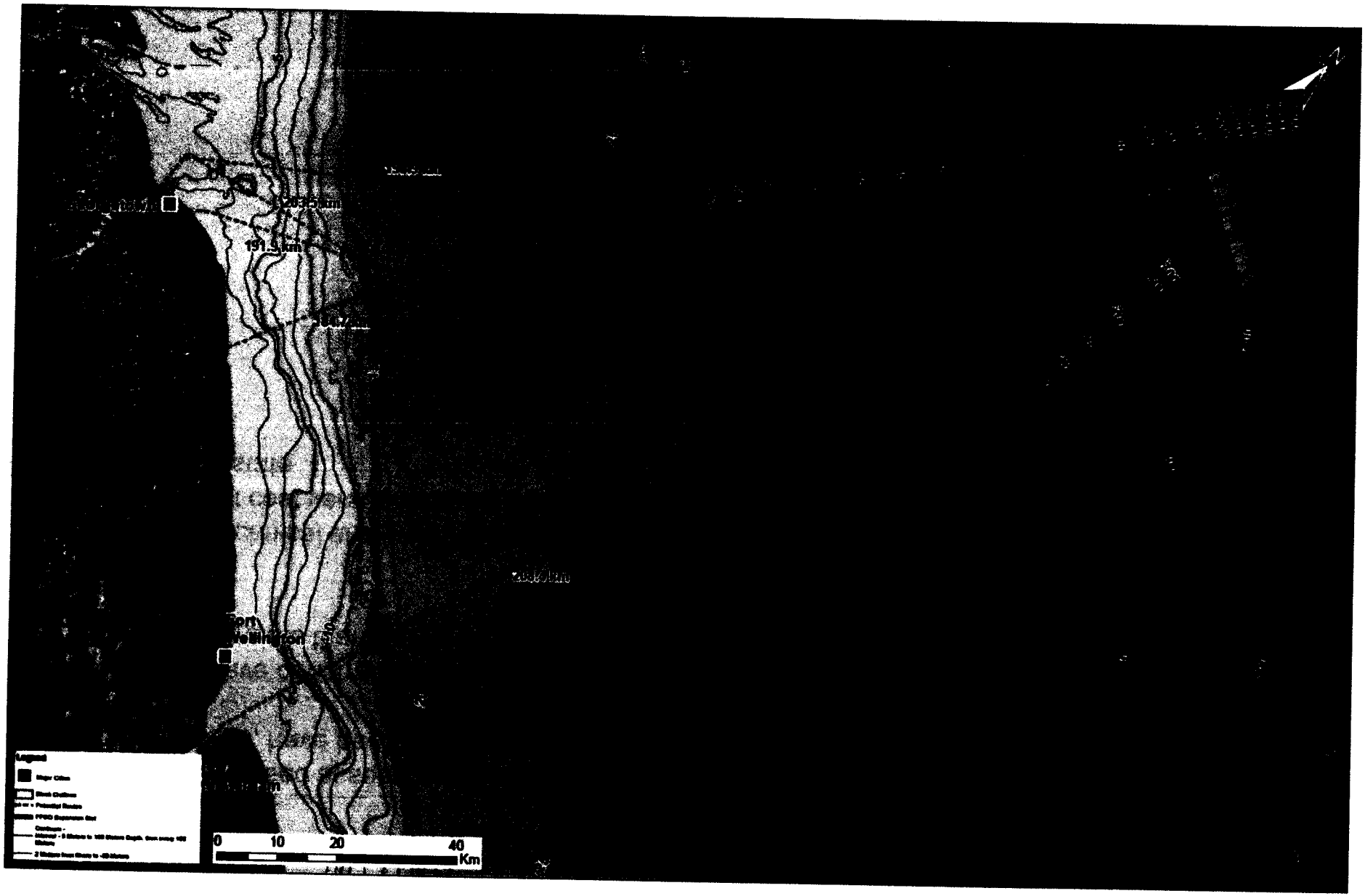
Contents

Summary

- 2 week field-based assessments of the Woodlands, Vreed-en-Hoop and its associated Wales Estate industrial area, have been completed
- Both sites have constraints but the original screening assessment that Woodlands offers fewer overall constraints than Vreed-en-Hoop has been confirmed, including loss of its elevation advantage
- Additional technical analysis has assessed Vreed-en-Hoop to have ~$72M US incremental development cost versus Woodlands, due to the requirement to connect power and gas supplies to the Wales Estate



Offshore Pipeline Routes



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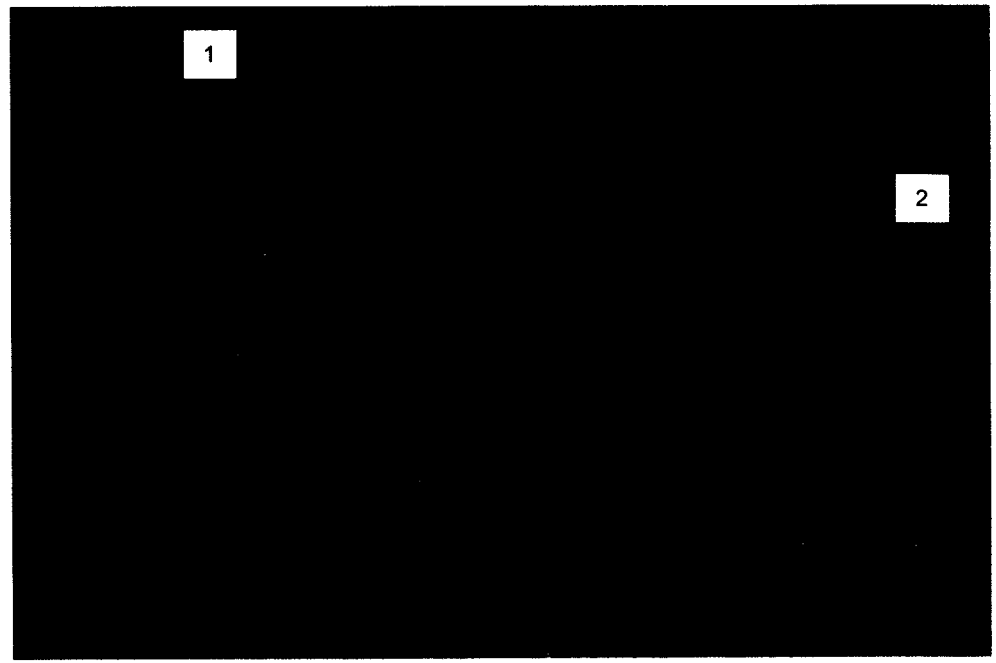
Vreed-en-Hoop Pipeline Landing Analysis

River Routing

- Pipeline landing directly up river to power plant site is not recommended due to technical complexity
- Restricted Marine Traffic During Installation
  - Shallow water installation by an anchored barge, restricting access to the ship channel (2-3 months)
  - High risk of marine traffic encroaching on the anchor lines
- Pipeline trenching
  - Pipeline would need to be buried 2-3 meters, possibly deeper if there are any plans to deepen the river
  - Trenching barge will likely struggle with currents at the mouth of the river
- Approach into the Plant
  - 90 degree turn from the river into the plan is a significant installation challenge



Alternative Routes:

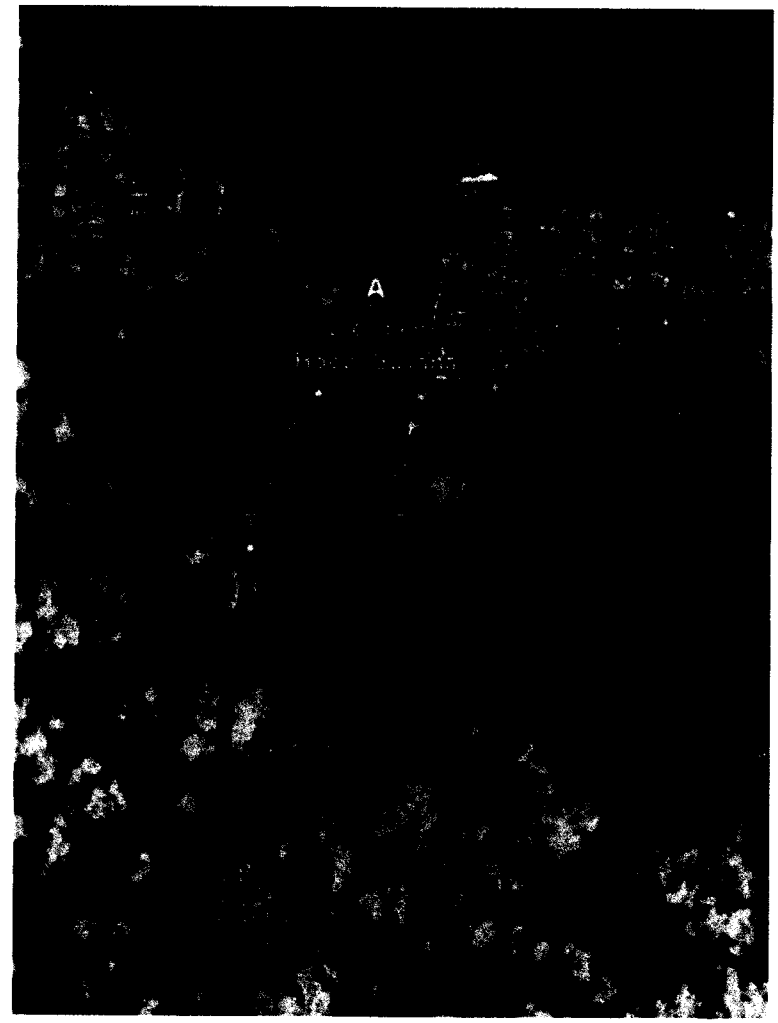
1. Further west and route pipeline through farmland to power plant location
   - Issues: land ownership; longer onshore pipeline; LPG freight
2. Direct to existing Vreed-en-Hoop power plant location
   - Issues: room for LPG plant; dense population area; still in proximity to river traffic; tunnel required with water crossing; barge likely required to support tunnel for ~3 weeks potentially impacting ferry service

Other Issues:

- Populated Area will increase the need for risk mitigations in the pipeline design, such as::
  - Increase pipe wall thickness.
  - Adopt more aggressive right-of-way monitoring program to ensure no encroachment onto pipeline route.
  - Increase burial depth of pipeline.
  - Place either warning tape or concrete slab above the pipeline to prevent third party contact with the line.

Vreed-en-Hoop Industrial Site (Wales)

- Vreed-en-Hoop power plant location's limited land footprint, requires pairing with a separate industrial zone
- Additional government infrastructure project required to integrate Wales location



Gas Pipeline and Transmission Routing

- Right of Way required for gas and electricity connections
- Transmission and pipeline routing directly up river to industrial site is not recommended due to technical complexity (including significant traffic disruption)
- EM has not sought to identify a specific Right of Way, but screening costs based on 15km onshore route
    - Cost estimates exclude any land acquisition
- Wales/Vreed-en-Hoop electricity infrastructure:
    - $15M transmission line
    - $10M 50 MVA new-build substation
- Wales/Vreed-en-Hoop gas infrastructure:
    - $25-35M low pressure gas pipeline

Site Capital Cost Comparison

- Pipeline capital costs provided during prior presentations to Ministers have not been revised
- Detailed engineering and associated data gathering for the selected location will occur subsequent to project confirmation of government wish to progress to negotiations

FPSO Modifications	10	
Riser FEED/EPC	30	32
Pipeline FEED	6	8
Pipeline - Materials	72	79
Pipeline - Installation	96	141
Project Team	19	25
Pre-Startup Operations	6	7
Insurance	5	6
Contingency	105	133
Withholding Tax (WHT)	28	37

Woodlands

- Cost estimates assumed a pipeline landing within the Clonbrook area, which is within sufficient proximity of the Woodlands location to be a direct equivalent
- Inclusion of the broader Woodlands footprint for industrial development does not impact costs as onward power/gas infrastructure requirements are negligible

Vreed-en-Hoop

- Capital costs associated with this site are estimated below
- Gas/power supplies to Wales estate will be the largest incremental cost

Scope Variable	Capital Cost SM US
Onshore Transmission to Kingston/Sophia	$0M*

* Assuming overhead high-pylon connection to Kingston (additional cost if submarine power cable)

- Vreed-en-Hoop estimates, if entirely capitalized as a cost of power generation would be +$0.7 c/kWh versus Woodlands

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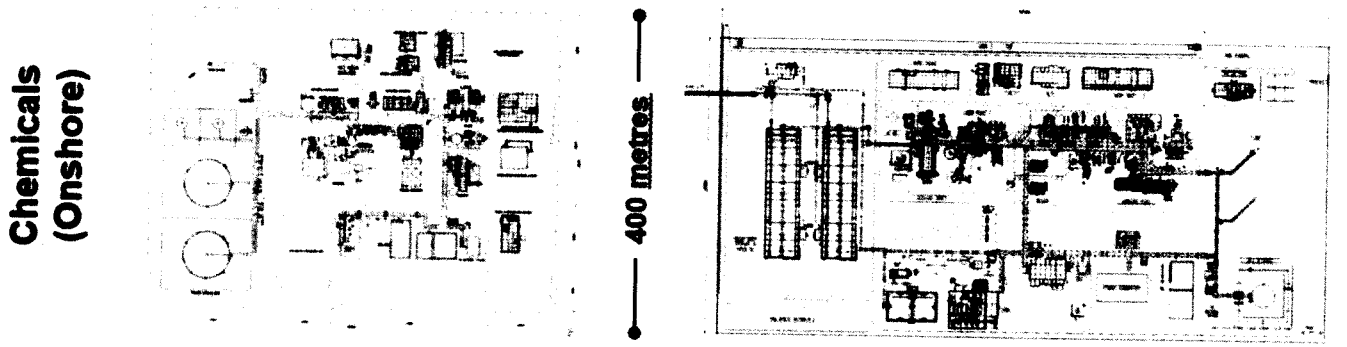
Gas Industry Considerations

- ExxonMobil has progressed feasibility studies for the potential commercialization of gas volumes in the event future discoveries identify suitable gas supplies above gas-to-power requirements
- Analysis has highlighted that while economics are challenged, requiring incentives, methanol and urea (fertilizer) producing large-scale industrial facilities appear to be the more likely viable foundation industries for investors
  - $1-2B+ US per facility; 15+ years gas supply; world-scale petrochemicals with significant export market focus
  - Pipeline landing analysis has not been based on suitability for these industries needs



Methanol: 3000T/d (85 Mcfd) **Urea: 3500T/d (77Mcfd)**

Assumptions utilized for viability screening

- **Methanol:** export vessels require deep water draft; export pipeline connected to offshore loading buoy in deeper water appears to provide a viable Guyana coastline export solution (13km offshore line utilized in Brunei)
- **Urea:** granular product with viable road-based sales domestically and potentially to immediate neighbouring countries; screening assessment includes construction of extended jetty and loading berths for direct regional exports via 5000 DWT vessels requiring 3-6M water depth

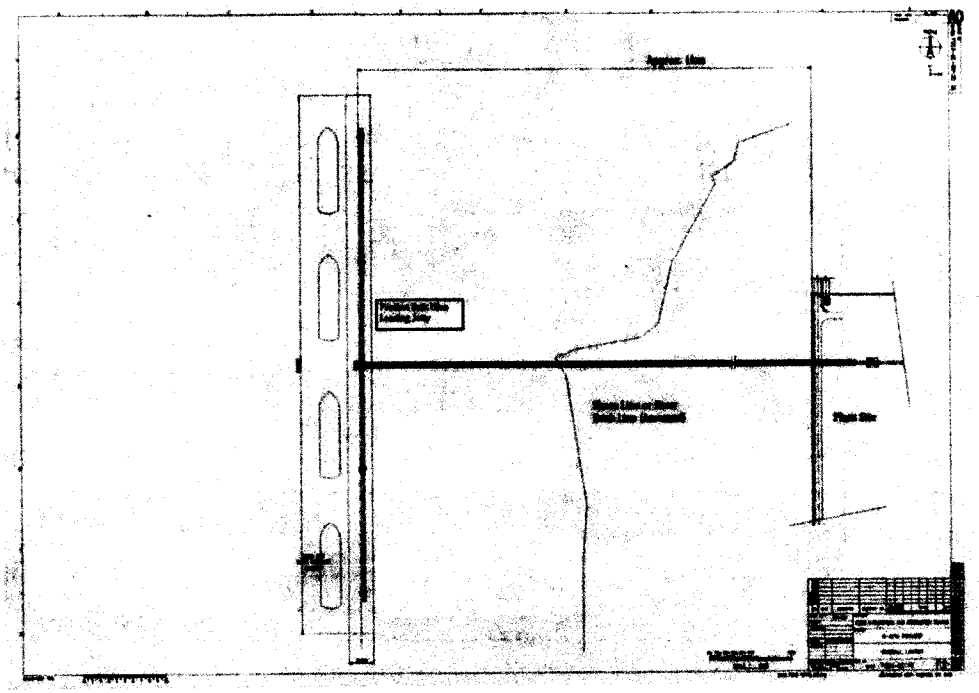
Observations

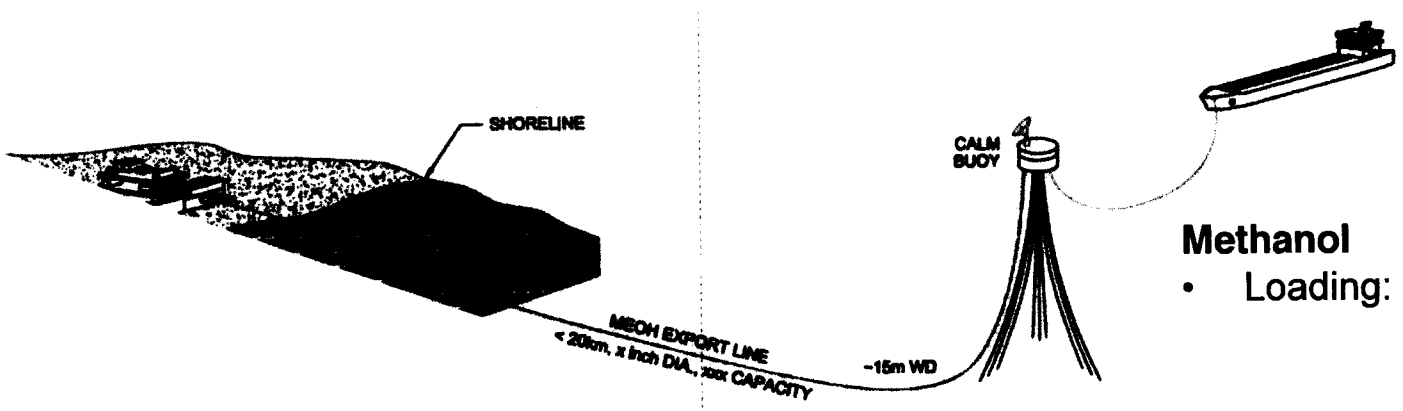
- Woodlands and Vreed-en-Hoop (Wales) locations will have challenges with these concepts that will require full assessment once gas supply has been identified; optimizations with existing Port facilities have not been assessed
  - Woodlands: direct coastal access for buoy concept; water depth issues for urea concept
  - Vreed-en-Hoop (Wales): bridge location versus export traffic; not on coast for buoy concept; potential water depth issues for urea concept

Gas Industry Export Concepts

Urea

- Loading: Max. 1200 tons/hour x 2
- Berth: Four berths
- Carrier: Max 5,000 DWT vessel
  <6m draft





Methanol

- Loading: Pipe to offshore Catenary Anchor Leg Mooring (CALM) Buoy in ~15m water depth
- Carrier: Up to 50,000 DWT vessel
  Up to ~10m draft

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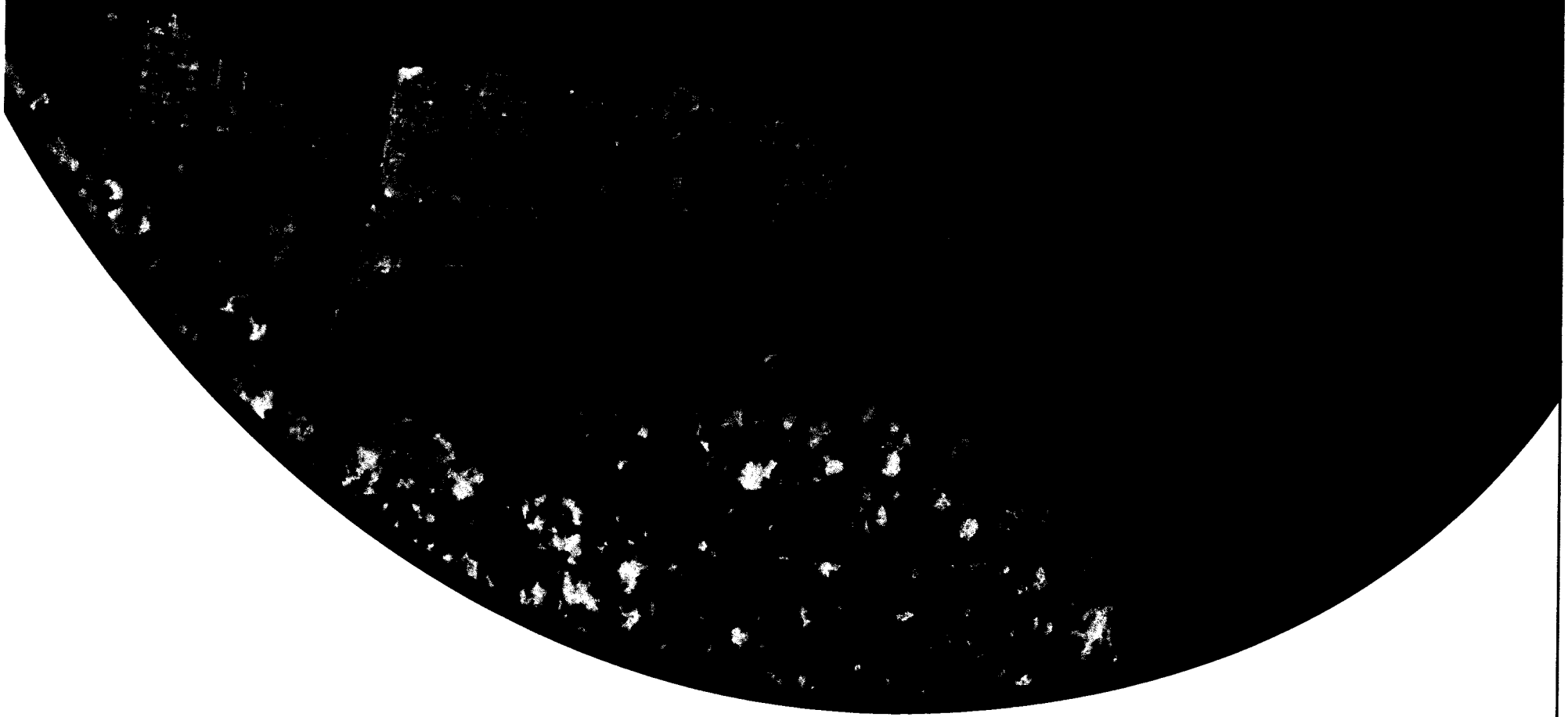
Power Plant and Natural Gas Plant Site Screening Assessment



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Introduction

- Two sites (Woodlands and Vreed en Hoop) were evaluated for the primary NGL/power plant development project:
  - A secondary site called the Wales site was evaluated should additional land beyond the Vreed En Hoop site be required in West Bank Demerara to accommodate industrial development.

- A preliminary analysis using basic geospatial analysis supplemented by field reconnaissance was undertaken for **four categories** of constraint: Surrounding Land Use, Biodiversity, Social/Cultural and Technical.

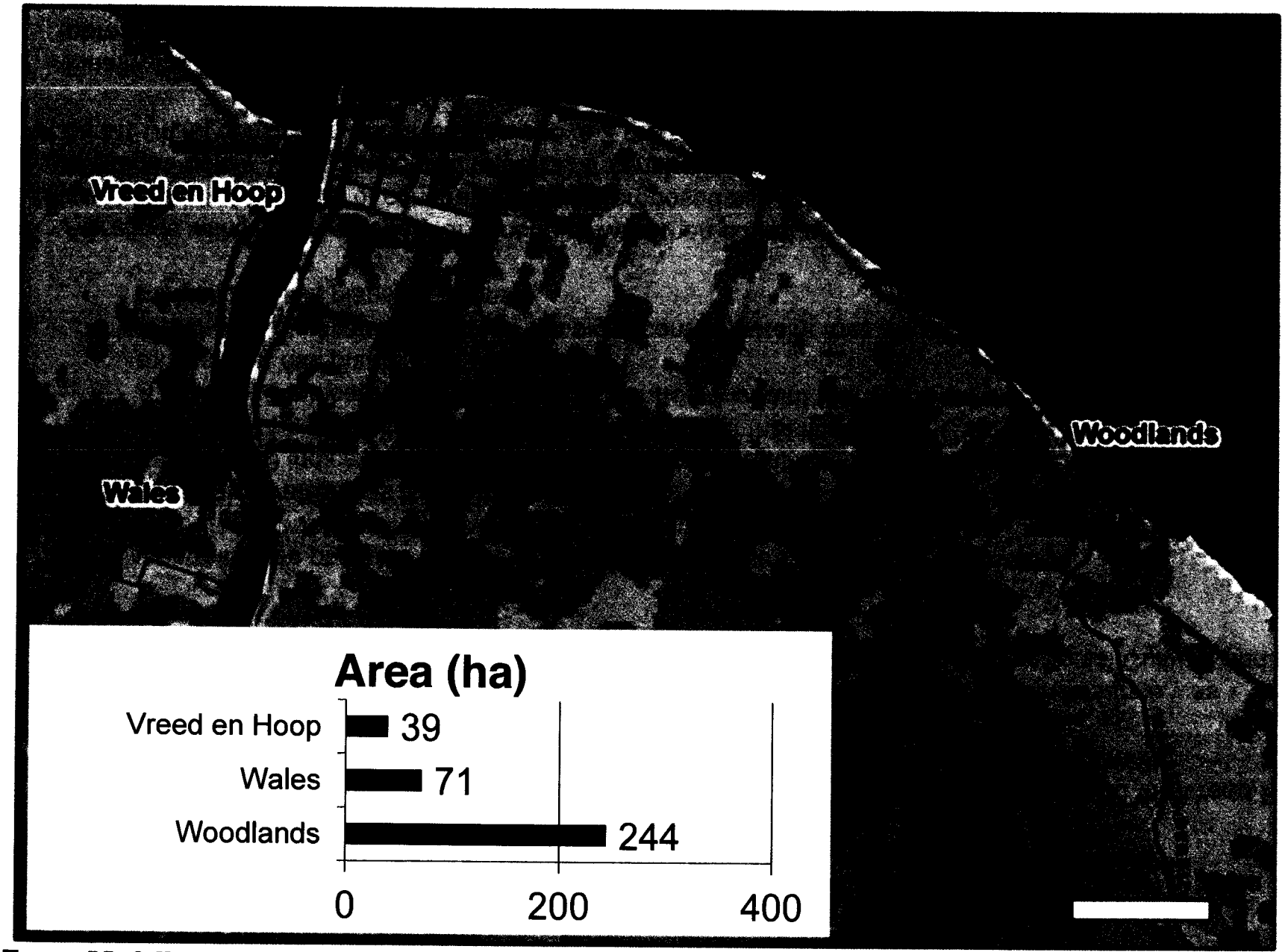
- Each constraint was provided a value (relevant to the constraint being measured).

- Each **constraint value** was then rated on a scale of 0 to 3.
  - A rating of 0 indicates that there is no known constraint within the proposed site;
  - A rating of 1 indicates that there is a constraint, but that it is limited;
  - A rating of 2 indicates that there is a moderate constraint that will require a modest amount of mitigations, risk planning or costs; and
  - A rating of 3 indicates that there is a significant constraint that will require a substantial amount of mitigations, risk planning or costs.

- All ratings within each category of constraint were then added up and averaged. This allows for a quick assessment of the level of constraint for each proposed site within each category of constraint. Averages below 1 are considered to be **LOW** constraint; averages between 1 and 2 are considered to be **MEDIUM** constraint; and averages above 2 are considered to be **HIGH** constraint.

- Finally, the ratings for all categories of constraint were combined for each of the proposed sites. The **combined constraint rating** allows for a comprehensive assessment of constraints across all categories.

Overview: Sites Evaluated



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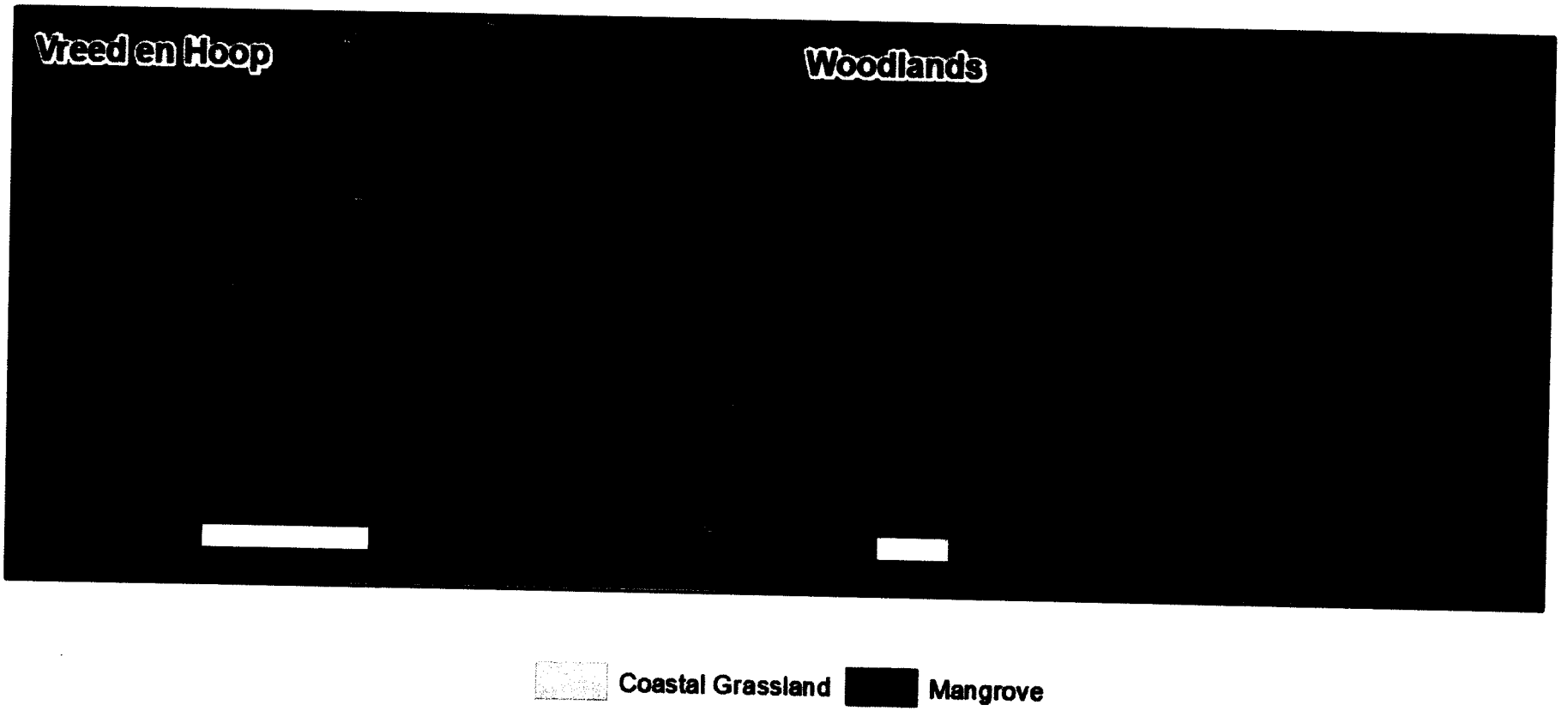
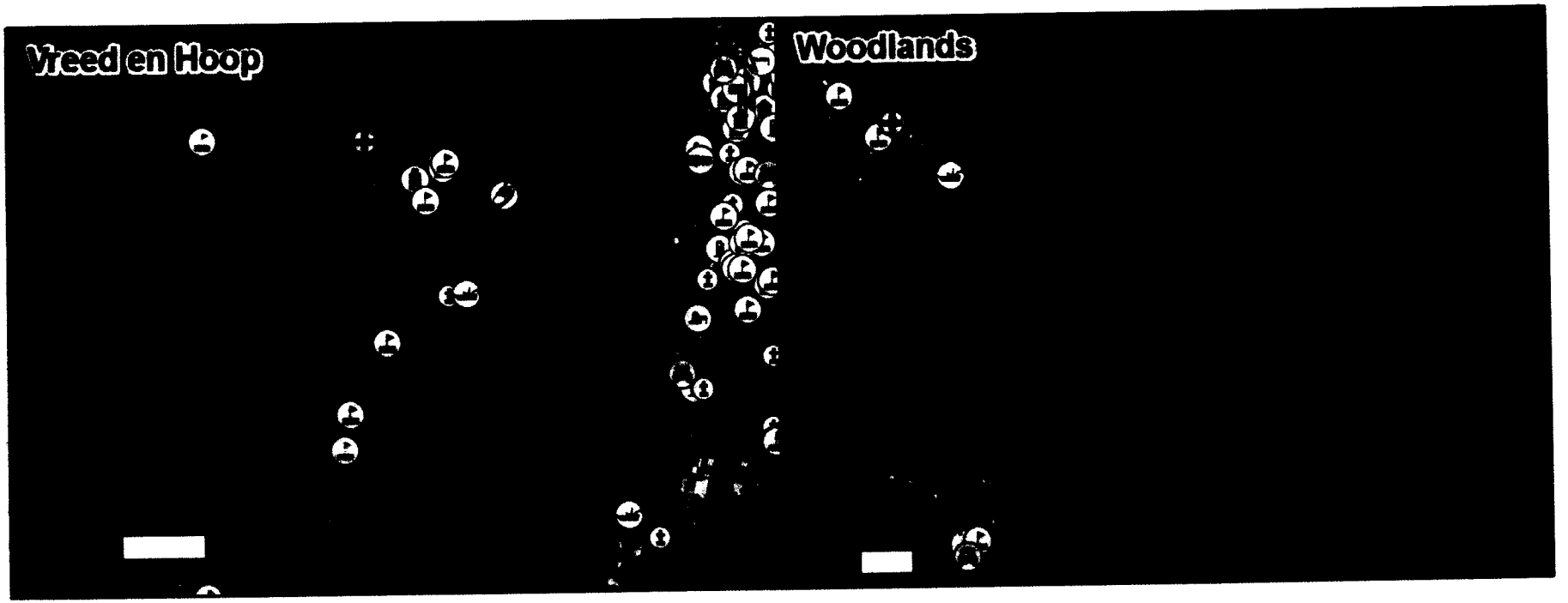
Landcover Comparison



Surrounding Landuse Comparison



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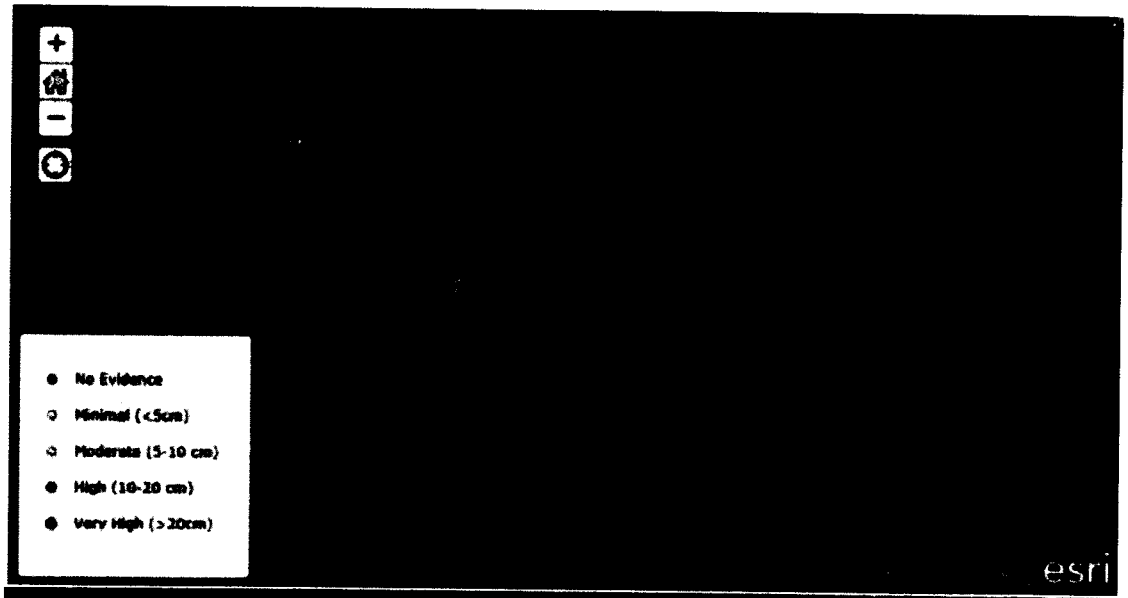
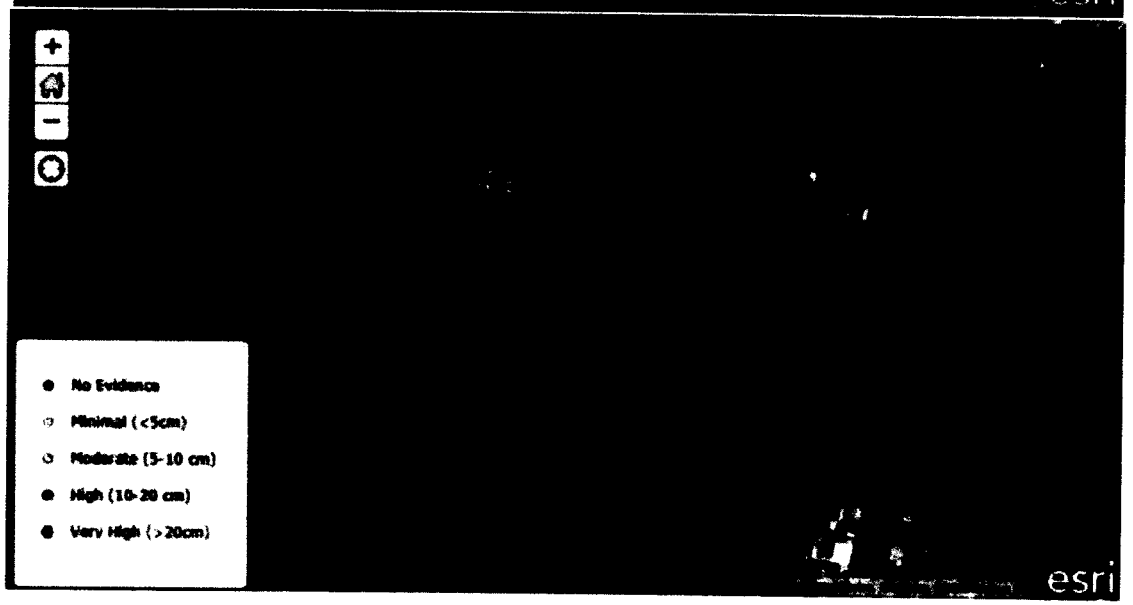
Evidence of Tidal Inundation

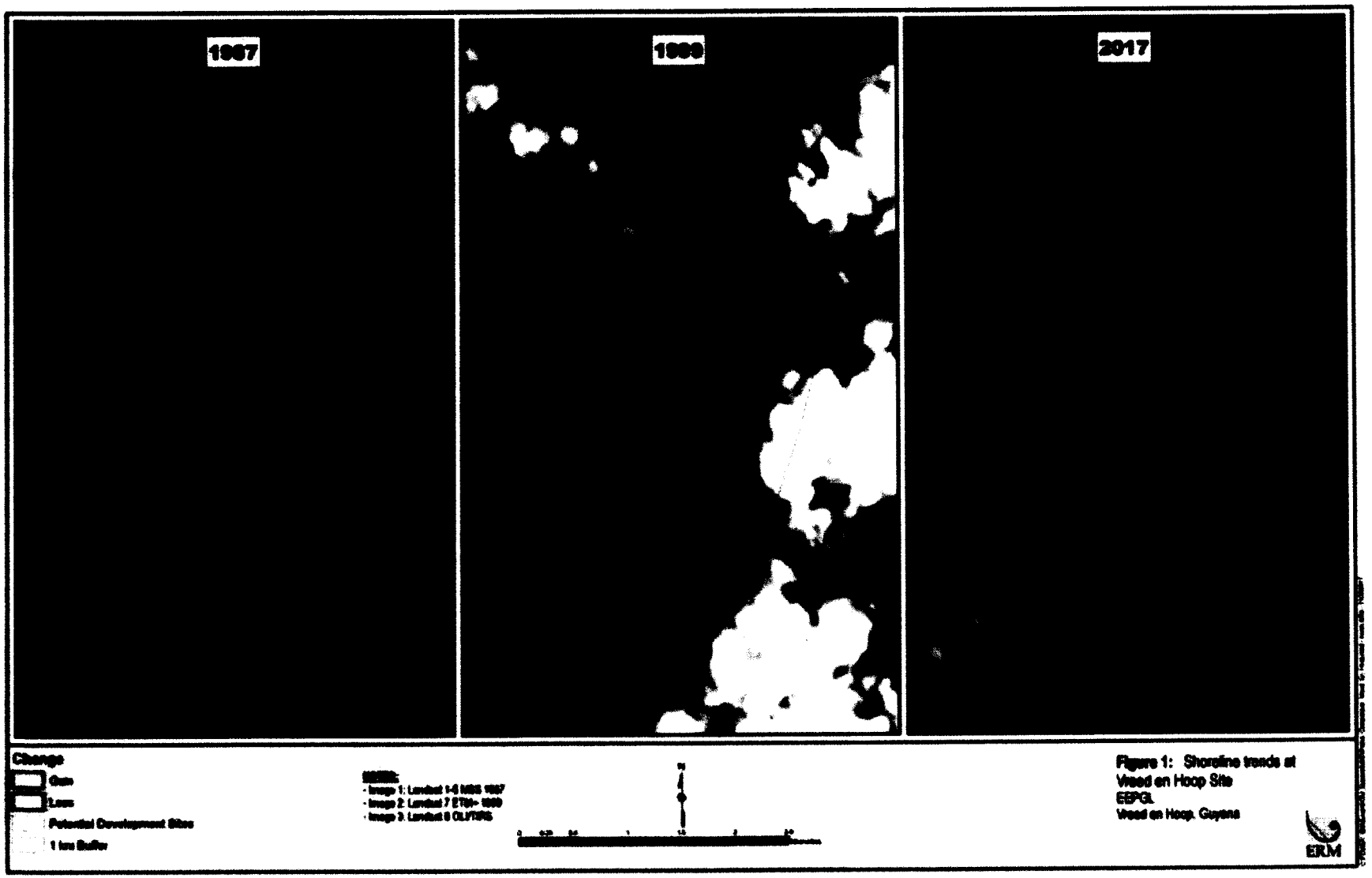


Evidence of Tidal Inundation observed at the Woodlands Site



Evidence of Tidal Inundation observed at the Vreed-En-Hoop Site

Shoreline Stability Assessment: Vreed en Hoop



Historic Landsat satellite imagery from NASA indicates that over the past 20 years the shoreline within the fenceline of Vreed en Hoop has expanded, while adjacent areas appear to have both expanded and eroded during this period.

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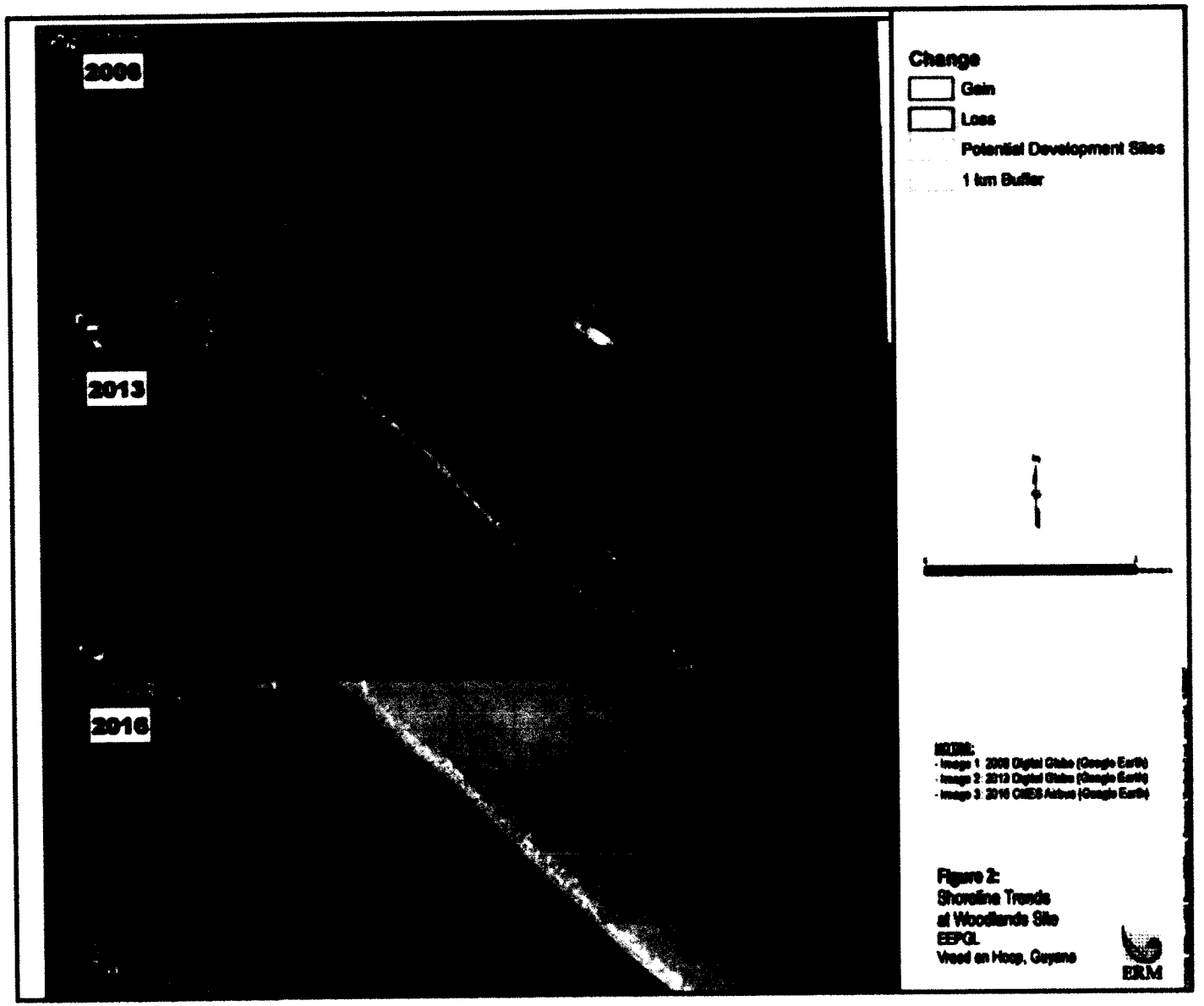
Shoreline Stability Assessment: Woodlands



Landsat satellite Imagery from NASA indicates that over the past 10 years the shoreline within the fenceline of Woodlands has experienced periods of expansion and erosion. This suggests that the shoreline stability of the Woodlands site is somewhat less than at Vreed en Hoop.

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Surrounding Landuse and Biodiversity Constraint Categories

																	LANDUSE CONSTRAINT RATING TOTAL	LANDUSE CONSTRAINT RATING AVERAGE
	Value	**Rating**	*Value*	**Rating**	*Value*	**Rating**	*Value*	**Rating**	*Value*	**Rating**	*Value*	**Rating**	*Value*	**Rating**	*Value*	**Rating**		
Woodlands	*Yes*	**1**	*1*	**1**	*0*	**0**	*0*	**0**	*0*	**0**	*1*	**1**	*Large*	**3**	*Low*	**1**	**7**	
Vreed en Hoop	*Yes*	**3**	*7*	**3**	*1*	**1**	*1*	**1**	*1*	**1**	*1*	**1**	*Medium*	**3**	*High*	**3**	**16**	

													BIODIVERSITY CONSTRAINT RATING TOTAL	BIODIVERSITY CONSTRAINT RATING AVERAGE
	Value	**Rating**	*Value*	**Rating**	*Value*	**Rating**	*Value*	**Rating**	*Value*	**Rating**	*Value*	**Rating**		
Woodlands	*229 ha*	**2**	*16 ha*	**0**	*Yes*	**3**	*High*	**3**	*No*	**0**	Very High	**3**	**11**	
Vreed en Hoop	*39 ha*	**2**	*0 ha*	**0**	*Yes*	**3**	*Moderate*	**2**	*No*	**0**	High	**2**	**9**	

[1]"The 16 ha of coastal grassland at the site would not be impacted by development of either a gas plant or power plant because site disturbance would be concentrated in the western portion of the site, so its presence would not constrain development at the site

[2]"Net Useable Area" moved from this location in the draft version to Technical Constraint Category in this version because net useable area is not entirely driven by biodiversity concerns. .

[3]Some areas of mangroves at the Woodlands site are mature and contain old trees and standing dead trees. The presence of these trees reduces the average vegetative health of the mangrove trees within the stand, but increases the habitat value of the site for cavity-dependent wildlife and provides opportunity for vegetative regeneration in gaps left by dead trees. This category was changed from "'Mangrove Health" to "Mangrove Quality" to reflect the greater relative value of the mature forest community at the Woodlands site compared to the younger community at the Vreed en Hoop site.

- *Proposed sites with <u>lower constraint</u> ratings are <u>more favorable</u>.*
- *Proposed sites with <u>higher constraint</u> values are <u>less favorable</u>.*

Avg. Rating <1
Avg. Rating 1-2
Avg Rating >2

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Social/Cultural Constraint Categories

Location	# of cultural/ archaeological properties within 1 km?		# of Amerindian Communities within 5 km		# of Protected Areas within 5 km of Facility		Sensitivity to Project-related traffic[1]		Sensitivity of ecosystem services[2]		SOCIAL/ CULTURAL CONSTRAINT RATING TOTAL	SOCIAL/ CULTURAL CONSTRAINT RATING
	Value	**Rating**	*Value*	**Rating**	*Value*	**Rating**	*Value*	**Rating**	*Value*	**Rating**		
Woodlands	--	--	*0*	**0**	*0*	**0**	Low	**1**	Very High	**3**	**4**	
Vreed en Hoop	--	--	*0*	**0**	*0*	**0**	High	**3**	Moderate	**2**	**5**	

*Could constrain either site, but not factored into assessment because no reliable data is available at this time.

[1]*Traffic related sensitivity was rated on the basis of existing congestion in the area immediately surrounding the site, the effect that traffic would have on a gas or power plant, and the effect that gas plant- or power plant-related traffic would have on the host community. Vreed-en-Hoop received a higher (more constrained) score because it is adjacent to a transportation hub (the Vreed -en-Hoop ferry stelling) and existing mixed-use development Both of which contribute to traffic congestion in the surrounding area. Additional development in this area would both exacerbate existing traffic-related impacts on the community and be affected by the existing traffic. The Woodlands site is located in a largely agricultural setting with comparatively few traffic-related constraints.*

[2]*"Ecosystem services are the social, economic, and cultural benefits conferred on a community by the ecosystems in which they are located. Ecosystem services emphasize the value of people's access to a resource, so they are not equivalent to but are rather derived from natural resources (e.g.; biodiversity, air quality, water quality).*

- *Proposed sites with lower constraint ratings are more favorable.*
- *Proposed sites with higher constraint values are less favorable.*

Avg. Rating <1
Avg. Rating 1-2
Avg Rating >2

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Technical Constraint Categories

Location	Linear Distance to Main Georgetown Substation		Requires River Crossing of Transmission Line?		Risk from River Dredging		Expansion Potential		Feasibility of Thermal Discharge		Water Quality		Ease of Access	
	Value	**Rating**	*Value*	**Rating**	*Value*	**Rating**	*Value*	**Rating**	*Value*	**Rating**	*Value*	**Rating**	*Value*	**Rating**
Woodlands	*28.6 km*	**3**	*No*	**0**	*None*	**0**	*Significant*	**0**	*Salt Water*	**2**	*Salt Water*	**2**	**Difficult**	**3**
Vreed en Hoop	*2.9 km*	**1**	*Yes*	**2**	*Low*	**1**	*Limited*	**2**	*Brackish*	**3***	*Brackish*	**2**	**Medium**	**2**

- *Proposed sites with lower constraint ratings are more favorable.*
- *Proposed sites with higher constraint values are less favorable.*

**: The constraint could be "3" depending on the river flows and downstream users. A thermal assessment to evaluate the thermal plume and impacts to other users will help clarify this constraint.*

Avg. Rating <1
Avg. Rating 1-2
Avg Rating >2

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Technical Constraint Categories (continued)

Location	Existing Sea Walls		Area below 2.5 m above sea level (preliminary flood risk assessment)[1]		Net Useable Area (is the site big enough for the planned development, without impacting mangroves or other protected habitats?)		Coastal Erosion Potential (y/n Fetchlim)		TECHNICAL CONSTRAINT RATING TOTAL	TECHNICAL CONSTRAINT RATING AVERAGE
	Value	**Rating**	*Value*	**Rating**	*Value*	**Rating**	*Value*	**Rating**		
Woodlands	*No*	**3**	*244 ha (100%)*	**3**	*18 ha*	**3**	Moderate	**2**	**21**	
Vreed en Hoop	*No*	**3**	*39 ha (100%)*	**3**	*0 ha*	**3**	**Low**	**1**	**23**	

[1]The initial desktop analysis indicated relatively high ground (>10 masl) at both sites based on low resolution digitally-modelled "near bare earth" elevation data, but the field verification exercise demonstrated that elevations at both sites were actually much lower (estimated to be <2.5 masl with evidence of regular tidal inundation at both sites. The largest error in the digital elevation data was in the western portion of the Woodlands site, which was verified in the field as a mature mangrove swamp.

Combined Constraints

Location	Surrounding Landuse Constraint Rating		Biodiversity Constraint Rating		Social/Cultural Constraint Rating		Technical Constraint Rating		COMBINED CONSTRAINT RATING	
	Total	Avg.	Total	Avg.	Total	Avg.	Total	Avg.	Total	Avg.*
Woodlands	7		11		4		21		43	
Vreed en Hoop	16		9		5		23		53	

*:The Combined Constraint Rating Average is an average of each category average..

- Proposed sites with lower constraint ratings are more favorable.
- Proposed sites with higher constraint values are less favorable.

Avg. Rating <1
Avg. Rating 1-2
Avg Rating >2

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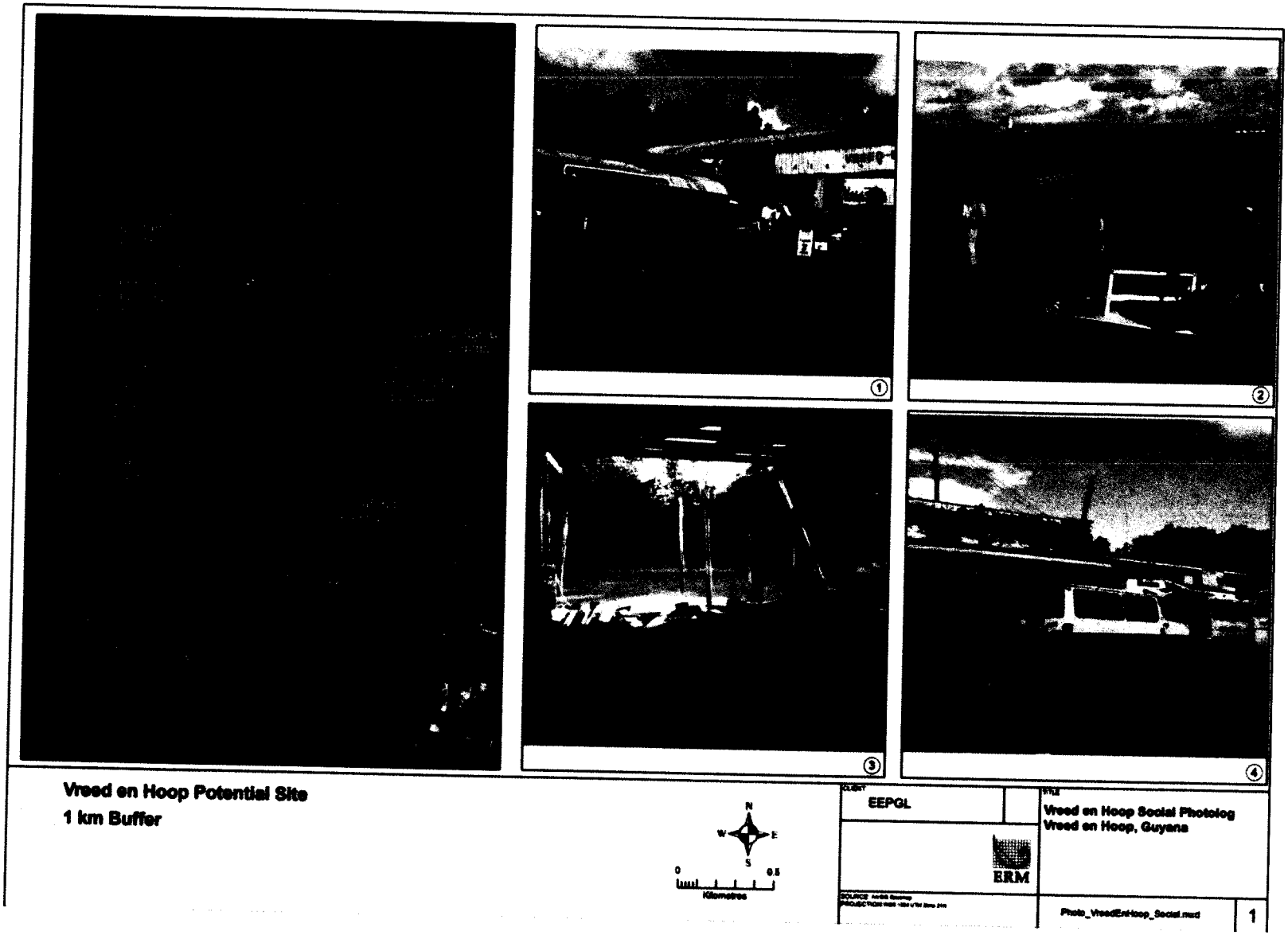
Conclusions

- Both the Vreed En Hoop and Woodlands site have significant constraints.

- **Concerning Surrounding Landuse**: The Vreed en Hoop site is slightly more constrained than the Woodlands site.
- **Concerning Biodiversity:** The Woodlands is more constrained than the Vreed en Hoop site. Both have significant constraints related to mangroves, but the mangrove at the Woodlands is more biodiverse and of higher conservation value than the Vreed En Hoop mangrove.
- **Concerning Social/Culture:** The Vreed en Hoop site is more constrained than the Woodlands site.
- **Concerning Technical:** The Vreed en Hoop site is more constrained than the Woodlands site.

Land Use


Vreed en Hoop Potential Site
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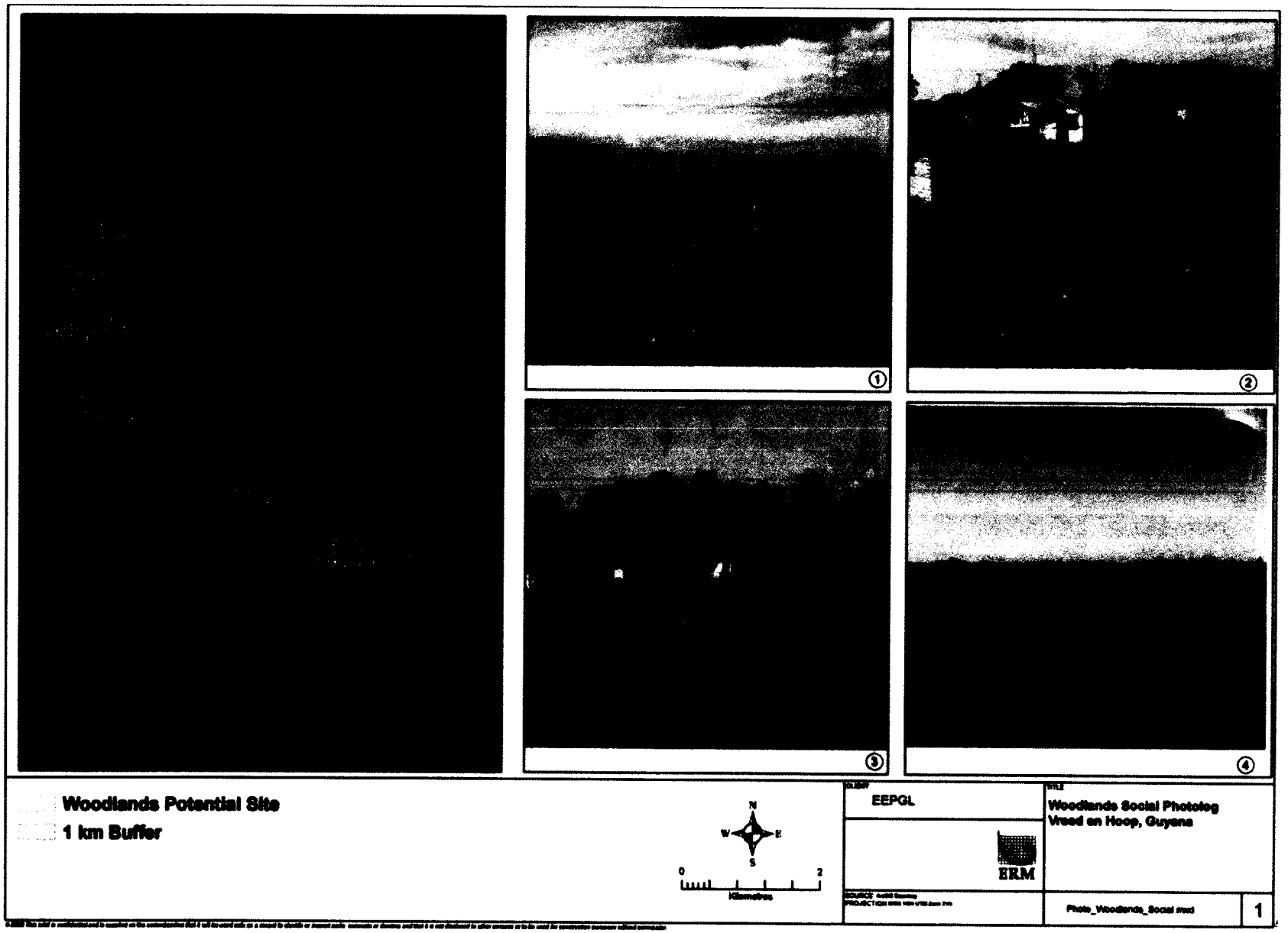
Land Use


Woodlands Potential Site
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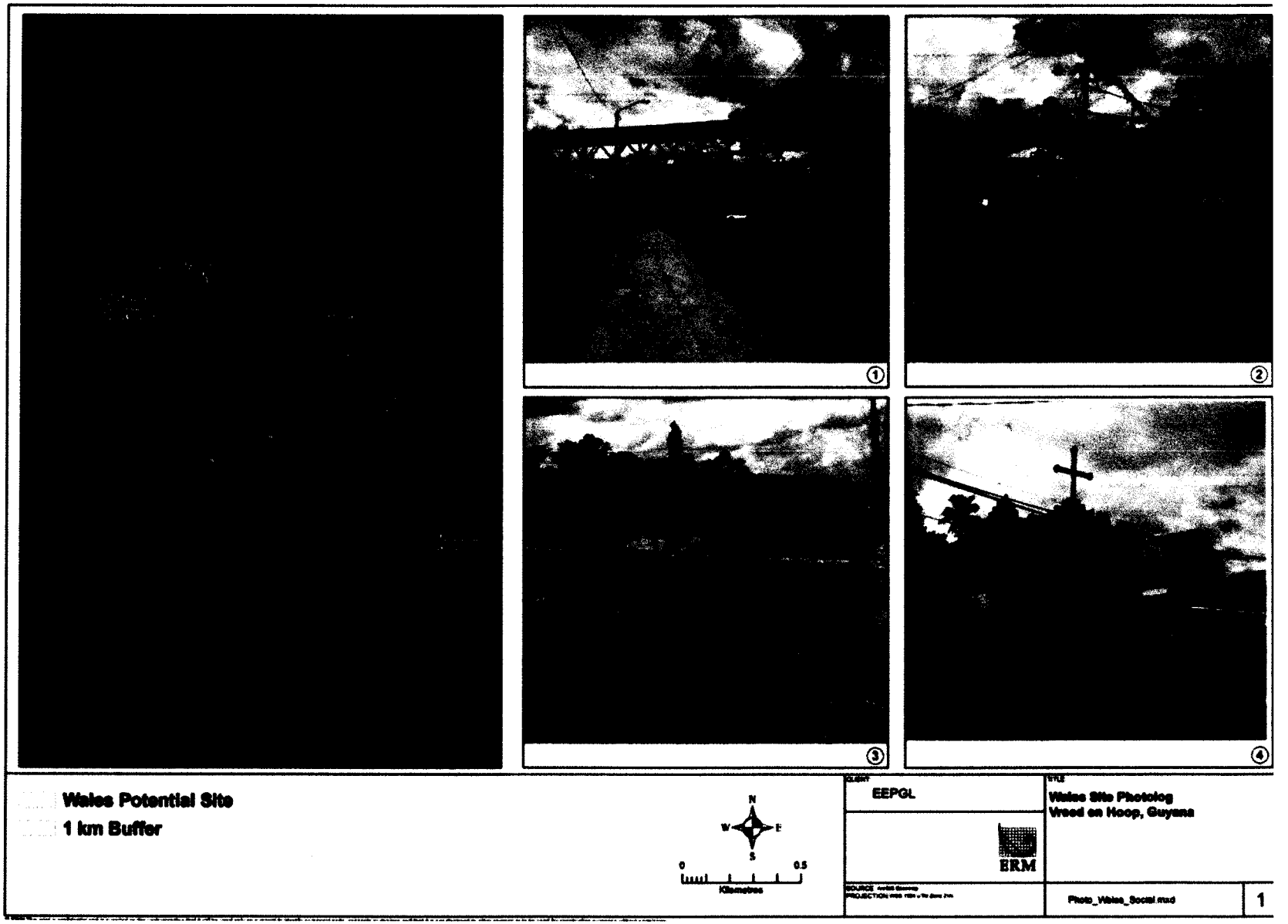
Land Use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MATRIX OF PROPOSED & PENDING STUDIES: 2018

Entity	Financing Gap	Study	Comment/Timeline	Summary of Study
IDB	$21 Million	Update of the Generation Expansion Study (2017)	**Completion by March 2018.** This study is expected to be funded under the GEF programme; however, subject to the allocated budget, additional funding from another study may be required. *The $21 Million may therefore not be applicable for this Study.	In 2014, the Inter-American Development Bank (IADB) commissioned an Initial Study on System Expansion of the Generation and Transmission System of Guyana with the objective of developing guidelines for the most adequate infrastructure for power generation and transmission in Guyana. In 2015, this study was updated at the request of the Government of Guyana to incorporate and consider the projected evolution of the national power system in light of regional initiatives. Having regard to the recent commercial discoveries, an update of the study is required. The purpose of this requested update is to conduct a review and further analyze the further development of Renewable Energy in the country when the current expansion plan may change as a result of the potential use of domestic natural gas in electricity generation. The necessity of this update is further emphasized in the context of the future National Renewable Energy Strategy having considered the promotion of RETs, increasing the quality of energy access and reduction of Greenhouse Gas emissions.

MATRIX OF PROPOSED & PENDING STUDIES: 2018

Entity	Financing Stem	Study	Comment/Timeline	Summary of Study
		Policy Guidelines	**Subject to completion and submission to Minister (mid-January 2018 for submission)**	This document is intended to serve as a guideline under which the diversification of the energy matrix can be addressed through a programmatic approach: energy security and affordability of the electricity supply, universal electricity access for the good life, development of the regulatory and organizational framework and capacity strengthening of the GoG electricity sector institutions. Accordingly, any projects that may be subsumed under the programme heads may be eligible for funding.
		Gas to Power Feasibility Analysis	**Mid January 2018** For review and consideration.	This proposed study is intended to narrow focus on the future use of natural gas, LPG and suitability of natural gas for power generation and associated infrastructure, specifically dual fuel generators. Proposed TOR will elaborate further on said objectives.
		Review of the Regulatory Framework	TOR is under consideration and discussion and may be better considered post Update of the Generation Expansion Study.	

MATRIX OF PROPOSED & PENDING STUDIES: 2018

Entity	Financing Sum	Study	Comment/Timeline	Summary of Study
World Bank	$15-20 Million	Needs Assessment Costing: a) **Support to contract negotiations/ monitoring** (includes elaboration of a fiscal/ economic model of the project(s), provision of reservoir engineering, project development and construction engineering, etc.) b) **Institutional assessment, institutional strengthening and capacity building** (including setting up of Petroleum Commission and National Data Repository for oil/gas sector, etc., support to the Ministry of Natural Resources, Ministry of Finance, etc.) **c) Policy, Strategy, Action Plan and Le-**	a) **US$5 million:** Ministry of Natural Resources b) **US$8-13 million:** Ministry of Natural Resources/ Ministry of Finance c) **US$2 million:** Ministry of Natural Resources	

MATRIX OF PROPOSED & PENDING STUDIES: 2018

Entity	Financing Sum	Study	Comment/Timeline	Summary of Study
Mitsubishi/ Chiyoda	Free	Energy Master Plan for the Emerging Oil and Gas Sector in Guyana	**Submission by March 2018** The company has indicated that the study is being financed by the Japanese Government. This study falls under the Government of Japan's cooperation to assist Caribbean countries in feasibility studies on the promotion of quality infrastructure export to the CARICOM countries.	
TO BE FINANCED	Estimate to be received on submission of comments	Proposal for Guyana 200MW Gas Fired Plant Evaluation Project (Siemens)	Under review and comments by GPL.	This study is intended to focus on the design of a transmission system and it will balance investments in transmission with investments in the natural gas pipeline and land availability for the Plant. A second objective of the study is the selection of technology for the new gas fired facility. In general the options to be considered include: a) combined cycle, b) single cycle – aeroderivative or with possibility of closing the cycle and c) reciprocating engines.

MATRIX OF PROPOSED & PENDING STUDIES: 2018

Entity	Financing Sum	Study	Comment/Timeline	Summary of Study
	Estimate to be determined	TOR for short-term contract for an in house Economic Analyst/Expert	TOR is in draft stages.	
	USD$125,000	Feasibility Study for Guyana's Offshore natural gas pipeline, LPG separation plant, and related electricity infrastructure (Jed Bailey)	**Proposed completion date: within 14 weeks.** Proposal was submitted to IDB for potential funding. However, IDB may not be willing to fund- awaiting letter of response.	In April 2017, the Government of Guyana contracted Energy Narrative to conduct a desk study of the options, cost, economics, impacts and key considerations of transporting and utilizing gas from Offshore Guyana primarily for the generation of electricity for local consumption. Having regard to this previous study, it may be prudent to build on this study in the form of a feasibility study of the proposed natural gas pipeline, LPG separation facility and related electric power system investments that are required to utilize natural gas produced offshore for electricity generation.